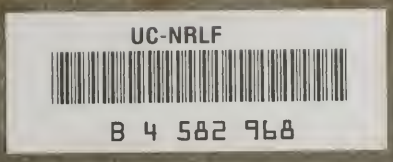
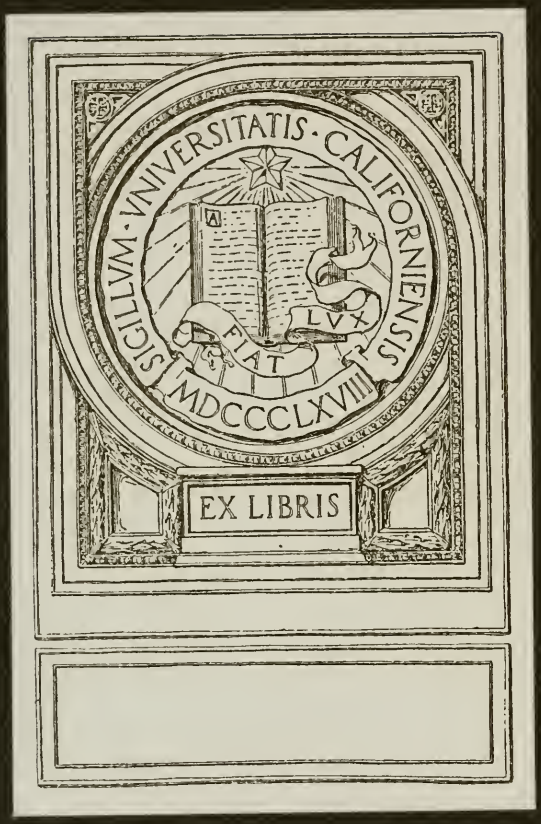




THE TRAFFIC OF THE SUBWAY

OF THE

Interborough Rapid Transit Company of New York City.

SUBMITTED TO THE

PUBLIC SERVICE COMMISSION

FOR THE FIRST DISTRICT OF THE STATE OF NEW YORK

BY

BION J. ARNOLD,
Special Consulting Engineer.

REPORT No. 6,

December 31st, 1908.

PUBLIC SERVICE COMMISSION,
154 NASSAU STREET,
NEW YORK CITY.

[Form 2125] [1000—D '08 (B)]

LETTER OF TRANSMITTAL.

New York, December 31st, 1908.

Public Service Commission for the First District of the State of New York, 154 Nassau Street, New York City:

Gentlemen—I have the honor to submit herewith my report upon "The Traffic of the Subway," this being the sixth of a series of reports which I have prepared for you upon the present Subway of the Interborough Rapid Transit Company.

This report contains the results of studies of the passenger and train movements which have been made from time to time in the preparation of the reports I have already submitted covering the safety, the comfort and the capacity of the present Subway. Parts of this report might have been issued before, but it has been thought best not to submit the traffic data used in drawing the conclusions reached in my other reports until they could be combined into a comprehensive record.

This report, therefore, shows a record of the traffic in the Subway as I found it a year ago; shows the results of the improvements that have been made during the past year and indicates the benefits that may be expected if other possible improvements are finally carried out.

This report also shows the advantages that are being enjoyed by the citizens of Greater New York as a result of the operation of the present Subway. To design, build and operate an expensive system of subsurface transportation furnishing facilities for a 17½ miles continuous ride at high speed through the heart of a crowded city, and underneath a broad river, for one five cent fare is an accomplishment which appears more creditable as the difficulties of duplicating it become appreciated.

The information in this report emphasizes the fact that has already been pointed out,—that one of the most serious defects of the present Subway is its lack of overload capacity; that is, its inability properly to carry the peak load traffic which must be handled twice each business day. In the building of future Subways this defect should be remedied, and in the operation of the present Subway every effort should be made to increase the carrying capacity during these rush hour periods.

During the past few months the carrying capacity during rush hours of the express tracks of the Subway has been increased about 10% by changes in the signal

system, and of the improvements that will further increase this capacity there still remain to be carried out the following:

1.—Additional doors in each side of each car. (Now being installed on experimental trains.)

2.—Speed control signals at the approach to each express station. (Now being developed and in operation at one point.)

3.—The elimination of the 96th Street crossover and the introduction of reservoir tracks at this point. (Now under construction.)

4.—The running of all express trains to Brooklyn by providing a shuttle train service between Bowling Green and South Ferry. (Necessary changes to accomplish this now under construction.)

5.—The adding of an additional car to each express train during the rush hour periods.

6.—The adoption of an automatic coupler so that trains can be quickly made up and broken up at intermediate points to save dead car mileage.

Much has been said in regard to furnishing "a seat for every passenger." With the present Subway there are more seat miles operated each day than there are passenger miles traveled, and therefore, if the passenger movement could be made to coincide with the seat movement, there would be a seat for every passenger and some seats to spare. However, as the passengers cannot be expected to travel to fit the convenience of railroad operations, unremitting efforts should be made to move the seats coincident with the passenger movement. In adopting a method of regulation for the future car movement of the present Subway upon a basis which will not be unjust to the Subway company, my recommendation is to divide the probable number of passengers by a constant determined as shown in the report, in order to establish the number of car miles that should be run, and then prepare a schedule calling for this number of car miles so distributed as to carry the greatest number of seated passengers.

Respectfully submitted,

(Signed) BION J. ARNOLD, Consulting Engineer.

THE TRAFFIC OF THE SUBWAY OF THE INTER-BOROUGH RAPID TRANSIT COMPANY OF NEW YORK CITY.

The system of transportation which is popularly known as the New York Subway is a rapid transit railroad in the Boroughs of Manhattan and The Bronx with a recently opened extension to the Borough of Brooklyn. Fully 75% of this road has been built beneath the surface, where its operation is not interfered with by the congested street traffic and its technical success during the three years a large part of it has been running demonstrates the practicability and desirability of a subsurface system of transportation under the conditions existing in New York City.

Location.

Plate I, showing the location and configuration of the routes, indicates that the part of the line serving Manhattan and The Bronx roughly resembles the letter "Y," the base of which is located at the southern extremity of Manhattan Island. The branching occurs at 103d Street and Broadway; the end of the westerly branch being at 242d Street near Van Cortlandt Park, and the end of the easterly branch at 180th Street and West Farms Road near Bronx Park. The Brooklyn division extends under the East River at nearly right angles to the stem of the "Y" serving lower Manhattan and ends at the intersection of Flatbush Avenue and Atlantic Avenue, Brooklyn, convenient to the terminal station of the Long Island Railroad.

In general the districts served by the Subway may be classified as follows:

1.—Brooklyn Terminal at Flatbush Station of Long Island Railroad.
2.—Business and Civic Center of Brooklyn.
3.—Ferry connections at South Ferry Station.
4.—Business District in the vicinity of Wall Street.
5.—Brooklyn Bridge Terminal and City Hall.
6.—Shopping Districts at 14th Street and 23rd Street.
7.—New York Central and Suburban train connections at Grand Central Station.
8.—Theatre District at Times Square.
9.—Residence District, upper Manhattan and Harlem.
10.—Van Cortlandt Park.
11.—Residence District, The Bronx.
12.—Bronx Park.

To serve the demand for transportation by means of the Subway, a combination of local and express service has been provided whereby the local service in addition to

carrying passengers from one local station to another local station acts also in a collecting and distributing capacity for certain points along the route, between which points a more rapid transit can be obtained by means of the express service. This transfer privilege is one of the distinguishing features of the New York Subway. To carry out this idea, that portion of the system represented by the stem of the "Y" is operated for the most part as a four-track road, the two inner tracks being operated as express tracks, the two outside tracks carrying the local service. An extension of this idea has been put in operation on the westerly branch of the system, whereby an express service in a downtown direction in the morning, and in an uptown direction in the evening is obtained. This is accomplished by using a third track between 137th Street and 96th Street during the morning and evening rush hours for an express service in the manner just indicated. The points or stations between which express service is given are Brooklyn Bridge, 14th Street, Grand Central station, 72nd Street and 96th Street, and in addition at 137th Street as noted above.

Plate II shows the relative distance between stations and the disposition of the tracks in detail. From the Brooklyn Bridge station to 96th Street station the line is four-tracked. On the Broadway branch (including 103rd Street station) there are three tracks to 145th Street, then two tracks to Dyckman Street, then three tracks again to Bailey Avenue. On the Bronx Park or Lenox branch there are two tracks to Brook Avenue, and from that point to Bronx Park (180th Street) there are three tracks. On the Lenox Avenue spur to 148th Street there are two tracks; on the City Hall loop, one track; on the Battery Park loop two tracks. The Brooklyn extension is a two track line through separate tubes under the East River to Borough Hall and practically a four-track line between Borough Hall and Atlantic Avenue. Liberal provision has been made in planning the line between Borough Hall and the end of the Brooklyn extension to take care of future extensions and connections.

In Manhattan there is a storage yard under Broadway between 137th Street and 145th Street on the Fort George branch, another on the surface at the end of the Lenox Avenue spur, Lenox Avenue and 148th Street, and a third on an elevated structure in The Bronx at Boston Road and 178th Street. There is a repair shop and inspection shed on the surface adjoining the Lenox Avenue spur at Harlem River, near 148th Street, and an inspection shed at the storage yard at Boston Road and 178th Street.

Length of Line.

The following table shows the shortest distance by way of the Subway lines between Brooklyn Bridge and 96th Street; between Brooklyn Bridge and 242nd Street, Broadway line; between Brooklyn Bridge and 180th Street on the Lenox Line, and from Brooklyn Bridge to Atlantic Avenue on the Brooklyn extension. The total length of the Subway system is 25.8 miles.

TABLE I.

Length of Road, Compared with Shortest Distance.

	Subway.	Straight Line.
Brooklyn Bridge to 96th Street	6.43 miles	5.84 miles
Brooklyn Bridge to 242nd Street	14.17 "	13.32 "
Brooklyn Bridge to 137th Street	8.55 "	7.87 "
Brooklyn Bridge to 180th Street	13.46 "	11.08 "
Brooklyn Bridge to 145th Street	9.45 "	8.18 "
Brooklyn Bridge to Atlantic Avenue	3.25 "	2.43 "

This table shows the shortest distance in miles from Brooklyn Bridge to these same points, and therefore indicates the extent of the diversion of the Subway from a straight line.

If the Subway had been built down Broadway from the Times Square Building to 14th Street instead of being diverted down 42nd Street to pass by the Grand Central Station, about ⅜ of a mile would have been saved in the length of the line from Brooklyn Bridge to upper Manhattan.

On the other hand, if the Lenox branch could have made connection directly with the Subway at the Grand Central Station instead of being carried west to Broadway, all of the Lenox passengers would have saved nearly one mile's travel each way between Brooklyn Bridge and The Bronx.

In addition to the larger diversions of the road, there are many small curves which not only add to the length of the line but also reduce the possible speed that could be economically maintained. Fully 25% of the total length of line is upon curves, the least radius of curvature being 147 feet. Upon the approaches to the tunnels under the Harlem River and East River there are grades of 3% and this is the maximum grade to be found in the Subway.

The longest continuous ride in the Subway without change of routes is from Atlantic Avenue in Brooklyn to 242nd Street—a distance of 17.5 miles. The longest continuous ride on the Manhattan elevated system is one of 14.6 miles on the Third Avenue Elevated line and the longest continuous ride without transfers on the surface lines is 12.3 miles on the Third Avenue line from the Post Office to Fort George.

Variations in Yearly Traffic.

In order that a comprehensive idea of the magnitude and growth of the passenger traffic of the Subway may be obtained, the data of Table II, shown graphically in Figure I, may be studied to advantage.

Table II.

Comparative Passenger Traffic by Years.

Period.	Tickets Sold.
*Oct. 27, 1904, to Dec. 31, 1904	16,241,869
Jan. 1, 1905, to Dec. 31, 1905	116,209,313
Jan. 1, 1906, to Dec. 31, 1906	149,778,370
Jan. 1, 1907, to Dec. 31, 1907	182,559,990
Jan. 1, 1908, to Dec. 31, 1908	220,991,212

* The date the Subway was opened to traffic.

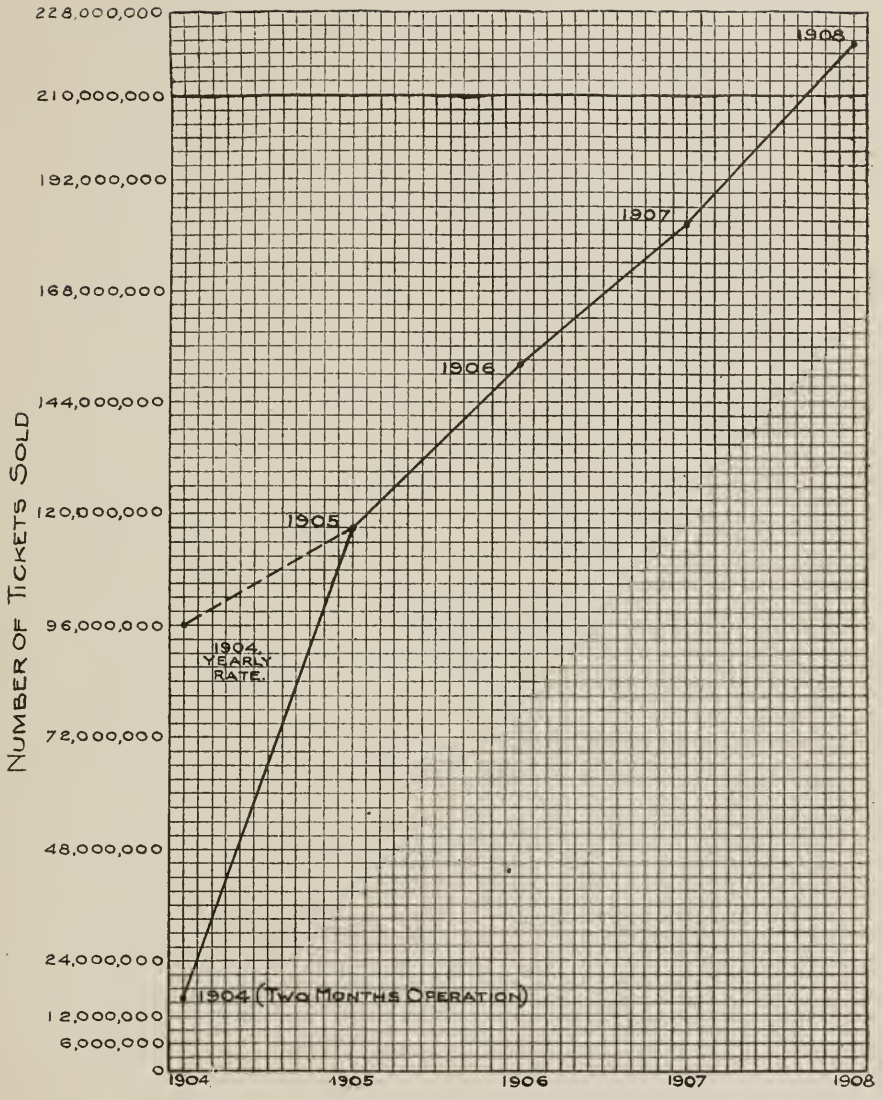


FIGURE 1.

Showing Increase in Subway Passenger Traffic by Years.

TABLE III.

London Tube Railways.

Traffic Figures for Half Year Ended June 30, 1908.

	Length in Miles of		Car Miles			Number of Passengers			Ratios	
	Road	Single Track Operated	Total	Per Mile of Road	Per Mile of Single Track	Total	Per Mile of Road	Per Mile of Single Track	Car Miles to Passengers	Passengers to Car Miles
½ Year Ending June 30, 1908										
City and South London.....	7.3	28.5	3,130,000	428,767	109,825	11,550,000	1,582,192	405,263	.271	3.69
Central London.....	6.9	22.5	4,100,000	594,203	182,222	19,901,750	2,884,312	884,522	.206	4.85
Great Northern and City.....	3.5	13.0	1,024,906	292,830	78,839	6,875,602	1,964,458	528,892	.149	6.71
Baker Street and Waterloo...	4.7	22.8	1,770,126	376,622	77,637	12,940,801	2,753,383	567,579	.137	7.29
Great Northern, Piccadilly and Brompton	9.5	40.7	3,742,507	393,948	919,535	19,446,477	1,836,472	428,660	.214	4.67
Charing Cross, Euston and Hampstead	8.1	39.8	2,596,526	320,559	65,239	12,132,639	1,497,856	304,840	.214	4.67
Total all roads for ½ year	40.0	167.3	16,364,065	409,102	97,813	80,847,269	2,005,012	479,381	.204	4.90

TABLE IV.

Comparative Traffic Figures for One Year.

	Length in Miles of		Car Miles			Number of Passengers			Ratios	
	Road	Single Track Operated	Total	Per Mile of Road	Per Mile of Single Track	Total	Per Mile of Road	Per Mile of Single Track	Car Miles to Passengers	Passengers to Car Miles
Interborough Subway.....	25.63	69.9	44,005,211	1,716,941	629,545	200,415,050	7,819,549	2,870,172	.219	4.56
Manhattan Elevated.....	37.6	90.66	64,584,611	1,717,659	712,382	282,870,590	7,523,153	3,120,125	.228	4.38
*London Underground Tubes..	40.	167.3	32,728,130	818,204	195,626	160,000,998	4,010,024	958,762	.204	4.90
Chicago Elevated Roads.....	35.62	150.53	39,264,008	1,102,316	261,760	147,267,113	4,134,390	981,780	.273	3.75

* In order to compare the New York Subway with enterprises of a similar character, Table III is given, showing the result of *six months'* operation of the Subways of London, England. In Table IV the results of this six months' period ended June 30, 1908, have been doubled so as to show a period of one year, and these figures are compared to the corresponding results with the Interborough, or New York, Subway for the year ended June 30, 1908, with the results of the four Manhattan Elevated lines for the year ended June 30, 1908, and with the four Chicago Elevated Roads for the year 1907.

It will be seen that the density of traffic of both cars and of passengers is nearly the same with both the Subway and the Elevated Lines in New York City. This density of traffic as indicated by the number of car miles and the number of passengers *per mile of road* is more than twice as heavy with the New York Subway as it is with the London tubes, and fully 50% greater than with the Chicago Elevated Roads.

Each mile of track in the New York Subway is used on an average of three times as efficiently for moving both cars and passengers as is the case with the London Tubes, and on both the Elevated and Subway tracks of New York City there are also three times as many passengers moved each year as are handled on an average on *each mile of single track* of all of the Chicago Elevated Roads, including the Union Loop.

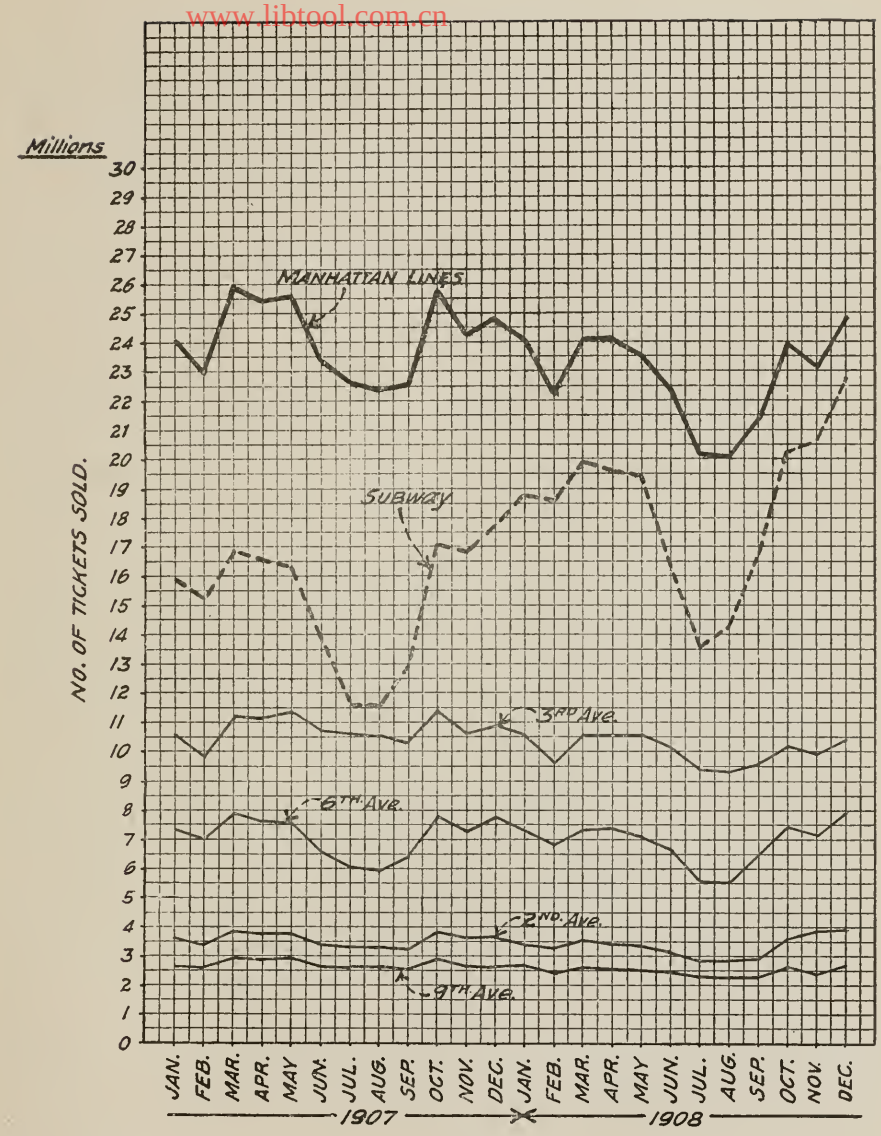


FIGURE 2.

COMPARATIVE PASSENGER TRAFFIC BY MONTHS.

Subway and Manhattan Elevated Roads.

The subway traffic has been steadily increasing. This diagram shows the comparative falling off of patronage during the summer months of the Elevated and the Subway lines.

Traffic By Stations.

The yearly ticket sales for the years 1906 and 1907 at the different stations are shown by Figure 3, the lightly shaded sections showing the sales for 1906 and the black sections representing the increase in sales during the year 1907, the distance from the base line to the top of the black sections thus representing the sales for 1907. This diagram represents at once therefore not only the relative ticket sales at the various stations but also shows the stations at which the business is increasing the fastest; for instance, it will be noted that the business at the Times Square station is increasing more rapidly than the business at the Grand Central Station, making it probable that the Times Square station may soon handle as many pay passengers as those who *now* purchase tickets at the Grand Central Station.

To show the geographical distribution of the Subway patrons, the relative ticket sales at various stations have been shown by means of circles upon the map, Plate II. This map indicates at once that the Lenox branch is much better patronized than the Broadway line and attention is at once attracted to the fact that the stations at the out-lying ends of both branches show comparatively the least number of ticket sales.

The opening of the Brooklyn extension to Borough Hall station on January 1st, 1908, and to Atlantic Avenue on May 1st, 1908, has decreased the number of ticket sales sold at the Brooklyn Bridge station by over 20% and at the same time has increased considerably the ticket sales at Bowling Green, Wall Street and Fulton Street. From present appearances the ticket sales during the year 1908 will be about 3,500,000 at Bowling Green, 10,000,000 at Fulton Street and 7,000,000 at Wall Street and these figures have been shown by the dotted circles at the respective stations in Plate II. The total increase in ticket sales at these three stations will show an increase of approximately 5,000,000 tickets during 1908 which will offset the falling off of ticket sales at Brooklyn Bridge. As a result the entire ticket sales on the Brooklyn side of the tubes under the East river may be taken as the measure of the influence of the Brooklyn extension on the earning power of the Subway. As near as the earnings can be estimated at present the ticket sales at the various Brooklyn stations after May 1st, 1908, will be at about the following *rates per year:*

Borough Hall	7,500,000
Atlantic Avenue	9,500,000
Nevins Street	2,500,000
Hoyt Street	2,500,000

—or a total for the Brooklyn extension of 22,000,000 passengers per year. The passenger traffic to and from Brooklyn is a fortunate addition to the Subway business as a large portion of the Brooklyn passengers ride a comparatively short distance and in a direction opposite to the Manhattan load tending to use more effectively the return cars and thus cut down the proportion of empty seats.

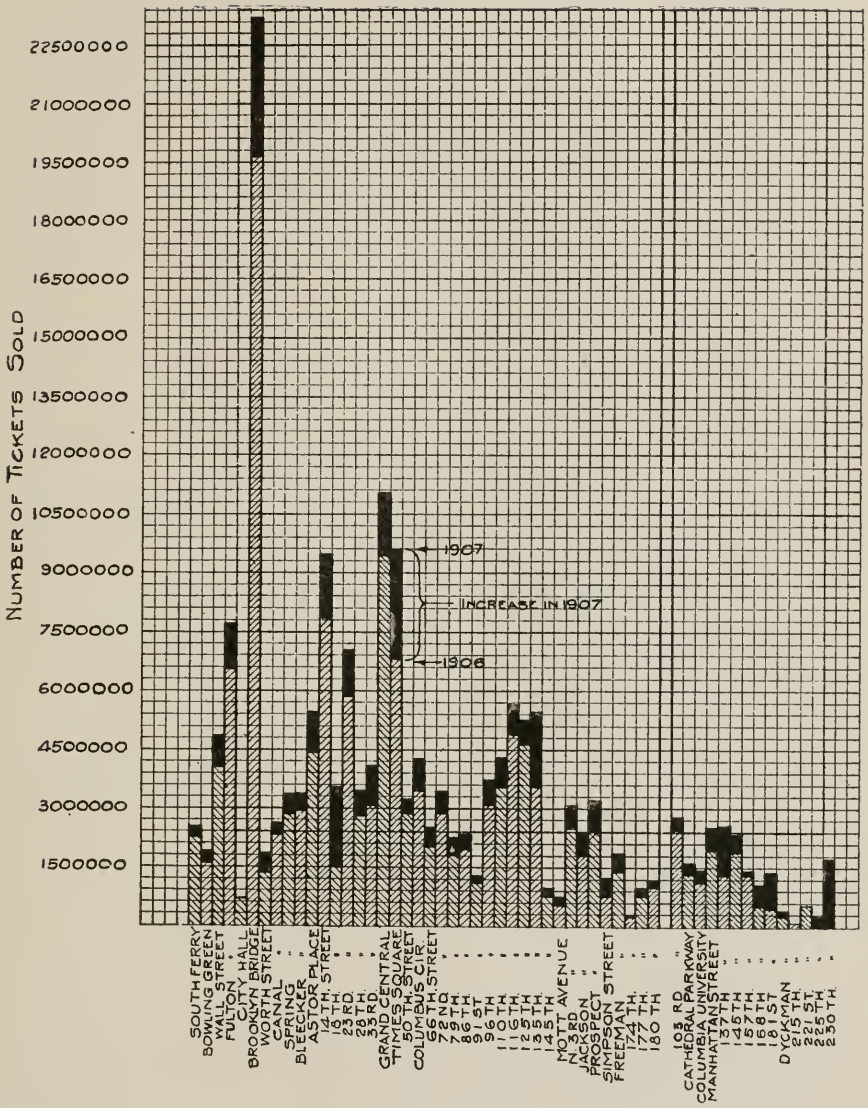


FIGURE 3.

Yearly Ticket Sales by Stations by Years.

This diagram shows graphically the relative patronage from the stations on the "Broadway" and the "West Farms" branches and indicates the small amount of patronage served in the outlying districts.

Monthly Variations in Traffic.

Figure 4 shows the variation of ticket sales from month to month, which sales may, for the purpose of this report be taken as a measure of the passenger travel for the periods in question. The curves show a characteristic variation throughout the year, the lowest values occurring during July and August of each year and the highest during December.

Table V shows the percentage relation of the lowest and highest monthly values to the average monthly value for the corresponding year, and the ratio each year between the maximum month and the minimum month. It will be noticed that this latter ratio is decreasing; that is, that the falling off in patronage during the summer months is less evidenced each year.

Table V.

Showing comparison of number of passengers during month of heaviest travel and month of lightest travel with average travel:

Year	Monthly average	Lowest month	Percentage of monthly average	Highest month	Percentage of monthly average	Ratio of maximum month to minimum month
1905.....	9,684,109	6,070,908	62.7%	13,704,576	141.5%	2.25
1906.....	12,481,530	8,555,795	68.67%	15,609,516	125.1%	1.82
1907.....	15,202,000	11,550,000	76. %	17,750,000	116.8%	1.58

Figure 2 shows the number of tickets sold each month during 1907 and 1908 in the Subway system and also on each of the four Manhattan Elevated lines for the corresponding months. This diagram indicates plainly that the decrease in the traffic of the Subway during the summer months is much more marked than the decrease in patronage of the elevated roads during the same time. Some of the patrons of the Subway leave the city for the summer months while many other passengers who regularly ride in the Subway prefer the elevated and surface cars during the summer. While the Subway does not get its proportion of passengers during the summer months it more than makes up this loss in the winter months when riding in the Subway is more comfortable than in the surface or elevated cars.

