STUDY OF STREET TRAFFIC CONDITIONS IN THE CITY OF LOS ANGELES

STUDY OF STREET TRAFFIC CONDITIONS

In The

CITY OF LOS ANGELES

and

THE PRACTICABILITY OF SUBSURFACE OR ELEVATED CONSTRUCTION

for

URBAN AND INTERURBAN TRANSIT FACILITIES.

E. W. Bannister,
Assistant Engineer.

October, 1915.

INDEX.

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INDEX - continued.

One of the outcomes of modern civilization has been the collection of populations into large centers at situations of geographical importance, as regarded from a commercial, or, as in the case of Los Angeles, a climatic point of view. The massing of such populations has necessarily given rise to numerous civic problems, not the least of which are the providing of adequate urban and inter-urban transportation and the relief of congestion in crowded streets. While the former question can only be regarded as two distinct and separate problems, each with its own share of difficulties, yet such divisions are so co-related, so dependent upon each other for the complete development of any given territory, that consideration should be given them as a whole, and any remedial measures devised accordingly.

The relief of congestion in city streets is, moreover, somewhat dependent on the solution of transportation problems, inasmuch as the means of transit in principal use in any populated center are the cars of the transportation companies, necessarily occupying, during passage, through clearance requirements, a large proportion of the width of the ordinary thoroughfare, temporarily restricting and compressing into smaller areas the vehicular traffic used in the conduct of modern business. Enlargement of street area or expansion of business area form the only solutions of consequent congestion. If the first is impossible, then the second becomes imperative. Proper transportation facilities in congested districts can not be provided without either, (1) augmentation of territory and resultant diffusion of traffic, or

(2) additional operating areas, free from obstruction, secured either by placing all trackage above or below the surface of the ground.

It is proposed to discuss generally, in the following pages, the question of traffic congestion and its relief in Los Angeles streets, together with the influence of surface car lines on existing conditions and the practicability, cost and necessity, or otherwise, of sub-surface or elevated construction in the present congested and partially congested districts.

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STREET CONGESTION

DISCUSSED GENERALLY AND LOCALLY.

CAUSES PRODUCING CONGESTION

and

PROBABLE METHOD OF RELIEF.

-O-O-

Congestion of traffic is a natural consequence of the congregating of population at certain strategic locations, considered from a commercial standpoint. As shipping facilities are essential to the development of commerce, it is only natural that such centers of business usually have their inception at the convergence of important waterways, at central points of inland travel, or on the shores of harbors providing safe and abundant anchorage and opportunity for interchange of raw or manufactured products. With the growth of business, the point of first settlement becomes a nucleus for further development and frequently remains the center of business activity even after it is demonstrated to be physically insufficient. People become accustomed to certain routes of travel and the transaction of affairs within certain territory, and will suffer serious inconvenience rather than accept any decided change. The streets and thoroughfares, originally laid out for a number of inhabitants, are, as a rule, narrow and inadequate to accommodate the constantly increasing volume of vehicles and pedestrians, causing blockades and impedance to traffic and transportation. Realty included within the favored sections assumes abnormal prices, rendering the construction of high buildings a necessity for the accommodation of those desirous of remaining in close touch with the commercial center, and the process continues until the limit of human endurance is reached and the original area is no longer able to provide business facilities. Expansion then gradually commences, controlled by geographical limitations, and proceeds along the line of least resistance.

The general plan of all cities is naturally regulated by the prevailing topography, and such plans may be roughly classed in the three following types:

(1) Peninsular, such as New York or San Francisco (See Plate #1), the city area being surrounded on three sides by water channels or natural barriers practically impregnable to civic growth.

(2) Valley, such as Pittsburg or Cincinnati, the first settlement and future congested area lying in the bottom of a natural depression, from which point business reluctantly ascends the surrounding elevations, and

(3) Circular, or radiating type, where natural boundaries are, practically speaking, non-existent, and the city is free to spread at will in all directions.

The growth of the peninsular type of city is naturally restricted to but one direction, i.e., toward the main land; forming, where the peninsular width is limited, as in New York, a long stretch of densely populated territory. With the valley type, actual congestion is confined to the usually limited business area, the demand for residence sites being satisfied by the partial utilization of the adjacent heights and the development of inter-urban transportation to more desirable locations. The radiating type of city, however, where the congested business area merely represents, approximately, the location of first settlement, is free to expand such area practically at will; and the fact that crowded conditions exist in this type of city only indicates that

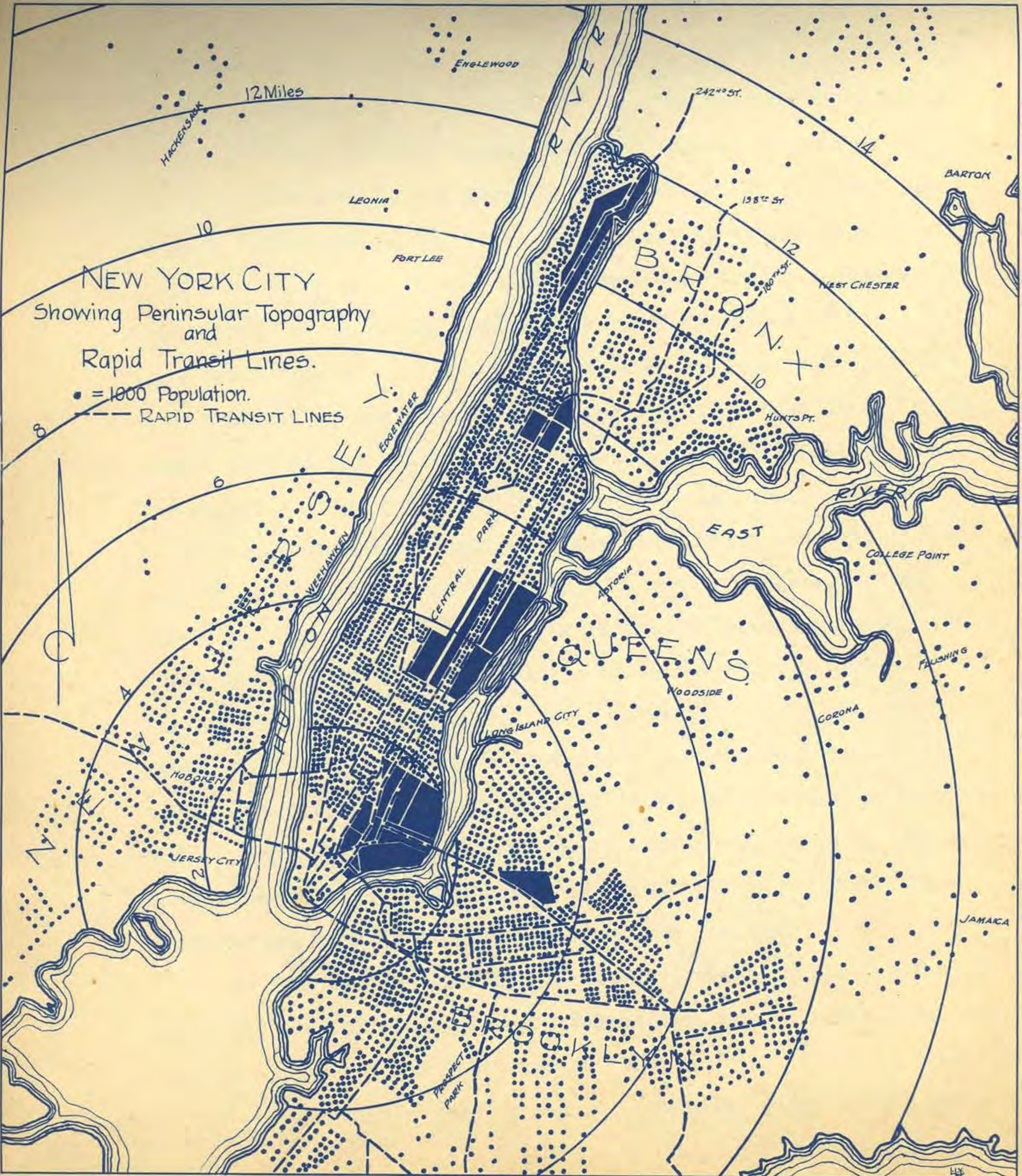
NEW YORK CITY
Showing Peninsular Topography and Rapid Transit Lines.
• = 1000 Population.
---- RAPID TRANSIT LINES
12 Miles
10
8
6
2
14
12
10
ENGLEWOOD
HACKENSACK
LEONIA
FORT LEE
EDGEWATER
WEEHAWKEN
HOBOKEN
JERSEY CITY
NEW JERSEY
HUDSON
RIVER
242ND ST.
198TH ST
180TH ST.
BRONX
WEST CHESTER
BARTON
HUNTS PT.
EAST
RIVER
COLLEGE POINT
ASTORIA
CENTRAL PARK
QUEENS
WOODSIDE
FLUSHING
CORONA
LONG ISLAND CITY
JAMAICA
BROOKLYN
PROSPECT PARK

PLATE I.

the crowding, or congestion, has not yet reached the "saturation point," beyond which the removal of business and its customers to more commodious quarters becomes simply a matter of course.

The City of Los Angeles, regarded in its entirety, can only be considered as belonging to the last mentioned type of municipalities; yet, if the present business district alone be considered, it possesses some of the characteristics of the peninsular type as well. A glance at the map (see Plate #1) will show the reasons for this, and why the center of population, first established at the Plaza by the founders of the original pueblo, has slowly drifted southward to its present location. Business activities, first congregating at the Plaza, have been restricted from expansion to the north and east by the Los Angeles river, which has been somewhat adequately bridged only during recent years; while on the west and northwest the hills have barred egress to all but seekers of home sites willing to suffer the inconvenience of steep climbs for the sake of better air and proximity to their work. The south, then, has remained as the sole direction in which the constant and abnormal increase of business could be accommodated, as evidenced by the location of the great bulk of the building construction completed during the past two decades.

The retail district of the city, which in Los Angeles forms the area of street traffic congestion, may be defined as that section lying south of First street, east of Hill street, and west of Main. Hill street forms a natural boundary, First street the


MAP
OF
PRESENT AND FUTURE
BUSINESS DISTRICTS
TOGETHER WITH
PROPOSED REARRANGEMENT
OF
RAPID TRANSIT FACILITIES
SUBWAY
Scale 1" = 1000'
ELEVATED
PRESENT RETAIL DISTRICT
WHOLESALE DISTRICT
DISTRICT
FUTURE RETAIL DISTRICT
BROADWAY
SPRING ST.
MAIN ST.
LOS ANGELES ST.
SAN PEDRO ST.
ALAMEDA ST.
CENTRAL AVE
SANTA FE AVE
RIVER
ALISO ST.
FIRST ST.
3RD ST.
4TH
5TH
6TH
7TH
8TH
10TH
12TH
PICO BLVD
14TH ST.
15TH ST.
16TH ST.
OLIVE
HILL
BUNKER HILL AVE
TEMPLE
SAN FERNANDO
MACY
INDUSTRIAL
PALMETTO
STEVENSON AVE
SHERRER ST
LOS ANGELES
MONO ST

present location of a line fixed by public convenience, and Main street a boundary established more through custom than topographical limitations, forming as it does the western edge of the wholesale district and the eastern fringe of retail business. There is no physical reason why retail houses should not establish themselves east of Main street; yet experience has amply proven that it is useless to attempt to force shoppers to penetrate territory hitherto given over to less attractive occupations, and that a line thus fixed by custom or habit is as immutable as one caused by natural difficulties, provided that other and more attractive districts are available.

Retail commerce is thus confined to a narrow strip averaging little more than 1200 feet in width, served by four main thoroughfares running approximately north and south. The most westerly of these, however, Hill street, terminates at Temple street; and as Spring street merges with Main, but two north outlets or inlets are available. Such north and south streets average fifty-six (56) feet between curb lines, with sidewalks varying from twelve (12) to seventeen (17) feet. East and west streets vary from thirty-six (36) feet to forty (40) feet in width, with ten(10) to twelve (12) foot sidewalks. The street car tracks are laid on eleven (11) foot centers in the middle of the street; and as the ordinary P.A.Y.E. car measures 9' 1" in width, step to step, car operation, when two cars are moving in opposite directions, requires a trifle over twenty (20) feet of thoroughfare; or, allowing one foot of clearance on each side, twenty-two (22) feet of the fifty-six (56) or forty (40) feet of street included between curb lines. Assuming that a sufficient number of cars are being operated to prevent the use of track area by vehicles, (which occasionally happens when cars are concentrated by blockades, or during the heaviest rush hours), and that the curbs are lined with standing automobiles or delivery wagons, as is usually the case, a narrow path only remains available for through traffic on either side, the width of which, allowing the smallest practicable clearance between standing and moving vehicles, cannot exceed ten (10) feet. Under such circumstances the course of traffic simply becomes a procession, the stoppage of which, more than momentarily, soon causes a complete blockade and consequent annoying delay.

This condition obtains from the entrance of traffic on the north to the end of topographical constriction on the south, which may be fairly placed at Sixth street, extending from Hill to Main. On and beyond Sixth street, vehicles are free to diverge to the west and relieve the situation, altho the larger percentage desiring a western or southwestern outlet proceeds to Seventh street, in order to take advantage of its greater width and opportunity for more rapidity of passage. South of Seventh street it is unusual for the traffic procession to assume unwieldy proportions, and beyond Ninth street all trace of congestion disappears. The reason for this, is of course, obvious. The great bulk of traffic, both street car and vehicular, plies to and from the south, west, and southwest sections of the city; and, if traveling toward the residential section, as in the evening, is confined to the four north and south main arteries, without chance for expansion or different choice of route, until Sixth and the following side streets are reached. The connecting side streets north of Sixth are of no benefit to such through traffic, as each north and south thoroughfare is equally crowded between the stated limits and affords little choice as to conditions of congestion. Sixth, Seventh and the following side streets, however, each draw their quota from the traffic stream as it passes them, and either distribute their burden among north and south streets as far west as Figueroa, or act as through routes to residence districts; so that after passing Ninth street, practically no traffic remains on Main thoroughfares leading south save their proper loading of southbound vehicles and cars, which they are amply able to carry without crowding or inconvenience. If the preponderance of traffic is directed toward the business area, as in the morning, the converse of the proposition naturally obtains. Each side street adds its contribution to the legitimate north bound traffic, the curb lines rapidly fill with waiting vehicles, reducing the area available for passage one half, and congested conditions recommence.

As the congestion of any area is simply a physical demonstration of its inadequacy, it follows directly that the solution lies in the increase of such area, and, if natural or artificial boundaries prevent growth and symmetrical expansion, the remedy automatically lies in the removal of the main business factors, or principal component parts, to a more suitable and commodious location. With the peninsular and valley types of city, such procedure is impossible, and congestion must be relieved, in part, at immense expense, by the removal, or partial removal, of transit facilities from the ground surface. With the radiating type of city, however, expansion in the most convenient direction or directions automatically affords such increase of territory, as is necessary for the accommodation of commercial needs.

The City of Los Angeles, while restricted by natural obstacles from expanding its present congested area symmetrically as has been already shown, has abundant opportunity to relieve inconvenient conditions through the occupation of a district immediately adjacent, which forms, as it were, a natural delta for the business stream. Inspection of a map (see Plate #2) of the central portion of the city can but convince that the territory lying south of Sixth and east of Main streets is destined to become the location of important business interests and is the logical location for the convenient transaction of retail commerce. Its proximity to the main residential sections and consequent accessibility to shoppers, coupled with the fact that practically every car line either skirts its edges or traverses it from end to end renders it peculiarly suitable for such purpose; and the added advantages of broad sidewalks on all north and south streets and sufficient alleys to do away with the nuisance of frontage deliveries and sidewalk trap doors can but effect much needed relief over prevailing pedestrian traffic conditions. The greatest asset of such district, however, lies in its flexibility, its power of indefinite expansion, rendering present congested conditions impossible of reproduction. Pico street on the south and Figueroa on the west would, in all probability serve as the limits for retail business during many years to come, including as they do, together with Sixth street, on the north, and Main street on the east, an area nearly four times the present retail area, with corresponding increase in available frontage. Yet, if the commercial volume attained unexpected proportions, there is no physical reason why such district should not expand so far to the south or west beyond these streets as the demand for business sites requires. There is no lack of evidence that this solution of present conditions has received abundant recognition; evidence so tangible that it presents itself in the erection of huge office and store buildings south and west of Sixth and Main streets, representing heavy investments and mature consideration of all probabilities. While a portion of such construction may be due to certain syndical realty operations, there is no doubt that the greater part has been dictated solely through recognition of the situation and realization of the inevitable. The establishment of the J. W. Robinson store and the Brockman building at Seventh and Grand has gone far to reassure the more timid of the permanency and desirability of such movement, as well as the practicability of lateral extension of the business area; and all the larger retail establishments, with the possible exception of one or two which have recently erected permanent quarters on their old locations, may be expected to follow suit in due time. The smaller business houses will naturally be compelled to secure locations in fairly close proximity, dependent as they are on the crowds attracted by the department stores; but, having a greater frontage available in the vicinity of such stores, will not be restricted to any one street or subject to the exhorbitant rentals heretofore demanded. Such diffusion of business, added to the improvement in delivery facilities, will automatically prevent the massing of wheeled traffic in any particular spot or on any one thoroughfare; and although it is to be expected that passenger vehicles will congregate near favored establishments, it will no longer be necessary for them to follow any particular route to obtain egress to the residence section, as at present. Each street will carry its quota, instead of a few north and south streets carrying it all; and any congestion, momentarily formed, will as rapidly disappear.

The efforts of property owners in the northerly business area to detain the southerly march by the construction of cuts and tunnels west of Hill street will have no appreciable effect on the ultimate result. While rendering their holdings more accessible, such construction will be chiefly valuable in affording a more convenient entrance from the north and northwest sections of the city, resulting in the better development of the territory and in the relief of any traffic congestion north of First street. Providing no increase in business area, the benefit derived will be simply residential accessibility, and can affect but a small portion quarters on their old locations, may be expected to follow suit in due time. The smaller business houses will naturally be compelled to secure locations in fairly close proximity, dependent as they are on the crowds attracted by the department stores; but, having a greater frontage available in the vicinity of such stores, will not be restricted to any one street or subject to the exhorbitant rentals heretofore demanded. Such diffusion of business, added to the improvement in delivery facilities, will automatically prevent the massing of wheeled traffic in any particular spot or on any one thoroughfare; and although it is to be expected that passenger vehicles will congregate near favored establishments, it will no longer be necessary for them to follow any particular route to obtain egress to the residence section, as at present. Each street will carry its quota, instead of a few north and south streets carrying it all; and any congestion, momentarily formed, will as rapidly disappear.

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It is not to be expected that this will be accomplished immediately, or in any given period. All changes of this description shape themselves slowly, though none the less surely, and it is probable that nearly as much time will be required for the removal of the retail center to the more commodious location as it has taken to move from above First street to its present situation. The steadily increasing volume of business will constitute the most potent factor in hastening such removal, which, when complete will have the effect of locating the scene of greatest activity at the ideal point for a city of the circular, or radiating, type, namely; at its geographical center, with abundant opportunity to expand as required and prevent any return of congested conditions.

As a natural consequence, such opportunity for the relief of congestion definitely eliminates any necessity for change of location of existing transportation facilities. Elevated roads and subways are only constructed when congestion can be relieved by no other method, or when thickly populated areas are located at considerable distances and create a demand for rapid transit. In a city of the radiating type such as Los Angeles, it will be readily seen that this is a function of interurban, not urban, transportation. With the lessening of congestion (always a consequence of territorial expansion) the investment necessary for the construction of an elevated or sub-surface road becomes less attractive, and the prospect of any financial return is decreased in proportion. The heavy cost of such construction means large fixed charges, and in order to make the expenditure profitable, there must be either higher rates of fare, dense traffic or many persons riding short distances. City ordinances prevent increase of fare, expansion of the business district scatters traffic, and the established city plan renders short rides the exception, and not the rule.

As a matter of fact, the popular estimate of the street space occupied by city surface cars is greatly exaggerated, and is probably due to the preponderance of size per unit, or car, as compared to the average vehicle, rather than to the number of cars operated on any street in any given period. A simple calculation will demonstrate this effectively, and show that street cars, even when operated to the limit of track capacity, are but a small factor in causing street congestion.

The ordinary end entrance P. A. Y. E. car operated in Los Angeles is 9 feet and one inch in width (9'-1"), and forty six feet seven inches (46' 7") long. With clearance included, the area occupied by such a car is approximately eleven by fifty feet (11 x 50 ft) or five hundred and fifty (550) square feet. The greatest number of such cars passing any given point on a single track is 110 per hour, or a car every 33 seconds; and the average running time between two points such as First and Broadway and Seventh and Broadway, is seven minutes. If both north and south bound tracks are carrying the same number of cars, then a maximum of 220 cars per hour will pass the given point, or, approximately four cars per minute. As each car requires seven minutes to pass from First to Seventh streets, in any one minute there will be 7 x 4 - 28 cars occupying street space inside the above stated limits. If each car occupies 550 square feet then 28 cars will require 15,400 square feet. Broadway is 56 feet wide, and measures 3856 feet in length from the street center at First to the similar center at Seventh, giving a total street area, after deducting all cross streets, of 202,496 square feet. Simple division will demonstrate that, in any minute of time at the busiest time of day, street cars are only occupying eight per cent of the total available street area, or, conversely, vehicular traffic occupies eleven and one half (11½) times as much street area as the street cars.

Objection may be made to the above example that partial blockades, emergencies, etc., may temporarily cause a large number of cars to be concentrated on a given street, or portion of a street. While dispatcher's records show this to be exceptional, the case may be assumed, as follows:

The largest number of cars which it is possible to operate on a single surface track is, admittedly, 180 per hour. This is equivalent to a car every 20 seconds, including stops, and is impracticable unless the tracks are free from obstruction and the "service stops" can be restricted to ten seconds or less. In cities with comparatively narrow streets, such as Los Angeles, stops will average several times ten seconds, as it is necessary for passengers to wait on the curb until their car arrives, instead of grouping on "Isles of Safety" or in the street, as is possible in Indianapolis or San Francisco. It is therefore probable that at no time has Los Angeles street car traffic ever approached such density for even an one-hour period.

One hundred and eighty cars per hour on a single track means three hundred and sixty cars per hour on double track, which, again, means 6 cars per minute passing any point, or a total of 42 cars occupying street space between First and Seventh streets in any minute of the hour. Forty-two cars, at 550 square feet per car, will occupy 23,100 square feet of street, which is only 11½ per cent of the total space available. In other words, with street car traffic operated to the maximum, vehicles are occupying nearly eight times as much area as are the cars.

Obviously, the remedy for congestion under such circumstances lies in the providing more vehicular area, rather than the relegation of transportation facilities to above or below the ground surface. The addition of one eighth (1/8), or a strip seven feet wide to the present street area would hardly compensate for the immense expenditure necessary for subway or elevated construction, especially when relief by natural expansion is simply a question of time.

SUB-SURFACE OPERATION

AS AFFECTED BY DENSITY OF POPULATION

and

CITY PLANS.

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Since the financial success of the original New York subway has become so generally known, congestion of the streets of any American City has served as a signal for a public demand for removal of street car trackage to sub-grade, or elevated roadway. That such demand is made, generally speaking, without due consideration or knowledge of the conditions necessary for successful financial and physical operation is evident to anyone conversant with the underlying facts. The large investment necessary to accomplish such construction is fortunately, however, a sufficient deterrent to any hasty action, and sufficient reason for the reference of the problem to competent authority. Crowded traffic conditions should be mitigated or prevented wherever possible according to the best practice; but it does not always follow that the only remedy is track elevation or sub-surface construction.

As noted under "Congestion," it is the shape, or plan, of cities that forms the chief factor in determining the final character of its transportation facilities. Cities of the peninsular and valley types, being restricted as to available area for business purposes, cannot but become more congested with increased population. When all available space has been utilized, or at any time previous when realization of the ultimate outcome crystallizes into a popular desire for improved conditions, the existing means of transportation are either reinforced or supplanted by the building of elevated roads, or subways. Elevated roads, although noisy and unsightly, have heretofore, in America, invariably been the first means of relief on account of their lesser cost. With the better understanding, however, of the problems of construction and maintenance, and above all, the development of electric traction, subway construction has come into greater favor, and a combination of both systems apparently forms the proper solution in most cases. But a city of the radiating type, unless its business district is cut up by water ways or completely hemmed in by natural barriers, has an opportunity to solve its congestion problem simply by the gradual extension of its business area, thus avoiding extraordinary obligations for transit facilities and consequent increase in taxation.

This holds true until the populated area becomes so extensive that the inhabitants are unable to reach the business district from their places of residence by surface roads without undue loss of time, or, conversely, until the congested area surrounding the business district has become sufficiently extensive in any one direction to approximate the conditions of population obtaining in a city with restricted boundaries. More rapid transit then becomes a necessity and possible, on account of the intensive population, from the standpoint of the operator, although it is often difficult to meet the emergency satisfactorily and secure an equable return on the capital invested. London is a fair example of this, for while it contains the greatest number of possible passengers within its limits of any city in the world, its underground roads, with one or two exceptions, are not self supporting. While this is partly due to lack of co-operation and faulty location of routes, the principal reason is that there is not sufficient available patronage along any one route. If theLondon underground system had been constructed according to modern methods, under a comprehensive plan which would allow opportunity for transfer, eliminate gauge differences, and carry its patrons directly to their destinations instead of by circuitous routes, it is probable that it would earn a fair rate of interest on the investment. It is doubtful, however, if it could ever approach the dividend ratio of the original New York subway, operating on Manhattan Island. The latter serves a district, which, through its topographical restrictions is congested from one end to the other, so that its total patronage is bounded only by its capacity. The London lines, on the other hand, while serving a greater population, would necessarily be obliged from the radial form of the city, to cover a far greater area with consequently larger mileage and less population per mile.

It may be readily seen, then, that congestion is a necessary factor to successful sub-surface operation. There is no doubt but that subways can be profitably operated under proper conditions, and at a lower operating ratio than can surface roads. While the first cost of surface roads is comparatively small, the platform expense and cost of conducting transportation is much higher; and the average speed being low on account of traffic obstruction and frequent stops, the capacity is proportionately smaller. As the amount of annual gross receipts of any enterprise regulates the amount of capital expenditure it follows that the large investment required for subway construction may be justified only when the demands of traffic call for the running of multi-car high speed trains at frequent intervals. But, such traffic demands or requirements necessarily involve the presence of capacity patronage, and such patronage is not possible without congestion of population. The carrying of a sufficient number of passengers on any line of transportation will, perforce, insure its financial success, but the people desiring such facilities must be there to carry.

