MULTI-LEVEL, AUTOMATED VEHICLE PARKING STRUCTURE

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ABSTRACT

A multi-level, automated vehicle parking structure comprising a plurality of horizontal, planar platform assemblies respectively located on a plurality of structure levels through which a central air shaft extends vertically. Each assembly comprises a rotary platform surrounding the shaft that is rotatable about a vertical axis of rotation extending through the shaft. In one embodiment, at least two oppositely directed vehicle elevators vertically and separately displaceable in the shaft have respective, substantially parallel, base centre lines that are off-radial with respect to the axis of rotation. Each rotary platform has a plurality of parking spaces arranged in circular array with respect to the axis of rotation and having respective base centre lines off-radially inclined in the same sense with respect to the axis of rotation. Each rotatable platform is rotatably displaceable so as to bring any selected pair of opposite parking spaces into respective communication with the elevators with the central base lines of the elevators being co-directional with the central base lines of the selected parking spaces. The structure further comprises at least one vehicle entry and exit level for selective communication with the elevators for transfer thereto and therefrom of vehicles to be parked and to be retrieved. Motorised dollies transport vehicles between the elevators and the parking spaces on the stationary platform.
MULTI-LEVEL AUTOMATED VEHICLE PARKING STRUCTURE

RELATED APPLICATION

[0001] This is a continuation-in-part of co-pending parent application PCT/IL01/00658 in which the U.S. has been designated, filed 18 Jul. 2001, the contents of which are hereby incorporated by reference, itself claiming priority from U.S. application Ser. No. 09/620,228, filed 20 Jul. 2000.

FIELD OF THE INVENTION

[0002] This invention relates, in general, to a multi-level, automated parking structure wherein entering vehicles can be automatically transferred by one or more elevators to levels of generally circular, particularly annular construction having vacant parking spaces and wherein means are provided for transferring vehicles from the elevators to the vacant parking spaces and, in reverse, for transferring the vehicles from the parking spaces to the elevators for subsequent retrieval.

BACKGROUND OF THE INVENTION

[0003] Automated parking systems are known which are provided with computerized and mechanical means to take control over a vehicle upon its arrival and to park it automatically in an available parking space, the vehicle being later returned to its driver, on demand. Recent developments in computerization and automation have lowered labor costs and rendered these systems speedier and more reliable. Automated parking systems offer obvious advantages over ramped garages, such as a saving in driver time and in fuel consumption, as well as the elimination of noxious fumes. These systems also minimize the dangers of accidents, theft and violence.

[0004] Nevertheless, few automated parking systems have actually been installed or enjoyed financial success, possibly because of high cost but mainly due to their inability to carry out vehicle parking and retrieving rapidly and efficiently enough when many clients are waiting in line, namely their steady throughput is too low and not reliable.

[0005] The prior art contains examples of automated parking structures having successive circular, particularly annular parking levels, none of which, however, have provided a solution for the combined problems of construction costs and rapid vehicle throughput. Such examples are to be found in U.S. Pat. Nos. 5,915,908; 5,851,098; 5,674,040; 5,478,182; 4,039,089, CH 684,203 A5; and European 0445,712-A1.

[0006] Of particular interest is U.S. Pat. No. 5,469,676 which discloses a circular parking garage which includes from two up to five rotating elevators in a central shaft of the parking system. This structure is volume-consuming as the inner diameter of the center, devoted to vehicle transfer, is very large, because of the spatial requirements of a central structural shaft wherein a plurality of rotatable elevators are located.

[0007] Also of interest is the disclosure in JP 4,149,377 of a multilevel parking structure, each level comprising a pair of coaxial rotary parking platforms respectively and independently served by inner and outer elevators. The structure is not provided with any means for ensuring transfer of vehicles from one rotating platform to its coaxial neighbor. Furthermore, the location and mode of operation of the elevators do not, for example, offer any back-up provision for the eventuality that the inner elevator fails to function.

[0008] U.S. Pat. No. 6,004,091 discloses a circular parking system using rotatable carousels to transfer vehicles to concentric spaces in a round, special purpose building. A few such carousels act to move the cars vertically and, by rotation of the carousel, also horizontally. Here one carousel is not able to approach the entrance of other levels because another carousel occupies the space at that time. Hence the response time of the system is slow. Also, the center shaft is dedicated to car transfer and therefore the volumetric efficiency of the system is relatively small.

[0009] U.S. Pat. No. 5,024,571 includes a ring of elevators, but each elevator serves only certain parking sites, so that temporary failure of said elevator will prevent exit of vehicles parked in these sites, so that no redundancies are optional. This patent, like many others in the prior art, uses pallets rather than dollies for transferring and storing the vehicles which makes it dependent on a pallet handling system and additional needed space, that further reduce the throughput of such system.

SUMMARY OF THE INVENTION

[0010] It is an object of the present invention to provide a new and improved multi-level, automated vehicle parking structure in which at least some of the disadvantages inherent in the prior art constructions are substantially reduced.

