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26. AUTOMATED PARKING GARAGE SYSTEM MODEL*

By

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SUMMARY

A one-twenty-fifth scale model of the key components of an automated parking garage system is described. The design of the model required transferring a vehicle from an entry level, vertically (+Z, -Z), to a storage location at any one of four storage positions (+X, -X, +Y, -Y) on the storage levels. There are three primary subsystems: (1) a screw jack to provide the vertical motion of the elevator, (2) a cam-driven track-switching device to provide X to Y motion, and (3) a transfer cart to provide horizontal travel and a small amount of vertical motion for transfer to the storage location. Motive power is provided by dc permanent magnet gear motors, one each for the elevator and track switching device and two for the transfer cart drive system (one driving the cart horizontally and the other providing the vertical transfer). The control system, through the use of a microprocessor, provides complete automation. This automation is accomplished by a feedback system which utilizes sensing devices.

INTRODUCTION

The scarcity of adequate automobile parking capabilities, not only in the United States but also in Europe and Japan, has become increasingly more critical during the past decade. Increases in world automobile production and the rising standard of living have coupled with the increases in urban property values to compound this problem. The traditional solution, the multilevel ramp garage, while satisfying many of the requirements, has several disadvantages; e.g., poor volumetric efficiency. Whereas mechanical garages have been developed in the past, and nearly 1,000 patents have been issued in this field, few have been successful to even the slightest extent. Such failures have been fundamentally attributed to: (1) economics, both in construction and in service, and (2) mechanical problems.

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While there is no panacea to all parking problems, the criteria considered to be most critical in solving these problems are economics, volumetric efficiency, customer convenience, and reliability. The model described in this paper represents the key elements of a unique automated parking garage system that is considered by many to be superior to other forms of high density parking systems. This consideration is based upon its storage density, capital costs per space, operational costs per space, personal safety features, and optimal environmental impact.

This model was originally built for a proof-of-concept demonstration. The scale of one-twenty-fifth was selected to be compatible with available plastic scale-model automobiles, which, therefore, dictated the relatively small scale of the model.

CONFIGURATION

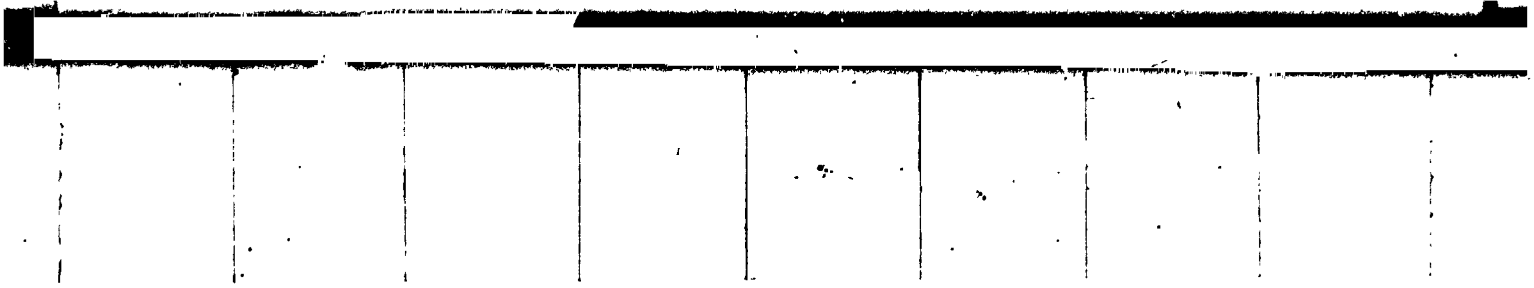
The basic configuration is shown in figure 1. An elevator is installed in the center core. There are three floor levels; the top is the loading or vehicle entry level and the bottom two are the storage levels. On each of the storage levels, there is a storage position on each of the four sides of the elevator. The storage levels have two sets of tracks, oriented 90° to each other, crossing at the elevator and extending into the storage positions. The transfer cart typically stays on the elevator but may travel to each of the four storage slots on each floor.