Daily Variation in Traffic.

Information with regard to the daily variation in traffic has not been shown as the ticket sales cannot be considered a measure of the number of passengers carried, since many persons acquire a small stock of tickets for convenience, thus apparently increasing the day's traffic. The effect of such practice on the apparent volume of traffic when considering periods of more than a day, however, is minimized to such an extent that it can be neglected. As a matter of general observation, it may be stated that the lightest traffic occurs on Sunday and the heaviest on Monday, the latter being due to the travel of shoppers attracted by the advertising in the Sunday papers.

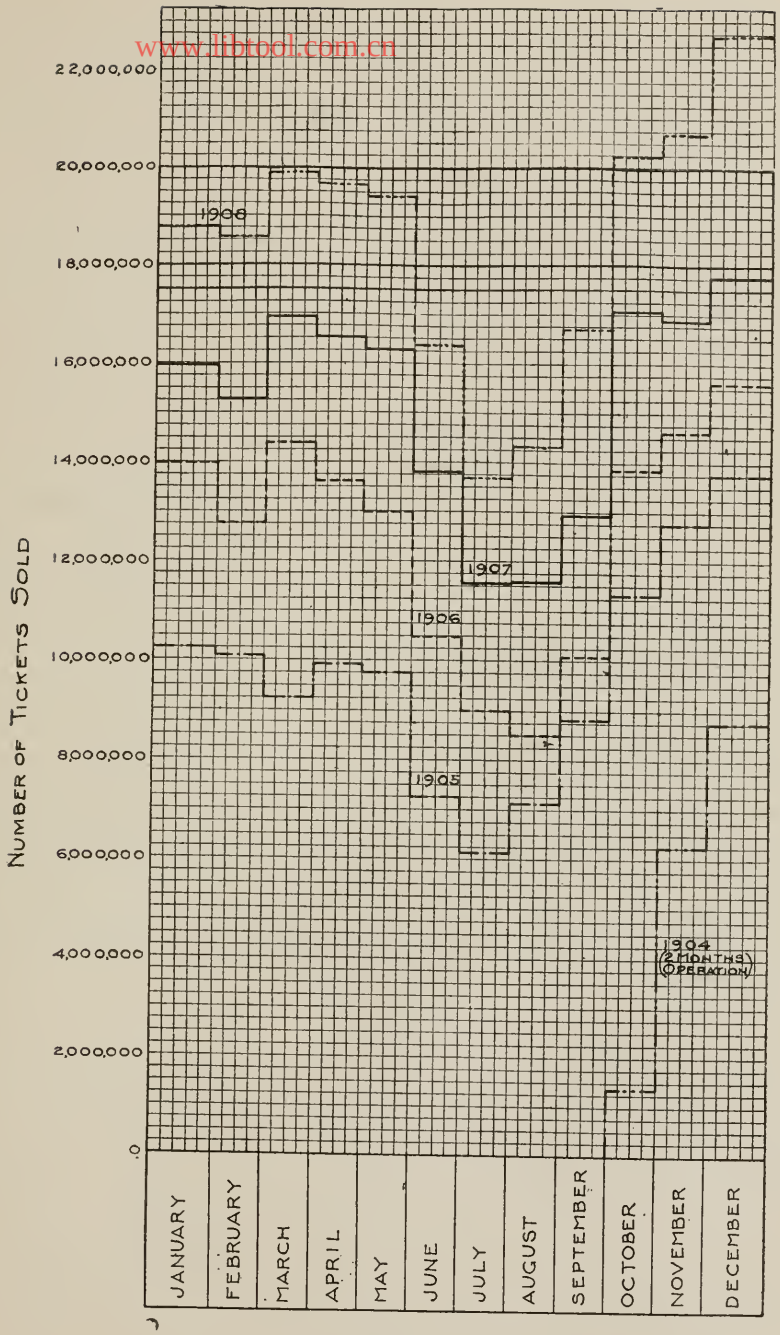


FIGURE 4.

Ticket Sales by Months for Years 1904 to 1908.

At the present time the Subway is carrying from 650,000 to 750,000 passengers per day. At the time of writing this report the heaviest record of ticket sales for one day was 886,000 on Monday, December 21, 1908.

Upon Sunday the traffic fluctuates between 350,000 and 450,000 passengers per day except in bad weather.

Daily Schedules.

Upon ordinary week days the cars and trains are run upon pre-determined schedules. These schedules, as at present operated, dispatch the cars from five different points and the following table shows these routes together with the length of each route, the number of cars each way each day from each terminal, and the total length of time required to make a trip in one direction from one end of the route to the other.

TABLE VI.

Details of Train Schedules.

	Length of route in miles	Cars each way each day	Minimum number of cars to maintain schedule	Total time to run one way, minutes
Broadway Lines—				
Local from 137th Street to Brooklyn Bridge....	8.55	954	90	33
Local-Express from 242d Street to South Ferry..	15.16	840	104	47
Local-Express from Dyckman Street to South Ferry.....	12.68	741	96	38
Lenox Avenue Line—				
Local from 145th Street to Brooklyn Bridge....	9.45	1,020	125	37
Local-Express from 180th Street to Atlantic Avenue, Brooklyn	17.52	1,726	278	50

The running or schedule time of the trains upon the various routes is shown by Table VII. These time cards only show the time for four routes, as the Dyckman Street Broadway express uses the same time card as the express leaving 242nd Street with the exception of the 8½ minute interval required to run from 242nd Street to Dyckman Street.

TABLE VII.

Time Cards.

	From	To	Time
Broadway—			
Local.....	137th St.	96th St.	7 minutes
	96th St.	72nd St.	4½ "
	72nd St.	Grand Central	7 "
	Grand Central	14th St.	6 "
	14th St.	Brooklyn Bridge	8½ "
			33 "

	From	To	Time
Broadway—			
Local-Expresses	242nd St.	Dyckman Street	8½ minutes
	Dyckman St.	96th St.	17½ "
	96th St.	72nd St.	3 "
	72nd St.	Grand Central	5 "
	Grand Central	14th St.	4 "
	14th St.	Brooklyn Bridge	4 "
	Brocklyn Bridge	South Ferry	5 "
			47 "
Lenox Avenue—			
Local	145th St.	96th St.	11 "
	96th St.	Brooklyn Bridge	26 "
			37 "
Lenox Avenue—			
Local-Expresses	180th St.	96th St.	23 "
	96th St.	Brooklyn Bridge	16 "
	Brooklyn Bridge	Flatbush Avenue	11 "
			50 "

Actual Time as Compared with Schedule Time.

Many observations have been taken of the time actually required by the trains to make the various runs in regular service. Under normal conditions and in non-rush hours, the trains are generally on time showing that the time cards are not unreasonable. At the beginning of the rush hours, the trains keep up to their schedule satisfactorily, indicating that even with heavy loads the motors are sufficiently large to maintain the speed that is necessary to make the trips on time.

As soon, however, as the rush starts in, the trains are held longer at the platforms, the delays begin to accumulate and a general congestion of train movement spreads along the line, particularly in that part of the system between 96th Street and Brooklyn Bridge. The individual causes for the various delays to which the trains are subjected during rush hours have been pointed out in detail in other reports. One record of the effect of these delays on the train schedule is shown graphically by Figure 5 in which the schedule time is shown in comparison with the actual time of several north bound express trains running between Brooklyn Bridge and 96th Street.

The distance between these two stations is 6.43 miles and the regular running time from a start at Brooklyn Bridge to and including a stop at 96th street is 16 minutes. This results in a schedule of speed of 24 miles per hour if a 40-second station wait at 96th Street is included and 25 miles per hour if the time is counted from the time the train begins to leave the Brooklyn Bridge platforms until it comes to rest at the 96th Street station.

The prolonged station waits at the express stations, particularly at Grand Central station, however, and the delays due to the cross over at 96th Street, during rush hours and the consequent congestion due to the signal system cause constant

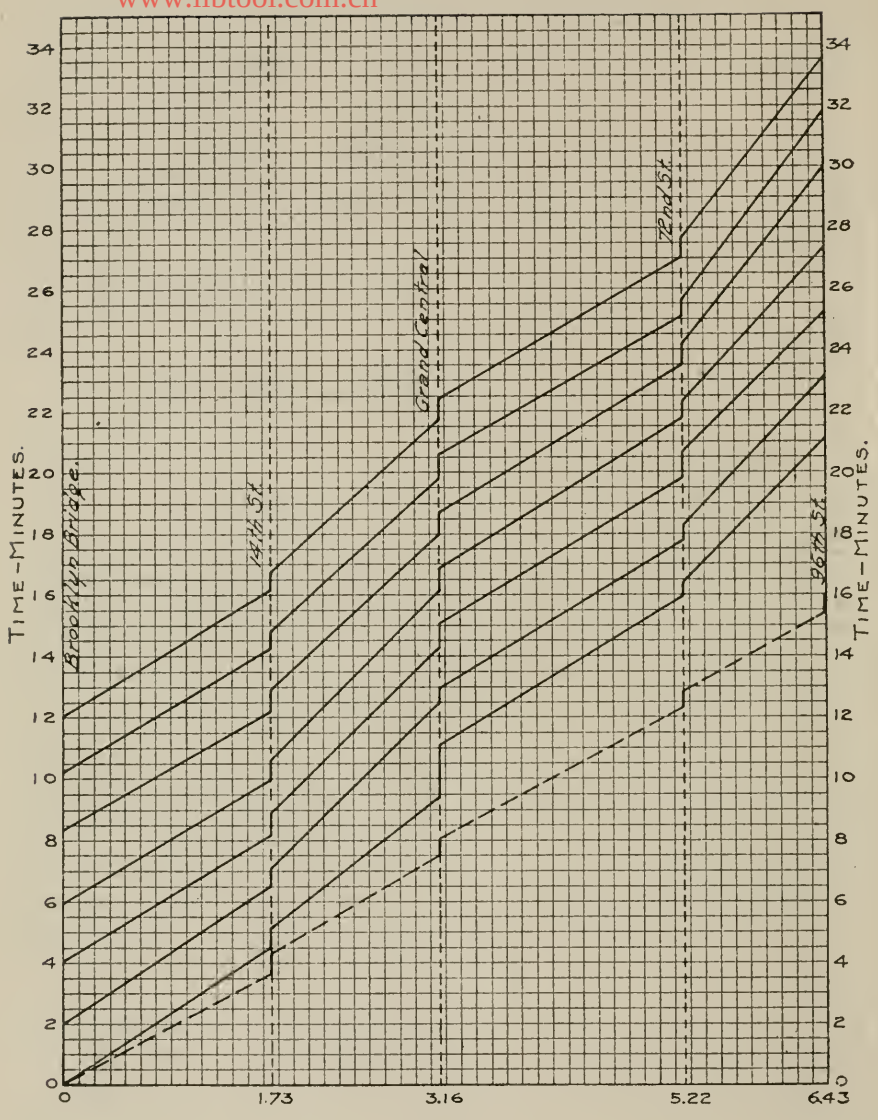


FIGURE 5.

DIAGRAM OF RUSH HOUR SCHEDULE (EXPRESS RUNS).

Showing Actual Time Compared with Time Table.

Solid lines show actual running times as found from tests made December 18, 1907. Broken line shows running time as per time table.

delays which rapidly accumulate until the actual running time from Brooklyn Bridge to 96th Street sometimes amounts to 21 minutes as shown by the diagram. The average speed of these delayed express trains is thus cut from 25 miles per hour to 18 miles and less per hour just at a time when the delays affect comparatively the greatest number of passengers.

Recent observations show that the improvements which have been made in the signal system have removed some of the causes for delay, and that the express trains are often moved during rush hours between Brooklyn Bridge and 96th Street at an average speed of 21 miles per hour, corresponding to a delay of about 2½ minutes behind schedule time, instead of a delay of 5 minutes as indicated above.

At the same time the express trains are being delayed a corresponding delay is taking place as a rule in the local service. The running time for the local trains between Brooklyn Bridge and 96th Street is 26 minutes, corresponding to an average speed of nearly 15 miles per hour. This run, however, during rush hours usually requires from 28 to 30 minutes, thus cutting down the average speed of the local trains to about 13 miles per hour, except during non-rush hours when the schedule is ordinarily maintained. The delays in the local service are due primarily to the prolonged station waits at the transfer stations.

Graphical Record of Train Movements.

The trains are started from the various termini upon headways which vary from time to time during the day, and the number of cars constituting each train also changes once or twice during the day, an effort being made by these changes to reduce the number of cars operated over the line as the passenger traffic falls off during the non-rush hours and to send as many cars over each route as the capacity of the Subway will admit during the rush hour periods.

Since I have been making a study of the Subway four different schedules have been in operation; it having been necessary to change the schedule which was in operation during the Winter of 1907 to a new schedule upon the occasion of the opening of the Brooklyn extension to Borough Hall on January 10th, 1908, and again the schedule was changed when the Brooklyn extension was opened to Atlantic Avenue on May 1st, 1908. The last schedule was put in operation December 1, 1908.

Three schedules have been plotted graphically as shown in Figures 10 to 14 inclusive. Each of these diagrams shows:

1st—The number of cars in each train;

2nd—The headway in minutes between trains at different times of the day;

3rd—Resulting cars per minute leaving any given terminal.

The results of the first schedule have been indicated upon the charts by a heavy line, the results of the second schedule having been shown by a line shaded in one direction, and the results of the last schedule indicated by a light line shaded in another direction, as shown by the key.

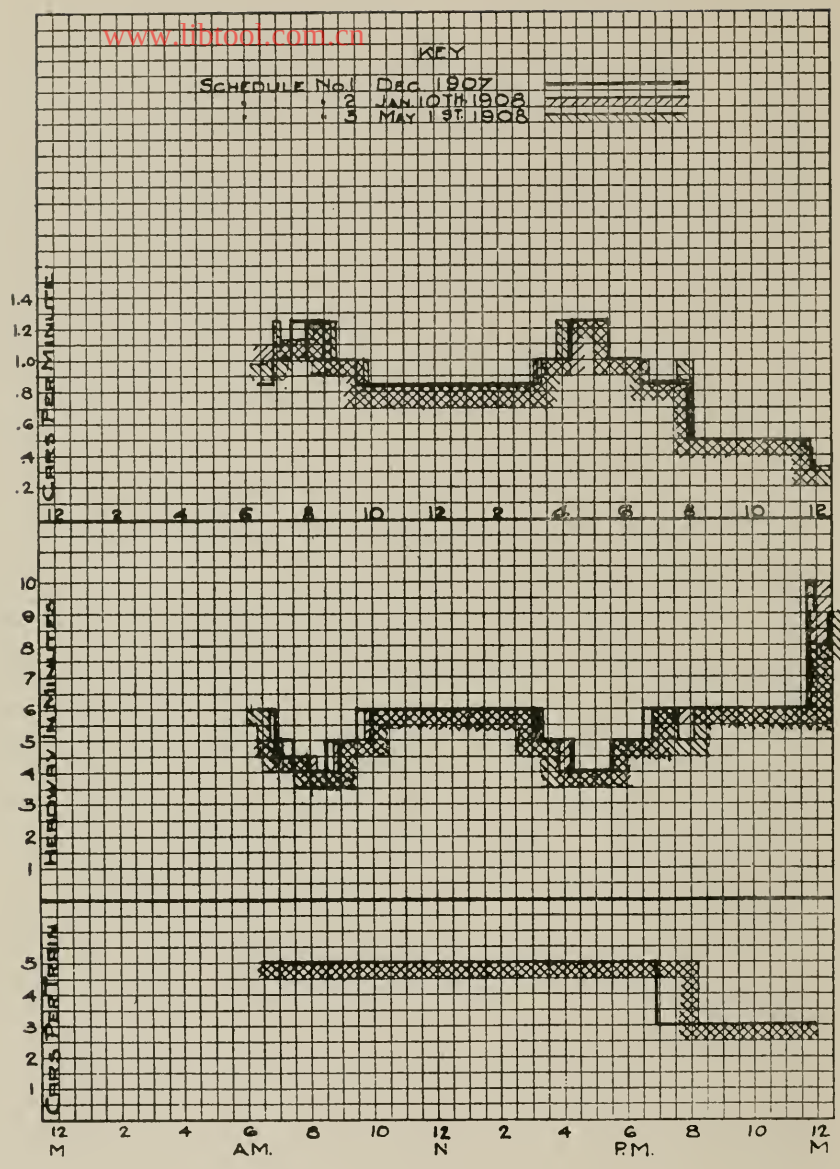


FIGURE 6.

GRAPHICAL RECORD OF DAILY SCHEDULE.

Broadway Local Line from 137th Street to Brooklyn Bridge.

These charts indicate that very little change was made in the operation of the 137th Street local trains. The last two schedules call for the 5-car trains to be continued until 8:10 p. m., whereas the first schedule reduced the length of trains from 5 cars to 3 cars about 7:00 p. m.

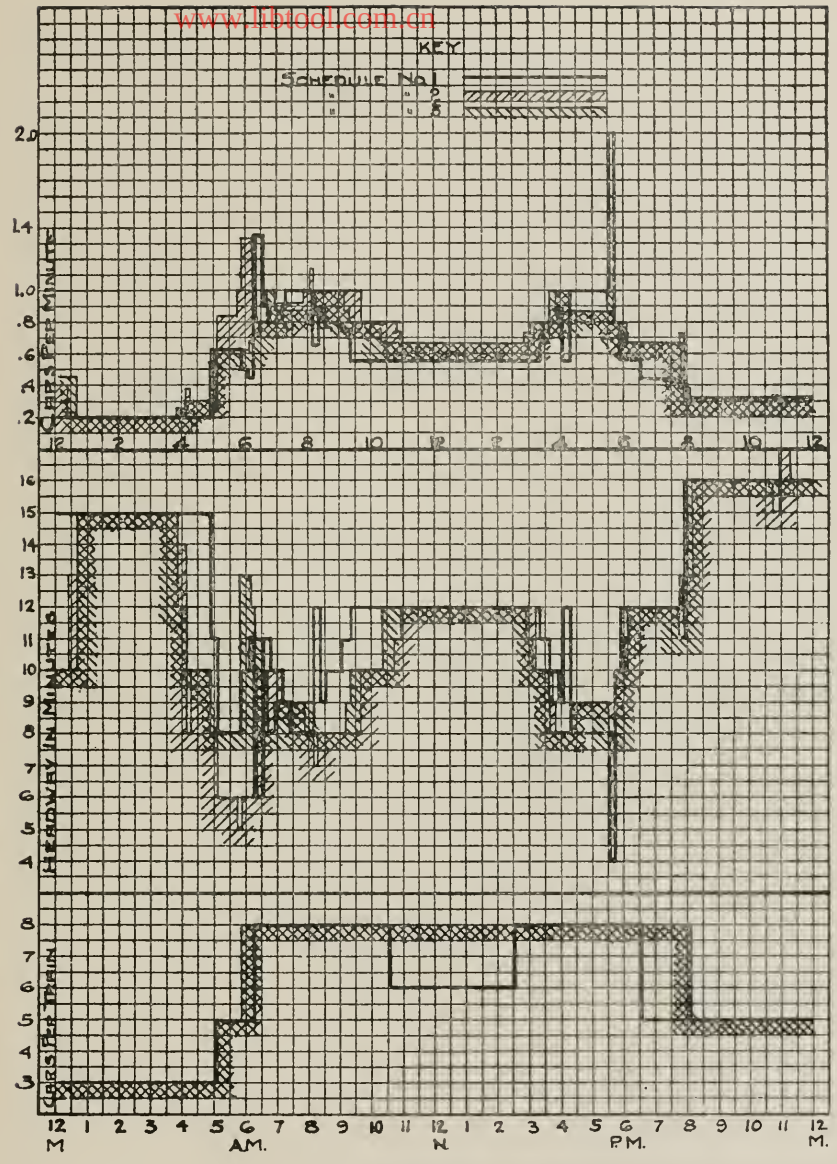


FIGURE 7.

GRAPHICAL RECORD OF DAILY SCHEDULE.

Broadway Local 'Express from 230th Street to South Ferry.

It will be noted that the schedule put in operation on May 1st increased the headway of the trains leaving 230th Street between 5:00 a. m. and 6:15 a. m. from 6 minutes to 8 minutes. Otherwise the two last schedules are practically the same.

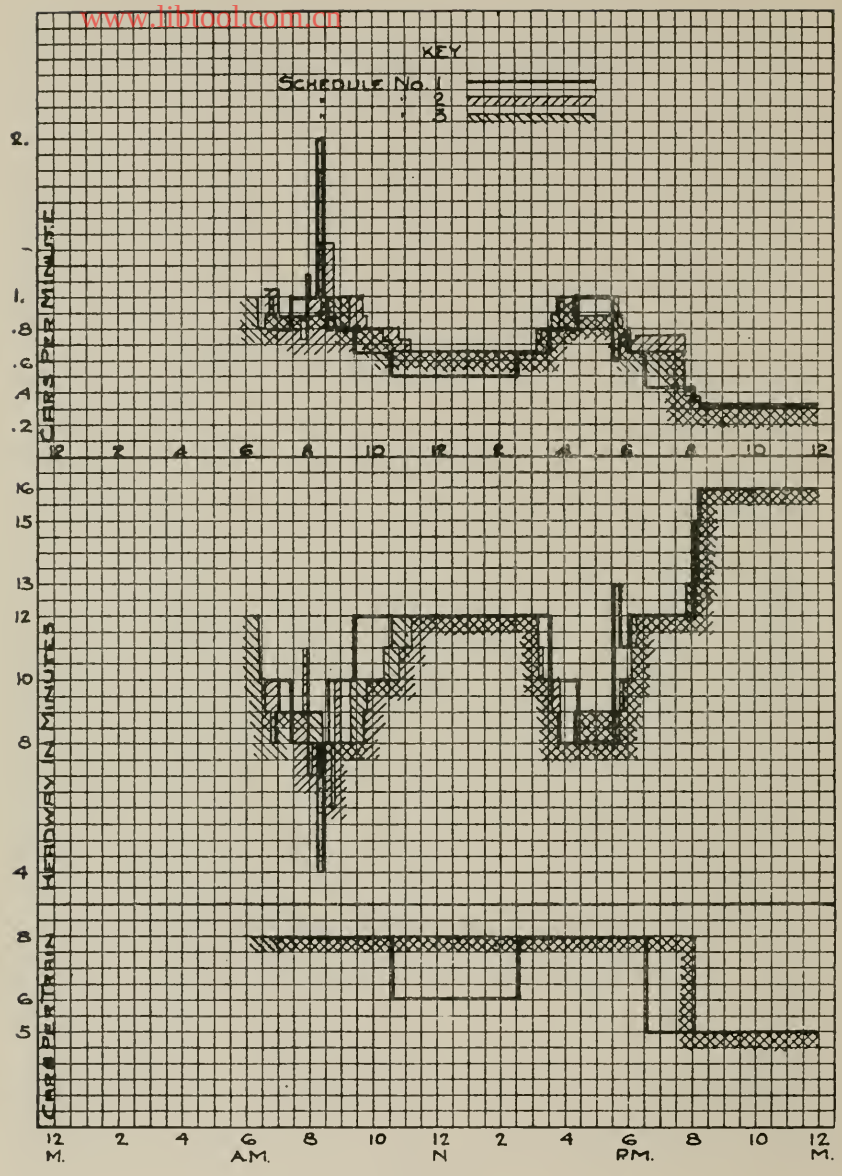


FIGURE 8.

GRAPHICAL RECORD OF DAILY SCHEDULE.

Broadway Local Express from Dyckman Street to South Ferry and to Atlantic Avenue During Rush Hours.

It will be noted that the Dyckman Street express trains do not start in until 6:05 a. m. and that a number of Dyckman Street trains were cut off when the Brooklyn extension was open to Atlantic Avenue on May 1st, 1908, at which time the Dyckman Street trains were run through the Brooklyn tubes instead of around the South Ferry loop as previously.

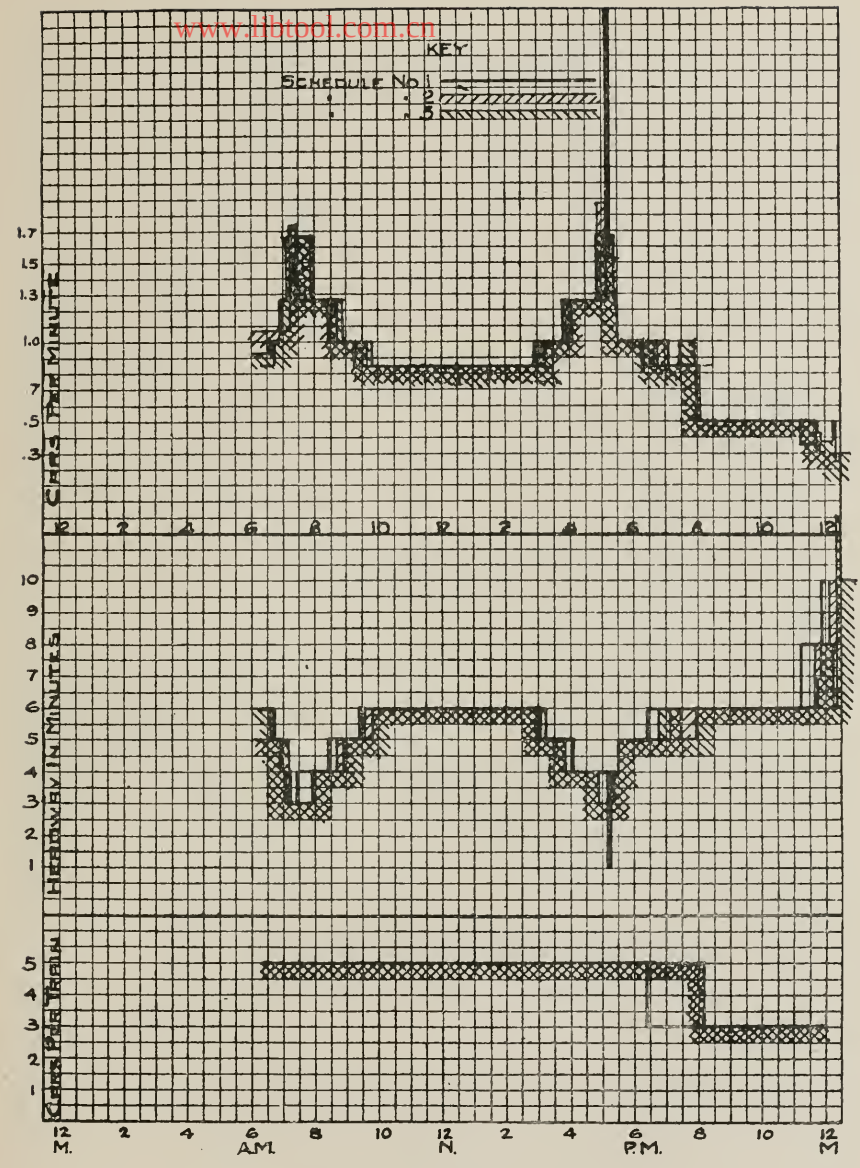


FIGURE 9.

Graphical Record of Daily Schedule.

Lenox Avenue Local Trains from 145th Street to Brooklyn Bridge.

Very few changes have been made in the operation of the 145th Street locals, the three schedules being similar.

It will be noted that the schedules call for a three-minute headway during both the morning and the evening rush hours and that this headway is scheduled for nearly an hour in the morning but for much less time during the evening rush hour.

