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Assessment of Low-Cost Elevators for Near Term Application in Transit Stations

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July 1982
Final Report

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U.S. Department of Transportation
Urban Mass Transportation Administration

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16. Abstract

This report presents an assessment of low-cost elevators for use in existing transit stations, the supporting data for selecting the screw column elevator for further evaluation, and an evaluation and assessment of the screw column elevator design and operation. This information will provide data to transit authority representatives enabling them to make informed decisions regarding appplication of the screw column elevator. The assessment team studied the screw column elevator of the Ebel Co. of Belgium, investigating design, construction, maintenance costs, and actual use. Onsite inspections were conducted in the plant and at elevator installations. It was determined that screw column elevators offer a low cost alternative for vertically moving elderly and handicapped patrons in transit stations. Low capital expense, minimum time for installation, low cost for standard site preparation, and low maintenance costs make the screw column elevator attractive for this application.

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16. Abstract

This study of low-cost elevators for use in existing transit stations was commissioned by the Transportation Systems Center and included a four-day site study of screw column elevators manufactured by the Ebel Company of Brussels, Belgium. The site studies were made at the company offices and plant and at Belgian elevator installation locations. Information was obtained on current practices pertaining to screw column elevator operation in Belgium, on current screw column elevator design, on code considerations both in Belgium and the United States, and on the Ebel Company's policy regarding the manufacturing of the product in the United States. The assessment team also studied design, construction, maintenance costs, and actual use. This document has been prepared in order to discuss elevators that offer low-cost options for providing access to transit stations that can be used by the elderly and handicapped and other transportation-limited persons who are unable to use stairs or escalators. The screw column elevator has been selected as an option to meet this need and is fully detailed in this report. This document presents supporting data for selecting the screw column elevator for further evaluation and an evaluation and assessment of the elevator design and operation. This information will be useful to transit authority representatives when selecting elevators to meet local accessibility needs. It was determined that screw column elevators offer a low cost alternative for vertically moving elderly and handicapped patrons in transit stations. The consensus of the assessment team was that the advantages of low cost, ease of installation, and minimum space requirements far exceeded the inconveniences of higher-than-average noise levels and somewhat abrupt starting and stopping. These findings lead to the conclusion that screw column elevators are appropriate for transit applications.

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PREFACE

This study of low-cost elevators for use in existing transit stations was commissioned by the U.S. Department of Transportation, Transportation Systems Center. It included a four-day site study of screw column elevators manufactured by the Ebel Co. of Brussels, Belgium, at the company offices and plant and at Belgian elevator installation locations, in order to obtain the detailed information necessary for this report. In addition, information was obtained on current practices pertaining to screw column elevator operation in Belgium, on current screw column elevator design, on code considerations both in Belgium and the U.S., and on the Ebel Co.'s policy regarding the manufacturing of the product in the U.S.

This document has been prepared to discuss elevators that offer low-cost options for providing access to transit stations in order that the stations can be used by the elderly and handicapped and other transportation-limited persons. The screw column elevator has been selected as an option to meet this need and is fully detailed in this report.

Data presented in this report has been prepared so as to be useful to transit authorities when selecting elevators to meet local accessibility needs.

The assessment team of K. M. Shea of DYNATREND Incorporated; M. R. Whitley, consultant to DYNATREND Incorporated; B. S. Mahapatra of Southeastern Pennslyvania Transportation Authority; and Joseph S. Koziol, Jr., of the Transportation Systems Center acknowledges the full support of, and particular thanks to Mr. Jose-Philippe Lefebvre and Mr. Jean-Marie Gilles de Pelichy of Ebel Co., Mr. Albert L. Gerard, affilliated with Eurolift

(Ebel U.S. manufacturer and distributor), and Mr. Robert Detilloux of Association des Industriels de Belgique (AIB) for providing information needed for this report. Acknowledgement of full support is also extended to Patricia E. Simpich, project sponsor, of the Urban Mass Transportation Administration's Office of Technology Development and Deployment for providing guidance in the conduct of this study.

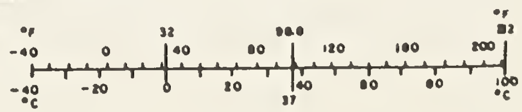
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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EXECUTIVE SUMMARY

The goal of accessibility to mass transit by elderly and handicapped patrons has resulted in this study of elevators, to explore less costly ways to provide vertical movement between floor levels by patrons unable to use stairs or escalators. Various elevator types exist. The most common are the conventional electric traction or cable, conventional hydraulic, and holeless hydraulic. Vertical platform lifts may also be suitable for limited level changes. The screw column elevator has recently been introduced to the United States. Each type has its own advantages and disadvantages. When a transit authority is constrained by the need to minimize costs and confronted with the problems associated with installation in an existing site (such as location of utilities, limited platform width, and fixed load-bearing capacity of the existing structure), a low-cost elevator requiring the minimum of site alterations would best meet the authority's needs.

Review of the various elevator types resulted in identifying the holeless hydraulic and screw column elevators as the best options for many low-cost applications. The screw column elevator was selected from these two for detailed study, because it appeared to offer the lowest cost and require the least site preparation. In addition, because screw column elevators have only recently been introduced to the U.S. market, timely information about them is needed.

Currently, the major producer of the screw column elevator is the Ebel Co. of Brussels, Belgium, which has installed 250 units (all in Belgium) over the past 16 years. Ebel will be distributing and manufacturing in the United States through Eurolift of Wooster, Ohio. The assessment team visited the Ebel Co. in Belgium in order to discuss the product, view the manufacturing of equipment, and conduct onsite inspections at typical installations.

The screw column elevator is a direct-drive unit which uses a stationary screw column and a rotating "nut." The screw is mounted vertically in the hoistway and the nut is rotated by a V-belt drive from a reversible electric motor. The nut either "climbs" or "descends" the screw column, depending on the direction of rotation of the motor. The guided elevator car is attached directly to the drive assembly and moves up or down as the motor rotates the nut. Safety devices have been included as needed to meet applicable Belgian standards.

Since all driving equipment travels with the elevator car, all maintenance is conducted from within the car (after removal of an access panel) rather than from above or below. Thus, no personnel will be working under or above the elevator car. With no requirement for refuge space or for automatic door operating equipment, this arrangement permits the elevators to be installed with minimum pit depths and limited top clearance -- an attractive feature where space conditions are limited as in an existing transit station. However, current considerations by the national elevator code development body in the United States will cover acceptable pit and overhead configuration.

Currently, the American National Standard Safety Code for Elevators (ANSI A17.1) does not apply to screw column elevators of the design studied. A code committee is, however, concluding its work at the time of this report to expand A17.1 to cover various types of screw column elevators. Considerations include acceptable pit and overhead clearance requirements, in addition to other safety requirements. The manufacturer has designed and operated safety devices which will meet the anticipated U.S. code. However, the pit and overhead clearances, plus safety equipment requirements, will still be dependent upon the recommendations of the code committee and their judgment of the requirements to ensure safe operation and maintenance of this elevator.

The units observed in operation all worked effectively, although they were somewhat noisy because of the proximity of the motor and rotating parts to the elevator car. The running operation of the units observed was smooth but slower than other types of elevators.

The elevator's starting and stopping was somewhat abrupt because of the use of a single-speed motor and the operation of a motor brake, although elderly patients using mobility aids at a hospital installation did not appear to be incommoded by the starting and stopping characteristic. Motor braking prevented any coasting and provided excellent leveling at the floor - a desirable feature for an elevator used by the handicapped and the elderly.

The consensus of the assessment team was that the advantages of low cost, ease of installation, and minimum space requirements far exceeded the inconveniences of higher-than-average noise levels and somewhat abrupt starting and stopping. These findings lead the assessment team to the conclusion that screw column elevators are appropriate for transit applications.

1.0 INTRODUCTION

Section 504 of the Rehabilitation Act of 1973 states that "no otherwise qualified, handicapped individual shall, solely by reason of his handicap, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving federal financial assistance." To comply with this law, transit authorities must ensure provision in the authority's service area of transportation that transportation-handicapped people can use. This may include providing access to existing transit systems. One element of such access is that of vertical movement between station entry level and train platform level in rapid transit stations.

Many solutions have been proposed that would provide vertical movement; but for timely implementation, application of existing off-the-shelf elevators rates high among potential solutions. Different types of elevators are available, each with its own particular advantages and disadvantages. The elevator best suited for application in an existing transit station is one that is low in cost, technically acceptable, and meets all site-specific requirements. Moreover, in an existing station, the optimal unit will require minimum space, be relatively easy to install, and have an overall low installation cost.

This study analyzes current elevator types to determine which type(s) best satisfies these requirements and then presents detailed data on a specific type, the screw column elevator, which appears to be promising.

2.0 ELEVATOR COMPARISON AND SELECTION

The issues and problems surrounding the vertical movement of patrons in transit stations call for certain requirements in the design of an elevator. Issues associated with selecting a unit that will result in an overall low cost and satisfy structural, spatial, and security needs pose design problems for elevators. Each of these problems has been addressed and a list of important requirements has been developed. These requirements pertain to elevator and station problems generally, but do not attempt to address site-specific problems which face the transit authority and architect/engineer at the time of planning for and designing a specific installation.

The following requirements have been identified as necessary to evaluate elevators for transit use. The elevator should:

1. Be capable of use by both the elderly and handicapped and other transit passengers.
2. Have a capacity of no less than 2000 pounds.
3. Be sized for wheelchair turnaround. This results in a net car dimension of 80" x 51" or 68" x 51" depending on location of the elevator door opening.
4. Be able to meet expected vertical rise (nominally 20 feet).
5. Have a low life cycle cost, which includes capital expense, installation, operations, and maintenance.
6. Be easily installed in existing locations.
7. Provide for passenger safety.
8. Provide for passenger security (such as against malicious attacks).
9. Give reliable service.
10. Meet and satisfy prevailing codes and standards.
11. Be capable of operating in a transit environment.

These specific requirements set the conditions for any technical analysis of elevators. In addition, for purposes of this report, a nontechnical requirement forms item 12:

12. Material should be available that provides information needed by transit authorities to select, purchase, and install elevators which result in the lowest overall cost.

These twelve items formed the basis for a comparison of available equipment.

Discussions with manufacturers were conducted and elevator specialists were interviewed in order to select initial elevator candidates. This activity resulted in the following list of equipment types to be considered:

1. Conventional electric traction (i.e., conventional wire-rope-supported), including basement traction

2. Conventional hydraulic

3. Holeless hydraulic

4. Screw column

5. Vertical wheelchair platform lift

Appendix A is provided for reference and contains information which identifies and describes the characteristics and operation of each of the equipment types. As it is completely detailed in the body of this report, the screw column is not included. (A review of the chain hydraulic type mentioned in a related report revealed that it is in the conceptual stage only. It is not immediately available and thus was not reviewed for this report.)

Each of the listed elevators was then compared against the previously stated requirements. A summary of this comparison is shown in Table 2-1.

Comparison of equipment types with specific requirements indicates the following:

1. All types, with the exception of the vertical wheelchair platform lift, can meet passenger, capacity and size requirements.

2. All units, with the exception of the vertical wheelchair platform lift, provide rises which can service normally expected floor-to-floor distances of approximately 20 feet.

3. For similarly sized units, cost comparisons which considered the cost of site alterations to accommodate the elevator, the elevator equipment and its installation indicate that the electric traction type is usually most costly. Following the electric traction type, the usual order of cost in descending order is the conventional hydraulic, the holeless hydraulic, and the screw column. The platform lift, with no hoistway, is the lowest priced.

4. All units can be retrofitted into existing buildings; however, the degree of difficulty of construction must be noted and compared. The conventional electric traction elevator requires a deep pit and a large overhead machine room which must be structurally supported. The conventional hydraulic requires a well hole to be drilled, which if required to be done inside an existing transit structure might prove to be difficult, if not impossible. Holeless hydraulic and screw column elevators require no overhead machine room and a

TABLE 2-1. COMPARISON OF ELEVATOR AND LIFT TYPES

Requirements	Conventional Electric Traction	Conventional Hydraulic	Holeless Hydraulic	Screw Column	Vertical Wheelchair Platform Lift
(1) Provide for both E&H and other passengers	yes	yes	yes	yes	Designed and intended for use by handicapped only
(2) Capacity (2000 lb min)	yes	yes	yes	yes	500 lb nominal capacity
(3) Size (80" X 51" or 68" X 51")	yes	yes	yes	yes	nominal size 42" X 62"
(4) Vertical Rise	unlimited	up to 60 feet	up to 25 feet	up to 60 feet	nominal rise up to 10 feet (Suitable for level changes within a single room or space)
(5) Cost (Total)	Highest	Medium	Low	Low	Lowest
(a) Capital	Highest	Medium	Low	Low	Lowest
(b) Standard Installation*	Highest	Medium	Low	Low	Lowest
(c) O&M	Data available for heavy use office building environments only				
(6) Retrofit Capability	Most difficult due to machine room, pit depth, and heavy structural requirements	Difficult due to need for well hole drilling	Requires limited building modification	Requires limited building modification and no machinery room space	Easily installed
(7) Safety	Safety mechanisms provided in accordance with equipment type				
(8) Security (Protection against assault)	Enclosed cars of glass are available - closed circuit television may be required				Open platform provides good security
(9) Reliability	No specific reliability differences can be identified				
(10) Code Satisfaction	yes	yes	yes	Code currently being developed	
(11) Effect of environment on elevator	Environment should affect all units. No perceived difference can be seen between units.				

* Relative costs could vary due to specific site conditons.

KMS311

shallower pit area than other types. Having been designed with retrofit application in mind, they present the least construction-related problems. Vertical handicapped platform lift can be easily fitted into existing locations. These retrofit problems are reflected in the cost comparison of item (5) of Table 2-1.

5. All units have been designed with features which provide for passenger safety.

6. All units using cars may offer less security than an open platform lift, but special glass enclosures are available, as necessary, to increase car security.

7. All units show reasonable reliability - no differences are readily apparent.

8. All units, with the exception of the screw column elevator, currently meet existing codes. The U.S. national elevator code committee, with cooperation from the screw column elevator industry, is currently working to develop an appropriate code.