ELEVATOR

The elevator is supported from and driven by two 1/4-28 lead screws on diagonally opposed corners (see figure 2). They are kept in rotational synchronization by a toothed slip-proof belt drive. The basic drive is a small 12-volt dc permanent-magnet motor through a spur gear directly to the master lead screw. There is also a slotted-wheel mounted on the master lead screw to provide rotational counting capability, thereby elevator position, by means of an electro-optical detector. There are limit switches at the extreme elevator positions to prevent damage and to initiate and verify the electronic counter.

TRACK SWITCHING

Directional control, from X-X to Y-Y, is accomplished by means of a track switching system mounted on the elevator (the track crossing position). The track is HO model-train equipment. The segments of track, as opposing pairs within the intersections, rotate down and out to clear the unused cart wheel flanges. Also, when the track rotates up and in, close centering of the cart is provided. The switching positions are: (1) X track and Y track segments both up to lock the cart on the elevator, (2) X track segments rotated



out and down out of the way to allow Y direction travel, and similarly (3) Y segments out of the way to provide X travel. The action is provided by a small 3-volt dc gear motor driving a cam (see figure 3) that in neutral position locks the track up and when rotated 30° holds one track up and rotates the other out of the way.

Small switches are mounted on auxiliary cams, to provide information on the three operating positions.

TRANSFER CART

The transfer cart is the key element in the system. It provides horizontal travel and vertical transfer (see figure 4). The horizontal drive is provided by a miniature 2-volt dc gear motor connected to two drive wheels for each direction. Neoprene tires were added to flanged HO model-train wheels, for added traction and quieter operation. As can be seen in figure 5, X and Y drive wheels rotate together, the unused ones clearing the retracted track. This allows travel in the +X, -X, +Y, and -Y directions with one gear motor by simply controlling the + and - directions by changing the respective dc polarity to the motor and the X and Y directions through the track switching.

The vertical transfer is accomplished by means of a vertical screw jack system. To provide good stability when the platform is in the raised position, four screw jacks are used. The originally specified 6-volt motor was marginal in performance, so it was replaced by a 12-volt unit. Reducing the face width of alternate spur gears was a significant aid in minimizing gear load. The final vertical transfer drive was through a 1670 to 1 reduction gear-head to the 1/4-28 screw jacks.

COMMAND SYSTEM

The on-board electronics consist of limit switches and a diode bridge for the vertical-transfer drive, power and signal rail contacts, and position contact sensors. The system command sequencing is provided by a microprocessor containing 6 read-only memory chips containing 256 instructions each and 4 random-access memory data chips containing a total random access storage of 320 words.

Data input is through a hexidecimal keyboard with a display monitor.

The command system provides the capability of automatically storing and retrieving vehicles in random order by vehicle identification.

