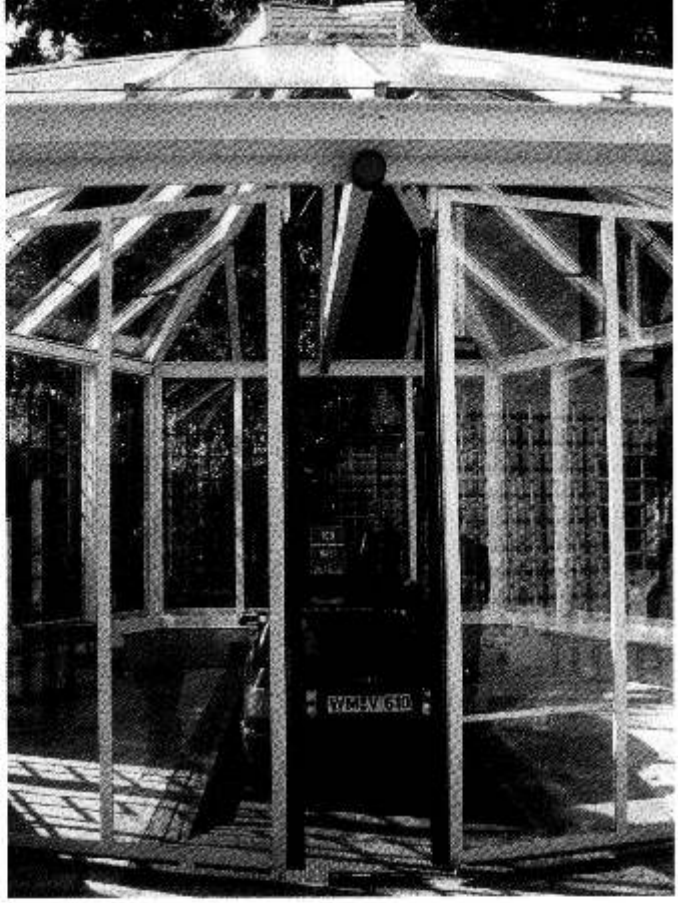
A Survey by Manfred Boltze and Andreas Moatz

MECHANIZED PARKING INSTALLATIONS

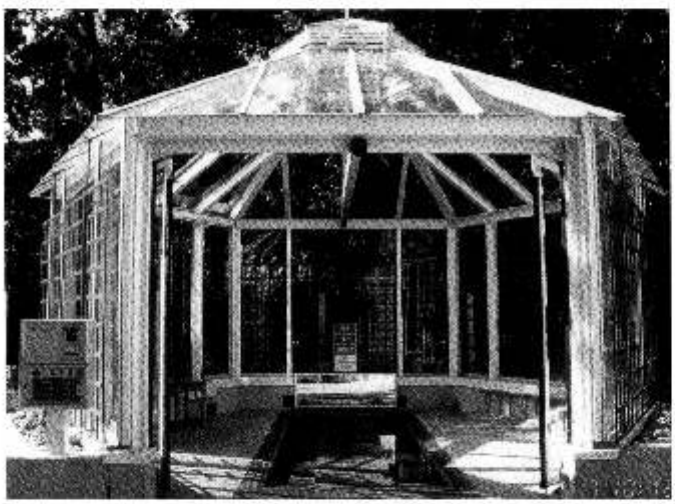


1. INTRODUCTION

For new buildings as well as for reconstructed buildings, the planner and the architect are confronted with the problem of creating cost-effective and sufficient parking space on a floor area as small as possible.

Generally, this requirement has been fulfilled until now by a conventional building, e.g. by an underground or a multi storey car park. In the meantime, however, the parking space requirements defined by the owner or by of the community regulations (parking space regulations) especially in city quarters with a high density of utilization may be increasingly realized with traditional methods only to an insufficient extent.

By operative means - such as a flexible space allotment for rental parkers instead of firmly assigned and frequently unutilized parking spaces - as well as with simple technical means, attempts were made to utilize available parking space more intensively. Primarily, the lanes in underground car parks were additionally utilized be the installation of movable plates, or, by means of lifting platforms, a multiple usage of floor space of a conventional parking lot was achieved. However, these mechanical devices in traditional parking buildings may increase the parking space capacity of a given floor space only to a limited extent.