[0011] In accordance with one aspect of the present invention there is provided a multi-level, automated vehicle parking structure, comprising:

[0012] a plurality of horizontal, planar platform assemblies respectively located on a plurality of structure levels;

[0013] a central air shaft extending vertically through said levels;

[0014] each assembly comprising a rotary platform surrounding said shaft and rotatable about a vertical axis of rotation extending substantially through said shaft;

[0015] at least two oppositely directed vehicle elevators vertically and separately displaceable in said shaft and having respective, substantially parallel, base centre lines which are off-radial with respect to said axis of rotation;

[0016] each of said rotary platforms having defined thereon a plurality of parking spaces arranged in circular array with respect to said axis of rotation and having respective base centre lines off-radially inclined in the same sense with respect to said axis of rotation;

[0017] said base centre lines of said vehicle elevators and of said parking spaces being substantially tangentially directed with respect to a circle centred on said axis of rotation and of diameter substantially equal to the normal distance between the parallel said centres of said vehicle elevators.
[0018] each rotatable platform being rotatably displaceable so as to bring any selected pair of opposite parking spaces into respective communication with said elevators with the central base lines of said elevators being substantially co-directional with the central base lines of the selected parking spaces;

[0019] at least one vehicle entry and exit level for selective communication with said elevators for transfer thereof and therefrom respectively vehicles to be parked and to be retrieved;

[0020] motorised dollies for transporting vehicles from and to said elevators to and from parking spaces on said stationary platform co-directional with said elevators; and

[0021] drive means for respectively rotatably displacing said rotatable platforms and for vertically displacing said elevators.

[0022] This provision of the structure with a plurality of centrally located elevators who central base lines are not radially directed with respect to the rotational axis of the structure and, their association with off-radially directed parking spaces on the platforms allows for a very significant economy in space in the central air shaft (as compared with the space required to accommodate radially directed elevators). This, together with the possibility of supplementing the central elevators with additional elevators disposed adjacent the outer peripheries of the rotatable platforms radially increases the vehicle throughput capacity of the structure.

[0023] Preferably, the rotatable platforms are surrounded by coaxial stationary platforms with similarly off-radial parking spaces, motorised dollies being provided for transferring vehicles between each pair of coaxial platforms. The outer stationary platform can be of segmented construction with the outer elevators being displaceable in the intersegmentary spaces.

[0024] It will be appreciated that, the provision, in accordance with this aspect of the invention, of a bank of elevators within the inner periphery of the rotatable platforms and which are off-radially directed and which are designed to communicate with similarly off-radially directed parking spaces on the platforms allows for a maximal number of elevators in a minimal spatial region thereby considerably contributing to an increased vehicle throughput with minimal increase of constructional space.

[0025] In accordance with another aspect of the present invention there is provided

[0026] a multi-level, automated vehicle parking structure, comprising:

[0027] a plurality of horizontal, planar platform assemblies respectively located on a plurality of structure levels;

[0028] a central air shaft extending vertically through said levels;

[0029] each assembly comprising a stationary platform surrounding said shaft and substantially coaxial with said shaft;

[0030] at least two oppositely directed vehicle elevators separably displaceable in a vertical direction in said shaft and being rotatable as a unit in said shaft about a vertical axis of rotation extending through said shaft, said pair of elevators having respective, substantially parallel, base centre lines which are off-radial with respect to said axis of rotation;

[0031] each of said stationary platforms having thereon a plurality of parking spaces arranged in circular array with respect to said axis of rotation and having respective base centre lines off-radially inclined in the same sense with respect to said axis of rotation;

[0032] said parallel base centre lines of said vehicle elevators and of said parking spaces being substantially tangentially directed with respect to a circle centred on said axis of rotation and of diameter substantially equal to the normal distance between the parallel base centre lines of said vehicle elevators;

[0033] said elevators being rotatably displaceable so as to bring the central base lines thereof into respective communication with any selected pair of opposite parking spaces with the central base lines of said elevators being substantially co-directional with the central base lines of the selected parking spaces;

[0034] at least one vehicle entry and exit level for selective communication with said elevators for transfer thereof and therefrom respectively vehicles to be parked and to be retrieved;

[0035] motorised dollies for transporting vehicles from and to said elevators to and from parking spaces on said stationary platform co-directional with said elevators, and for return to their respective elevators; and

[0036] drive means for respectively rotatably displacing said elevators and for their separate vertical displacement.

[0037] As distinct from the prior art structures, referred to above, there is the continuing possibility of transfer of vehicles from the inner rotary to the outer stationary platforms and vice versa. Furthermore, optimal use of constructional space is achieved when the outer stationary platforms are constructed in segmental form with the elevators vertically displaceable in the inter-segmental spaces or intervals.

[0038] Preferably said vehicle entry and exit level comprises:

[0039] a rotatable transfer platform having defined thereon a plurality of vehicle transfer locations arranged in circular array with respect to a vertical axis of rotation of said platform;

[0040] said elevators being vertically displaceable for selective communication with the transfer locations and the parking spaces on the rotatable platforms of each of said levels to convey vehicles to, and to retrieve vehicles from said levels;

[0041] a plurality of vehicle entry and exit stations radially distributed about an outer periphery of said
rotatable between vehicle entry and exit positions and an intermediate vehicle delivery and collecting position aligned with a vehicle transfer location;

[0042] said rotatable transfer platform being rotatably displaceable so as to bring any selected transfer location thereon into alignment with said station entry and exit position so as to receive a vehicle from or to deliver a vehicle to said station and so as to bring any selected transfer location thereon into alignment with an elevator so as to deliver a vehicle to or receive a vehicle from said elevator; and motorised dollies for transporting vehicles from and to said transfer stations to and from aligned transfer locations of said transfer level; and for transporting vehicles from and to said elevators to and from aligned transfer locations and parking spaces.