Density of population, then, is a prime necessity for profitable operation of sub-surface transit lines. A city area given over to private dwellings, each with its own premises, can not furnish a population sufficient to support a subway unless the ride is short and the rate of fare high. The ride is not apt to be short as realty values in the central part of any city are ordinarily so high that people must go some distance to have separate houses, and if the fare is high the great majority of the inhabitants cannot afford to pay it and are forced to live in crowded quarters and within walking distance. The great advantage possessed by Los Angeles, or any other city of the radial type, in being an aggregation of one-family houses, becomes a disadvantage when the development of a costly means of transportation is concerned.

In connection with this phase of the subject, it may be worth while to compare Los Angeles with the larger eastern cities now possessing rapid transit systems. The following table shows their population density within corporate city limits.

POPULATION DENSITY IN CORPORATE CITY LIMITS.

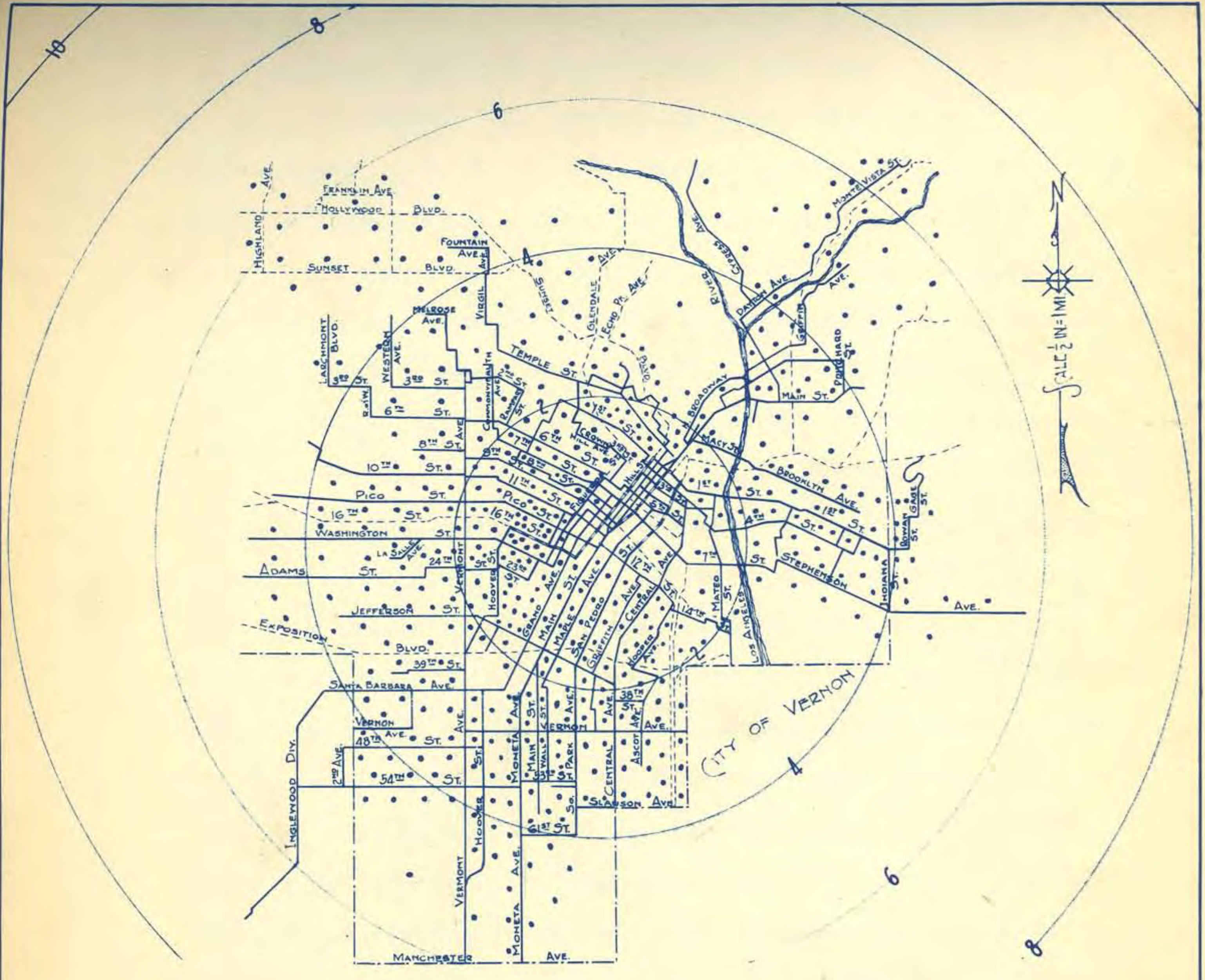
	Land area Sq. miles.	Population density per acre of land area. 1900.	1910.	1914.
New York (Manhattan & Bronx)	62.6	51.2	69.	
Brooklyn	77.6	23.4	32.9	
Chicago	179.6	14.8	19.	
Philadelphia	129.6	15.6	18.6	
Boston	87.3	15.7	19.0	
Los Angeles (1900)	43.3 *	3.7		
Los Angeles (1910)	77.3 *		6.3	
Los Angeles (1914)	84.2 *			9.3 *

* = North of Manchester avenue.

The population density of Los Angeles, as shown in above table, is only half that of Philadelphia or Boston, both of which cities and particularly the latter, are restricted from expanding in a natural manner by various waterways. Philadelphia, moreover, to a greater extent than any other American city, consists of individual communities built up around large manufacturing industries as centers, necessitating the use of rapid transit facilities in order to insure homogeneous growth. Los Angeles territory, south of

Manchester avenue has been neglected in this compilation, as its transportation service, from the length of ride, more properly falls under the classification of inter-urban traffic. The population of Los Angeles for the year 1914 has been taken as per the figures given by the Los Angeles directory, less the population of Wilmington and San Pedro. The table shows conclusively the difference in density of population between cities of the peninsular and radial or partly radial types, New York having over twice as many people per acre as Brooklyn, and nearly eight times as many as Los Angeles. It should be remembered that the figures shown are averages. Certain districts in New York house as many as 1000 persons per acre, while the apartment house sections average 250 to 400, and the better class of tenements 600 to 700 per acre. If the fact be considered that an acre of ground is contained within an area a trifle over 200 feet square, some idea of the population density and consequent resultant traffic may be obtained. Rapid transit in such case is vital to city existence, and must be operated either above or below the ground surface for the simple reason that there is no other place to put the tracks.

A good idea of the diffusion of the 1914 population of Los Angeles, and the relative population density of the several residential districts may be had by inspection of Plate #3 herewith appended. This plate has been made up from existing maps of city territory and the 1915 Los Angeles directory records of the number of householders in each precinct division; and while it does not



MAP OF CITY OF LOS ANGELES SHOWING TRANSPORTATION LINES AND COMPARATIVE DENSITY OF POPULATION IN DIFFERENT MILE ZONES

• 1000 POPULATION

------- LOS ANGELES RAILWAY

- - - - - - - - - PACIFIC ELECTRIC RAILWAY

━━━━ JOINT TRACK

include the transient population, will serve as a sufficient index as to the relative growth of the different sections. It can be plainly seen that Los Angeles is, practically speaking, growing equally in all directions, and is, to all intents and purposes, a round city with an average 5 mile radius. No residence congestion, or massing of any considerable part of the resident population in any limited area, exists, due doubtless to the comprehensive plan of street car trackage affording equal accessibility to practically every portion of the municipality. Some conception of the effeciency of street car system and the large part it has played in symmetrical city expansions through the liberality of its extensions may be had when it is realized that it operates 100 miles more trackage than any city on the Pacific Coast, or about 1 mile of track to every 1300 people, while the average for the United States is 1 mile to 1800 population. More cars are run, in proportion to the population, than on any surface road in America, the car miles averaging 72 per capita, or 3 times as many as New York City, and twice as many as Chicago. Naturally, such liberality has its effect on the earning capacity, the number of passengers per car mile and annual earnings per track mile being only about one-half that of San Francisco and considerably less than either Portland or Seattle.

Statistics covering the number of dwellings contained within the boundaries of any city and the average number of persons inhabiting each dwelling, are most significant as indicating its population density. The term "dwelling," may be broadly defined as "a place in which one or more persons regularly sleep, having a separate entrance from the street." Under this definition an apartment house or tenement, even if housing several hundred persons, is classed as one dwelling. The following tables show the number of dwellings within the corporate limits of Los Angeles, as compared with the larger Eastern cities previously mentioned:

TABLE #3 - NUMBER OF DWELLINGS WITHIN CORPORATE CITY LIMITS.

U.S. Census	New York (A)	Brooklyn	Chicago	Philadelphia	Boston	Los Angeles
1880	73864	62233	61069	146412		
1890	81828	82282	127871	187052	87985	10368
1900	100547	113972	193895	241589	119595	22531
1910	104143	147666	246744	295220	133516	69061

(A) Manhattan and Bronx.

TABLE #4 - POPULATION PER DWELLING WITHIN CORPORATE CITY LIMITS.

1880	16.4	9.1	8.2	5.8		
1890	18.5	9.8	8.6	5.6	7.6	4.9
1900	20.4	10.2	8.8	5.4	7.4	4.5
1910	26.5	11.1	8.9	5.2	7.9	4.6

Inspection of the above tables shows conclusively the difference in living conditions, and, consequently, the relative congestion, between cities of limited areas and the radial or semi-radial types which are free to expand. During the period 1900 - 1910 the entire number of dwellings, tenements, apartment houses and residences, constructed in New York City only totaled 3956, while the population per dwelling mounted to 26.5, an increase for the decade amounting to nearly 150% of the total population per house in Los Angeles. During the same period, the latter city built 46530 dwellings without increasing the population per dwelling but a fraction of one per cent. In like manner, the average number of families per dwelling increased from 4.3 to 5.6 in New York; while Los Angeles, with a proportionately greater increase in population, still preserved its ratio of one family to each home. Although this means that practically every inhabitant enjoys the benefits of abundant living space, it also marks the fact that the number of people who can conveniently patronize any given transportation line is comparatively limited. Experience has shown that possible passengers will not walk more than ten minutes to reach a car line, if any other means of transit are available. The average person walks at a pace not exceeding 3 miles per hour, and a 10 minute walk would therefore mean practically half a mile of distance. Patronage, therefore, would be confined to an area not exceeding one mile in width; and, supposing such line to extend to the city limits, five miles long; a total of five square miles, or less than one fifteenth of the territory to be served. A subway system adequately serving a city of the circular type, supposing such city to be equally inhabited in all sections, would resemble the spokes of a wheel, with the different lines radiating from the business center; involving the necessity of a total mileage whose construction cost would be prohibitive.

<u>SURFACE CAR DIVERSION</u>

to

<u>SUB-SURFACE TRACKAGE.</u>

It may be urged that while Los Angeles, taken as a whole, cannot perhaps present such conditions of population as would justify the installation of extensive subway construction, that the congestion, or partial congestion, of certain portions of the present business district should be relieved by sub-surface trackage.

It is apparent that the matter is entirely a question of public welfare and convenience. The necessarily heavy expenditure either is, or is not, justifiable, according to whether the situation admits of no other remedy, or whether, by natural means, it will automatically adjust itself. No expenditure, however great, should be considered disproportionate when used in overcoming otherwise insuperable natural difficulties or hindrances to civic growth; but, on the other hand, no municipality is justified in adopting a policy which would tend to retard the removal of business centers to their natural geographical location. Such a policy would be nothing less than a deliberate exploitation of civic resources for the benefit of the limited number of property owners enjoying abnormal incomes from rental privileges; and at best, could only serve as a palliative, since the final location of the business center of any growing city is regulated entirely by its topography and is altogether beyond individual or corporate control. Such removal; or partial evacuation of territory, involves no municipal loss. Diminution of assessable values in the one case is offset by increase in the other; and individual loss on any particular lot or parcel can only be regarded as the natural subsidence of inflation.

The inference may be drawn from the preceding paragraph that the indebtedness incurred in the construction of subways is, primarily, a civic obligation. This is true in the large majority of cases. A subway is a public improvement whose enormous initial cost renders the undertaking uninviting to private capital, unless the general topography concentrates a heavy traffic over a considerable length of route. This is only possible in rare instances. Cities with a wide spread radial system of track with only a congested or semi-congested center, can only hope for an underground diversion through their center, and that only if the traffic conditions are sufficiently rigorous. As such diversion not only creates no accession to the income of the transportation line, but increases its expenses by the added problems of ventilation, lighting and station operation; and as the responsibility for the adequate provision of thoroughfare for the needs of its inhabitants is inherent with the city, it naturally becomes the province of the municipality to provide any extraordinary methods of facilitating transit.

This principle has been generally recognized. With the exception of the Market street subway in Philadelphia, no underground construction has been undertaken by other than public funds. Contracts signed in 1913, however, for the construction of the so-called "Dual System" in New York and Brooklyn, provide for a nearly equal division of expense between the operating companies and the

City. This, though, is an extension and amplification of the rapid transit system, including both subway and elevated. Boston is the only city which has definitely committed itself to the policy of supplying sub-surface accommodations for surface lines, owing to the extreme congestion obtaining in its central business section, caused by narrow and irregular streets and restrictive waterways. The City undertakes and owns all underground construction, practically forcing the operating company to lease same on completion at a rental of from 4½ to 4-7/8 per cent of original cost, the rate being calculated to provide sinking funds as well as interest.

While the construction of underground transit facilities by a municipality for the operation of urban car lines, in cases where the traffic area is insufficient without possibility of expansion, or where removal from a certain advantageous commercial situation by enforced expansion may work permanent hardship and inconvenience, and is without doubt justified by the necessity of supplying a larger area for vehicular transport, it is difficult to see the equity of the rental exacted therefor.

It is true that passage, free from obstruction has been provided for car operation, but it is an improvement which the transportation company could, in most cases, well do without. It can be readily seen that all passengers using trolley systems, always supposing that no more rapid means of transit exist, will use them whether below ground or on the surface, as being the best and perhaps the sole means of reaching their residences or other destinations.

The running time may be lessened by the use of the subway through the crowded sections, but this is merely a convenience to passengers and does not materially benefit the operators. Practically all possible revenue will be secured as readily by surface as by sub-surface operation, with considerably less expense. The City, however, through the possession of paramount authority within its boundaries, compels the adoption of the new facilities, reaping enormous benefits through increased taxable valuations and freer movement of traffic; and, altho retaining perpetual title to such facilities, forces the operating company to contribute a sufficient annual rental, or percentage of their cost, to cancel both principal and interest in a certain given period, thus increasing fixed charges and proportionately decreasing income without possibility of recourse. The railway company, then, is placed in the anomalous position of being obliged to occupy and pay for something which it does not want; and through its annual contributions to the amortization or sinking fund, defray the entire cost of something which it can never own.

It is admittedly the duty of the city to provide adequate streets. Why then, when the removal of any particular class of traffic essential for the transaction of business and the well being of its participants, is considered imperative, should a charge be made for the privilege of operation over what is nothing more than an extension of street area? If the expenditure incurred in subway construction had been employed in the demolition of existing surface structures and the widening of the identical streets under which the subway runs, or the construction of tunnels, long or short, to connect adjacent sections of the city, one with the other, the users of such additional accommodations would ridicule the idea of payment for daily passage, considering the expense incurred as a necessary concomitant to civic existence and a legitimate addition to municipal bonded indebtedness. As a subway is simply an amplification of street area, a tunnel below the ordinary gradient, any payment for its use can but be regarded as a toll. Toll collections, with the progress of civilization, have been generally and definitely abolished; and the principle that streets and roads are free to the users thereof has become axiomatic.

Inasmuch as any city transportation company, contributing its share through general taxation to the common funds, is regarded in the eyes of the law, as an individual entity, no discrimination should be made between it and any other participant in city traffic. It may occasionally be necessary to remove the cars from existing streets to make more room for smaller vehicular units, but if so, other accommodations should be provided at a no further cost than that entailed by such removal. Congestion of thoroughfare is not caused by street cars, but by the influx of traffic following their installation. It should be remembered that transportation lines form the principal factor in city development and render business centers possible; and that no city or concentration of commercial activity can exist without cheap, efficient and convenient means of transit to adjoining territory.

to exact compensation for the use of subway construction designed for the operation of urban cars and the relief of congested streets by the removal of such cars, unless it can be clearly demonstrated that the operating company increases its revenues, over and above the normal increase, by the use of such facilities. In like manner, the amount of any compensation paid should bear a reasonable proportion to such increase of revenue only, without reference to the original cost of the work.

The case of Boston having been cited, the financial experience of the operating company prior to and since the construction of subways may be pertinent to this discussion. Owing to the use of the latter by both rapid transit and surface cars, one company operating all city lines with practically universal transfer privileges, it is impossible to segregate the single effect of the transfer of surface lines to underground trackage. The total result, however, is valuable in illustrating the truth of the statement that subway operation is unremunerative in all but abnormal cases; and a brief resume of conditions, etc., is therefore subjoined.

Boston, like New York, is a peninsular city, (See Plate #4). The original settlement being at the point of the peninsula in close proximity to shipping facilities, the growth of business has gradually caused the occupation of and filled to overflowing all available space. Unlike New York, the peninsula is comparatively short and the congested area consequently limited, the entire

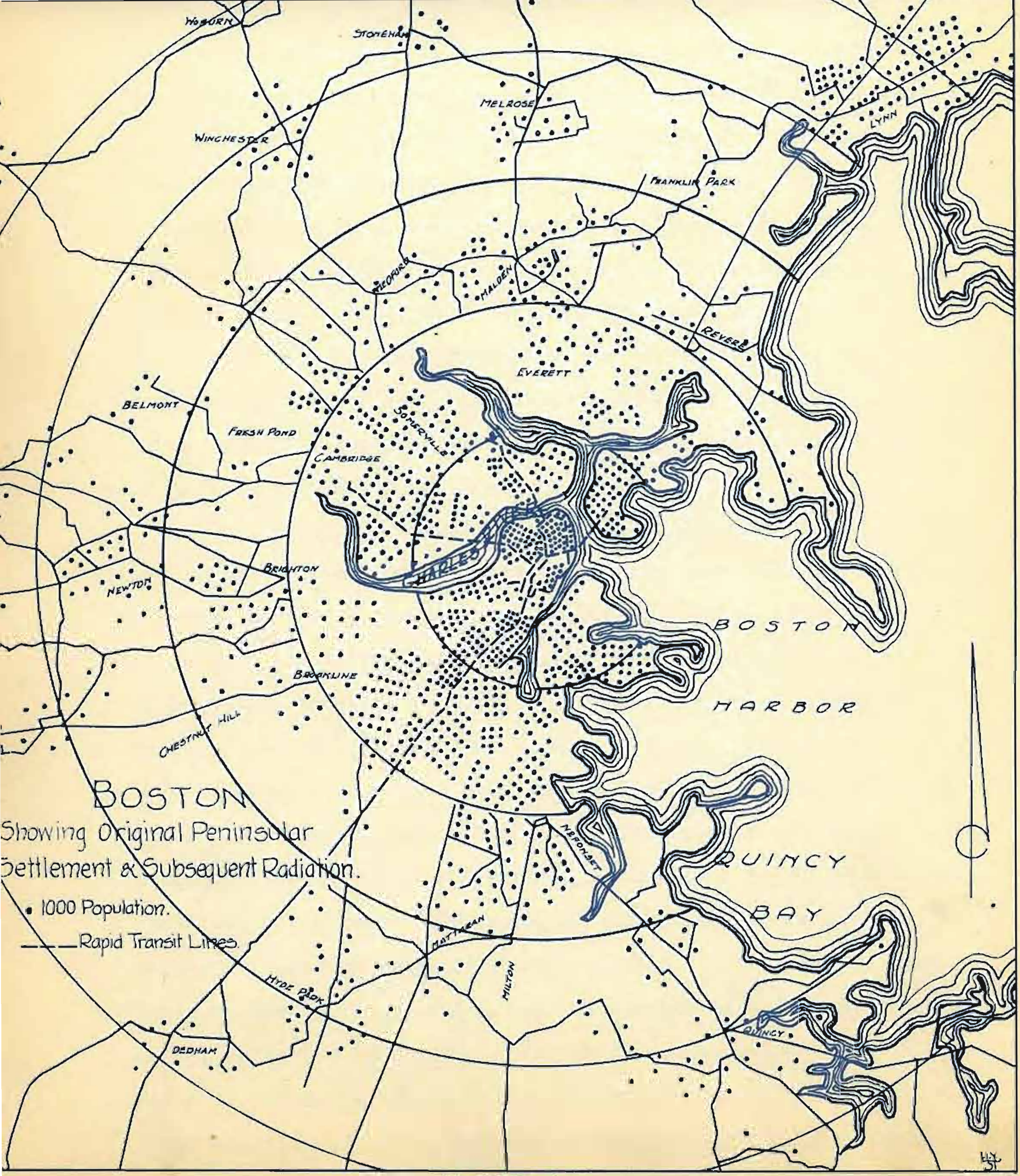

WOBURN
STONEHAM
MELROSE
WINCHESTER
FRANKLIN PARK
LYNN
MEDFORD
MALDEN
REVERE
EVERETT
BELMONT
FRESH POND
SOMERVILLE
CAMBRIDGE
CHARLES
BRIGHTON
NEWTON
BOSTON
HARBOR
BROOKLINE
CHESTNUT HILL
BOSTON
Showing Original Peninsular
Settlement & Subsequent Radiation.
• 1000 Population.
—— Rapid Transit Lines.
NEPONSET
QUINCY
BAY
MATTAPAN
MILTON
HYDE PARK
DEDHAM
QUINCY

PLATE 4.

mainland being available for residence or other purposes as soon as the neck of the peninsula, or point of constriction, is passed. This naturally causes diffusion of population with more or less concentration at suburban centers and a change in city contour to the semi-radial form, so that the population density of the metropolitan district, or territory included within the 16 mile circle is only 4.1 per acre, or less than one quarter of that of the larger city. The opportunity for heavy patronage is therefore confined to a relatively small district, while New York, as represented by Manhattan Island, presents practically uniform conditions of congestion for nearly 13 miles.

With the consolidation of existing horse car lines in 1888, the transportation interests were in possession of a property yielding a gross revenue of $4,888,000.00. This represented an invested capital 2.39 times as great, which experience has shown to be a safe and conservative ratio of expenditure. The average half trip was 3.62 miles long, and the revenue passengers per half trip averaged 22.5, which insured a satisfactory return over and above operating expenses. The electrification of all lines, with consequent higher speed and extensions to other territory, brought the total revenues in 1898 to $9,257,000.00 and increased the number of passengers per half trip to 28.9. Absorption of surface lines by the Boston Elevated Railway Company then took place and subway operation commenced, first simply as an adjunct or extra facility for surface cars, later in connection with a complete rapid transit system of combined subway and elevated trackage, the latter only being constructed by the company. In 1903, with ordinances compelling universal transfer, the half trips were so lengthened that the number of passengers per half trip was reduced to 23, while in 1912 it only averaged 25.5.

Meanwhile the total capital expenditure necessitated by the popular demand for rapid transit amounted to over 34 million, and the City, in the construction of subways, expended 17 million more, or a total of 51 million dollars. As the City expenditure can but be regarded as an addition to company expenditure, on account of the enforced liability of the latter to take care of interest and sinking fund charges, the company had increased its obligations over 200 per cent; while, even with a gain of 500,000 possible patrons through growth of city population, <u>there were only 3 more revenue passengers per half trip than with the horse cars in 1888</u>. Gross revenues had increased over 80%, but such gain was only normal. As voiced by a prominent official of the railway company, "Boston experience would seem to indicate that no addition to transit facilities accelerates the ordinary growth of business."

It is true, in the case of Boston, that without such additional facilities, the normal business increase could hardly have been realized through lack of physical space; but from the investment standpoint, the point of view of net financial results, the change was decidedly for the worse. Certainly three additional passengers per half trip do not begin to compensate for such an enormous increase in investment, practically forced upon the company by municipal plans. Naturally, the number of half trips was increased many fold; but it must be remembered that any increase in operation brings a like increase in operating expense, in equal, or, as in the case in point, even larger ratio. And that the slight increase of income is not only burdened by the extra operating expense, but by the heavy augmentation of fixed charges, of which the city share, or subway rental, forms a lien prior to any other obligation.

There is no particular reason to believe that subway operation in Los Angeles with considerably less congestion, with only 1/8 as much congested area, and but 1/3 the city population, would produce any more favorable results. If, for the purpose of discussion, it is assumed that the present southward trend of business be abruptly checked and retail commerce, at least, be confined within its present limits, it is only necessary to estimate roughly the probable cost of sub-surface construction through such district to ascertain the amount of patronage necessary to justify the investment from the view-point of private capital, or its operation by the present company under a leasing arrangement similar to the system now obtaining in eastern cities.

Following the present routing with two-track tunnels on Main, Spring and Broadway, from 11th and Main to the Temple block junction, together with cross town tunnels on all east and west streets except Sixth, emerging through inclines between Olive and Hill streets on the west, and Main and Los Angeles streets on the east, (see detail in "Cost of subways."), gives, approximately, a total of five and seven tenths (5.7) miles of structure. A system of this magnitude would serve to eliminate all surface trackage in the present retail area except on Sixth and on Hill streets. Sixth street, between Olive and Main, is used exclusively by the Pacific Electric. Hill street, while utilized as an outlet for both urban and inter-urban cars, is not deemed sufficiently congested to be included in this study. Both streets, however, together with Main street between First and Ninth, will be further considered under "Rapid transit."

The probable construction cost of two-track tunnel large enough to accommodate the present surface cars will average approximately, according to experience elsewhere, $1,500,000.00 per mile of structure. Neglecting the additional cost of station platforms and stairways, realty and easements, etc., 5.7 miles of such construction would represent an investment of $8,550,000.00. If it is assumed that the cost of surface and subway operation will cancel, an erroneous assumption, since the problems of station operation, ventilation and lighting are all foreign to surface maintenance, there must still be considered the payment of interest on the capital invested, plus sinking fund percentage. If money be secured at 4% on city credit, and the sinking fund, or amortization percentage placed at 1%, the usual figure, then 5% on $8,550,000.00, or $427,500.00 must be paid annually for the privilege of riding underground. Reduced to the fare basis, such over 25,000 extra revenue passengers per working day. (340 working days are considered the working year by transportation companies, Sundays being taken as half days). The word "extra" is emphasized as it must be understood that the patronage represented by these 25,000 passengers is over and above the number ordinarily riding. In other words, the construction of such a sub-surface system must increase the riding habit of the entire population by 6.2 per cent, over and above the natural increase, in order to defray the interest charge and provide a sinking fund adequate to retire construction bonds in an hundred year period.

