INFORMATIONAL REPORT

Trip Generation

By ITE Technical Council Committee 6A6

The primary objective of Committee 6A6's report, here summarized, is to provide traffic and transportation engineers with a single document and guide on trip generation rates for all land uses and building types. It is intended that the full report, soon to be published by the Institute, will be updated periodically.

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Trip generation rates have been developed for the average weekday, Saturday and Sunday for the peak hours of the generator and of the adjacent street traffic. However, in some cases, only limited data could be obtained and thus may not be too indicative of a particular building type. This report is intended as a guide in estimating the number of trips which may be generated by a specific building or land use.

Variations in generation rates for the same building or land use type exist and have been identified in the report. Because of these variations, sample size and special characteristics of a site being analyzed, extreme care must be made in the use of the rates. The data in this report represents weighted averages of those collected throughout the United States since 1966. At specific sites, the traffic and transportation engineer may wish to modify the generation rate presented in this report because of public transportation service, proximity to other developments which may reduce vehicle trip making through walking or combining trips or because of special characteristics of the site or the surrounding area.

Definition of Terms. The following definitions of terms are presented to clarify the terminology used throughout the text and tables:

Trip: A single or one-direction vehicle movement with either the origin or destination (exiting or entering) inside the study site.

Trip End: The origin or destination of a trip. Each trip has two ends. On a daily basis, each end has two trips: one entering and one exiting for an attractor of trips, and one exiting and one entering for a producer of trips. In this report, trip end refers to a two-direction vehicle movement at the origin or destination of a trip.

Average Trip Rate: A weighted average of the number of trips or trip ends per unit of related independent variable, i.e., trip ends per dwelling unit, employee, etc. The average rate was calculated by summing all trips or trip ends and all independent variables where paired data was available and then dividing the trip sum by the sum of the independent variable to obtain a weighted average.

Average Weekday Vehicle Trip Ends (AWDVTE): The weighted 24-hour total of all vehicle trips counted to and from a study site from Monday through Friday.

Average Trip Rate for Peak Hour of Adjacent Street Traffic: The weighted average trip rate during the hour of the highest volume of traffic passing the site on adjacent streets between 7 and 9 A.M. or between 4 and 6 P.M.

Average Trip Rate for Peak Hour of Generator: The weighted trip rate during the hour of highest volume of traffic entering and exiting the study site in the A.M. or in the P.M. It may or may not coincide in time or volume with the trip rate for the peak hour of the adjacent street traffic.

Independent Variable: A physical measureable and predictable unit quantifying the study site or generator, i.e., building area, employees, seats, acres, dwelling units, etc.

Regression Equation: An expression of the optimal mathematical relationship between two or more related items (variables) according to a specified criterion, as: $Y = a + bX$.

The objective in developing the relationship between X (independent variable) and Y (dependent variable) is to determine values of the parameters "a" and "b" so that the expected error involved in estimating the dependent variable given estimates of the independent variable will be a minimum.

Correlation Coefficient (R): A measure of the degree of linear association between two variables. The correlation coefficient indicates the degree of which the model estimated values account for the deviations in the individual observed values of the dependent variable from their mean value. Numerical magnitudes for "least squares" models range from -1 to $+1$ with larger absolute values representing higher degrees of linear association. The correlation coefficient for rate models is undefined when the use of a constant of trips is better than the use of the rate model (this does not occur with least square models) (Figure 1).

Data Collection Procedure

The data analyzed in this report was obtained from various local governmental agencies, consulting engineers, universities and colleges and technical reports from sections of the Institute of Transportation Engineers. No attempt was made to conduct original field surveys for this initial report.

Field Data Collection. Generally, the data has been collected with automatic counters varying from one weekday to seven days, by counting vehicular traffic entering and exiting a site. These counts cordoned the site and did not include through traffic. They were made on driveways of sufficient length to avoid double counts of turning vehicles. In some cases, counts were nondirectional and therefore did not separate entering from exiting vehicles. Manual counts supplemented some of the automatic counts to obtain vehicle occupancy and classification, to check the reliability of

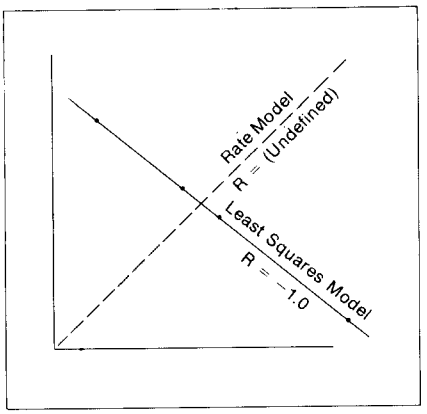

Figure 1.

the automatic counters and to obtain directional counts during peak periods where a nondirectional automatic count was being made. In other cases, only manual counts were made during peak periods. Therefore, all data summarized in this report results in vehicle trip generation rather than person trip generation.

Because some data provided only average weekday volumes, some only nondirectional peak hour volumes and some directional peak hour and average weekday volumes, separate analyses were made for each type of measurement to obtain generation rates for various time periods of the day or week. Therefore, in most cases, the peak hour entering plus exiting rates do not equal the total two-way rates. Before the reader uses these rates, an adjustment in the entering and exiting rates usually must be made to equal the total two-way rate.