For some time now, the number of manufacturers offering parking equipment as a solution to the problem whereby the whole parking process is completely mechanized, has increased. The arguments supplied by the manufacturers promoting their use are manifold: economical aspects are brought forward as well as the potential for design possibilities or safety and convenience aspects. This type of parking equipment, however, could not gain ground as a fully accepted alternative in town and traffic planning. The future city and traffic development, however, gives reason to expect an increasing pressure towards such solutions.

Until today, a detailed assessment of this range of subjects has not been available from a planning point of view. Therefore, it has been taken into account in the research field "Town Planning and Traffic" of the programme "Experimental Housing and Town Planning" (ExWoSt) programme which has been initiated by the German Federal Minister for Regional Planning, Building and Urban Development. The extensive model project of the City of Frankfurt/Main "Parking Guidance Systems and Mechanical Parking Equipment in Town Planning and Traffic Concept" is financed by resources of the Federal Minister and by the City of Frankfurt/Main and is handled by Albert Speer & Partner GmbH (AS&P).

An essential object of the research is to show the town planning and traffic integration possibilities as well as appropriate fields for use of mechanical parking equipment and thus offer a decision finding support with architects and planners. A final report of the projects results is expected by 1993.

The present paper - in anticipation - describes the different parking devices and their operative features while obvious terms independent from manufacturers were used for individual parking systems. Principally, the terms used in the "Empfehlungen für Anlagen des ruhenden Verkehrs" (Forschungsgesellschaft für Straßen- und Verkehrswesen, Köln 1991) were taken into account. However, partial differences were made in order to achieve a better categorization in the total of the terms. With the terms introduced, a contribution to the discussion about the further guideline establishment is intended.

The authors express their gratitude to Dr.-Ing. L. Dunker, Head of the working committee who has drawn up the "EAR 1991", for the suggestions and hints on the coordination of this contribution.

Mechanisches Parken - Eine Umfrage **D**

Im Zuge der Bestrebungen zur Schaffung von ausreichenden und kostensparenden Parkflächen, prüfen Planer und Architekten auch die traditionellen Methoden des Baus von Parkhäusern. Auch der Gebrauch mechanischer Parksysteme in andernfalls traditionell erstellten Konstruktionen bietet noch immer keine optimale Lösung. Die Umfrage, die von der Albert Speer & Partner GmbH durchgeführt wurde, konzentriert sich auf die Vor- und Nachteile dreier Systeme: konventionelle Gebäude und solche, die halb oder ganz auf den automatisierten Betrieb umgestellt sind. Sie berücksichtigt auch in detaillierter Form den Gebrauch von Plattformen, Schiebesystemen, Türmen und Etagengestellen. Außerdem wird auch Umlaufsystemen, Zylindern und einigen Systemen, die verschiedene Komponenten verbinden, Aufmerksamkeit geschenkt. Die Zahl der Geräteanbieter steigt, ebenso wie die Diversifizierung und der Grad der Ausgereiftheit der Geräte. Trotz mangelnder Akzeptanz erwartet man den weiteren Einsatz moderner, mechanischer Alternativen, wobei betriebliche und wirtschaftliche Kriterien eine weniger große Rolle spielen, als Umweltbewußtsein und soziale Aspekte. Es ist eine deutliche Tendenz zu umfassenden Verkehrs- und Parkraumsteuerung festzustellen. Der Schlußbericht wird für 1993 erwartet.

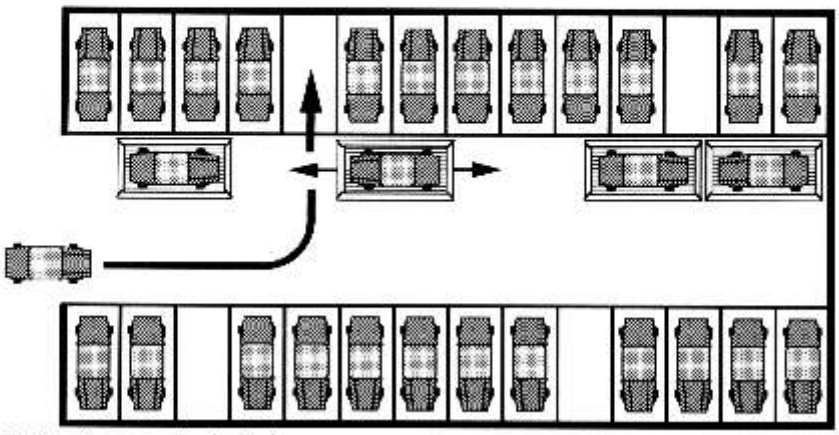


Fig. 1: Parking plates (longitudinal)

2. CLASSIFICATION OF SYSTEMS

General

Mechanical parking equipment is understood as being permanently installed, force driven installations exclusively intended for parking vehicles.