It is hard to see just how this could be accomplished, It is, of course a fact well borne out by the experience of all cities, that the providing of rapid transit facilities is followed by an increase in the general riding habit. Mattersdorf endeavors to prove that the relation of city traffic to its population varies as the square of such population; while the N. Y. Public Service Commission, in an analysis of New York City growth, arrives at the conclusion that traffic increases at a per cent rate of about twice that of the increase in population. The lack of similarity in regulating conditions makes it probable that no hard and fast rule can be laid down that will apply to all cases. It is in general the change from town to city, the change from walking to riding rendered necessary by the growth of the city, that causes an increase of traffic at a greater rate than population. The individual does not make more trips from home or place of business than when he walked, but the greater distances involved by city growth render riding imperative to save time. One thing, however, is apparent, that such city growth and traffic increase, while the natural consequence of rapid transit, can never be effected by mere sub-surface diversion through limited territory. Increase of patronage, or the habit of using any means of transportation is mainly realized through the establishment of more comfortable riding conditions, the time saved by greater speed, or the removal of patrons beyond the limit of pedestrianism. Any one familiar with subway travel knows that it is not a particularly comfortable method of transit. The noise, heat, and lack of ventilation render it the reverse of popular when other means are available. The time gained by its use is the factor which contributes most largely to its prosperity in large cities, but this element is absent, or nearly so, when a subway is used for the operation of surface cars. When it is realized that the present running time of cars in the business district of Los Angeles is only, including stops, one minute per block, it will be readily seen that there can be but little change in schedule. Again, the fact that 20 or 25 feet of stairway must be negotiated on entering or leaving the structure is a distinct detriment to the comfort of the average individual. Stairways grow slippery with moisture and usage, and accidents are numerous. Escalators, or moving staircases, would be out of the question here, on account of the number required. It must be kept in mind that a subway for surface cars in no way reduces the number of necessary stops, and is not comparable to a rapid transit line whose shortest station interval, even for local work, is rarely less than one quarter mile.

There is, then, no particular time saving and a decided decrease in convenience. With the two factors most productive of business increase practically eliminated, from what source could the requisite income emanate? There is no credible reason for any belief that it would be produced. Transportation would be rendered no easier from the public standpoint. There would be no more cars, no shorter routes. While the obstruction to loading and unloading by other vehicles would no longer exist, the lessened danger to passengers would be more than offset by the risk of being pushed from a crowded platform in front of a moving car, and the discomfort of ascending and descending stairways made slippery by weather conditions and the tread of countless feet. That portion of the population who found it necessary to ride, would ride; but the total number would not exceed the number which would have been carried had the cars been operated on their former level. It is more than probable that the gross receipts, instead of increasing, would show a considerable decrease, as many people who had hitherto resisted the importunities of the motor buses would prefer crowded and uncomfortable riding conditions in the open air to transit and delivery beneath the surface of the ground.

If there is no reasonable expectation of any accession of income, it will be readily seen that private capital, as represented by the transportation company, could not afford to shoulder the responsibility of meeting the annual interest and amortization charges caused by such construction. The margin remaining after the deduction of the operating expenses of an electric surface railroad is altogether too slight to carry other than its legitimate burden without additional compensation. Few patrons of the present system realize that 3-3/4 cents of their 5 cent fare is required to defray actual running expenses, leaving but 1¼ cents to cover rentals, sinking fund, and bond interest ~~and dividends~~, to say nothing of surplus. Inspection of recent balance sheets can but convince the most skeptical that this percentage is insufficient to insure even a moderate return on the investment and is entirely inadequate to meet any further demands.

If the railway company cannot afford to pay these charges, there only remains the city to defray them through additional taxation, recouping itself through possible increase in assessed valuations along the route. While such increase would undoubtedly occur if the business area served was restricted and immutable, it is improbable that there would be any lasting rise in realty values when such area is capable of indefinite expansion. With the latter condition and a constant increase of business and demand for convenient business locations, the center of activity at present obtaining could only be temporarily restrained from southerly movement. The subway system, then, as herein outlined, would be sooner or later entirely removed from the scene of any possible congestion, representing only an economic waste and an irreparable civic blunder.

SUBWAY DESIGN

CONSTRUCTION REQUIREMENTS

AND DIFICULTIES.

Sub-surface accommodations for transit facilities may be divided into two classifications; shallow and deep level construction. Both are sub-ways, but the modern interpretation of the word has come to signify a railway built as close to the ground surface as possible, with staircases affording ready access to stations. Deep level construction is principally exemplified by the London "Tubes," or tunnels driven through the thick bed of firm clay which underlies the entire city at an average depth of 70 feet, such tunnels being lined by cast iron segments bolted together to circular form. Stations are formed by enlargement of the section, and elevator systems, furnish transportation to and from the street.

While deep level tunnels have been definitely disapproved by the great majority of subway engineers, there were many good reasons for their adoption in London. English laws are far more drastic on the subject of property rights than are American, the custom of condemnation of private property and valuation by appraisement for the accommodation of public utilities being unheard of, and each property owner being the sole judge of the monetary value of right of way or easements. Cellars extend beyond the sidewalk lines and are protected by ordinance and custom; unlike New York City which held that house vaults (cellars extending beyond the property line) were not property, but were maintained only on a revocable license from the city. The streets are narrow, there being but three thoroughfares, even as late as 1908, 100 feet in width, while those as wide as Broadway in New York City (80 ft)

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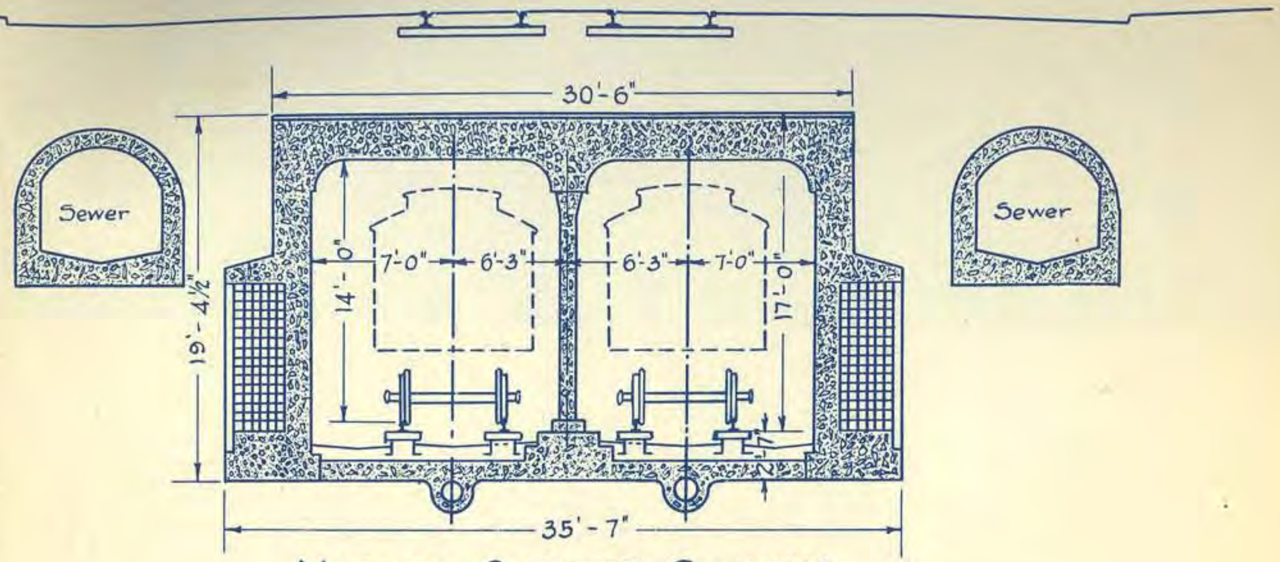
Buda Pesth was the first city to adopt the shallow subway section, a line being constructed from the center of the city to public gardens several miles distant in the center of a broad thoroughfare, with such distinct saving in construction expense that its example has been followed in practically all similar work since that time. Boston was the first American city to construct such transit facilities, demonstrating the fact that cut and cover work, even in soft and permeable soils can be sufcessfully carried on even in sections as congested as the London streets. Paris has built extensive subway lines of this type, Philadelphia a few miles of a proposed comprehensive sub-surface system, while Berlin, Hamburg and other European cities possess similar lines of moderate mileage. New York City, beginning in 1900, constructed approximately 73 track miles of shallow type rapid transit road, combining both subway and elevated forms of construction, and is now, under the present plan and in connection with the operating companies, expending $330,000,000.00 additional in the building of 260 additional miles of track. This, when complete, will have a capacity of three billion passengers per annum, or, expressed in another way, the ability to transport ten million passengers from the residence section to the community center and back again in a single day, affording practically everyone a seat. The mileage of the completed system will exceed the combined rapid transit mileage of all other cities in the world, and is unique in being the only installation to combine express service with local traffic, a feature which has proved to be the deciding factor in its financial success.

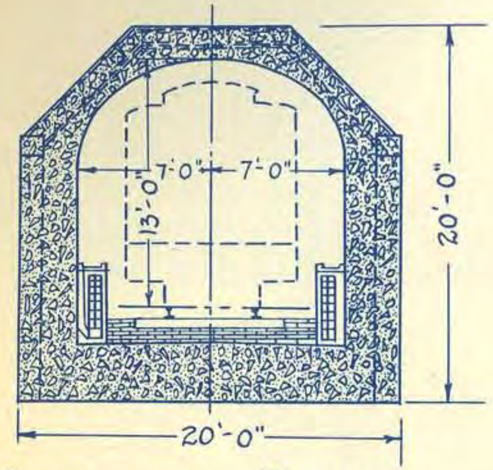
STRUCTURE:

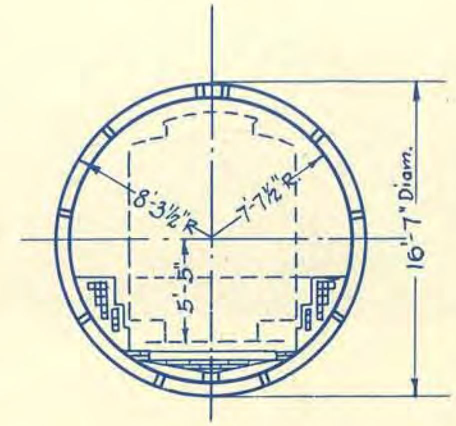
The character of the section developed for the use of subways in different cities has naturally varied according to the sizes of rolling stock proposed to be employed, the topographical features encountered, and the plans of the designer. Plate # 5 shows typical sections employed in the several localities. It will be readily seen that arch construction, while probably affording better ventilation, is not possible in restricted rights of way or under narrow streets, being objectionable on account of the massive abutment walls required and the necessarily added distance from street to platform. The arched roof is applicable to tunnel construction, or in certain locations affording unlimited head room, and in such cases is more economical, on account of the saving in reinforcement, the quantities of excavation and lining being practically identical. The circular section is, of course, only applicable in the case of extraordinary hydrostatic pressures, such as are met with in underground river crossings in permeable soils. The flat or nearly flat roofed structure, reinforced sufficiently to withstand the expected loads, insures the least possible distance from street to platform level, reduces the construction quantities to the minimum, and affords the maximum of convenience.

Live loads that may be imposed on a subway roof are of

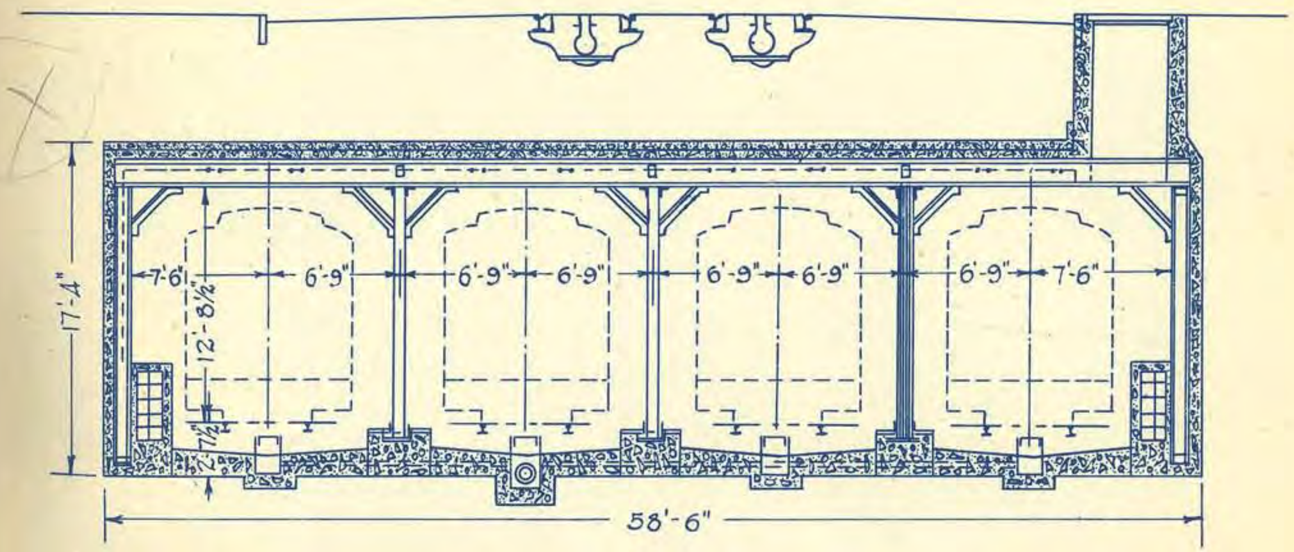


MARKET STREET SUBWAY
PHILADELPHIA, PA.

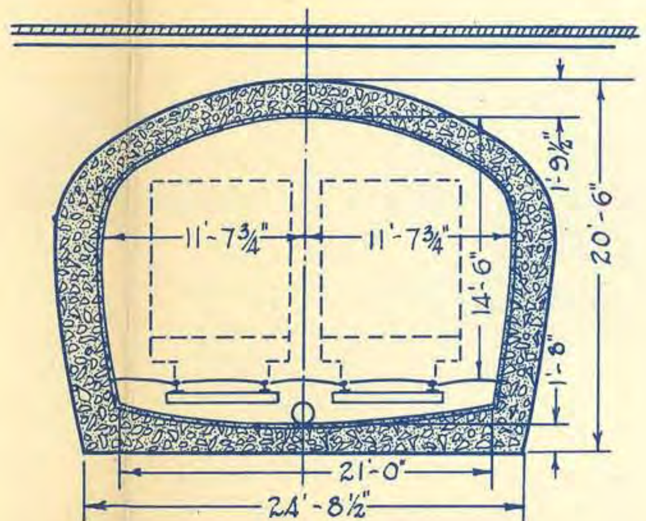




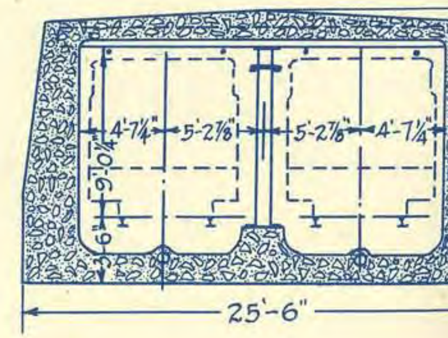
CONCRETE TUNNEL IRON TUNNEL
HUDSON & MANHATTAN RAILROAD
NEW YORK.



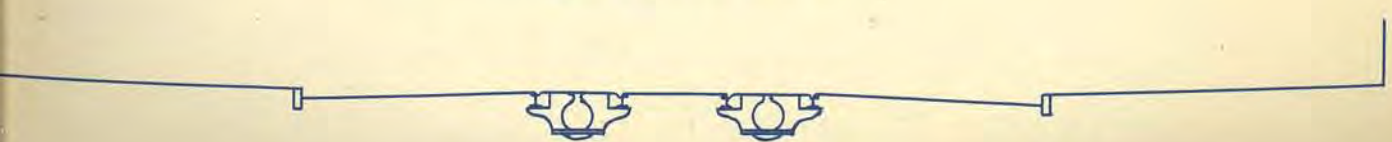
NEW YORK RAPID TRANSIT, SUBWAY SYSTEM.
TYPICAL 4 TRACK SECTION ABOVE WATER
CONTRACT NO. I.

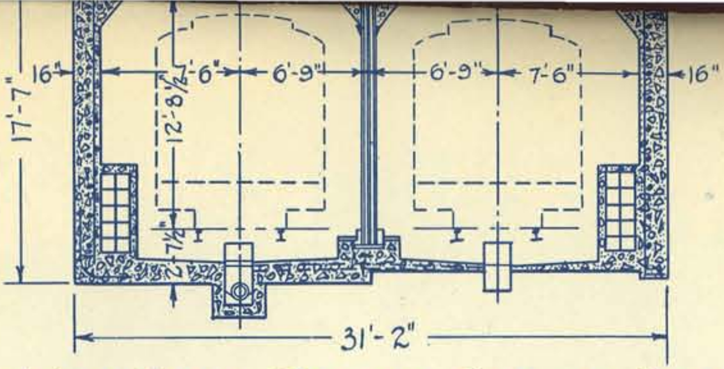


METROPOLITAN RAILWAY.
OF PARIS
FRANCE.

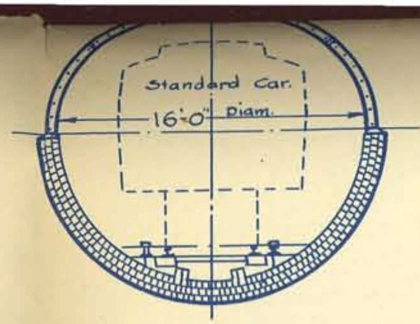


BUDA-PEST SUBWA
BUDA-PEST
AUSTRIA.

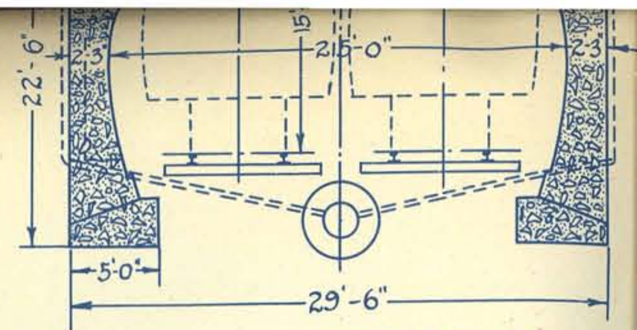




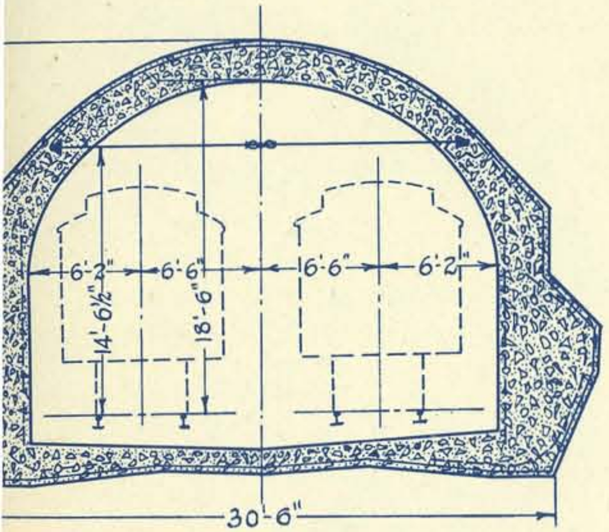
NEW YORK RAPID TRANSIT SUBWAY SYSTEM.
TYPICAL 2 TRACK SECTION – LEXINGTON AVE.



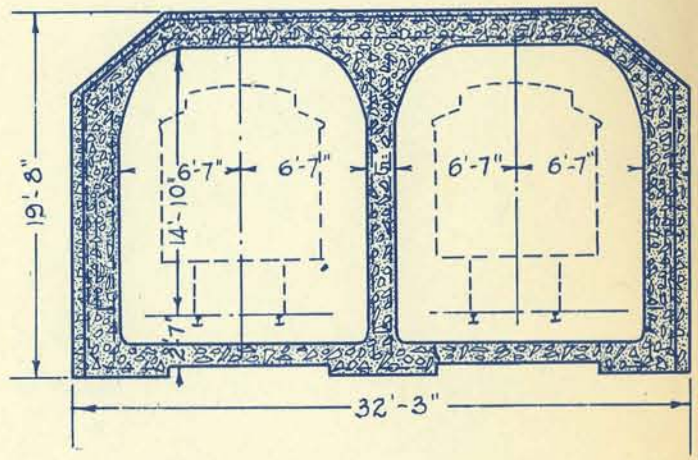
GREAT NORTHERN & CITY RAILWAY.
LONDON, ENGLAND.



METROPOLITAN & DISTRICT
RAILWAY OF LONDON.



BOSTON SUBWAY.
WASHINGTON ST. TUNNEL.

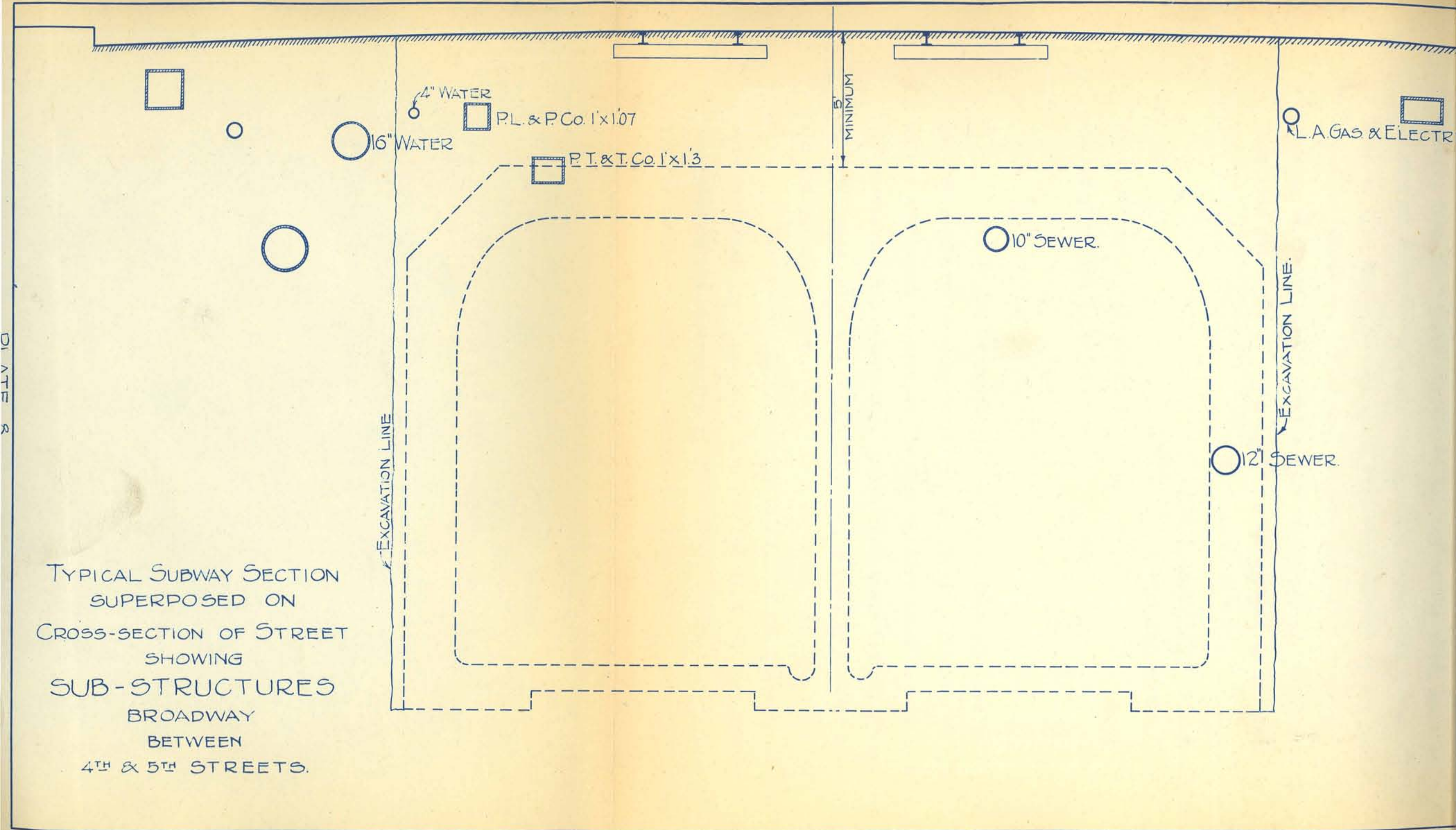


BOSTON SUBWAY
CAMBRIDGE CONNECTION NEAR BRIDGE.

TYPICAL CROSS SECTIONS OF AMERICAN AND EUROPEA SUBWAYS

PLATE 5.

PLATE 8



TYPICAL SUBWAY SECTION
SUPERPOSED ON
CROSS-SECTION OF STREET
SHOWING
SUB-STRUCTURES
BROADWAY
BETWEEN
4TH & 5TH STREETS.

three kinds; rolling loads of heavy vehicles such as trucks or surface cars; the shocks due to falling walls as the result of fires; and piles of building or other materials. The depth of cover, from the street surface to the top of the roof, must be sufficient to distribute the concentrated loads over a wide enough area to make the effect upon the roof construction of the least possible intensity. It is also obvious that there will be a greater loading at the sides of streets than at the center, which must be kept open for traffic. Such loads may be assumed as follows:

	Center of street.	Side of street.
	Pounds per square foot.	
Heavily congested district	750	900
Medium congested district	500	650

It should be remembered, however, that the area of congestion in a new, or comparatively new, city, is subject to change unless absolutely restricted, so that maximum loads should be assumed in practically all such cases. Total roof loads naturally consist of live loads, plus the weight of cover, generally assumed to be 100 lbs per cubic foot.

Roof construction, as may be seen in the sketches of the Buda Pesth and first New York subways (See Plate #5) originally consisted in the superposing of steel beams transversely across the line of track, the end and central supports being built up columns of standard angles and intermediate plates. Wall columns and roof beams were surrounded by poured concrete, such beams being stiffened laterally by short jack arches. Central columns or supports between tracks, were in some cases left exposed, but the more recent practice is to surround them with concrete to prevent corrosion. Modern subway plans call for reinforced concrete roofs, altho' structural members are used for girders in all conditions of heavy stress. The thickness of the roof naturally varies with the amount of cover. New York plans specified 18½ inches for 5 feet of cover, increasing to 21½ inches with a 10 foot depth. In the design of such roofs, from 500 to 600 lbs. per square inch is allowed in compression on the concrete, and 12,000 lbs. per square inch tension on the steel.

Walls are built according to the space available, the amount of cover, and the probable strains to be expected. Structural members are used in thin walls to make up any deficiency in strength of section, but the ordinary wall, where there is no lack of room, is the usual reinforced type, calculated to withstand the thrust of the earth backing, and, possibly, eccentric strains from contiguous future excavations for foundatinns or sewers. New York subway walls were made from 14 to 16 inches thick, increasing where deemed necessary. Inverts are built flat, or nearly so, of a thickness varying with the underlying material, heavily reinforced where the gradient carries the structure below ground water level and introduces hydrostatic pressures. I beams were used in the heavy ground encountered in New York, the beams extending from column to column, and encased in 15 inches of concrete, instead of the usual 8 inch floor.

