STUDY FOR PARKING GARAGE

ON

M I T PROPERTY

BY

BJORN SANDSTO

CANDIDATE FOR THE DEGREE OF

BACHELOR OF SCIENCE

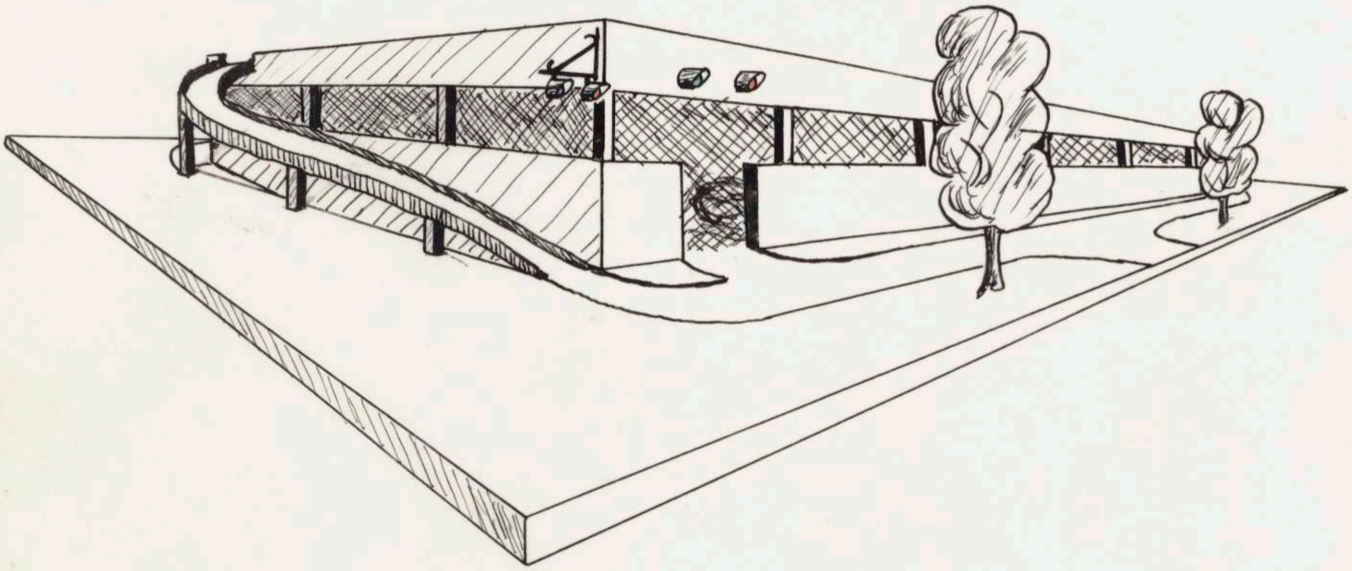
JUNE 1951

Signed Signature redacted
Author

Certified by Signature redacted
Thesis Supervisor

Approved by Signature redacted
Head of Department

MIT



PARKING GARAGE

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31 Queensberry Street
Boston 15, Massachusetts
May 18, 1951

Professor J.S. Newell
Secretary of The Faculty
Mass. Institute of Technology
Cambridge, Massachusetts

Dear Professor Newell:

It has been the object of this thesis to investigate the demand for a parking garage on M.I.T. property and if such a demand existed, to construct the functional design for such a garage.

I am greatly indebted to Prof. A.J. Bone for suggesting the project and for the valuable assistance he rendered.

In partial fulfillment of the requirements for the Bachelor of Science Degree, I submit the following thesis.

Respectfully yours,

Signature redacted

Bjorn Sandsto

SUMMARY

This thesis had as its object to find the demand at present and in the future for parking spaces at the Massachusetts Institute of Technology.

A study was also made to find a design of a garage that would fit the institute's particular need.

It was found that there would be a demand for about 300 additional parking spaces over the 1819 presently available by the end of 1952, and that there would be an additional demand of 400 spaces by the end of 1962.

It was therefore recommended that a three-deck open wall garage with a capacity of 300 cars be constructed by the end of 1952 on a strip of land west of Mass. Avenue between the graduate house and the Rockwell Cage parking lot. It was also recommended that a second similar garage should be built around 1961, and it was suggested that this garage be erected on a site available near the south east corner of Vassar St. and Main St.

It was recommended that the garages be completely automatically controlled, and that no attendants be engaged except a police officer on regular duty.

It was felt that the parking fee should be ten cents per day, since this would result in a yearly revenue of about $7500.00, which would return 7.5% of the institute's investment of approximately $100,000.00, per garage.

In conclusion it should be said that it is the responsibility of the institute to maintain adequate parking facilities for its students, staff and employees.

Introduction

Once upon a time the parking problem at M.I.T. was no problem at all. One could come at almost any time and always find a parking space; but after the war with increased building programs and increased production, more people with automobiles entered the institute as new buildings grew up on the sites of the institute's parking facilities.

Pretty soon the parking situation became acute and it was felt that something would have to be done about it.

Previous Work

Not much previous work had been done in the field of institute parking, so in 1947 two students (Geraldine Mar and Donald Rehkopf) decided to conduct a survey of parking facilities at M.I.T. which they compiled into a thesis on January 1948. They came to the conclusion that much could be done about the existing parking facilities (1947) in order to increase their capacity, but their ultimate conclusion was that the demand for parking spaces at M.I.T. would soon exhaust the supply, and need for more parking space would be eminent.

Purpose

The purpose, then, of this thesis is to determine

1. How great will demand for parking space be in the near future?

2. How can we provide enough parking spaces to satisfy these demands?

Sources of Information

The sources of information in regard to demand were a comparison between the survey based on actual counts, the total amount of parking stickers issued and the exact number of parking spaces available (May 1951) as compiled by the office of Buildings and Power at M.I.T.

In regard to the functional design of parking lots and garages, no literature is available on the problem as applied to universities and colleges, but a great variety of information is available on commercial parking, solution of problems and design of lots and garages. Therefore in deciding on the functional design, information and ideas from many of the latest publications and papers on mass parking have been incorporated into this design in order to make it fit the particular conditions at M.I.T.

Discussion of Demand

The best sources of information in regard to the demand for parking spaces at the institute was the survey conducted in the fall of 1947 as a thesis project by Geraldine Mar and Donald Rehkopf of the parking facilities at M.I.T. The next best source was the number of parking spaces available and the number of parking stickers issued (1951) as compiled by the office of Buildings and Power at M.I.T.

The survey by Mar and Rehkopf was based on actual counts of cars parked around the institute; plus the taking of polls from the students, staff and employees of Bldg. I. They found that there was a possible demand for 2247 car spaces. They called this number a "possible demand" because it represented an actual count of cars parked at the institute (1947).

A generous reduction of 20% was allowed for persons who might have classes on only certain days of the week, producing a net demand of 1798 car spaces. The 20% reduction from possible demand or gross demand, to net demand was supported by findings of the poll of staff and employees of Bldg. I. There the number of cars to be expected in any one day was reduced below the number of cars used for transportation to school by 20%. Many of the faculty came on only one of the patterns of class days.

However, since the staff and employees are, roughly, only one half of the total number of persons seeking parking space, the more regular attendance of the students would make the 20% assumed above, if anything, too high a reduction.

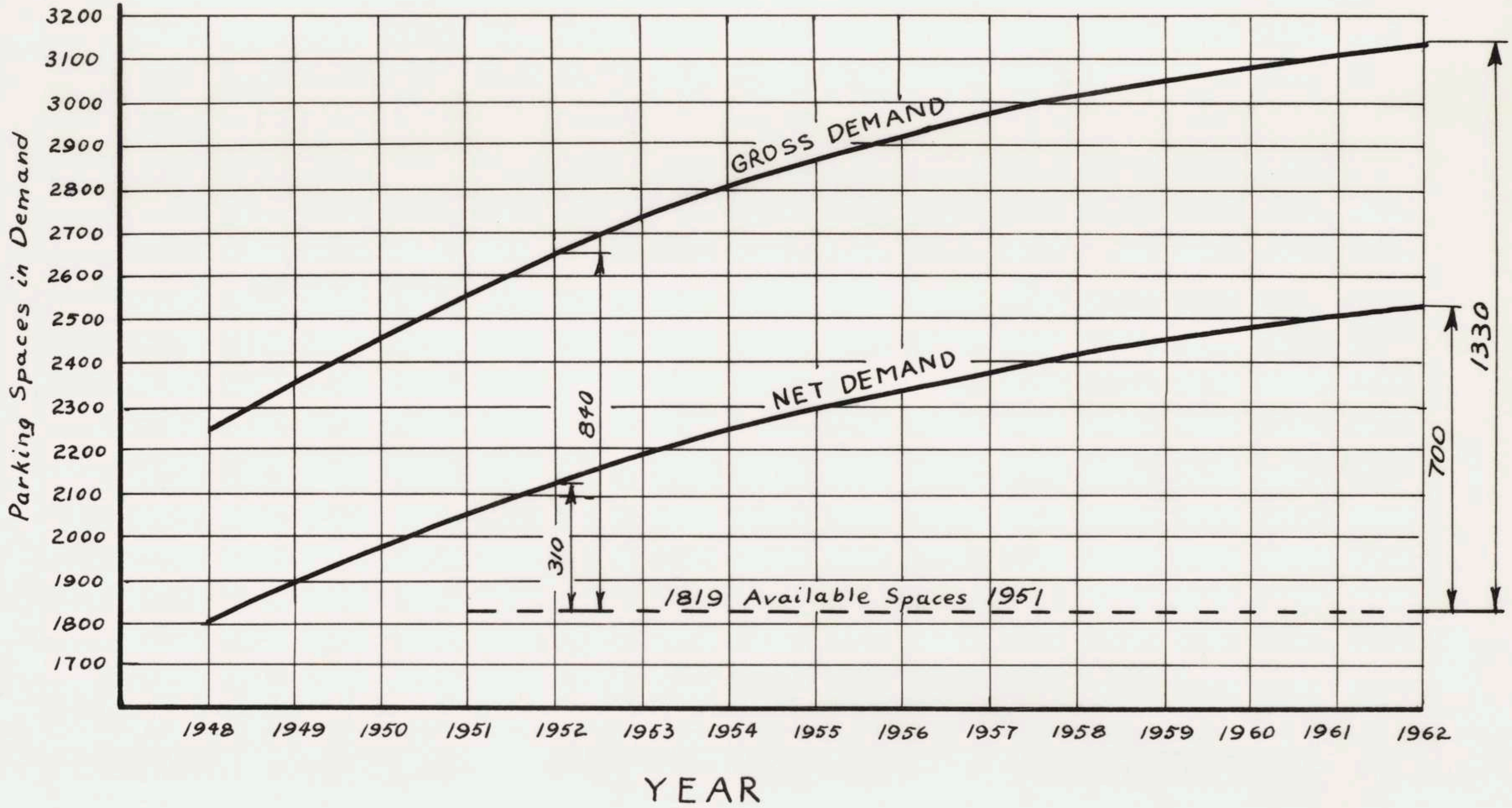
By conservative interpretation of passenger vehicle registration trends, as applied to finding the change of demand for parking space to be expected at M.I.T., Mar and Rehkopf found that the future demand for car spaces may be expected to reach the following values:

Year	Gross Demand	Net Demand
By 1953	2751	2200
By 1958	3026	2421

These figures, together with the gross and net demand for 1948, were incorporated into the graph shown on page 8 and compared with the graph representing the number of spaces available in the spring of 1951. The number of spaces available at present and stickers issued in 1951 are 1819 and 3005 respectively.