[0043] Such an arrangement allows for a radically increase potential for rapid and effective vehicle throughput especially during peak traffic times.

[0044] In all cases the motorised dollies which are employed to transfer vehicles from and to the elevators and between the rotary and stationary platforms can be of the AGV (Automatic Guided Vehicle) type whilst appropriate computer controlled systems are used to ensure the ready elevator availability and the appropriate positioning of a vacant parking space as well as the control of the motorised dollies.

BRIEF DESCRIPTION OF THE DRAWINGS

[0045] In order to understand the invention and to see how it may be carried out in practice, preferred embodiments will now be described, by way of non-limiting examples only, with reference to the accompanying drawings, in which:

[0046] FIG. 1 is a schematic representation of a multi-level vehicle parking structure in accordance with the invention;

[0047] FIG. 2 illustrates an embodiment of a multi-level parking structure having two elevators installed in a central air shaft serving the inner perimeter of a rotatable parking platform wherein the inner elevators and parking spaces are in non-radial alignment with the center of rotation; all parking places are turned in one tendency from radial.

[0048] FIG. 3 illustrates an embodiment on which each level of the multi-level structure is a rotary annular platform serviced by a central bank of four elevators with non-radial centerlines operating within a vertical air shaft bordered by the inner periphery of the non-radial parking platform. An additional, outer stationary annular non radial array of parking spaces, receives vehicles from and, returns them to, the rotatable parking platform.

[0049] FIG. 4 illustrates the drive-in, drive-out level of an embodiment according to FIG. 3 wherein a bank of four non-radial elevators operates within the air shaft of the building, serviced by several turntables to facilitate easy ingress and egress.

[0050] FIG. 5 illustrates an embodiment in which on every level of the multi-level structure is a stationary annular parking platform, with non radial parking places, serviced by a rotating central bank of two elevators operating within a vertical air shaft bordered by the inner periphery of the stationary parking platform.

[0051] FIG. 6 is a plan view illustrating one level of a parking structure for parking vehicles with a rotatable annular parking platform having radially aligned parking spaces. Elevators are spaced at the outer periphery of said rotating platform and additional stationary parking spaces between the outer elevators receive vehicles from, and return them to, the rotatable parking platform.

[0052] FIG. 7 is a plan view illustrating an embodiment of a multi-level parking structure having a rotatable annular parking platform with elevators at its outer periphery. Additional parking spaces between the outer elevators and an additional inner stationery central annular parking platform, receive vehicles from, and return them to, the rotatable parking platform.

[0053] FIG. 8 illustrates a plan view of the drive-in, drive-out street level of the parking structure of FIG. 7 serviced by twice as many turntables as the number of elevators.

[0054] FIG. 9 illustrates a parking level in accordance with a further embodiment of the invention;

[0055] FIG. 10 illustrates an entry/exit level of a further embodiment in accordance with the invention; and

[0056] FIG. 11 illustrates an embodiment of the invention that includes a double-decker elevator of adjustable deck heights increases the throughput of the system where there exists separate drive-in, drive-out levels and parking levels of varying heights.

DETAILED DESCRIPTION OF THE INVENTION

[0057] FIG. 1 shows a vehicle-parking installation generally indicated by 1. The installation is designed as a circular building with a central vertical axis X. An entry/exit level 3 may be located at ground level as shown in FIG. 1. Alternatively, the entry/exit level 3 may be located above or below ground level, in which case, the entry/exit level is accessed by one or more ramps. The parking installation 1 may also have separate entry and exit levels located at different levels in the installation 1. The entry/exit level 3 is shared by a plurality of parking levels 2 that may be either above, below or partly above and partly below the entry/exit level. In accordance with the invention, each parking level 2 includes one or more circular or annular platforms that are rotatable around the axis X of the installation 1.

[0058] The installation 1 includes one or more elevator shafts 5 extending vertically through the installation. Each elevator shaft includes an elevator car 9 for transferring vehicles between each of the parking levels 2 and the entry/exit level 3. The elevator shafts may be located in the center of the installation as shown in FIG. 1, or may be located around the periphery of the installation.

[0059] Each parking space in the installation 1 preferably has an associated sensor that determines whether the parking space is occupied or vacant. A change in the status of each space (occupied or vacant) is transmitted in real time to a computer and stored in a database associated with the computer. The sensor may be, for example, an electromag-
ncetic permeability detector planted in each parking space which senses the metallic presence of a vehicle overlying the sensor, to generate a signal which is supplied to the data base of the computer to indicate whether the parking space is free or taken.

[0060] When a vehicle enters the entry/exit level 3 the computer generates a map-giving the existing status of the parking spaces in the facility and determines the closest vacant parking space on the parking levels 2 that elevator. The car is delivered into an elevator car, and the computer then generates a command signal to the elevator car to rise to the parking level 2 upon which the determined vacant parking space is located. Movement of vehicles on the entry/exit level 3 and on the parking levels 2 is by means of motorized dollies, as described in detail below.

[0061] Where a high throughput is desirable, drive-in and drive-out facilities can be located on two levels, for example, with one being at street level and the other at basement level, accessible by way of a ramp or ramps. During regular operation, drive-in facilities could be in the basement and drive-out at street level, but at peak hours both levels could cooperate to serve either entering or departing vehicles. The two parking levels can be served by a double-decker elevator as described in detail below.