The following table illustrates the comparative cost of the two methods of construction, by giving the quantities of the principal items in a typical section with the same amount of cover.

TABLE #5.

	Beam Construction.			Reinforced concrete.		
	2 tracks	3 tracks	4 tracks	2 tracks	3 tracks	4 tracks
Excavation, Cu. Yd.	22.2	32.0	41.7	22.8	32.5	42.3
Concrete, Cu. Yd.	5.7	7.7	9.6	6.3	8.3	10.2
Steel, Tons (2000#)	0.38	0.56	0.74	0.74	0.46	0.62

The reinforced concrete method calls for a trifle more concrete but less metal, and the metal used costs less per pound.

WATERPROOFING:

Wherever the subway gradient drops below ground water level, means must be taken to render the structure impervious to moisture, or as nearly so as is humanly possible. Damp walls naturally increase the humidity and add to ventilation difficulties, besides providing ideal conditions for various species of foul smelling fungus growth, difficult to eradicate. Accepted practice, under ordinary conditions, consists of building into the invert, walls and roof a continuous course of asphalted felt and asphalt. The former is generally the ordinary roofing felt paper, weighing 12 to 15 lbs. per square; while the asphalt is much purer than the usual commercial grade, and is mixed with either a flux of petroleum residuum or with powdered limestone or sand in the case of low or high temperatures in order to maintain the proper degree of fluidity.

As generally applied, a bed of concrete half the calculated invert thickness is laid in the bottom of the excavation, upon which a layer of hot asphalt is spread. While still hot, a layer of felt is placed, followed by alternate thicknesses of asphalt and paper to the extent required by the conditions obtaining. On top of the last course is laid the upper half of the subway floor. To waterproof the walls the same course if carried upward. A half wall of rough concrete, or hollow tile set vertically to serve as drain, is constructed, and the combination of paper and asphalt is carried to the roof line. The roof, or cover, is finished in the same manner, the waterproofing being applied after the roof concrete has thoroughly set, the final result being that a continuous envelope of waterproofing material surrounds the entire structure. In order to protect the roof waterproofing from damage by subsequent street excavation, a layer of concrete 3 to 4 inches thick is usually spread over it.

This method of keeping a subway dry has been demonstrated to be entirely satisfactory under moderate hydrostatic pressure. Where higher pressures are encountered, porous bricks are used, being dipped in liquid asphalt and then laid inntwo or more layers, with broken joints. After laying, hot asphalt is poured over them, filling all spaces.

STATIONS: (~~See Plate #6~~)

The basis for the design of all stations serving subway traffic is the location of all platforms as close to the surface of the street as is possible, so as to give the minimum height of staircase from platform to sidewalk and avoid the use of mechanical means of ascent and descent. Subways with three, four or more tracks, used for express as well as local service, are necessarily obliged to depress the rail level at stations in order that overhead passageways may be constructed to the island, or intermediate platforms. Sub-passages below the tracks are rarely used and are seldom practicable, though the chief objection lies in the added length of stairway climb. The amount of earth covering, or distances from the top of the roof to the street surface, necessarily regulated by the design of the structure; the roof thickness, and the overall dimensions of the standard equipment are the controlling factors in fixing stairway heights. In a subway diversion of surface cars, through a business district, such as might be planned for Los Angeles, if the minimum cover be taken at five feet, this height would approximate 20 feet at the shallowest points, increasing wherever drainage crossings, etc., rendered a change of grade expedient. The cover on the New York subway averaged 6 feet, making the shallowest distance from sidewalk to top of rail, 17 feet.

Subway stations are simply sectional enlargements whose width varies with the number of tracks. Cast iron, built-up, or reinforced concrete columns, set back a sufficient distance from the platform edge, carry the necessary roof beams. Platforms are of such length and width as may be required to carry expected traffic, the edges projecting nearly to the line of car clearance. Eastern subways platforms intended for local traffic average 200 feet in length, the central 100 feet being 20 feet wide, narrowed to 10 feet at either end. Stairways for ingress and egress are usually five feet wide, leading from the sidewalks to the platform center. Stairway entrances are protected by Kiosks, constructed of steel and wire glass. The stairway treads are usually built of reinforced concrete, properly supported, any open sides being protected by wrought iron grills.

PERMANENT WAY:

Permanent way, on sub-surface trackage differs but little from ordinary street railway construction, with the exception that no paving is required. Ties and rock ballast are generally employed, although Philadelphia has adopted the plan of eliminating both, securing the rails to concrete blocks spaced at regular intervals, claiming that such construction prevents rail corrugation and its attendant noise. The general practice, however, is to use untreated ties, the odor arising from creosoted timber being objectionable in such confined quarters, with sufficient ballast to afford good bedding and a certain amount of elasticity. Drainage is taken care of in the construction of the invert, All water being led to sumps provided with automatic ejectors connected with contiguous sewers. Spécial work at grade crossings, in the case of surface car diversion, is of course, identical with original surface layouts.

VENTILATION:

One of the most important factors in the successful operation of any sub-surface means of transit is the provision of adequate and satisfactory methods of ventilation. In a long or extensive system that is a prime consideration. In a simple diversion of surface cars it is probable that sufficient, or nearly sufficient ventilation will be accomplished by natural means; but any structural design should embody provisions for an abundant supply of outside air in order to offset the effect of possible future extensions.

All subways grow warm with age. The temperature is normal for the first few months, or even longer, depending on the service; but in time the walls and surrounding material become saturated with the heat generated by the consumption of electrical energy. It is evident that such heat must either pass through the walls and their backing, or else escape with the air. A structure on first use will be able to absorb any heat which is not carried away through ventilating passages; and, if surrounded with wet or moist material the conductivity will be considerable. If the backing be dry, however, and the ventilation insufficient, the heat will gradually accumulate, only partially relieved by any change in outside temperature and uncomfortable riding conditions will result. In this connection, the importance of proper waterproofing will be readily seen. Any moisture penetrating walls, roof or invert is transformed into aqueous vapor, creating extraordinary conditions of humidity, and making for the discomfort of occupants of cars.

Increase of temperature, however, does not necessarily imply vitiation of atmosphere. The increase in the percentage of carbon dioxide (carbonic acid gas) in warm subway air is relatively small and not to be compared with conditions commonly obtaining in schools, theaters and other public places. Analysis made under the direction of the Boston Transit Commission showed as follows:

	Parts in 10,000 volumes.	
Boylston street station, 5 ft. above platform	9.45	Samples taken between 5 and 5;30 P. M. on January week day.
Track between stations	6.54	
Park street station, 5 ft. above platform	7.78	
Adams sq. station	6.62	
Haymarket station	9.13	
On street in central part of the city	4.5 to 5.9	Made at same time.
In center of car about to enter subway	24.97	Car contained 65 passengers. Forward ventilator closed. Rear ventilator open.
City Council chamber, 2/3 full	10.12 to 14.6 - Floor. 13.22 to 18.6 - Gallery.	

	Parts in 10,000 volumes.
Public Hall, near open door with in-draught	13.93
Public Hall, well filled	32.59 - Floor 36.43 - Gallery
Four theaters	16.16 to 48.7
Two churches	12.45 to 18.2
Twelve schools	7.1 to 23.5

In this connection, it may be remarked that people remain several hours in the rooms referred to, while a passenger ordinarily remains in a subway but a few minutes.

Possibly the most thorough investigation ever made of subway ventilation was undertaken by the officials of the New York subway, occasioned by complaints of patrons and unfavorable comment by the press. Heat became noticeable after five months service and caused a popular belief that the air was vitiated. The highest professional talent was engaged and a comprehensive program arranged, involving study of prevailing conditions in both America and Europe. Five thousand determinations were made of temperature and humidity, two thousand samples of air analysed for carbon dioxide, and 3,000 bacteriological examinations undertaken. Microscopic examinations were made of the atmospheric dust and studies effected of the force and direction of air currents set up by moving trains, the utility of fans and blowers, the results of cleaning processes, the efficiency of chemical disinfectants, and the longevity of bacteria under sub-surface conditions.

The results of the investigation were, briefly, as follows: Temperature studies showed conclusively that the degree of heat within the structure, as compared with the outside air, was greatly exaggerated, the average difference being only four or five degrees Fahrenheit. The greatest difference was 15 degrees Fahrenheit, occurring during a sudden cold snap in November . Outside thermometers at this time showed an average reading of 50 degrees Fahrenheit, making the subway temperature the very comfortable figure of 65 degrees Fahrenheit. The heat was found to emanate almost entirely from the electrical equipment, the amount of bodily heat from passengers being negligible. The most objectionable feature of the heat was less the actual elevation of the temperature than the fact that the subway remained warm continually while the streets, during the summer nights, became relatively cool. It was at such times that the greatest inconvenience was experienced. In winter the heat given off was advantageous, since if low temperatures occurred, they would, with strong drafts, render riding conditions uncomfortable. During the hottest week of such investigation the street temperature averaged 78 degrees and two tenths, while subway temperature averaged 83.4 degrees, Fahrenheit. The relative humidity was slight, the actual weight of aqueous vapor being practically identical in subway and outside air. When the temperature was higher in the subway than in the street, the humidity was more noticeable within the structure, and vice versa.

Chemical analyses showed that the air was not deficient in oxygen and that carbon dioxide from the lungs of passengers was not present to an objectionable extent. The highest amount of CO_2 found was 8.89 parts per 10,000, the average being 4.81, while the average for street air was 3.67.

Bacterial analyses showed only one half as many bacteria in the subway as were present in the outside air.

The impurity most noticeable in microscopic examinations of the air was iron dust, caused by the wear of metallic surfaces, principally brake-shoes. Investigation developed the fact that the consumption of the latter amounted to one ton per month. This dust is found in all subways and the amount contained in the New York subway air was practically equal to that contained in the Paris subway air. Examinations of employes did not show that it caused any ill-health effects, though the time occupied in the investigation was not of sufficient length to render this conclusive.

It was found that the principal causes of the local subway odor were the oil drip and consumption of lubricants by hot wearing surfaces. A large number of disinfecting machines were installed at the inception of subway service, but were soon discontinued, as the results were found to be more objectionable than the conditions they were intended to correct. Washing down of stairways and platforms was also found to be the reverse of beneficial, the cooling effect of evaporation being negligible and the escaping water vapor adding to the humidity.

Actual ventilation was demonstrated to be principally accomplished by the action of trains upon the atmosphere, the latter moving freely through sufficiently large openings to the outside air. For a given volume of air space in any section it was found that a certain calculated area of opening was necessary; and that success in subway ventilation lay in arranging openings to the outside air so that they should be of proper area and location. Experience with conditions encountered in New York showed that, beside the amount of ventilation which took place in this way, the exchange of air which could be produced by means of mechanical blowing devices was immaterial.

In connection with the subject, it may be of interest to note that the average temperature in the London "Tubes" is 68 degrees Fahrenheit. Ventilators are provided wherever possible; and, in order to prevent any accumulation of carbon dioxide, the station doors are closed each night and approximately all air is exhausted, the process continuing until an amount equal in volume to three times the cubic contents of the tubes has passed the pumps.

SUBSTRUCTURES:

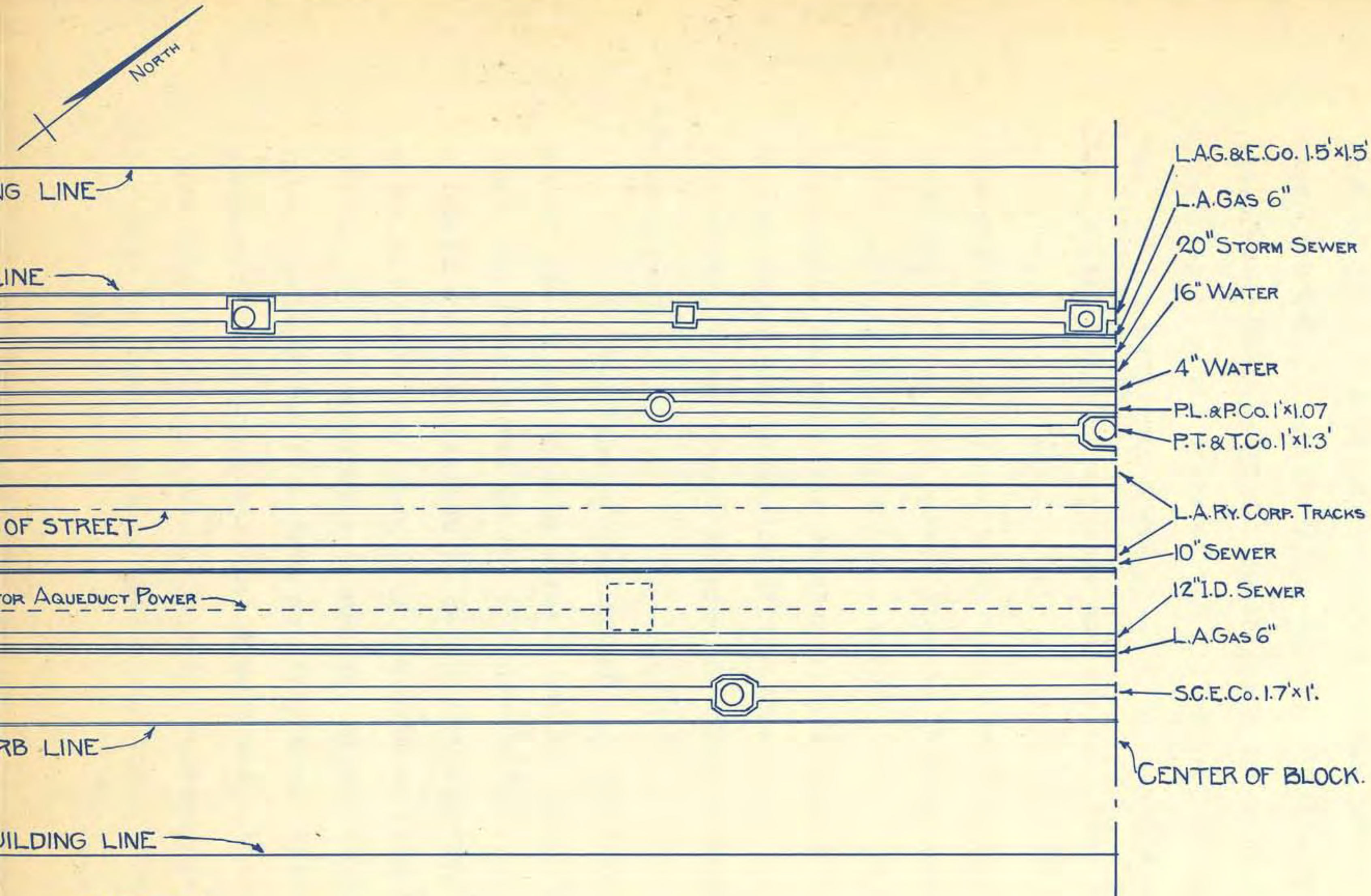
As may well be imagined, the problem of the disposal, temporary removal, or rearrangement of underground structures, contributes one of the most important items of the expense incurred in subway construction. The tangle of gas, water, steam and cold storage pipes, the various conduits carrying the wires of the sanitary and storm sewers, occupy a large portion of the street area and form serious obstacles in the case of narrow thoroughfares. An additional difficulty lies in the fact that few cities possess accurate records of the structures underlying street surfaces, the necessity for such records not becoming apparent until proposed subway or similar underground construction renders the acquisition of such information imperative in order to estimate the probable cost. So called underground surveys are usually taken up at an advanced point in the City's maturity and all possible data collated from the available private company records. The result, however, is far from satisfactory, and a liberal allowance must be added to any preliminary estimate to cover the handling of unforseen contingencies. Generally speaking, the most serious limitation to rapidity of subway construction is the time required to readjust sub-surface structures.

As practically all these pipes and conduits are laid at an comparatively shallow depth, the simplest solution of such difficulties would seem to be the lowering of the gradient to a point so that the subway roof could be built below their level. This, however, would practically nullify the object attempted, namely; to construct transportation facilities at the minimum depth below the surface. Each foot of extra depth means just that much extra climb from delivery platform to the surface, besides materially adding to the quantity of excavation, thus increasing cost and decreasing convenience. This is especially true in the case of a sub-surface trolley car diversion, as the necessary head room, or distance from top of rail to roof, must be, through equipment requirements, considerably in excess of a subway built for specially constructed cars. Thus, the New York and Philadelphia subways are operated with from 12' 8" to 14 feet of head room, power being obtained through a third rail, allowing the construction of passenger platforms at easy walking distance fromnthe sidewalk level. An overhead trolley car, however, of the type generally operated in Los Angeles, measures 14' 5" from the top of rail to the top of the hooked, or unused trolley, necessitating a clearance of not less than 16 feet from trolley wire to rail for successful operation. If the minimum cover, say 5 ft, and 1½ ft of roof thickness be added, the vertical height of stairway from platform to street would be not less than 20 feet at any point.

An additional objection to the lowering of a subway structure lies in its interference with drainage problems. While service conduits, gas and water pipes, may follow the natural gradient, sewer grades are practically fixed within certain limits by the topographical conditions. Reconstruction to suit subway convenience may entirely derange a well formulated civic plan; and, if the grade be slight, prove impossible. It is, however, entirely practicable to construct sewers of a limited size as an integral part of the subway walls, and such procedure has been followed in both New York and Boston. When drainage must be passed across the line of subway and the clearance from roof to street surface is insufficient, the points of crossing are made as few as possible by constructing intercepting sewers on the upper side and conducting the drainage to a few chosen points. Manholes are built at such points, leading to chambers connected with pipes passing beneath the subway floor. In general, all longitudinal sewers along the line of subway are made as small as possible, being relieved of their contents at crossings by lateral drains. As an example of what sewer reconstruction may amount to, it may be interesting to note that in fourteen miles of cut and cover work on the New York subway, 17 miles of sewers, ranging in size from 15 feet to six inches, were entirely rebuilt.

Gas and water mains are easily handled and replaced. As they are seldom of large diameter, it is usually possible to carry or cross them above the subway roof level, either in their original form or by dividing them, in the case of a shallow crossing, into a number of smaller pipes whose aggregate capacity equals the required flow. Some cities specify that no water or gas mains shall be carried beneath the subway floor, although the plans for the New Philadelphia improvements provide for a pipe gallery directly beneath the tracks, large enough to carry a number of large diameter mains. During construction, especially in narrow streets, where it is not possible to replace them between the curb and subway wall, it is customary to suspend all mains on trestles at the side, thus maintaining temporary service. It is generally deemed unsafe to permit the maintenance of gas mains beneath the wooden roof, or temporary street surface used during construction, as accidental breakage, injury or leakage might cause a severe explosion, heavy construction damage and serious loss of life. Service conduits containing the cables of different utility companies are not difficult to deal with, being either moved bodily to their new location, the cables being cut and respliced, or else supported temporarily above structural lines until subway completion, the cables being then drawn through ducts built in the subway walls. Steam pipes supplying live steam at high pressure from a central plant, are probably the most dangerous of all substructures to readjust, as a break would fill the excavated section beneath the temporary roof and result in the fatal injury of all those in the immediate vicinity.

The streets of the business district of Los Angeles, on account of its relatively smaller population and comparatively recent growth, do not begin to be as thickly underlaid with sub-surface structures as the streets of the older municipalities previously mentioned; yet, taking into consideration their lesser width, (Broadway, New York City, is 80 feet and Broadway Los Angeles is 56 feet between curbs), the percentage of occupied area is practically the same. A state law enacted for the protection of workmen provides that no excavation for the installation of sub-surface utility conduits or manholes shall approach more closely than two feet from the outer edge of the outer rail of the street



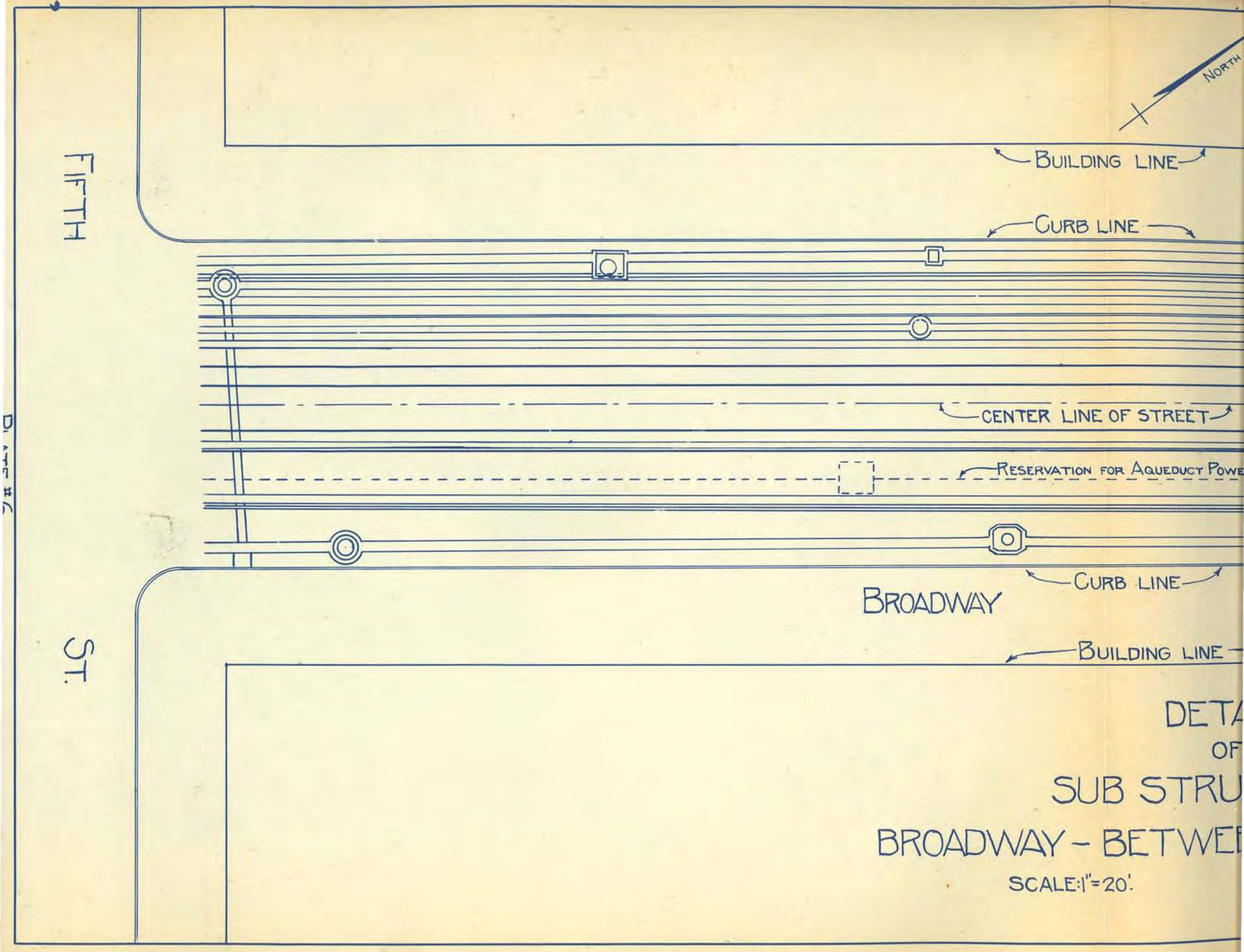
DETAIL

OF

B STRUCTURES

BETWEEN 4TH AND 5TH STS.

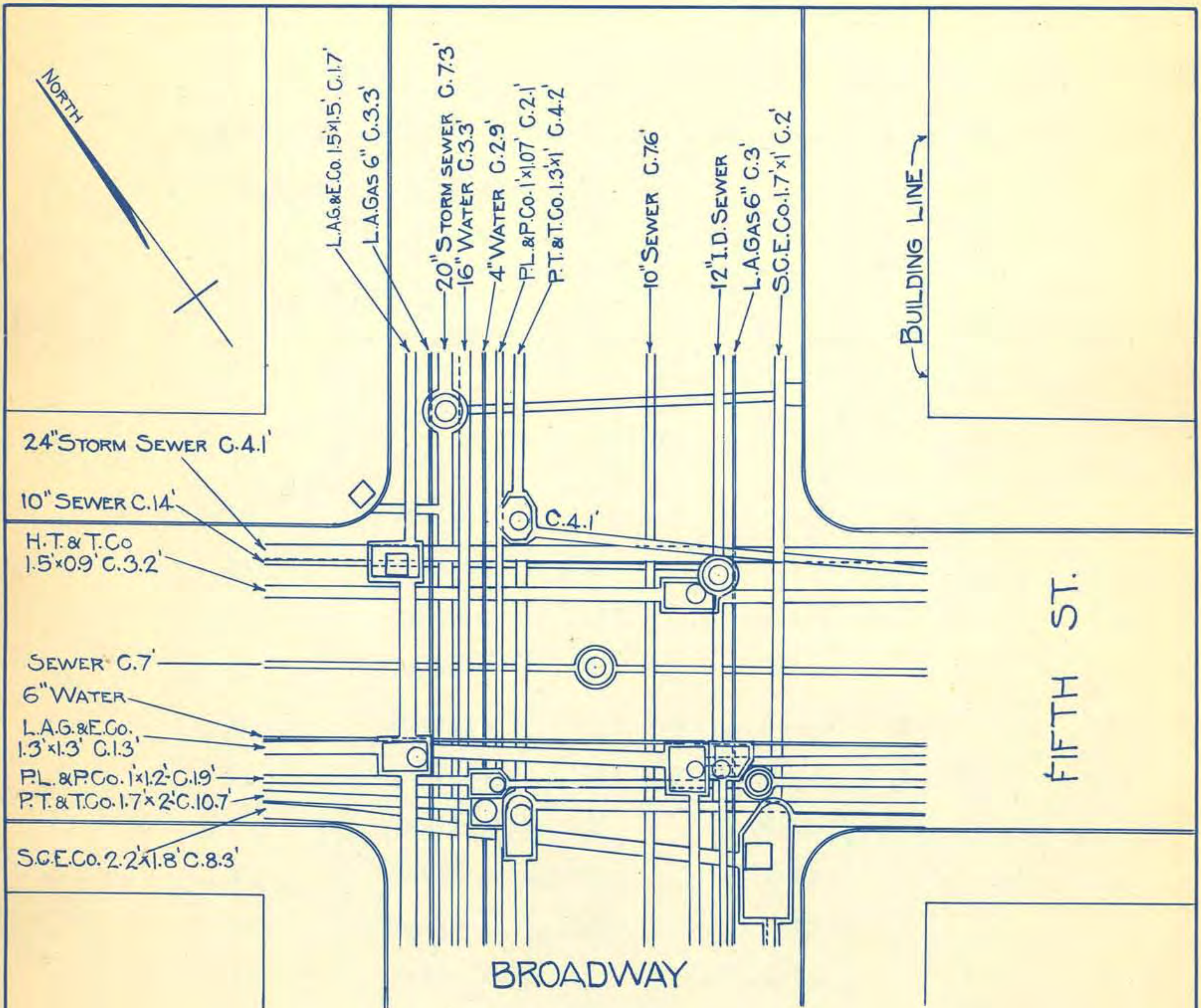
20'. OCT. 19, 1915.