From the data obtained in the survey by Mar and Rehkopf this graph was brought forward to 1962 and using the year of 1952 as a base year for investigating the demand for parking space, the net or gross demand can be arrived at any time between 1948 and 1962.

As one can see from the graph, in 1952, assuming 1819 available parking spaces, the gross and net demands over 1819 are 840 and 310 car spaces respectively and in 1962 these figures would be 1330 and 700 respectively over 1819 available spaces.



MIT PARKING GARAGE
FUTURE DEMAND

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Being consistent with the Mar and Rehkopf survey, the net demand is the "design demand." Consequently, a garage or parking lot of 300 cars capacity would take care of the demand up through 1952, provided that the present number of parking apaces be kept constant. Along the same line, the net demand in 1962 would be 700 spaces over the present number of available parking spaces, or a growth of 700 in ten years.

One can therefore recommend on the basis of these findings that 300 parking spaces be constructed by the end of 1952 and an additional 400 spaces be provided by 1962.

If any of the present parking spaces are disturbed by expanded building programs, the necessary adjustments must of course be made, such that the total net demand of 2120 spaces be satisfied by 1952 and the total net demand of 2520 spaces be satisfied by the end of 1962.

Lot Vs. Garage

It has been concluded that by the end of 1952 the institute will be in need of approximately 300 additional parking spaces. Whether a parking lot or a multi-story parking garage should provide for these 300 spaces is a matter of economy and convenience.

Since the institute is steadily expanding its land use, the land becomes more and more valuable, and at a certain point it becomes cheaper to build a multi-story garage than to take land for a parking lot of the same capacity. It seems that this point has been reached, and that building a multi-story garage would be justified. There is of course some land on the institute proper that could be used for parking lots which has a relatively low value, but this would be so far away from the center of the institute that not many would use it because of the great inconvenience. Extensive studies have shown that few people would park more than 1200 ft. away from their destination.

A parking lot would of course be cheaper to maintain and no attendants, except for those policing, would have to be present.

But if a garage with customer parking and with an automatic control system could be devised, it would, it is felt, be economically advisable for an institution such as M.I.T.

Since no attendants, except for those policing, are necessary; the yearly cost of such a garage would be the cost of interests, depreciation costs, operation costs and maintenance costs. It is, therefore, recommended that a 300 car customer parking garage be built on the most convenient location as close to the end of 1952 as possible. Any additional parking spaces should be incorporated into similar structures as the demand increases.

Location

Since it has been decided to build a 300 car garage, the question comes up about where to locate it.

The Mar and Rehkopf survey found that the demand for parking spaces was strongest on the parking areas located on both sites along Mass. Avenue, the next on the parking lot east of Bldg. 8.

Therefore, there are at once two possible sites for the garage that will come in the foreground:
1st - one area available between the Rockwell Cage parking lot and the parking lot behind the graduate house; 2nd - an unused strip of land near the east parking zone on the south corner of Vassar St. and Main St. These two areas are marked on the map of the institute shown on page 12.

It will be seen that the west and the east lot will be the center of circles with a 1200 ft. radius, which is the maximum distance a customer will park away from his destination. The periphery of these circles will pass through the vicinity of Bldg. 8 and 10 respectively as shown on the map.

It was felt that these two lots could be used for a parking garage without unnecessary destroying of recreational facilities or scarce grass land.

Since the demand is stronger along Mass. Avenue, it is suggested that this lot will be taken for the first garage, and that the east lot be taken into consideration when the second be built.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

DEPARTMENT	BLDG. NO.
ACOUSTICS	20
ADMINISTRATION	3, 4, 7, 10, 1
AERONAUTICAL ENGINEERING	17, 23, 33, 80
ARCHITECTURE & CITY PLANNING	5, 7
BIOLOGY	3, 10
BUILDING ENGINEERING & CONSTR.	5, 7
BUSINESS & ENGIN. ADMINISTRATION	14
CHEMISTRY	2, 4, 6
CHEMICAL ENGINEERING	4, 12, 38
CIVIL & SANITARY ENGINEERING	1, 21, 48
GRAPHICS	24
ECONOMICS	14
ELECTRICAL ENGINEERING	4, 7, 10, 20, 32
ENGLISH	14
FOOD TECHNOLOGY	20
GEOLOGY	24
LIBRARY	5, 6, 8, 10, 14
MATHEMATICS	2
MECHANICAL ENGINEERING	1, 3, 5, 7, 31, 35
MEDICAL & INFIRMARY	11
METEOROLOGY	24
METALLURGY	4, 8, 35
MILITARY SCIENCE	20, 24
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NAVAL ARCHITECTURE	5
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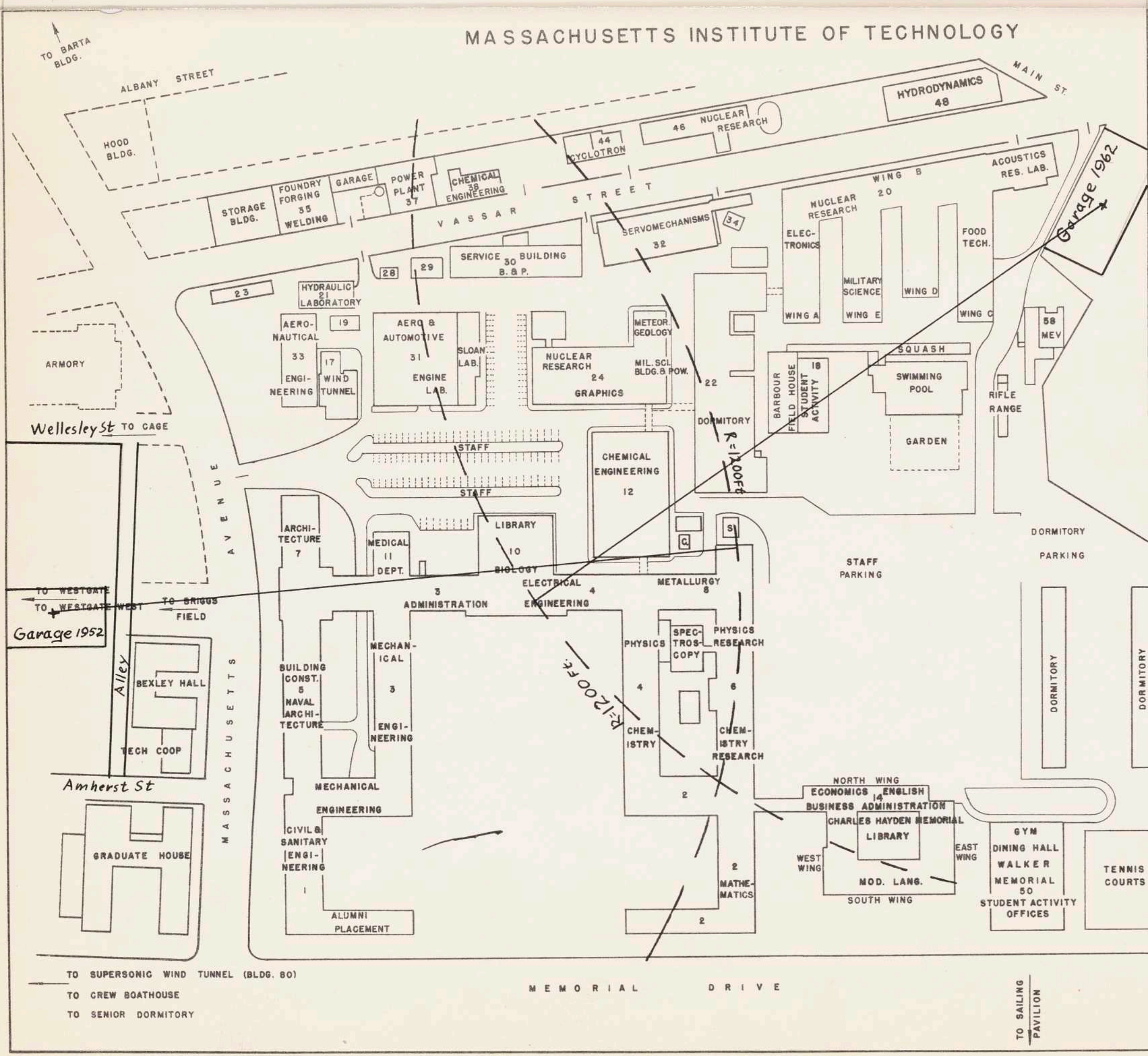

It is the object of this thesis to do the functional design of the first garage only, and let the design for the second garage be done when that time arrives. It can only be mentioned in passing that the two lots are approximately the same size, so the design adopted to one lot could, with some modifications, easily be adopted to the other.

TRAFFIC DESIGN

Factors Effecting The Success of A Parking Garage

The success of a parking garage depends on the way the incoming and outgoing traffic is handled. If a car can be driven into a garage and parked in a reasonable short time, as well as be unparked and driven out in a short time, the garage will be a success. Of course in a garage where attendants locate the empty stalls and park and unpark the cars, the time cycle can be kept at a minimum because of the attendants' familiarity with the garage, but the cost will be higher. On the other hand, when the customer parks his car, and there are no attendants, the cost of the garage will be kept at a minimum, the customer has the satisfaction of handling his own car, and even if the process of parking takes a little longer, the customer feels that the time is not lost as it would be when he has to wait for the attendant to take care of his car.

In opposition to an attendant parking garage where precision parking is necessary in order to get the most efficient use of the space, the customer parking garage must be easy to park in, and it must also be easy to locate empty stalls. This means that "Drive-In" angle parking must be used in opposition to "Back-Up" parking, since many women drivers have great troubles backing into an empty stall.

To ease the location of an empty stall, the driver will have to be led through all the aisles, which should be laid out in the pattern of a maize so that an empty stall may be found wherever it is. The stalls, of course, will have to be properly and rigidly marked so that they may readily be discovered when empty.

In order to design the width of the stall and aisle, the lengths and widths of 1947 model cars were compared and compiled into the chart on page 15. The extreme turning movements for the same cars were investigated and compiled into the chart on page 16.