Parking buildings may be classified as follows according to size and the type of mechanical support for the whole parking process after entering the parking building:

* conventional parking buildings,
* semi-mechanized parking buildings, and
* fully mechanized parking buildings.

Considering today's state of technology, a fully automatic flow of the mechanical parts of the parking process may be assumed.

Conventional parking buildings also include multi-storey car parks or underground car parks accessed through ramps, besides ground level parking spaces. The complete parking process - from entrance to exit - is completed by the drivers without the aid of any mechanical support.

Semi-mechanized parking buildings are understood as being primarily freely accessible, conventional parking buildings in which the number of parking spaces is increased by means of mechanical parking equipment whilst maintaining a constant floor space. Here, for example, the available lanes are additionally utilized by movable parking plates or parking spaces are laid out for multiple occupancy by lifting platforms. A special case is the parking lift which allows the vertical transportation of vehicles instead of using ramps.

In fully mechanized parking buildings, the vehicles to be parked are left by the drivers at the entrance to the car park. Usually, this entrance is an enclosed room only accessible to the drivers, containing a mobile platform which may be equipped with a turning device, if required. After leaving the entrance, the vehicles are transported automatically by mechanical means to a free parking space. From there, they may be called again and then be picked up at the exit. Lanes and ramps are not required with fully mechanized systems.

For the more detailed classification, the systems offered have been assigned to a certain function principle. In practice, a manufacturer may have objections to the description and classification of this system. However, a classification taking into account all technical details may not be useful for a survey and therefore has not been established. Moreover, the classification is intended to be laid out in such an open manner that it also does justice in future to current new developments emerging in this market. Of course, the authors appreciate any suggestions and amendments.

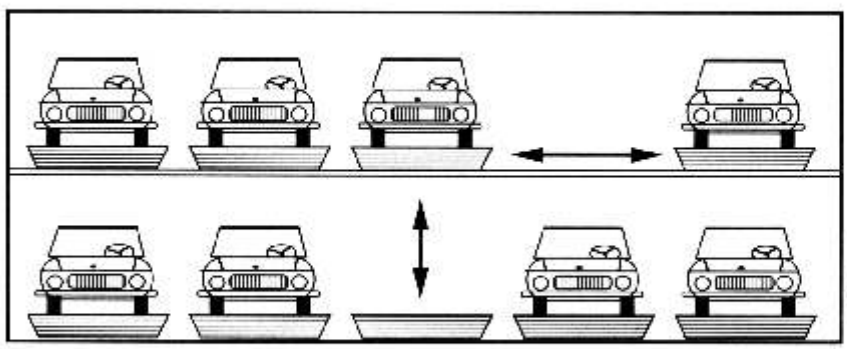


Fig. 2: Sliding parking system (normal version)

Parking lift

The most simple version of a mechanical parking device is the parking lift. This term may be used as a synonym to the "Car lift" used in the "EAR 91". A decisive factor for the choice of the term was the linguistic classification in the total of the terms indicated in the following. It is installed in multi-storey car parks and takes over the function of the ramps which as a rule may not be used for space reasons. The lift automatically transports the vehicle, parking in to or driving out of the storey selected. The horizontal transport on the corresponding parking level, as well as the parking into and out of the lift and into the parking space, is effected in the traditional manner by the driver.

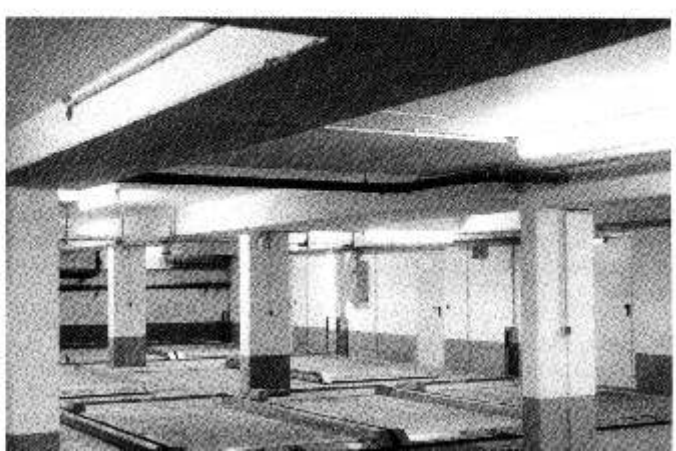
Parking plates

With the use of cross or longitudinal sliding parking plates (Fig. 1), where the cars left are transported without any driving force of their own, the available space of parking level may be utilized more intensively by parking additional cars e.g. on parts of the lanes or in the "dead" space behind columns.