NORTH
BUILDING LINE
CURB LINE
FIFTH
CENTER LINE OF STREET
RESERVATION FOR AQUEDUCT POWE
CURB LINE
BROADWAY
BUILDING LINE
ST.
DETA
OF
SUB STRU
BROADWAY - BETWE
SCALE: 1" = 20'.

car track, which has resulted in the preservation of practically 19 feet of clear ground in the center of each thoroughfare, the only exception being that of Spring street, which carries a 12" sanitary sewer at an average 10 ft. depth below the center line. As usually constructed, a two track subway will occupy 30 feet of street width; and, if its center line was planned to coincide with the center line of the street, only five and one half (5½) feet on either side would need to be cleared. This would necessarily involve some re-arrangement of pipes and conduit systems, but the cost would not be excessive. In a more narrow street, however, such as Fourth, which measures only forty feet between curb lines, only five (5) feet of space would be available between such curb and the subway wall, necessitating the deepening of the excavation and consequent lengthening of stairways to provide adequate pipe room above the subway roof.

A fair idea of the number and relative location of sub-structures in Los Angeles streets may be gained from the following list, and from Plates #8 and #9, showing same in plan, together with a detail of the situation at Fourth and Broadway. The information given and shown was taken from the maps on file in the City Engineer's office, and is presumably accurate. As the maps, however, are of recent compilation from data gathered from different utility company records and occasional street excavations, it is possible that other pipes or sewers, laid in previous years and unrecorded, may also be encountered if excavation for a subway is undertaken.



DETAIL

SHOWING PRESENT ARRANGEMENT OF

SUB STRUCTURES FIFTH AND BROADWAY

C = VERTICAL DISTANCE BELOW SURFACE.

SCALE: 1" = 20'. OCT. 18, 1915.

PLATE #7

List of substructures on Broadway between 4th and 5th streets. Distances from east curb line, beginning at approximately the center of the block:

Distance out from curb. Ft.	Kind.	Size	Owner	Distance Below surface Ft.
4	Conduit	1' x 2'	So. Cal.Ed. Co.	2.8
7	Conduit	1' x 1'	L.A.I.& C.S.Co.	4.3
8	Gas main	6"	L.A.G. & E. Co.	
11	Sewer	12"	City	15.6
14	Conduit	1.3' x 1.3'	L.A.G. & E. Co.	1.3
17	Sewer	12"	City	8.0
40	Conduit	1' x 1.5'	P L & P Co	1.8
44	Conduit	1.5' x 1.5'	L.A.G. & E. Co.	2.3
46	Water main	16"	City	
49	Water main	4"	City	
50	Sewer	20"	City	7.0
51	Water main	6"	City	
53	Conduit	1.5' x 0.9		3.4
54	Conduit	1.5' x 0.9		3.4

In addition to these there are two tunnels carrying steam pipes crossing Broadway diagonally near Third street, and three small conduits crossing at right angles at different points.

Plate #~~10~~ 8 shows a section of the street with a typical two track subway section superposed with the top of roof five feet below the surface. This distance, or cover, will naturally be regulated by the amount of room required for the accommodation of pipes and conduits at street intersections.

A typical case, showing the difficulties occasionally encountered by subway constructors in large cities, was the situation at Fourth avenue and 23rd street, New York City, during the building of the original subway. Exclusive of sewers, there were found in Fourth avenue, north of 23rd, seventeen lines of pipe or conduit on the east, and eighteen lines on the west side of the street, with all the usual manholes, valve boxes, etc. Some of these ran through, some turned from one street to the other, but all were in service and had to be maintained. Owing to the laxity of the City officials, they were neither at a uniform level, being sometimes above and sometimes underneath adjoining mains, nor followed any given route, the constructors having crossed and recrossed the thoroughfare apparently at will to secure more convenient or economical conditions for excavation. The tangle was so complete that it was impossible to secure thorough identification until all pipes were exposed. The situation was further complicated by the fact that the subway grade had been raised to avoid a transverse sewer at 22nd street, bringing the roof to the minimum limit from the surface, such distance (30") being fixed by the depth of the tramway yokes which carry the underground trolley for surface cars. In addition, nearly as many mains and conduits occupied space in 23rd street, and a double track surface car intersection carried, during the morning and evening rush periods, 800 cars per hour. A timber roof was erected, the ground excavated, and the pipes and conduits entirely re-laid on different planes, the crossings at the subway roof being either accomplished by pipe division, shallow box construction, or through utilization of the space between cross girders. Plates were laid on the bottom flange of such girders, the mains placed, and then solidly surrounded by concrete to the usual roof line. Another method employed was the carrying of mains far enough on either side of the proper intersection to a point where room was available to pass above the subway, then crossing and returning to a junction with the main in place.

The situation above described was not unusual, but was a fair example of the underground conditions discovered at many points in the older districts of the city.

SUBWAY COSTS

and

APPROXIMATE ESTIMATES.

While the unit costs of subway construction naturally vary with each separate enterprise, owing to differences in the size and character of the excavation and in the prices of the materials and labor used, a sufficient amount of shallow subway has been built in American cities to afford reliable data, on which estimates for similar work can be based. Absolute accuracy in such estimates is not to be expected as it is beyond any human power to foresee the various emergencies or difficulties contingent upon the driving of tunnels or the opening of heavy cuttings. A liberal percentage of the estimated cost should be added to cover any exigencies and prevent the inevitable, though often unjust, criticism attendant on requests for additional appropriations.

The size, or width, of subway; the breadth of the thoroughfares, beneath which the structure is to be built; the head room and side clearance required for the equipment intended to be used; and the number and character of sub-structures which must be moved and readjusted, are all important factors in the cost of subway construction. The larger the subway, the larger the necessary cutting and amount of construction quantities. The wider the street, the less necessity, if any, to plank over the excavation during the construction period, and the better opportunity to excavate, remove excess material and prosecute the work at all times without interference with existing traffic; and the fewer pipes, sewers or utility conduits that must be moved or relaid, the less the amount of auxiliary expenditure necessary to the successful completion of

Structural steel	-------------------	97,500 tons.
Rail steel	-------------------------	12,600 tons.
Cast iron	--------------------------	38,000 tons.

More recent costs achieved in subway construction in Boston show that the figures from the New York reports are not unusual. Experience in Boston seems to indicate that excavation for subways through streets carrying a fairly heavy traffic, including support of street railway trackage and the necessary trench sheeting or bracing, pumping, etc., will cost from $2.50 to $5.00 per cubic yard, possibly averaging $4.00. Concrete, including forms, but exclusive of steel or placing, has averaged $10.00 per cubic yard; and reinforcing steel, including bending, cutting and wiring in forms, has cost 2-3/4 cents per pound in place. Removal and care of gas and water pipes, utility conduits and sewers, has averaged $13.50 per lineal foot of trench for all subways. Such cost has, of course, been many times exceeded in the more narrow and congested streets, where the tangle of substructures presented as many complications as certain portions of New York, but the more orderly arrangement of the wider and more modern thoroughfares reduced the unit cost in proportion to the number and length of the latter.

Underpinning buildings along the route wherever the subway structure penetrated within property lines, has been most expensive, but such cost is difficult to reduce to a unit basis, on account of divergent conditions in nearly every case. The following examples will serve to give an approximate idea of such work.

Case #1 - Four story brick building, foundation 21 feet deep, underpinned along frontage only - $122.00 per lineal foot.

Case #2 - Four story brick building, foundation 11 ft. 6 in. deep, underpinned along frontage only-$120.00 per lineal foot.

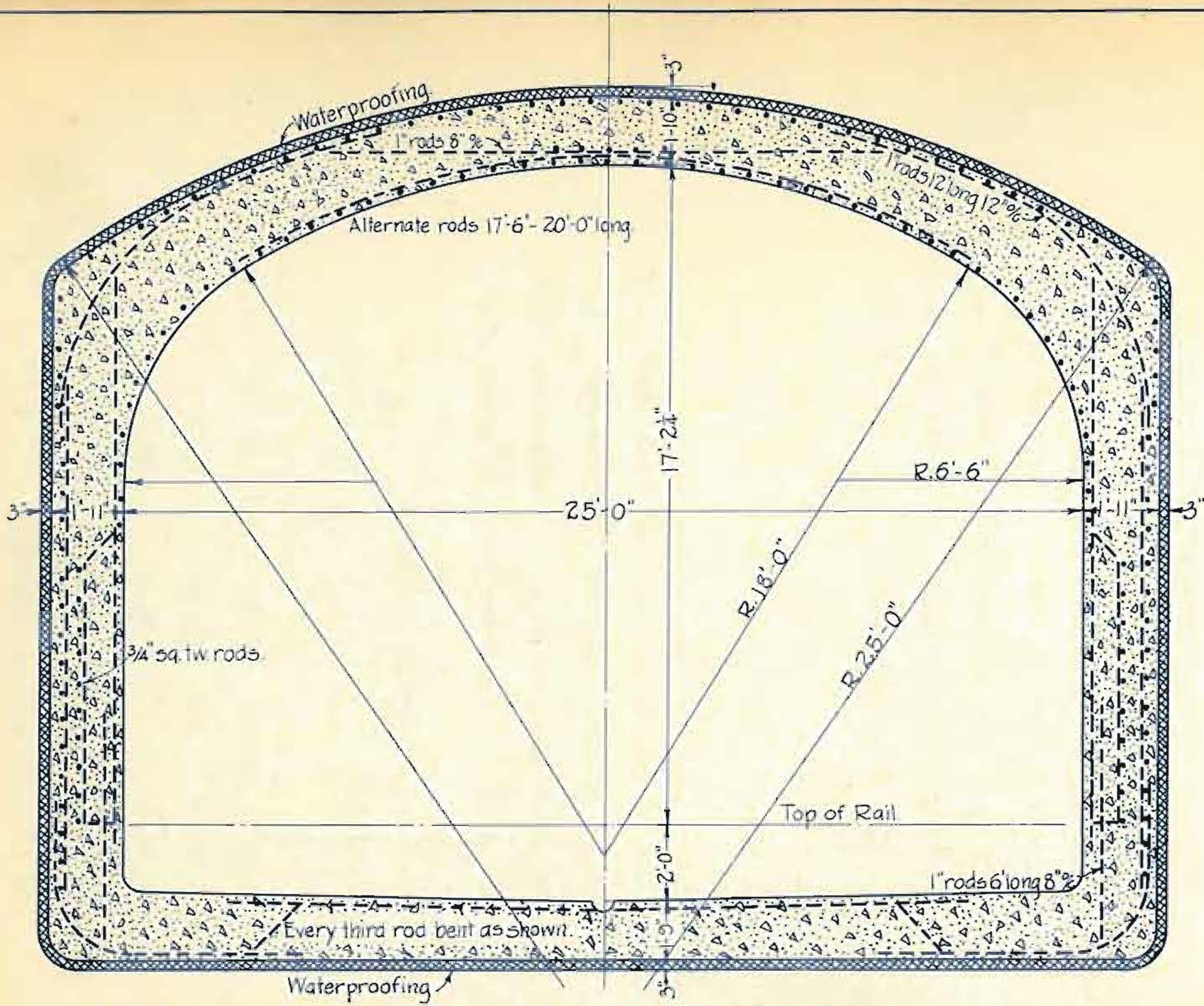
Case #3 - Seven story brick building - stone front, foundation 20 feet deep, underpinned along frontage and part of side - $153.00 per lineal foot.

From the costs tabulated for the underpinning of all buildings since the commencement of subway work, it is now estimated that a six story brick building will cost $150.00 per lineal foot, and a two story brick building $90.00 for each lineal foot of underpinning under ordinary conditions.

The following tabulation of unit costs has been taken from the Boston bid sheets of 1913, and shows the average prices which obtain for sub-surface work under favorable circumstances. The material to be excavated was a firm clay, with occasional sand pockets. All cement and reinforcing steel was furnished by the city, but was hauled by the contractor. Haul of excavated material averaged one mile, being dumped into scows and carried out to sea. The prices quoted, of course, include contractor's profit:-

1.	Earth excavation	open cut	Cu. Yd.	$4.00
2.	Earth excavation	tunnel	Cu. Yd.	4.75
3.	Concrete (Incl. forms)	Open cut	Cu. Yd.	10.00
4.	Concrete (Incl. forms)	Tunnel	Cu. Yd.	11.00
5.	Brick masonry	Tunnel	Cu. Yd.	17.00
6.	Placing steel (Bending, etc.)		Ton	15.00

PLATE 14



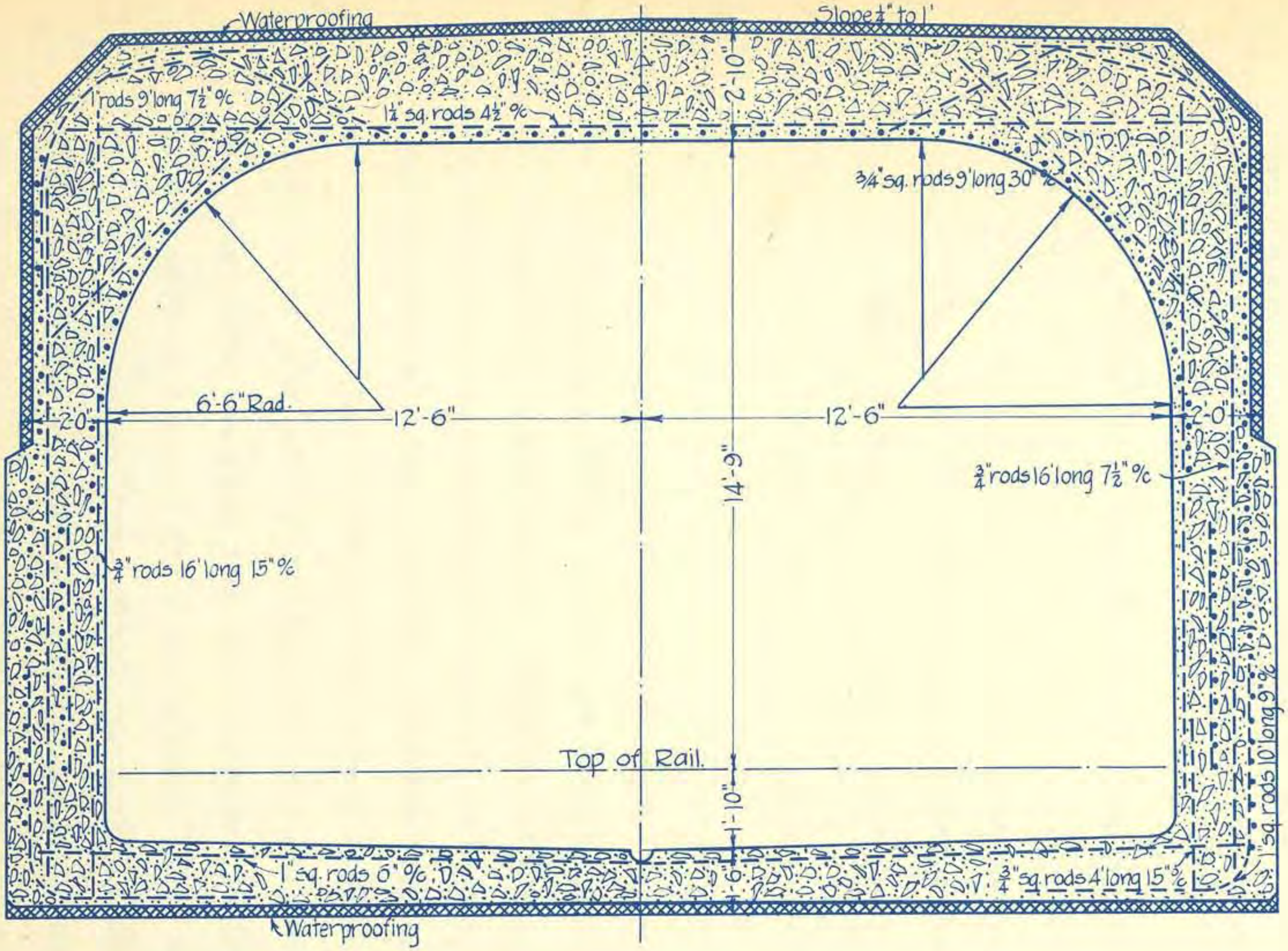
DOUBLE TRACK CONSTRUCTION

ARCHED ROOF SECTION

BOSTON SUBWAY

SCALE $\frac{1}{4}$" = 1'

			Brought forward ---	$219.60
			Add 15% ------------------	32.94
			Total ----	$252.54
2.	Arched Section - 27 ft. to top of rail,			
	(A)	Excavation - 35.6 cu. yd.	@ 4.00 ---	143.00
	(B)	Concrete - 8.19 " "	@10.00 ----	81.90
	(C)	Steel - 850 lbs.	@ 2.75 ----	23.35
				$248.25
			Add 15% ------------------	37.24
			Total ----	$285.49
3.	Flat roof section - 21 ft. to top of rail,			
	(A)	Excavation - 27.4 cu. yds.	@ $4.00 --	109.50
	(B)	Concrete - 8.36 cu. yds	@ 10.00 --	83.60
	(C)	Steel - 990 lbs.	@ 2.75 --	27.20
				$220.30
			Add 15% ------------------	33.04
			Total -----	$253.34
4.	Flat roof section - 27 ft. to top of rail,			
	(A)	Excavation - 34 Cu. yds.	@ $4.00 ----	136.00
	(B)	Concrete - 8.36 " "	@ 10.00 ----	83.60
	(C)	Steel - 1075 Lbs.	@ 2.75 ----	29.60
				$249.20
			Add 15% ------------------	37.80
			Total -----	$286.58



DOUBLE TRACK CONSTRUCTION

FLAT ROOF SECTION

BOSTON SUBWAY

SCALE ¼" = 1'

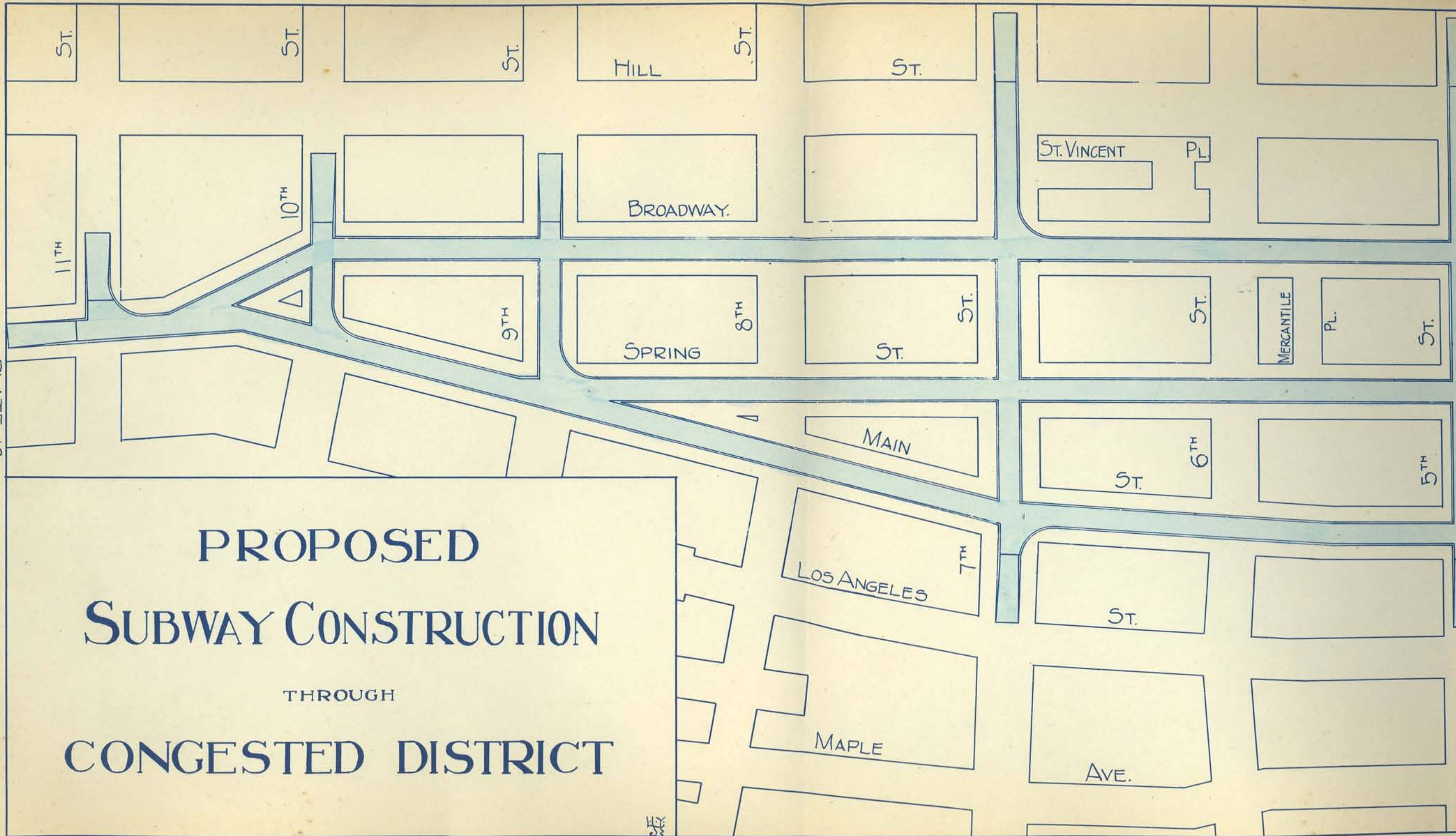
H.Y.

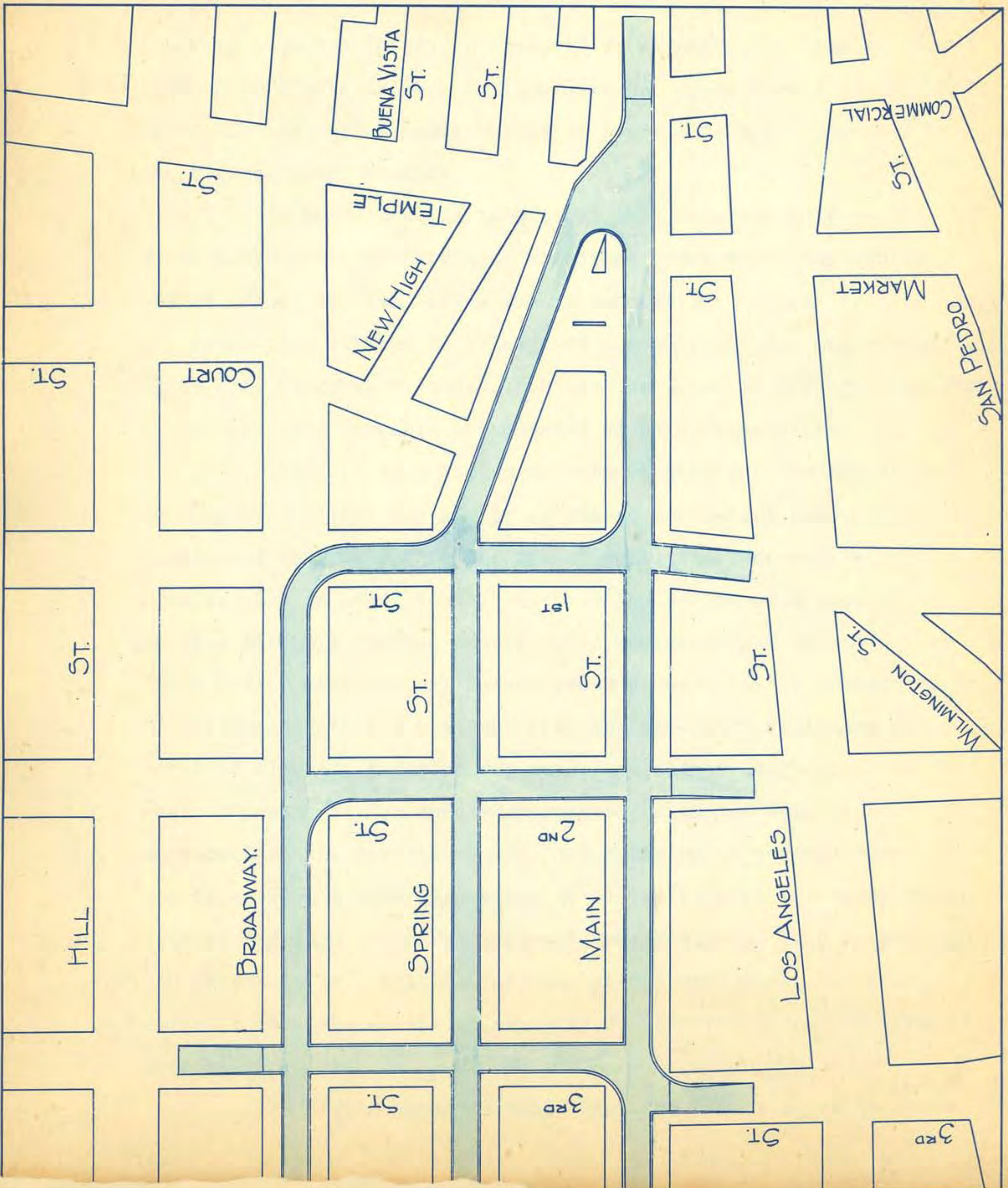
In addition, from $12.00 to $15.00 per lineal foot has been expended for the readjustment of substructures, and an average of $19.00 per foot for water-proofing and the placing of concrete over the water-proofing.