From this data it was possible to arrive at design vehicle with the following dimensions and turning radia:

Width	78" or 6'-6"
Length	216" or 18'-0"
Minimum turning radius of extreme outside point	26'
Minimum turning radius of rear wheel	16'

After the investigation of the movements of this design vehicle, it was found that the following stall dimensions would be most efficient:

OVER-ALL LENGTHS AND WIDTHS OF STANDARD 1947 MODEL AUTOMOBILES

LENGTHS	WIDTHS 5'9"-6'0"	6'0"-6'3"	6'3"-6'6"	6'6"-6'9"	6'9"-7'0"	No. of Models This Length	No. of Models This Length or Less
16'0"-16'3"	Studeb. Champion					1	1
16'3"-16'6"		Plymouth Ford Chevrolet				3	4
16'6"-16'9"		Nash 600				1	5
16'9"-17'0"	Studebaker Comm.	Kaiser Frazer Mercury	Oldsmobile 66			5	10
17'0"-17'3"			Dodge Pontiac 25-27			2	12
17'3"-17'6"		Nash Ambassad.	DeSoto Buick 40 Chrysler C-38 Packard 2000-1 10-11	DESIGN VEHICLE		5	17
17'6"-17'9"			Pontiac 26-28 Oldsmobile 76-78	Buick 50		3	20
17'9"-18'0"			Chrysler C-39 Packard 2003-6	Cadillac 61 Oldsm. 98		4	24
	DESIGN VEHICLE						
18'0"-18'3"			Lincoln	Buick 70		2	26
18'3"-18'6"				Cadill.62		1	27
18'6"-18'9"				Cadill.60s		1	28
18'9"-19'0"					Cadill.75	1	29
19'0"-19'3"							
19'3"-19'6"							
19'6"-19'9"			Chrysler C-40 Packard 2126			2	31
No. Models of This Width	2	8	14	6	1		
No. Models of This Width or Less	2	10	24	30	31		

MIT PARKING GARAGE

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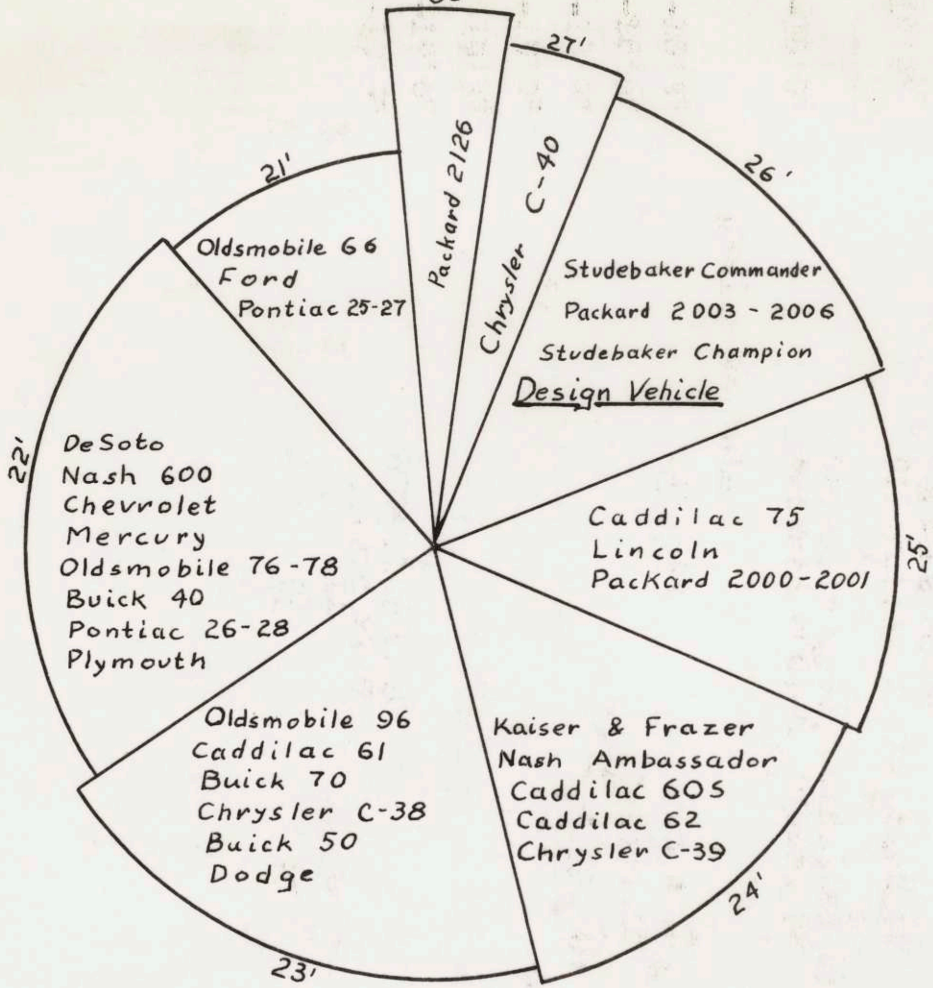
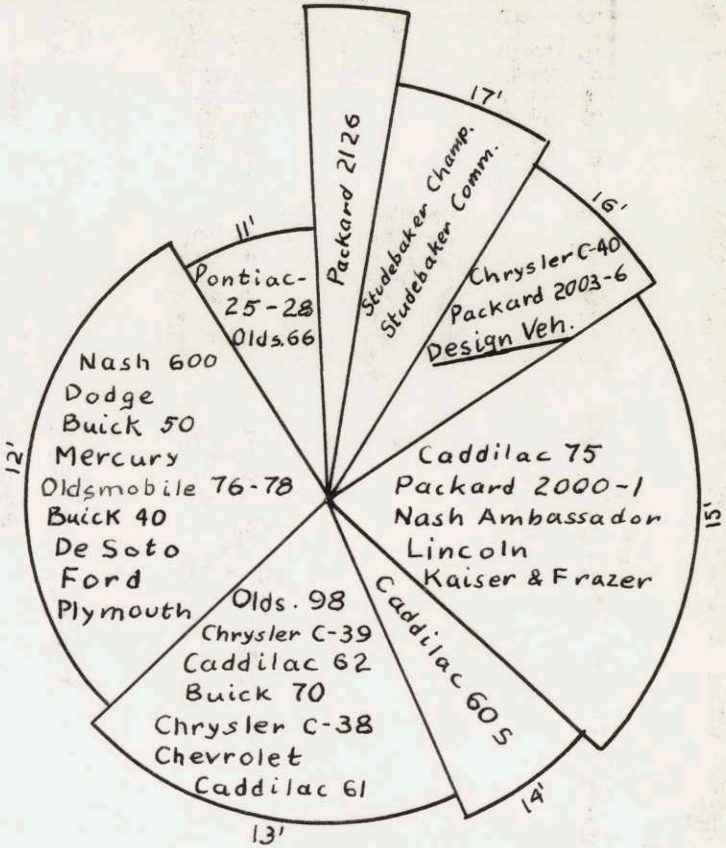


Minimum Turning Radius of Extreme Outside Points; Standard 1947 Model Cars.



Minimum Turning Radius of Inside Rear Wheel; Standard 1947 Model Cars.

MIT PARKING GARAGE

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Angle of Parking	60°
Aisle Width	167" or 14'
Stall Depth	226" or 19'
Stall Width	118" or 9'-10"
Area (stall plus ½ aisle)	253 Sq. Ft.

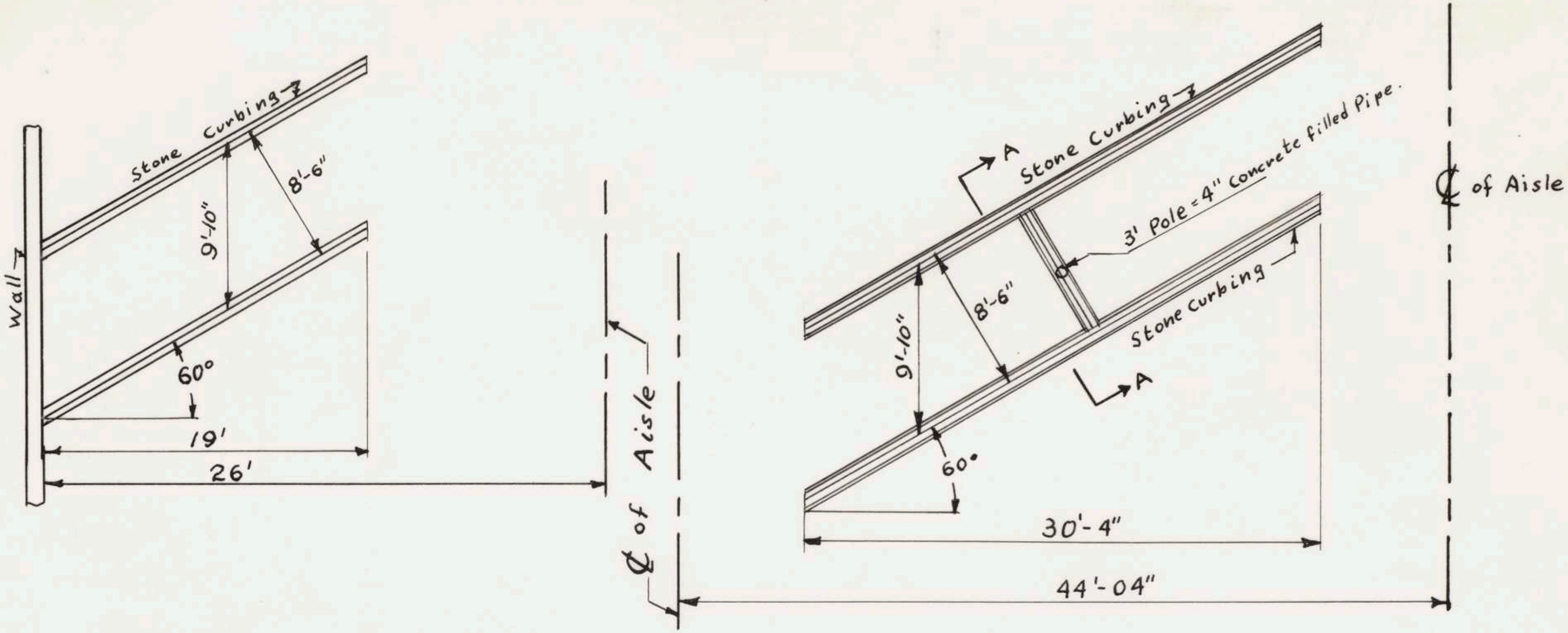
The stalls are illustrated on page 18 where the intermeshing of the angle parking stalls are also shown.

It is suggested that the stalls be marked with stone curbing as shown in section on page 18 so that the empty stalls will be easier to locate. It is also suggested that concrete filled iron pipes be used as bumpers at the bottom of the stalls.

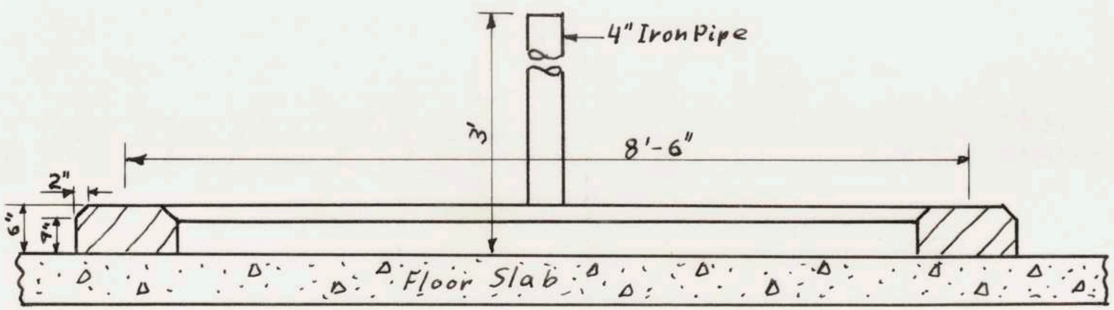
A stall with these dimensions leaves a minimum clearance of 24" between the cars of the same size as the design car, which should give ample room to open doors enough to get in and out of the car.