►

Parking mécanique - Enquête **F**

Les méthodes traditionnelles de construction de parking sont en train d'être reconsidérées vu que les planificateurs et architectes essaient de résoudre les problèmes de création d'espaces de parking suffisantes et rentables. Même l'usage de systèmes de parkings mécanisés dans des structures construites traditionnellement n'est toujours pas une solution optimum. L'enquête menée par Albert Speer & Partner GmbH se concentre sur les avantages et désavantages de trois systèmes : bâtiments conventionnels, semi-mécanisés et entièrement mécanisés et considère également en détail l'utilisation d'échafaudages, systèmes coulissants, tours et grilles. De plus, l'attention est également portée sur les systèmes de circulation, les cylindres et des systèmes combinant des composantes diverses. Le nombre de fabricants fournissant l'équipement va en augmentant, de même que la diversification et le degré de sophistication de l'équipement. La perspective est une utilisation ultérieure d'alternatives mécanisées modernes - malgré leur manque d'acceptation - en se concentrant moins sur les critères économiques et opérationnels et plus sur les critères sociaux et écologiques, avec une tendance vers une gestion complète de la circulation et du parking. Un rapport final est attendu pour 1993.



The cross-sliding plates are arranged in one or multiple rows in front of a row of conventional parking spaces. They are displaced so that the selected space may be freely accessed or left. Due to the specific dimensions and the track system with subfloor drive, cross-sliding plates are not suited for retrofitting. (according to "EAR 91")

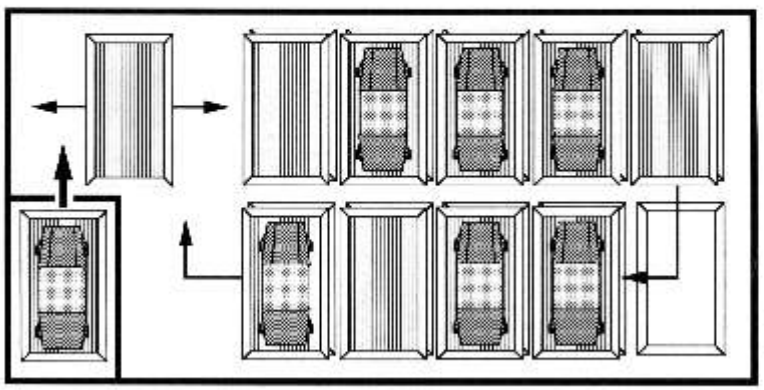


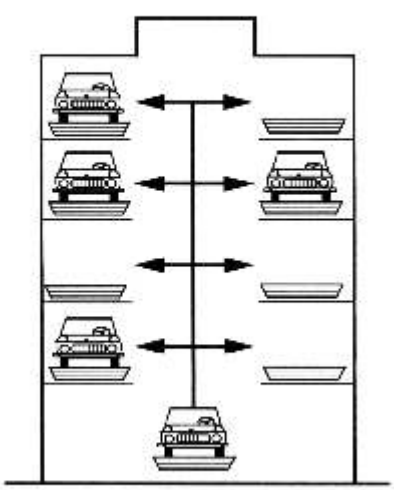
Fig. 3: Sliding parking system (special version)

Longitudinal sliding plates are installed and moved in the lane and they allow retrofitting. If a vehicle is parked on a plate blocking a conventional parking space located behind it, the plate is moved, until this space becomes free. If the plates located in front are empty, they do not have to be displaced since they may be driven over. Individual designed of longitudinally sliding plates allow the accommodation of up to four vehicles. (according to "EAR 91")

Both types operate on the basis of the same mechanical principles: the plates are guided on a rail and rollers or on two rails. The plates are displaced by means of an electric motor which is activated by a control command. The mechanical sliding parking system may be installed either above ground or underground. Practically, an installation - given a corresponding clearance - in a traditional underground car park is feasible, however, then it becomes part of a semi-mechanized parking building.