9. Each type will be affected differently by interior transit station environment and changes in outdoor weather conditions. The platform lift is usually located indoors and accordingly would not be subjected to changes in the weather.

These comparisons have been made by comparing similar elevators being installed at a "standard" site. This site is an existing station which requires a 20-foot rise with openings at two different levels. Selection of appropriate elevators can be made when these conditions are tested against the comparison result. When this is done, it is determined that:

1. Conventional electric traction, due to overall high costs and problems in modifying the existing stations to accommodate the unit, will usually not be the best choice.

2. Conventional hydraulic, although with lower costs than electric traction, offers potential problems in modifying the existing stations to accommodate the unit, especially in placement of the well hole for the hydraulic jack, and thus will usually not be the best choice.

3. Vertical handicapped platform lifts are strictly limited to transport of individual handicapped persons for very low rise and as such do not meet requirements. However, these units might be suitable for other, special handicapped-only level changes.

4. Holeless hydraulic and screw column elevators will usually be the most appropriate types because of the overall lower cost and the fact that station alterations to accommodate their installation are less difficult. These units should therefore be considered the most applicable for vertical movement in existing transit stations.

With the selection of the holeless hydraulic and screw column elevators as technically applicable elevators, a decision was made, with the assistance of the Low Cost Vertical Elevator Liaison Board (See Appendix B for membership), to consider the additional requirement of this report, that is, the need for information. This consideration was made with the realization that large American manufacturers are actively marketing holeless hydraulic elevators and that applicable information regarding these elevators is available from these manufacturers and consulting engineers. The screw column elevator, which is considered to be an acceptable alternative, and additionally has the advantages of no machinery room and limited pit and overhead clearances, is new to the American market, and is at present being sold primarily in Europe; as such, information pertaining to screw column elevators is limited. The need for information on screw column elevator installation requirements, operation, and performance was confirmed by the Liaison Board, as it would present another option for transit authorities, with the potential result of lowering the overall cost of elevator installation. Use of these elevators could then result in program savings for the transit authority and the Government sponsoring agency. These considerations underscore the need for the technical information detailed in this report.

3.0 INTRODUCTION TO THE SCREW COLUMN ELEVATOR

The screw column elevator is a direct-drive unit which operates on the screw lift principle. For elevator installations, a stationary screw threaded column is located in the hoistway, and a rotating "nut" is driven around the threaded column, providing the vertical movement. This drive mechanism and principle has been employed on elevators since 1965 in Belgium, where a total of 250 units have been installed by one manufacturer. Only recently have screw column elevators been introduced to the American market.

This particular elevator has a well-defined market. The primary service for which the elevator is designed is for retrofit installation at relatively low rises. It has proven to be competitive where low rises (within 60 feet), lower capacities (up to 2500 pounds), and retrofit installations have been required. The screw column elevator is not competitive as a high volume traffic elevator such as those used in high rise office buildings because of the limited rise and also because the travel speed is slower than that of other elevator types.

The screw column elevator, when compared to other available types, can be seen to have the following advantages and disadvantages:

ADVANTAGES OF SCREW COLUMN ELEVATORS

1. Requires less space in the building or structure than other elevator types having the same capacity, size and speed. (Does not require an overhead machine room like the conventional electric traction elevator, or a machine room outside the hoistway like conventional and holeless hydraulic elevators. Also, lateral space requirements between the elevator car and hoistway are less.)

2. Is usually easier to accommodate in existing buildings/structures than other types of elevators as it requires no machinery room and less space.

3. Adds less loading to the building/structure than do other types of elevators. Furthermore, the loading is spread equally over an entire hoistway wall rather than concentrated overhead as with a conventional electric traction elevator or concentrated at pit level as with a conventional hydraulic elevator.

4. Has good leveling accuracy with all load variations, which is especially important to persons in wheelchairs and other handicapped users.

5. Costs less, overall, than conventional electric traction or conventional hydraulic elevators.

DISADVANTAGES OF SCREW COLUMN ELEVATORS

1. Is designed currently for limited capacity (up to 2500 pounds), limited speed and limited travel installations (rises up to 60 feet).

2. Has a higher noise level in the car than do other types of elevators. (Motor and drive unit is mounted on the car.)

3. Starts and stops somewhat abruptly.

In order to obtain the detailed information on screw column elevators which would be valuable to transit authorities in assessing the applicability in existing transit stations, an assessment team was formed to study and evaluate screw column elevators. The assessment was made of elevators of a Belgium manufacturer who has over 250 units installed.

The manufacturer has installed these units in many varied locations such as warehouses, offices, hospitals, apartment buildings and private residences. As there is no current Belgium program requiring transit accessibility, no elevators of any type, including screw column elevators, have been installed in transit locations specifically for handicapped patrons. Evaluation of the elevators took place in the manufacturer's plant plus seven locations in Belgium. These locations were chosen so the assessment team could obtain a broad picture of the manufacturer's units and gather information which would be most appropriate for transit operation. These locations along with other pertinent information are given in Appendix C, while persons contacted while in Belgium are listed in Appendix D.

The screw column elevator represents a simple, straightforward, economical approach to providing basic vertical transportation service. Even with existing limits on the capacity, the speed, and the rise of the unit, it appears to be ideally suited for the movement of handicapped persons in transit stations, where large capacities, high speeds, and high rises are not needed.

The following sections of this report present the findings of the assessment team and describe the equipment which is currently being manufactured and installed in Belgium. Some data is presented on manufacturer efforts to modify or improve the unit so that it is made more acceptable to the U.S. market.

4.0 DESIGN OF THE SCREW COLUMN ELEVATOR

4.1 GENERAL

The screw column elevator utilizes a cantilevered car to which the drive mechanism is directly attached. The motor, which is connected to the "nut" by V-belts, rotates the "nut" on the stationary screw column and provides the power to move the car both upward and downward. The screw column is supported only from the top and, thus, is in tension. The belt drive permits desirable slippage should the motor continue to run because of a control malfunction. Movement of the car in the hoistway is stabilized through the use of permanently fixed guide rails.

The relationship between the car, hoistway, screw column, drive mechanism and guide rails, as well as other subcomponents is shown in Figure 4-1. As each unit is engineered specially for the site, this manufacturer does not currently maintain detailed specifications or technical-data catalogue of pre-engineered or standard models. However, pertinent typical information for an elevator to be installed in a transit station was obtained and is presented below. In addition to the features listed below, the units can be designed for any door location, or with both entry and exit doors, and for various car interiors. All installations to date employ a manually activated swing door, which is the common European practice for small elevators. American standards call for automatic doors.

<u>TECHNICAL DATA FOR A TYPICAL TRANSIT STATION INSTALLATION</u>

Rise:	20 feet - two openings
Rated capacity:	2000 pounds
Empty car weight:	775 pounds (with no accessories)
Add for automatic door:	440 pounds
Car door:	single slide type - 36 inch opening - off center

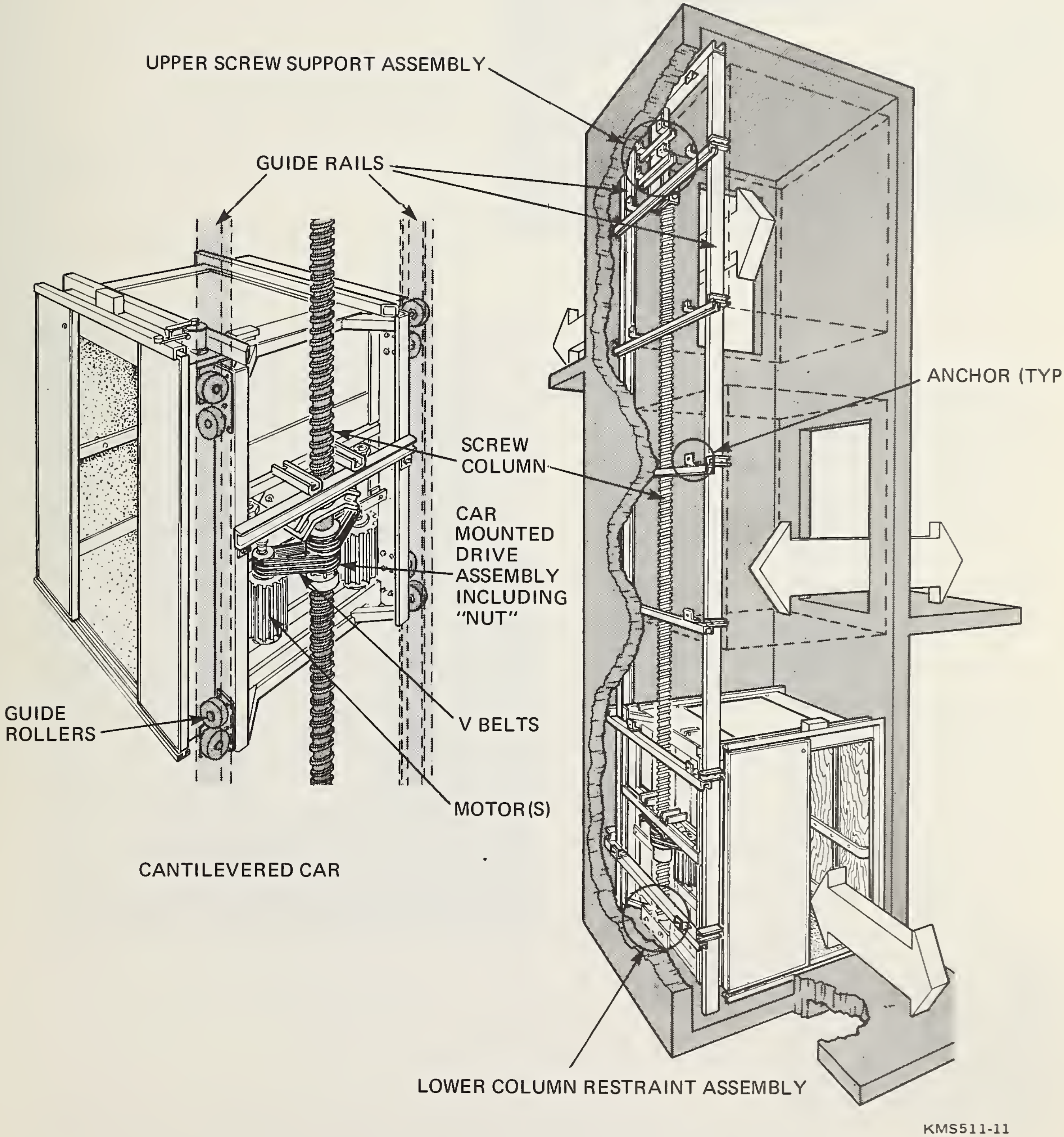


FIGURE 4-1. SCREW COLUMN ELEVATOR SCHEMATIC SHOWING VARIOUS AUTOMATIC DOOR-OPENINGS OPTIONS

Car interior:	68 x 51 inches, finished as specified
Leveling tolerance:	1/4 inch
Normal velocity:	70 ft/min (approximately)
Safety provisions:	safety nut, hand lever for manual movement of car
Motor:	(2)5 HP, 240V, 3ph, 60Hz
Brake:	internal motor brake, conical type
Drive mechanism:	motor, V-belts, and nut

4.2 MAJOR COMPONENTS

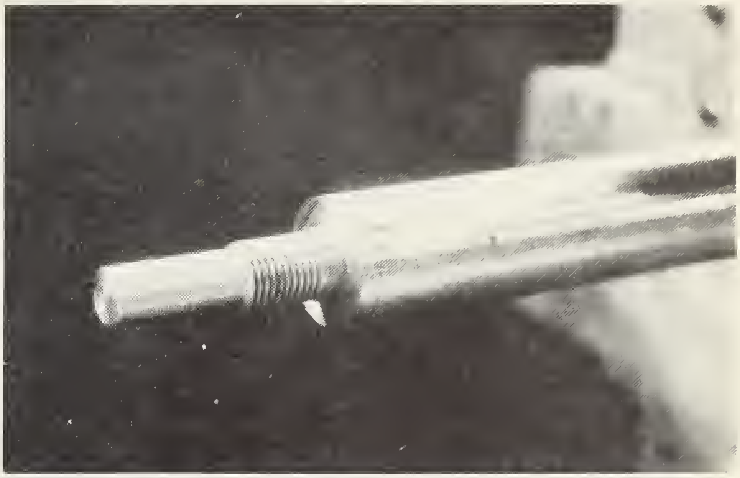
Specific details of major components and subcomponents are discussed and illustrated in the following sections.

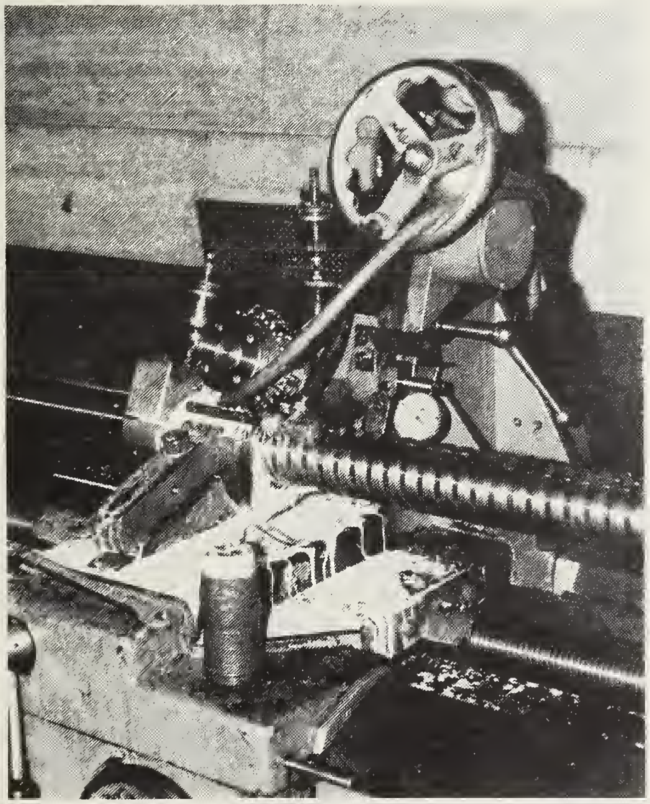
4.2.1 Screw Column

The screw column is cut from cylindrical 1040 steel in 12 foot sections. The milling operation cuts threads into this stock as shown in Figure 4-2. Male- and female-threaded ends are prepared in each section so that the sections can be assembled into the total length needed for a particular installation. The sections are assembled and locked together using a taper pin prior to thread cutting. The thread is then cut with the cut passing through the jointed section so that no misfit or misalignment occurs. After threads have been cut on the entire length of stock, the sections are disconnected in order to provide ease in both shipping and installation. The assembly of the screw column in the hoistway is fast and alignment is maintained through use of the taper pin set (see Figure 4-2).