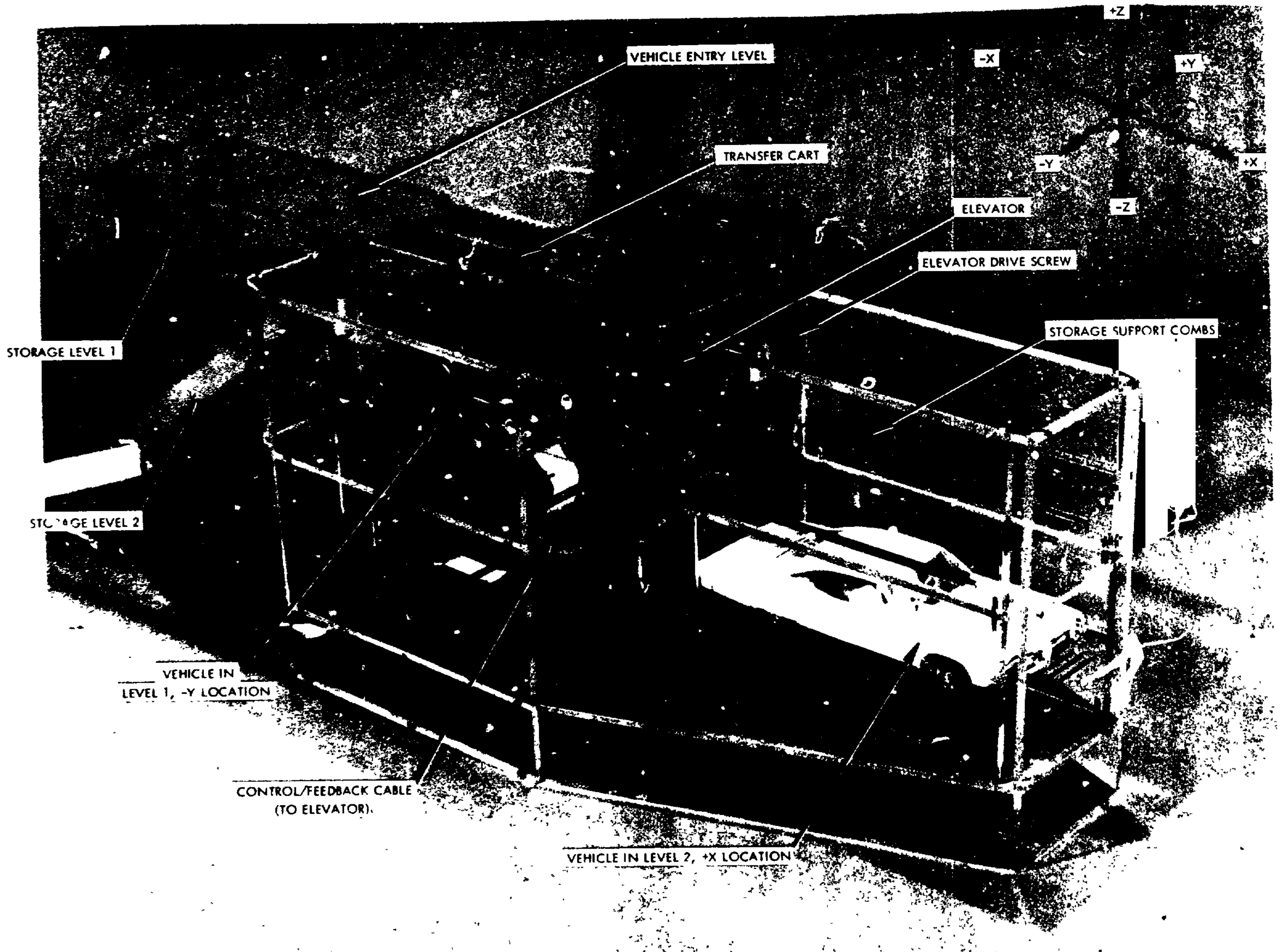


Figure 1. - Automated parking garage model configuration.