Per installation, a magnitude of 20 to maximum 70 parking spaces makes sense. The lower the number of parking lots, the shorter the access time.

Space requirement per parking lot depends, of course, on the individual conditions of the space. As a guideline, between three and eight square metres per parking lot may be realized.



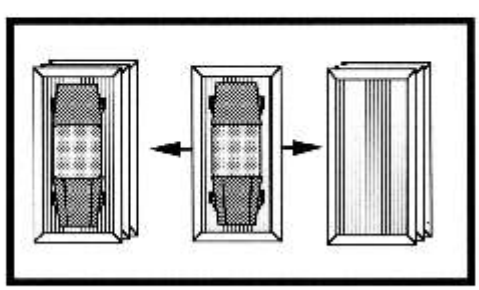


Fig. 4: Parking tower

A variant of the sliding parking system is a system which has been installed in Germany only once until now; by means of a vertically sliding conveyor unit (lift), parking levels may be accessed where - as against the normal sliding parking system - multiple rows of cross-sliding plates are installed. Here, the plates with the vehicles may be moved also in longitudinal direction (Fig. 3). With this system, 16 parking spaces were incorporated on one level (area of approx. 300 sq. metres) in the case already realized. According to the manufacturer, a maximum of 48 parking spaces per lift may be realized.

systems require comparatively little expenditure; only worn components need to be replaced on a regular basis. During the installation, however, very careful execution of the work is required since rough patches, distortions and similar circumstances obstruct the smooth operation of the parking plates and may lead to failures.

Parking Scaffold

A further system for semi-mechanized parking buildings is the parking scaffold which may be installed as a self-supporting unit in yards and other empty areas. With currently offered systems, up to three vehicles may be stacked on top of each other. They are parked on platforms, one of which is at ground level and the second (or third) platform is lifted by means of hydraulic cylinders either upwards or is lowered into an existing pit. With the variant without a pit, the lower vehicle - provided that both platforms are occupied - must leave the platform before the upper vehicle may drive off ("dependent parking"). The design with a pit, on the other hand, allows independent parking.

Sliding Parking System

For the fully mechanized sliding parking system (Fig. 2), a vertically sliding conveyor unit - similar to the parking scaffold - lifts or lowers the vehicles already in the entrance area for parking, to a parking level with multiple, cross-sliding plates in a row. A transfer unit at the end of the parking levels may also transport the parking plates - if required - from one level to the other. This automated process is necessary for example if an empty plate is needed for transportation of vehicles to be parked and if this plate may get to the conveyor unit only by transfer.

Depending on the manufacturer and the requirements, the conveyor unit may be installed at the end or in the centre of the system, so that it is possible to adapt the system to existing estate dimensions and building standards. The

Parking Tower

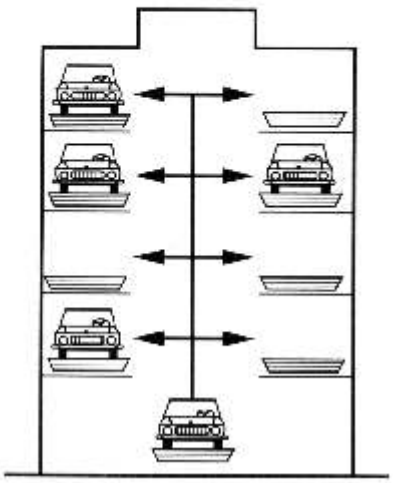
In the case of the fully mechanized parking tower (Fig. 4), the additional parking space is not generated through floor space but primarily through height. That means that the vehicles to be parked are no longer displaced horizontally on the parking level; rather, a lift transports the vehicles to levels where usually only one parking space is available each to the left and to the right of the lift. There, the vehicles stand on a transfer pallet or being transported by a telescopic arm, are moved into the parking spaces.

The parking tower lends itself to tight sites where 10 to 40 parking spaces have to be established either above ground or underground. The specifications for the floor space requirements range from 2 to 7 sq. metres per lot. The floor space requirement for a complete installation is specified with 50 sq. metres. Here, the same applies as for the other fully mechanical systems, i.e. the driveways need to be added to the floor space requirement. For small installations for long term parking a direct access from the road is possible subject to corresponding building laws, while for large installations a back-up area must be added.