Entrances and Exits

The layout of the entrances and exits is shown on page 19 and it will be seen that all entrances are on one side of the building and the exits on the other side. Thus, one can enter the garage from either Mass. Avenue or Memorial Drive through Amherst St. and the present parking lot. The parking lot would have to be reorganized, and one such possible reorganization is shown on page 19. The exit road which is suggested to be on the north side of the garage, between the garage and the proposed gymnasium, will be 15 ft. wide and connected to the alley behind Bexley Hall through two 30' curves.



SINGLE STALL Scale 1" = 10' DOUBLE STALL



SECTION A-A
Scale 1" = 24"

MIT PARKING GARAGE

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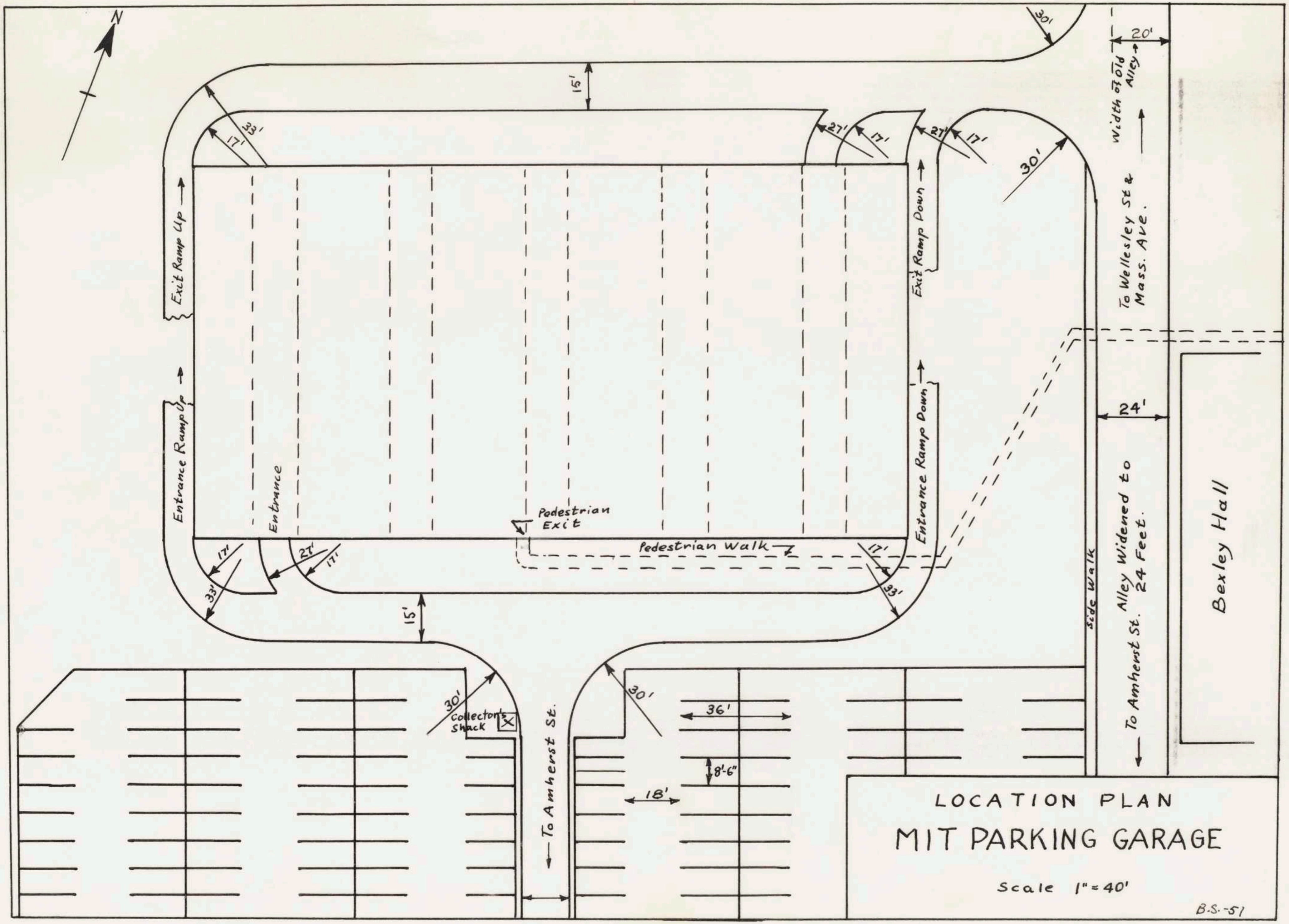
N
Width of Old Alley
20'
30'
15'
33'
17'
27'
17'
27'
17'
30'
Exit Ramp Up
Exit Ramp Down
To Wellesley St & Mass. Ave.
Entrance Ramp Up
Entrance
Pedestrian Exit
Pedestrian Walk
Entrance Ramp Down
24'
Alley Widened to 24 Feet
Bexley Hall
Side Walk
To Amherst St.
17'
27'
17'
33'
17'
33'
15'
30'
Collector's Shack
To Amherst St.
30'
36'
8'-6"
18'
LOCATION PLAN
MIT PARKING GARAGE
Scale 1" = 40'
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This alley which connects Amherst St. with Wellesley St. would have to be widened to 24' in order to take care of movements in both directions.

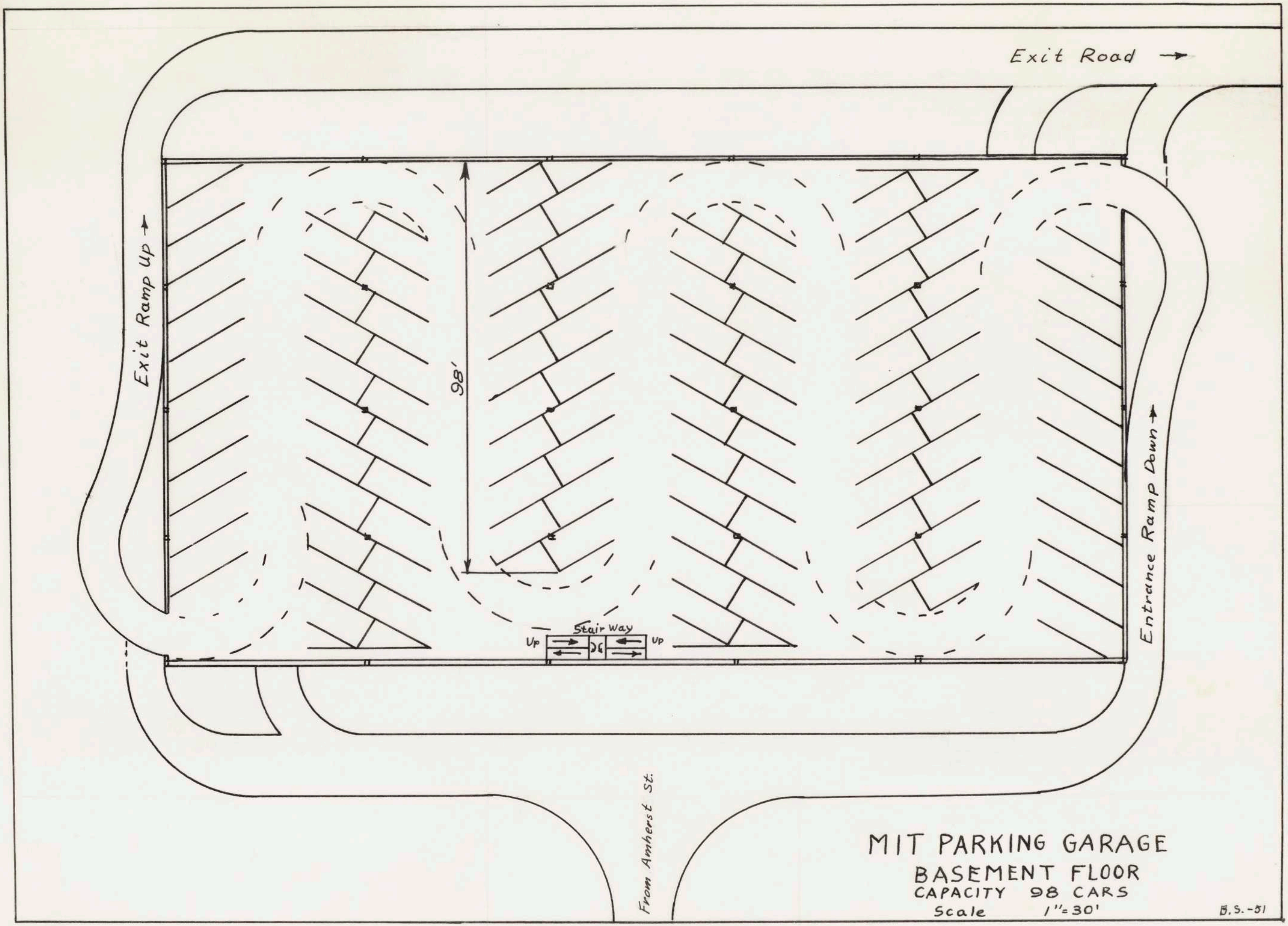
Through this arrangement, the lawn between Bexley Hall and the commercial bldg. need not be disturbed, and no increase to the traffic confusion on Mass. Avenue will be created.

There are separate entrances and exits to each floor, and the layout and the aisles and stalls together with the entrances and exits can best be described by the drawings on pages 21, 22 and 23.

Storage Floors

The garage has three storage floors. First, the basement floor which has a capacity of 98 cars and has the entrance on the right side of the garage and the exit on the left as seen on page 21.

When a car enters through the entrance door, it has to start to look for an empty stall, and by driving through the empty aisles, which in reality is one long aisle, it will finally find the empty stall even if it is the last stall. The total length it will have to drive to get through to the exit is approximately 600 ft, which with the prevailing gasoline prices will cost about $0.002. This amount, together with the cost of the time spent, is not prohibitive as long as one is sure that there exists one empty stall.