Data concerning the generator or site was obtained either through personal interviews, actual measurements, telephone conversations or mail-back questionnaires.

Data Reports. In almost all cases, the data analyzed in this report was contained in published reports listed in the References, which appear in the full report. Additional data was provided from unpublished analyses by governmental agencies, firms or individuals. The References provide detailed information concerning specific generators; numbers at the bottom of the trip generation rates tables refer to References.

Generation Rate Analyses

The generation rate analyses were performed by coding the data from each source document and then, by use of computer, determining the related variables, the average trip generation rates and regression equations.

Coding Format. All data was coded uniformly on a six-page input form. This form was established to permit additional land uses not studied thus far and to add other variables, if necessary. All data was coded to a Standard Metropolitan Statistical Area (SMSA) when known. The SMSA four-digit code was obtained from the 1970 Geographic Identification Code Scheme of the Bureau of the Census.

A three-digit land use code was established to identify the types of uses studied or requiring study. This code (see Appendix) can easily be expanded to include uses not presently identified.

The data coded and keypunched on cards permits additional computer analyses for any one land use or building type and an opportunity to examine the data from each set and source.

Statistical Programs. Three statistical computer programs were used to produce the rates and regression equations and their associated statistics:

1. Statistics. Statistics for each variable were developed using program BMDO1D "Simple Data Description."* This program, part of a series of statistical programs developed by the University of California at Los Angeles, computes simple averages and provides measures of dispersion of the variables specified.

Certain methods for handling blanks and special values can be specified by the user. For this analysis, blanks were not counted and did not enter the computations as this situation was the result of missing data or data that was not available from the source studies.

The output of this program includes: means; standard deviations; standard errors of the means; maximum values; minimum values; ranges; and sample sizes. All items were calculated for each land use activity measured, e.g., number of employees, persons, vehicles, etc., and each trip variable. Only the maximum and minimum values and sample sizes were used from this program as the means produced are developed by averaging the mean of each set, and thus not a weighted average.

2. Rates. The rates (for all combinations of paired variables) were developed using program MATCH** which was written to obtain rates based on the totals of each variable that had valid data coded for each source study. These rates can be quite different from rates developed using BMDO1D, which develops a rate for each case first, then computes an average rate.

The output from this program (in matrix format) includes: number of observations; means of each dependent variable with respect to all independent variables; means of each independent variable with respect to all dependent variables; and trip rates for each independent/dependent variable combination. A flow chart of the program logic is included in the full report together with an example of the computer program output.

3. Equations. Equations were developed using the "Sub-Program Regression" in the Statistical Package for the Social Sciences (SSPS).* This is a stepwise multiple regression program which allows the choice of independent variables that will give the "best" final equation so that certain statistical limitations are satisfied. Use of a specified option allowed the deletion of cases which contain missing data values. Thus, if a value of either an independent or dependent variable were missing from the data, the case involving that variable was eliminated from the calculations.

The output of the program includes: variable means and standard deviations; simple correlation coefficients; and, for each step: the variables in the equation; variables not in the equation; the regression coefficients for each variable; the equation constant; R^2; standard error of estimate; degrees of freedom; and the F value.

Generation Rates

Vehicle trip generation rates, correlation analyses between average weekday vehicle trip ends and the independent variables and regression equations were made for land uses and/or building types within the following categories:

ITE Land Use Code	*Description*
000	Ports and Terminals
100	Industrial and Agricultural
200	Residential
300	Lodging
400	Recreation
500	Institutions
600	Medical
700	Office
800	Retail
900	Services

Table 1 summarizes the average weekday vehicle trip ends generation rates for each land use/building type studied. For each measured building or land use within the categories in the table, a description of each has been presented to-

*Complete user documentation, including brief descriptions of the statistical principles involved, is available in "BMD Biomedical Computer Programs Manual," published and distributed by the University of California Press, 2223 Fulton, Berkeley, California 94720.

** Documentation and source deck can be obtained from Dan H. Bryant, Urban Planning Division, Federal Highway Administration, Washington, D.C. 20590.

* Nie, Norman, Dale H. Bent and C. Hadlai Hull, *Statistical Package for the Social Sciences*, New York City: McGraw-Hill Book Co., 1970.

Table 1. Average Weekday Vehicle Trip Ends Generation Rate Summary.