Parking Rack

Parking racks (Fig.5) are fully mechanized parking installations which are modelled on the high-bay shelf constructions of the warehouse systems in industrial and commercial businesses. In these installations, vehicles are moved into stationary or also moveable parking spaces by a conveyor unit (lift). Compared with the parking tower, the conveyor unit may be moveable in a vertical direction as well as in a horizontal direction.

For vehicles to be parked longitudinally, the conveyor unit picks up the vehicle



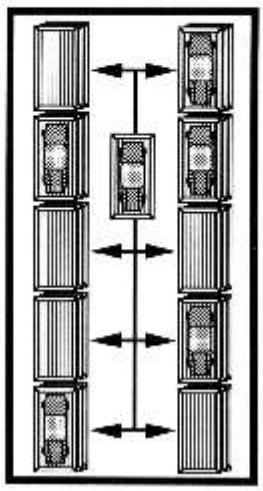


Fig. 5: Parking rack

at the entrance and moves it in a vertical direction to a level with empty parking lots where it is then transported horizontally in front of a free parking box. There, the vehicle is moved into a parking box either by a telescopic arm or - especially with the latest equipment - it is parked by means of a transfer pallet from the lift to the parking boxes equipped for this purpose. For the return journey, a separate exit may be used or a turning device.

With the currently offered parking racks with cross parking the vehicle is also lifted or lowered vertically to a level with free parking spaces. In the case of simple, small systems, the car standing on a transfer pallet is moved into the parking space directly across while in the case of more large scale systems, additional horizontal transportation may follow.

From their conceptual idea, parking racks are designed for a relatively large amount of parking spaces since they may be expanded in height as well as in length, theoretically to an indefinite extent. Moreover, for cost reasons, such a large-scale system should be considered only for a larger number of parking spaces.

Circulating Parking System

The principle of the fully mechanized circulating parking system is based on the field of materials-handling technology or - as also stated by an Austrian manufacturer - on the pattern of the old-Chinese "Rosemary mills", designated after their "Principle of Chain Arts". Circulating parking systems are offered in vertical as well as in horizontal designs. The vertical circulating parking system may be compared to a paternoster elevator for persons while the horizontal parking system is similar to a conveyor belt.

The technology of the vertical circulating parking system has been adapted from Japan and the U.S. where this type of equipment has been used for more than two decades. Generally, 20 to 40 parking platforms are linked to each other by a chain system. If a driver wishes to enter the parking system with his vehicle or if he wants to call his car from the system, the platforms will circulate until a free platform or the requested vehicle has reached the entrance area.

The design of this equipment is especially suitable for application on open, narrow estates or installation in enclosed narrow building gaps, desirable from a town planning point of view as well as being necessary for noise protection reasons. One advantage of the vertical circulating parking system is the comparatively low floor space requirement of approx. 50 sq. metres per installation (in the case of erection on top; internal dimension approx. 9 m in diameter). There, approx. 20 passenger cars may be accommodated. A disadvantage, on the other hand, is the high demand made on the mechanical system and the drive. A subterranean construction is possible, but is often more difficult to achieve for engineering reasons (ground water etc.) and above all, more expensive than an above-ground solution.

The horizontal circulating parking system, on the other hand, is rather suitable for the creation of underground parking space. The entrance into the horizontal circulating parking system is preferably carried out above ground, with the vehicle parked on a pallet being lowered by a conveyor unit to the upper of the two levels and being displaced afterwards by rotation. The entrance and exit position may be incorporated at any given location. If the circulating parking system is integrated into a conventional underground car park, a direct access to one of the two levels is also possible. To achieve an access time as short as possible, the conveyor belt may run in both directions. At both ends of the circulating parking system, the vehicles are lifted or lowered by a transfer device in a horizontal position to another level.

The capacity of the horizontal circulating parking system is as high as that of the vertical one so that it is primarily suitable for especially long narrow estates. For example the floor space requirement for approx. 40 parking spaces is indicated at a little under 300 sq. metres.