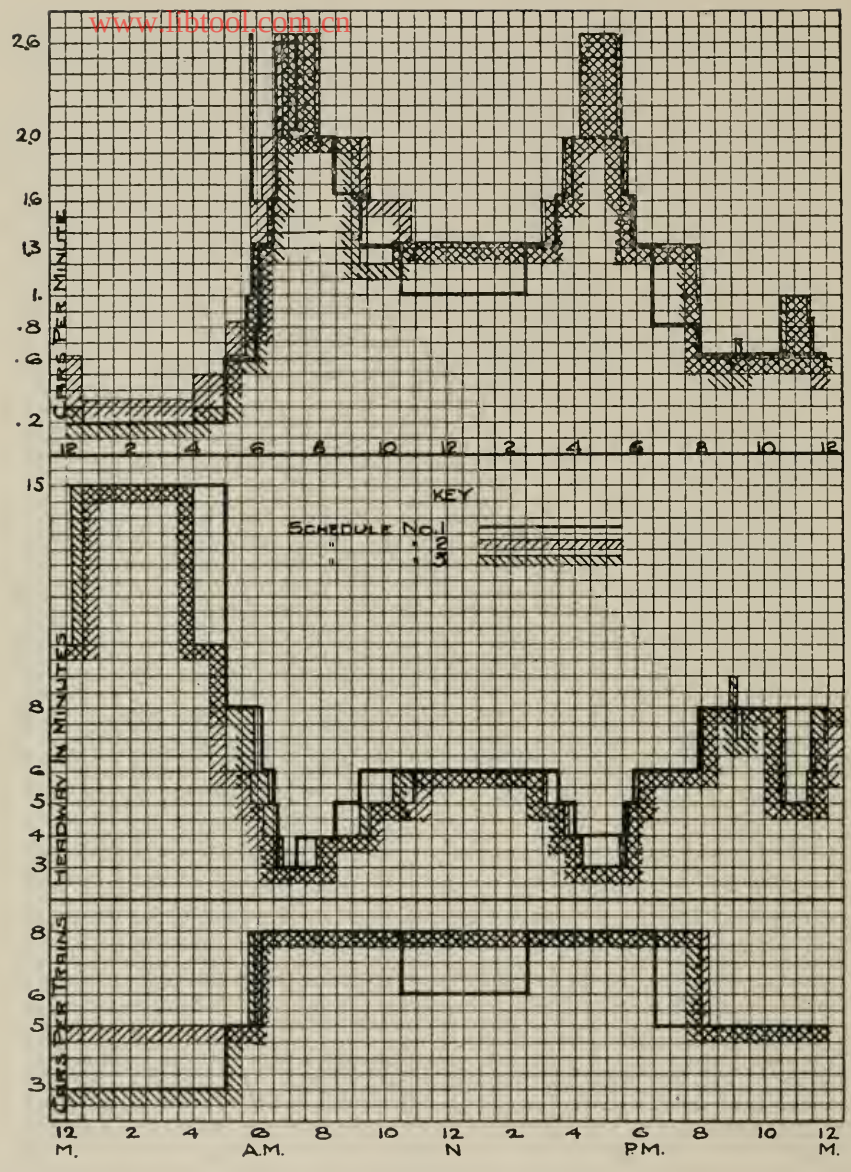


FIGURE 10.

GRAPHICAL RECORD OF DAILY SCHEDULE.

Lenox Avenue Local Express Train from 180th Street to Flatbush Avenue.

It will be noted that this schedule calls for three-minute headway or twenty trains per hour during the rush hour periods and that the theatre rush was recognized by sending out a number of additional trains between 10:30 p. m. and 11:30 p. m.

The schedule put in operation on May 1st at the time the Dyckman Street-Broadway trains were first sent through the Brooklyn tubes shows that a number of the Lenox Avenue express trains were taken out of service particularly between 9:15 a. m. and 10:30 a. m.

Study of Passenger Movement on Individual Trains.

Observers were placed on different trains during various days and in the rush hour periods to count the passengers getting on and off at the various stations in order to determine

a—Location and extent of the standing load;

b—Average length of travel of passengers on the express and the local trains;

c—Relative carrying efficiency of the express and the local trains;

d—Distribution of passengers throughout the different cars of the trains.

The trains chosen for these observations were 8 local trains during various days in February and March, 1908, and 10 express trains during January and February, 1908. Subsequently when the Subway system was extended to 242d Street and the Brooklyn extension was opened to Atlantic Avenue, observations were made on 6 additional express trains in order to measure the influence of the fall traffic and the longer runs due to the two extensions upon the averages already obtained.

The results of the detailed observations have been plotted and shown in Figures 11 to 39 inclusive.

To each diagram has been appended a description showing the number of passengers boarding the train, the greatest number on the train at any one time, the time lost between Brooklyn Bridge and 96th Street and the average length of passenger travel. Attention is also called to the characteristics of the passenger movement in each case.

The information in regard to the trains which were observed during January, February and March, 1908, is shown by Table VIII.

The information in regard to the trains which were observed during October, 1908, is shown by Table IX.

The comparison of the local trains with the express trains and also the comparison between the express trains during January and February, 1908, and during October, 1908, is shown by Table X.

A study of the figures in these tables and of the diagrams showing the passenger movement with each individual train will show the following conclusions:

a—Taking an average of eight local trains, the total number of passengers carried on each trip averaged 2.58 times the maximum number carried on the train at any one time while with the ten express trains first taken this ratio averaged but 1.62, and with the six express trains in October, 1908, this ratio averaged 1.64. These figures indicate that the local trains are used to much better advantage than the express trains.

b—The ratio of the total number of passengers boarding the train to the number of seats in the train shows that these local trains carried 4.36 passengers for every seat while the express trains carried 3.24 and 3.62 passengers per seat, thus showing again that the seating capacity of the locals is used more efficiently than the seating capacity of the express trains.

c—The ratio of the number of passengers in the train at the time of maximum load to the total number of seats provided which indicates the comparative crowding of the trains is less with the local trains (1.71) than with the express trains which show averages of 2.17 passengers and 2.20 passengers per seat in the trains at points of heaviest loading.

d—The average distance traveled by passengers on local trains, taking the results of the eight local trains shown by the table, was found to be slightly more than two miles and the average distance traveled by passengers on the ten express trains studied was found to be 5.5 miles and of the later six express trains to be 5.75 miles, thus indicating the extent to which the local trains get the benefit of the short haul passengers and also the extent of the burden of the long haul passengers upon the express trains.

e—The average length of passenger haul on the express trains is gradually increasing as the road is added to and as the outlying districts become built up. The total number of passengers entering a train is a measure of its earning power, whereas the number of car miles traveled by the train is a measure of the expense involved in moving the passengers; therefore, if the number of passengers upon any train is divided by the number of car miles made by the train in making a trip in one direction, the result will be the average number of passengers per car mile, and the higher this result, the greater will be what might be called the earning power of the train. This ratio for the eight local trains shows 26 passengers per car mile, whereas the result from the express trains shows 12.6 and 11.4 passengers per car mile, thus indicating that during rush hours the locals have an earning power equal to fully twice that of the express trains.

TABLE VIII.

RECAPITULATION OF TRAFFIC DATA

Number of Diagram	Train	Direction	Division	Terminals: From	Terminals: To	Leaving Time	Date	Time Between 36th St. and Brooklyn Bridge: Southbound	Time Between 36th St. and Brooklyn Bridge: Northbound: Actual	Time Between 36th St. and Brooklyn Bridge: Northbound: Behind	Cars per Train	Seats per Car	Seating Capacity	Total Number of Passengers	Number of Passengers at Point of Heaviest Loading	Ratios: P/Q	Ratios: P/R	Ratios: Q/R	Average Length of Travel of each Passenger	Length of Trip	Car Miles (C.M.)	Passenger-Miles	Total Number of Passengers per Train Mile	Total Number of Passengers per Car Mile
1	Local	North	Broadway	City Hall	137th St	8:14 AM	Jan 18th 1908	26	35 53	9 05	5	260	1213	571	435	.267	.760	2.09 M	2.72	43.75	2536	58.05	27.7
2	"	"	"	"	"	8:40 AM	Feb 14th "	26	39 08	9 15	5	260	1295	507	375	.293	.740	1.99 "	"	"	2658	60.75	31.88
3	Local	South	Broadway	137th St	City Hall	8:55 AM	Jan 15th 1908	26	28 47	9 47	5	260	850	375	265	.317	.720	1.37 M	3.63	43.15	1681	38.90	96
4	"	"	"	"	"	9:00 AM	Feb 14th "	26	29 16	9 31	5	260	958	337	273	.325	.770	1.26 "	"	"	1624	38.60	91.9
5	Express	North	Broadway	South Ferry	230th St	5:14 PM	Dec 9th 1907	16	21 13	3 38	8	416	1160	927	746	.384	.772	5.75 M	4.86	114.08	7975	69.50	18.5
6	"	"	"	"	"	6:36 PM	Jan 15th 1908	16	23 29	3 29	8	416	1307	922	732	.305	.672	5.47 "	"	"	6297	61.30	15
7	Express	South	Broadway	230th St	South Ferry	4:30 PM	Jan 16th 1908	16	18 55	2 42	8	416	1663	1008	747	.405	.742	5.86 M	4.86	114.08	9205	80.50	22
8	"	"	"	"	"	5:10 PM	Feb 29th "	16	21 13	3 23	8	416	1771	738	529	.287	.717	3.80 "	"	"	6792	59.60	16.7
9	Express	North	Broadway	South Ferry	Dyckman St	8:33 AM	Jan 15th 1908	16	18 55	2 38	8	416	1367	826	642	.329	.777	6.04 M	5.68	101.68	6284	67.30	13.47
10	"	"	"	"	"	8:38 AM	Jan 16th "	16	26 40	10 49	8	416	1021	719	545	.250	.758	5.20 "	"	"	5411	59.30	11.87
11	Local	North	Lenox Ave	City Hall	145th St	8:57 AM	Mar 2nd 1908	26	37 57	11 57	5	260	1478	591	463	.570	.778	7.35 M	3.66	48.30	3792	78.6	19.6
12	"	"	"	"	"	8:58 AM	Mar 9th "	26	37 43	11 28	5	260	1401	597	436	.540	.730	7.07 "	"	"	3783	78.35	19.0
13	Local	South	Lenox Ave	145th St	City Hall	7:41 AM	Jan 18th 1908	26	29 21	9 21	5	260	913	366	230	.351	.631	1.81 M	3.53	47.65	1684	38.50	19.2
14	"	"	"	"	"	8:07 AM	"	26	30 33	4 35	5	260	913	319	226	.351	.715	1.83 "	"	"	1670	38.00	19.16
15	Express	South	Lenox Ave	Bronx Park	Borough Hall	8:06 AM	Feb 7th 1908	16	21 15	5 15	8	416	1606	871	647	.391	.743	5.75 M	5.86	126.68	9008	71.50	17.85
16	"	"	"	"	"	8:08 AM	Feb 28th "	16	21 21	5 31	8	416	1853	1044	776	.429	.743	5.97 "	"	"	9228	83.40	20.5
17	Express	North	Lenox Ave	Borough Hall	Bronx Park	5:36 PM	Feb 27th 1908	16	20 06	4 05	8	416	1869	1089	776	.469	.712	6.86 M	5.86	126.86	10721	84.80	21.2
18	"	"	"	"	"	5:40 PM	Feb 28th "	16	23 00	7 00	8	416	1527	894	638	.417	.713	5.58 "	"	"	8141	64.30	16.05
19	Express	South	Lenox Ave		Borough Hall		Feb 27th 1908	16	9 40	3 10	8	416		581									
20	"	"	"		"		Feb 28th "	16	16 20	0 40	5	316		654									
										2 Lines													
21	Express	North	Lenox Ave	Borough Hall		5:15 PM	Feb 27th 1908	16	15 13	0 27	8	416		859									
22	"	"	"	"		5:20 PM	Feb 28th "	16	18 33	0 57	8	416		488									

TABLE IX.

RECAPITULATION OF TRAFFIC DATA

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
Number of Express	Train	Direction	Division	Terminals		Leaving Time	Date	Time Between 96th St and Brooklyn Bridge			Cars Per Train	Total Seating Capacity	Total Number of Passengers	Maximum Number of Passengers at one Time	Ratios			Average Length of Travel of each Passenger	Length of Trip	Car Miles (L+T)	Passenger Miles	Average Number of Passengers per Car (O÷L)	Average Number of Passengers per Mile (O÷V)
				From	To			Yesterday	Actual	Behind					O/N	N/M	M/O						
						h. m.		m. s.	m. s.	m. s.													
23	Express	North	Broadway	South Ferry	Van Cortlt Pk	9:03 AM	Oct 21, 1908	16	18 29	2 29	8	416	1617	1010	1.60	3.89	2.43	5.246	15.19	121.52	9449.60	7.920	13.31
24	Express	South	Broadway	Van Cortlt Pk	South Ferry	9:27 AM	Oct 21, 1908	16	18 32	2 32	8	416	1091	721	1.51	2.62	1.73	6.148	15.19	121.52	6707.47	5.520	8.90
25	Express	North	Broadway	Atlantic Ave	Dyckman St	9:00 AM	Oct 19, 1908	16	18 19	2 18	8	416	1735	947	1.83	4.17	2.28	4.292	17.55	140.40	8470.27	6.035	12.36
26	Express	South	Broadway	Dyckman St	Atlantic Ave	9:06 AM	Oct 19, 1908	16	18 23	2 23	8	416	1395	928	1.50	3.33	2.23	5.268	17.55	140.40	7348.80	5.234	9.94
27	Express	South	Lenox Ave	Bronx Park	Atlantic Ave	7:33 AM	Oct 20, 1908	16	18 52	2 52	8	416	1473	941	1.57	3.54	2.26	5.960	16.82	134.56	8779.06	6.524	10.95
28	Express	North	Lenox Ave	Atlantic Ave	Bronx Park	5:34 PM	Oct 20, 1908	16	19 09	3 09	8	416	1734	955	1.82	4.17	2.30	6.294	16.82	134.56	10930.80	8.11	12.89

TABLE X.

	Average of 8 Local Trains Feb. & Mar. 1908.	Average of 10 Express Trains Jan. & Feb., 1908.	Average of 6 Express Trains October, 1908.
Time lost between 96th St. and Brooklyn Bridge..	6 min. 20 sec.	5 min. 52 sec.	2 min. 27 sec.
Ratio of the total number of passengers boarding the train to the maximum number on the train at the time of heaviest load.....	2.58	1.62	1.64
Ratio of the total number of passengers boarding the train to the number of seats provided.....	4.36	3.24	3.62
Ratio of the maximum number of passengers on the train at the time of heaviest load to the number of seats provided.....	1.71	2.17	2.20
Average length of trip of each passenger, miles...	2.08	5.52	5.75
Average number of passengers per car.....	53	69.5	65.5
Average number of passengers per car mile.....	26	12.6	11.4

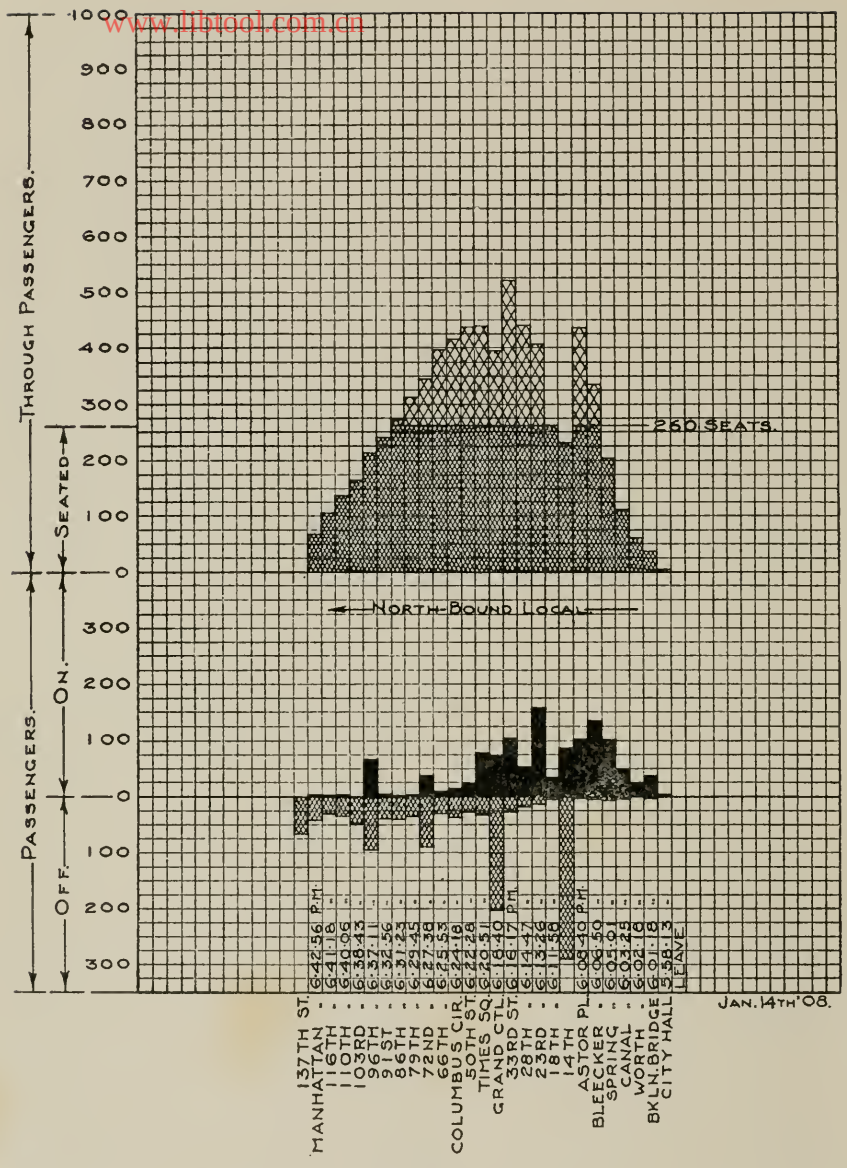


FIGURE 11.

BROADWAY LOCAL.

Leaving City Hall for 137th Street at 5:58 P. M.

January 14th, 1908.

Total number of passengers..... 1213
Greatest number of passengers at any one time..... 521
Length of time from Brooklyn Bridge to 96th Street.....35 min. 53 sec.
Time lost between Brooklyn Bridge and 96th Street..... 9 min. 53 sec.
Average length of passenger travel.....2.09 miles

This diagram indicates characteristics of north bound local trains during the evening rush hours. Standing passengers appear at Bleecker Street and Astor Place, but the exodus of passengers at 14th Street empties the train of the standing passengers. The largest number of passengers boarded this local train at 23rd Street and there were standing passengers until the train reached 86th Street.

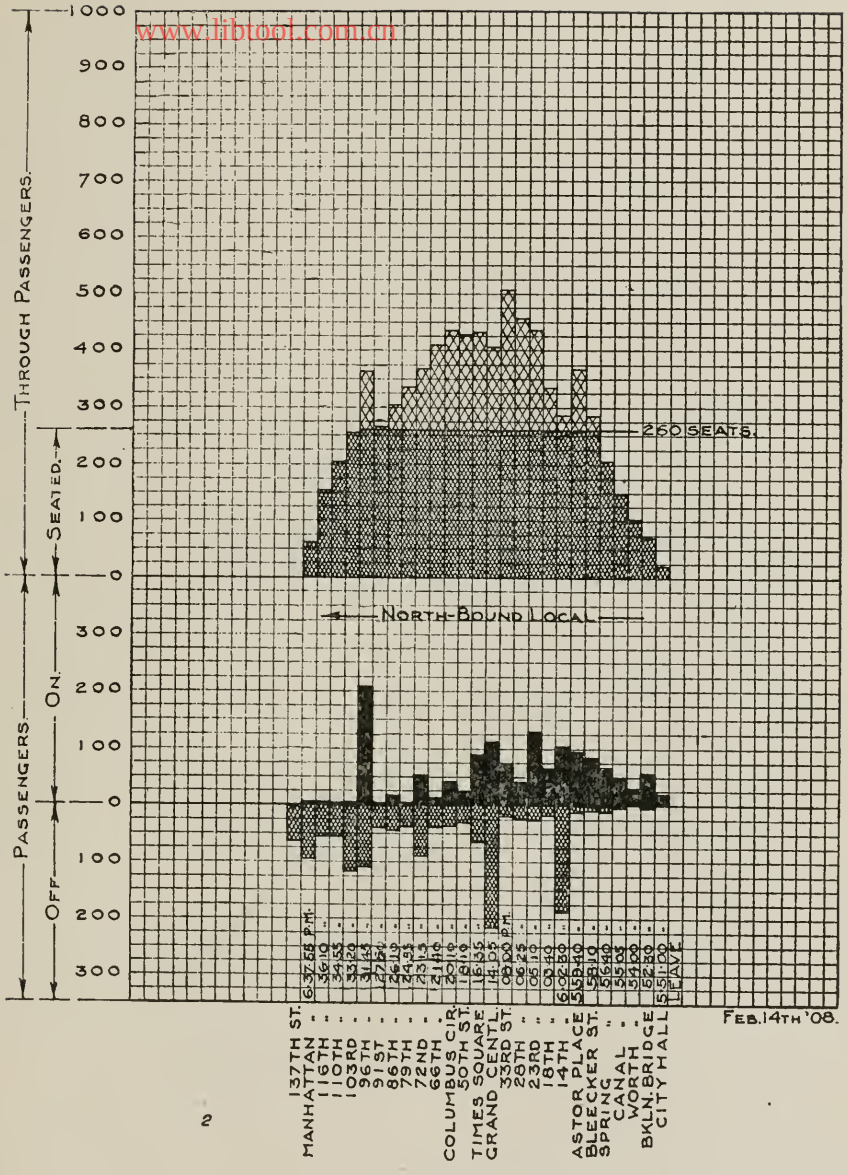


FIGURE 12.

BROADWAY LOCAL.

Leaving City Hall for 137th Street at 5:51 P. M.

February 14th, 1908.

Total number of passengers	1395
Greatest number of passengers at any one time	507
Length of time from Brooklyn Bridge to 96th Street	39 min. 15 sec.
Time lost between Brooklyn Bridge and 96th Street	13 min. 15 sec.
Average length of passenger travel	1.9 miles

This diagram plotted from information taken one month later than the previous figure shows the same characteristics with the exception that fewer passengers left the train at 14th Street and a greater number boarded the train at 96th Street. This train was slightly more efficient than the train shown by Figure 11, as the length of travel was less and there was a greater number of passengers handled with a relatively smaller maximum load.

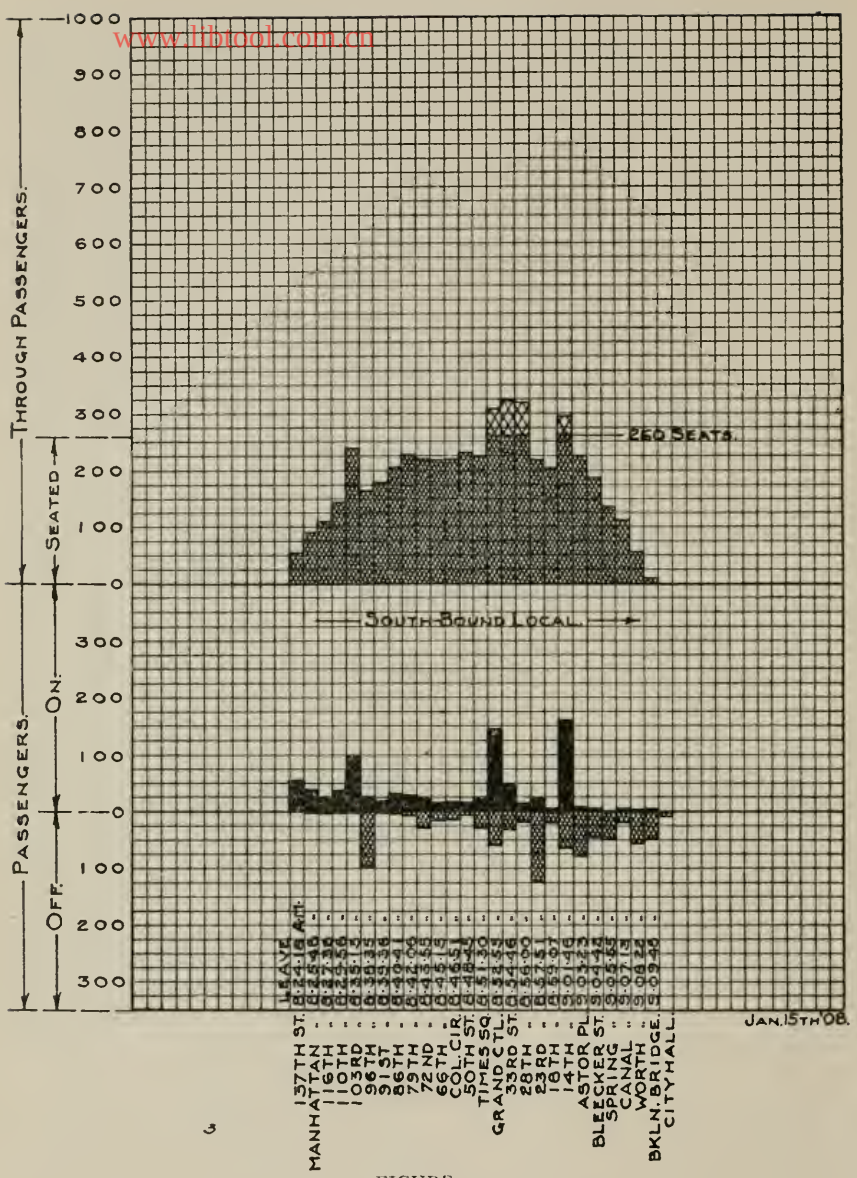


FIGURE 13.

BROADWAY LOCAL.

Leaving 137th Street for City Hall at 8:24 A. M.

January 15th, 1908.

Total number of passengers	850
Greatest number of passengers at any one time	323
Length of time from 96th Street to Brooklyn Bridge	28 min. 47 sec.
Time lost between 96th Street and Brooklyn Bridge	2 min. 47 sec.
Average length of passenger travel	1.97 miles

This diagram indicates that the local trains, running south during the morning rush hours are not loaded to as great an extent as the evening local trains running in the opposite direction. Standing passengers appeared upon this train only between Grand Central and 23rd Street stations and a few between 14th Street and Astor Place.

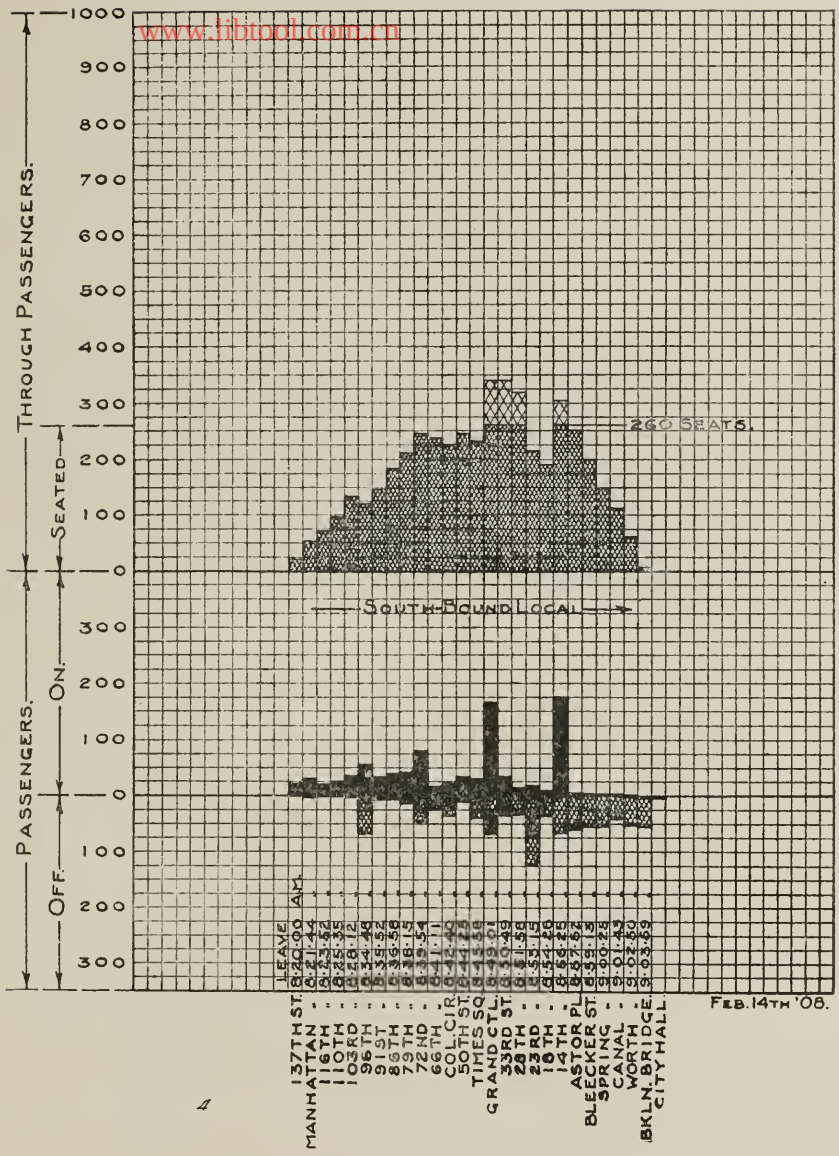


FIGURE 14.