First Embodiment

[0062] FIG. 2 shows one embodiment of the parking level 2, generally indicated by 2a. The parking level 2a includes an annular platform 8 rotating about the central axis X of the installation. Two elevator shafts 4 and 6 are centrally located in an interior central space 26 of the parking level 2a. The elevators 4 and 6 share a common wall 10 that lies on a diameter of the parking level 2a. The elevators 4 and 6 have parallel base centerlines 14a and 14b, respectively, which are off-radial, i.e., neither of which lie on a diameter of the parking level 2a. The elevator shafts 4 and 6 each have an opening 15a and 15b, respectively, at the parking level 2a, facing opposite directions. The annular platform 8 comprises a plurality of parking spaces 20, having off-radially aligned center base lines, represented by broken lines 14.

[0063] Transferring a vehicle from an elevator car, for example, the elevator car 9a located in the elevator shaft 6, to a vacant parking space 20a takes place at a position wherein the center base line 24 of the parking space 20a is aligned with the center base line 16 of the elevator car 9a. The centerlines 14 of the parking spaces 20 are tangential to a circle 28 having its center at the axis X, where the diameter of the circle 28 is the distance between the centerlines 14 and 16, of the two elevator shafts 4 and 6, respectively.

[0064] This arrangement of the two elevator shafts 4 and 6 in which the two center lines 14 and 16 do not lie on radii of the parking level 2 minimizes the area of the central space 26, which need only occupy an area slightly greater than a single rotating elevator. Two central elevators whose centerlines lie on a diameter of a circular parking level require a central area at least twice the area of the central space 26. A rotary drive (not shown) rotates the rotatable platform 8 around the axis X so as to align the centerline of an available parking space 20 with the center base line of an elevator car 9a.

[0065] Vehicles 30 are transferred between the elevator cars 9 and the parking spaces 20 by motorized dollies 17 that are attached to the floor of the elevator cars 9 by umbilical electrical or hydraulic cords. The motorized dollies 16 may be, for example, electrically powered through an umbilical point cord tethered to the elevator. The cord winds around a spring-loaded reel so that when the dolly travels out of the elevator, the cord unwinds from the reel, and when the dolly returns to its elevator station, the cord re-winds.

Second Embodiment

[0066] Further attention is now directed to FIG. 3, illustrating a second embodiment of a parking level 2, generally indicated by 2b, that is part of the parking installation 1. The parking level 2b comprises an inner annular parking platform 54, and a rotatable outer parking platform 56. The parking platforms 54 and 56 are both coaxial with the axis X of the installation 1. The inner platform 54 has a sufficiently large inner diameter to surround a central region 59 including four elevator shafts 64a-64d, each servicing all levels of the installation 1.

[0067] The central region 59 is divided into four quadrants A, B, C and D by a cruciform partition wall 70.

[0068] In each one of the elevators 64a-64d, is an elevator car 9 upon which an electrically-powered motorized dolly 76 is installed. The motorized dolly 76 is loadable by a vehicle to be parked and functions in the same manner previously described, to transfer a vehicle from an elevator car 9 to a vacant parking space 80 that is in line with the elevator. As in the previous embodiment, the center base lines of the parking spaces 80 do not lie on a radius of the parking platform 2b. The center base lines 82a-82d of the elevators 64a-64d, respectively, coincide with the center base lines 86 of a parking space 80.

[0069] The center base lines 86 of the parking spaces 80, are tangential to a circle 90 having a common center with the center X of the installation, where the diameter of the circle 90 is the distance between the centerlines of each pair of elevators 64a and 64b; and 64c and 64d.

[0070] In the embodiment shown in FIG. 3, the elevator shafts 64a-64d in the central bank operate independently. Hence, if four vehicles to be parked enter the installation, they need not await their turn to be parked. Each vehicle may be driven into a different elevator in the elevator bank and transported by that elevator to a level 2b in the installation having an available parking space. The outer platform is rotated so that a vacant parking space (e.g., the space 80a) is aligned with the elevator. The number of parking spaces is a multiple of four, so that when a parking space is aligned with one elevator, a parking space is aligned with each of the remaining three elevators, so that up to four vehicles transfers from or to the elevators can take place on a single parking level 2b simultaneously.

[0071] In the facility illustrated in FIG. 3 there is a bank of four elevators 64a-64d in the central region 59. However, the bank may consist of only two or three elevators depending on the required operating time of the system. Thus with a facility having 10 levels, four elevators operating simultaneously may be necessary to achieve rapid parking. However, if there are only four levels in the facility, a bank of two elevators may be sufficient to provide acceptable fast service.
[0072] The outer stationary platform 56 and the inner rotary platform 54 each has a circular array of parking spaces 80. The outer stationary platform 56 has a greater number of parking places than the inner rotary platform 54. The motorized dollies, 57 are powered by a rechargeable battery power pack, and are therefore unfettered. The dolly is therefore itinerant, being free to travel throughout the facility to transfer vehicles to and from spaces in the rotary platform 54 and spaces in the stationary platform 56. The itinerant dollies, when not active, are stationed in vacant spaces in the stationary platform.

[0073] Encircling the stationary platform 56 is a rail 59 with sockets for recharging the power pack of a dolly when a plug at the rear of the pack engages the socket (not shown).