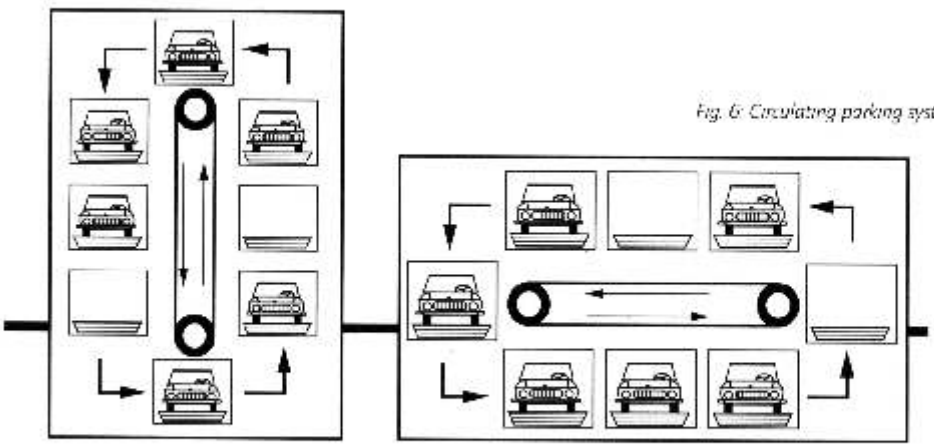
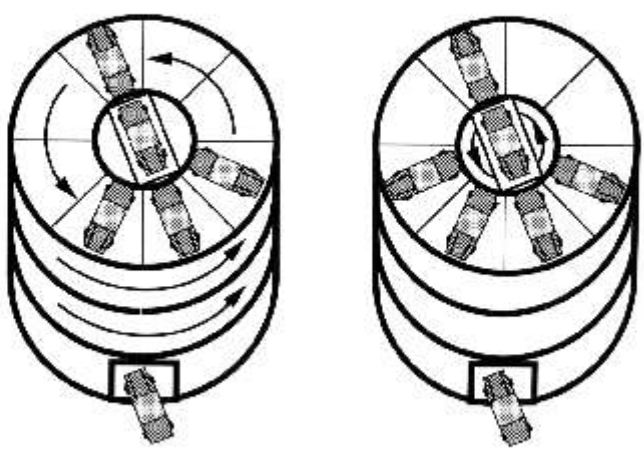


Fig. 6: Circulating parking system

Parking Cylinder

With the parking cylinder (Fig. 7) currently being realized, the internal parking lots are arranged in a circle. These parking buildings, which are generally designed as underground car parks shall contain various parking levels, if possible, which may be accessed through a parking elevator. Per level - in a star- ►

Fig. 7: Parking cylinder



shaped arrangement - approximately 70 vehicles are parked with more than 10 parking levels. The whole parking cylinder can be realized on a floor space with a diameter of 19 metres (approx. 280 sq. metres).

Basically, the parking cylinder may work on the basis of two principles. Either, the parking levels are accessed horizontally as well as vertically by a rotating elevator in the case of stationary parking lots, or vertically operating parking elevator accesses the various parking levels where rotating parking lots may accommodate the vehicles. According to manufacturer's specifications, this type of mechanical parking equipment has been designed for a supply of more than one hundred parking spaces and specifically also for short term parking.

Combined Systems

These systems for fully mechanized parking buildings are composed of various components of the parking installations described above. In the main, they are fully mechanized systems as mentioned before, which are supplemented by horizontally moving parking plates.

If, for example, multiple parking spaces (plates in a row) are available with a parking tower on both sides of the elevator, the number of parking spaces is increased to more than 100 units per installation. However, the access time is also increased by the larger distance between the parking spaces and the elevator and also the time required for horizontal displacement. Linking a number of parking towers thus equipped, the total capacity of such a fully mechanized parking building may be increased again considerably.