BROADWAY LOCAL.

Leaving 137th Street for City Hall at 8:20 A. M.

February 13th, 1908.

Total number of passengers	922
Greatest number of passengers at any one time	337
Length of time from 96th Street to Brooklyn Bridge	29 min. 11 sec.
Time lost between 96th Street and Brooklyn Bridge	3 min. 11 sec.
Average length of passenger travel	1.76 miles

The data secured for this train taken one month later than those for Figure 13 show almost precisely the same characteristics, indicating that these south bound local trains at this time during morning rush hours were not over crowded and were being used efficiently.

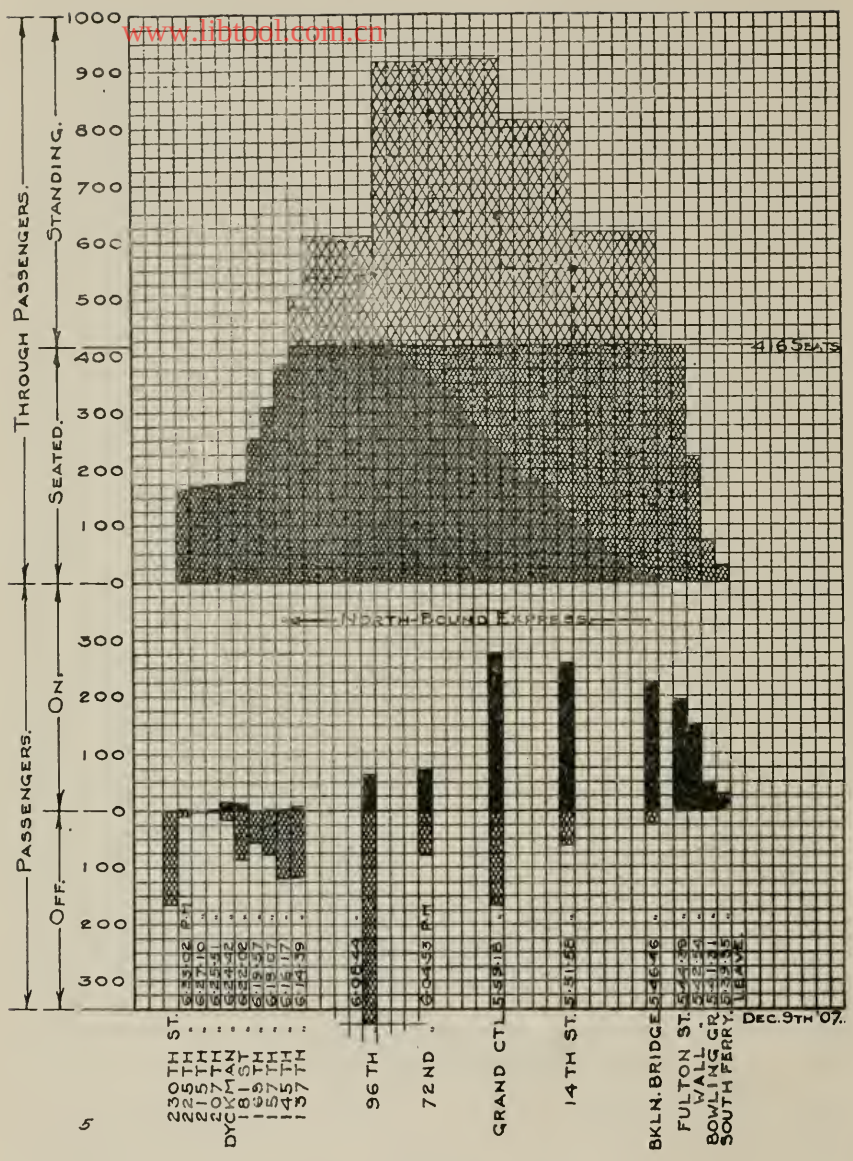


FIGURE 15.

BROADWAY KINGSBRIDGE EXPRESS.

Leaving South Ferry for 230th Street at 5:39 P. M.

December 9th, 1907.

Total number of passengers	1350
Greatest number of passengers at any one time	922
Length of time from Brooklyn Bridge to 96th Street	21 min. 58 sec.
Time lost between Brooklyn Bridge and 96th Street	5 min. 58 sec.
Average length of passenger travel	5.875 miles

This diagram which was prepared before the Brooklyn Extension was opened shows an excessive number of standing passengers and indicates that standing passengers appear at Brooklyn Bridge and that large additions were made to the standing load at 14th Street and Grand Central stations, congestion being somewhat relieved by a large number of passengers leaving the train at 96th Street many of whom transferred to a local or Dyckman Street express, as this train did not stop at 103rd Street, 110th Street, 116th Street or Manhattan Street stations.

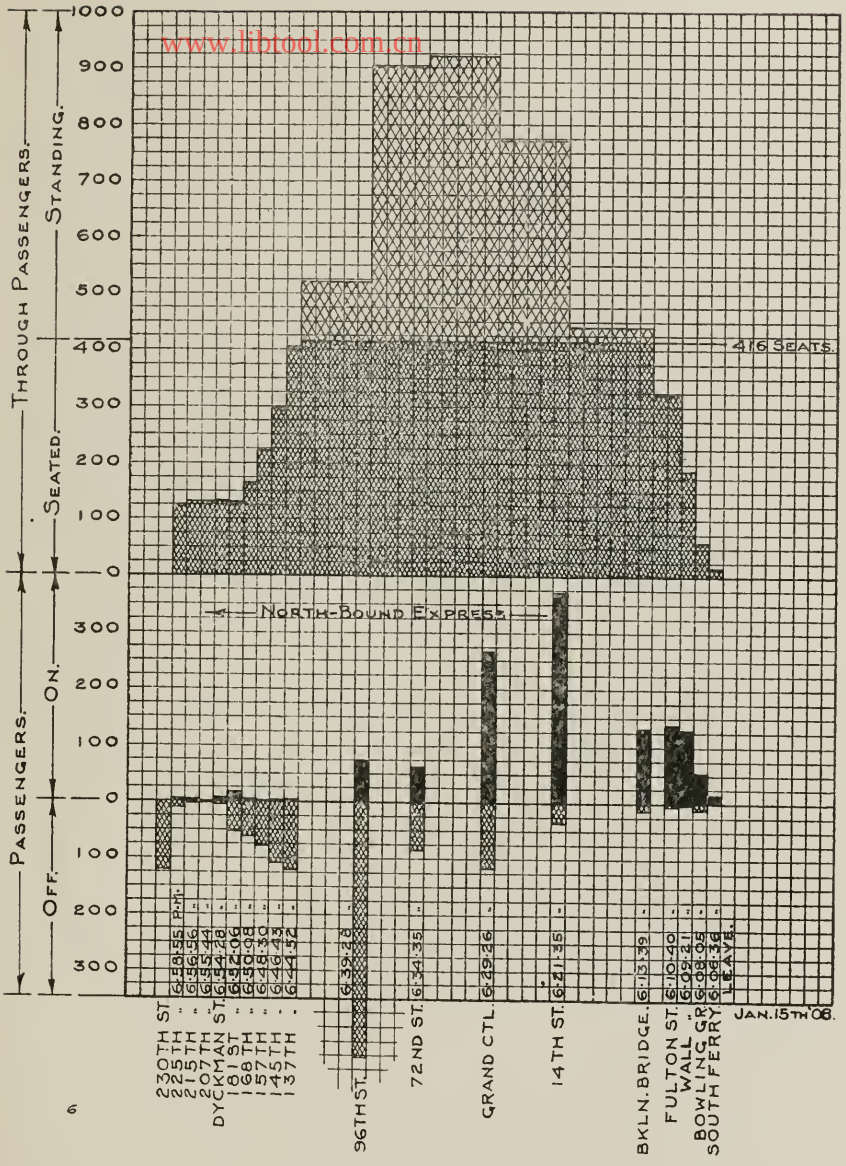


FIGURE 16.

BROADWAY KINGSBRIDGE EXPRESS.

Leaving South Ferry for 230th Street at 6:06 P. M.

January 15th, 1908.

Total number of passengers	1280
Greatest number of passengers at any one time	922
Length of time from Brooklyn Bridge to 96th Street	25 min. 49 sec.
Time lost between Brooklyn Bridge and 96th Street	9 min. 49 sec.
Average length of passenger travel	5.47 miles

The information for this diagram was obtained after the Brooklyn extension had been opened and indicates at once the falling off in the number of passengers boarding trains at Brooklyn Bridge. There was a comparatively larger number of passengers boarding this train at 14th Street and leaving again at 96th Street than was shown by the previous diagram, otherwise the characteristics are the same.

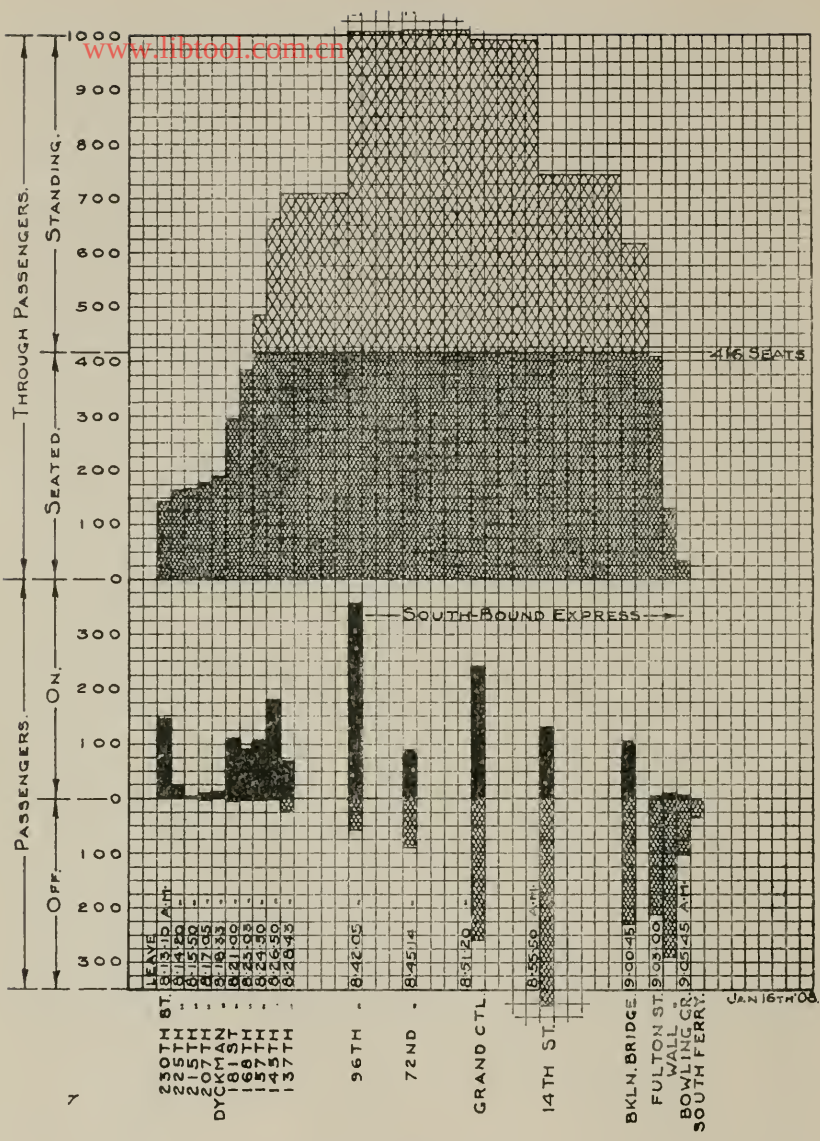


FIGURE 17.

BROADWAY KINGSBRIDGE EXPRESS.

Leaving 230th Street for South Ferry at 8:13 A. M.

January 16th, 1908.

Total number of passengers..... 1683
Greatest number of passengers at any one time..... 1008
Length of time from 96th Street to Brooklyn Bridge.....18 min. 40 sec.
Time lost from 96th Street to Brooklyn Bridge..... 2 min. 40 sec.
Average length of passenger travel.....5.48 miles

This diagram shows the appearance of standing passengers at 168th Street and large additions to the load at 96th Street due largely to passengers who had been collected by the local trains making intermediate stops between 137th Street and 96th Street. Some of the passengers were standing until the train reached Fulton Street. A larger number of passengers left the train at 14th Street than at any other station, as shown also by previous diagrams indicating that with express trains the peak of the standing load appears between 96th Street and 14th Street.

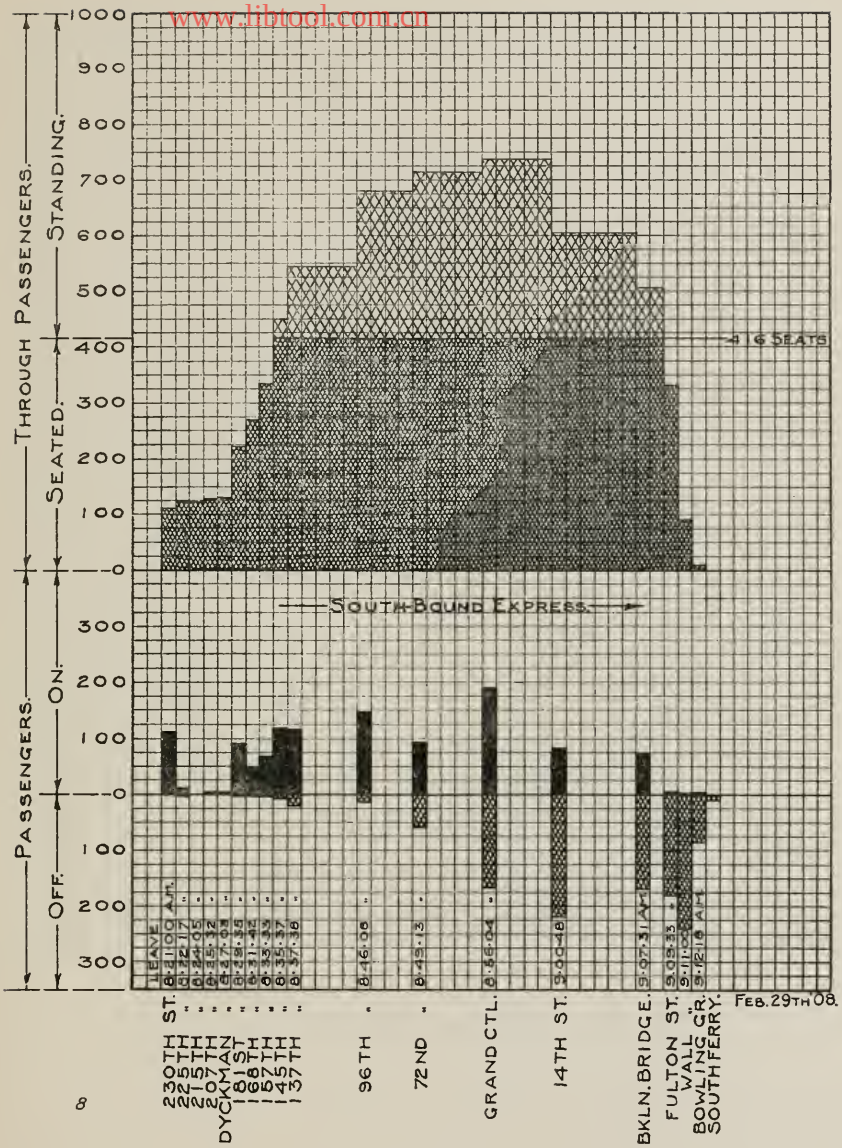


FIGURE 18.

BROADWAY KINGSBRIDGE EXPRESS.

Leaving 230th Street for South Ferry at 8:21 A. M.

February 29th, 1908.

Total number of passengers	1171
Greatest number of passengers at any one time	738
Length of time from 96th Street to Brooklyn Bridge	21 min. 23 sec.
Time lost from 96th Street to Brooklyn Bridge	5 min. 23 sec.
Average length of passenger travel	5.8 miles

This diagram shows the same characteristics as the previous Kingsbridge express diagrams in that few additions are made to the load secured at 230th Street until the train reaches 181st Street; that is, four coaches would carry all of the passengers comfortably from 230th Street to 181st Street and the eight coaches comprising the train are not uncomfortably loaded until the train reaches 145th Street. At the end of the route however the trains have a standing load until they reach Fulton Street although the greatest congestion always appears between 96th Street and 14th Street.

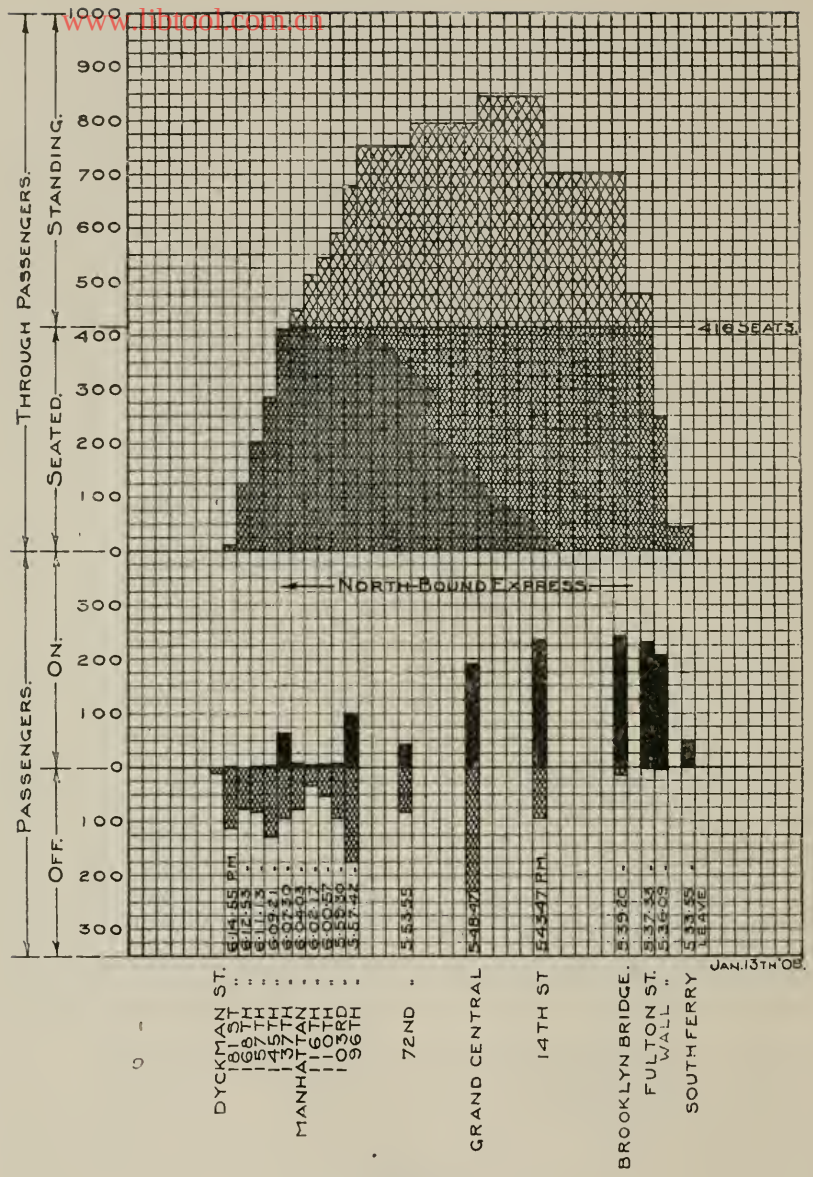


FIGURE 19.

BROADWAY EXPRESS.

Leaving South Ferry for Dyckman Street at 5:33 P. M.

January 13th, 1908.

Total number of passengers	1367
Greatest number of passengers at any one time	846
Length of time from Brooklyn Bridge to 96th Street	18 min. 22 sec.
Time lost between Brooklyn Bridge and 96th Street	2 min. 22 sec.
Average length of passenger travel	5.04 miles

This diagram indicates a train that was used very efficiently; that is, there was but a short distance of its travel that all of its seats were not occupied.

The Dyckman Street Express diagrams do not show the number of empty car miles shown by the Kingsbridge express train diagrams.

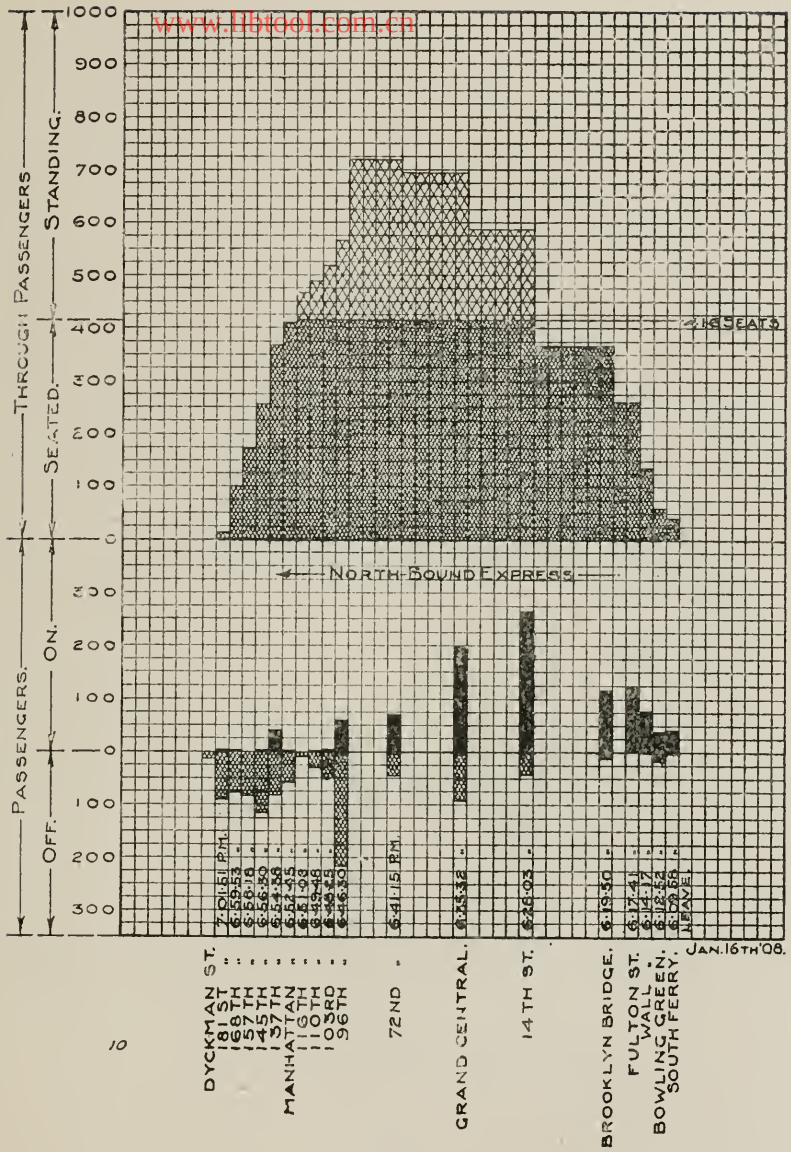


FIGURE 20.

BROADWAY DYCKMAN EXPRESS.

Leaving South Ferry for Dyckman Street at 6:09 P. M.

January 16th, 1908.

Total number of passengers	1041
Greatest number of passengers at any one time	719
Length of time from Brooklyn Bridge to 96th Street	26 min. 40 sec.
Time lost between Brooklyn Bridge and 96th Street	10 min. 40 sec.
Average length of passenger travel	5.2 miles

On account of the opening of the Brooklyn extension, the standing passengers on this train do not appear until the train reaches 14th Street and a comparatively large number of passengers leaving the train at 96th Street left few standing passengers north of that point. These passengers were about equally distributed at each of the five stations between Manhattan Street and 181st Street inclusive.

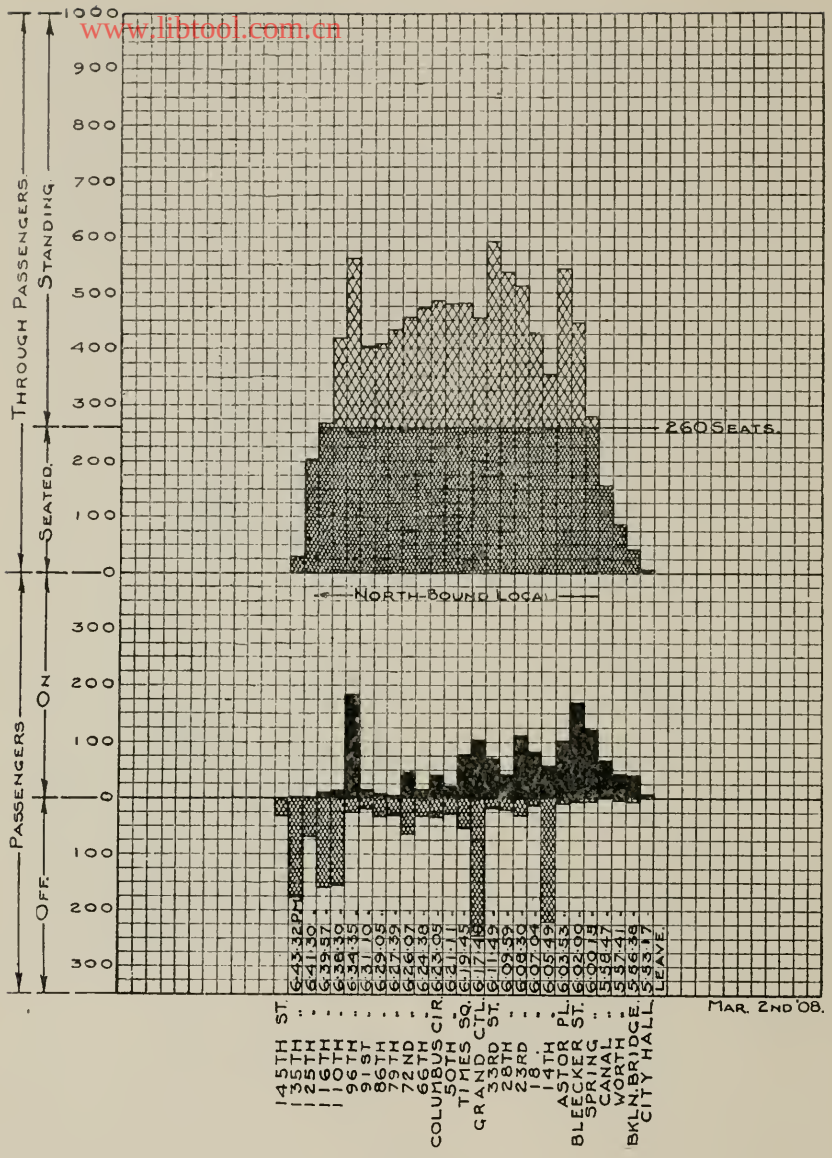


FIGURE 21.

LENOX AVENUE LOCAL.

Leaving City Hall for 145th Street at 5:53 P. M.
March 2nd, 1908.

Total number of passengers	1478
Greatest number of passengers at any one time	591
Length of time from Brooklyn Bridge to 96th Street	37 min. 57 sec.
Time lost between Brooklyn Bridge and 96th Street	11 min. 57 sec.
Average length of passenger travel	2.575 miles

This diagram shows the characteristics of all north bound local trains due to the collection of passengers at stations intermediate between the express stations and the delivery of a large number of these passengers to the express trains. At 96th Street, however, the situation is reversed, and a large number of passengers board the locals at this point to be delivered to various stations north of 96th Street. This diagram shows that a large number of passengers transfer from the Broadway express trains to the Lenox Avenue local trains at 96th Street.