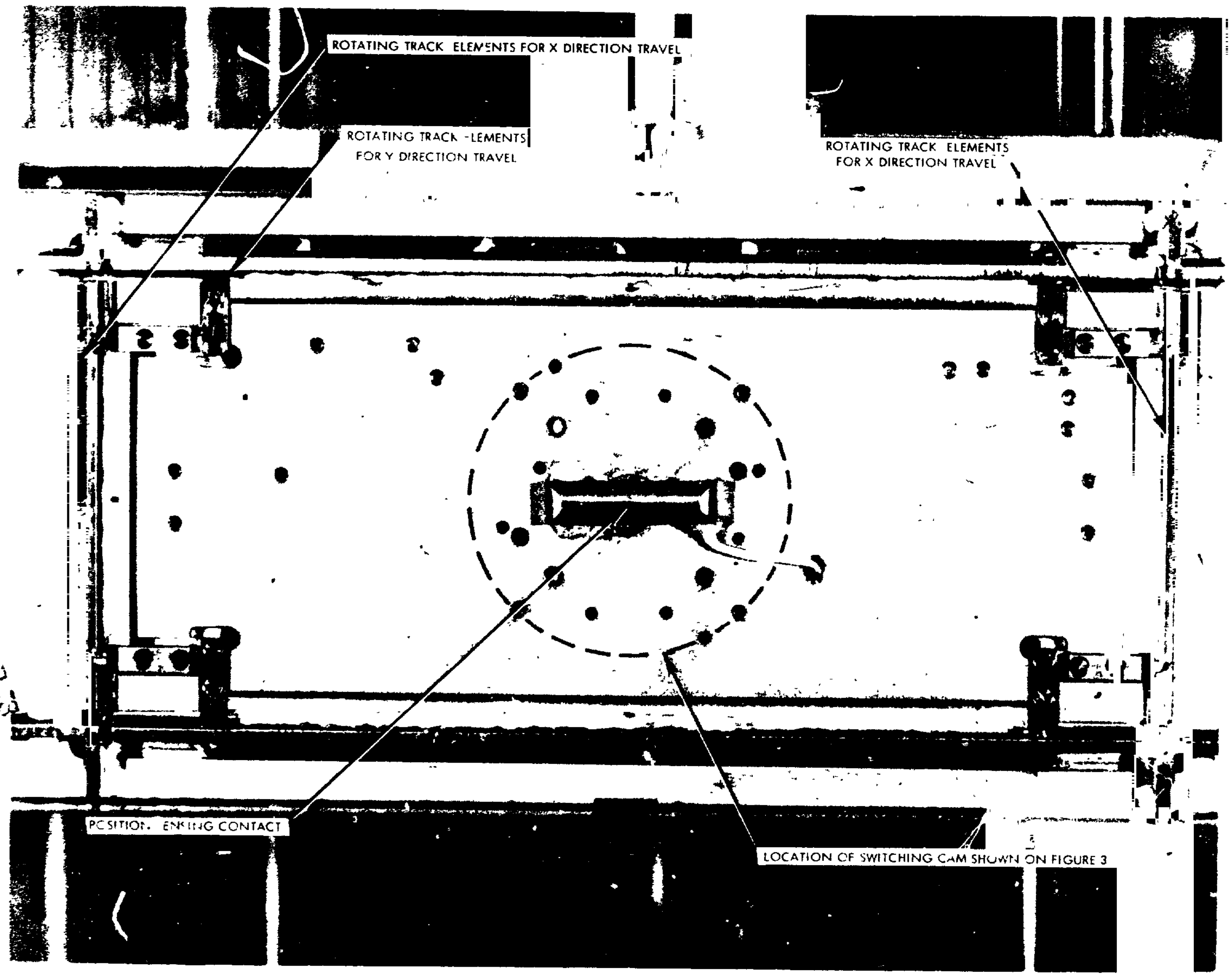


Figure 2. - Plan view of elevator.