Overhead charges on subway work may be assumed as follows:

1.	Incidentals and contingencies ------	10%
2.	Engineering and superintendence ----	10%
3.	Organization and administraction, legal and financial expense ---	3%
4.	Interest during construction -------	7%
	Total -------------	30%

Taking each item in order, the 10% assumed for incidentals and contingencies is the percentage adopted by the New York Boston and Philadelphia commissions, based on past experience. The 10% estimated for engineering and superintendence is a mean of New York and Boston costs. Item #3, organization and administration, etc., has amounted in New York to nearly 2.5% of the cost of structures. The amount of Item #4, interest during construction, will vary with the time required, methods of financing and rate of interest on loans. The total expense under this item amounted to 8% in the construction of the New York Transit System, and to about 6% in Boston. As any subway designed and constructed for the use of city surface cars through the present retail district of Los Angeles would be admittedly built simply as a measure tending toward the supply of greater area for vehicular traffic, there is no particular reason why any one of the three main arteries should be favored over the others. The street widths are practically identical, all frontage is fully occupied, and the vehicular traffic while varying in quantity on different streets at different times, is practically the same in any 24 hour period. If any one thoroughfare requires the street area occupied during the passage of cars, then all three streets, Broadway, Spring and Main, should be supplied with sub-surface facilities. Topographical features, as well as business considerations, practically enforce such procedure, as otherwise cars entering the district from side streets must pass directly across town; or, if using a single subway, must follow each other in slow procession, forming a car blockade equally as objectionable as those now obtaining on the surface. No single subway could be operated to carry the cars now serving any two of the thoroughfares mentioned, as may be readily seen from data given in previous pages. The capacity of trackage for single cars is limited by the headway, or time interval between cars. This, again, is regulated entirely by the length of station stop; which, under the most favorable conditions, cannot average less than 20 seconds. Twenty second headway means 180 cars per hour per track; and as rush hour traffic on Los Angeles streets shows a peak of 110 cars hourly, it is clear that 40 of the cars now running on any two parallel streets must be retired from service for want of physical space to operate. It must be realized that sub-surface trackage will accommodate little, if any, more traffic than surface


PROPOSED
SUBWAY CONSTRUCTION
THROUGH
CONGESTED DISTRICT
HILL ST.
BROADWAY.
SPRING ST.
MAIN ST.
LOS ANGELES ST.
MAPLE AVE.
ST. VINCENT PL.
MERCANTILE PL.
11TH ST.
10TH ST.
9TH ST.
8TH ST.
7TH ST.
6TH ST.
5TH ST.


HILL
ST.
BROADWAY.
COURT
ST.
SPRING
ST.
ST.
MAIN
ST.
1ST
2ND
3RD
ST.
NEW HIGH
TEMPLE
ST.
BUENA VISTA
ST.
ST.
LOS ANGELES
ST.
ST.
ST.
COMMERCIAL
ST.
MARKET
SAN PEDRO
WILMINGTON
ST.
3RD
ST.

trackage when the latter is operated to capacity, as long as cars are run as single units. Trailer service, or multi-car trains, forms the only practicable method of increasing track capacity over the figures above stated.

In such case, it is evident that separate subways must be constructed on each individual street in order to accomplish the object proposed, with the necessary connections, inlets or inclines, and cross-town subways to allow exit and entrance for equipment. Plate #13, herewith attached, has been arranged to show graphically the extent of a possible arrangement of this description.

The cost of a system of subways covering the routes as designated in Plate #13 may be estimated accurately enough for the purpose of this report by the use of unit values accomplished in similar work in other localities; and the design of a typical section suitable for the operation of equipment now in use. (See Plate #16). Stations may be estimated as sectional enlargements of uniform length and breadth, with the necessary stairways and entrance kiosks. Right of way expense would be confined to the cost of easements for necessary curves, since the City owns its streets; and the cost of removal and relaying of substructures may be estimated from inspection of Plate #8, with a liberal percentage addition for more difficult construction. Such an estimate can naturally be little better than an approximation, but will serve to show the extent of expenditure required for sub-surface work.

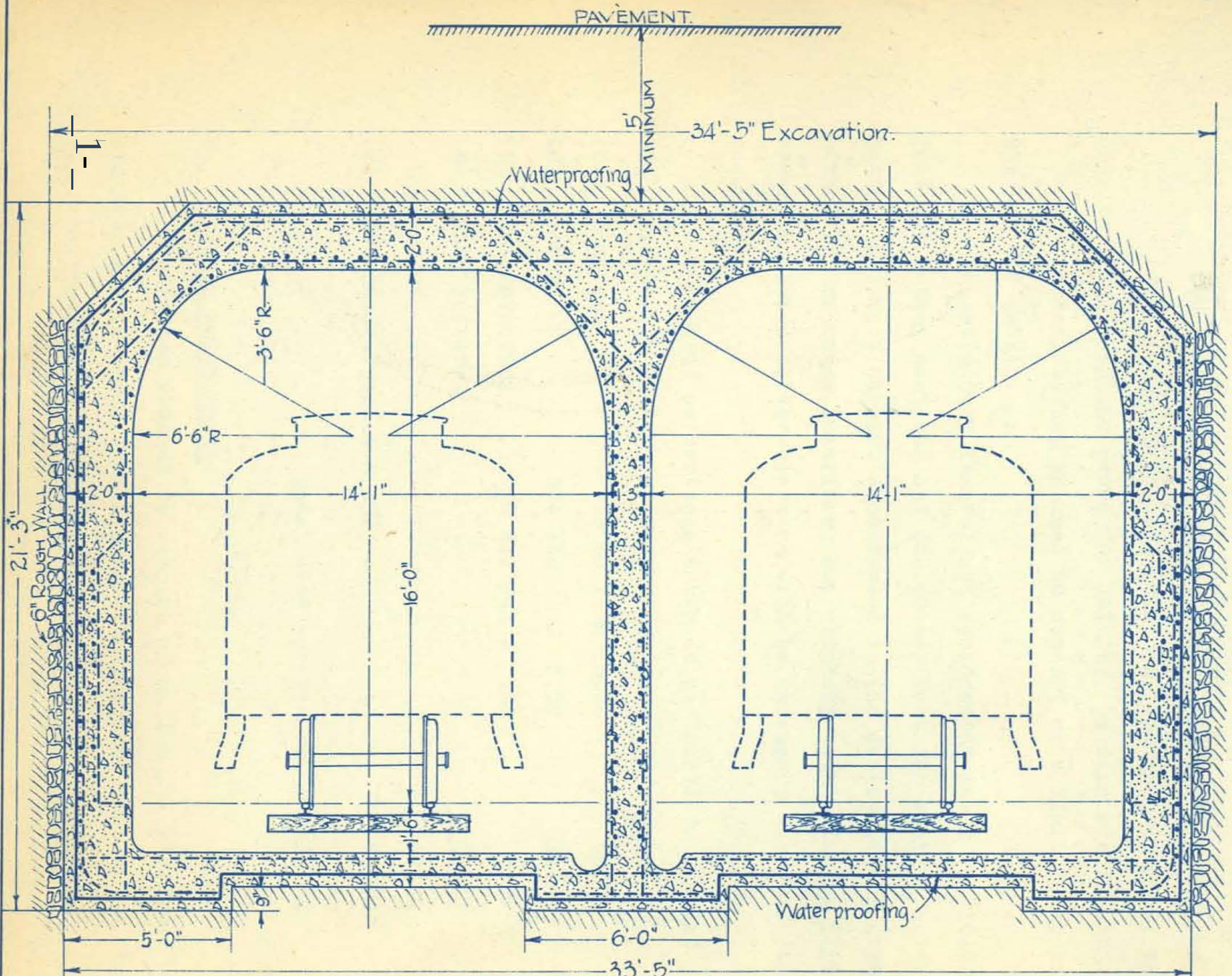
Referring again to Plate #13, the following table shows the lineal feet of double track subway section, together with the number of stations and entrance or exit inclines necessary to supplant the present system of surface cars:

	Street.	Lineal feet Subway Section.	Station Enlargements	Inclines.
1.	Broadway	5885.9	19	--
2.	Spring	6088.7	21	--
3.	Main	7587.3	22	2
4.	First	865.8	5	1
5.	Second	910.5	5	1
6.	Third	971.8	6	2
7.	Fifth	1375.0	8	2
8.	Seventh	1675.0	8	2
9.	Ninth	475.0	3	1
10.	Tenth	325.0	3	1
11.	Eleventh	50.0	1	1
		26210.0	101	13

Taking each item in order, without going into the smaller details, unit costs may be assumed as follows:

1. Subway Section - Double track:

Excavation taken to be earth and gravel with little, if any, surface water pumping . Price per cubic yard to include all trenching, sheeting and bracing, roofing of trench and support of car tracks during construction, haulage of spoil to nearest dump, backfill and street replacement after completion of structure.



TYPICAL SECTION
OF
TWO TRACK SUBWAY FOR SURFACE CARS.

Concrete price includes cost of materials and forms.

Steel assumed to cost $2.25 per 100 lbs. F. O. B. Los Angeles, plus 3/4¢ per pound for cutting, bending and placing.

Waterproofing assumed to consist of a light layer of asphalt and fabric.

Substructure removal and replacement taken at $10.00 per foot for subway section, and $20.00 per foot for station enlargements. The main subway, constructed in the center of the street with 5 ft. of cover interferes but slightly with existing pipes or conduits, but considerable work will be necessary wherever stations occur.

Overhead percentages taken as per previous tabulation.

(A)	Excavation -	33.5 C. Y. @ $4.00	$134.00
(B)	Concrete	7.5 C. Y. @ 10.00	75.00
(C)	Steel	824 lbs. @ 3.00	24.72
(D)	Waterproofing	12 sq. yds @ .50	6.00
(E)	Substructures		10.00
			$249.72
(F)	Overhead expenses - 30%		74.92
		Total cost per lin.ft. -	$324.64

2. Station enlargement:

Station assumed to consist of an 100 ft. platform, with stairway and entrance from street. Unit prices same as in Item #1.

(A)	Excavation -	1150 C. Y. @ $4.00	$4600.00

(B)	Concrete	159 C. Y.	@ $10.00	$1590.00
(C)	Steel (Reinf.)	13787 lbs.	@ 3.00	413.61
	Steel - Girder	100 ft.	@ 3.50	350.00
	Steel - columns	4	@ 50.00	200.00
(D)	Waterproofing	88 sq yd	@ .50	44.00
(E)	Entrance Kiosk			250.00
(F)	Substructures -	100 ft.	@ 20.00	2000.00
				$9447.61
(G)	Overhead expenses - 30%			2834.28
			Total -------	$12281.89

3. - Inclines:

Assumed to be 300 ft. in length, with reinforced concrete side walls, headwall and invert. Excavation, concrete and substructure costs reduced on account of better working facilities.

(A)	Excavation	6645 C. Y.	@ $ 2.00	$13290.00
(B)	Concrete	1031.8 " "	@ 8.00	8254.90
(C)	Steel	44488 lbs.	@ 3.00	1334.64
(D)	Substructures	300 feet	@ 5.00	1500.00
(E)	Railing	635 feet	@ ___	100.00
				$24479.54
(F)	Overhead expenses - 30% -------------			7343.71
				$31822.75

The following tabulation shows the cost of each street and total cost of the entire system as shown in Plate #13. Unit costs for each item taken at

1. Subway section - per lineal foot ----- $ 325.00

2.	Station Section - each	----------	$ 12,280.00
3.	Incline Section - each	----------	31,825.00

Broadway:

5886 lineal feet subway	@ $ 325.00 ------	1,912,950.00
19 stations	@ $12,280.00 ------	233,320.00

Spring:

6089 lineal feet subway	@ $ 325.00 ------	1,978,925.00
21 stations	@ $12,280.00 ------	257,880.00

Main:

7587 lineal feet subway	@ $ 325.00 ------	2,465,775.00
22 Stations	@ $12,280.00 ------	270,160.00
2 Inclines	@ $31,285.00 ------	63,650.00

First street:

866 Lineal feet subway	@ $ 325.00 ------	281,450.00
5 Stations	@ $12,280.00 ------	61,400.00
1 Incline	@ 31,825.00 ------	31,825.00

Second street:

910 Lineal feet subway	@ $ 325.00 ------	295,750.00
5 Stations	@ $12,280.00 ------	61,400.00
1 Incline	@ $31,825.00 ------	31,825.00

Third street:		
972 Lineal feet subway	@ $ 325.00 ------	315,900.00
6 Stations	@ $12,280.00 ------	73,680.00
2 Inclines	@ $31,825.00 ------	63,650.00
Fifth street:		
1375 Lineal feet subway	@ $ 325.00 ------	446,875.00
8 Stations	@ $12,280.00 ------	98,240.00
2 Inclines	@ $31,825.00 ------	63,650.00
Seventh street:		
1675 Lineal feet subway	@ $ 325.00 ------	544,375.00
8 Stations	@ $12,280.00 ------	98,240.00
2 Inclines	@ $31,825.00 ------	63,650.00
Ninth street:		
475 Lineal feet subway	@ $ 325.00 ------	$154,375.00
3 Stations	@ $12,280.00 ------	36,840.00
1 Incline	@ $31,825.00 ------	31,825.00
Tenth street:		
325 Lineal feet subway	@ $ 325.00 ------	105,625.00
3 Stations	@ $12,280.00 ------	36,840.00
1 Incline	@ $31,825.00 ------	31,825.00
Eleventh street:		
50 Lineal feet subway	@ $ 325.00 ------	16,250.00
1 Station	@ $12,280.00 ------	12,280.00
1 Incline	@ $31,825.00 ------	31,825.00
	Total cost ---	$10,172,255.00

The above total of $10,172,255.00 is exclusive of any easements required for curves or station entrances on private property, should it be deemed advisable to remove the entrance Kiosks from the sidewalk. No estimate can be given for such easements, as valuations would necessarily be fixed by appraisal and condemnation. The total figures simply show, approximately, the cost to the City of constructing a sufficient length of sub-surface roadway to relieve the present retail section of surface car traffic and provide equal transportation facilities to those now obtaining.

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REARRANGEMENT

OF

RAPID TRANSIT FACILITIES.

Opinion may be divided as regards the retirement of urban cars to sub-surface accommodations, but there can be no reasonable doubt as to the advisability of removing interurban cars from surface trackage. This must be patent to the most casual observer, if notice be taken of conditions obtaining on Main street during the hours of the morning and evening rush. The entire traction right of way, and more, considering the overhang and necessary car clearance, is solidly occupied from crossing to crossing by the equipment of the city and interurban lines, movement being restricted to car lengths, resulting in disruption of surface car schedules and annoying delays to the patrons thereof. Relief is impossible until the 7th street junction is cleared by south bound traffic, and the 1st street corner passed by north bound traffic, such outlets allowing the interurban cars opportunity to reach their private right of way. While some measure of relief has been accomplished by the diversion of various inter-urban lines to San Pedro street and the Los Angeles street temporary terminal, the remaining interurban cars are sufficient in number to seriously hamper city street car service on Main street between the limits before mentioned. Their removal would mean the placing of the traffic problem of this thoroughfare on a parity with that of adjacent streets, and its solution by natural expansion.

In considering the transportation problem of any city, due regard must be paid to the fact that the area requiring such facilities is not alone that included within existing city boundaries but is all territory tributary to such city lying within the limits of commutation traffic. As the latter are regulated entirely by the speed of interurban cars, it follows directly that the minute and not the mile forms the controlling unit of service, and that the total metropolitan, or greater city, area is bounded only by a line whose radius is the greatest distance possible to be traversed within a reasonable riding period by rapid transit cars, operated under the highest conditions of safety and non-interference by surface obstructions. The avoidance of the latter automatically forces the placing of the tracks above or below the ground surface within the more densely populated area.

It has been well said that "The economic point of city expansion, as influenced by surface railway extension, and operation, is fixed by the time in which surface cars can reach such point, as compared with the time in which interurban cars can reach residential sections equally desirable." That this point has been reached, and even over-lapped, in the case of Los Angeles, is easily demonstrated by comparison of existing schedules. The following list gives the average running time of typical surface and interurban routes, showing that the surface lines, following a liberal development policy, have extended their trackage beyond the boundaries of profitable operation, and are serving territory properly belonging to interurban facilities.

TABLE #6.

WESTERLY LINES.

System.	Route.	Distance Miles.	Fare Cents	Running time Minutes.
Los Angeles Ry.	Rimpau Western terminus to 5th & Spring.	6.35	5	36
Los Angeles Ry.	West Adams Western terminus to 3rd and Main.	7.38	5	45
Los Angeles Ry.	Pico. Western terminus to 1st & Broadway.	6.00	5	33
Pacific Electric Railway.	Venice Short Line.	17.00	10*	35

SOUTHERLY LINES.

System.	Route.	Distance Miles.	Fare Cents	Running time Minutes.
Los Angeles Ry.	Inglewood. Southern terminus to 6th and Main.	12.90	10	52
Los Angeles Ry.	Homeward avenue. Southern terminus to 4th & Spring	9.00	10	39
Los Angeles Ry.	Vermont Heights. Southern terminus to 4th & Spring	9.96	10	46
Pacific Electric Railway.	Long Beach	21.1	12*	45

* - Commutation ticket - 54 ride.

While it is impossible to increase the speed of surface cars operating in city streets on account of existing ordinances, vehicular obstructions and the numerous stops, without introducing the "skip stop" or similar system, it is perfectly feasible to formulate plans for interurban operation which will increase the capacity and scope of the present lines. This may be accomplished to a combination of re-routing and the elevation or depression, according to topographical conditions, of all interurban trackage, affording unobstructed entrance and exit to high speed trains. The latter condition is a sine qua non to the success of rapid transit operation.

Inspection of a map of the present interurban system shows a network of potentially high speed lines terminating at two points within the business center, the western lines using the old L. A. P. station on Hill street, while the southern and more easterly lines are divided between the Pacific Electric terminal at 6th and Main, and the temporary terminal at 6th and Los Angeles streets. All these terminals in their present condition, have one common characteristic, inadequacy, and each succeeding day makes the fact more apparent. This condition, however, while discreditable to the municipality and inefficient in its workings, should not be blamed on the present management, being due partly to the unprecedented growth of population and consequent outstripping of arrangements ordinarily sufficient; and partly to the annexation of lines previously operated as a separate and distinct system with little, if any, modern equipment. The Hill street terminal, even in its present state, is certainly an improvement over the old method of turning cars on Fourth, between Hill and Broadway; but its inadequacy becomes daily more patent to all concerned, while the increasing number of cars, rendered necessary by the steady growth of patronage, bids fair in a short time, to create traffic blockades as serious as those on Main street.

Two principal facts must be taken into account when the problem of the rearrangement of Los Angeles rapid transit facilities is presented for consideration. First, the purchase or acquirement of real property of sufficient dimensions to accommodate such facilities in any more convenient location that the present/ Pacific Electric holdings on Sixth street, is impracticable, if not impossible from the enormous cost involved and the inevitable economic loss through destruction by demolition of existing modern structures. The block bounded by Sixth, Los Angeles, Seventh and Maple avenue, must on account of this fact, be the scene of future terminal improvements. The Pacific Electric building and present central station, is, and will be hereafter valuable only for offices and stores, its usefulness as a traffic terminal having passed with the growth of the city.

Second; no arrangement of building and trackage should be approved which is not planned with full recognition of the fact that terminals, in the strict sense of the word, located within civic boundaries, are objectionable and should not be tolerated where the topography allows the operation of interurban lines <u>through</u>, and not merely <u>to</u> a city. Any terminal, so-called, erected in Los Angeles for the accommodation of suburban passengers and operation of interurban cars, should consist of nothing more than a central station of sufficient capacity to accommodate present and estimated future traffic, through which, trains or single cars may be operated from one suburb or one beach to another without turning except at the actual ends of lines, thus eliminating the use of expensive space for switching, repairing, etc., the major part of such operations being conducted at the real terminals and in less valuable situations. In this manner may be secured the maximum of capacity with the minimum of equipment, particularly at times of peak loads, together with the highest occupational efficiency of necessarily restricted station area.

That this is feasible and economically possible in the City of Los Angeles will be shown in the following paragraphs.

Rearrangement of the main east and south rapid transit lines (See Plate #2) in such a way that both may enter the City and delivery passengers at a central point without burdening main thoroughfares with their equipment, is, from the physical standpoint, a relatively simple matter. As any re-routing on the ground surface, while affording temporary relief, can but become a source of congestion with increased density of population, the proper and most economical solution would seem to be track elevation to a point of connection with existing trackage beyond the congested area. The elevated structure at the rear of the present terminal building should be extended due east to a junction at San Pedro street, continuing thence north on San Pedro to Aliso street, and east on Aliso street across the Los Angeles river and San Pedro, Los Angeles and Salt Lake Railway tracks to a grade connection in that vicinity, while the trackage to serve Long Beach and related lines should turn south on San Pedro street to Seventh street, east on Seventh to Alameda and thence south to a grade connection with the private right of way. It is understood that the private property between Maple and San Pedro streets on this proposed route has been acquired by the corporate interests in anticipation of its ultimate necessity. A franchise for elevated railroad operation would be required from the city, which in view of the benefits to be derived from the more rapid passage of cars and evacuation of streets, should be granted on liberal terms.

The construction of this amount of elevated structure would practically eliminate the presence of inter-ruban cars from the eastern half of the business district, and would relieve Main, Seventh, Ninth and First streets from any present, or possibility of future, congestion from this source. There would need to be no suspension of service. Erection of the necessary columns and superstructure could be carried on without interfering with existing schedules; and, if built according to the more recent designs, would, when complete, afford unobstructed passage to cars with less noise than now obtains.

No diminution of property values traversed by, or adjacent to an elevated road need be feared, according to the general experience of other cities. While admittedly detrimental to residential sections, its presence, as a rapid transit line, has always proved beneficial in increasing valuations when utilized through areas of a commercial character. Authoritative proof of this fact is shown in the subjoined table, compiled by the Director of the Rapid Transit Commission of Philadelphia, Mr. A. Merritt Taylor, demonstrating the effect of elevated railway operation on assessed valuations on Market street, upon which the road is located, and on Arch and Chestnut streets, which are parallel and one block distant.

Assessed valuation of real estate along Market, Arch and Chestnut streets prior and subsequent to the construction of the Market street Elevated Road:

TABLE #7.

	Property between 32nd street and the City Line, fronting on -		
	Market st.	Arch st.	Chestnut st.
Assessed valuation			
1900 (A)	$4,159,000	$2,015,000	$5,157,000
1906 (B)	4,916,000	2,095,000	6,291,000
1912 (B)	7,671,000	2,197,000	8,721,000
Increase (Amount			
1906 over 1900	757,000	80,000	1,134,000
1912 over 1906	2,755,000	102,000	2,430,000
1912 over 1900	3,512,000	182,000	3,564,000
Increase (Per cent)			
1906 over 1900	18.2	4.0	22.0
1912 over 1906	56.0	4.9	38.6
1912 over 1900	84.4	9.0	69.1

(A) Basis of assessment was 80% of value. Figures are adjusted to 100% to compare with 1906 and 1912.

(B) Basis of assessment 100% of value.

The total increase on Market street, from 1900 to 1912, was $3,512,000 or 84.4 per cent; while on Chestnut street, it was $3,564,000, or 69 per cent. Therefore, the construction of the elevated roadway not only caused no decrease of values, but stimulated the increase beyond that on neighboring streets.

The question of the elimination of the westerly beach lines and Glendale cars from Hill and Sixth streets, presents considerably greater difficulties, yet nothing insuperable if the exigencies of the situation seem to warrant the necessarily heavy expenditure. It may be assumed that Hollywood and Colegrove cars form nothing more than local service, and as such are entitled to surface trackage, running from Sunset boulevard down Hill street to 16th street; thence west to Vineyard station or similar terminus and return. Cars serving Van Nuys and Fernando Valley points, while constituting a definite interurban service, are too infrequent to add measurably to street congestion; and, until the demand for such service reaches a considerably higher point, may follow their present routing, turning back on upper Hill street, or other convenient location. Later, if the settlement of this particular district demands a better service and its installation results in the occupation of too much street area, a connection running south from Hollywood to the proposed western beach line may be constructed. The present Hill street terminal between Fourth and Fifth streets should be definitely abandoned, being both incapable of suitable enlargement and more valuable for building sites than for traffic operations.

The main problem, then, resolves itself into the feasibility of discovering a practicable route from existing trackage at the western boundary of the city to the proposed central station at Sixth and Los Angeles streets, always keeping in mind the necessity for the retirement of interurban equipment from the street surface, and the need for securing the most direct line possible in order to secure the utmost rapidity of passage.

It is evident that track elevation, while unobjectionable and even desirable in a wholesale business district, is unsuitable construction in high-class residence sections. Moreover, any route practicable for elevated construction and operation leading westerly from Sixth and Los Angeles streets must inevitably follow the present line along 16th street, or, if located on a parallel street, would injure still more valuable residence properties. It is true that an elevated structure might be built south from the proposed central station, along Los Angeles street, to the intersection of 16th street; thence turning west, and that such construction would improve Hill street conditions; but such a line would merely parallel present routing and would be deficient in the primary requirement for successful interurban service, namely; the shortest possible location, without which, even with unobstructed trackage, speed, or rapidity of passage cannot be obtained. Reduction of speed means less area possible to be served, thus vitiating the results properly accruing from the expenditure. The old adage that "A curved line for pleasure and a straight line for business" is best exemplified when applied to the question of transportation.

If surface tracks are a source of congestion and an elevated structure objectionable, then there remains but one measure of relief; sub-surface, or subway construction$. If southerly and easterly trackage is brought into the central station on an elevated structure, then, in order to afford continuous trackage and the operation of trains through the city and central station to actual terminals, a connection between subway and elevated structures must be perfectly feasible and satisfy all conditions of operating requirement. That this is practicable may be shown as follows:

Let the elevation of the floor, or platform, of the main concourse of the proposed central station be at the same elevation as the top of rail on the elevated structure now occupying a portion of the station site, or 19 feet above the ground surface. The elevation of the top of rail of any subway leading westerly from Sixth and Los Angeles streets may be taken as follows:

Clearance, top of subway rail to subway roof ------	15.0 ft.
Thickness of subway roof --------------------------	2.0 ft.
Top of roof to ground or pavement surface ---------	1.0 ft.
Total ---------	18.0 ft.
Add distance from top of rail on elevated structure to ground surface --------------------	19.0 ft.
Total distance from top of elevated rail to top of subway rail ----------------------------	37.0 ft.