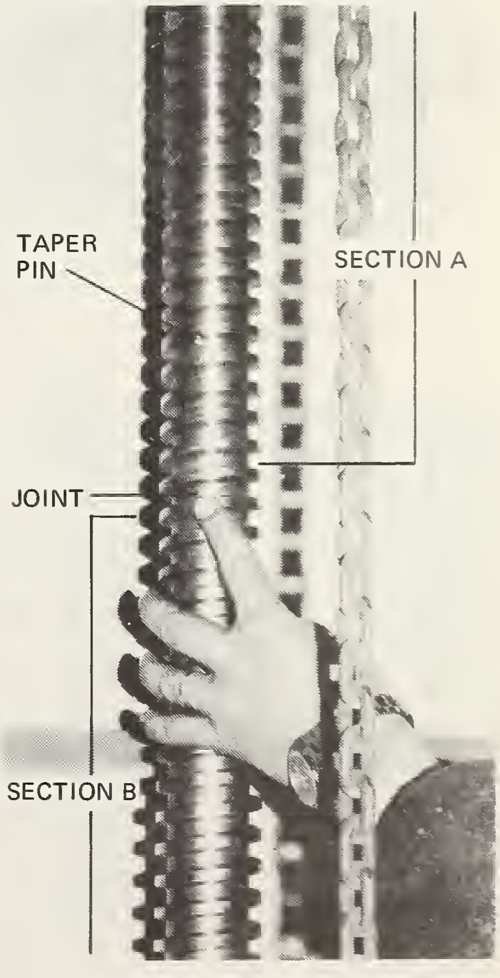
The ends of the total length screw column are prepared to fit the upper support assembly and lower restraint assembly. The top section is mill-finished for approximately 6 inches and drilled through, while the bottom shaft portion is mill-finished only.

DETAIL OF MALE END OF 12FT COLUMN SECTION (ENDS CUT BEFORE THREADING SCREW)





THREADING PROCESS



CONNECTION OF AN INSTALLED SCREW COLUMN

KMS511-16

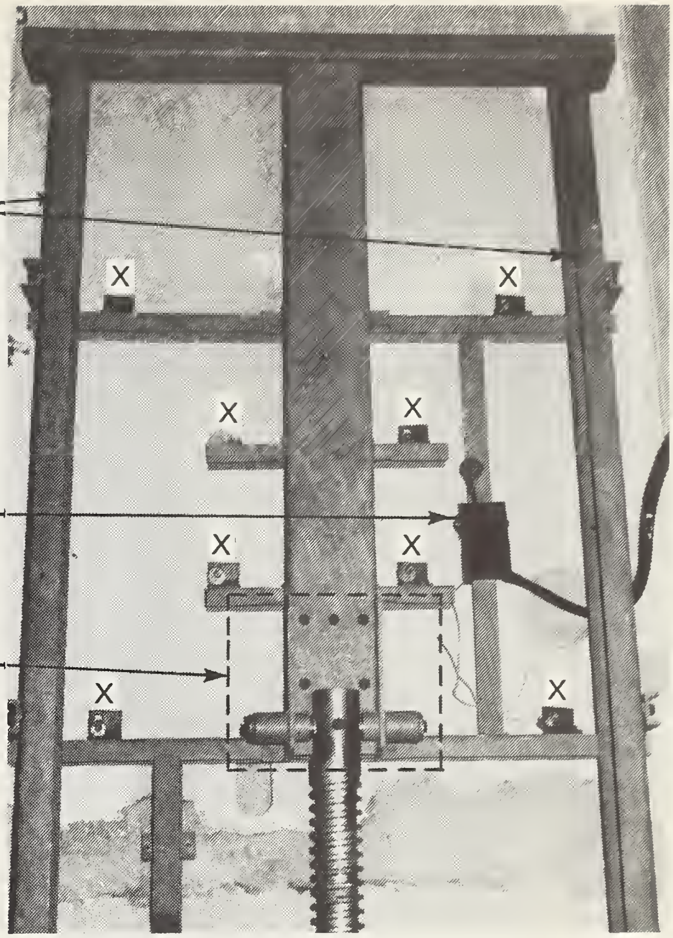
FIGURE 4-2. SCREW COLUMN FEATURES

4.2.2 Screw Column Supports

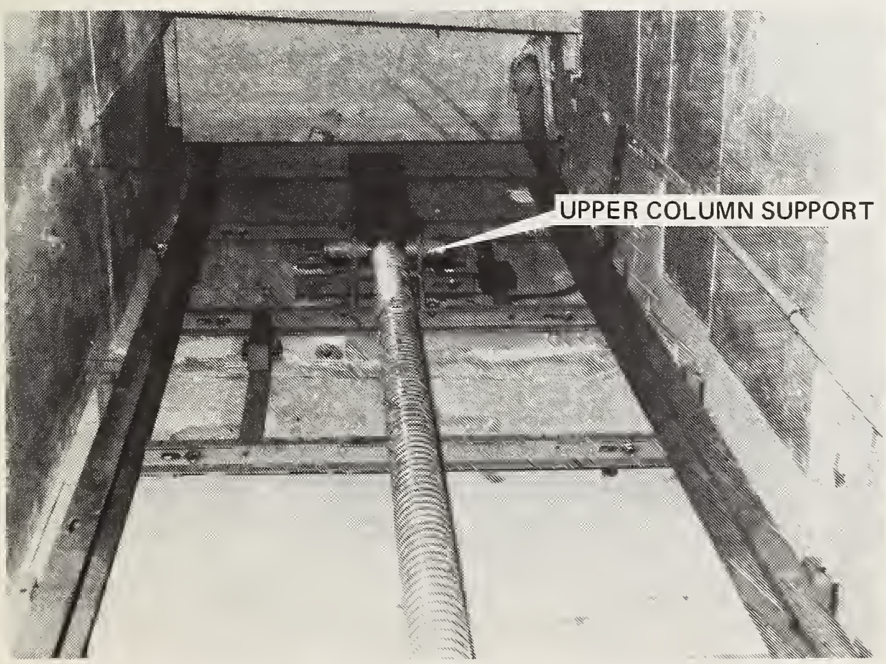
The screw column is supported only from the top end and thus is in tension. The lower end is restrained (guided) to fix its position. The column does not rotate.

Upper Screw Column Support - This assembly is used to support the entire screw column, the elevator car and its live load, and to transmit these loads to the structural load-bearing elements. The top of the column, which has been drilled through, is located as shown in Figure 4-3. The column is held in position by a rod which is fitted through it and which, in turn, is secured in the holding fixture. This fixture is attached to the main structural framing. The guide rails and structural system provide the means to distribute the load across the load bearing wall. As displayed in Figure 4-3, only one load bearing wall is needed to support the entire elevator assembly (where a load bearing wall is not available, free-standing steel framing can be utilized to support the elevator). Figure 4-3 also shows the relationship between screw column, the upper screw column support assembly, and guide rails. (Note that this unit has been installed on an existing wall.) For this installation, and others like it, expansion bolts are used to attach guide rails and structural steel to the bearing wall. Different types of expansion bolts are used for brick, concrete, or concrete-filled masonry block walls. Through-bolts with backing plates are used as necessary, if the design permits. The manufacturer stated that no problems have occurred using expansion bolts, and in addition, it was determined that they are checked by inspection officials during site visits and no problems have been observed.

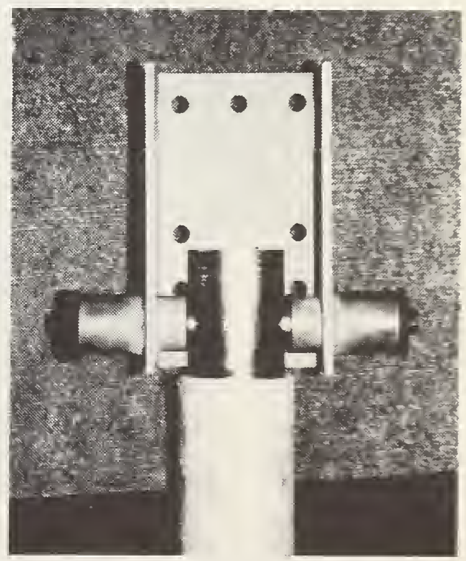
Lower Column Restraint - This assembly is appropriately called a guide since the lower end of the screw column is fitted into the bearing but not fixed. The device is used to prevent undesired lateral movement by the screw column. The assembly is displayed



SHOWING UPPER COLUMN SUPPORT AND MAIN STRUCTURAL BRACING
(X MARKS EXPANSION BOLT PLACEMENT)



SCREW COLUMN AND STRUCTURAL SUPPORTING ASSEMBLY



UPPER COLUMN SUPPORT DETAIL

KMS511-6

FIGURE 4-3. UPPER SCREW COLUMN SUPPORT AND STRUCTURAL SUPPORT SYSTEM in Figure 4-4. Figure 4-4 shows the underside of the device and sleeve bearing, the device with the bottom of the screw column inserted, and the device installed. The minimum loads that the lower restraint device must support permit the assembly to be mounted directly on the bearing wall as shown in Figure 4-4.

4.2.3 Structural Support

The entire elevator assembly, is supported by the structural support system mounted onto the bearing wall. This support system consists of rails, beams, and braces affixed to the wall as shown in Figure 4-3. The structure is factory-prepared, shipped to the appropriate site, and assembled and installed on site. The elevator manufacturer changes only the width between rails when installing an elevator having a wide-body car.

4.2.4 Drive Mechanism

The drive mechanism is an assembly that consists of a motor, V-belts, and a lifting/bearing device called the nut. The entire assembly is mounted on the elevator car and is integral with the car as the unit ascends and decends the screw column. Figure 4-5 shows the assembly at a low travel location. The motor normally used is 5 hp, although for larger units two motors are used and arranged at either side of the nut. The motor drives the nut through standard V-belts with one belt provided per horsepower. The rotating nut provides the motion for vertical travel. The motor is fitted with an internal conical brake which is used to eliminate coasting and assure leveling accuracy.

The nut, depicted in Figure 4-6, is the main component of the elevator system. The complete nut assembly is shown as an exploded view in Figure 4-6. As noted in the figure, it is made up of two subassemblies, one rotating and one stationary. The entire load of the moving elevator car is transmitted from the rotating nut to the stationary mounting brackets affixed to the