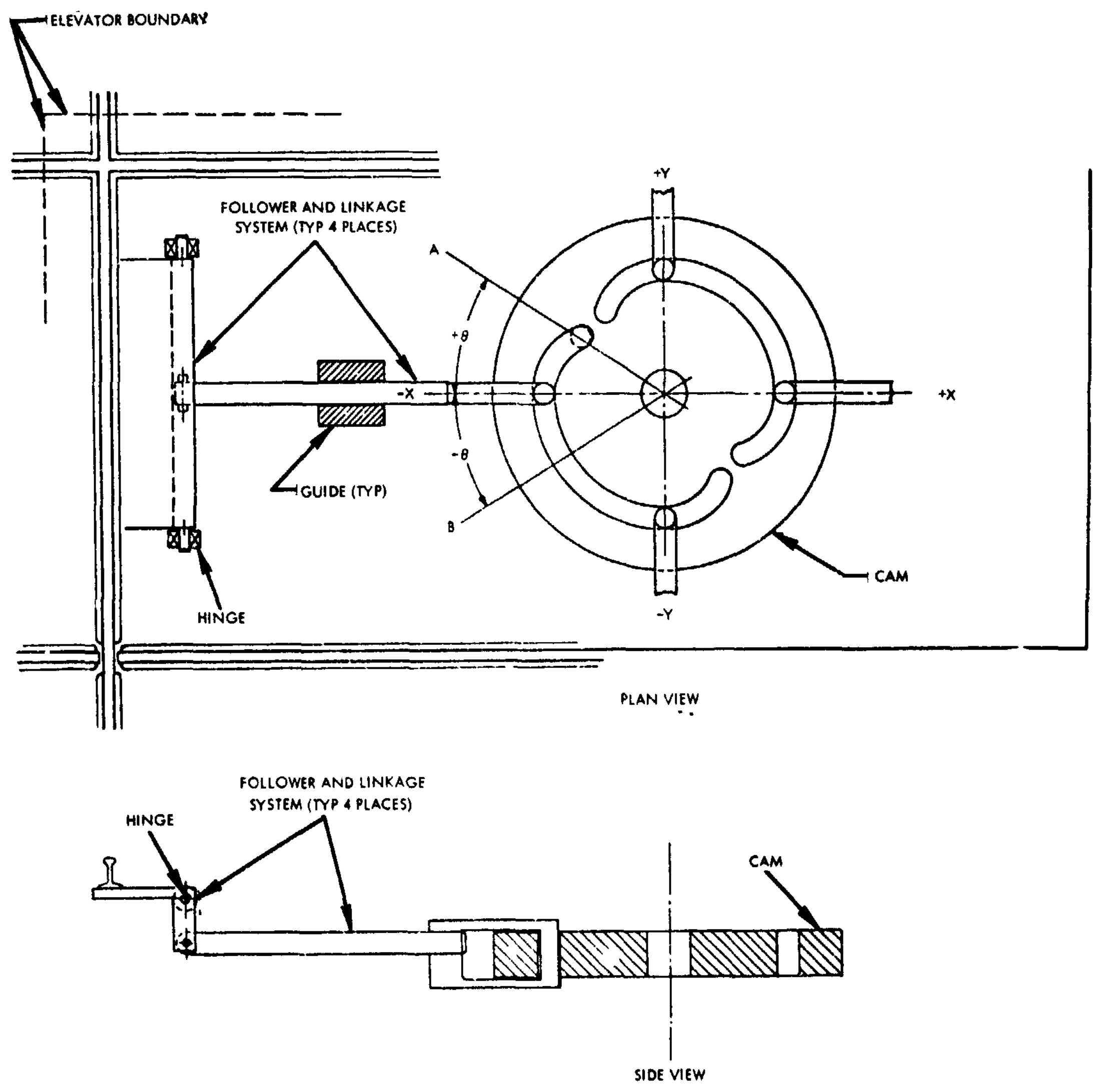


Figure 3. - Track switching mechanism.

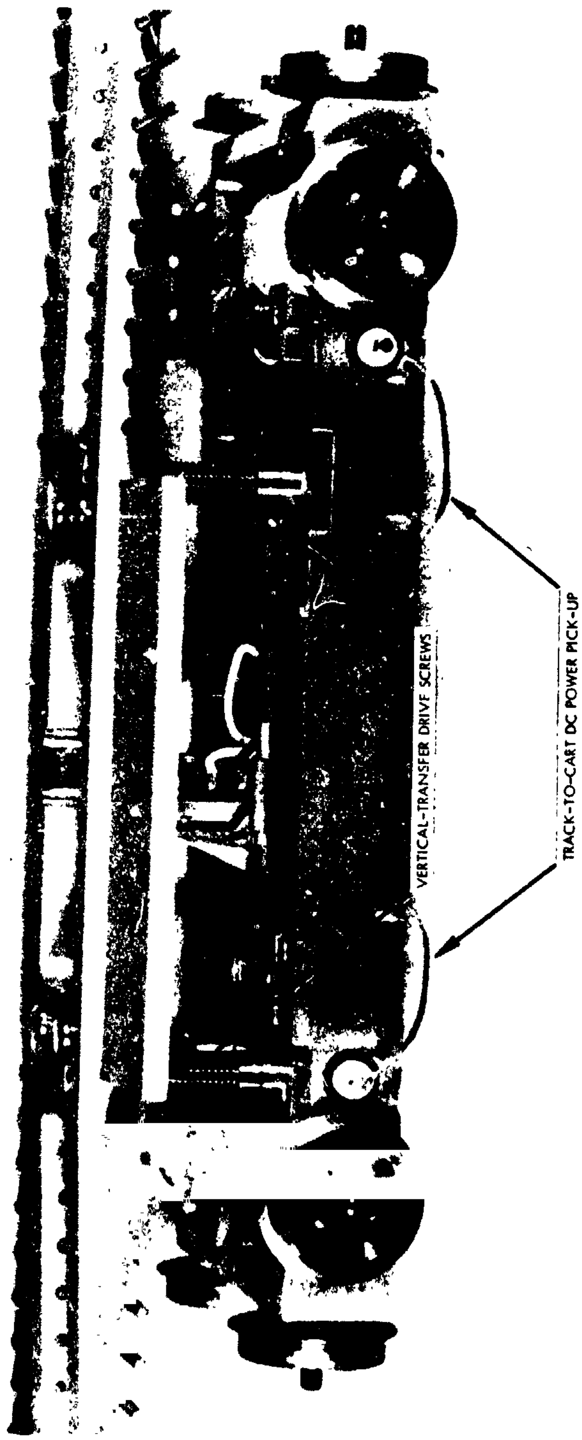


Figure 4. - Transfer cart configuration.