Exit Road
Exit Ramp Up
Entrance Ramp Down
98'
Stair Way
Up
Up
From Amherst St.
MIT PARKING GARAGE
BASEMENT FLOOR
CAPACITY 98 CARS
Scale 1"=30'
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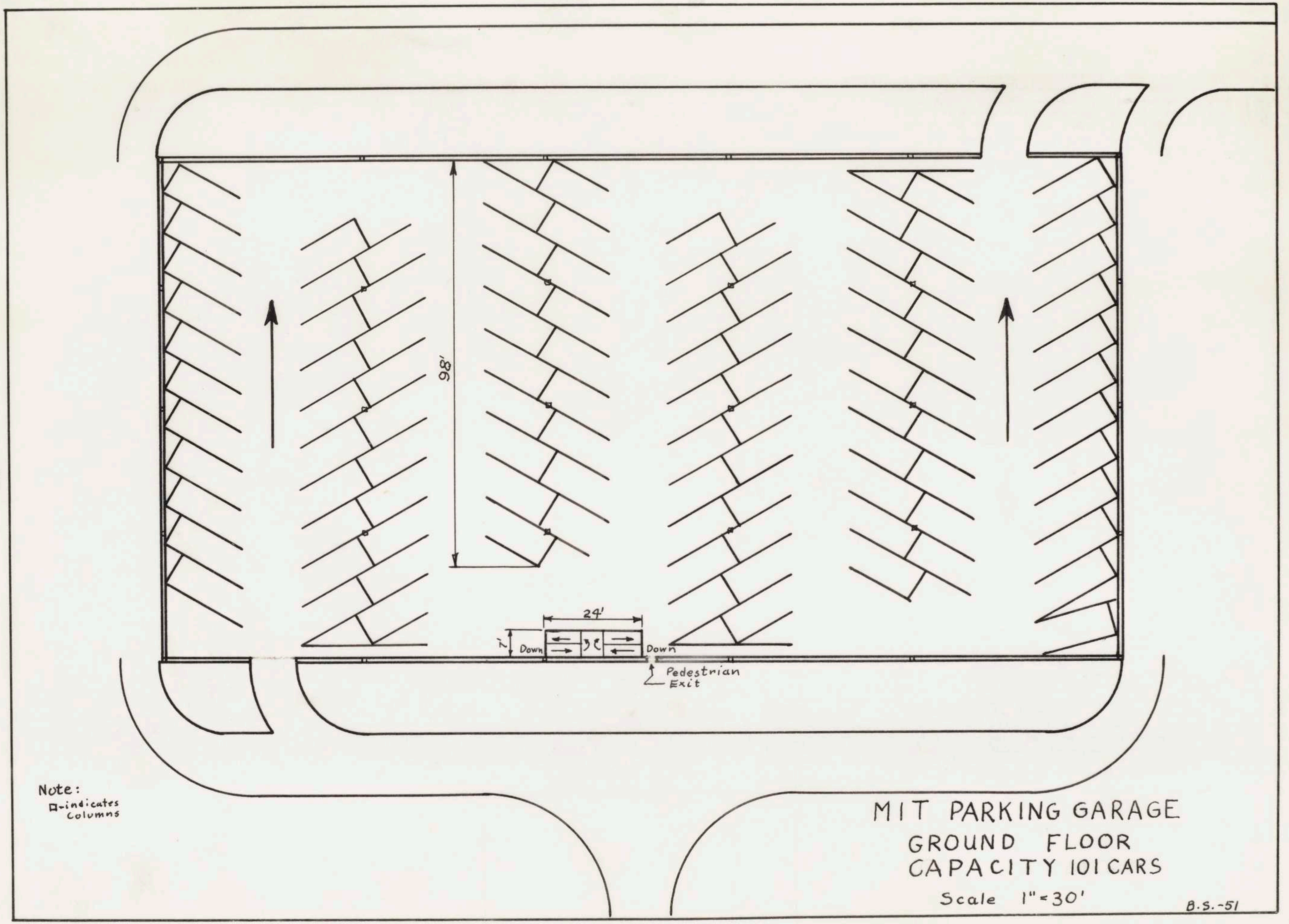
98'
24'
7'
Down
Down
Pedestrian Exit
Note:
□-indicates Columns
MIT PARKING GARAGE
GROUND FLOOR
CAPACITY 101 CARS
Scale 1" = 30'
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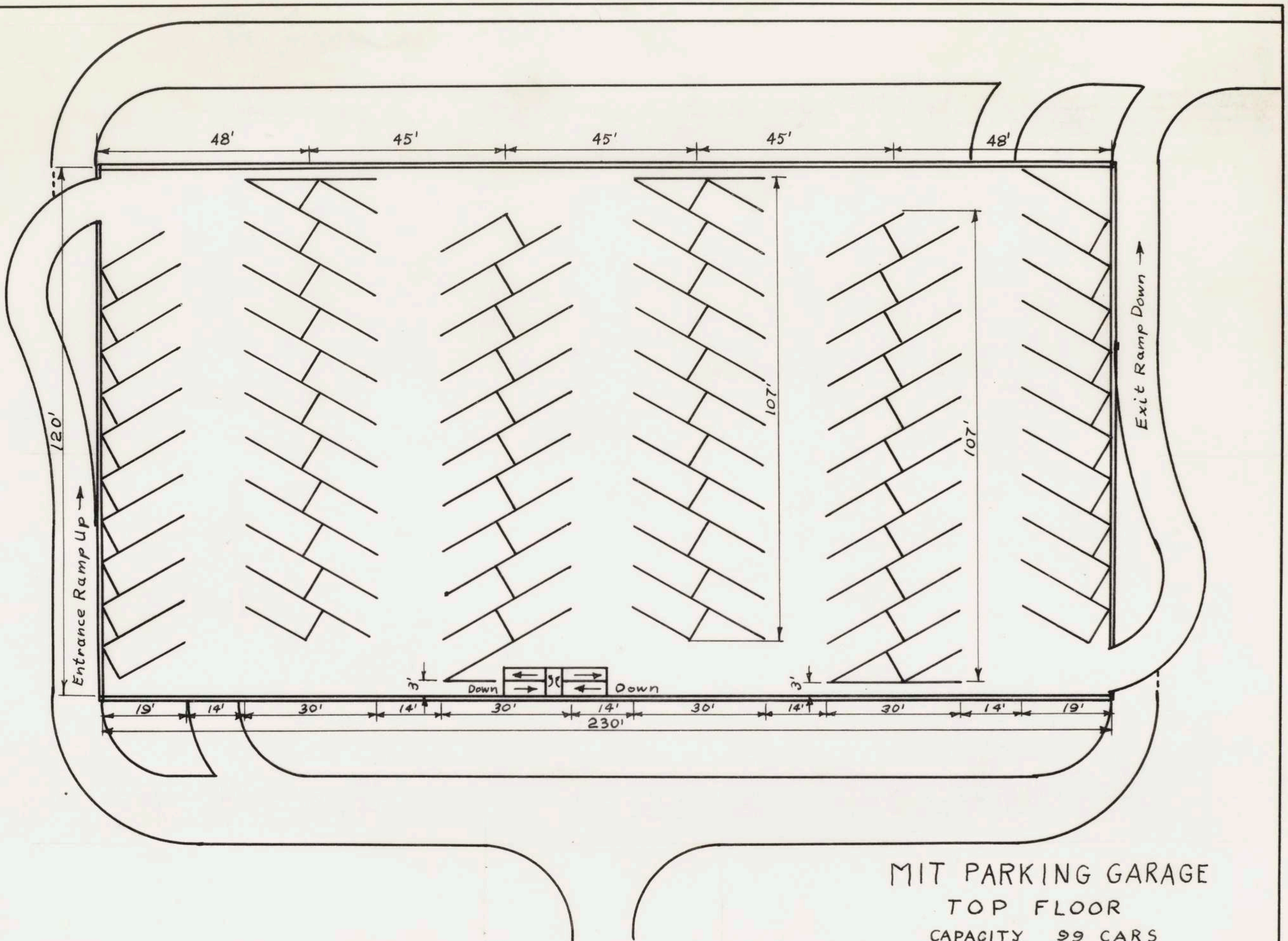

MIT PARKING GARAGE
TOP FLOOR
CAPACITY 99 CARS
Scale 1" = 30'

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How to know if there is one empty stall available, will be discussed later under Control Systems.

Then there is the ground floor, which is level with the ground and has the entrance on the left side of the front of the building and the exit on the right side of the rear of the building. This floor has a capacity of 101 cars and a plan view is shown on page 22.

The top floor is not closed in and has a capacity of 99 cars. The entrance ramp to the top floor passes up along the left side of the garage and the exit ramp is on the right side as evidenced by the drawing on page 23.

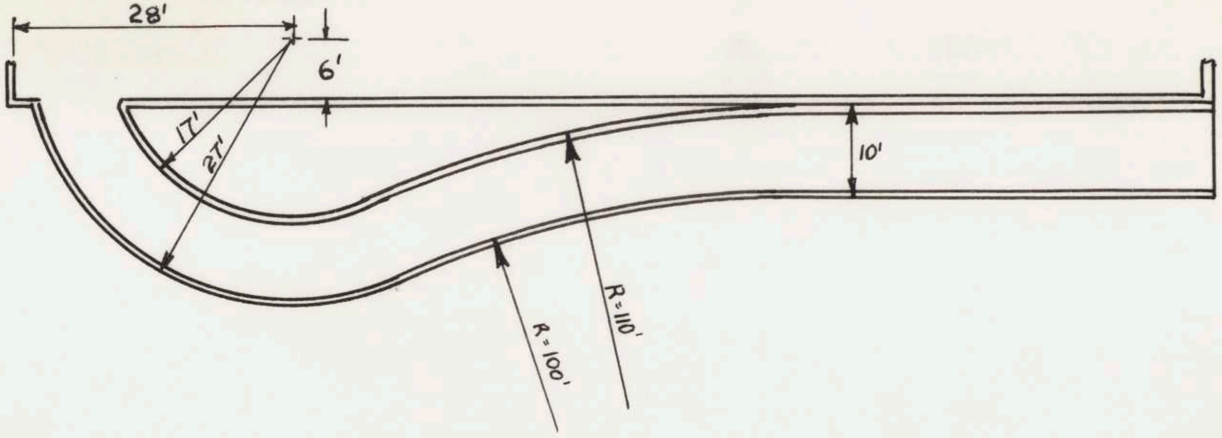
<u>The Ramps</u>

The ramps are attached to the outside of the building in order to preserve space, and it was felt that economy could be gained by this solution. Since the ramps are not enclosed, less material and labor will be needed.

Plan and section of a typical ramp are shown on page 25.

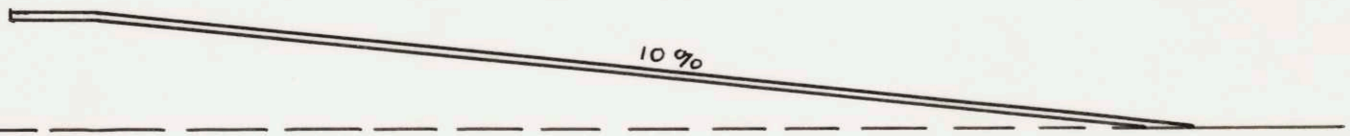
The turning radia were kept at 17 ft. and 27 ft. and 1 ft. larger than the minimum turning radia for the design vehicle in order to provide for slip. The speed on the ramps should not be more than 10 M.P.H.

The transition curve was held at a radius of 100 ft. and the clear width of the ramp is 10 ft.