[0074] Since the outer platform 56 is stationary, an elevator 61 may be located in the platform 56 to carry a vehicle to be parked to any level of the facility having a vacant space.

[0075] When a vehicle at the entry/exit 3 level wishes to enter one of the elevators 64a-64d, the vehicle must be correctly oriented with respect to the center line 82a-82d of the respective elevator, so that the center line of the entering vehicle is aligned with the center line of the elevator so that the vehicle does not veer to one side of the elevator.

[0076] Attention is now directed to FIG. 4 which illustrates the entry/exit level 3 of a parking installation having the parking levels 2e. Four turntables 92a-92d are provided each enclosed within a cylindrical shell 98a-98d, respectively. Each cylindrical shell 98a to 98d has an entry opening 100a-100d for a vehicle to be parked, and an exit opening 102a-102d for a departing vehicle. In operation, a vehicle 110 rides onto the turntable 92a through the entry opening 102a, as shown in FIG. 4, and is rotated so that the center line of the vehicle 10 is aligned with the centerline of elevator 64a. Hence the vehicle 110 can now move into the elevator 64d and be loaded on the dolly 76 stationed therein.

[0077] When a vehicle 114 departs the installation 1, it is brought down by an elevator, say elevator 64c, and is deposited by its dolly 76 onto the turntable 92c. The turntable 92c then turns to align the vehicle 114 thereon with exit opening 102c so as to permit the vehicle to depart the installation.

Third Embodiment

[0078] FIG. 5 illustrates another embodiment of a parking level 2, generally indicated by 2c. In this embodiment, the installation 1 comprises two elevators 156a and 156b located within a rotatable central circular region 160 in the interior of an annular stationary platform 162. The elevators 156a and 156b share a common wall 164 that lies on a diameter of the parking level 2c. The elevators 156a and 156b have parallel center base lines 166a and 166b respectively that face in opposite directions that are not radially aligned. The platform 162 comprises a plurality of non-radially aligned parking spaces 166, represented by dashed lines. The difference between the present embodiment and that illustrated in FIG. 1 resides in that the platform 162 is stationary and is served by the rotary bank of elevators 156a and 156b.

[0079] The bank of elevators rotates, until they are aligned with a parking space. Although the elevators turn together, they travel vertically quite independently which differentiates them from a single central elevator system with two parking places.

Fourth Embodiment

[0080] FIG. 6 illustrates another embodiment of the parking level 2, generally indicated by 2d. The parking level 2d comprises a rotatable annular platform 214 and a stationary platform 224 surrounding the annular platform 214. Rotatable platform 214 is divided into segments, i.e. is segmented and has a circular array of parking spaces 216 for vehicles 218 and stationary platform 224 has a circular array of parking spaces 226 for vehicles 228. The parking spaces in both platforms 214 and 224 extend radially with respect to the axis X of the installation 1. The parking level 2d also includes four elevators 210 which are vertically displaceable in the inter-segmentary intervals in the stationary platform 224. Each elevator 210 carries an electrically powered motorized dolly 211 adapted to accommodate and be loaded by a vehicle to be parked which is transported by the elevator 210 to the parking level 2d on whose rotatable platform 214 is a vacant parking space 216. The platform 214 is then rotated to align the vacant space 216 with the elevator 210. The dolly 211 then transfers the vehicle 218 from the elevator to the parking space 216 where it is unloaded from the dolly. The unloaded dolly 211 then returns to the elevator 210 so that it can subsequently retrieve the parked vehicle or receive another vehicle to be parked.

[0081] Vehicles can be transferred between the rotatable platform 214 and parking spaces 226 on the outer stationary platform 224 and back by means of an electrically powered, motorized dolly 222 on a turntable 220 whose center is the axis X of the installation 1. The rotatable platform 214 rotates so that the vehicle to be transferred is aligned with an available parking space 226 on the stationary platform 224. At the same time central turntable 220 rotates and aligns dolly 222 with the vehicle and the available parking space 226. Dolly 222 is then powered to travel under the vehicle, load it, transfer it to the available parking space 226 on the stationary platform 224, unload it there and then return to the turntable 220. In reverse, a vehicle 228 parked on the stationary platform 224 can be transferred to the rotatable platform 214. As the dolly 222 only travels in straight lines, it can be tethered to the center of the turntable 220 by an umbilical electric line.

Fifth Embodiment

[0082] Attention is now directed to FIG. 7 illustrating another embodiment 2e of a parking level 2 of the parking installation 1. The parking platform 2d comprises an inner annular rotatable platform 254 and an outer annular stationary platform 256 surrounding the inner platform 254. Parking spaces are arranged in the outer annular platform with the center base line of each parking space being oriented radially on the platform. Stationary platform 256 includes a bank of three elevators 264a,b,c and c. The elevators 264a-264c communicate with the parking spaces on the inner rotatable platforms 254 of each of the parking levels to convey vehicles to and from vehicles from, the parking level 2d. Rotating the inner annular platform 254 brings each parking space on the rotatable platform 254 into and
out of alignment with an elevator 264 and into and out of alignment with a parking space 282 on the stationary platform 256.

[0083] An electrically powered, motorized dolly 276 is stationed on each of the elevators that is adapted to accommodate and be loaded by a vehicle that is to be parked. The rotatable inner platform 254 is rotated so as to align a vacant parking space with the elevator 264. The dolly 276 is then powered to transport the vehicle from the elevator 264 to the vacant parking space on the rotatable platform 254 and to unload the vehicle in the vacant space. The unloaded dolly 276 then returns to its station in the elevator 264 so that it can subsequently retrieve the parked vehicle or receive another vehicle to be parked.