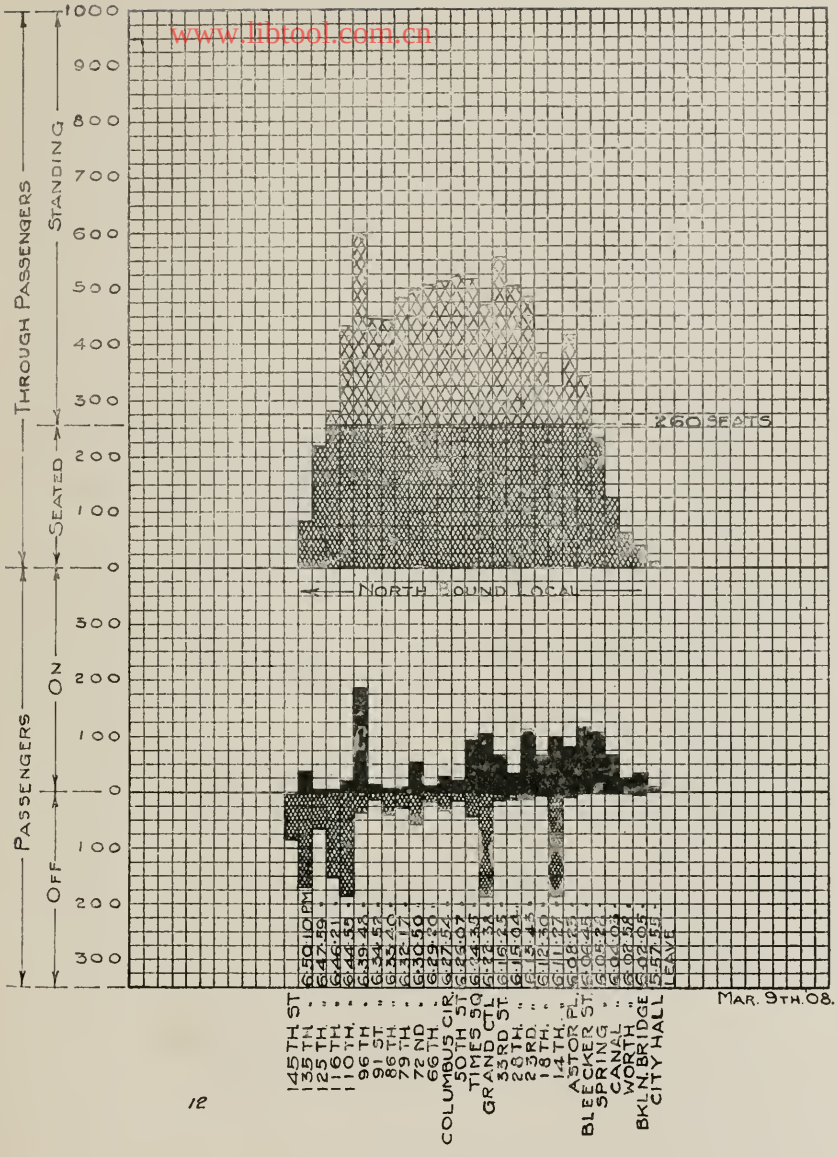


FIGURE 22.

LENOX AVENUE LOCAL.

Leaving City Hall for 145th Street at 5:57 P. M.

March 9th, 1908.

Total number of passengers..... 1401
Greatest number of passengers at any one time..... 597
Length of time from Brooklyn Bridge to 96th Street.....37 min. 43 sec.
Time lost between Brooklyn Bridge and 96th Street.....11 min. 43 sec.
Average length of passenger travel.....2.707 miles

This diagram indicates that the Lenox Avenue local trains are being used very efficiently; that is, there are but short distances in which the empty cars are run. This diagram indicates the comparative number of passengers who transfer at 137th Street to use the stub end track into the 145th Street station; otherwise its characteristics are the same as the previous diagram.

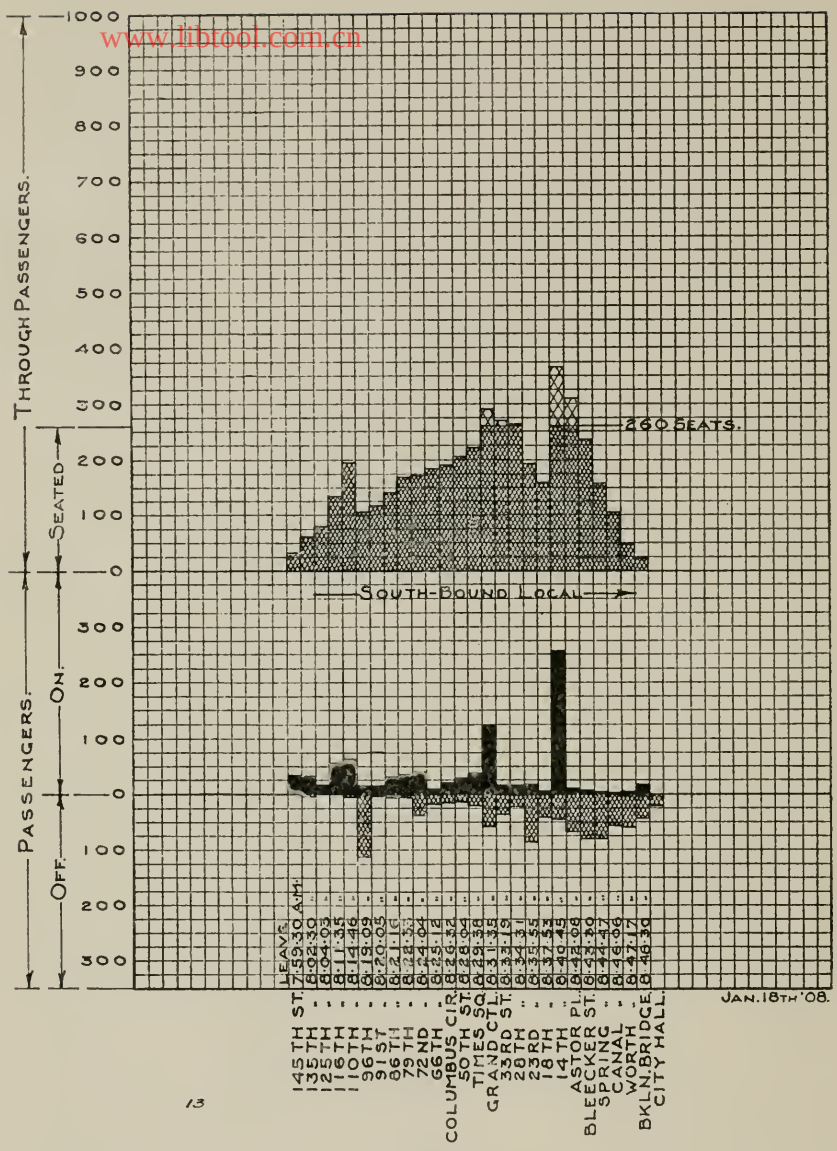


FIGURE 23.

LENOX AVENUE LOCAL.

Leaving 145th Street for City Hall at 7:59 A. M.

January 18th, 1908.

Total number of passengers	915
Greatest number of passengers at any one time	366
Length of time from 96th Street to Brooklyn Bridge	29 min. 21 sec.
Time lost between 96th Street and Brooklyn Bridge	3 min. 21 sec.
Average length of passenger travel	1.838 miles

This diagram when compared with the one shown in Figure 24 indicates at once that the south bound local trains are not so crowded as the north bound trains and that there are seats for all until 14th Street is reached and then the standing load is comparatively small and lasts but for one or two stations. The time schedule shows that these trains are operated much nearer the schedule than the north bound trains during evening rush hours.

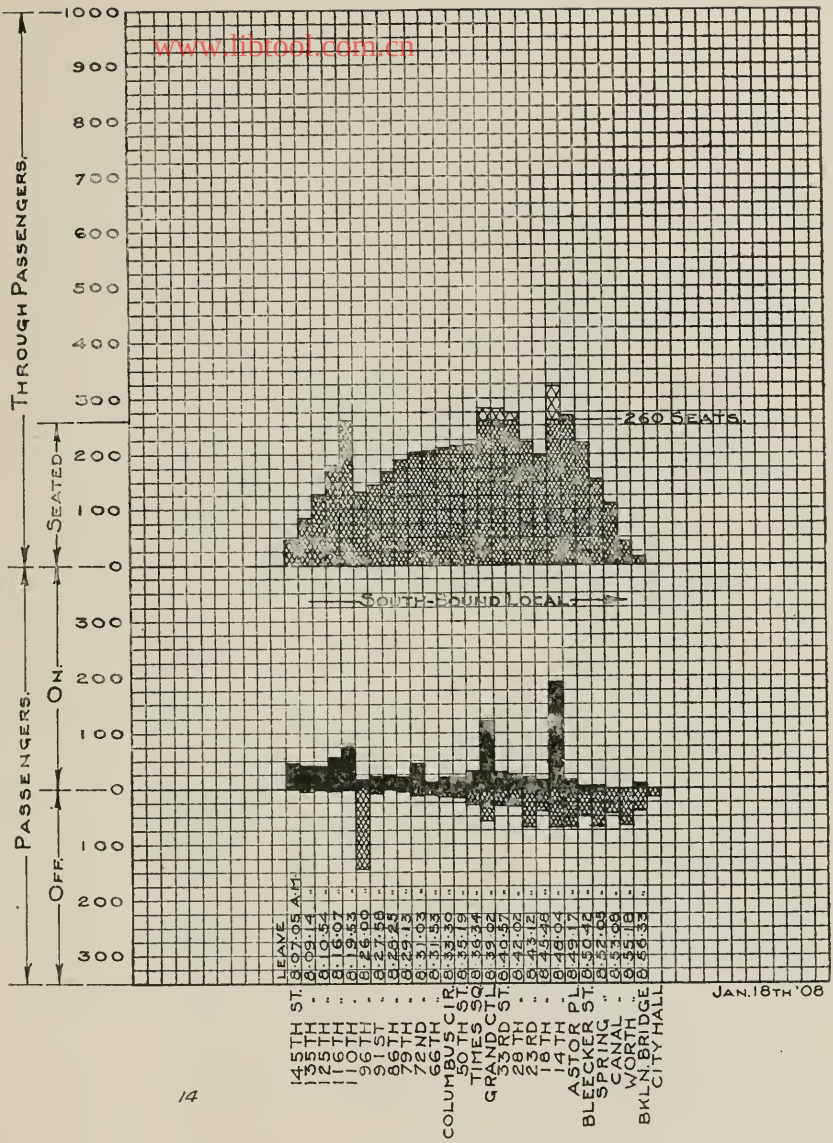


FIGURE 24.

LENOX AVENUE LOCAL.

Leaving 145th Street for City Hall at 8:07 A. M.

January 18th, 1908.

Total number of passengers	913
Greatest number of passengers at any one time	319
Length of time from 96th Street to Brooklyn Bridge	30 min. 33 sec.
Time lost between 96th Street and Brooklyn Bridge	4 min. 33 sec.
Average length of passenger travel	1.825 miles

This diagram shows the same characteristics as the previous diagram indicating that the south bound local trains act as a collecting agency north of 96th Street and a distributing agency south of 96th Street and that although a large number of passengers are handled by one 5-car train, a constant movement of passengers in at one station and out at the next few stations prevents the accumulation of a standing load except during short intervals.

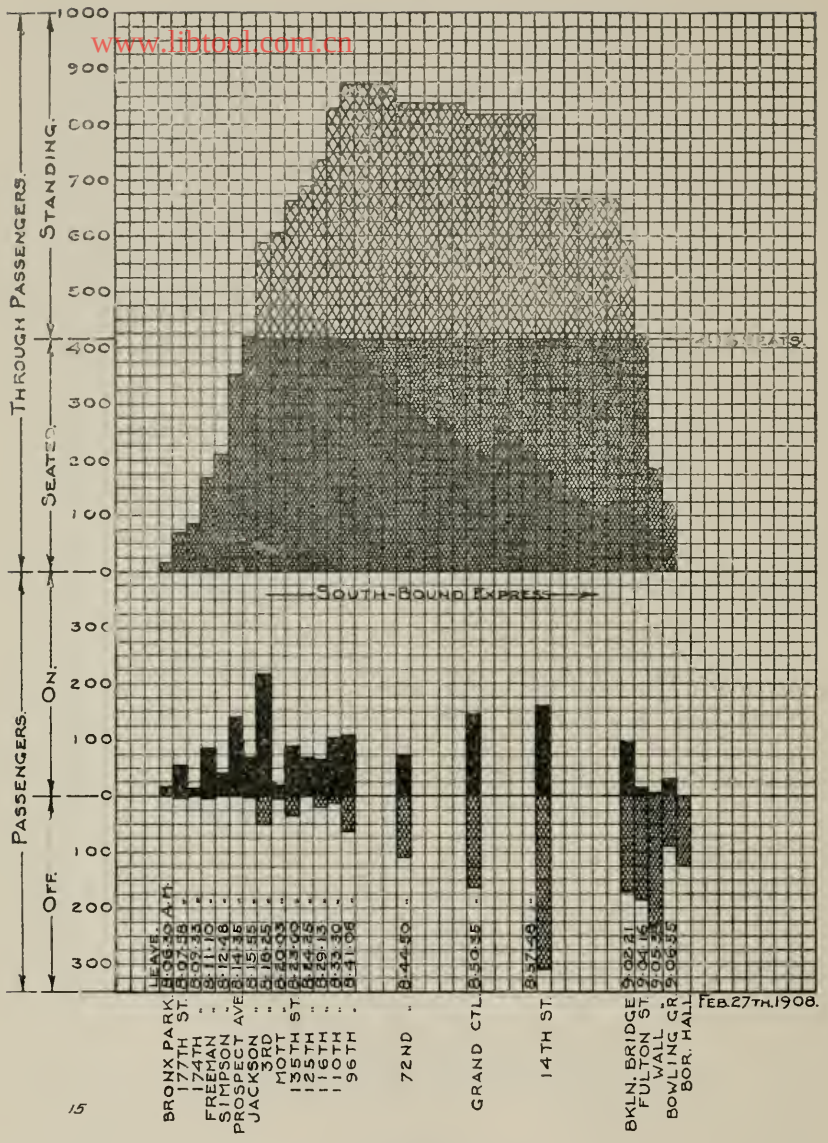


FIGURE 25.

West Farms Express.

Leaving Bronx Park for Borough Hall at 8:06 A. M.

February 27th, 1908.

Total number of passengers..... 1626
Greatest number of passengers at any one time..... 871
Length of time from 96th Street to Brooklyn Bridge.....21 min. 15 sec.
Time lost between 96th Street and Brooklyn Bridge..... 5 min. 15 sec.
Average length of passenger travel.....5.575 miles

This diagram was taken after the Brooklyn extension was opened to Borough Hall and indicates that comparatively few passengers are traveling to Brooklyn during the morning rush hour on that date. The greatest number of passengers boarding this train was found to be at Third Avenue where free transfers are provided between the Elevated Road and the Subway. A large number of passengers left the train at 14th Street. The standing load lasted from Third Avenue to Brooklyn Bridge.

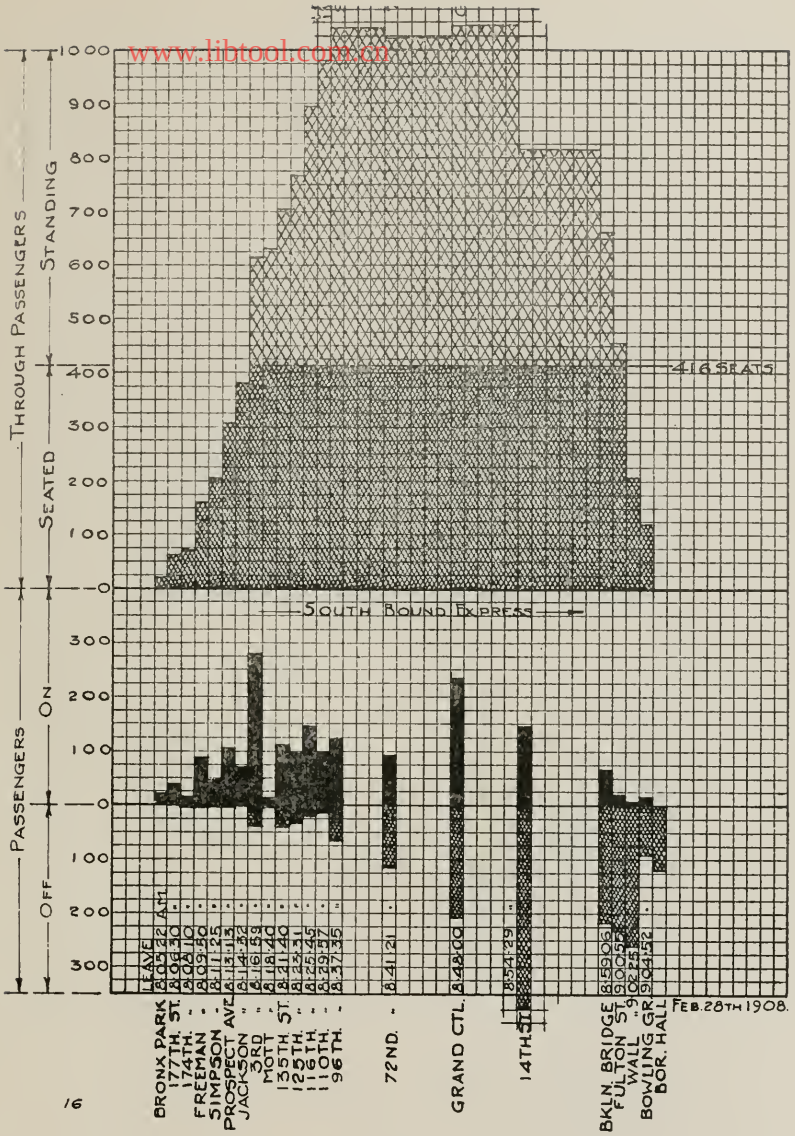


FIGURE 26.

WEST FARMS EXPRESS.

Leaving Bronx Park for Borough Hall at 8:05 A. M.

February 28th, 1908.

Total number of passengers	1838
Greatest number of passengers at any one time	1044
Length of time from 96th Street to Brooklyn Bridge	21 min. 31 sec.
Time lost between 96th Street and Brooklyn Bridge	5 min. 31 sec.
Average length of passenger travel	5.72 miles

This diagram has almost identical characteristics with the former diagram with the exception that the load upon this train is somewhat larger. It indicates the comparative number of empty cars which are operated under present arrangements from Bronx Park to about Prospect Avenue. It indicates that if 8-car express trains could be broken in two at some point in the vicinity of Prospect Avenue, a considerable amount of the empty car miles now operated could be saved.

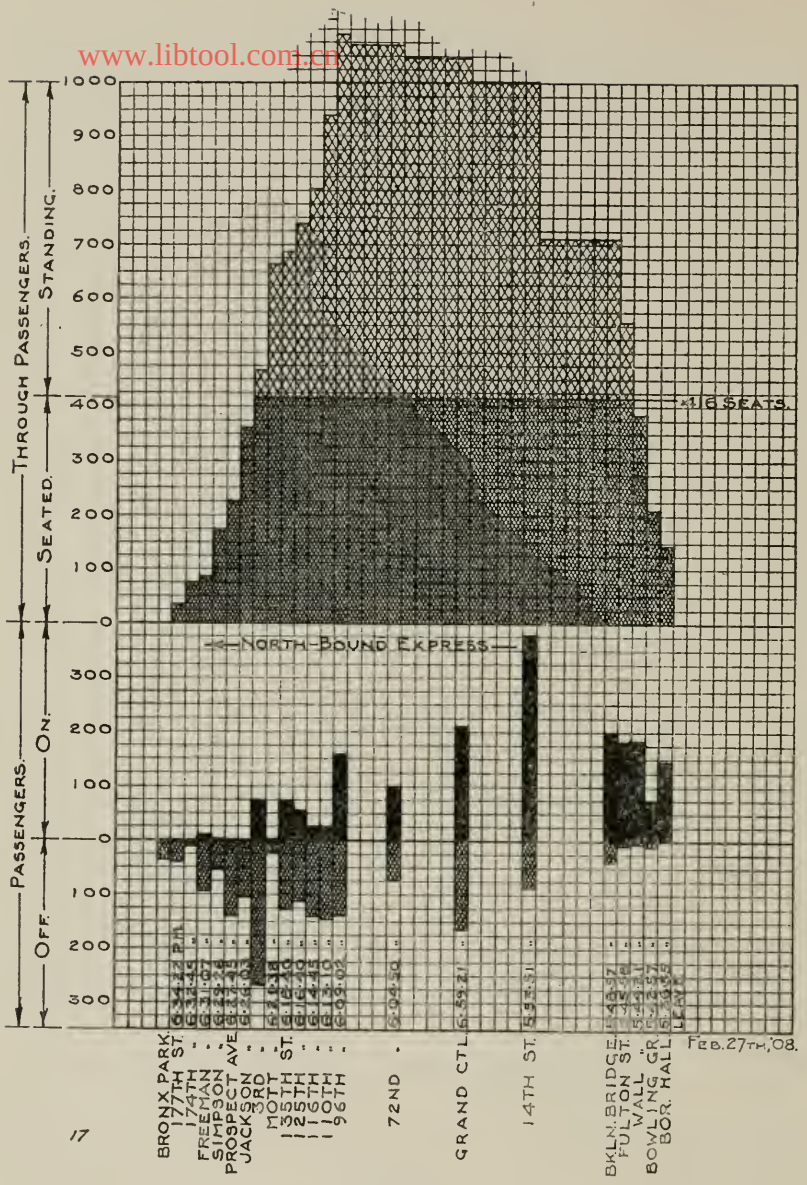


FIGURE 27.

WEST FARMS EXPRESS.

Leaving Borough Hall for Bronx Park at 5:36 P. M.

February 27th, 1908.

Total number of passengers	1869
Greatest number of passengers at any one time	1089
Length of time from Brooklyn Bridge to 96th Street	20 min. 5 sec.
Time lost between Brooklyn Bridge and 96th Street	4 min. 5 sec.
Average length of passenger travel	5.74 miles

This diagram indicates that comparatively few passengers travel from Brooklyn to Manhattan during the evening rush hour and that a large portion of the load of a West Farms express is obtained at 14th Street. More passengers boarded this train at 96th Street than left it, but a large number were distributed to the four stations directly north of 96th Street and nearly twice as many passengers left the train at Third Avenue to transfer to the Elevated as left the train at any other station.

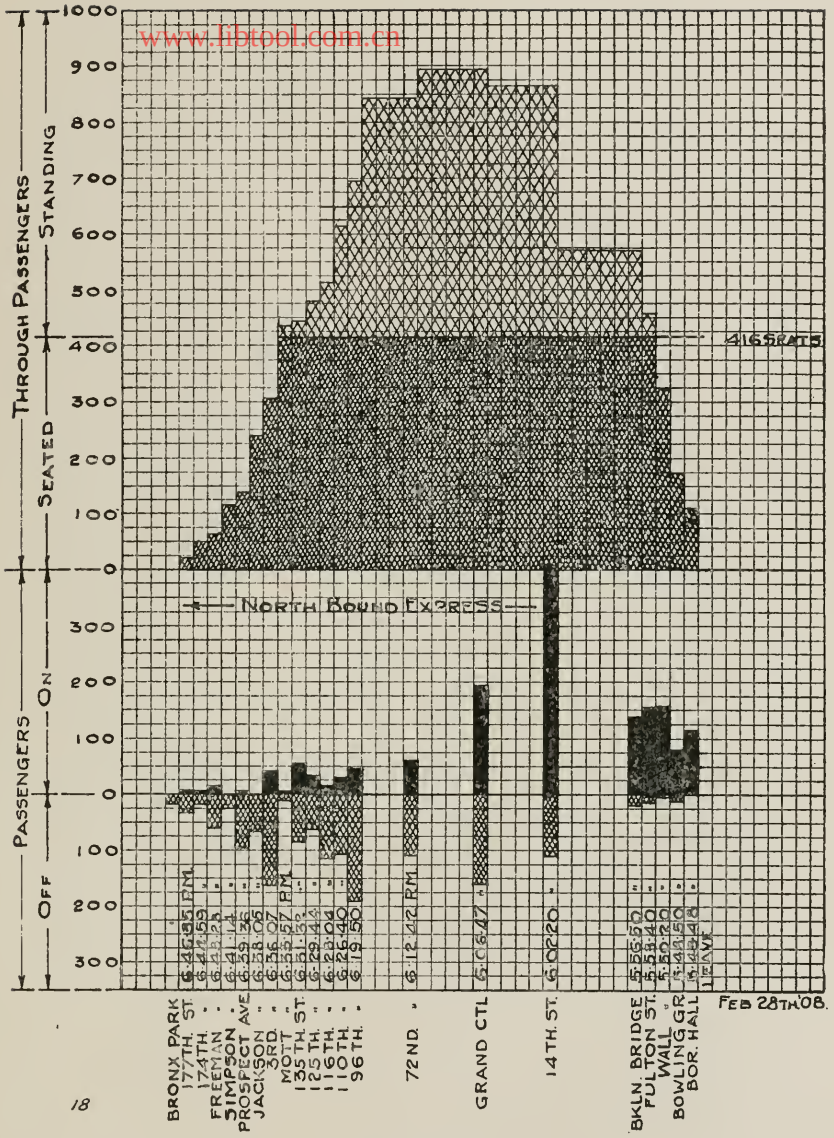


FIGURE 28.

West Farms Express.

Leaving Borough Hall for Bronx Park at 5:43 P. M.

February 28th, 1908.

Total number of passengers..... 1527
Greatest number of passengers at any one time..... 894
Length of time from Brooklyn Bridge to 96th Street.....23 minutes
Time lost between Brooklyn Bridge and 96th street..... 7 minutes
Average length of passenger travel.....5.34 miles

This diagram has the same characteristics as the previous one although the total load is smaller; the number of passengers boarding the train at 14th Street is larger and the number of passengers leaving the train at Third Avenue is smaller.

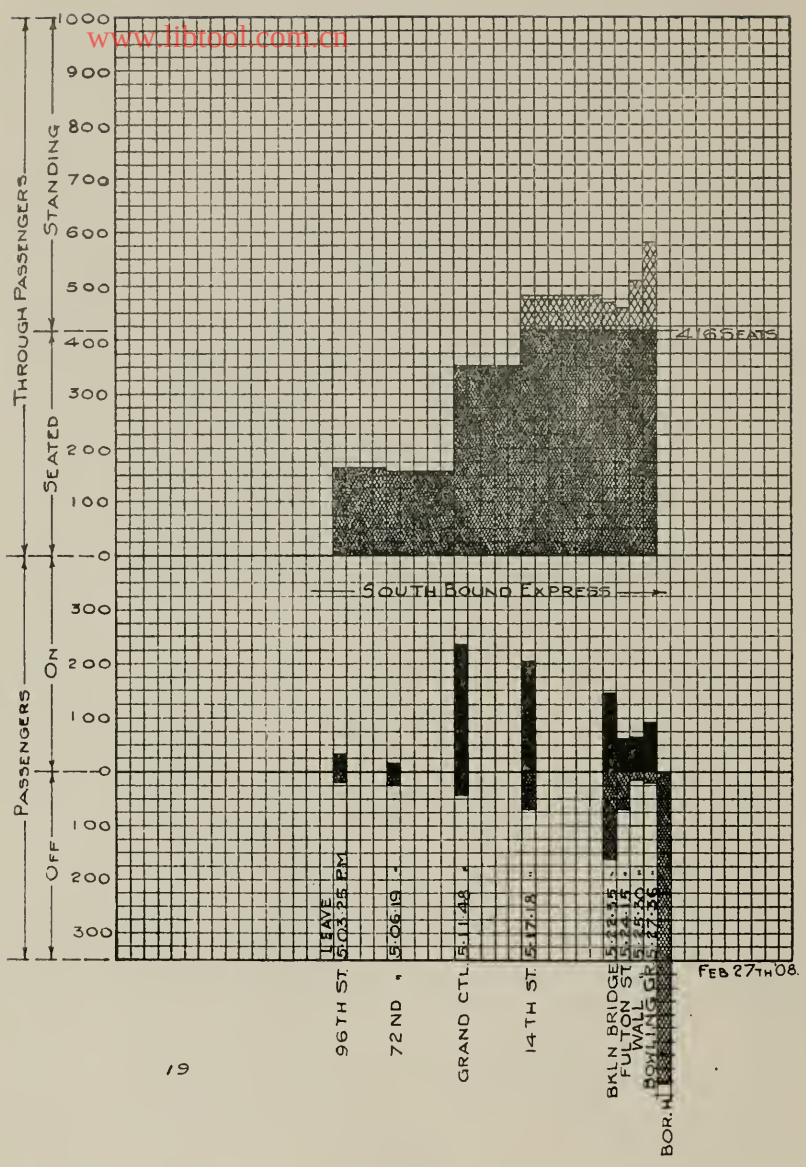


FIGURE 29.

WEST FARMS EXPRESS.

Leaving 96th Street at 5:03 P. M.

February 27th, 1908.

Length of time from 96th Street to Brooklyn Bridge.....19 min. 10 sec.
Time lost between 96th Street and Brooklyn Bridge..... 3 min. 10 sec.