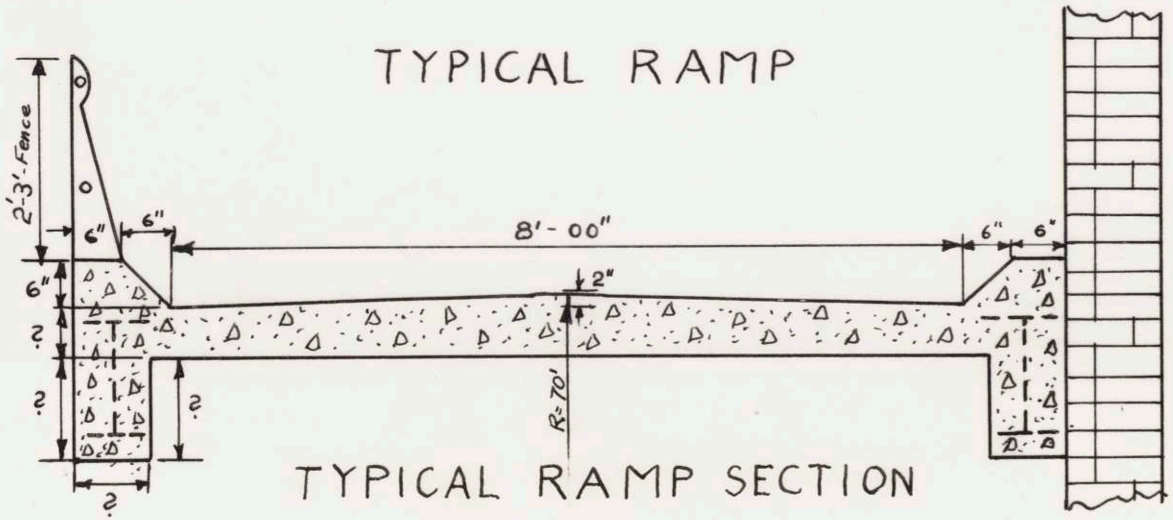


Scale 1" = 20'

Elevation.



TYPICAL RAMP



TYPICAL RAMP SECTION

Scale 1" = 24"

MIT PARKING GARAGE

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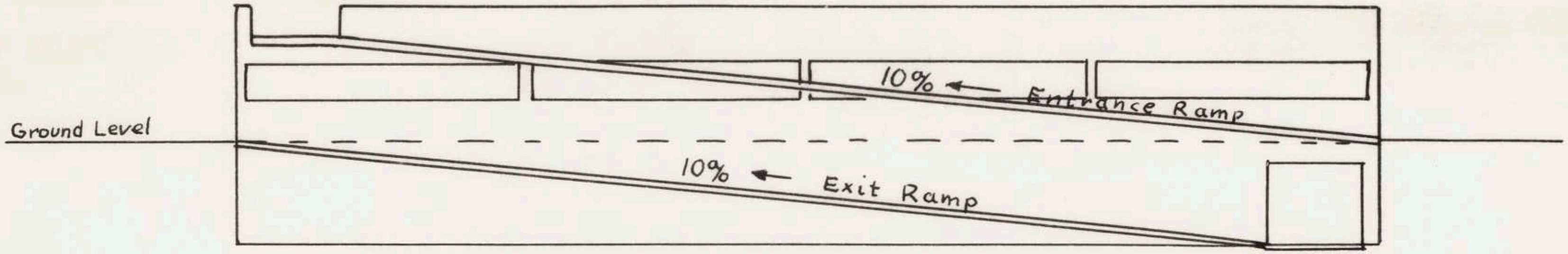
The ramp going up to the top floor and the ramp going down to the basement floor should be alike. The top floor ramp would have to be supported on columns if it could not be cantilevered from the wall, and the basement floor ramp would rest on the ground.

The ramps are shown in elevation on page 27, and one will see that the slope of the ramps need not be greater than 10%, even though the maximum permissable slope for garage ramps is 15%.

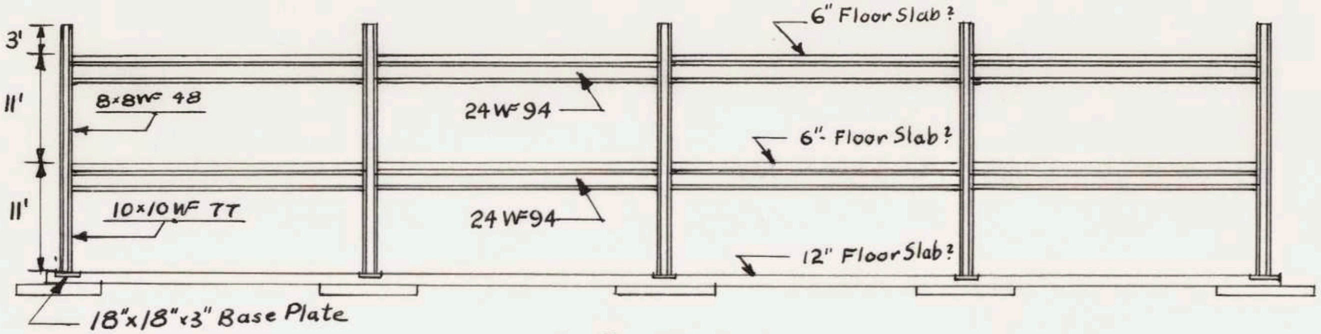
Column and Beam Arrangement

An attempt was made to arrange the beams, girders and columns so that they would fit in with the arrangement of aisles and stalls. It was assumed that for a structure of this kind, with partly opened walls, it would be most economical to use concrete floor slabs resting on a steel-frame-structure, and with sandstone brick walls in order to keep up with the tradition of the institute.

The floor framing is illustrated on page 28 and shown in elevation on page 27 and page 29 together with the elevation of the south and north walls. As evidenced by the calculation sheets in Appendix I, the sizes of the beams, girders and columns were calculated. The girders and beams came out to be 24 WF 94 and the top column should be 8"x8" WF 48 and the bottom column should be 10"x10" WF 77.

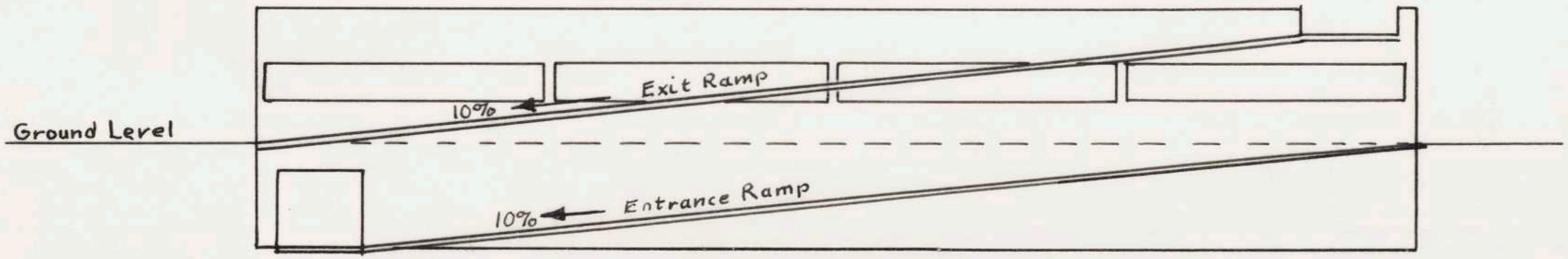


WEST ELEVATION



4 @ 30 Feet

Elevated Section of Columns & Floor Beams



EAST ELEVATION

MIT PARKING GARAGE

Scale 1" = 20'

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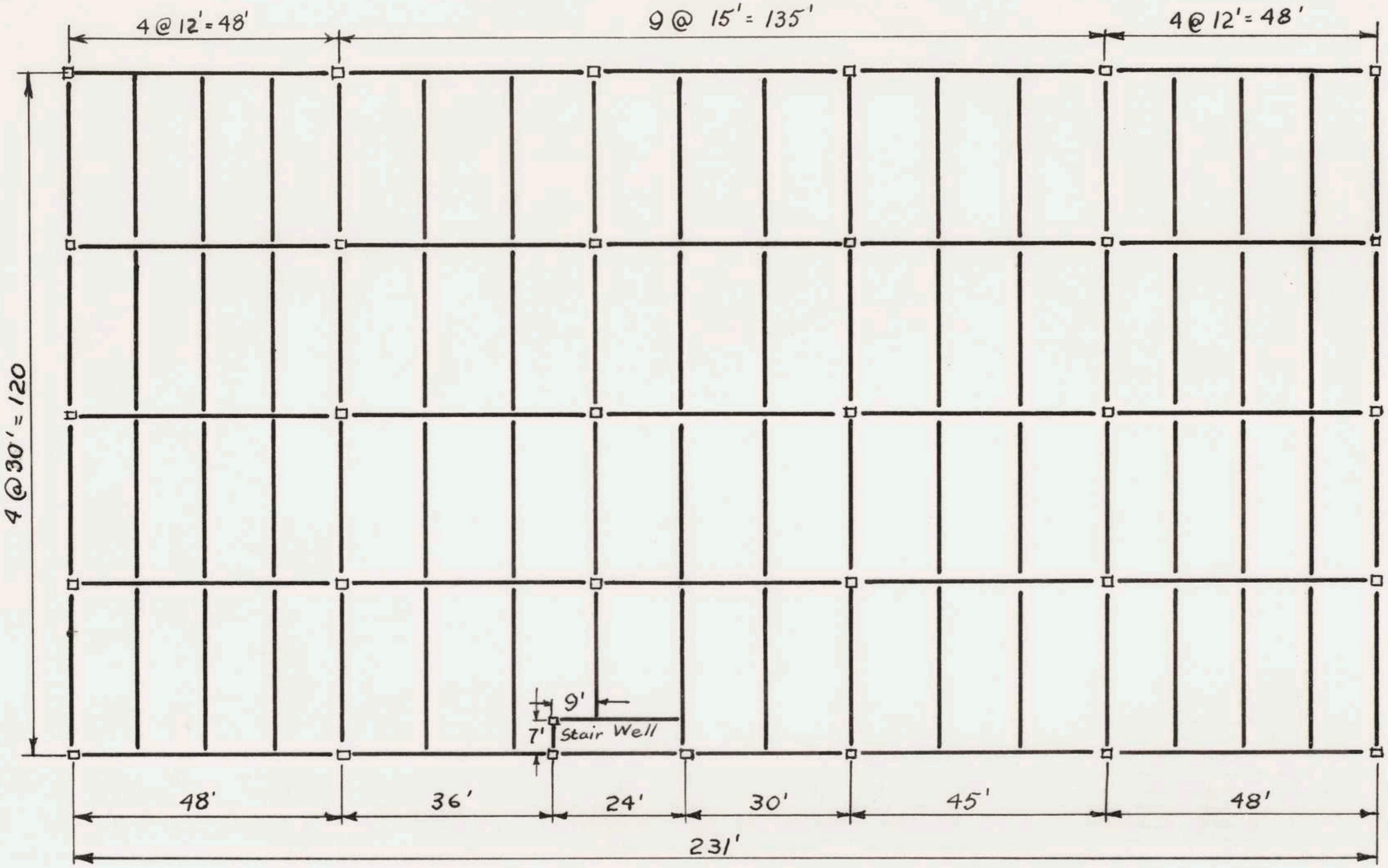
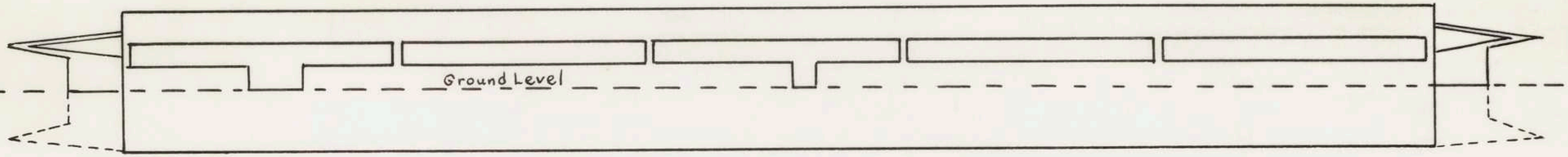
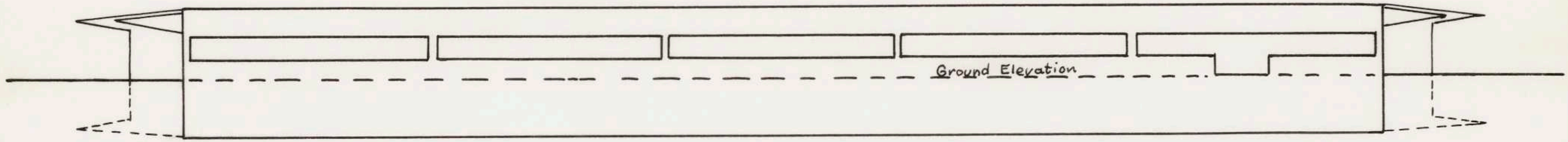