[0084] Vehicles can be transferred between the rotatable platform 254 and the stationary platform 256 by means of electrically-powered motorized dollys 258, stationed on a turntable 260, whose center is on the axis X of the installation I. The rotatable platform 254 is rotated so that a vehicle in a parking space on the rotatable platform 254 is aligned with an available parking space 282 on the stationary parking platform 258. At the same time, the central turntable 260 rotates and aligns an electrically powered dolly 258 with the vehicle and the available parking space 282. One of two dollys 258 is then powered to run under the vehicle, load it, transfer it to the available parking space on stationary platform 256, unload it and return to turntable 260. As the dollys travel in straight lines they can be tethered to the center of the turntable 260 by an umbilical electric cord which winds around a spring-loaded reel so that, when the dolly 258 leaves the turntable 260 the cord unwinds and when the dolly returns to the turntable the cord then rewinds. The two dollys 258 are shown in FIG. 7 as lying on the same diameter of the turntable 260. In this case the two dollys 258 can only move along radii separated by 180°. Alternatively, each dolly can be supported on a small platform at the extremity of an arm (not shown) that pivots on the axis X (the two arms thus acting like the hands of a clock) so that each dolly can move along radii having any angle between them.

[0085] FIG. 8 illustrates an entry/exit level 3a of an embodiment of the parking installation I having the parking levels 2d shown in FIG. 7. The entry/exit level 3a includes a rotatable transfer platform 252 and the bank of three elevators 264a-264c. Seven turntables 290 are located outside the rotatable transfer platform 252. The turntables 290 are enclosed by security walls or screens 292 having three openings that can be closed off by roll down shutters. An entry opening 294 for a drive-in vehicle, an exit opening 296 for a drive-out vehicle and a security opening 298. Each security wall 292 and corresponding turntable 290 can serve as a drive-in or a drive-out facility, thus at particular peak hours most, or all, of the seven turntables, could serve arriving vehicles and at other peak hours, departing vehicles.

[0086] An important feature of this embodiment is that the center base lines of the three elevators 264 are 22.5° apart and the center base lines of the seven turntables 290 lie on radial lines 45° apart. The rotatable transfer platform 252 in the entry/exit level has 16 transfer spaces on radial lines 22.5° apart. The rotation of the rotatable transfer platform 252 is programmed to stop precisely with the center base line of a transfer space 291 aligned with the center base line of an elevator 264. Due to the 16-fold radial symmetry of parking level 2d, the remaining 2 elevators and the 7 turntables will also be aligned with other transfer spaces 291 so that a number of vehicle transfers can take place simultaneously and to and from elevators 264a-264c and to and from turntables 290 while the rotatable transfer platform 252 is temporarily stationary.

[0087] An arriving vehicle rides onto a turntable 290 and is rotated thereby so that the center base line of the vehicle is radially aligned with a transit space 291 on the rotatable transit platform 252. An electrically powered mechanical dolly 270 on a central turntable 272 transfers the vehicle from the turntable 290 to a transient space 291 on the rotatable transfer platform 252. The alignment of an available parking space 291 on the rotatable transform platform 252 and a vehicle on a turntable 290 generates a command to the dolly 270 to cross the rotatable transfer platform 274, which is stationary during the transfer, and enter the security cell 292 through opening 298. It then loads the vehicle standing on the turntable 290, transfers it to a transfer space 291 on the rotating transfer platform 252, unloads it and returns to turntable 272. The reverse procedure is performed when a vehicle is to be moved from the rotatable transfer platform 252 to a turntable 290. The motorized dollys 270 may be powered through umbilical cords tethered to the turntable 272. The four motorized dollys on the center turntable 272 are shown at fixed right angles to each other, so that when the turntable 272 is aligned with a turntable 290, the other three dollys will be aligned with three other turntables 290. As described above, the four dollys can also be supported by swinging arms (not shown) that pivot around the central axis, much like the hands of a clock.

[0088] Vehicles are transferred from the rotatable transfer platform 252 to an elevator 264 by an electrically-powered, motorized tethered dolly 276 stationed in the elevator; which moves under the vehicle on the rotatable transfer platform; loads the vehicle and transfers it to the elevator which then rises or descends to a parking level. The reverse procedure occurs when a departing vehicle is to be moved an elevator 264 to the rotatable transfer platform 252, and in a further transfer, onto a turntable 290 during departure.

Sixth Embodiment

[0089] FIG. 9 illustrates a parking level 2 in accordance with another embodiment generally indicated by 2c. This embodiment includes an inner stationary platform 325, an outer stationary platform 330, and a rotatable platform 315. It also includes six equally spaced elevators 310 in the outer stationary platform 330. A dolly 309 parked on a central turntable 320 and tethered to a central point of said turntable, is enabled to transfer a vehicle from the rotatable parking platform 315 to a parking space on the inner stationary parking platform 325 and also to perform the reverse procedure. The large number of parking spaces on every level necessitates a large number of elevators (6). Spacing of vehicles on the parking level 2c is along radial lines at 12° spacing from each other. Elevators are on radial lines spaced 60° apart. Every parking space on the inner stationary platform 325 is radially aligned with every second parking space on the rotatable parking platform 315. Thus when one of the 30 parking spaces on the rotatable parking platform 315 is aligned with an elevator, another five parking spaces will simultaneously be aligned with the remaining 5 eleva-
tors and 15 of the parking spaces will be simultaneously aligned with 15 parking spaces on the inner circular parking platform 325. At peak arrival and departure times, these features increase the number of vehicles that can be handled simultaneously.