The information for this diagram was secured in order to show the characteristics of the travel to Brooklyn during the evening rush hour, and therefore the information was not secured of the passenger movement on and off the train north of 96th Street. This diagram shows a large number of passengers riding to Brooklyn boarding the train north of Brooklyn Bridge; that is, considerable traffic is being accommodated from Grand Central station and 14th Street directly through to Brooklyn.

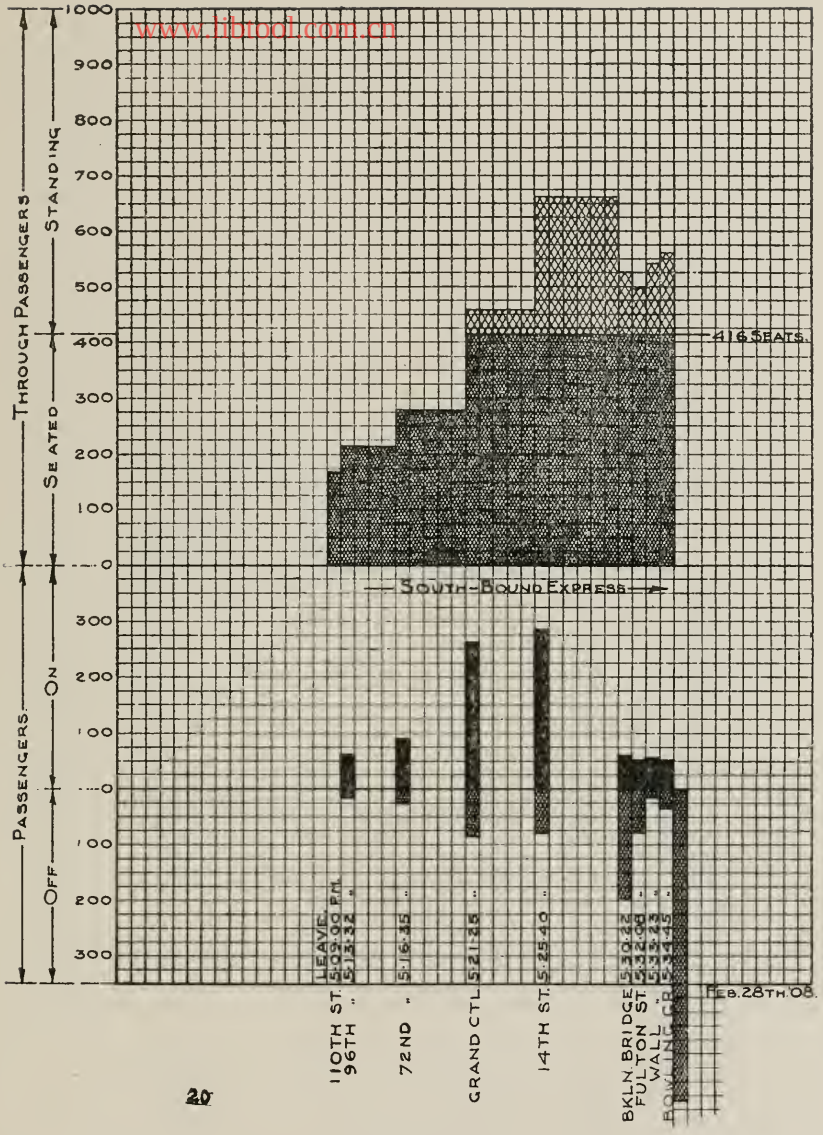


FIGURE 30.

West Farms Express.

Leaving 110th Street for Borough Hall at 5:09 P. M.

February 28th, 1908.

Length of time from 96th Street to Brooklyn Bridge.....16 min. 50 sec.
Time lost between 96th Street and Brooklyn Bridge.....50 sec.

This diagram shows a larger number of standing passengers than shown by the previous diagram, but the exodus of passengers at Brooklyn Bridge reduced the number of standing passengers. This train was not uncomfortably crowded when it passed through the tunnel to Brooklyn.

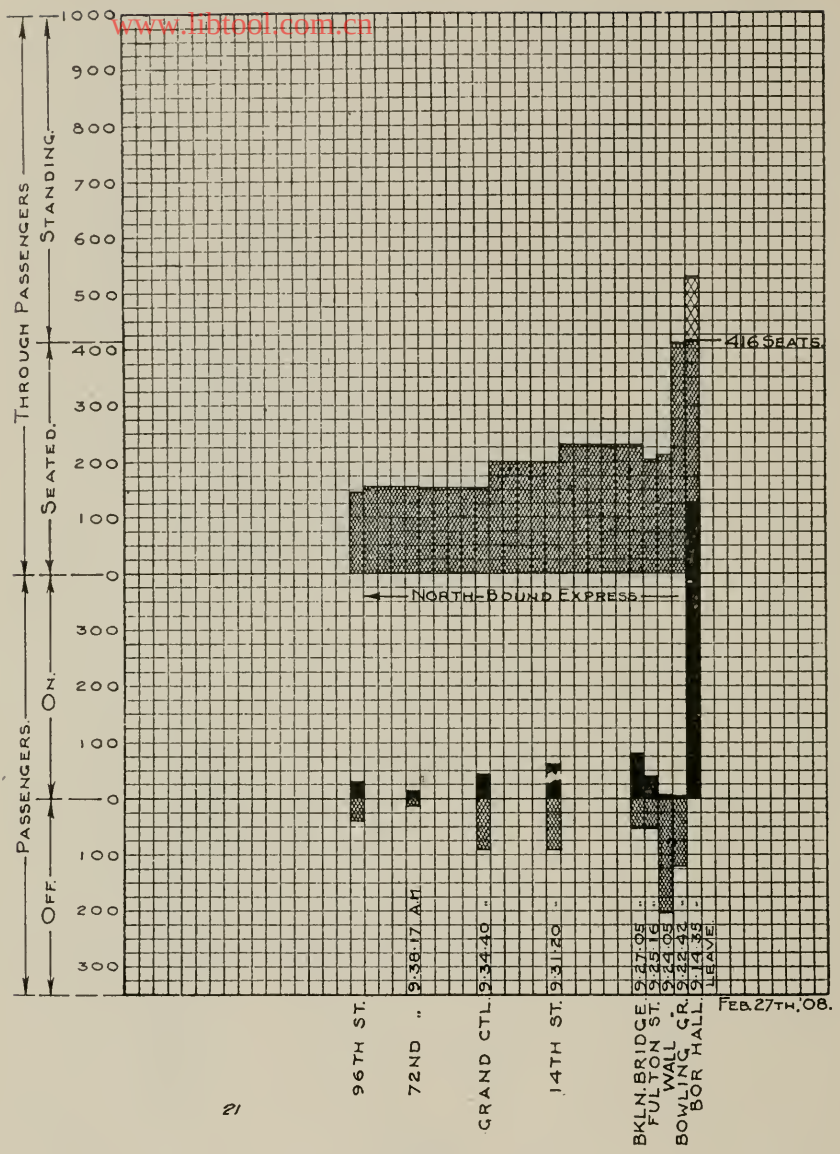


FIGURE 31.

West Farms Express.

Leaving Borough Hall at 9:14 A. M.

February 27th, 1908.

Length of time from Brooklyn Bridge to 96th Street.....15 min. 13 sec.
Time gained between Brooklyn Bridge and 96th Street.....47 sec.

This diagram was prepared to show the travel of passengers from Brooklyn to Manhattan during the morning rush hours and indicates that there was a standing load on the Brooklyn train only from Borough Hall to Bowling Green. This diagram also shows that a number of passengers traveled from Borough Hall through to Grand Central station.

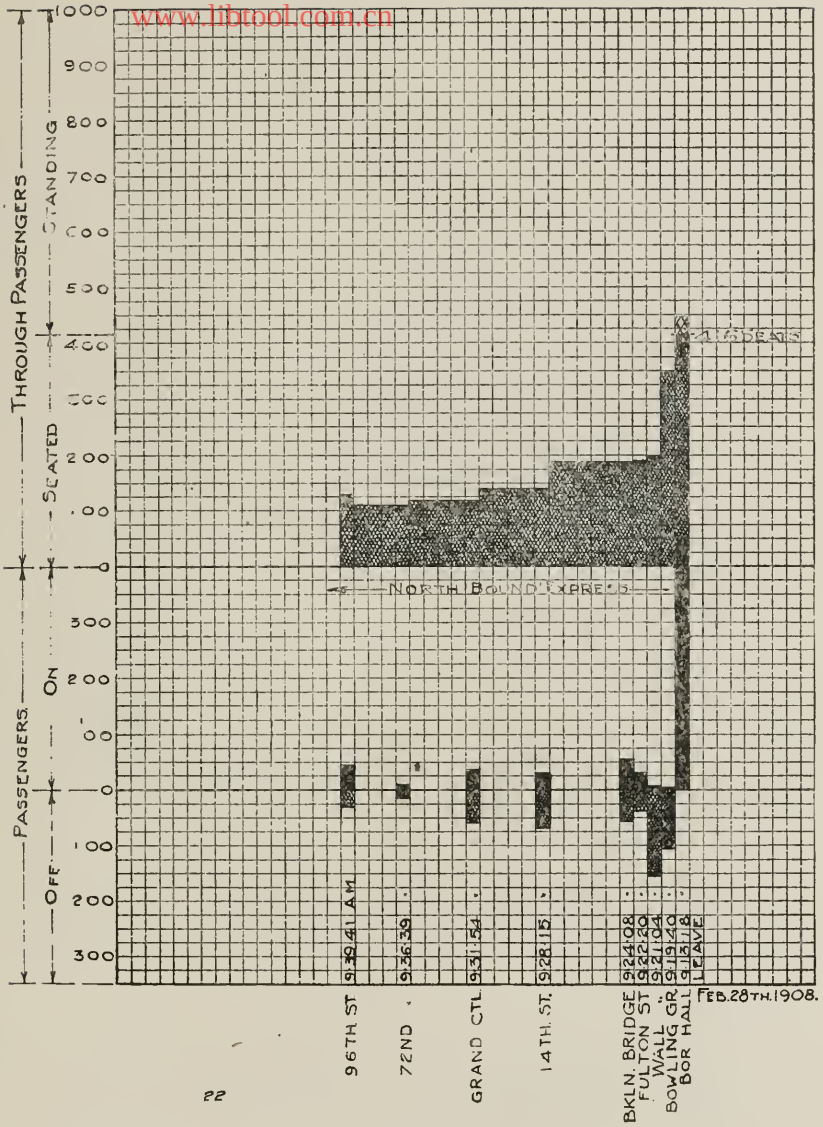


FIGURE 32.

West Farms Express.

Leaving Borough Hall at 9:13 A. M.

February 28th, 1908.

Length of time from Brooklyn Bridge to 96th Street.....15 min. 33 sec.
Time gained between Brooklyn Bridge and 96th Street.....27 sec.

This diagram indicates the same characteristics as the previous diagram, showing that while a large number of the Brooklyn passengers left the train at Bowling Green station and still a larger number at Wall Street station, at the same time some of the Brooklyn passengers were being carried as far north as 14th Street and Grand Central station. Both of the trains indicated by the two last diagrams, being comparatively empty, made the run from Brooklyn Bridge to 96th Street in less than scheduled time.

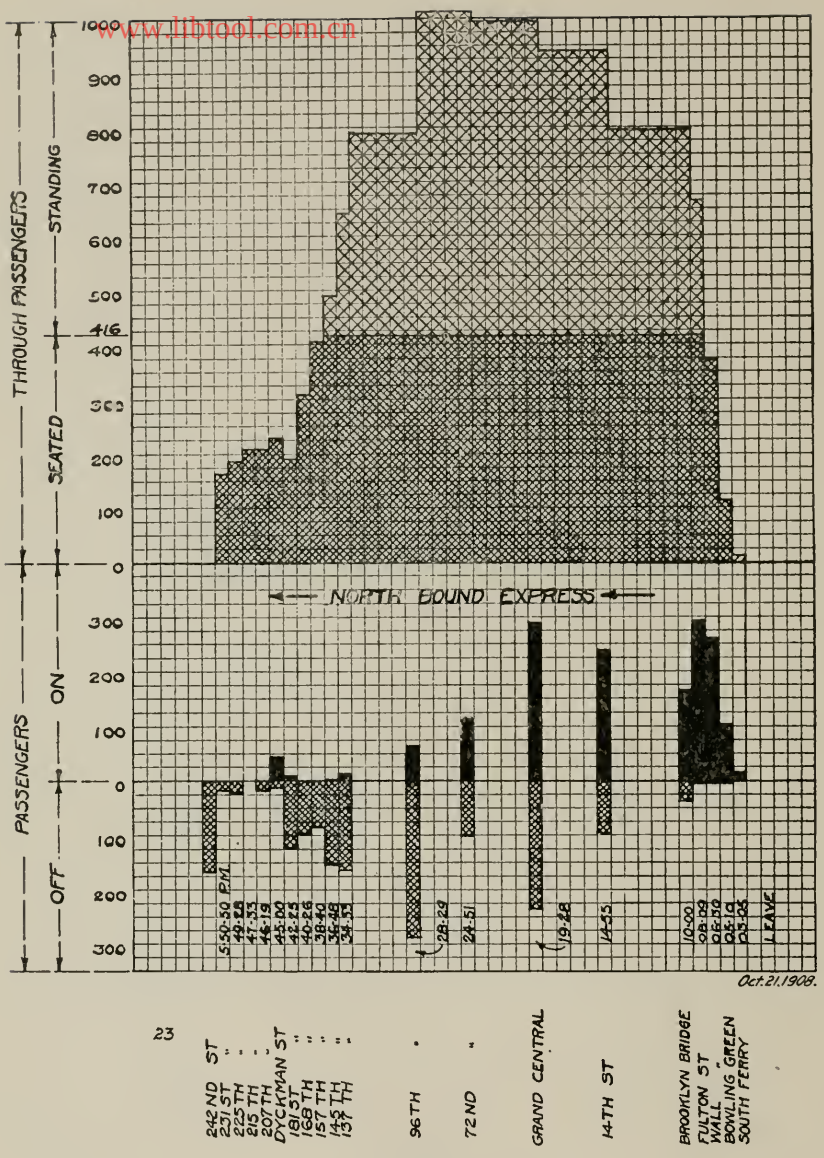


FIGURE 33.

BROADWAY KINGSBRIDGE EXPRESS.

Leaving South Ferry for 242nd Street at 5:03 P. M.

October 21, 1908.

Total number of passengers	1617
Greatest number of passengers at any one time	1010
Length of time from Brooklyn Bridge to 96th Street	18 min. 29 sec.
Time lost by train between Brooklyn Bridge and 96th Street	2 min. 29 sec.
Average length of passenger travel	5.95 miles

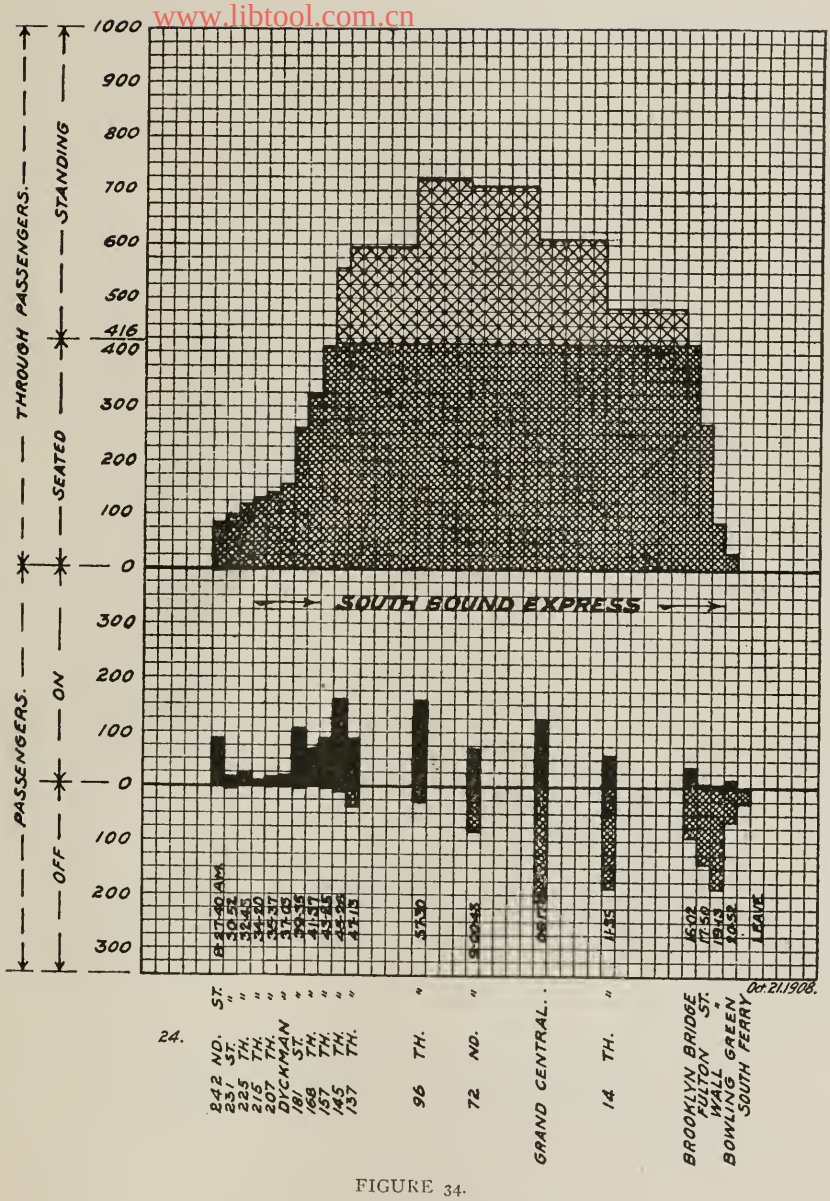


FIGURE 34.

BROADWAY KINGSBRIDGE EXPRESS.

Leaving 242nd Street for South Ferry at 8:27 A. M.

October 21, 1908.

Total number of passengers	1091
Greatest number of passengers at any one time	721
Length of time from Brooklyn Bridge to 96th Street	18 min. 32 sec.
Time lost by train between Brooklyn Bridge and 96th Street	2 min. 32 sec.
Average length of passenger travel	6.14 miles

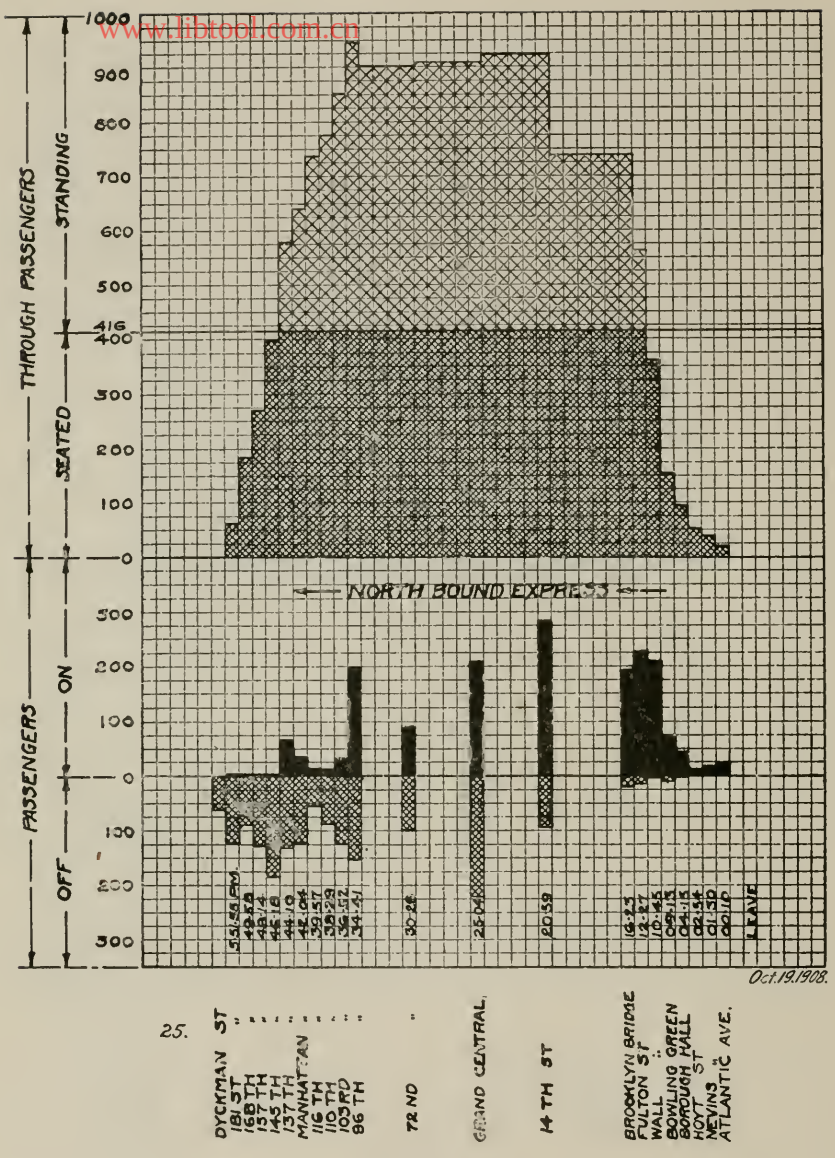


FIGURE 35.

Broadway Dyckman Street Express.

Leaving Atlantic Avenue for Dyckman Street at 5:00 P. M.

October 19, 1908.

Total number of passengers	1735
Greatest number of passengers at any one time	947
Length of time from Brooklyn Bridge to 96th Street	18 min. 18 sec.
Time lost by train between Brooklyn Bridge and 96th Street	2 min. 18 sec.
Average length of passenger travel	4.88 miles

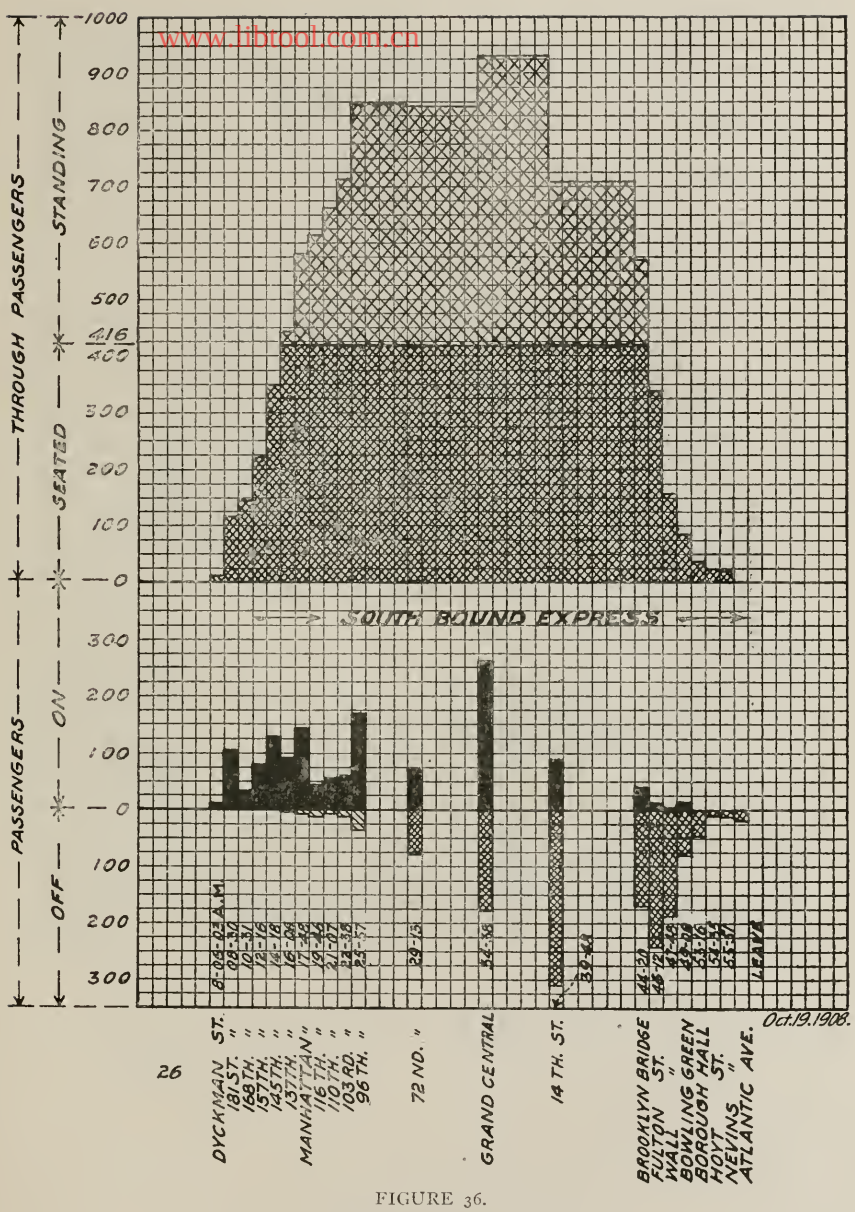


FIGURE 36.

BROADWAY DYCKMAN EXPRESS.

Leaving Dyckman Street for Atlantic Avenue at 8:06 A. M.

October 19, 1908.

Total number of passengers	1395
Greatest number of passengers at any one time	928
Length of time from Brooklyn Bridge to 96th Street	18 min. 23 sec.
Time lost by train between Brooklyn Bridge and 96th Street	2 min. 23 sec.
Average length of passenger travel	5.26 miles

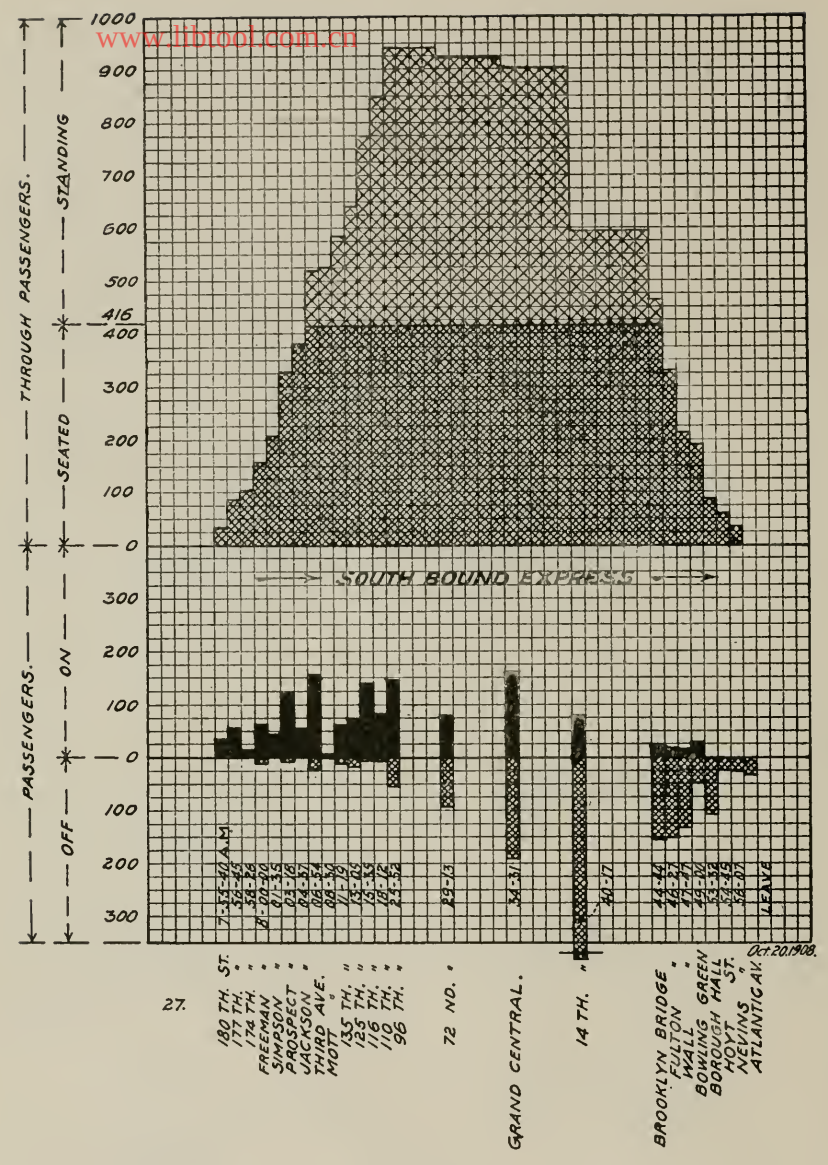


FIGURE 37.

West Farms Express.

Leaving Atlantic Avenue for 180th Street at 7:55 A. M.

October 20, 1908.