MIT PARKING GARAGE
FLOOR FRAMING
Scale 1"=30'

B.S.51

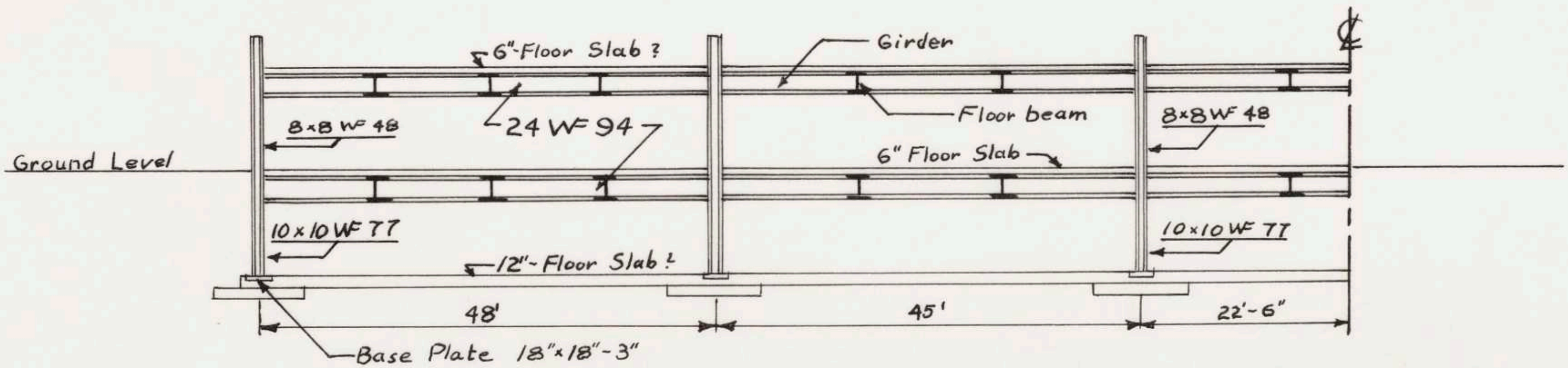


SOUTH ELEVATION



NORTH ELEVATION

Scale 1" = 30'



ELEVATED SECTION

Columns, Girders & Floor Beams.

Scale 1" = 20'

MIT PARKING GARAGE

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This shows that with fireproofing, the largest column will not take up more space than 1 sq. ft. (12"x12").

When one now goes back and looks at the indicated columns on pages 21 and 22, it can be seen that the columns will be positioned exactly on the stone curbing outlining the stalls, and that they will be positioned in front of the front door of any car that is parked, and thus not interfering at all with the operation of the garage.

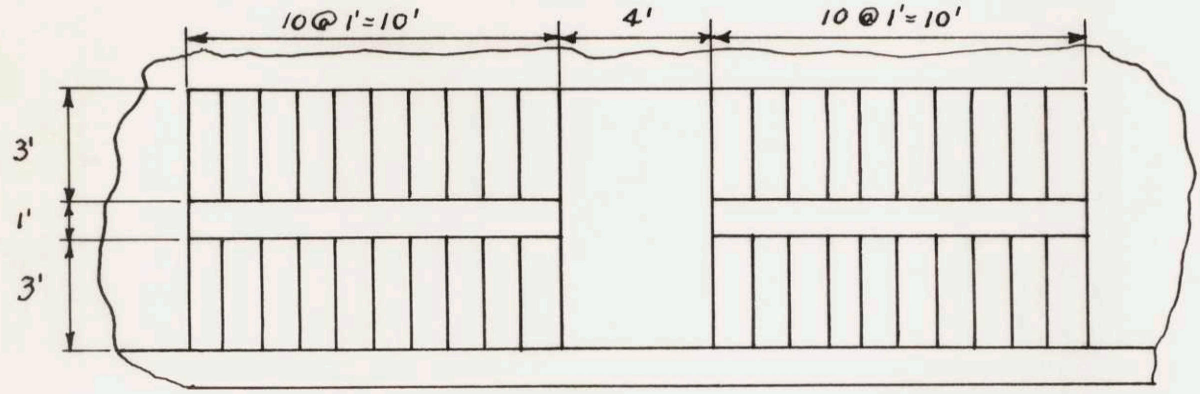
<u>Pedestrian Exits</u>

On pages 21, 22 and 23 it will be noticed that the pedestrian staircase and the exit are located in the middle of the south side of the building or in the front. This staircase has a double stairway which can be entered either from the left or the right side. A detailed drawing of the staircase is shown on page 31. It will be noted from the drawings on pages 21, 22 and 23 that there are 3 ft. pedestrian walks on either long side of the garage in order to facilitate efficient pedestrian movements towards the stairway.

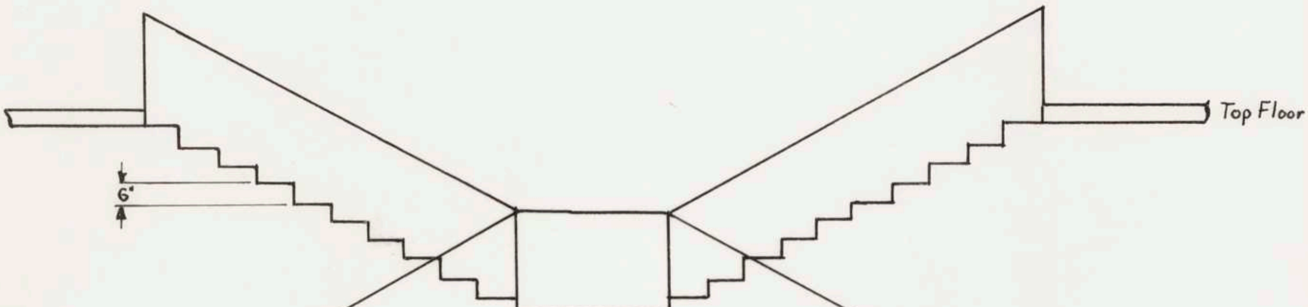
Only one pedestrian exit is incorporated into the design because it was felt that in case of emergency, the entrance and exit ramps could very well be used.

<u>Control System</u>

It was felt that in order to keep operating costs down, there should be no attendants to locate empty stalls



Plan.



STAIR CASE
Scale 3/16" = 1'

MIT PARKING GARAGE

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and park and unpark cars etc. Instead one should rely upon the common sense of the parker plus some kind of automatic control system.

It is suggested that there be a red and green light over every entrance which will indicate that all spaces are taken when the red light is lit, and that vacancies exist when the green light is lit.

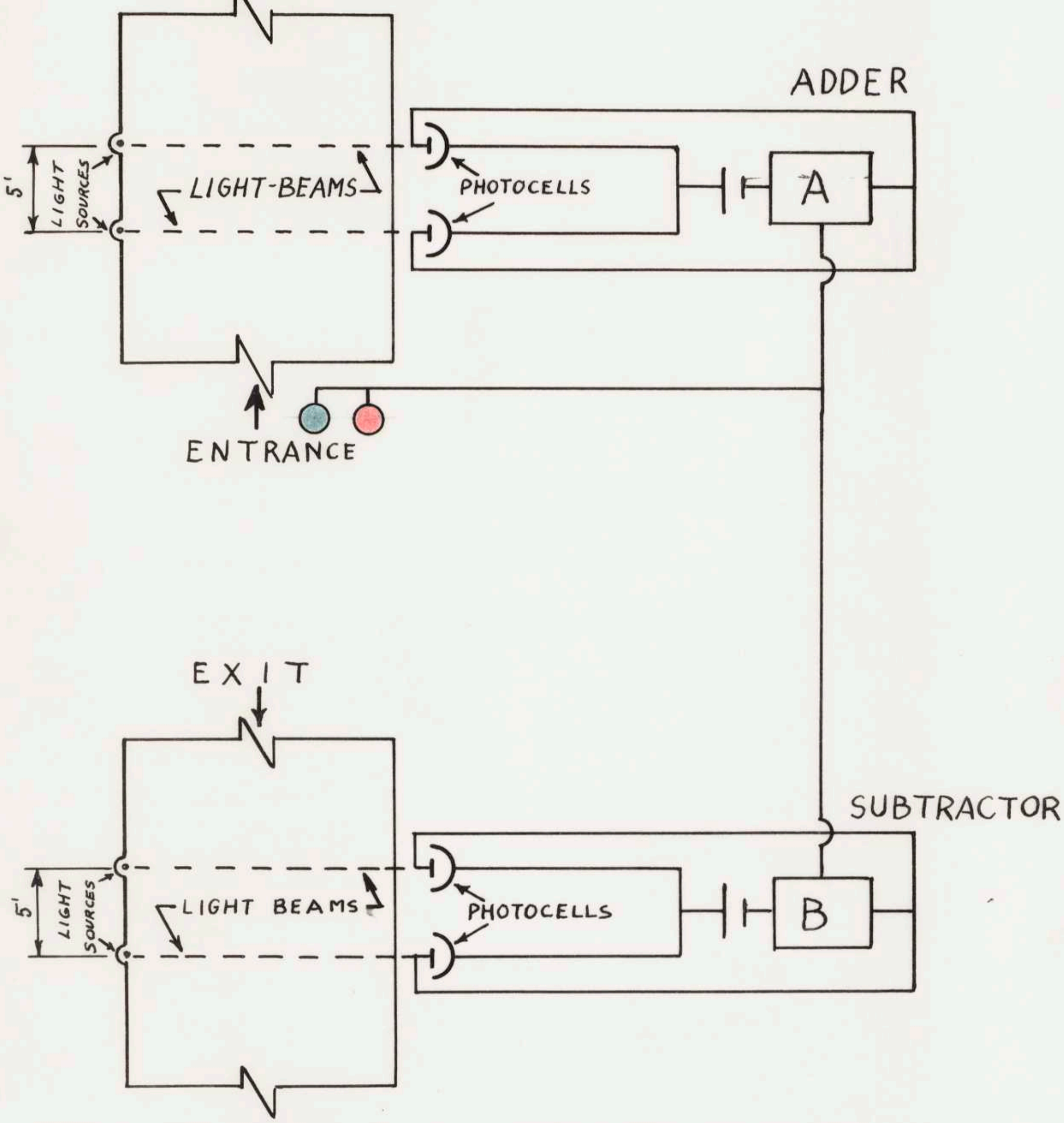
Indications such as suggested may be very simple to achieve through a "mechanical brain" for each floor that counts the cars entering and leaving and keeps track of how many are left on the floor.