[0090] FIG. 10 illustrates an entry/exit level 3b of an embodiment of the parking installation 1 having parking levels 2d. The entry/exit level 3b includes turntables 290 enclosed by security mesh with roll down gates 292 for drive-in entry, drive-out exit and transfers between turntable and elevator, as in the embodiment shown in FIG. 8. In comparison to that embodiment, a rotatable transfer platform 252 has a greater diameter and there are more turntables. Each of six dollies 400 is tethered to an individual transfer platform 410 which travels on accurate tracks 420 in shallow recesses 425 in the central area. The upper surface of each platform 410 is level with the overall floor level, the level of the platform 252 and the level of the turntables 290. Each platform 410 is motorized and travels between two radii connecting the center of two adjacent turntables to the axis X of the installation 1. The platform 410 is positioned at one limit of its travel, at which position it’s center base line and the center base line of the dolly 400 is carrying is aligned with a vehicle on a turntable. The dolly leaves its platform, travels over a vacant parking space on the rotatable transfer platform 430, stops under the vehicle; lifts it and carries it to the vacant parking space, unloads it and returns to the small platform. The process is reversed when a vehicle is to be moved from the rotatable parking platform to the turntable.

Seventh Embodiment

[0091] FIG. 11 illustrates an embodiment of the elevator car 9 that may be used with any of the embodiments of the invention. The embodiment of FIG. 11 is a double-decker elevator car that can accommodate two vehicles simultaneously, one on top of the other, where the difference in the levels of the two vehicles corresponds to the difference in the levels of two adjacent parking levels (or the exit/entry level and a parking level) in the installation 1. The elevator is built like a freight elevator having a cabman 120 suspended on steel cables 121 stiffened by a regular double beam structure 122.

[0092] The elevator 120 includes an upper floor 125 supported by two or more vertically-extending columns 126 whose height is fixed to align the upper floor 125 and the lower floor 129 with the surfaces of two adjacent parking levels 2 and 2’ from which or to which the two vehicles are to be transferred. Floor 125 of the elevator has a dolly 127b therein for transferring the vehicle on that floor to the parking level 2, and lower floor 129 has a dolly 127b therein for transferring the vehicle on that floor to the adjacent parking level 2’.

[0093] Both floors 125 and 129 preferably include chocks 130 at both ends of the dollies 127 to prevent horizontal movement of the dollies and vehicle until the floors 125 and 129 are aligned with the parking levels 2 and 2’, respectively. The elevator may be provided with sensors and controls to assure that the chocks 130 can only be withdrawn into the elevator floor when the elevator floor is properly aligned with the a parking level 2 or an entry/exit level 3. No elevator doors are then required.

[0094] While in the specific embodiments described above the use of tethered and untethered motorized vehicles has been mentioned, it is clear that an AGV type device can be used throughout.

1. A multi-level, automated vehicle parking structure, comprising:

a plurality of horizontal, planar platform assemblies respectively located on a plurality of structure levels;
a central air shaft extending vertically through said levels;
each assembly comprising a rotary platform surrounding said shaft and rotatable about a vertical axis of rotation extending substantially through said shaft;
at least two oppositely directed vehicle elevators vertically and separately displaceable in said shaft and having respective, substantially parallel, base centre lines which are off-radial with respect to said axis of rotation;
each of said rotary platforms having defined thereon a plurality of parking spaces arranged in circular array with respect to said axis of rotation and having respective base centre lines off-radially inclined in the same sense with respect to said axis of rotation;
said base centre lines of said vehicle elevators and of said parking spaces being substantially tangentially directed with respect to a circle centred on said axis of rotation and of diameter substantially equal to the normal distance between the parallel base centre lines of said vehicle elevators;
each rotatable platform being rotatably displaceable so as to bring any selected pair of opposite parking spaces into respective communication with said elevators with the central base lines of said elevators being substantially co-directional with the central base lines of the selected parking spaces;
at least one vehicle entry and exit level for selective communication with said elevators for transfer thereto and therefrom respectively vehicles to be parked and to be retrieved;
motorised dollies for transporting vehicles from and to said elevators to and from parking spaces on said stationary platform co-directional with said elevators, and drive means for respectively rotatably displacing said rotatable platforms and for vertically displacing said elevators.

2. A vehicle parking structure according to claim 1 wherein each platform assembly furthermore comprises a stationary platform surrounding the rotary platform and having defined thereupon a plurality of like off-radial parking spaces, there being furthermore provided motorised dollies for transporting vehicles from and to said rotary platforms to and from parking spaces on said stationary platforms. A vehicle parking structure according to claim 2 wherein there are furthermore provided additional elevators located adjacent to an outer periphery of each rotary parking platform and having similarly off-radial center lines.

3. A vehicle parking structure according to claim 2 wherein there are furthermore provided additional elevators, vertical displaceable in additional elevator shafts located.
adjacent to an outer periphery of each rotary parking platform and having similarly off-radial center lines.