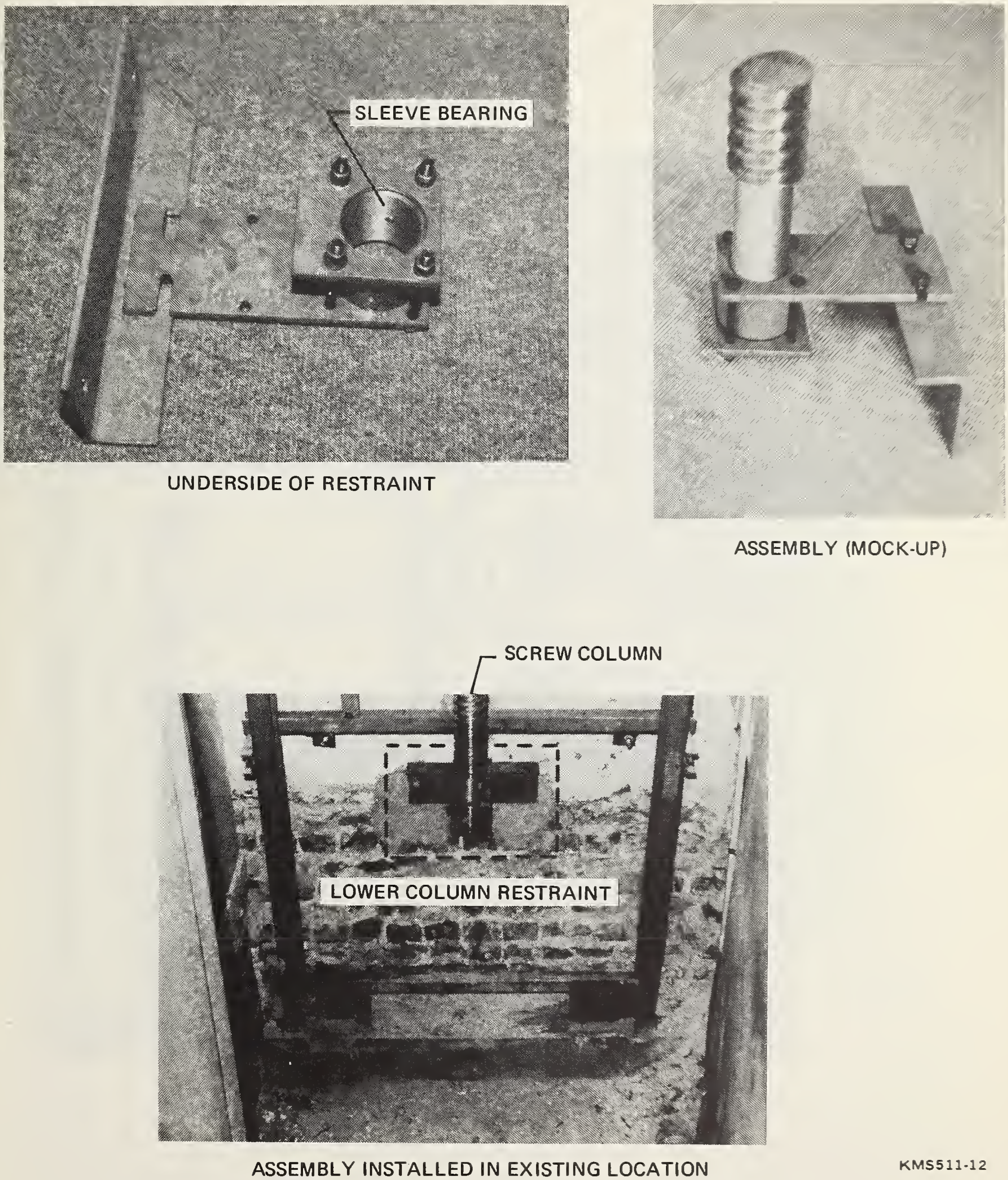
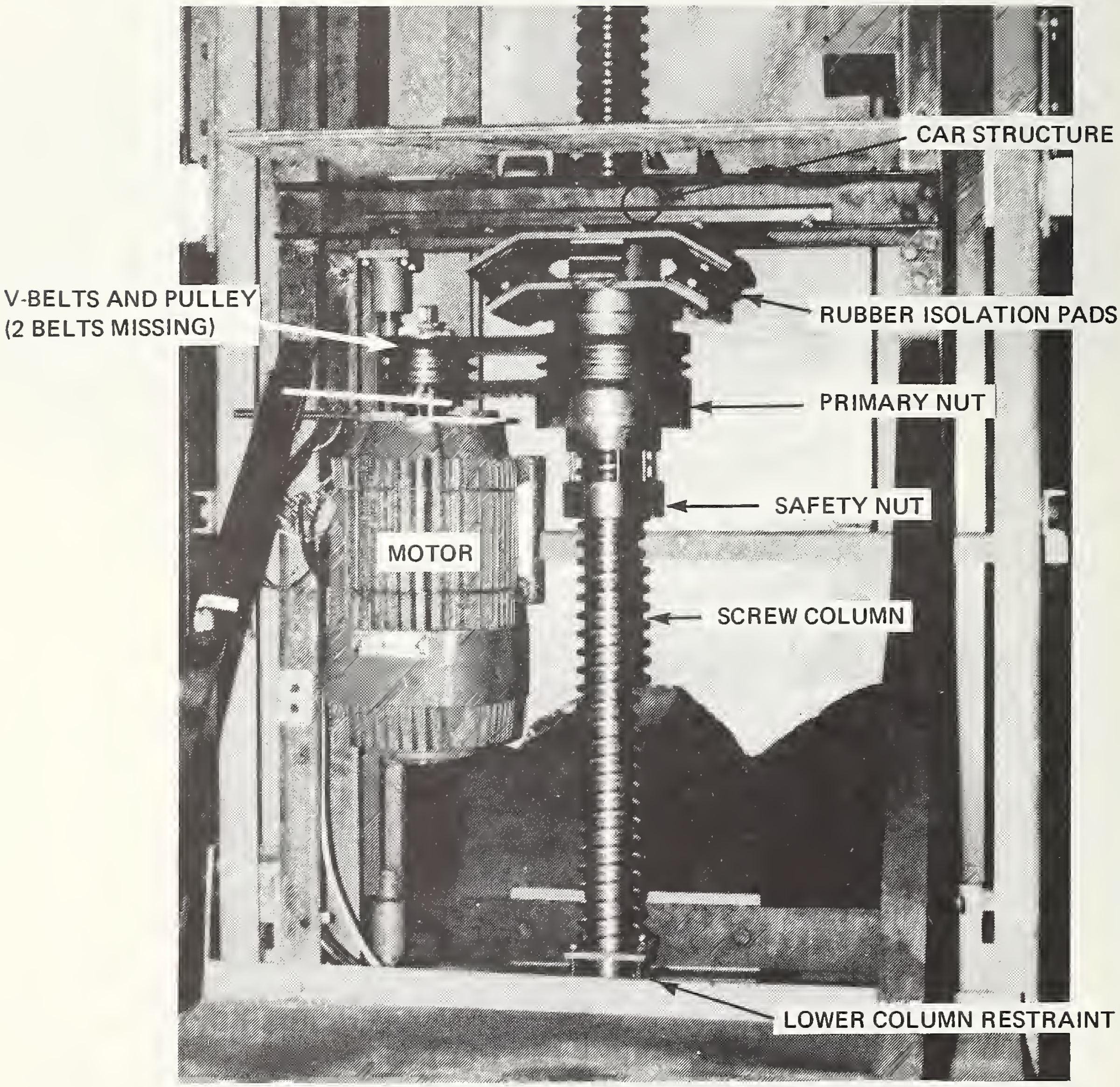
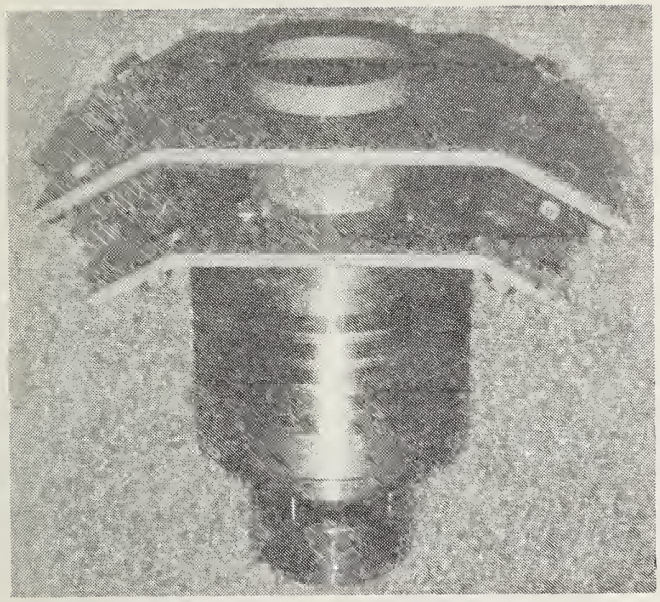


FIGURE 4-4. LOWER COLUMN RESTRAINT



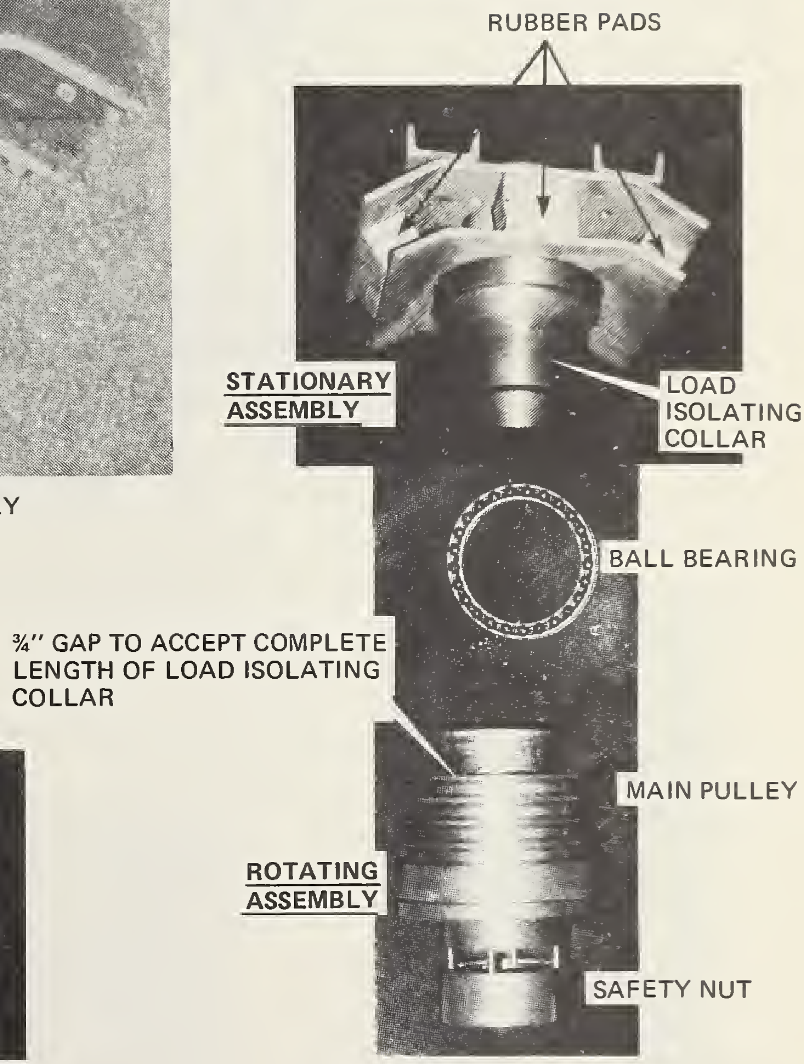
(PLANT INSTALLATION) KMS511-13

FIGURE 4-5. SCREW COLUMN ELEVATOR DRIVE MECHANISM



COMPLETE NUT ASSEMBLY

TOP VIEW OF ROTATING ASSEMBLY WITH PULLEY REMOVED. LOCATION OF BALL BEARING SHOWN. NOTE INTERNAL THREADING



EXPLODED VIEW OF COMPLETE NUT ASSEMBLY. BALL BEARING REMOVED FROM INTERNAL LOCATION

FIGURE 4-6. NUT ASSEMBLY DETAILS

car. Thus, as the nut rotates in response to motor direction, the interaction between the internally threaded bronze nut and screw column raises or lowers the car. Ball bearings within the assembly transmit only the up and down motion of the rotating nut to the assembly. These bearings transmit the elevator load through the load-isolating collar to the mounting bracket, which is secured to the car structural members.

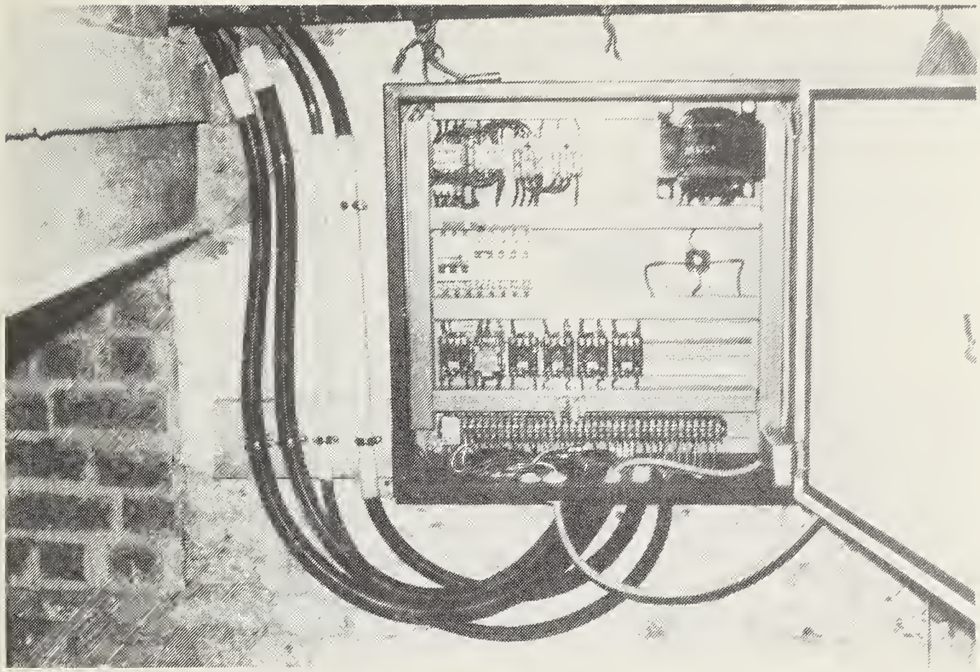
The safety nut at the lower end of the assembly rotates with the primary (driving) nut but carries no load. It serves a dual purpose: first, to take the load should the threads of the primary nut somehow fail and second, to be an indicator of the amount of wear on the internal threads of the primary nut. To date, after 15 years of experience, no primary nut has failed which would have required the load to automatically transfer to the safety nut.

The mounting brackets are separated with rubber isolation pads, which together with the plate design, minimize the abruptness of stops and act as an aid in preventing noise transmission, thereby reducing sound levels.

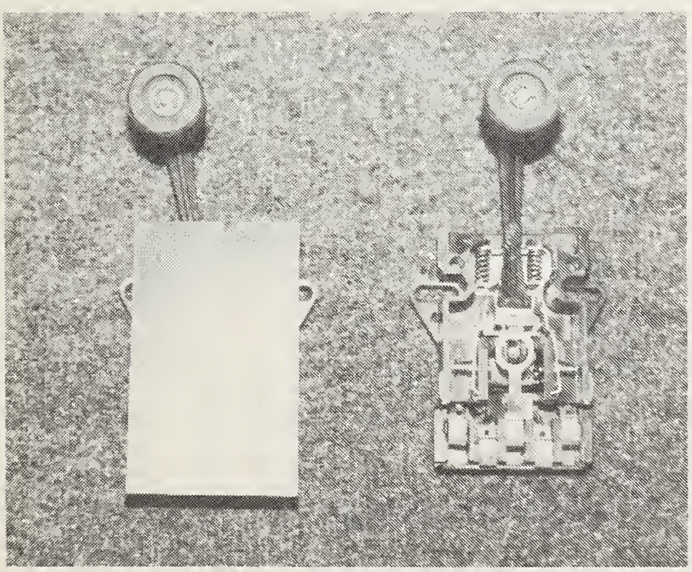
4.2.5 Controls

The controller is located in a locked metal cabinet mounted on the exterior hoistway wall, usually near the lowest entrance to the hoistway.