AS & P	Parksystem	max. Anzahl der Stellplätze	max. Anzahl der Parkebenen	Grundflächenbedarf* (qm/Fz)	(qm gesamt)	Hersteller realisiert		Angebot/ Planung
Systeme für Teilmechanische Parkbauten	Parkaufzug					•	LÜDICKE, andere Aufzughersteller	
	Parkbühne	2	2	7	14	•	BHS (Duplex)	
		3	3	4-6	13	•	KLAUS	
		3	3	5-7	14	•	WÖHR	
	Parkplatten	beliebig	1	11		•	KLAUS	
		beliebig	1	12		•	WÖHR	
Systeme für vollmechanische Parkbauten	Verschiebeparker	etwa 6 bis 16 pro Ebene	6	.		•	BHS	
			3	etwa 3 bis 8 pro Ebene	abhängig von der Anzahl der Parkebenen	•	KLAUS	
			6			•	KRUPP	
			3			•	WÖHR	
		etwa bis zu 20 pro Ebene	4	k.A.			KLAUS	•
			5	11		•	WÖHR	
	Parkturm	20	10	3	46 (20 Fz)		KLAUS	•
		40	20	2	45		KRUPP	•
		13	7	7	84 (13 Fz)		VOLLERT	•
		24	12	5	52	•	WÖHR	
	Parkregal	240	10	3-6	1255 (240 Fz)	•	ALR	
		128	8	k.A.	k.A.		KLAUS	•
		1000	7	4	1152 (354 Fz)		Stahlbau Necker	•
		112	7	5	418 (84 Fz)	•	VOLLERT	
	Umlaufparker	41	2	8	296 (41 Fz)	•	BHS	
		60	2	7-8	450	•	KRUPP	
		30	15	2-3	43-50	•	PARKTEC	
		42	k.A.	1-2	51		WÖHR	•
	Parkzylinder	108	12	2-3	280 (Ø 19m)		VOLLERT	•
		108	12	2-3	290		KRUPP	•
	Kombinierte Systeme	117	20	1	110	•	KRUPP	

* ohne Zufahrten k.A.=keine Angaben Alle Angaben lt. Hersteller (gerundet) Stand: II '92

Table 1

Summary

The essential characteristics of the different systems are shown again as a summary in Table 1.

3. PRODUCT SUPPLY BY THE MANUFACTURERS

Currently, the range of manufacturers of mechanized parking equipment is quite distinct. Thus, at the time of the survey in summer 1991 (subsequent survey in winter 1992), approximately a dozen domestic suppliers were found. In addition, an Austrian company is documented. However, for the product survey in Table 1, it should be taken into account that some manufacturers do not market their products themselves but cooperate with a distributor. For clarity, only manufacturers of mechanical parking equipment are listed. These can supply further information on request.

Obviously, fully mechanized parking equipment in particular offers promising market perspectives to the manufacturers and distributors of this equipment in the near future. Although currently the diversification of the product range is quite distinct, more and more suppliers of this equipment are working their way into the market, offering new, modified, traditional or advanced systems. But also established manufacturers incorporate their experiences, gained with the operation of their existing equipment, into their product range.

The course is currently set, determining which of the fully mechanized systems and which manufacturer will dominate the market in future. Therefore, many manufacturers specifications are very "optimistic", e.g. with reference to access times, parking place capacities, application ranges and, above all, the costs for such systems. Especially concerning the costs, it has to be taken into account that the price per parking space, which is often given in comparison to conventional installations only refers to the mechanics as such. As a rule of thumb, it may be said that remaining construction costs (earthwork, foundations and other building costs) are about the same as for the mechanics. Moreover, the manufacturers are not willing to indicate any fixed prices for their systems since the costs per parking space decrease with increasing numbers.

As a rough estimate, a price scope of DM 20,000 to DM 40,000 per parking space (systems for fully mechanized parking buildings) may be assumed. It is also important to know that currently the manufacturers and distributors are interested in setting up model or demo equipment as soon as possible. Practical experience has shown that manufacturers are frequently willing to produce model drawings including a statement of cost for a detailed plan.

One can expect, that in the near future more engineering firms, steelconstruction firms, manufacturers of similar products and the automotive industry press into the market for mechanical parking equipment which seems to be expandable. Therefore, it cannot be excluded that Table 1 has not taken into account some of these new suppliers. The authors would appreciate any information about changes in the range of products.

4. OUTLOOK

Mechanized parking equipment increasingly becomes an alternative to be taken seriously compared to conventionally equipped parking buildings. Operational and economical problems which partially are still a handicap for the selection of this option for parking space generation, certainly become less important in the near future.

More decisive would be questions regarding the useful application range and on the application limits of these parking units. Town integration possibilities, integration in total traffic and parking space management, social acceptance and environmental aspects are only some of the keywords giving an idea of the complexity of this field of topics.

Within the framework of the model project of the City of Frankfurt/Main "Parking Guidance Systems and Mechanized Parking Equipment in Town Planning and Traffic Concept", the office of Albert Speer & Partner GmbH (AS&P) will also deal with these questions, going beyond the introduction given here. A final report may be expected next year. ●