The above tabulation shows a total difference in gradient of 37 feet between trackage to be used for elevated incoming trains

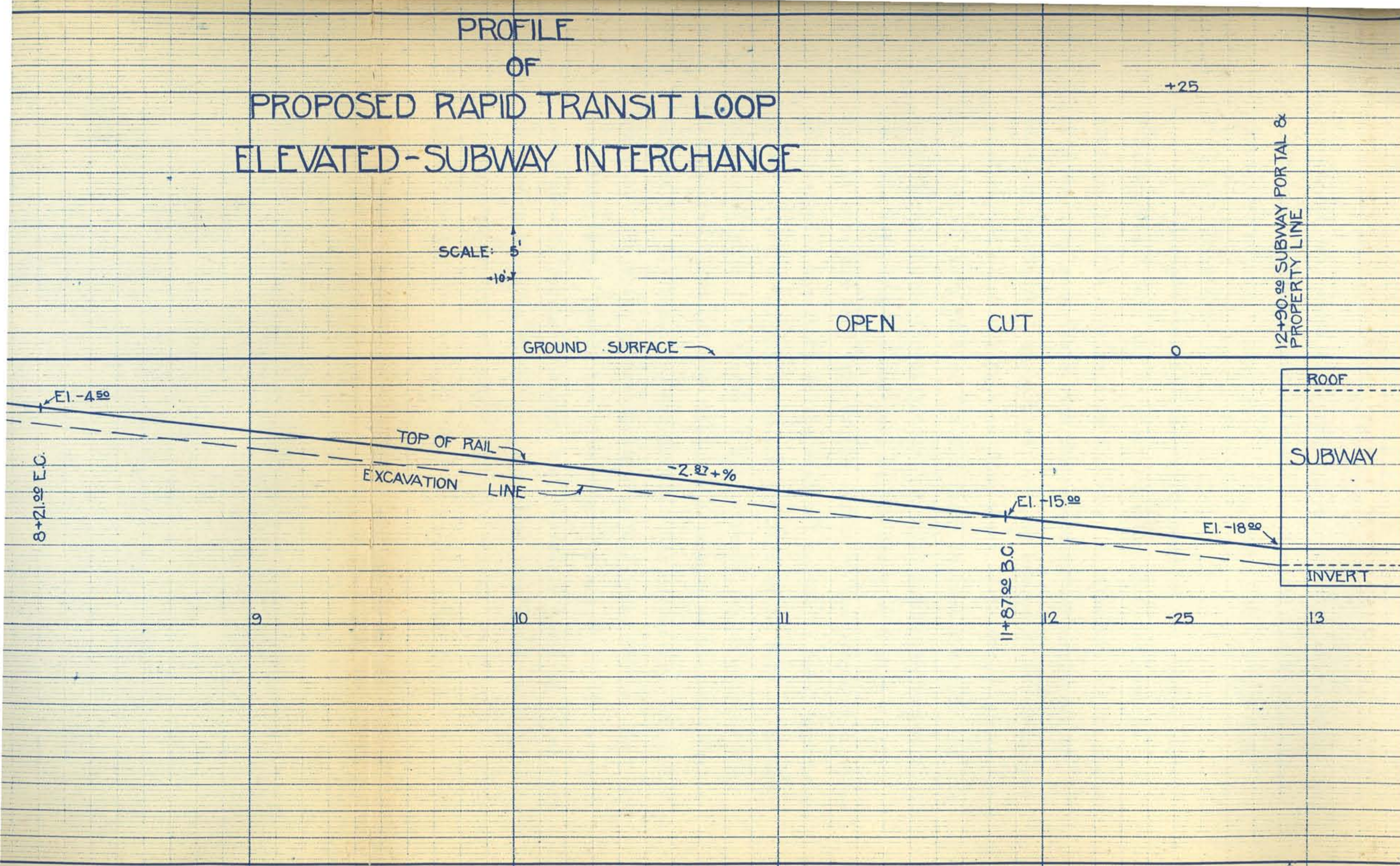
PLAN
OF
PROPOSED RAPID TRANSIT LOOP
ELEVATED-SUBWAY INTERCHANGE

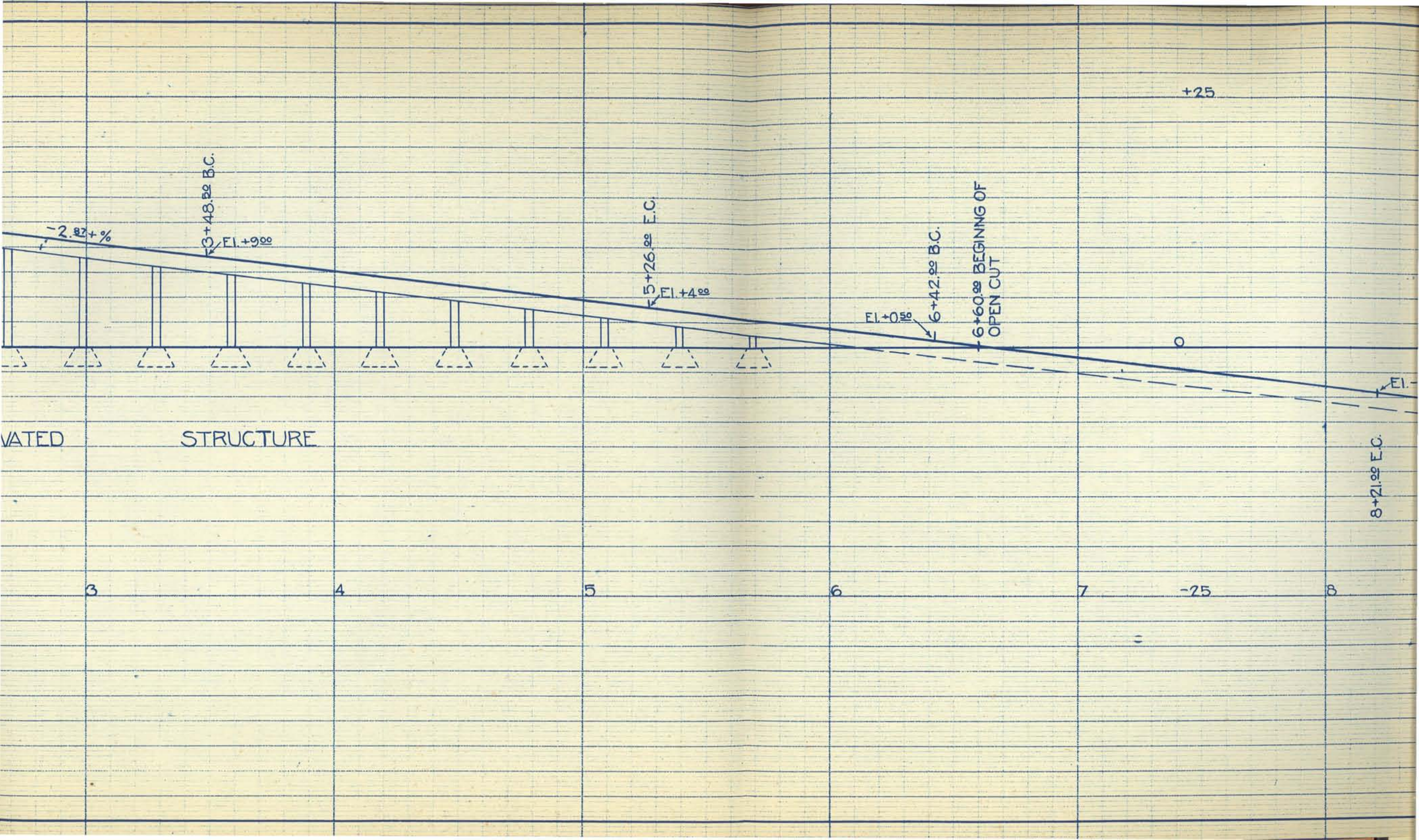
and trackage used for subway out-going trains, or vice versa, as the case may be, which must be overcome in such manner that equipment may be interchanged from one route to the other without switching or other hindrance.

Inspection of a map of the central portion of the City, (See Plate #9), shows that the so-called Terminal site, or block bounded by Sixth, Seventh, Maple and Los Angeles streets, is approximately, of the following dimensions:

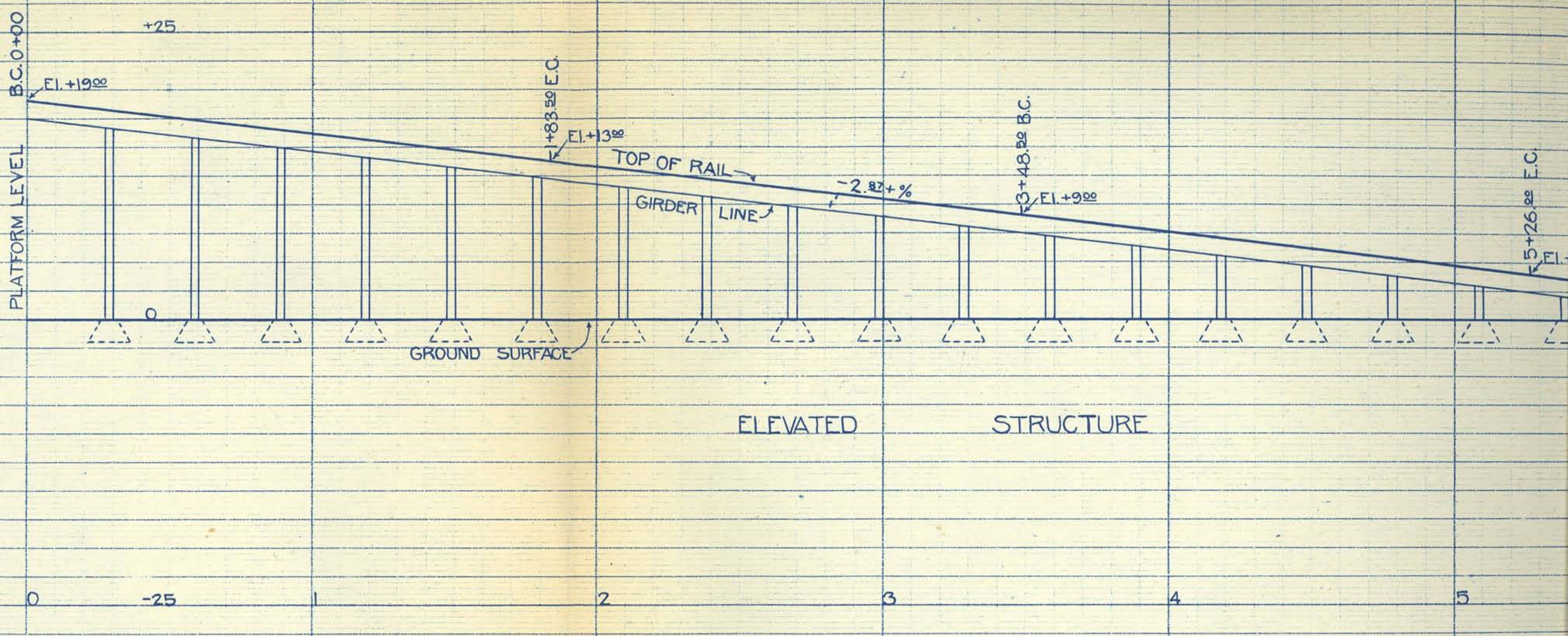
Los Angeles st., 6th to 7th streets --------	581 ft.
Seventh street, Los Angeles to Maple -------	390 ft.
Maple avenue, 6th to 7th street ------------	607 ft.
Total ------	1578 ft.

If the distance from the center of the present elevated structure to the corner of Sixth and Los Angeles street, or 162 ft., be subtracted from this total, a remainder of 1416 lineal feet of distance is found to be available for the development of a connection between elevated and sub-surface tracks. If even two hundred and odd feet be lost in withdrawing the center line of the connection to a suitable location within the boundary lines, and in the necessary curvature, 1200 feet of distance are still available for such development, which would absorb the 37 feet of difference in track elevation with nothing more formidable than a three (3) per cent grade. When it is realized that city surface cars are successfully operated over gradients as high as twelve (12) per cent, there should be no serious objection to the above. The


PROFILE
OF
PROPOSED RAPID TRANSIT LOOP
ELEVATED-SUBWAY INTERCHANGE
SCALE: 5'
10'
+25
12+90.00 SUBWAY PORTAL & PROPERTY LINE
OPEN CUT
GROUND SURFACE
0
ROOF
SUBWAY
INVERT
El. -4.50
TOP OF RAIL
-2.87+%
EXCAVATION LINE
El. -15.00
El. -18.00
8+21.00 E.C.
11+87.00 B.C.
9
10
11
12
-25
13



+25
-2.87+%
3+48.50 B.C.
El. +9.00
5+26.00 E.C.
El. +4.00
El. +0.50
6+42.00 B.C.
6+60.00 BEGINNG OF
OPEN CUT
0
El. -
VATED
STRUCTURE
8+21.00 E.C.
3
4
5
6
7
-25
8


B.C. 0+00
El. +19.00
PLATFORM LEVEL
+25
0
+83.50 E.C.
El. +13.00
TOP OF RAIL
GIRDER LINE
-2.87+%
3+48.50 B.C.
El. +9.00
5+26.00 E.C.
El. +
GROUND SURFACE
ELEVATED STRUCTURE
0
-25
1
2
3
4
5

street and only small easements there to provide extra width for platforms. Transfer traffic could be accommodated by passenger crossovers between subway roof and pavement, or via the usual entrances and exits.

A rapid transit line constructed on the routing above outlined would form the shortest possible location between the proposed central station site and existing trackage at the western city boundary compatible with the necessity for avoidance of valuable residential properties; and, by reason of the increased speed possible through freedom from track obstruction, grade crossing etc., place every foot of the territory between the city and the ocean in as close, if not closer, physical communication as is now possible with city surface cars within the 4 or 5 mile circle. This is none the less true of the effect of the proposed elevated roads serving territory to the east and south. A heavy percentage of the actual running time of present interurban cars is consumed in passing through the crowded city streets, which reduces the commutation limit and area directly tributary to city activities in just the corresponding proportion. As cities grow and distances increase, the speed of transportation facilities becomes more and more important. Double the size of a city and there are not only twice as many people to carry, but, generally speaking, they must be carried twice as far. And as elapsed time rather than mileage controls the radius of modern suburban travel, doubling the distance means doubling the speed in order to maintain the same conditions of convenience.

While the architectural features of a central station on the Sixth and Los Angeles site are beyond the province of this discussion, it is possibly advisable to designate the most important part of such construction, as regarded from the public point of view. All arrangements should be made subservient to the one idea of providing adequate floor space at track level for a main concourse sufficiently extensive to care for a patronage of at least twice the present passenger traffic, with enough reserve to accommodate the holiday crowds. It should be kept in mind that track elevation and depression will inevitably force practically all passengers to board cars at this point, instead of the present custom of waiting at street intersections. The floor of such concourse should be planned to carry the maximum live load and should be unobstructed by booths, cigar stands, or the like, all of which should be relegated to the walls of the room. Adequate elevator service should be provided from the Los Angeles street level to the concourse floor, and the present entrance for interurban cars into the Pacific Electric station should be turned into a grade entrance for foot passengers from Main street, abolishing the present system of allowing passengers to use the same doorways as building tenants. Sub-passage below the ~~passage~~ tracks should connect both sides of the concourse and afford means of exit to either street.

The area within the enclosure, or terminal block may be utilized for storage tracks, etc., connection being made with the subway elevated incline at, or about, the intersection with the ground plane. Entrance to the enclosure for equipment may be provided on the Maple avenue side, near Sixth street, as the subway structure would be completely below the surface at that point. This would eliminate all difficulties as to the use of the present shops at 7th and Central.

The station building might be either constructed in toto, or in only such part as would be necessary for the housing of the concourse floor and passageways. Sufficient foundation provision should of course be made for the addition of upper stories, whenever the need for same becomes apparent. It is certain, however, that any office facilities thus provided would be in demand on account of their convenience and central location. Actual street frontage on the street level would retain its value for commercial purposes, as the proposed incline could be located so as to interfere but little with shallow stores.

HISTORY AND STATISTICS.

In considering any comprehensive plan for supplying the transportation needs of any metropolitan area, it is interesting and instructive to note the methods of other municipalities as shown by inspection of maps and compilations of expenditures and operating statistics. It is true that the few American cities which have installed other than surface facilities are far in advance of Los Angeles as regards the amount of population included within their metropolitan circles and afford no means of exact comparison on account of divergent topography. There is reason to believe, however, that all territory within an hour's ride of the city center will, in the course of a comparatively few years, through climatic and other advantages, be fully occupied if efficient means of transportation be supplied. Such occupation, if only of the usual suburban density, would afford a patronage which would amply compensate for the construction of a far more costly system than now obtains; but neither the occupation nor the system are possible nor can the city proper derive the full benefit from the tributary area unless free and convenient egress and ingress for transportation units through urban districts, with consequent rapidity of passage, be provided. If the first efforts to secure means of rapid transit are so planned as to form a convenient nucleus for future additions, even though the first cost seem disproportionately large to the results immediately secured, such additions may be made whenever requisite with a minimum of expense and inconvenience, and a total avoidance of any waste of resources, either territorial or financial.

Temporary expedients may afford transient relief and defer the period of construction; but such policy can only result in an increase of expenditure when the day of reckoning finally arrives, together with the practically total loss of capital thus employed.

Inspection of the following data can but convince that the cost of well designed and located primary units, constructed during the inception of city growth, is inconsiderable as compared with the enormous expense required for identical operations in after years.

The following brief statements cover the growth of rapid transit in the largest American cities. A rapid transit line is taken, for the purpose of this report, as consisting of a city passenger electric railway located in (1) a subway or tunnel, (2) on an elevated structure, or viaduct, or (3) on the surface of a private right of way, or, in minor instances, of a street operated by trains stopping at stations at intervals of at least several blocks and making delivery of passengers at one or more stations in the central business district. Suburban branches of steam railroads are therefore excluded.

NEW YORK (MANHATTAN AND BRONX BOROUGHS).

The necessity for high speed street transportation in New York City became acute after the Civil war by reason of the rapid growth of population, and also largely because of the narrow and confined limits of Manhattan Island. As underground operation was not feasible before the development of electric traction, this necessity led to the construction of the elevated system, which was completed by 1880, substantially as it exists today, except that the motive power has been changed from steam to electricity. The construction of this elevated system permitted rapid and intensive development of the territory north of 59th street, and further had the effect of concentrating business near the southern end of the island. Ten years after its completion the congestion of traffic again became so great that relief was imperative. The north andsouth streets were so limited in number and width that it was practically out of the question to build more elevated lines south of Central Park; and, as subways had now become feasible, because of the great density of population and volume of traffic and because of the improvements in electric traction, a north and south subway line with two branches above the Park was projected in the early 90's and placed in operation in 1904. Six years after its completion it was carrying as many passengers as the four elevated lines and the congestion of traffic made a further development of the system necessary.

The existing system (elevated and subway) comprises a total of 11 north and south tracks opposite Central Park, where the island is about two miles wide. North of the Park four lines spread into Bronx Borough and the northern part of the Manhattan, reaching points from 11 to 13 miles distant from the city hall. With the new lines now authorized there will be a total of 15 tracks opposite Central Park and 6 branches to the northward, reaching points 12 to 15 miles from the city hall. Of the three elevated lines at the Park, one has three tracks, the middle track being used for express service southward in the morning and northward in the afternoon, to a point about 7 miles north of the business center. Third tracks to be used in a similar manner are now authorized on the two other elevated lines. Of the four tracks in the present subway, two are used for express service, making only 3 stops between the down town district and 96th street, $5\frac{3}{4}$ miles north of the city hall.

The elevated system in New York was built entirely by private capital, but the subway system, with its elevated branches in the northern part of the city, was built by the city and leased to an operating corporation which furnished all equipment. A large part of the surface lines on Manhattan Island is now controlled and operated by the company which operates the high speed lines. Transfer privileges, however, are given at few points and to a very limited extent.

BROOKLYN:

The establishment of elevated railways on Manhattan Island led to their introduction in Brooklyn between 1885 and 1890. The Brooklyn lines, being projected by different companies and operating in comparatively thinly settled districts, did not attain the success of the New York system either financially or in point of utility. Since then, they have been brought under one management and have obtained direct delivery into Manhattan and have been a prime factor in the rapid growth of the population and the wide extension of the settled area. The system, however, is far from homogeneous, and if designed at the present time a much more efficient and satisfactory track layout could be obtained. A large proportion of the mileage is devoted to Coney Island and resort business. Except on some of the latter lines the system is practically all two track, with local service only. In 1908 the Manhattan subway was extended into the Brooklyn business district. A subway line extending out 4th avenue in the direction of Staten Island is now nearly completed, and the authorized rapid transit extensions in Brooklyn comprise 20.3 miles of subway and 38.5 miles of elevated lines. Practically all of the rapid transit and surface transportation service in Brooklyn is under the control of one company, and transfer privileges between surface and elevated lines are given in many cases.

GREATER NEW YORK (See Plate #1):

The rapid transit extensions authorized in Greater New York cover the use of the Steinway tunnel leading from 42nd street under the East river to Long Island City, together with several lines in Queens Borough. The operation of the new lines in Greater New York is to be divided between the two principal transportation systems so that each company will have good delivery routes in the lower part of Manhattan Island. The Interborough Company, operating principally in Manhattan, will serve the boroughs of Manhattan and Bronx with lines into Brooklyn and Queens, while the Brooklyn Company will serve Brooklyn Borough with lines into Queens and delivery lines in Manhattan.

A summary of the rapid transit lines now in operation and authorized to be constructed within the Greater City is as follows. The cost, etc., may be found in related tables.

FOR OPERATION BY THE INTERBOROUGH RAPID TRANSIT COMPANY.

	Track miles.
Existing subway ------------------------------------	73.0
Existing elevated lines ----------------------------	118.0
Subway and elevated lines for construction jointly by city and company ------------------	149.0
Elevated railroad extensions to be constructed by the company -----------------------------------	10.4
Third tracks on elevated roads to be constructed by the company ----------------------------	10.5
Total -----	360.9

FOR OPERATION BY THE N. Y. MUNICIPAL RY. CO (Brooklyn).

	Track miles.
Existing elevated lines ----------------------------	105.0
Subway and elevated lines for construction jointly by city and company ------------------	110.41
Elevated extensions for construction by the company --------------------------------------	35.29
Third tracking and reconstruction by company ------	9.30
Total -----	260.00
Grand total completed Dual system ------	620.90

Within the past ten years, tunnels under the Hudson river, which had been long projected, were completed for use as part of an independent rapid transit system, the special object of which was to connect the railroad passenger terminals on the New Jersey side of the river with the principal business districts of Manhattan Island and with the Grand Central station, or terminal for the New York Central, New York, New Haven and Hartford, and allied roads. This system, popularly known as the "McAdoo Tubes," is substantially completed and in operation, and consists of two sets of tunnels, those at the north running via 33rd and 6th avenue, to Christopher street; thence westward under the Hudson to Hoboken; thence south along the river to Jersey City. The south tunnel commences at Church street in Manhattan, runs west under the Hudson to a connection with the north tunnel at Jersey City, from which point both lines run as far as Newark, N. J., on surface tracks leased from the Pennsylvania Railroad. The system in Manhattan has 3.2 miles of road and 7.1 miles of single track, and is a distinct and separate enterprise from the City Rapid Transit improvement. The system carries entirely short haul traffic, having traffic agreements with the railroads whose termini it serves.

During the year ending June 30th, 1911, the period at which the Dual system was planned, the New York rapid transit lines carried 798, 281,850 passengers, divided as follows:

Interborough R. T. Co., subways & elevated -- 578,154,088

Brooklyn Elevated R. R. system -------------- 167,371,328

Hudson & Manhattan R. R. (McAdoo tubes) ----- 52,756,434.

During the year ending June 30th, 1913, the subways and elevated in Manhattan and Bronx alone, neglecting the McAdoo tubes, carried 327,471,510 and 306,845,006 passengers respectively, or a total of 634,316,516. During the year ending June 30th, 1914, the subway alone averaged 1,001,215 passengers daily, Sundays being taken as half days; and the total number of passengers on all routes amounted to the stupendous total of 1,813,204,692. Such figures demonstrate conclusively the necessity for efficient transportation in the metropolis.

CHICAGO - (See plate No. 11):

The distinct features of the transportation problem in Chicago are the widely extended area, the numerous steam railroad lines and the shape of the city, which is one-sided, owing to the location of its central business district near the lake. The rapid transit system is entirely elevated and was built largely between 1890 and 1900. There is one principal line to the north, one to the northwest, three to the west and one to the south. All of these lines come into a loop about 2 miles in circumference, which encloses the central business district. There are adjacent to the loop four stub terminals, from which trains are despatched in the rush hours. The line to the north extends to Wilmette, a distance of 14 miles, where connection is made with a high speed electric line to Milwaukee. This line is four-tracked for about 7 miles. The lines to the northwest and west reach points from 5 to 9 miles from the loop, and the trains of a high speed interurban line from the west are brought up to the loop over one of these elevated lines. The south side line runs directly south with three tracks for four

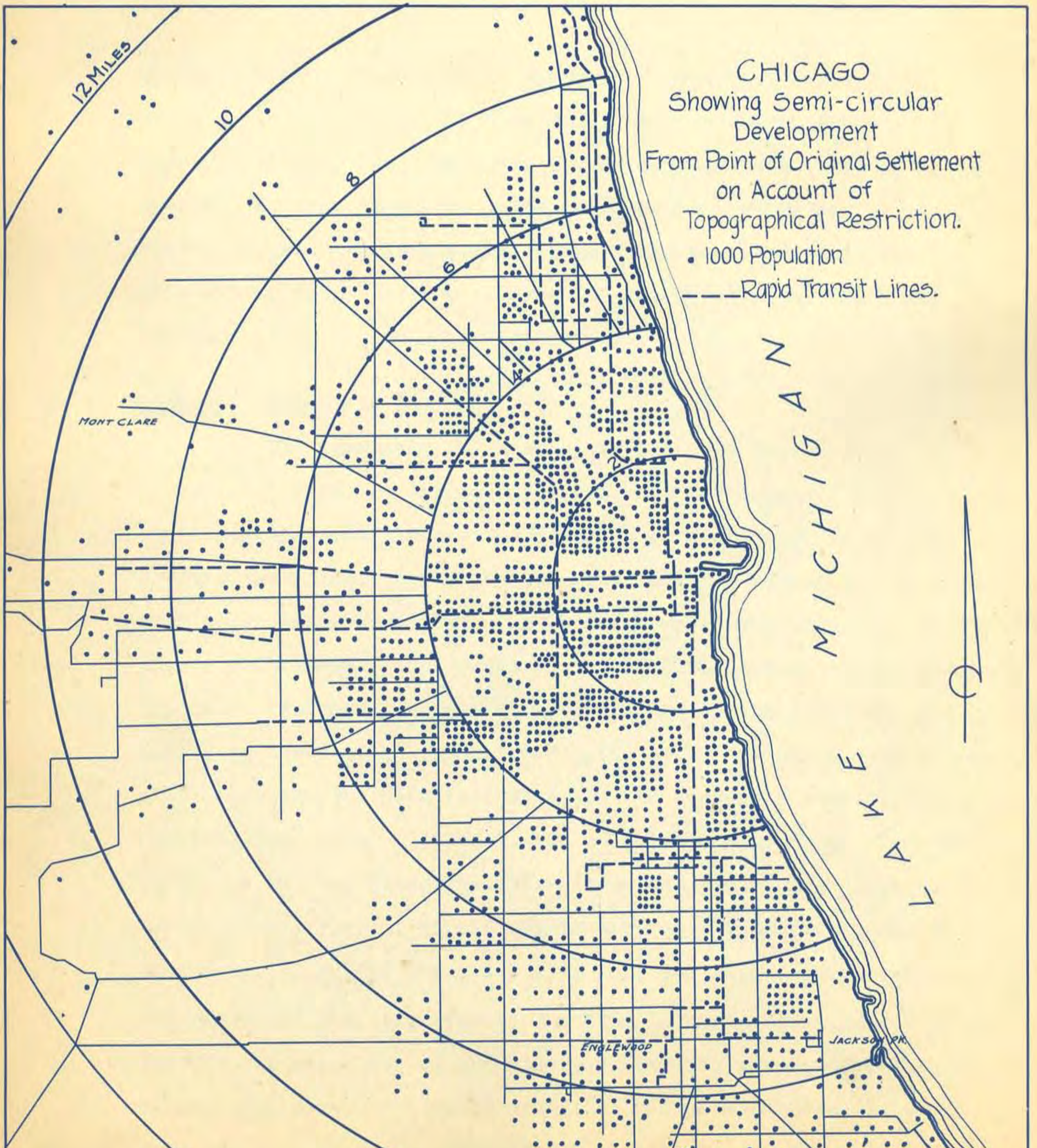

CHICAGO
Showing Semi-circular
Development
From Point of Original Settlement
on Account of
Topographical Restriction.
• 1000 Population
— — — Rapid Transit Lines.
12 MILES
10
8
6
4
2
MONT CLARE
ENGLEWOOD
JACKSON PK.
LAKE MICHIGAN

PLATE II.

miles. Beyond this point it throws off several two track branches, covering the territory for four miles farther south and about $3\frac{1}{2}$ miles in width. Until recently these rapid transit lines have been operated by four companies independent of each other and of the surface lines. Various plans for supplementang the present system by a subway loop, or by a complete system of subways, are under contemplation.