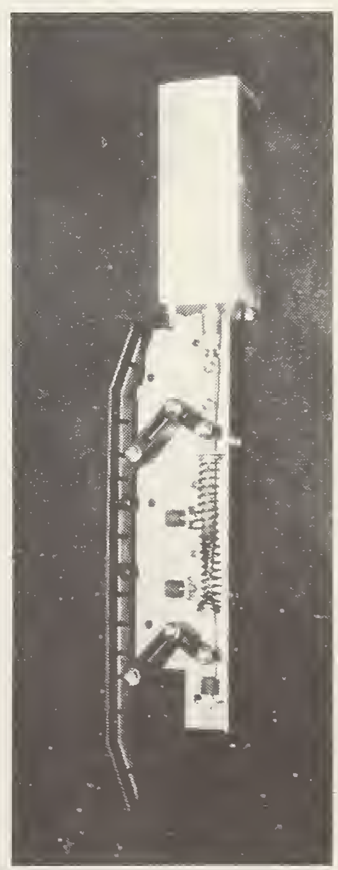
The controller uses conventional elevator electro-mechanical relays to govern the starting, stopping, and direction of motion of the elevator. The controller, shown in Figure 4-7, connects, disconnects, and reverses power to the motor in response to signals from the pushbuttons located outside the elevator adjacent to each hoistway entrance, and from the pushbutton panel located inside the car. Passenger activation of a pushbutton indirectly starts the motor in the proper direction of rotation. Release



CONTROLLER WITH POWER CABLES



LIMIT SWITCH (EXTERNAL AND INTERNAL VIEWS)



SOLENOID ACTUATED DOOR
UNLOCKING DEVICE (RETIRING CAM)

KMS511-14

FIGURE 4-7. CONTROLS EQUIPMENT

of the internal motor brake is automatic when the motor starts. A retiring cam located on the exterior of the elevator car unlocks the door for the desired floor as the elevator arrives. Excessive overtravel is prevented by placement of upper and lower travel limit switches which function to interrupt the voltage to the motor and stop the elevator.

The units installed to date have not required sophisticated electronic controls to adjust to traffic demand. Simple floor-to-floor travel does not warrant sophisticated electronic controls. In addition, since the Belgian experience is to use manually activated swing doors, no controls are now available for automatic door opening. The automatic door unlocking device (retiring cam) and overtravel limit switches are also shown in Figure 4-7. More complex controls required for automatic door opening, which would be required for elderly and handicapped service, should present no significant problems if required for future installations.

4.2.6 Elevator Car

The car is constructed in the manufacturer's plant using U-channels and sheet metal cut to size and welded accordingly. Sizes vary as required by specification, as does the number of door openings, the location of door openings, wall covering, and outside sound insulation. The car is designed with removable panels, as required to permit free access to the drive mechanism, hoistway limit switches, lower screw column restraint, and upper column support. The lower removable panel intrudes into the passenger compartment at hip level. The placement of the lower panel results in a 4 inch shelf on one wall. Illumination is also provided in the car in accordance with the project specifications. All units sold to date by this manufacturer have used manually activated swing hoistway doors and no car doors. Power operated sliding doors can be provided if desired by the purchaser.

4.2.7 Safety Equipment

Equipment which is provided to assure safe operation of the elevator is described in Section 5.0.

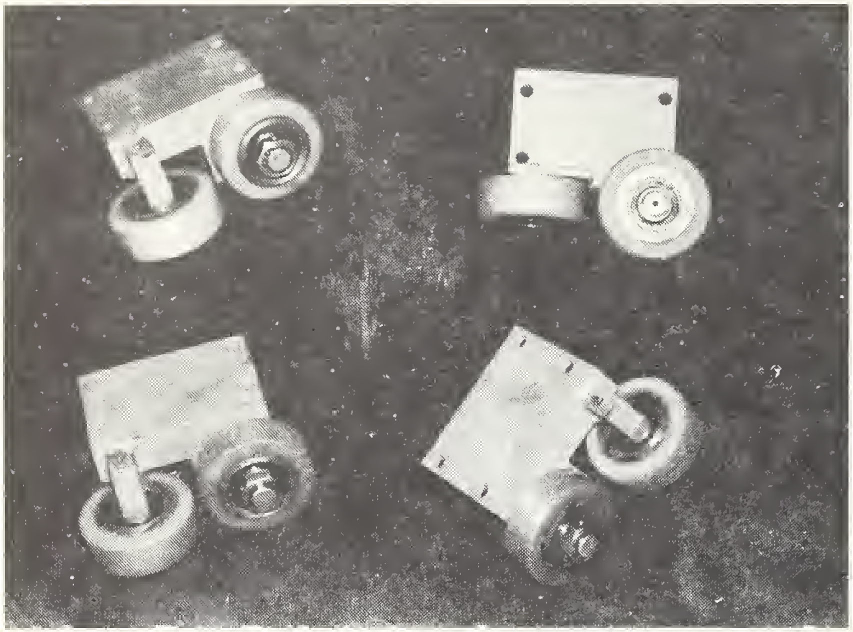
4.2.8 Miscellaneous Equipment

Rollers

The car is maintained in its position by guide rails and rollers which are attached to the car. These rollers, shown in Figure 4-8, can be adjusted about their axis in order to minimize roller-to-guide-rail tolerance so that car shake is minimized.

Traveling Cable

Power for the elevator motor(s) is transmitted through flexible traveling cable (power lines) which follows the car through its up and down travel.



COMPLETE SET OF FOUR ROLLERS

DETAIL OF ROLLER INSTALLED IN GUIDE RAIL

KMS511-8

FIGURE 4-8. ELEVATOR ROLLERS

5.0 OPERATION AND MAINTENANCE

The operation of the elevator is relatively simple. Pressure of pushbuttons activates control voltage, and circuit logic is arranged to power the motor. The motor, in turn, drives the nut and the car up or down the screw column. Logic controls keep uninvolved doors locked and prevent the car from stopping at uninvolved floor levels. Floor switches are used to stop the unit at the selected level. Should the unit overtravel, limit switches are provided at the positions of uppermost or lowermost travel.

In response to a call for service from outside the hoistway or for floor selection from within the car, the motor is activated and the car moves in the direction to service the call. The motor used is a single speed, high torque type, which results in a slightly abrupt start but quickly brings the car to steady travel. Travel is smooth although the speed is relatively slow. Noise, generated primarily by the motor, is noticeably higher inside the car during travel than competing models. The manufacturer noted that the sound pressure level recorded in the car is in the area of 60 dBA. Since this is one of the disadvantages of screw column elevators, the manufacturer is pursuing methods, involving both the drive mechanism and hoistway, to minimize noise perceived by the occupant. The car continues its travel to the selected floor and stops somewhat abruptly. The single speed motor and activation of the brake used to achieve leveling accuracy is the major reason for sudden stops. However, leveling accuracy was noted as excellent with no noticeable unevenness between car and floors observed. Leveling accuracy is established by the precise placement of floor switches at time of installation.

Wheelchair Use

Elevators to be installed in Belgium for use by handicapped individuals are to be provided in accordance with the International

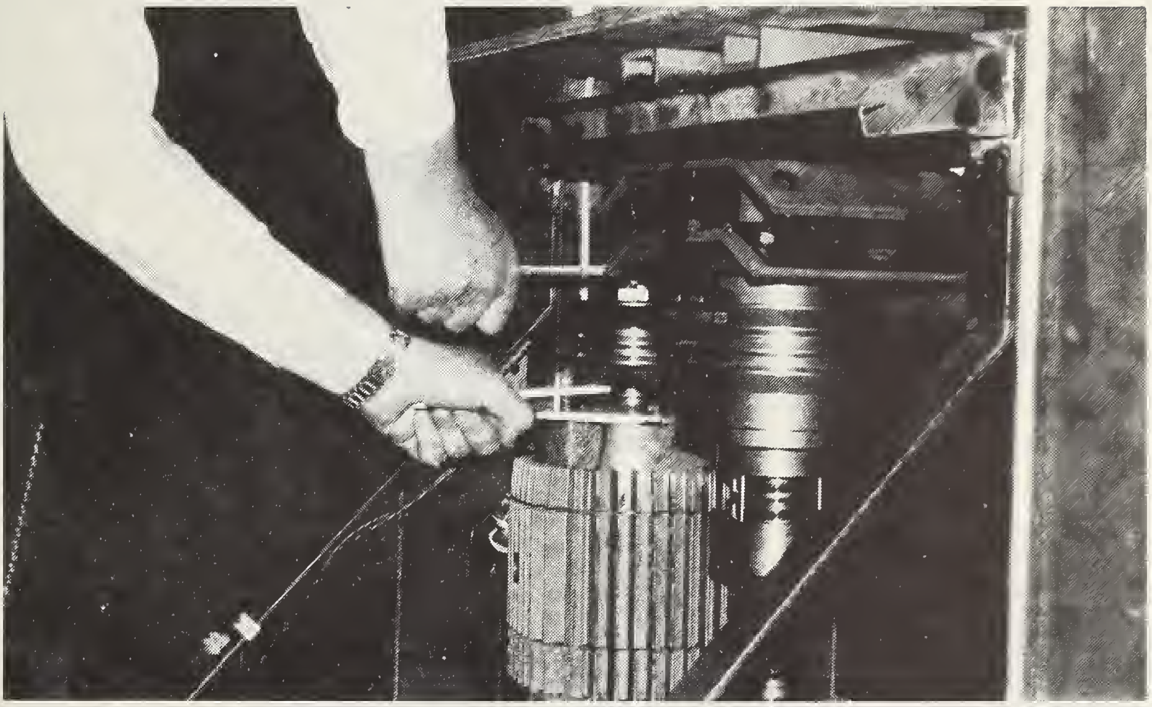
Standards Organization standard ISO/TC 59/WG1 N of 1980. This calls for a car of minimum dimensions of 1100mm x 1400mm (43 in. x 55 in.) using a swing door and not offering space for wheelchair turnaround. Larger units are advised if automatic doors and wheelchair turnaround are desired. The manufacturer presently provides elevators which meet these minimum requirements, but has not been requested to provide any larger units for handicapped usage. No wheelchair use of elevators was observed. However, during the site inspection of a five-story nursing home in Brussels, one unit (1000mm x 1000mm), somewhat smaller than the standard, was operating under heavy usage for elderly persons. No problems were observed with the use of the swing door, the small car size, or the abrupt start or stop.

Safety and Emergency Operations

The safety record of screw column elevators is excellent. According to the manufacturer, no accidents involving passenger injuries or insurance claims against the manufacturer have occurred during the operating history of the elevator.

The design of the elevator drive mechanism with its constant-speed motor is such that the nut, because it surrounds the screw column, prevents any overspeed travel or free-fall conditions. However, should thread wear be excessive so as to possibly endanger the screw/nut interaction, a safety nut is provided to prevent the car from falling. To date, on the numerous installations in Belgium, thread wear of the nut has been insignificant and no occurrences of safety nut use have been recorded.

For evacuation from an inoperable car, the manufacturer provides the car occupant a mechanical method for self-evacuation. By opening the access panel from within the car and gaining access to the drive mechanism, an occupant can use a rachet to manually rotate the nut to achieve vertical movement. This is shown in Figure 5-1. This system was tested during this evaluation and



METHOD OF SELF EVACUATION
(RATCHET IN RIGHT HAND, BRAKE RELEASE IN LEFT)

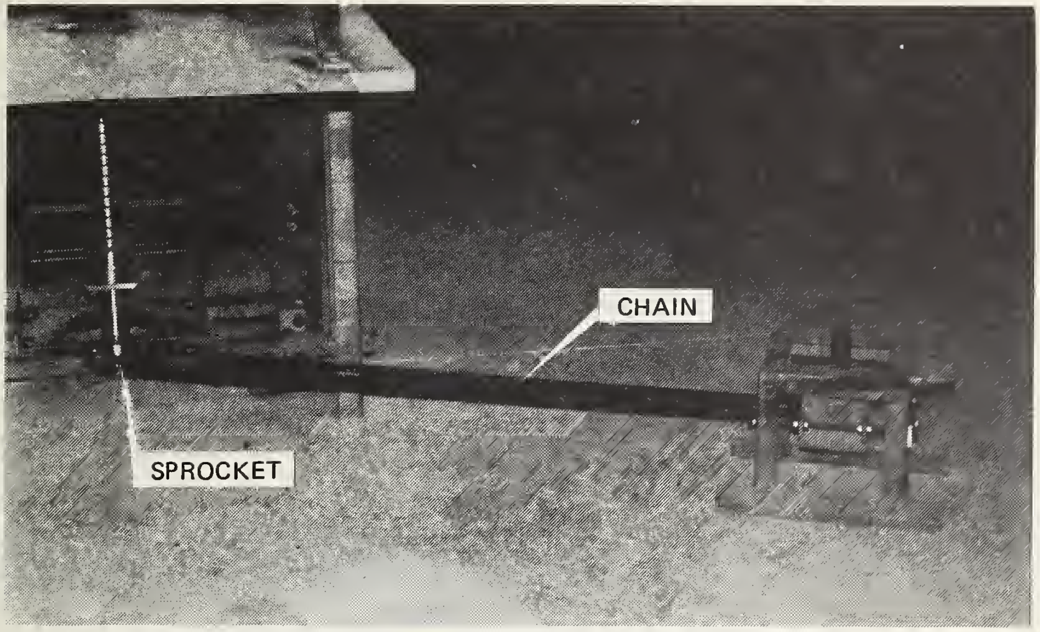
KMS511-9

FIGURE 5-1. SELF EVACUATION PROCEDURE

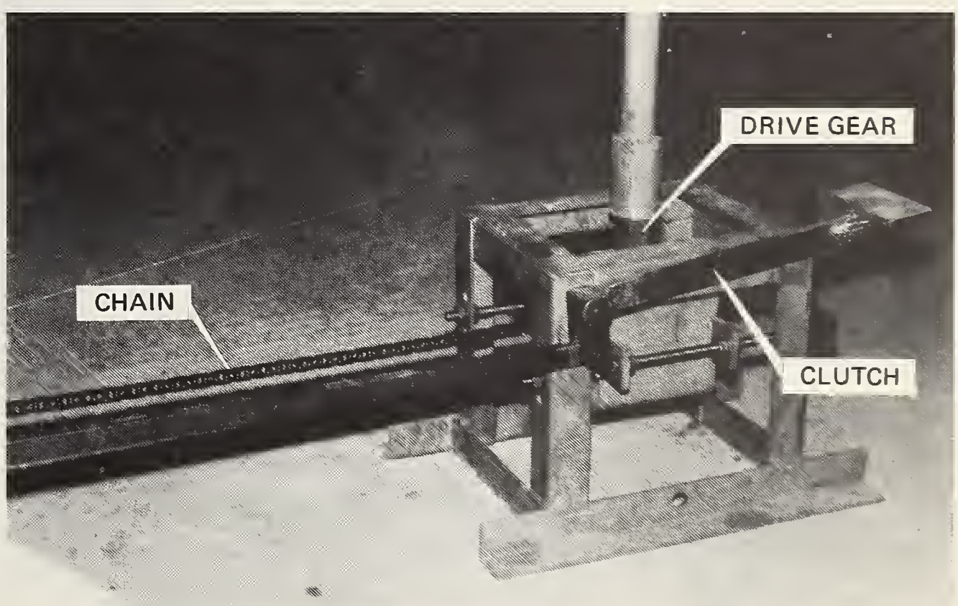
was operated successfully by the assessment team. However, concerns about vandalism and use of this system by elderly and handicapped were discussed with the manufacturer prior to this site inspection and led them to consider an alternative method which is shown in Figure 5-2. It is shown here in its conceptual design configuration. A chain and sprocket has been added to the bottom of the screw column and a cylindrical bearing added to the top so that the screw can be manually rotated by a person outside the hoistway. The rotating screw moves the stationary nut to achieve vertical movement. This system was also tested by the authors and found to work effectively. This method was noted to be potentially more reliable than a battery powered emergency power source since it does not present problems associated with battery and inverter maintenance. The manufacturer is continuing to test and finalize this method for external car evacuation.