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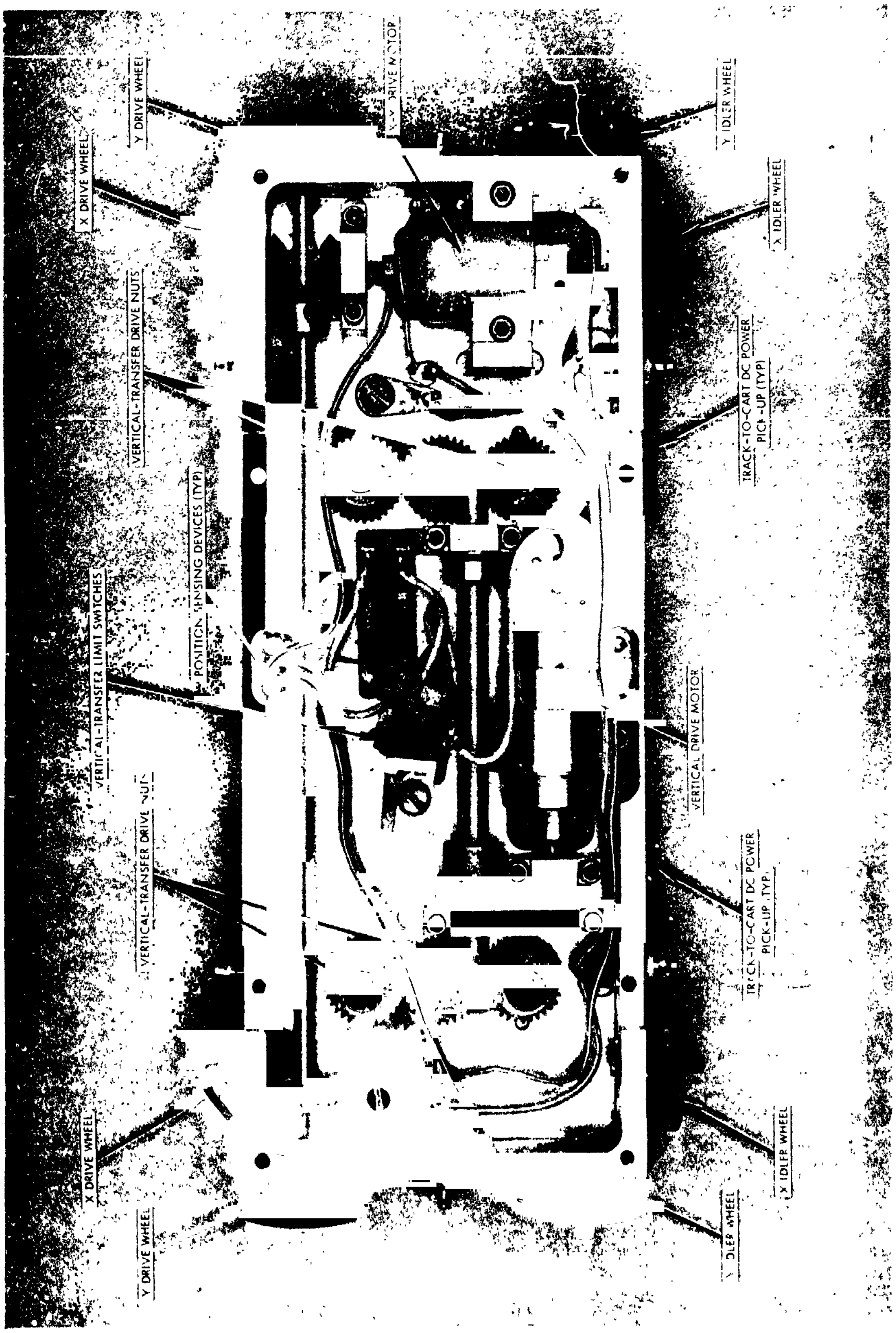

Figure 5. - Transfer cart chassis.

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