BOSTON - (See Plate #4):

The necessity for high speed lines in Boston arose principally from the extreme congestion in the narrow streets of the principal business district. In 1893 a partial solution of the problem was undertaken by the construction of a subway for surface cars under Boylston and Fremont streets, which was completed in 1898. This was followed by the construction of a high speed system consisting of an elevated line extending two miles to the north and another extending three miles to the southwest, both connecting with a loop which enclosed the principal district and connected the two large railroad terminals. The east side of this loop is on an elevated structure running along the water front and two of the original tracks of the Fremont street subway were used temporarily for the west side. A subway about one mile long was then constructed under the principal business street, and this is now used permanently for through operation of the elevated lines to the north and south. The elevated line to the south has been extended to a distance of 5 miles from the center, and it is proposed to extend the northern arm to about the same distance.

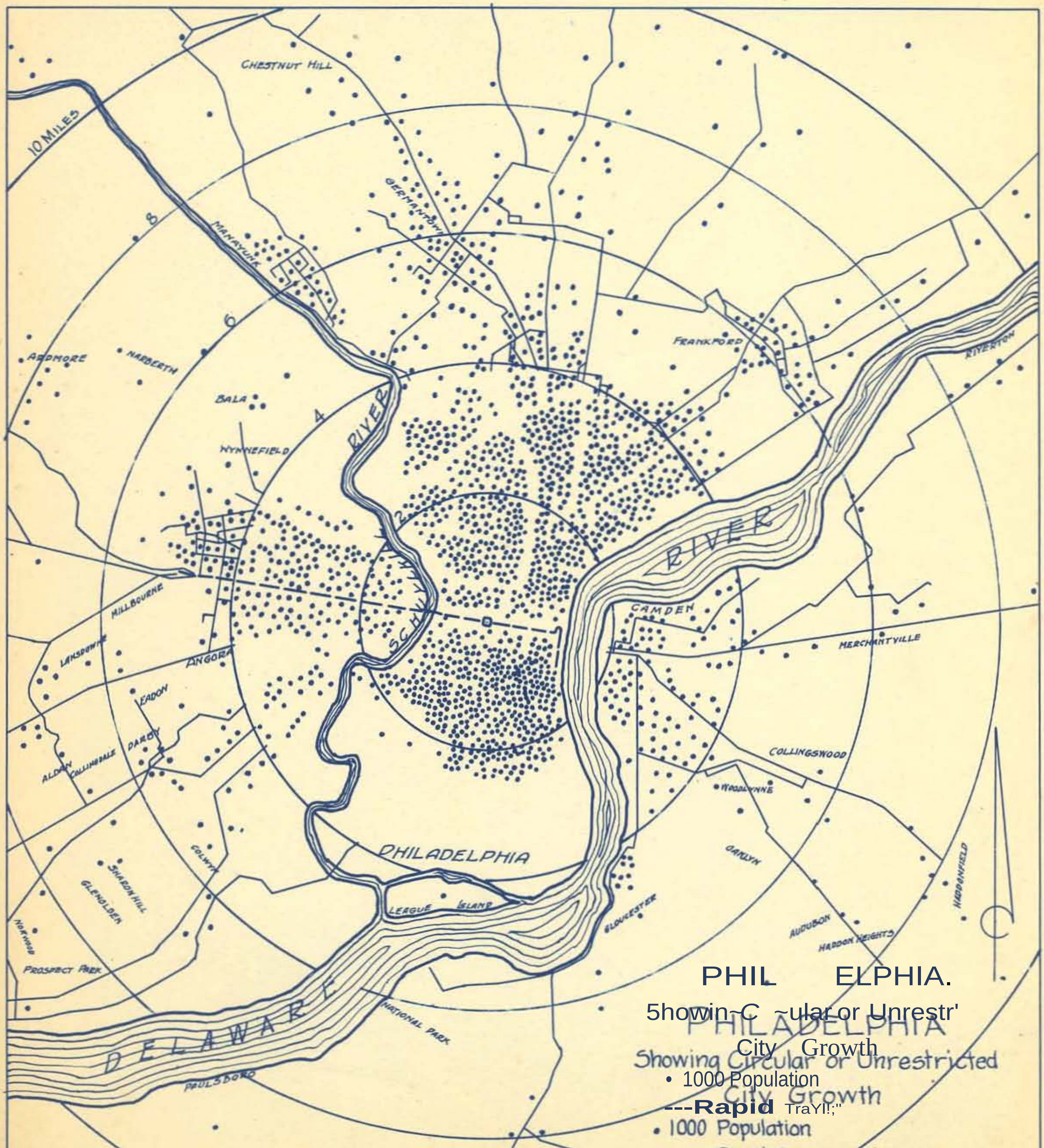
A tunnel has also been driven under the harbor to East Boston extending into the heart of the business district, where connection is made with the north and south line. Special type cars are operated singly in this tunnel and run out on the surface lines of East Boston.

Somewhat recently a subway line running about three miles westward to Cambridge has been placed in operation. Standard rapid transit service is maintained in this subway. An extension of this line eastward through the business district and thence southward for a distance of about two miles, has been authorized and is in process of construction. An elevated line for surface cars extends about a mile to the northwest and an extension of the subway for surface cars is being constructed to a point about two miles from the city hall.

All underground construction was undertaken by the city, while all of the elevated construction belongs to the operating company, which also owns and operates practically all of the surface system. All the high speed lines have elaborate terminals for the transfer of passengers to and from surface cars. This method of transfer is the most important feature of the Boston rapid transit system.

PHILADELPHIA - (See Plate #~~15~~12):

From a comparative standpoint, Philadelphia resembles Chicago in its wide area and in having its main business district


PHILADELPHIA
Showing Circular or Unrestricted City Growth
• 1000 Population
10 MILES
8
6
4
2
CHESTNUT HILL
GERMANTOWN
MANAYUNK
ARDMORE
NARBERTH
BALA
WYNNEFIELD
RIVER
SCHUYLKILL
MILLBOURNE
LANSDOWNE
ANGORA
EADON
DARBY
ALDAN
COLLINGDALE
SHARON HILL
GLENOLDEN
NORWOOD
PROSPECT PARK
COLWYN
PHILADELPHIA
LEAGUE ISLAND
DELAWARE
PAULSBORO
NATIONAL PARK
GLOUCESTER
FRANKFORD
RIVERTON
RIVER
CAMDEN
MERCHANTVILLE
COLLINGSWOOD
WOODLYNNE
OAKLYN
AUDUBON
HADDON HEIGHTS
HADDONFIELD

located near its eastern limits, thus causing unsymmetrical development. To a greater extent, however, than any other American city, it consists of individual communities built up around manufacturing industries as centers. The proportion of traffic to the central delivery district is not as great as in the other large cities described. The central business district is not restricted topographically but as the streets are narrowand as there is so much crossing of traffic, the usual city congestion occurs. The transportation requirements of the important outlying districts have been fairly well supplied in the past by good steam railroad accommodations, the city terminals of the railroads being in the heart of the business district. The development of electric traction has had the usual effect of extending the building districts, but the area within the distance of a reasonable surface car ride is now well occupied. There is no congestion of population in Philadelphia comparable with that in parts of other large cities, and there has been but little development of tenements or apartment houses.

The existing Market street subway - elevated line is of the best and most highly developed design throughout, and is so located as to provide the east and west arm of a complete system, serving the entire city.

COMPARATIVE STATISTICS:

The following series of tables show the most important traffic and financial statistics of rapid transit service in the cities above mentioned. Information contained therein relates to the year ending June 30th, 1912, unless otherwise stated, as later statistics for all cities are not available. It should be remembered that such data is principally valuable for the purpose of comparison. Construction of the various improvements outlined is being actively prosecuted in New York, Brooklyn and Boston. Philadelphia and Chicago have apparently deferred action until a more favorable financial period.

TABLE #8.

TRACK MILEAGE OF PASSENGER STREET TRANSPORTATION SYSTEMS.

City	Total	Surface	Rapid transit. Elevated.	Rapid transit. Subway.	Rapid transit. Total.	Ratio of Rap transit to Total track %
New York - (Manhattan and Bronx)	647.8	457.2	119.6	71.0	(A) 190.6	29.4
Brooklyn - (Including Queens)	820.7	698.8 (b)	116.7	5.2	121.9	14.8
Total - Greater New York	1468.5	1156.0	236.3	76.2	312.5	21.3
Chicago	809.9	666.2	143.7		143.7	17.8
Philadelphia	579.4 (c)	564.7	10.6	4.1	14.7	2.5
Boston	446.5 (d)	420.0	17.7	8.8	26.5	5.9

(A) In New York 17.4 miles of elevated track belong to the subway system, but are here classed as "Elevated." All the McAdoo track is classed as "Subway," though 11.7 miles are in New Jersey.

(B) Only about 64.5 miles of the "Elevated" track in Brooklyn and Queens are on elevated structures.

(C) Philadelphia has included in "Surface" track 1.9 miles of subway track used for surface cars.

(D) Boston has 11.4 miles of subway and elevated track for surface cars, here included in surface track.

TABLE #9.

PASSENGER SYSTEM REVENUES.

City.	Total.	Surface.	Rapid Transit.	Ratio Rap.transit to total %
New York - (Manhattan and Bronx) (A)	$56,599,771	23,102,948	33,496,823	59.2
Brooklyn - (Incl. Queens)	26,438,850	18,440,209	7,998,641	30.3
Total - Greater New York	83,038,621	41,543,157	41,495,464	50.0
Chicago (B)	30,008,030	22,125,872	7,882,158	26.3
Philadelphia	21,697,703	19,950,920	1,746,783	8.1
Boston	15,491,052	(Not segregated)		

(A) Including Hudson and Manhattan R. R.

(B) Year to 6/30/10.

TABLE #10.

NUMBER OF REVENUE PASSENGERS CARRIED (C).

City	Total.	Surface.	Rapid Transit.	Ratio Rap.transit to total %
New York - (Manhattan and Bronx) (A)	1,128,254,194	463,075,271	665,178,923	59.0
Brooklyn - (Incl. Queens)	539,699,942	379,896,151	159,803,791	29.6
Total - Greater New York	1,667,954,136	842,971,422	824,982,714	49.5
Chicago (B)	606,770,027	445,562,120	161,207,907	26.6
Philadelphia	444,704,602	409,762,847	34,941,755	7.9
Boston	310,310,009	255,980,509	54,329,500	17.5

(A) Including Hudson and Manhattan R. R.
(B) Year to 6/30/10.
(C) In New York over one-half the passengers travel on the rapid transit system, while in Brooklyn one-third, in Chicago one-quarter, and in Philadelphia 8% use high speed lines.

TABLE #11.

CAR MILES OPERATED - (C)

City.	Total.	Surface.	Rapid Transit.	Ratio Rap.transit to total %
New York - (Manhattan & Bronx)	208,270,527	71,240,564	137,029,963	65.8
Brooklyn - (Incl.Queens)	97,832,490	67,244,944	30,587,546	31.3
Total - Greater New York	306,103,017	138,485,508	167,617,509	54.8
Chicago (A)	129,191,172	85,788,797	43,402,375	33.6
Philadelphia	82,868,950	76,745,454	6,123,496	7.4
Boston (B)	54,564,378	45,202,162	9,362,216	17.2

(A) Year to 6/3o/10
(B) Boston Elevated Ry. Co. system only.

TABLE #12.

CAR MILES OPERATED PER MILE OF TRACK - (C)

City.	Surface.	Rapid Transit.	Ratio Rap.transit to surface %
New York - (Manhattan and Bronx)	155,800	699,800	4.5
Brooklyn - (Incl. Queens)	96,200	262,100	2.7
Average - Greater New York	119,800	536,400	4.5
Chicago (A)	128,800	302,000	2.5
Philadelphia	135,900	416,600	3.1
Boston (B)	107,600	353,300	3.3

(A) Year to 6/30/10.
(B) Boston Elevated Ry. Co. system only.
(C) Car miles operated per mile of track indicates density of traffic. Naturally, the traffic and car mileage over rapid transit track is much greater than over surface track. The relative number of car miles per track mile shows the relative efficiency of track layouts. In the case of

rapid transit lines, these comparative figures show roughly how near each city is to the limit of track capacity, as the number for New York represents a fair limit. On this basis, twice the present car mileage can be added in Chicago and Boston, and 70% more in Philadelphia.

TABLE #13.

REVENUE PASSENGERS PER MILE OF RAPID TRANSIT LINE (C).

New York - (Manhattan and Bronx)	9,124,500
Brooklyn - (Including Queens)	3,241,200
Average - Greater New York	6,751,000
Chicago - (A)	2,941,800
Philadelphia	4,786,500
Boston (B)	4,054,400

(A) Year to 6/30/10.
(B) Boston Elevated Ry. system only.
(C) Limit of capacity indicated to some extent by this table, but allowance must be made for the difference in length of haul, as with a shorter haul more passengers may be carried.

TABLE #14.

REVENUE PASSENGERS PER CAR MILE (C).

City.	Surface.	Rapid Transit.	Ratio Rapid transit To surface %
New York - (Manhattan and Bronx)	6.5	4.9	75
Brooklyn - (Incl. Queens)	5.6	5.2	93
Average - Greater New York	6.1	5.0	80
Chicago (A)	5.2	3.7	71
Philadelphia	5.3	5.7	108
Boston (B)	5.7	5.8	102

(A) Year to 6/30/10.
(B) Boston Elevated Ry. system only.
(C) Note that, except in Philadelphia and Boston, the revenue passengers per car mile are less on rapid transit than on surface lines, in spite of the fact that the former cars are larger. This is the result of the longer haul or greater number of passenger miles per passenger on rapid transit lines.

TABLE #15.

REVENUE RIDES PER YEAR PER CAPITA.

City.	Surface.	Rapid Transit.	Total.
New York - (Manhattan and Bronx)	159	229	388
Brooklyn - (Including Queens)	186	79	265
Average - Greater New York	171	167	338
Chicago (A)	204	74	278
Philadelphia	252	22	274
Boston (B)	234	50	284

(A) Year to 6/30/10
(B) Boston Elevated Ry. System only.

TABLE #16.

REVENUE RIDES PER CAPITA SINCE 1890 (C).

Year.	New York incl. Manhattan & Bronx	Brooklyn incl. Queens.	Greater New York	Chicago (A)	Phila-delphia.	Boston (B)
1890				159	158	172
1895				180	192	200
1900	276	208	249	200	220	229
1905	312	230	279	235	258	255
1910	376	251	325	278	258	274
1912	388	265	338		274	284

(A) Year to 6/30/10.
(B) Boston Elevated Ry. system only.
(C) The development of the habit of riding since the introduction of electric traction is shown by above table. Boston, Brooklyn and Philadelphia have followed about the same general rate. Chicago has increased more rapidly, while New York is in a class by itself. This is due to the distribution of population and to the large number of visitors continually in the city from distant or suburban points.

TABLE #17.

POPULATION PER MILE OF TRACK.

City.	Population	Rapid transit. Miles of Track	Rapid transit. Pop per mile of track	Surface. Miles of Track	Surface. Pop per mile of track	Total. Miles of Track	Total. Pop per mile of track.
New York - (Manhattan and Bronx)	2,904,906	190.6	15241	457.2	6353	653.0	4449
Brooklyn - (Including Queens)	2,038,154	121.9	16720	698.8	2917	815.5	2499
Total - Greater New York (A)	4,943,060	312.5	15818	1156.0	4276	1468.5	3366
Chicago (B)	2,185,283	143.7	15207	666.2	3280	809.9	2698
Philadelphia (A)	1,623,200	14.7	110422	564.7	2874	579.4	2802
Boston (A)	1,094,831	26.5	41314	420.0	2607	446.5	2452
Total	9,846,374	497.4	19796	2806.9	3508	3304.3	2980

(A) Estimated for year 1912.

(B) United States Census - 1910.

TABLE #18.

MILEAGE OF PROPOSED EXTENSIONS TO RAPID TRANSIT SYSTEMS.

City.	Elevated Line	Elevated Track	Subway Line	Subway Track	Total Line	Total Track
New York - (Manhattan and Bronx)	18.7	63.0	27.9	89.4	46.6	152.4
Brooklyn - (Including Queens)	38.5	109.5	20.3	58.4	58.8	167.9
Total	57.2	172.5	48.2	147.8	105.4	320.3
Chicago			56.4	131.7	56.4	131.7
Philadelphia	16.9	33.9	8.6	25.4	25.5	59.3
Boston (A)	3.1	6.2	1.8	3.7	4.9	9.9
Total under construction	60.3	178.7	50.0	151.5	110.3	330.2
Total under construction and recommended	77.2	212.6	115.0	308.6	192.2	521.2

(A) Boston has also under construction 1.7 miles of lines, comprising 4.5 miles of subway track for surface cars.

TABLE #19.

MILEAGE OF RAPID TRANSIT SYSTEMS AFTER CONSTRUCTION OF PROPOSED EXTENSIONS.

City	Elevated Line	Elevated Track	Subway Line	Subway Track	Total Line	Total Track	Ratio to Total of all Cities - % . Line	Ratio to Total of all Cities - % . Track
New York - (Manhattan & Bronx)	62.5	182.6	55.3	160.4	117.8	343.0	30.2	33.8
Brooklyn - (Including Queens)	87.8	226.2	22.0	63.6	109.8	289.8	28.2	28.5
Total-Greater N.Y.	150.3	408.8	77.3	224.0	227.6	632.8	58.4	62.2
Chicago	54.8	143.7	56.4	131.7	111.2	275.4	28.5	26.9
Philadelphia	22.2	44.5	10.7	29.5	32.9	74.0	8.4	7.3
Boston	12.1	24.0	6.2	12.5	18.3	36.5	4.7	3.6
Total	239.4	621.0	150.6	397.7	390.0	1018.7	100.0	100.0

TABLE #20.

APPROXIMATE INVESTMENT IN RAPID TRANSIT SYSTEMS (H)

		City	Company	Total Investment
New York - (Manhattan and Bronx)	Subway	$40,000,000	$111,000,000(A)	151,000,000
	Elevated	10,000,000	110,000,000(B)	120,000,000
	Total	50,000,000	221,000,000	271,000,000
Brooklyn - (Incl. Queens)	Subway	5,000,000	4,000,000	9,000,000
	Elevated		51,000,000(C)	51,000,000
	Total	5,000,000	55,000,000	60,000,000
Total - Greater New York	Subway	45,000,000	115,000,000	160,000,000
	Elevated	10,000,000	161,000,000	171,000,000
	Total(D)	55,000,000	276,000,000	331,000,000
Chicago	Subway			
	Elevated		98,000,000(E)	98,000,000
	Total		98,000,000	98,000,000
Philadelphia	Subway			
	Elevated			
	Total(F)		17,000,000	17,000,000
Boston	Subway			
	Elevated			
	Total(G)	9,000,000	35,000,000	44,000,000
	Grand total -	$64,000,000	$426,000,000	$490,000,000

(A) Including investment in Hudson and Manhattan R. R., assumed at $74,000,000

(B) Including investment in Manhattan Ry., assumed at $101,000,000.

(C) Representing investment assumed at par value of bonds, notes and stock of Brooklyn Union Elevated R. R. and Sea Beach Ry. Co. Track is partly on the surface and power plant cost not included.

(D) Approximated from reports of Public Service Commission.

(E) Investment assumed at estimate of cost of reporduction of physical property.

(F) Approximate investment after deducting surface car subway.

(G) Approximate only, as it is impossible to separate the company's rapid transit and surface investments. City has additional investment of $8,000,000 in subways for surface cars and company has additional investment in subways and viaducts for surface cars.

(H) In New York all subways and elevated extensions of subways in outlying

TABLE #21

ESTIMATED PROPOSED INVESTMENT IN RAPID TRANSIT FACILITIES RECOMMENDED FOR IMMEDIATE CONSTRUCTION.

		City.	Company.	Total Investment.	Status
New York - (Manhattan and Bronx)	Subway	$97,000,000	$70,000,000	$167,000,000	Under
	Elevated	7,000,000	38,000,000	45,000,000	Constr-
	Total	104,000,000	108,000,000	212,000,000	uction.
Brooklyn - (Including Queens)	Subway	45,000,000	30,000,000	75,000,000	Under
	Elevated	14,000,000	29,000,000	43,000,000	Constr-
	Total	59,000,000	59,000,000	118,000,000	uction.
Total Greater New York	Subway	142,000,000	100,000,000	242,000,000	
	Elevated	21,000,000	67,000,000	88,000,000	
	Total	163,000,000	167,000,000	330,000,000	(A)
Chicago	Subway	96,000,000	35,000,000	131,000,000	
	Elevated				
	Total	96,000,000	35,000,000	131,000,000	(B)
Philadelphia	Subway	31,000,000	7,000,000	38,000,000	
	Elevated	4,000,000	16,000,000	20,000,000	
	Total	35,000,000	23,000,000	58,000,000	
Boston	Subway	7,000,000	2,000,000	9,000,000	Under con
	Elevated		6,000,000	6,000,000	struction
	Total	7,000,000	8,000,000	15,000,000	(C)
Total	Subway	276,000,000	144,000,000	420,000,000	
	Elevated	25,000,000	89,000,000	114,000,000	
	Total	301,000,000	233,000,000	534,000,000	

(A) Comprises the "Dual System," to be owned by the City jointly with the two companies. Includes cost of equipment (about $47,000,000) and extensions of existing elevated lines (about $46,000,000) to be the property solely of the companies.

(B) Comprises a subway system to be owned by the city and leased to a company, which would own the equipment.

(C) Proposed subway is being built by the city and the elevated line is being built by the Boston Elevated Railway, which will own the entire equipment. Boston, also, has under way the construction of subways for surface cars to cost $8,300,000.00.

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and that no one individual is entitled to more than his, or her, fair share.

The provision of adequate area for the operation of public transportation is vital to the growth of any city, since cheap and expeditious means of transit form the greatest factor in civic development. The character of such operating area, subway, elevated or surface, as the case may be, is economically determined by the topography of the city; but sub-surface construction as applied to urban traffic, should be looked upon as a measure of last resort, a necessity forced by conditions for which there is no other remedy. As an inlet for an extensive system of inter-urban lines, the construction of a subway occasionally becomes warranted, since there is no way by which a city can so effectively extend its sphere of influence as by the provision of unobstructed entrances and exits for high speed transportation.

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SUMMARY.

It is possible that future years will bring an even greater growth of population to the City of Los Angeles and its environs than the product of the past amazing decade, and it is far from improbable that all territory contained within its metropolitan circle, will, in a comparatively brief period, be solidly built up with residential improvements of high class character, the homes of that proportion of the inhabitants who desire individual places of abode and less crowded conditions than inevitably obtain within a city's actual boundaries. Business activities will naturally increase in corresponding ratio, and the area required for the transaction of business must be capable of meeting the necessity of territorial expansion in exact proportion to the exigency, if the full measure of commercial prosperity is to be realized. Convenience of operation is a strong attraction and frequently the deciding factor in the location of commercial institutions, other things being equal, and inconvenience is only tolerated when natural remedies are incompetent to provide relief. A city is nothing more than an aggregation of population, and as such, is subject to the same natural laws as regulate each individual component. Cramped quarters can but produce cramped growth, and complete development can only be attained in adequate and suitable surroundings. A few cities, like a few individuals, have their inception under unfavorable circumstances, and labor, throughout their periods of existence, under conditions of physical disability.

Unable to achieve their proper growth in a normal manner, their development is only possible by the use of abnormal measures. A city, however, so located as to be free from topographical limitation, inherently possesses the ability to acquire symmetrical development with complete utilization of all possible tributary area, thus realizing the benefit of resources otherwise latent.

Los Angeles is fortunate in being so situated, and any measures employed to check or restrain its business area from expanding to its proper location can only be regarded as a subversion of natural forces fully able to provide their own solution of the congestion problem. As a matter of fact, the City is just passing from the adolescent stage; and the accommodations for the transaction of its business, together with its customs or ordinances for the conduct of its traffic, vehicular and pedestrian, are insufficient for a municipality containing possibly a million people. The problem of providing a larger area for commercial transactions will solve itself automatically by expansion or removal in the most convenient direction; and the passage of more stringent regulations governing the conduct of traffic will go far to relieve the present uncomfortable conditions. Rural customs are only permissible in rural communities. Frontage deliveries and the practice of standing vehicles on central thoroughfares can only be tolerated prior to civic growth and consequent population density. It should be realized that the vested right of any individual to the occupation of the common property, or streets, of any community, diminishes in direct proportion to the increase in the number of the inhabitants, districts are owned by the City, and the subway equipment is owned entirely by the company, except in the case of the Hudson and Manhattan where the company owns both structure and equipment. The elevated system complete is owned by private corporations.

Chicago and Philadelphia systems were constructed entirely by private capital.

Boston subway structures within the city limits are owned by the City. All elevated structures, whether connected or not with the subways, all subway equipment, and the subway structure in Cambridge, are owned by the operating company.

Figures in this table taken to the nearest $1,000,000.