Also in the conceptual design stage is a guide rail safety grip system which may be necessary in order to meet U.S. codes and standards. This system shown in Figure 5-3 would be used to prevent a free fall situation. As the drive mechanism, by its configuration, prevents overspeed, this scenario could not be tested under actual overspeed conditions. However, manual activation of the safety grip system showed that the system effectively prevented the elevator from continued downward travel. The condition under which the guide rail safety grips might be required is in the event of a failure of the screw column support, or material or joint failure which results in separation of the column. These possibilities appear extremely remote due to the design of the system.

The safety equipment currently supplied with the unit, that is, the safety nut and rachet release, is accepted by local authorities for use in Belgium.



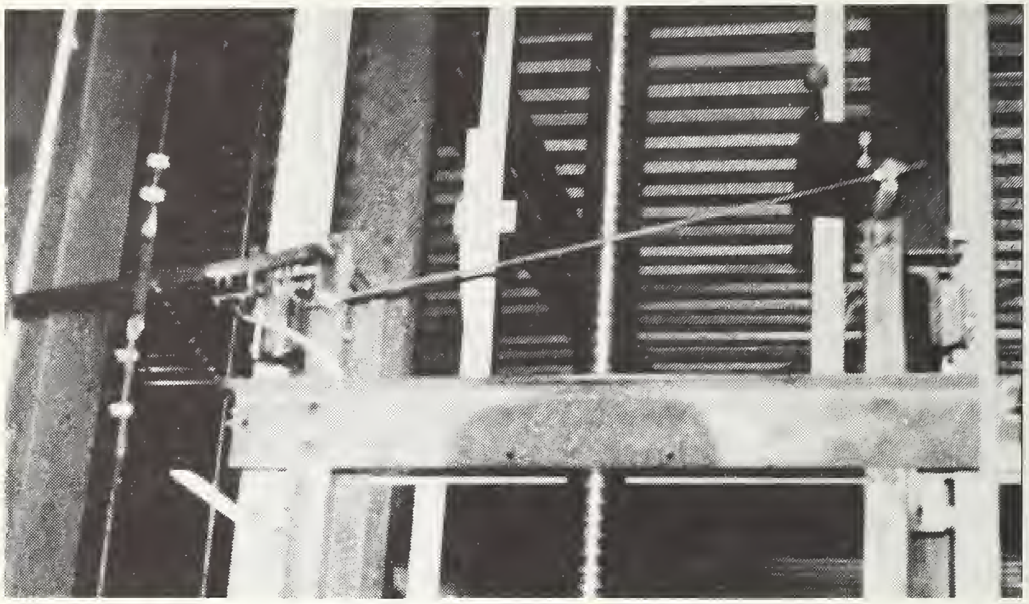
CHAIN AND SPROCKET EVACUATION CONFIGURATION



PRELIMINARY CONCEPT OF CHAIN DRIVE

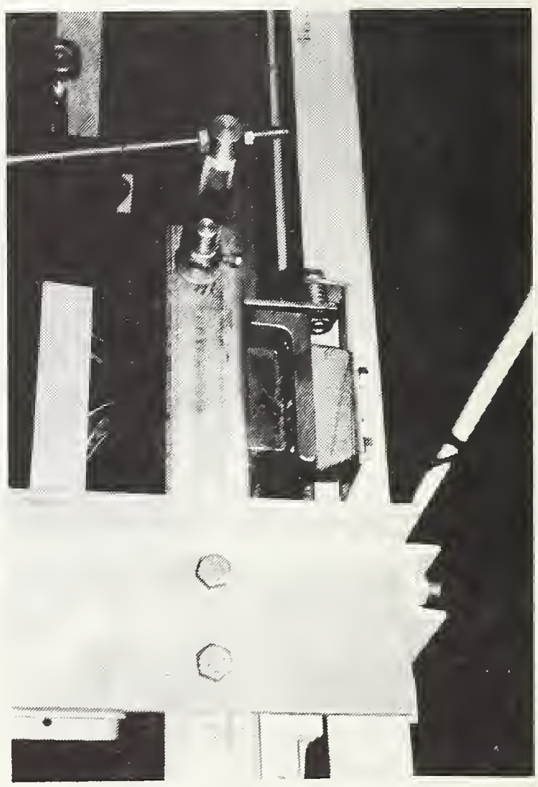
KMS511-10

FIGURE 5-2. EXTERNAL EVACUATION SYSTEM



GUIDE RAIL SAFETY GRIP SYSTEM

DETAIL OF SAFETY
GRIP DEVICE ON
GUIDE RAIL



KMS511-15

FIGURE 5-3. SAFETY GRIP SYSTEM

Pit and Overhead Clearance

The design and installation of the screw column elevator is attractive because it requires minimum overhead and pit dimensions and no separate machine room. Current practice in Belgium is to provide a pit with a minimum depth of 30cm (approximately one foot) regardless of speed, and overhead space with minimum clearance of 40 cm (15 3/4 inches) for elevators using swing doors. The manufacturer anticipates that when automatic doors are used, overhead space will be required to be approximately three feet (with two feet being provided for the door operator mechanism). U.S. safety requirements are being developed presently, and pit and overhead clearances are issues that will be discussed.

Maintenance

The manufacturer offers maintenance contracts for each installation, which may be purchased by the owner. These contracts are generally for parts, oil and grease (POG). Maintenance requires visits to each contracted unit generally every eight weeks. This results in six visits per year per elevator for preventative maintenance. Maintenance records show that for all elevators the total calls are 6.55 visits per year or a total of .55 visits per unit per year for call-back. This call-back service was not further broken down to determine specific causes. This includes otherwise avoidable calls (usually someone pushing stop button), as well as forced outages due to equipment failure.

Further investigation shows that maintenance histories appear to be excellent. For 250 units, only one nut has been replaced during the past 15 years. Examination of another nut replaced after seven years of service by the manufacturer for research purposes showed little evidence of wear on internal thread or wear surfaces. Also, the manufacturer noted that no roller bearing, located between the nut and the isolating sleeve as shown in

Figure 4-5, has ever been replaced. From information obtained, it appears that over and above planned maintenance, the major maintenance item is minor adjustments and replacement of contacts in the controller. Information obtained from elevator owners as well as from the manufacturer indicates that long-term operation with minimum maintenance problems can be expected. Use of automatic doors may result in a higher maintenance need.

Because of the limited need for maintenance, no spare parts need to be stored at the site, nor are there any unique parts which can be purchased only from the manufacturer (other than certain drive assembly components).

Environment

All units installed are protected from direct exposure to the weather by the enclosing hoistway. This protects all parts and components from inclement weather, but does not protect them from changes in temperature. Outdoor elevators with unheated hoistways were inspected and did not show any noticeable problems from this exposure, and, as such, should be acceptable for transit use. However, the effects of rail dust, as might be present in a transit station, could not be determined. The effects of rail dust on operation and maintenance could only be determined after long-term use at an appropriate site.

6.0 CODES AND STANDARDS

6.1 CODE STATUS AND INSPECTION PRACTICES IN BELGIUM

Screw column elevators are not specifically covered by the current Belgium Elevator Code (Institut Belge de Normalisation - NBN 250). However, the requirements in the Belgium Elevator Code for Electric Traction Elevators are followed to the extent applicable and practical.

The Belgium Ministry of Employment and Labor (Ministre de L'Emploi et du Travail) has taken the position that the effort necessary to develop specific code rules for screw column elevators is not justified, since there is only one manufacturer (Ebel) in Belgium and the design is standardized, has been inspected and tested, and has an established reputation for safety. Therefore, the Ministry has granted a derogation (blanket exception) to Ebel to cover those requirements in the Belgian Elevator Code for Electric Traction Elevators which are not applicable to screw column elevators. The result is somewhat comparable to placing these elevators on an approved products list.

Elevator inspections are made by an independent, not-for-profit, inspection authority. The Belgium inspection authority which performs most elevator inspections is known as AIB (Association des Industriels de Belgique). This organization understands fully which Belgium Code requirements are applicable to screw column elevators and has established a uniform approach to performing precommissioning (equivalent to acceptance tests and inspections in the U.S.) and periodic (routine) inspections of screw column elevators. In a lengthy interview, Mr. Robert Detilloux, Principal Inspector, AIB made it clear that AIB is entirely satisfied with the safety standards for screw column elevators. However, he advised that any significant changes in design such as using automatic doors rather than swing doors would necessitate a review and possible modification of the requirements for the precommissioning and periodic inspections. There should not be any problem with their installation and use since automatic doors are widely used and understood.

The Belgium Elevator Code - NBN 250 has been phased out and is being replaced by the new European Standard Safety Rules for the Construction and Installation of Lifts and Service Lifts, Part 1 - Electric Lifts (conventional electric tradition elevators only). The new elevator code will be known as CEN (Comite European de Normalisation) EN 81-1. The CEN Elevator Code was developed by the national standards organizations of Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom. This code has been adopted by Belgium to replace NBN-250. In its statement of scope, the CEN Elevator Code EN 81-1 states that it does not cover rack and pinion elevators, screw column elevators, mine elevators, ships' hoists, private residence elevators, certain limited-use lifts for the handicapped, etc. However, the code further states that this standard may be taken as a basis for such elevators, thus establishing a general safety standard. Mr. Robert Detilloux of AIB and the manufacturer expect the screw column elevator's design and inspection procedures to be unaffected once the European Elevator Code, CEN EN 81-1 becomes fully effective in Belgium.

6.2 CODE STATUS AND INSPECTION PRACTICES IN THE USA

The American National Standard Safety Code for Elevators, Dumbwaiters, Escalators and Moving Walks, ANSI A17.1, includes rules covering a type of screw column elevator that was manufactured and installed in the U.S. in limited numbers several years ago. These rules do not cover the newer types of screw column elevators currently being manufactured.

However the Code Committee has drafted new code rules covering various types of screw column elevators, including the type manufactured in Belgium and planned for manufacture in the United States. A proposed revision to ANSI A17.1 was submitted and sent out for letter ballot on December 30, 1981. Areas covered under the new code rules include rescue provisions for trapped passengers, overhead and pit clearances, traveling cable installation, and possible governor/safety requirements. As mentioned earlier, each of these items has been recognized by the manufacturer and provisions have been planned to comply as required.

Public review and balloting on the draft rules is expected to continue in 1982 to determine whether they will be added as a new section to ANSI A17.1.

Pending the availability of code rules covering the newer type of screw column elevators, state and local building officials (the enforcing authority) may approve the installation of screw column elevators on a case-by-case basis, based on a review of the design to determine that the installation will provide reasonable safety. Acceptance tests and inspections and periodic inspections will be made in accordance with the usual practices in the jurisdiction.

Thus, changes in the design features of screw column elevators to be manufactured in the U.S. will be dependent upon the outcome of the A17.1 Code Committee. Upon completion of code development, it is expected that the manufacturer will incorporate all necessary modifications, if any, in order to be acceptable and meet U.S. standards.

7.0 SCREW COLUMN ELEVATOR COSTS

The cost comparison of all elevators evaluated is given in Section 2.0. Data obtained from manufacturers were estimated costs for a two-stop unit with a vertical rise of 20 feet and a capacity of 2000 pounds. This comparison of equipment costs indicated the screw column elevator to be lowest. Further evaluation indicates that the cost for a basic screw column elevator assembly may be approximately $18-20K. As procurement specifications may require additional items such as automatic doors, special wall covering, phone system, etc., this cost will increase accordingly. However, unit comparative costs should not change. Installation costs depend on the rates of local unions who have jurisdiction for installation or other local labor rates. Screw column elevator installation time for a prepared hoistway is quoted as being a total of 48 hours for an experienced two-man crew.

Total cost differences for equipment and installation between screw column elevators and holeless hydraulic elevators, the other low cost option, indicate that the screw column may be approximately $3-4K lower. These costs are small, however, when considered against the total cost of the installation. Site preparation costs in an existing location must also be considered. The savings in preparation costs for screw column elevators may be significant as the screw column requires: (1) bearing wall (or similar arrangement) as opposed to floor support; (2) potentially smaller pit and overhead requirements; (3) no machine room; and (4) the least hoistway space for the same sized car. These features must be considered by the site designer/architect in arriving at the final selection. Because of the wide diversity of transit station sites and authority operating philosophy, this report does not address site specifics and associated costs, but leaves this to the responsible transit representative.

8.0 SUMMARY

Screw column elevators appear to be an acceptable low-cost option for providing vertical movement for elderly and handicapped transit patrons, while providing the transit authorities with minimal installation problems at existing transit sites.