4. A vehicle parking structure according to claim 3 wherein said additional elevators are located in intervals formed in said stationary platforms.

5. A vehicle parking structure according to claim 1 wherein there are provided a pair of successive entry and exit of said structure and wherein one or more of said elevators is/are formed with double, superimposed decks designed respectively to communicate with respective successive entry and exit levels of said structure.

6. A vehicle parking structure according to claim 1 wherein two pairs of said oppositely directed elevators are provided, each pair being directed substantially normally with respect to the other pair.

7. A vehicle parking structure according to claim 1 wherein a vehicle entry turn-table is provided having an automatic centering device for aligning the entering vehicle with the associated elevator center-line.

8. A multi-level, automated vehicle parking structure, comprising:

- a plurality of horizontal, planar platform assemblies respectively located on a plurality of structure levels;
- a central air shaft extending vertically through said levels;
- each assembly comprising a stationary platform surrounding said shaft and substantially coaxial with said shaft;
- at least two oppositely directed vehicle elevators separately dischargeable in a vertical direction in said shaft and being rotatable as a unit in said shaft about a vertical axis of rotation extending through said shaft, said pair of elevators having respective, substantially parallel, base center lines which are off-radial with respect to said axis of rotation;
- each of said stationary platforms having defined thereon a plurality of parking spaces arranged in circular array with respect to said axis of rotation and having respective base center lines off-radially inclined in the same sense with respect to said axis of rotation;
- said parallel base center lines of said vehicle elevators and of said parking spaces being substantially tangentially directed with respect to a circle centered on said axis of rotation and of diameter substantially equal to the normal distance between the parallel base center lines of said vehicle elevators;
- said elevators being rotatably dischargeable so as to bring the central base lines thereof into respective communication with any selected pair of opposite parking spaces with the central base lines of said elevators being substantially co-directional with the central base lines of the selected parking spaces.

9. A multi-level automated vehicle parking structure comprising:

- a plurality of horizontal, planar platform assemblies respectively located on a plurality of parking levels of said structure;
- each assembly comprising a rotary, annular parking platform having a vertical axis of rotation and a stationary, annular platform surrounding said rotary platform, each of said platforms having defined thereon a plurality of parking spaces arranged in circular array with respect to said vertical axis;
- a plurality of elevator shafts located adjacent to peripheries of the rotatable platforms and being vertically dischargeable for communication with the parking spaces on the rotatable platforms of each of said levels to convey vehicles to, and to retrieve vehicles from selected levels;
- each rotatable platform being rotatably dischargeable so as to bring any selected parking space thereon into and out of selective communication with the or each elevators and into and out of selective communicating, co-directional alignment of a parking space thereon with a parking space on said stationary platform;
- motorised dolly's respectively for transporting vehicles from and to said elevators to and from aligned vacant parking spaces on said rotary platform;
- motorised dolly's for transporting vehicles from and to said rotary platforms to and from parking spaces on said stationary platforms;
- at least one vehicle entry and exit level for selective communication with said elevators for transfer thereto and therefrom of respectively of vehicles to be parked and to be retrieved; and
- drive means for respectively rotatably discharging said rotatable platforms and for vertically discharging said elevators.

10. A vehicle parking structure according to claim 9 wherein said vehicle entry and exit level comprises:

- a rotatable transfer platform having defined thereon a plurality of vehicle transfer locations arranged in circular array with respect to a vertical axis of rotation of said platform;
- said elevators being vertically dischargeable for selective communication with the transfer locations and the parking spaces on the rotatable platforms of each of said levels to convey vehicles to, and to retrieve vehicles from said levels;
- a plurality of vehicle entry and exit stations radially distributed about an outer periphery of said rotatable transfer platform, each station being rotatable between vehicle entry and exit positions and an intermediate vehicle delivery and collecting position aligned with a vehicle transfer location;
said rotatable transfer platform being rotatably displaceable so as to bring any selected transfer location thereon into alignment with said station entry and exit position so as to receive a vehicle from or to deliver a vehicle to said station and so as to bring any selected transfer location thereon into alignment with an elevator so as to deliver a vehicle to or receive a vehicle from said elevator; and

motorised dollies for transporting vehicles from and to said transfer stations to and from aligned transfer locations of said transfer level; and for transporting vehicles from and to said elevators to and from aligned transfer locations and parking spaces.

11. A parking structure according to claim 9 wherein the radial distribution of said elevators and said vehicle stations with respect to the radial distribution of the transfer locations are such that rotary displacement of said transfer platform into alignment with an entry/exit position of a vehicle station results in the simultaneous respective alignment of the entry/exit positions of the other vehicle.

12. A parking structure according to claim 10 wherein motorised dollies are positioned on a central turntable of said structure coaxial with and surrounded by said transfer platform, said turntable being rotatable so as to align an available dolly with an aligned entry/exit position of a vehicle station and an aligned transfer location on said transfer platform whereby said available dolly can be displaced through said aligned transfer location into said aligned entry/exit position so to be loaded with a vehicle and to displace said vehicle to said transfer location, or so as to be loaded with a vehicle in said transfer location and to displace it into said vehicle station, in either case the unloaded dolly returning to said central turntable.

13. A vehicle parking structure according to claim 9 wherein there are provided a pair of successive entry and exit of said structure and wherein one or more of said elevators is/are formed with double, superimposed decks designed respectively to communicate with respective successive entry and exit levels of said structure.

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