One way to do this is to have an "adder" that adds up all the cars entering, through impulses sent to it from the entrance. At the same time impulses sent from the exit every time a car leaves, activate a "subtractor" which subtracts the number of cars leaving from the number of cars that entered, which are already registered by the "adder." Thus, when the difference between the number of cars that entered and the number of cars that left is equal to the capacity of the floor, i. e. the floor is filled up, the red light will automatically be switched on.

This kind of control system is outlined on the diagram on page 33, where two light beams in conjunction with two photo-electric cells are employed as exciters. It is known when a ray of light hits a photo cell, it generates current, and this property is used here.

CONTROL SYSTEM

SCHEMATIC



RED LIGHT WHEN A-B = CAPACITY OF FLOOR
GREEN LIGHT WHEN A-B < CAPACITY OF FLOOR
ON COUNT WHEN BOTH LIGHT BEAMS BROKEN SIMULTANEOUSLY

MIT PARKING GARAGE

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When the light beam is broken by a passing object, an impulse will go from the photo cell to the "mechanical brain". As will be seen from this diagram, however, no impulse will be sent unless both light beams, placed 5 ft. apart, are broken simultaneously, thus assuring that only an automobile passing through the entrance, and not persons or animals, will be able to break both beams simultaneously.

The beams should run parallel about 3 ft. above the pavement.

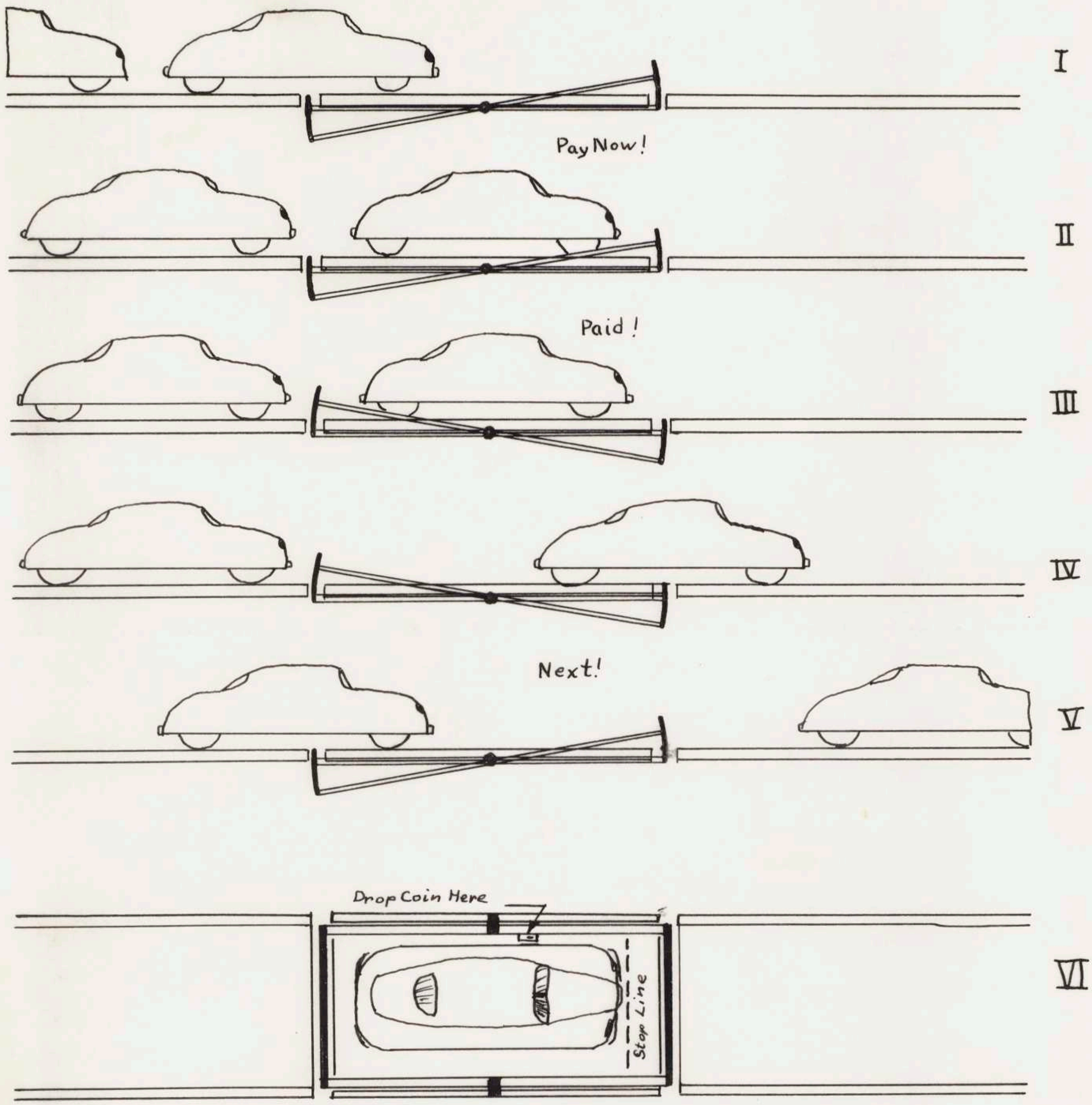
Automatic Pay Station

If any money is to be charged by the institute for parking in the garage, it will certainly be a great saving if one could eliminate the attendant at the pay booth.

One solution to an automatic pay station is suggested on page 35 which is simple in construction and cheap in operation. It is merely a revolving gate activated by the dropping of a coin into a coin receiver. This receiver might be of the type that gives change back on a "quarter" and takes in a combination of nickles and dimes.

Referring to the diagram on page 35, it is seen that in position I the gate is in locked position and the car drives up to the "stop-line" (see plan view VI). Now drop coin in slot at left side of car and the gate will revolve dropping the front obstruction, and raising an

AUTOMATIC PAY STATION
SCHEMATIC



MIT PARKING GARAGE

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obstruction in back of the car that just paid, so that the next car may not enter (III). The car drives away activating a tripper (IV) that turns the gate into the original position, and the next car may enter (V).

Economy

Open wall structures for multi-deck parking has obvious economies of construction, and lack heating and ventilating problems, as oppossed to enclosed parking garages which usually are assessed high on tax rolls and have large operating costs.

As to the cost of the structure itself, no attempt was made to estimate the cost of the garage here presented by calculating the amount of steel and concrete etc. that would go into the structure.

However, figures from some garages recently constructed will give an idea of the construction cost that might be anticipated. Recently a Washington, D.C. store built an open deck parking garage at a cost of $182.00 per car space. In Spokane, Wash. a ramp parking garage was built at a cost of $360.00 per car space. Several other garages were constructed at costs between $250.00 and $400.00 per car space.

We may conclude that this garage will not belong in the least expensive class, but it will certainly not be as expensive as an enclosed garage at $400.00 per car space. Therefore, a cost of $300.00 per car space might seem reasonable to assume, thus bringing the total cost of the garage up to $90,000.00 - $100,000.00. If now ten cents were charged for daily parking and say that there are 300 parkers per day, (which is a conservative estimate) five days a week, then the revenue would be $7,500.00 per year or, roughly, 8 - 7½% return on the investment, which might take care of the interests on the capital plus maintenance costs.

This would seem to be sufficient revenue from the garage to justify its construction since the institute does not get any revenue whatsoever from the parking lots it is presently maintaining. It is felt that it is the responsibility of the institute to maintain adequate parking facilities for its students, staff and employees.

Conclusions

The conclusions of this thesis will be as follows:

1. There will be a definite demand for approximately 300 parking spaces above the present 1819 available by the end of 1952, and this demand will have increased to an additional 400 parking spaces in ten years or by the end of 1962.

2. It is recommended that a 300 car three-deck customer parking garage, of the type discussed, be built by the end of 1952 on the land available between the Rockwell Cage parking lot and the graduate house parking lot which is right in back of Bexley Hall as marked on page 12.

3. It is also recommended that a garage of similar type be planned and constructed on the land by the south east corner of Vassar St. and Main St. as indicated on page 12.

4. It is recommended that these garages be automatically controlled, such that the operating cost be kept as low as possible.

5. It is recommended that a fee of ten cents be charged each customer upon entrance to the garage. This fee is good from 8:00 A.M. to 6:00 P.M.

6. It is also recommended that the garage west of Mass. Avenue be used during special events in the proposed auditorium and gymnasium at fees later determined.

Appendix I

Calculation Sheet.

Columns, beams and girders of interior panel.

6" concrete slab @ 150 lbs. per cubic foot.

Steel at 120 lbs. per foot.

Passenger cars at a gross weight of 4000 lbs. per car.

Total uniform load will then be 1475 lbs. per foot.

M= WxLxL/8 which comes to 295,000 lb.ft. for interior floor beam. The shear is 29,500 lbs. and section modulus is 197 cubic inches. From Steel Handbook,then the most economical size is 24WF94 with an S equal to 220.9 cu.in.

Check for shear : v equalto V/th is 2500 which is less than 11000 lbs. per sq. in. and thus O.K.

The interior girder has a Moment of 295,000 lb.ft. and a shear of 59,000 lbs.

Section Modulus is 197 cu.in., therefore use 24WF94 for interior girder. Shear is 4800 lbs. per sq.in. which is O.K.

Interior Column, has a loading of two times 59,000 lbs. and two times 29,500 lbs., or a total of 177,000 lbs.

The top column will have a concentric loading of 177 kips, and the bottom column will have a concentric loading of 354 kips. From Steel Hand Book,

Use for top column : 11 Ft. 8x8WF48 sections

Use for lower column:11 Ft.10x10WF77 sections.

APPENDIX II

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