Although limited to distribution primarily in Belgium, the market is expanding in various countries including the United States for this type of elevator. The manufacturer interviewed is the largest supplier of screw column elevators and is currently establishing sales and manufacturing in the United States. Rise, Inc. of California is also supplying screw column elevators, and reports that only a few units have been installed in six years. Also, at the same time, code activity is being conducted to provide guidelines for installation and operation of these elevators. Differences between current European practices and anticipated United States guidelines are being investigated by the Code Committee and the manufacturer, and practical solutions are being conceptualized and tested. The manufacturer is committed to the U.S. market and all units sold in the United States will be manufactured in the manufacturer's stateside facility.

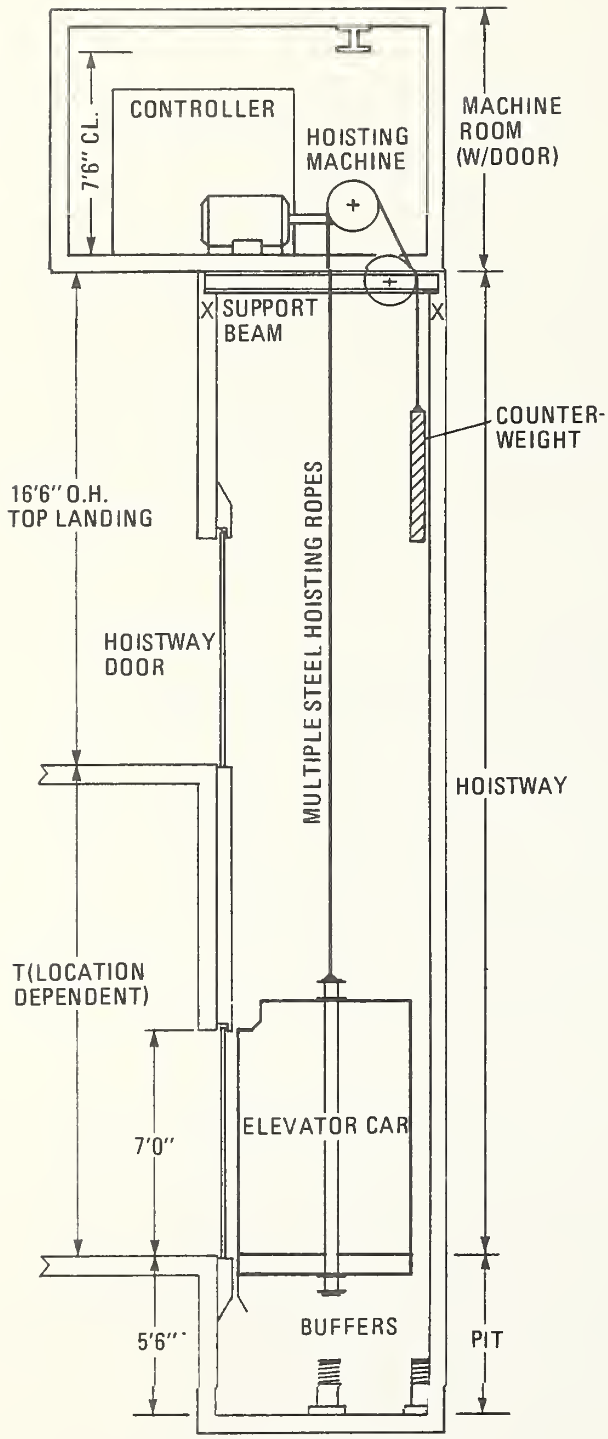
This investigation team has reviewed the design, operation, and maintenance of these units and found no particular issue or item which would prove to be unacceptable to architects, engineers, or owners of these units. The advantages and disadvantages have been stated. It is the conclusion of this team that for providing transit authorities with overall low-cost vertical elevators, the advantages of the screw column elevator far outweigh the disadvantages. Since there is no need for high capacity, high-speed transport, the primary source of concern is noise level which is slightly higher than that of other elevator types. As the patron is subjected to the noise for such a short time, it is considered to be more of an annoyance than a problem. However, the manufacturer is currently attempting to reduce internal car noise levels.

Also, the transit needs, guidelines for accessible design, and customer or patron demands will require modifications to current design. These modifications may include: (a) provision of power operated hoistway doors and car doors; (b) larger car size and capacity than the basic minimum elevator provided for handicapped persons in Belgium (1100 mm x 1400 mm); (c) provisions to permit the rescue of persons (possibly severely handicapped) trapped in a stalled elevator, utilizing outside help; (d) emergency voice communication system; (e) specially marked car bin operating panel which can be used by the blind; and (f) possibly an independent governor and safety device if the safety nut principle used by this manufacturer is not accepted by U.S. code authorities. Further, refuge space for a trapped workman above and below the car may be required in accordance with the provisions of the ANSI (U.S.) Elevator Code, A17.1 and the European Elevator Code CEN EN 81-1. However, even with these modifications, the screw column elevator appears to offer an economical approach to providing safe vertical transportation for the patrons in transit stations and should be highly competitive for installations having extremely tight space conditions.

It is the recommendation of this assessment team that, based on the data presented herein and on the observations made from on-site inspection, a demonstration of screw column elevators at an existing transit station should be considered. A demonstration will permit data to be collected that will identify how these elevators will perform in a transit environment.

APPENDIX A

CHARACTERISTICS AND OPERATION OF EQUIPMENT TYPES



NOTES:

1. Select 1500 2000 or 2500 lbs. capacity if movement of handicapped persons is the only concern. 1500 lbs. capacity will accommodate standard wheelchair with no turn-around. 2000 lbs. capacity will accommodate standard wheelchair with turn-around. 2500 lbs. capacity will permit turn-around or ambulance type stretcher, if single panei door utilized.

2. 1500 lbs. capacity rated at 10 passengers.
   2000 lbs. capacity rated at 13 passengers.
   2500 lbs. capacity rated at 16 passengers.

3. For general passenger movement select larger capacity elevator. For higher rises (greater T distances), select higher speed.

4. Structural support for hoisting machine, passenger car and counterweight must be provided at X-X locations.

*5. As an Alternate Arrangement, machine room can be located adjacent to the hoistway at the lower landing. Elevator car can be overslung with a reduction in space required above top landing served. Elevator car can be underslung with a major reduction in space required above top landing served but a deeper pit will be required. If hoisting machine is located adjacent to hoistway at lower landing, structural anchors will be required to prevent machine uplift. Consult elevator manufacturers for details.

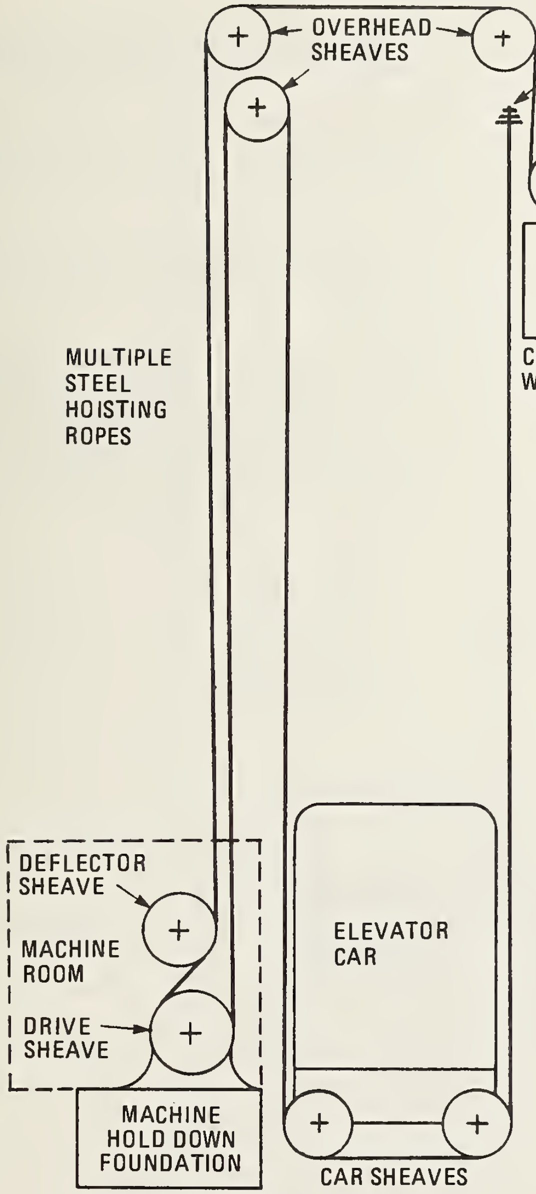
6. Special provisions required if there is occupiable space below elevator.

* See following page for illustration

KMS511-2

FIGURE A-1. CONVENTIONAL ELECTRIC TRACTION PASSENGER ELEVATOR
(One-to-one roping traction machine)

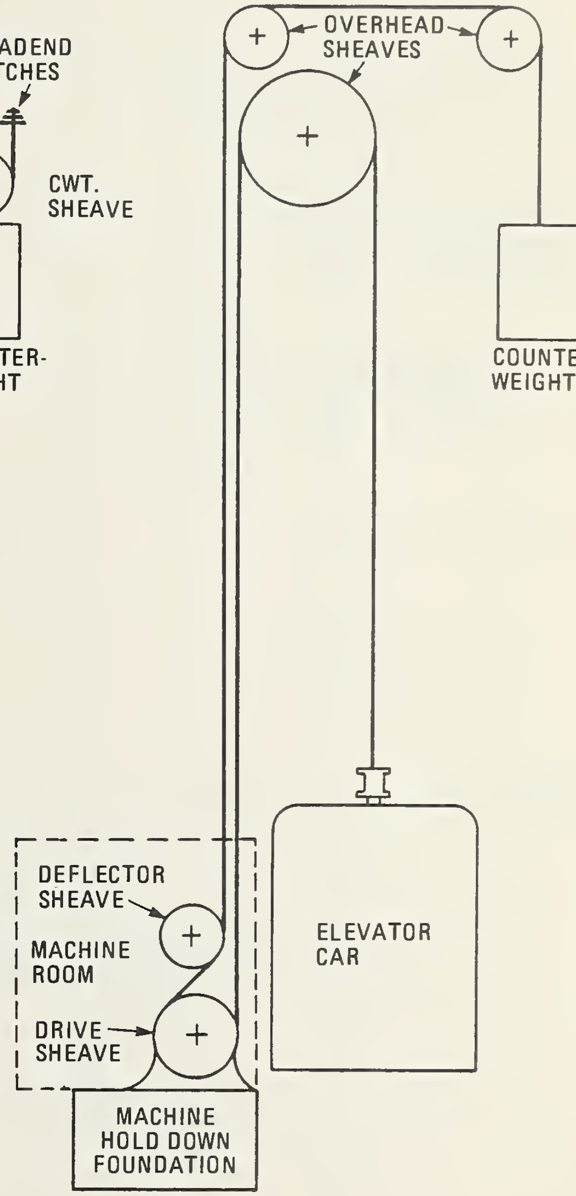
BASEMENT UNDERSLUNG (2:1)
ROPING DIAGRAM



CHARACTERISTICS:

1. Requires much less space above top landing than conventional electric traction elevator.
2. Requires much greater pit depth than conventional electric traction elevator.
3. Requires substantial machine foundation to prevent uplift.

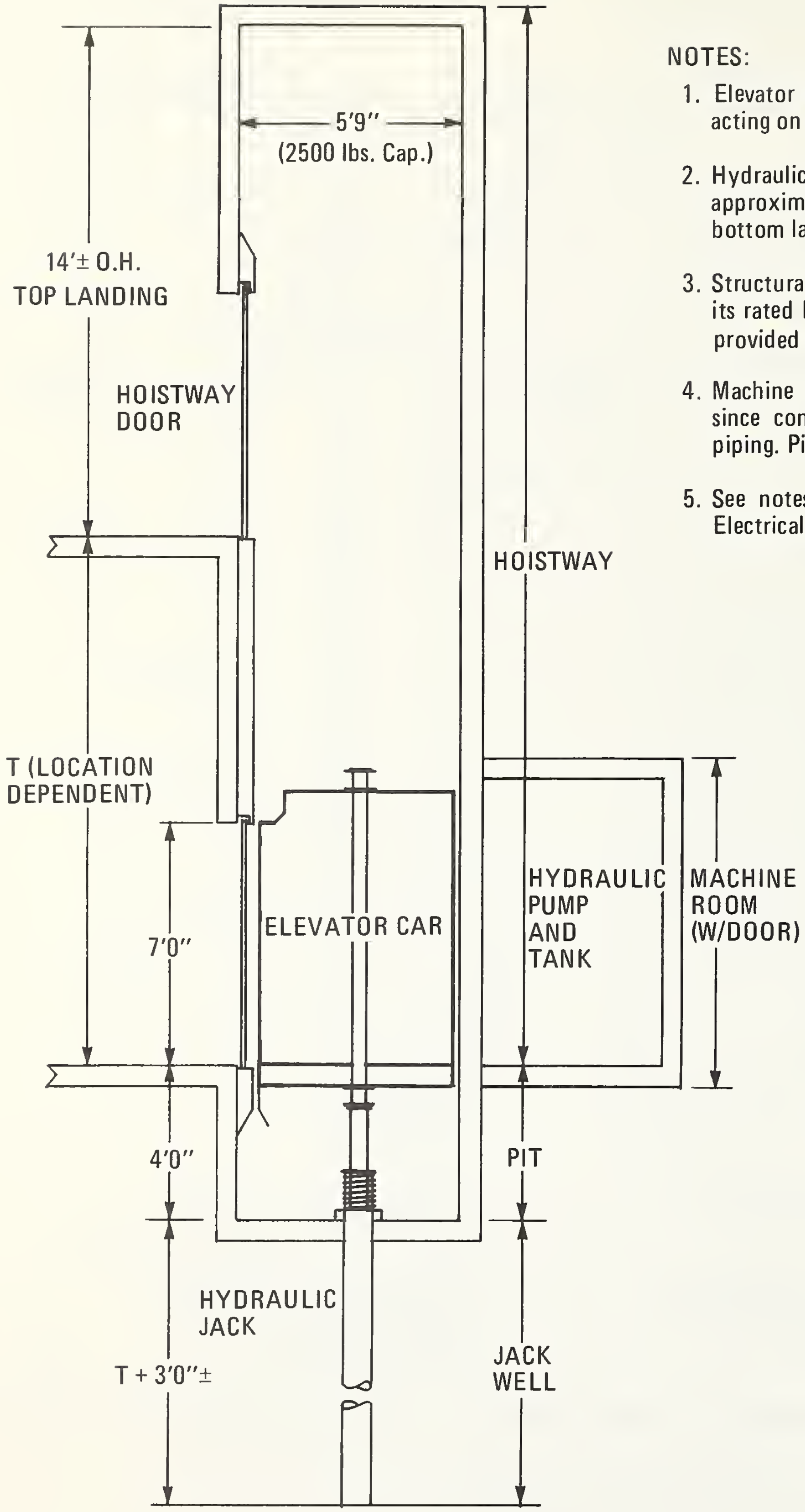
BASEMENT MACHINE (1:1)
ROPING DIAGRAM



1. Requires less space above top landing than conventional electric traction elevator.
2. Requires approx. same pit depth as conventional electric traction elevator.
3. Requires substantial machine foundation to prevent uplift.