Total number of passengers	1473
Greatest number of passengers at any one time	941
Length of time from Brooklyn Bridge to 96th Street	18 min. 52 sec.
Time lost by train between Brooklyn Bridge and 96th Street	2 min. 52 sec.
Average length of passenger travel	5.96 miles

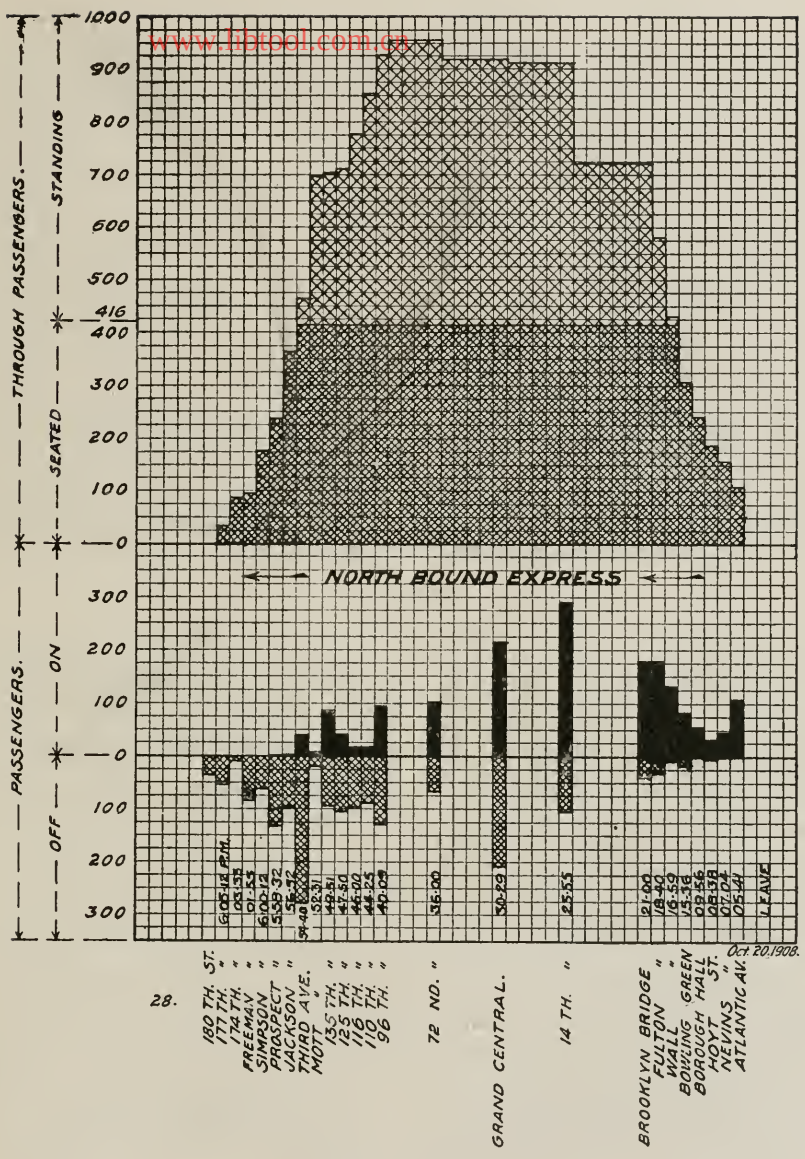


FIGURE 38.

West Farms Express.

Leaving Atlantic Avenue for 180th Street at 5:05 P. M.

October 20, 1908.

Total number of passengers	1734
Greatest number of passengers at any one time	955
Length of time from Brooklyn Bridge to 96th Street	19 min. 9 sec.
Time lost by train between Brooklyn Bridge and 96th Street	3 min. 9 sec.
Average length of passenger travel	6.29 miles

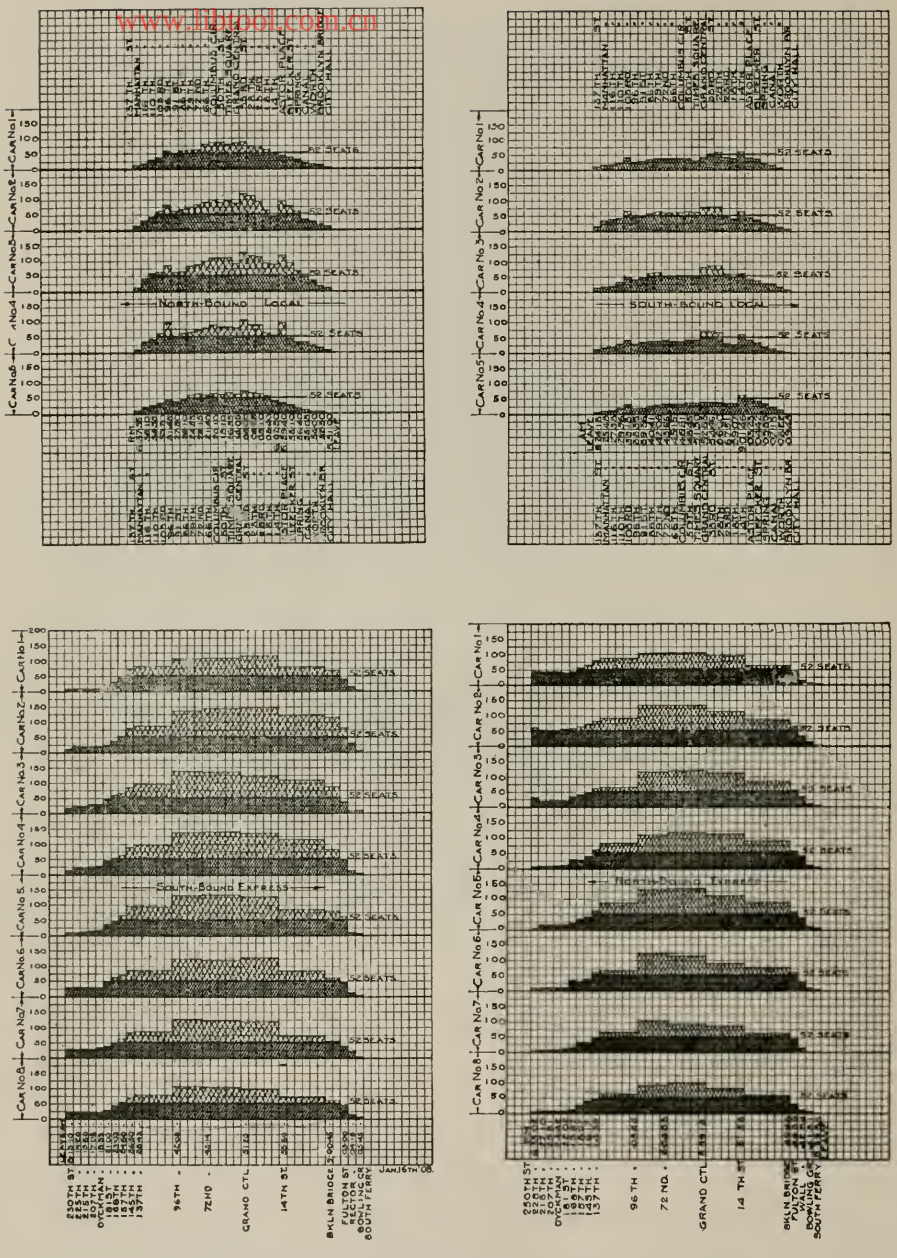


FIGURE 39.

Distribution of Passengers Throughout the Trains.

Distribution of Passengers Throughout the Trains.

It is often said that while the middle cars of the train are crowded, there is plenty of room in the end cars. In order to determine the relative location of the standing passengers in the various cars of the train, the diagrams in Figure 39 are shown.

These diagrams show the extent of the location of the standing load in the cars of four different trains, two of which were 137th Street locals, one north and one south bound, and the other two trains were Kingsbridge express trains, one north and one south bound.

A study of these diagrams will indicate that there is a much more even distribution of passengers through the express trains than through the local trains, due, no doubt, to the fact that the passengers will take more trouble to avoid a crowded car in boarding an express train than they will in boarding a local train as in the latter case most passengers travel but a short distance.

The diagrams indicate, however, that considerable improvement could be made in more evenly distributing the passengers throughout the length of all of the trains.

Hourly Variation in Traffic.

From the point of view of the railroad operator the most interesting and at the same time the most important variation of traffic volume is that which occurs from hour to hour throughout the day. Not only is the range of variation great, but its maximum value results in demands for transportation that greatly exceed the present facilities of the system. Since these excessive demands occur at various points of the system during certain hours of the day a careful study of these points is a necessary preliminary to the formulation of any comprehensive plan for the increase or regulation of traffic facilities.

A large number of studies of the hourly variation in traffic have been made by the Transportation Bureau of the Public Service Commission from time to time. Some typical results of the information collected have been plotted in the form of graphical logs and shown in the diagrams, Figs. 40, 41, 42, 43, 44 and 46.

It will be seen that each curve shows the rate of passenger movement through the station during the day and also the number of seats in the trains at the same time, indicating at once the number of passengers who were standing in the trains as they left that particular station.

A study of these curves reveals the following characteristics:

a The peak load during which standing passengers appear for any great length of time lasts for about two hours in the morning and again for two hours in the evening. This rush hour load rises to a sharp peak for a half hour during each period.

b The seating capacity during these rush hour periods is limited by the physical limitation of the Subway.

c The maximum number of passengers through a station at any one time is equal to about four times the average for the portion of the day shown by the curves. Of the passengers traveling in one direction during the day, fully 33% travel during the two hours of the rush period.

d On account of the necessity of returning the rush hour cars to their storage tracks in the morning and carrying them back again only partly loaded at night, there are a good many partly loaded cars traveling in a direction opposite to the flow of rush hour traffic.

e As the Subway is now operated, there are more than enough seats passed through it each day to provide a seat for every passenger if the passenger load and the train movement could coincide, but unfortunately this *condition cannot* be approximated without making radical *changes* in its *design* and *construction.*

The train movement in future Subways, however, can be made to approximately coincide with the passenger load by doubling the track facilities at stations, either by double decking or otherwise, and providing suitable storage yards at both ends of the longer lines so as to reduce to a minimum the movement of empty cars.

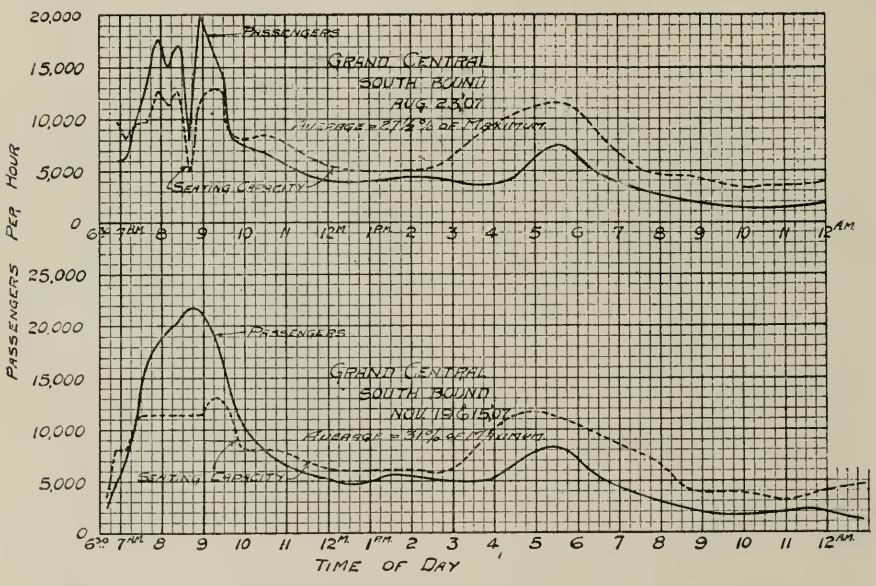


FIGURE 40.

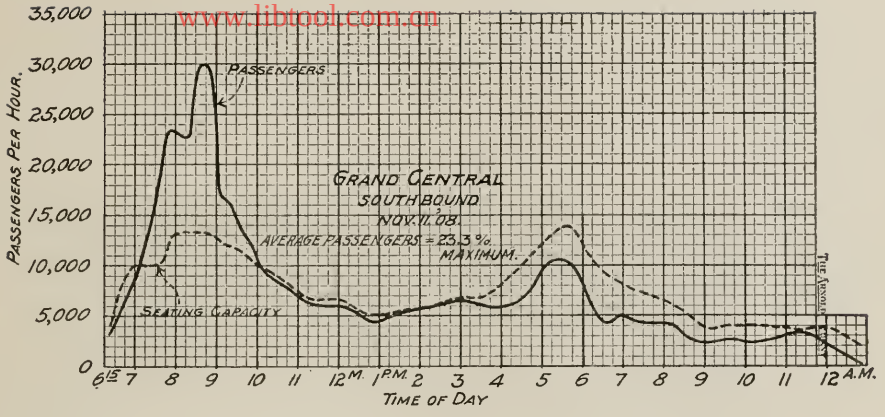
RECORD OF TRAFFIC OBSERVATIONS.

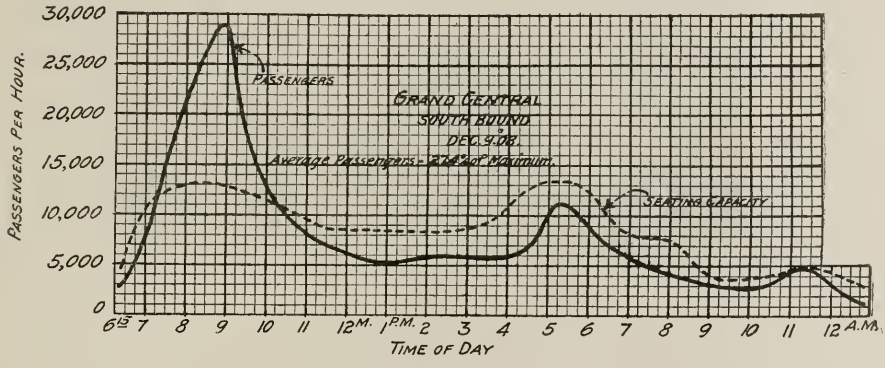
South Bound Express Service.

Grand Central Station.

The curves in Figures 40 and 41 show the results of actual counts made of the number of passengers and the number of seats leaving Grand Central Station on the south bound express tracks on five days, distributed over more than a year's time as follows: Aug. 23, 1907; Nov. 19, 1907; Nov. 11, 1908; Dec. 9, 1908, and Dec. 14, 1908.

It will be noticed that during this period the maximum morning peak load has been growing from 20,000 passengers per hour to 28,000 passengers per hour, and that the average traffic during the middle of the day has increased in about the same proportion, or from 4,000 to about 6,000 passengers per hour.





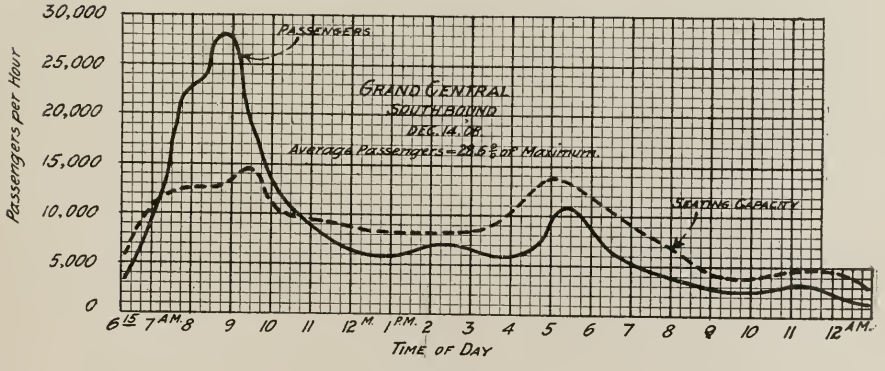


FIGURE 41.

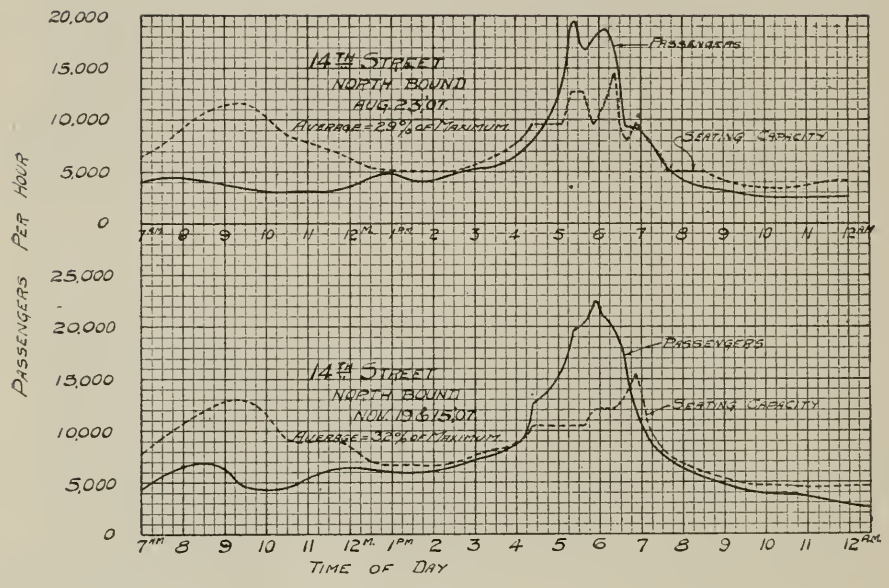


FIGURE 42.

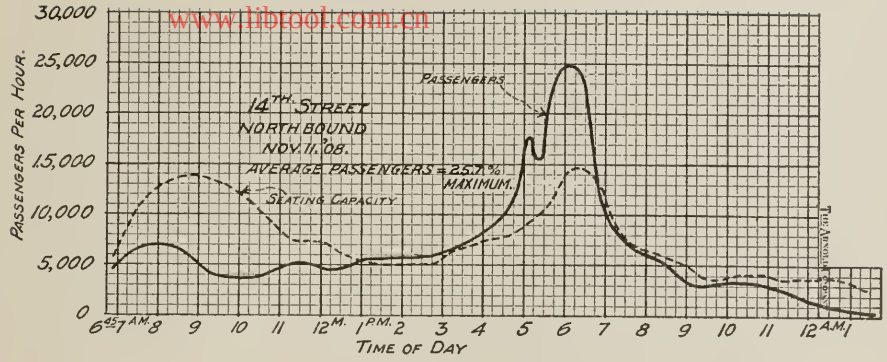
RECORD OF TRAFFIC OBSERVATIONS.

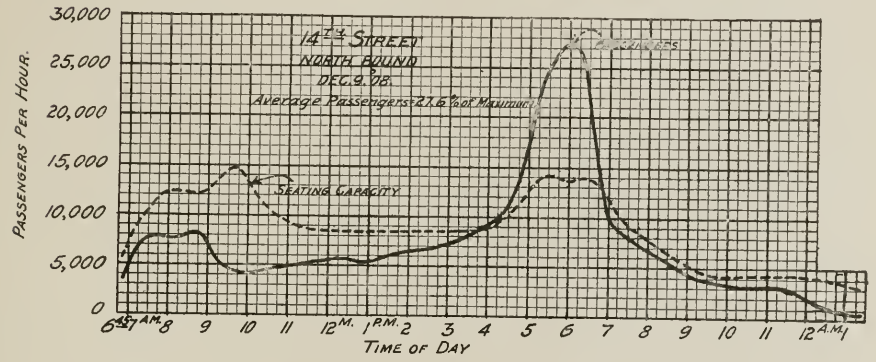
North Bound Express Service.

14th Street Station.

The curves shown in Figures 42 and 43 indicate the situation on the *north* bound express tracks at 14th Street station on the same days as shown by the Grand Central Station curves. These two stations have been selected as the points showing the greatest crowding.

The peak in the evening is not as high or as sharp as that in the morning, showing that the passengers go home more leisurely than they go to work in the morning. The increase in the number of seats provided during the middle of the day is noticeable in the last two curves, which also show considerable improvement in the length of time the maximum seating capacity is maintained during the evening rush hours.





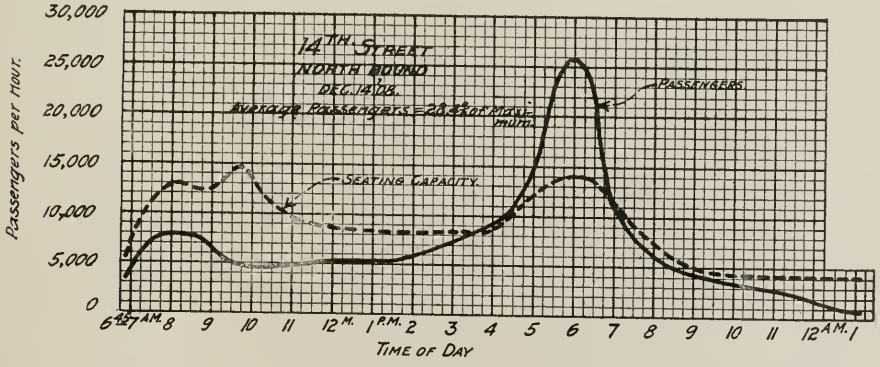


FIGURE 43.

Increases in Capacity to be Expected.

The one great difficulty in the way of supplying every passenger with a seat during the rush hours is due to the physical limitations of the Subway. When I first began to study the Subway (October, 1907) the maximum train hour capacity of the express tracks was about 29 trains of 8 cars each. During the past year this capacity has been increased to 33 trains of 8 cars each. With the introduction of additional doors in the sides of the cars, with improvements which will remove the cross-over delays at 96th Street, by means of a speed control signal system or otherwise, there is every reason to expect a train capacity of 40 trains per hour. If each of these trains is composed of 9 cars, instead of 8 cars, the possible car capacity of the Subway will be still further augmented. In other words, the peak load capacity of the express tracks in seats per hour may be taken as follows:

Table XI.

	Seats per Hour.	
	Increase.	Total.
Capacity during fall of 1907	.....	12,000
Improvement during year 1907	1,250	13,250
Improvement anticipated due to additional doors in sides of cars near ends	1,250	14,500
Improvements anticipated by use of a speed control signal system	650	15,150
Improvements anticipated due to changes at 96th Street	850	16,000
Additional capacity to be secured by running 9 cars on each express train, instead of 8 cars	2,000	18,000

While these improvements are being made, it is easy to be seen that the maximum passenger load which last year averaged about 22,000 passengers per hour, will probably increase to 36,000 passengers per hour. The result will be that the relative crowding during the rush hour period will not be decreased until other Subways are built.

These future Subways should be designed with reservoir stations on the express tracks, as pointed out in the report on "Capacity," and with this arrangement of tracks may be expected to have a maximum seat capacity of 30,000 seats per hour, which will be a great improvement over the possible seat capacity of the present Subway.

Proposed System for Regulation of Subway Traffic.

The present Subway is now completed as far as officially planned, and has been running a sufficient length of time to establish precedents for future regulation and operation.

The number of passengers carried during any given period divided by the number of car miles run during that same period gives a ratio which can be taken as a comparative measure of the quality of service rendered. This ratio can not be used accurately in comparing different roads or systems of transportation, but upon any one system with a given and fixed set of conditions it should indicate very closely the comparative seating capacity per passenger furnished from day to day, or from month to month.

FIGURE 44.

Showing Ratio of Number of Passengers to Number of Car Miles.

This ratio of the number of passengers to the number of car miles has been determined for each month's operation of the present Subway during the years 1907 and 1908, and the results are shown graphically by Figure 44. It will be noted that compared with the ticket sales, relatively more cars are operated in the summer season than at any other time of the year, and that during the latter part of this year this ratio ran up higher than it has ever been before.

It would appear from this curve that, if the service in the Subway is to be regulated so as to provide for the constantly increasing traffic and not be *worse* in the future than it has been in the past, an effort should be made to anticipate the requirements of the service, and provide a schedule calling for sufficient car miles, so that the ratio between passengers and car miles will never exceed 5. Judging from the curve showing past results, this ratio can be bettered during the summer months. From a study of the record of the past year, it would appear to be fair to the Subway Company to require a ratio of 5 during the months of October to April inclusive, 4.5 for May, 4. for June, July and August, and 4.5 for September.

After determining the number of car miles that should be furnished to take care of any anticipated passenger traffic, the next problem is to so arrange a schedule that will move as many as possible of these car miles in the direction and at the time of passenger movement. In the present Subway two vacant seats mean a standing passenger at some other part of the route, or at some other time of the day. Every effort, therefore, should be made to cut down the number of empty seats, and to move the seats when and where they are needed. It costs nearly as much to move an empty car as it does a car comfortably filled with seated passengers, and as only a certain number of car miles can be run with a given income the importance of cutting out the empty cars during non-rush hours and also at the ends of the road becomes apparent. With the present Subway little is to be expected of the possibility of storing cars so as to avoid empty car miles in the direction opposite to the peak load travel, but considerable economy is to be expected eventually from the adoption of an automatic coupler which will allow the breaking up and assembling of trains at some intermediate point instead of running full length trains to the extreme ends of each division as is done at present.

Without any of these refinements, however, there still remains considerable room for improvement in the arrangement of the Subway schedules, as the last curves of the traffic observations indicate that there are useless car miles being operated, many of which might be eliminated and on the other hand there are standing passengers when more cars should be provided.

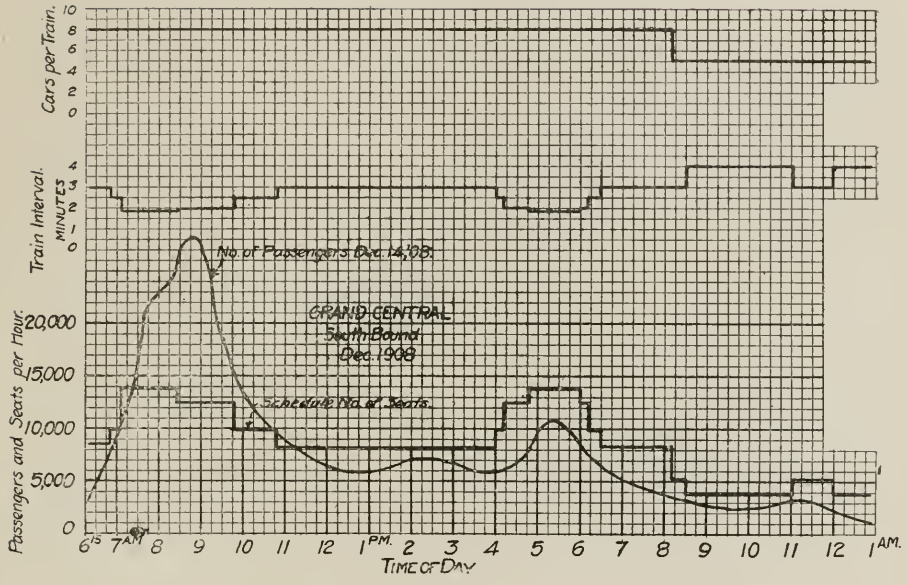


FIGURE 45.

DIAGRAM SHOWING SCHEDULE NUMBER OF SEATS COMPARED TO NUMBER OF PASSENGERS CARRIED.

Southbound Express Traffic, Grand Central Station, December, 1908.

This diagram indicates that more cars can and should be operated in the southbound express service during the morning rush hours—that is, that the maximum schedule now in force from 7 a. m. until 8.30 a. m. at Grand Central Station should be continued until 10 a. m.

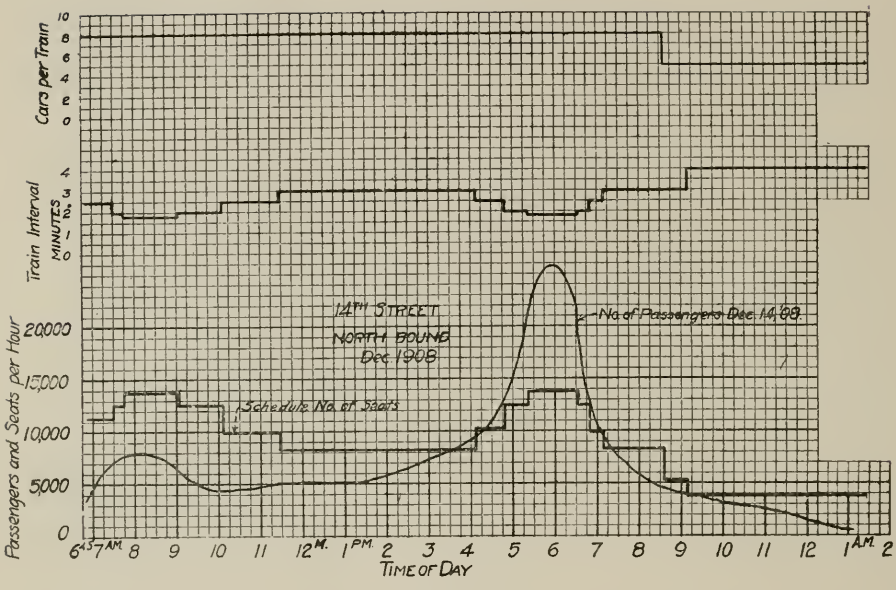


FIGURE 46.