KMS511-5

FIGURE A-2. ALTERNATIVE ARRANGEMENTS - ELECTRIC TRACTION ELEVATORS



NOTES:

1. Elevator car is raised and lowered by hydraulic jack acting on channels underneath car platform.

2. Hydraulic jack extends a distance below center of pit approximately equal to the distance between top and bottom landing served by the elevator plus 3 feet.

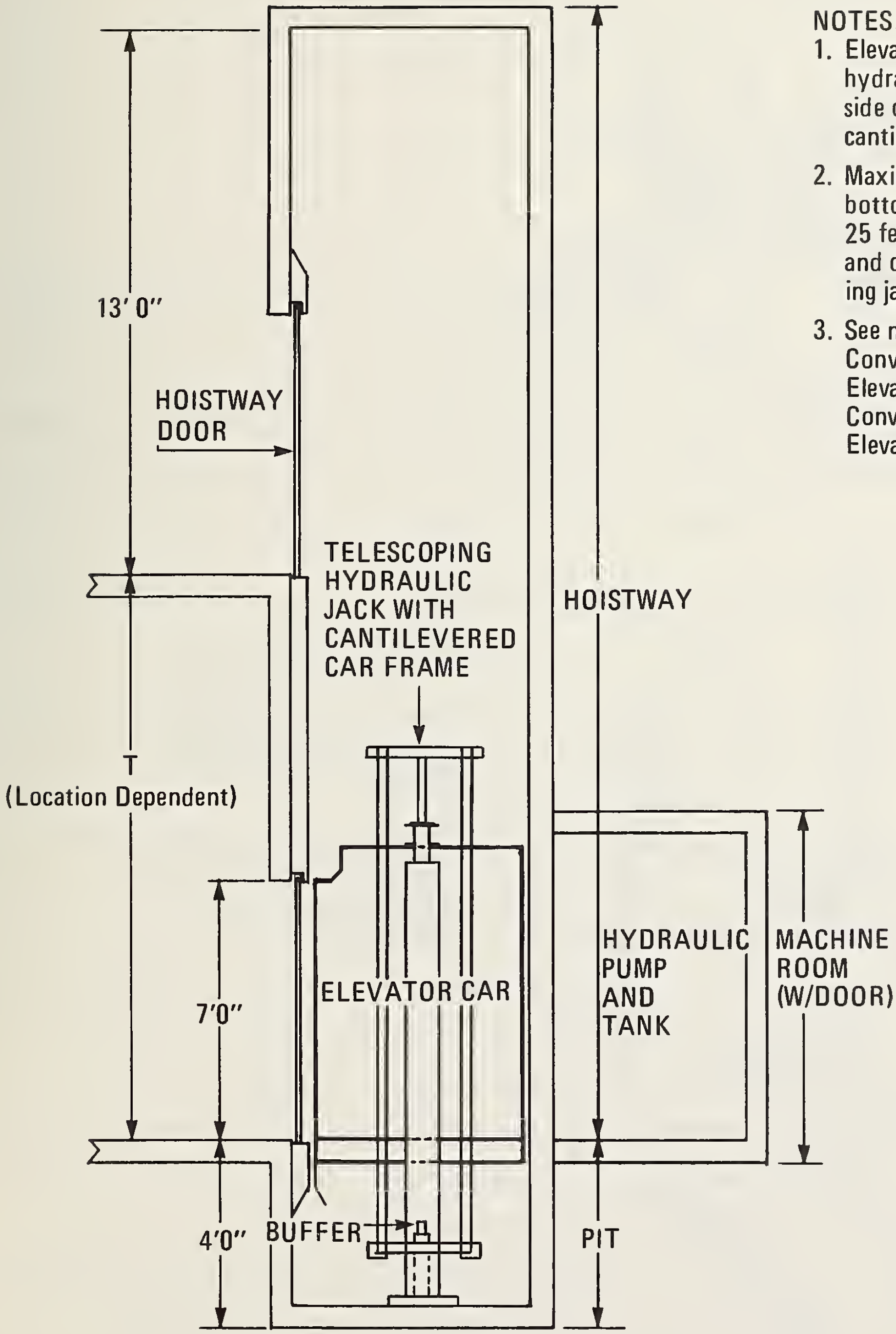
3. Structural support for the weight of the passenger car, its rated load and weight of the hydraulic jack must be provided at pit level.

4. Machine room may be located at alternate location since connection of hydraulic pump and tank is by piping. Piping run should be kept as short as practical.

5. See notes 1, 2, and 3 of sheet titled: Conventional Electrical Passenger Elevator.

KMS511-3

FIGURE A-3. CONVENTIONAL HYDRAULIC PASSENGER ELEVATOR

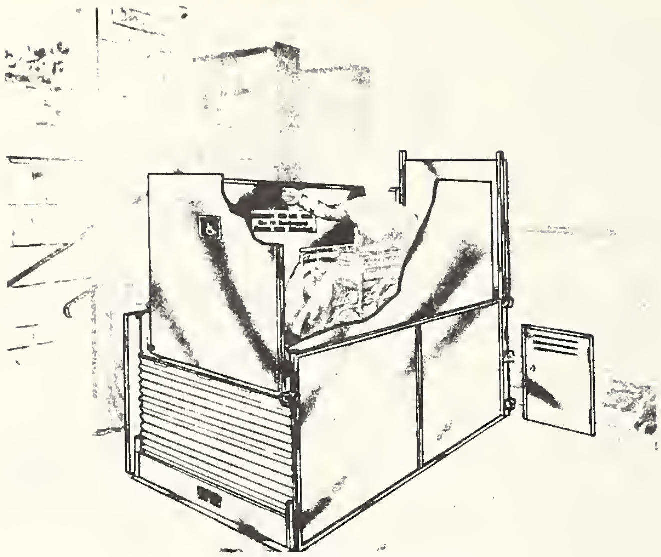


NOTES:

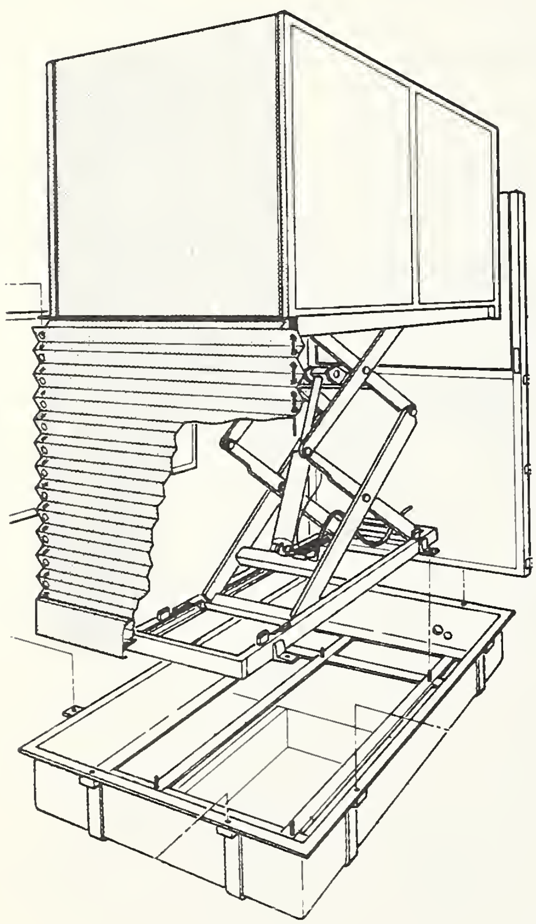
1. Elevator car is raised and lowered by hydraulic jack located within and at side of hoistway acting on top of cantilevered car frame.
2. Maximum distance between top and bottom landings served is approximately 25 feet for telescoping hydraulic jacks and considerably less for non-telescoping jacks.
3. See notes 1, 2 and 3 of sheet titled: Conventional Electric Passenger Elevator and note 4 of sheet titled: Conventional Hydraulic Passenger Elevator

KMS511-4

FIGURE A-4. HOLELESS HYDRAULIC PASSENGER ELEVATOR



TYPICAL INSTALLATION



NOTES:

1. Units are nominally driven by hydraulic-scissors action depicted.
2. General design is for handicapped use specifically although if deemed useful could be used by mobility impaired.
3. Structural support is not demanding due to the low weight of the unit. Pit preparation are required for safety purposes.

KMS511-7

FIGURE A-5. VERTICAL WHEELCHAIR PLATFORM LIFT

APPENDIX B

LIAISON BOARD FOR STUDY OF LOW-COST VERTICAL ELEVATORS

MEMBERS

George Wood	Foster Miller Assoc., Waltham, MA
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Dennis Cannon	Architectural and Transportation Barriers Compliance Board, Washington, DC
Charles Krouse	Professional Staff-House of Representatives Committee on Public Works and Transportation, Washington DC
M. Ray Whitley	Consulting Engineer and Chairman of ANSI Ad Hoc Committee on Screw Machine Elevators Longwood FL

APPENDIX B

LIAISON BOARD FOR STUDY OF LOW-COST VERTICAL ELEVATORS (Continued)

EX OFFICIO MEMBERS

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Theodore Gordon	Senior Engineer, American Public Transit Association, Washington, DC
Joseph S. Koziol, Jr.	Project Engineer, Transportation Systems Center, Cambridge, MA

APPENDIX C

TABLE C-1. ELEVATOR INSTALLATIONS INSPECTED IN BELGIUM

LOCATION	DESCRIPTION	COMMENTS
1. CITIBANK 249 Avenue de Tervueven Brussels	Elevator added to relatively new, modern office building to serve from first floor banking office to vaults at lower level. Capacity: 4 pass. or 300 kg. Car size: 1 meter x 1 meter. Travel: 6 meters. Capacity: 3 persons 225 kg. Car size: 0.9 meter x 0.9 meter. Travel: 6 meters.	Installed 4 years ago. There have been no service interruptions. Mr. Willems of Citibank is well satisfied with elevator. Drive unit is somewhat noisy.
2. EEC BUILDING Avenue de Joyeuse Entree Brussels	Unit being installed to connect two adjacent buildings, one old and one new, both of which will be occupied by EEC. Floor levels different in buildings; double entrance car.	Elevator equipment on site, but not yet installed. Hoistway construction underway. Building construction to accommodate elevator appeared to be relatively simple.
3. ARCHITECT'S OFFICE	3-stop elevator, having front and side entrances. New hoistway constructed alongside an existing older multistory residence. Exposed to outside temperature fluctuations.	Elevator permits direct entry to architect's office located on upper floor of this multistory residence. Older drive unit without sound isolation. Unit is somewhat noisy. Light usage.
4. TOWN HOUSE 54 Avenue Jeanne, Brussels	4-stop unit being installed in in an existing older townhouse as a part of complete renovation. Travel: 11 meters.	Unit not yet in service. Observed installation work which appears to be relatively simple. Unit was retrofitted to a standard double-thick brick wall.

APPENDIX C

TABLE C-1. ELEVATOR INSTALLATIONS INSPECTED IN BELGIUM (Continued)

LOCATION	DESCRIPTION	COMMENTS
5. ST. JOHN HOSPITAL 114 Rue du Marias, Brussels	Hospital car sized for a wheeled stretcher. Connects existing building with an extension building having different floor levels. Capacity: 8 persons or 650 kg. Car size: 1.2 meters x 2.4 meters. Travel: 1.5 meters.	Special purpose elevator, not required to meet passenger loading requirements. Front and rear entrances to permit through passage. Light usage.
6. WAREHOUSE, NOPRI Supermarket; Florennes Belgium	3 stop unit. Car size: 1 meter x 1.5 meters deep. Capacity: 6 persons or 500 kg. Travel: 5.73 meters.	Used primarily to transport stock loaded on wheeled carts. Very heavy usage. Unit retro-fitted to existing warehouse.
7. NURSING HOME Brussels	5 stop unit: Car size: 1 meter x 1 meter. Capacity: 4 persons or 300 kg. Travel: 11.4 meters.	Installation is 1 1/2 years old. Accommodate special scaled down wheelchair. Very heavy usage by elderly occupants of residence.

APPENDIX D

INDIVIDUALS INTERVIEWED

1. Jose-Philippe Lefebvre
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   Belgium

2. Jean-Marie Gilles de Pelichy
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   Ebel s.p.r.l.
   Parc Industriel
   B-1430 Braine-le-Chateau
   Belgium

3. Robert Detilloux
   Principal Inspector
   Association des Industriels de Belgique (AIB)
   Avenue Andre Drouart 27-29
   B-1160 Brussels, Belgium

4. Albert L. Gerard
   Senior Vice President
   Ferro Corporation
   One Erieview Plaza
   Cleveland, Ohio 44114
   (Chairman of Eurolift, US manufacturer)

APPENDIX E

REPORT OF NEW TECHNOLOGY

This report presents a comparison of elevator types, rationale for selection of the screw column elevator as an appropriate low-cost elevator for transit use, and a detailed description and assessment of the screw column elevator. There is sufficient technical information to allow the owners and operators of transportation properties to assess the appropriateness of this elevator for their system's needs and requirements. Complete details have been presented which fully describe the elevator mechanics, maintenance history, code and standards covering the elevator, and costs.

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