DIAGRAM SHOWING SCHEDULE NUMBER OF SEATS COMPARED TO NUMBER OF PASSENGERS CARRIED.

Northbound Express Traffic, 14th Street Station, December, 1908.

This diagram indicates that more cars can and should be operated in the northbound express service during the evening rush hours—that is, that the maximum schedule now in force from 5.23 p. m. to 6.33 p. m. at 14th Street Station should be maintained from 4.45 p. m. to 6.45 p. m.

Study of the Transfer System.

In order to determine the characteristics of the transfer system prevailing between the local and the express tracks in the Subway, a careful record of passenger movement upon the station platforms and into and out of the trains was made during the evening rush hours at the five express transfer stations. The results of this canvass are shown in Table XII and the figures have also been plotted graphically and are shown in Plate III.

These diagrams indicate the number of passengers traveling for one hour during the evening rush period on both the local and the express north bound trains from Brooklyn Bridge to 96th Street. At each station a careful count was made for one hour showing the number of passengers entering both classes of trains from the street, the number leaving both trains to reach the street as well as the number transferring from the locals to the express trains and vice versa.

The diagrams therefore indicate the total number of passengers using each class of train during the hour; where these passengers came from and where they went to, and the number of passengers who were standing, as compared with those who were seated while in the trains.

A study of these figures shows the following conclusions, it being understood that all of the facts relate to the north bound trains during the evening rush hours.

a—The express trains carry their maximum loads as they *leave* Grand Central station and the local trains are most heavily loaded as they *enter* Grand Central station.

b—More passengers leave both classes of trains to *reach the street* at the Grand Central station than leave the trains at any other express station. Nearly twice as many passengers leave the *express* trains and go directly to the *street* at this station as leave the *local* trains at this station for the *street*.

c—Four times as many passengers take the express trains at the express stations *from* the *street* as take the local trains from the street; that is, of the number of passengers entering the five transfer stations from the street 20% do so to take a local train. The express trains secure a large increase in load at Brooklyn Bridge and at 14th Street.

d—Of the passengers on the express trains an average of 326 on each train transfer to other trains. About 40% of this transferring now takes place at 96th Street and about 25% at Grand Central Station.

e—Of the passengers on the local trains an average of 474 transfer from each train to an express train and of this movement about 40% takes place at 14th Street and about 30% at Grand Central station.

f—Relatively the total transferring between both classes of service is done as follows: At Brooklyn Bridge 3%; at 14th Street 32%; at Grand Central station 28%; at 72nd Street 13%; and at 96th Street 24%.

g—The average number of passengers entering the doors of the *express* trains is 1300 per train, of which an average of 326 or 25% transfer to the local service—that is, the local distributing service is used by 25% of the patrons of the express service.

h—The average number of passengers entering the doors of the *local* trains is 1400 per train, of which an average of 474 or 34% transfer to the express service—i. e. the express trains are the destination of 34% of the local train patrons.

i—Of 1400 passengers, therefore, using a local train, 326 have come from express trains and 474 are on their way to express trains leaving 600 passengers or 43% of the total number using the local trains who are strictly local passengers riding from one local station to another.

j—The express stations contribute an average of 114 new passengers and the express trains transfer an average of 326 passengers making a total of 440 passengers to each local train to offset the 474 passengers which the locals furnish to the express service.

k—Of the 1400 passengers who patronize a local train there are 474 who transfer to the express trains. The income from this local trip may therefore be taken at $(1400 - 474) \times 5c.$, or $46.30, and as this train is composed of 5 cars and has traveled an average of 9 miles in one direction the income per car mile for this part of the trip is equal to $\frac{\$46.30}{5 \times 9}$ or $1.03 per car mile for rush hour service.

l—In a similar way the income from an express train carrying 1300 passengers may be found by deducting the 326 passengers who transfer to the local trains, making the income for one express train north bound trip $(1300 - 326) \times 5c.$ or $48.70. This express train however consists of 8 cars and travels an average of 15.38 miles in one direction, thus reducing the income per car mile to $\frac{48.70}{8 \times 15.38}$ or 39 cents.

m—This result confirms the conclusions that the earning efficiency of the local service is more than twice that of the express service. The advantage which the local trains possess over the express trains is that they serve the short haul passenger in a short run train of comparatively few cars while the express trains carry long haul passengers who pay the same 5c. fare in long trains, running long distances.

n—Even crediting the local train with an average of 600 strictly local passengers only, the resulting $30.00 income divided by the fewer number of car miles required to maintain a local train in service will make a showing of earnings per car mile, equal to that of the express train earnings figured without any deduction for transfer passengers. That is, the local service is capable of not only maintaining itself, but it can also earn enough more to maintain the burden of the entire collecting and distributing system of which it is a part and assist in compensating for the loss due to long haul business carried by the express trains.

Short Haul Passengers in Short Haul Cars.

It is comparatively easy to draw the conclusion that "all the money is made from the short haul passengers." This popular conception is undoubtedly true but it has been necessary to collect considerable data to determine just how much of a burden the long haul passengers are upon the system as a whole.

The Subway system has now been in operation long enough to demonstrate that, in order to make this method of transportation self-sustaining upon the present flat fare basis, the income should average at least one cent per passenger mile. *In other words, with a uniform fare of 5 cents the average length of ride should not exceed 5 miles.*

The analysis resulting from the study of the passenger movement on individual trains proves that the average length of travel on the express trains is now 5½ miles or slightly above the critical average whereas the average length of ride on the local trains is but two miles. It is apparent that as the Subway is extended and the out-lying districts become more thickly populated that the average length of the long haul rides will become greater, and that unless the fare for these longer rides is increased, it will be necessary to cultivate the short haul business and increase the profit from that source if the present 5-cent flat fare is to be retained.

The extension of the present Subway to Brooklyn was a move in this direction as the total business was increased about 10% and the average haul of the Brooklyn passengers will be about four miles, thus tending to reduce the average haul. The benefits to be derived from the Brooklyn business however are somewhat offset by the fixed charges on the first cost of the extension consisting of two tubes under the East River, each nearly 7,000 feet long, and about a mile of expensive four to six track subway construction in Brooklyn. Moreover, many passengers who formerly patronized the Subway from the Brooklyn Bridge station now ride to and from Brooklyn through the tunnels under the river and thus many former short haul passengers were changed, at the time the Brooklyn extension was opened, to long haul passengers, and in these particular cases the expense of handling the passengers was increased while nothing was added to the income. The trains which serve the Brooklyn passengers are used again on each trip for the Manhattan and the Bronx passengers so that the earning power of those express trains which now run to Brooklyn has been increased and the average income per car mile should show some improvement on account of this Brooklyn extension. As the Brooklyn line however is extended the average length of haul will be increased and a point will eventually be reached where the business of this section will not tend to decrease the average length of haul.

The problem of the future, therefore, if the fixed fare of 5 cents is retained, will be to find a way to handle *short haul passengers* in *short haul cars* and to make enough profit on this short haul business to be able to sustain the loss due to the long haul burden. In other words, the fact that the local trains in the present Subway are proven by careful analysis to have twice the earning power of the express trains, points out

the solution of the problem of eventually developing a comprehensive Subway system for Greater New York. The development of the short haul business must be encouraged by furnishing a convenient, rapid, safe and comfortable service of ample capacity. It is not improbable that a commercial demonstration of the moving platform may prove that the short haul passengers can be transported at a lower cost by means of a moving platform than by the present local train method. Irrespective of whether the short haul business is handled by means of moving platforms or by cars—the profit made from the short haul rides should be so used as to offset the losses due to the long haul.

The building of Subways should start at the centre of the city and work out rather than start from the out-lying districts and work in. Any plan for future Subways which fails to make ample provision for the down-town local business, in a degree greater than is done with the present Subway, will suffer from a fundamental defect which will not only cripple its usefulness from the start but this defect will become more apparent as the out-lying districts develop and as the average length of the long haul becomes greater.

Conclusions.

Briefly, the conclusions that may be drawn from this report are as follows:

1. The capacity of the express tracks of the present Subway can be increased (from 12,500 seats per hour) to 18,000 seats per hour, and as the peak load is now over 28,000 passengers per hour, and increasing rapidly, every effort should be made to augment the maximum carrying capacity. Additional doors should be put in the sides of the cars, and the speed control signal system which has now been developed should be installed at all express stations. These improvements should be followed by the addition of one extra car on each express train, and the use of an automatic coupler should receive early consideration. The installation of a shuttle train service at Bowling Green station, in order to increase the capacity of the Brooklyn tubes, should be pushed, and eventually the cross-overs should be eliminated at 96th Street.

2. The equitable way to control the number of cars which should be furnished to provide for the constantly increasing Subway traffic is to determine upon a constant by which the number of passengers to be expected can be divided. The result will be the number of car miles which the schedule should provide. Judging from past records, this constant during the winter months may be taken as 5.

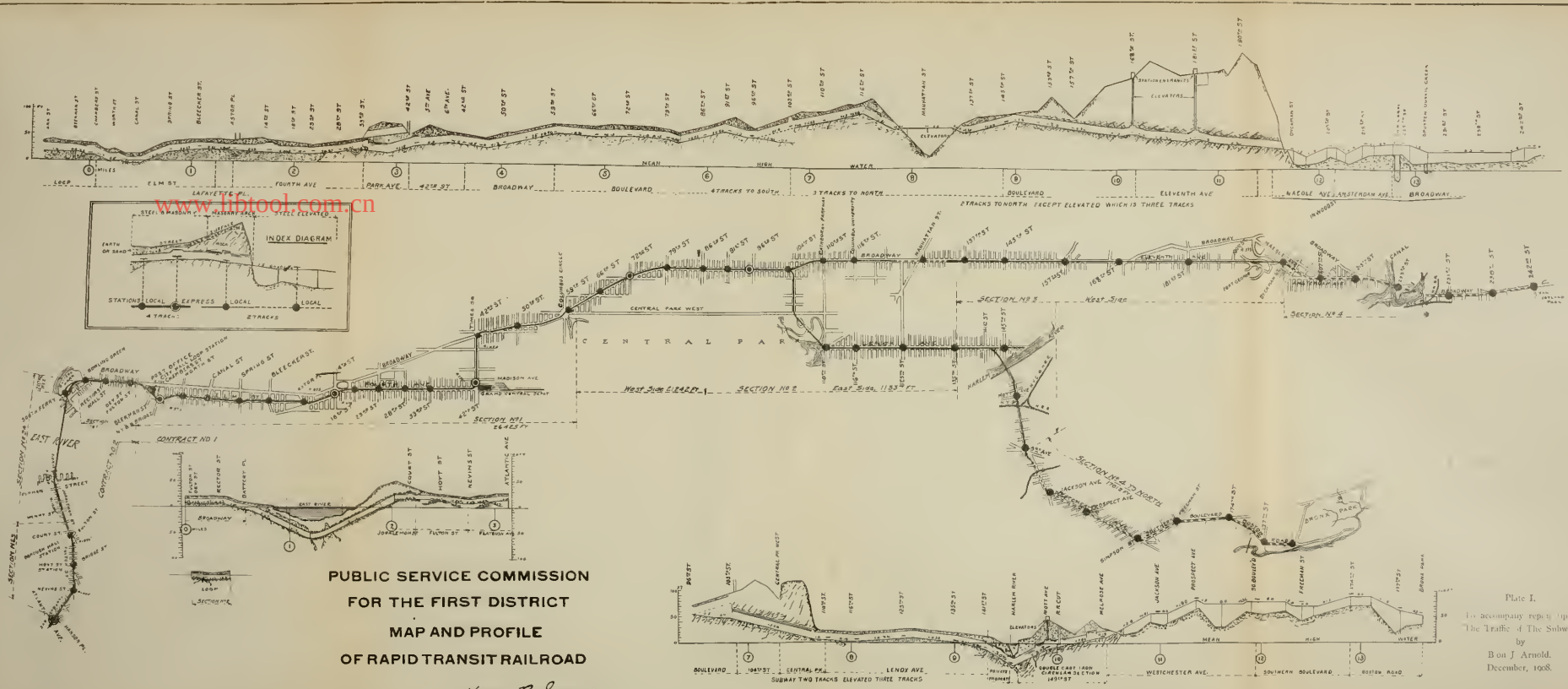
3. A more thorough study should be made to determine where useless car miles can be eliminated from the present schedule, and where an equal number of car miles can be introduced in such a way as to reduce the standing load to a minimum.

4. A study of the transfer system indicates that the local tracks have a greater earning power than the express tracks. If a uniform fare of 5 cents is to be maintained with the present and future Subways, progress must be made along the lines of cultivating and effectively serving the short haul business by providing a compre-

hensive system of local short haul trains. In this connection the merits of the moving platform system of transportation should be thoroughly investigated.

5. The measure of the ultimate usefulness of any Subway is its peak or overload capacity. If the present Subway could handle 60 trains an hour on each express track, its usefulness would be materially increased over its present service of 30 trains, and beyond its ultimate capacity of 40 trains per hour. Future Subways should be planned to get the full advantage of the investment in the main line tracks, by running 60 trains an hour during the morning and evening rush periods.

Note—Since this report was written, the special speed control system recommended in my report upon "The Signal System of the Subway" has been apparently successfully developed by the Subway Company, and is nearly ready for installation on the express tracks at each express station. Under these circumstances I believe it will be wise to hold the improvements at 96th Street until the full effect of the speed control signal system improvement can be tested, as the latest reports on this device indicate that it will add considerably more to the carrying capacity of the Subway than at first thought possible. It may be found that the expenditure of $1,000,000 which the removal of the 96th Street cross-overs eventually would cost will not be necessary at present.



PUBLIC SERVICE COMMISSION FOR THE FIRST DISTRICT

MAP AND PROFILE OF RAPID TRANSIT RAILROAD

DATE JAN. 21, 1908

Henry B. Seaman
CHIEF ENGINEER.

Plate I.
To accompany report upon
"The Traffic of The Subway"
by
Bion J. Arnold.
December, 1908.

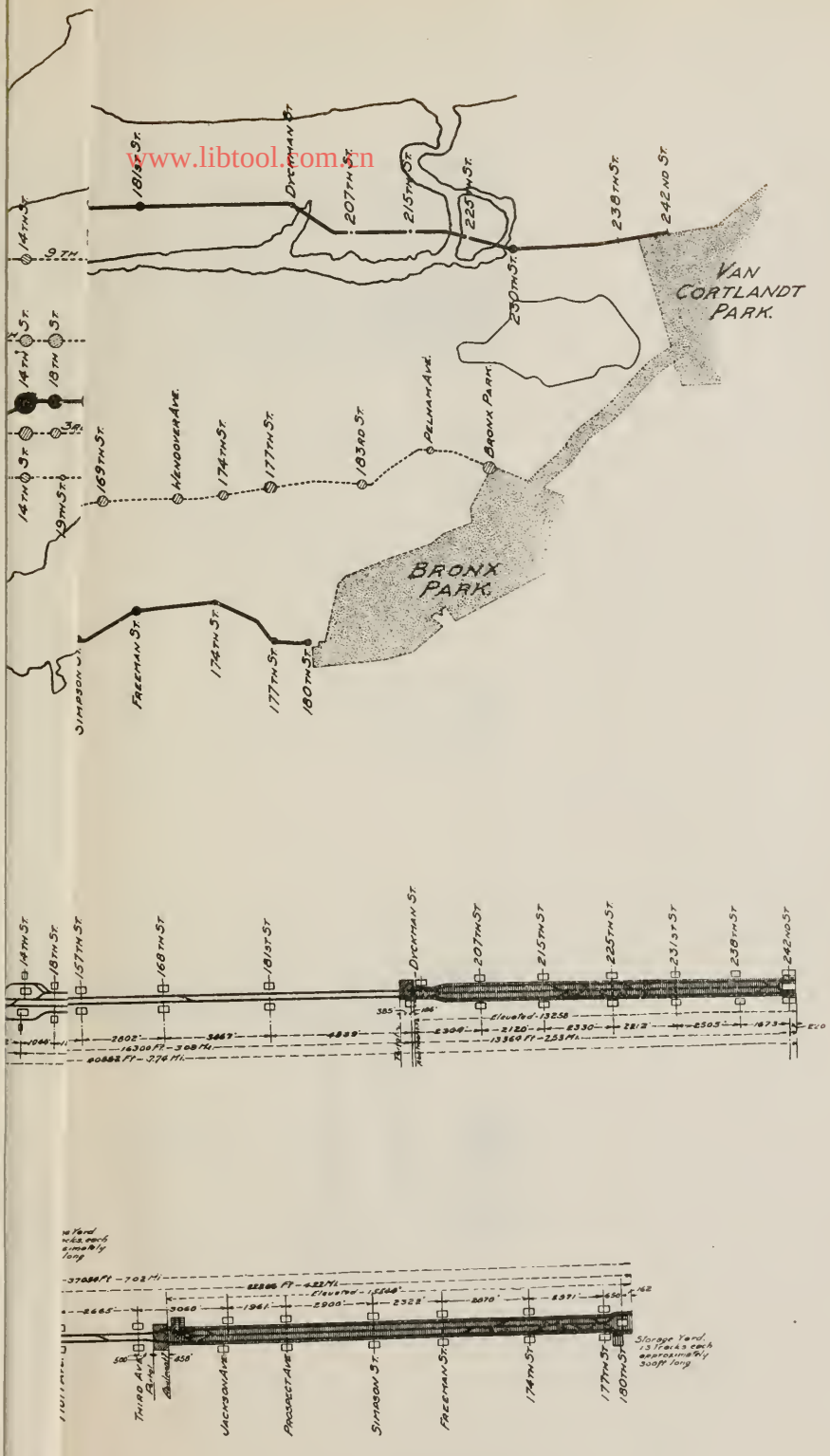
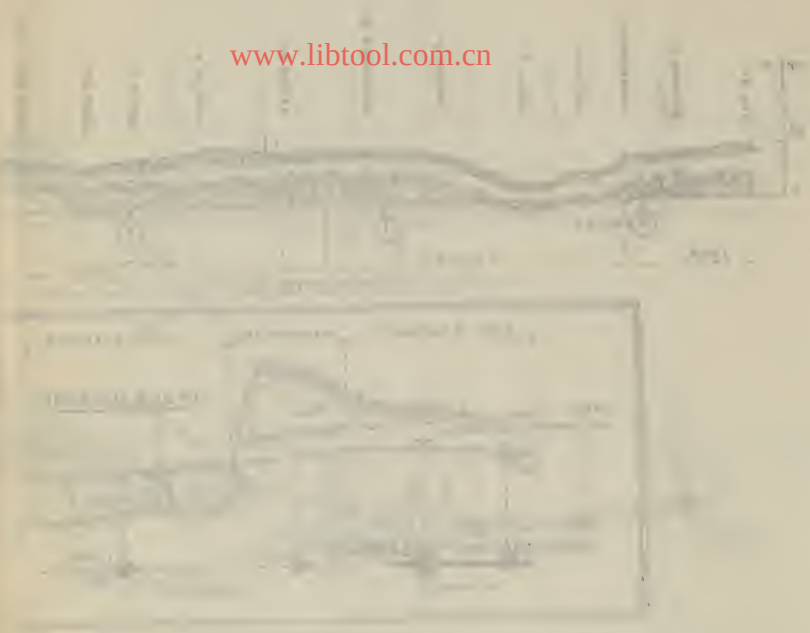
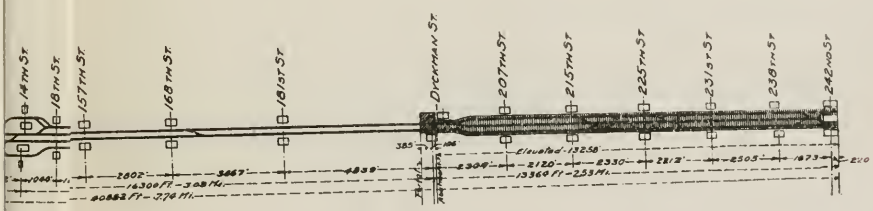


Plate II.
To accompany report upon
The Traffic of The Subway
by
Bion J. Arnold.
December, 1908.





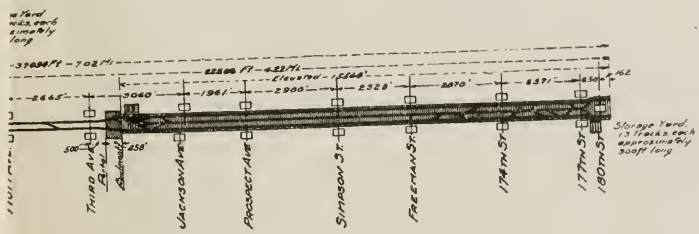
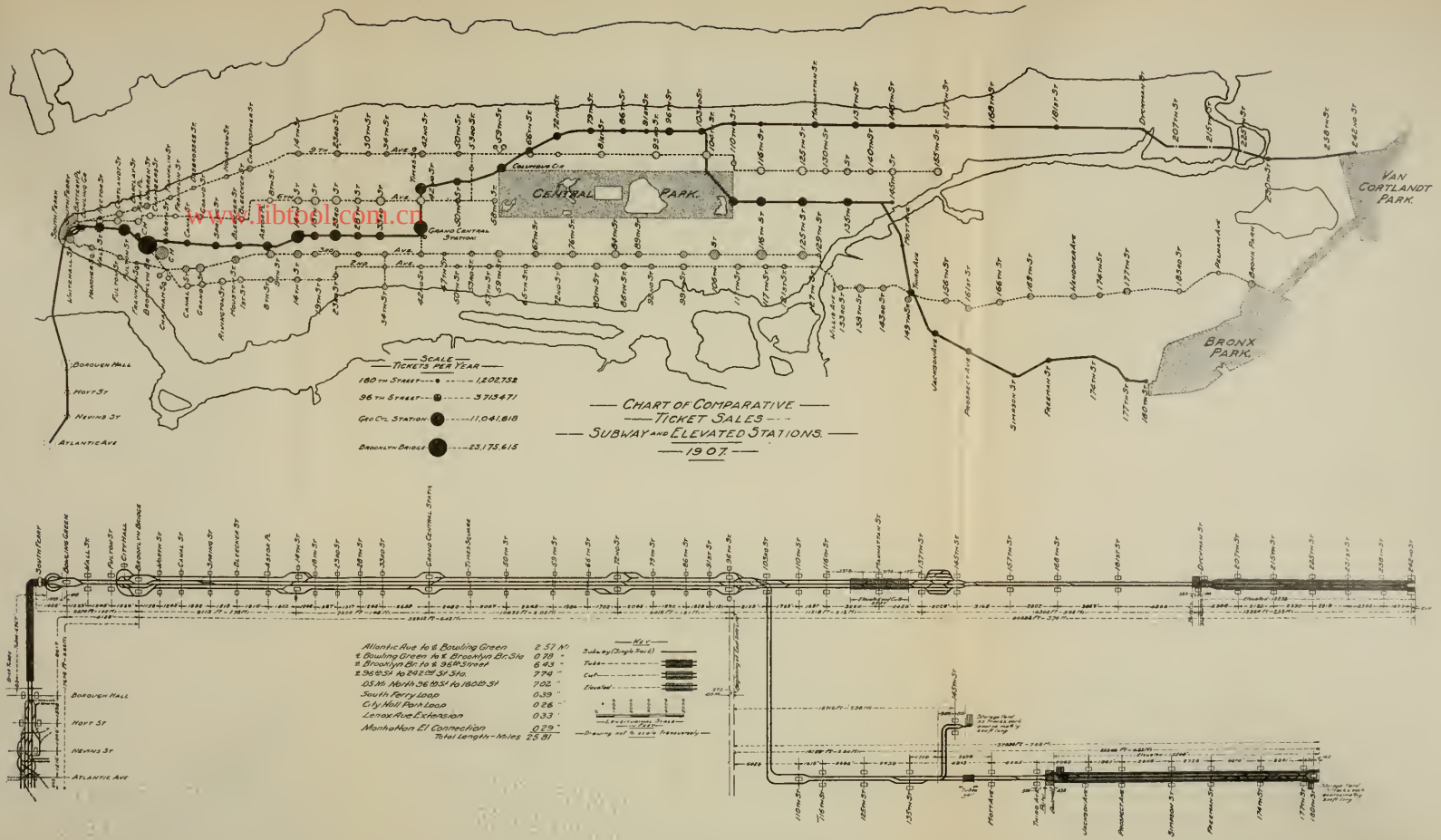


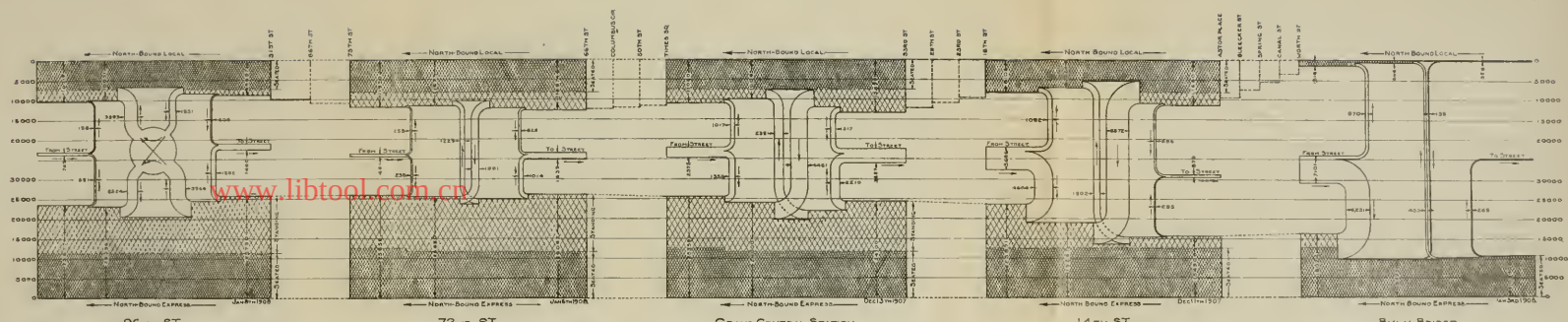
Plate II.

To accompany report upon
The Traffic of The Subway
by
Bion J. Arnold.
December, 1908.



Location and Length of Tracks,
Interborough Subway,
New York City.

Plate II.
To accompany report upon
The Traffic of The Subway
by
Bion J. Arnold.
December, 1908.



TRAFFIC CHART
SUBWAY EXPRESS STATIONS
5.30 TO 6.30 P.M.

TABLE XII.

RECORD OF PASSENGER TRAFFIC, FROM 5:30 TO 6:30 P. M.

Northbound from Brooklyn Bridge to 96th Street.

	Express Trains.						Local Trains.			
	On Trains				Transferring.				On Trains	
	Coming Into Station.	Going Out of Station.	To Street from Trains.	To Trains from Street.	Express to Local.	Local to Express.	To Street from Trains.	To Trains from Street.	Coming Into Station.	Going Out of Station.
Brooklyn Bridge	10,380	16,024	269	6,231	435	135	0	870	326	1,514
14th Street	15,490	21,871	293	4,604	1,802	5,872	586	1,082	11,680	8,106
Grand Central	24,100	25,358	2,210	1,358	2,351	4,461	1,317	1,017	13,490	11,080
72nd Street	26,662	25,858	1,014	238	1,229	1,801	625	253	12,874	11,930
96th Street	25,790	23,677	1,252	581	3,966	1,951	188	208	8,897	10,319
Totals			5,038	13,012	9,783	14,220	2,716	3,430		
Average passengers per train—										
(Total ÷ 30)			168	433	326	474	90	114		

This diagram shows a typical distribution of cars and of passengers for one hour during the evening rush at the northbound express stations. A separate diagram is shown for each of the five express or transfer stations. Each diagram shows for one hour (a) the number of seats on both the express and the local service; (b) the number of passengers both entering and leaving the station on each class of trains; (c) the number of passengers entering and leaving the station from and to the street; and (d) the number of passengers transferring from local to express trains, and vice versa. The exact figures are shown by the table.

Plate III.
To Accompany Report Upon
The Traffic Of The Subway
by
Bion J. Arnold.
December, 1908.