ITE Land Use Code	Land Use of Building Type	Vehicle Trip Ends Rate
021	Commercial Airport	11.8/Employee
022	General Aviation Airport	6.5/Employee
110	General Light Industrial	3.2/Employee
130	Industrial Park	4.1/Employee
140	Manufacturing	2.2/Employee
150	Warehousing	4.3/Employee
210	Single Family Detached Unit	10.0/Unit
220	Apartment	6.1/Unit
230	Condominium	5.6/Unit
240	Mobile Home	5.4/Unit
310	Hotel	10.5/Occupied Room
320	Motel	9.6/Occupied Room
330	Resort Hotel	10.2/Occupied Room
411	City Park	60.0/Acre
412	County Park	5.1/Acre
413	State Park	0.6/Acre
420	Marina	3.8/Boat Berth
430	Golf Course	9.1/Acre
501	Military Base	1.8/Employee
520	Elementary School	0.5/Student
530	High School	1.2/Student
540	Junior/Community College	1.6/Student
550	University	2.4/Student
590	Library	41.8/1,000 gross square feet
610	Hospital	12.2/Bed
620	Nursing Home	2.7/Bed
630	Clinic	5.9/Employee
710	General Office Building	11.7/1,000 Gross Square Feet
720	Medical Office	75.0/1,000 Gross Square Feet
820	Shopping Center	116.0 to 26.5/1,000 Gross Square Feet
831	Quality Restaurant	56.3/1,000 Gross Square Feet
832	High Turnover Restaurant	164.4/1,000 Gross Square Feet
833	Drive-in Restaurant	553.0/1,000 Gross Square Feet
844	Auto Service Station	748.0/Station
850	Supermarket	125.0/1,000 Gross Square Feet
851	Convenience Market	578.0/1,000 Gross Square Feet

Table 2. Summarization of Rate Tables of Different Types of Dwelling Units.

Type of Dwelling Unit	Average Weekday Average	Vehicle Trip Maximum	Ends per Unit Minimum
210—Single Family Detached Unit	10.0	21.9	4.3
220—General Apartment	6.1	12.3	0.5
221—Low-Rise Apartment	5.4	5.5	4.7
222—High-Rise Apartment	4.3	6.4	3.1
230—Condominium	5.6	5.6	5.6
240—Mobile Home	5.4	6.8	2.8
250—Retirement Community	3.3	4.9	2.8
270—Planned Unit Development	7.9	10.0	6.2

Table 3. Correlation Between Average Weekday Vehicle Trip Ends and Independent Variables for Single Family Detached Houses.

Independent Variable	Correlation Coefficient (R)
Persons	0.995
Number of Units	0.937
Number of Vehicles Owned	0.999
Units per Acre	0.999
Acres	0.339

gether with the trip characteristics, trip generation rate tables and data limitations. The following is an example of the detail provided for each building type, taken from the section concerning residential land uses (200) and, more specifically, single family detached housing (210).

Residential 200. This section summarizes trip generation for all types of residential dwellings. Each category of residential housing, particularly single-family detached housing and apartments, used data from a wide range of units with varying sizes, price ranges, locations and ages. Consequently, there could be as wide a variation in trips generated within each category as there is between different categories. As expected, dwelling units that were larger in size, more expensive or farther away from the Central Business District (CBD) had a higher trip generation rate per unit than those smaller in size, less expensive or closer to the CBD. However, other factors such as geographic location within the country and type of adjacent and nearby development also had an effect on the generation rate. Thus, only the above general statement (instead of some linear relationship) concerning size, cost and location of dwelling unit and the income of the occupant could be made.

Table 2 summarizes the rate tables of the different types of dwelling units. As expected, the single family detached unit has the highest generation rate of all residential uses. This is followed by apartments, with retirement communities having the lowest rate. The rate for planned unit developments which have a mix of single family, detached units and apartments is in between these two types. The single family detached unit has the highest rate because: they are the largest units in size and have more people and more vehicles per unit than the other types of units; they are generally located farther away from shopping centers, employment areas and other attractors than are other types; and they have fewer alternate modes available because they are not as concentrated as other types of units.

Single Family Detached Housing 210. Any single family detached home on an individual lot is included in this category. A typical example is a home in a modern subdivision.

Slightly over 200 different studies were made of subdivisions containing single family homes. The average size subdivision contained 506 dwelling units for a total of more than 105,000 dwellings studied. These subdivisions were located primarily in suburban areas throughout the United States.

The average development density was 3.5 units per acre with 3.7 persons per

Table 4.

SUMMARY OF TRIP GENERATION RATES

Land Use/Building Type Single Family Detached House ITE Land Use Code 210

Independent Variable—Trips per Dwelling Unit

			Average Trip Rate	Maximum Rate	Minimum Rate	Correlation Coefficient	Number of Studies	Average Size of Independent Variable/Study
Average Weekday Vehicle Trip Ends			10.0	21.9	4.3		208	506
Peak Hour of Adjacent Street Traffic	A.M. Between 7 and 9	Enter	0.3	0.6	0.1		37	248
		Exit	0.6	1.7	0.2		38	258
		Total	0.8	2.3	0.4		173	269
	P.M. Between 4 and 6	Enter	0.7	1.8	0.3		38	245
		Exit	0.4	1.2	0.1		38	245
		Total	1.0	3.0	0.4		196	292
Peak Hour of Generator	A.M.	Enter	0.3	0.6	0.1		38	245
		Exit	0.6	1.7	0.2		38	245
		Total	0.8	2.3	0.4		175	271
	P.M.	Enter	0.7	1.8	0.3		40	252
		Exit	0.4	1.2	0.1		38	245
		Total	1.0	3.0	0.4		193	261
Saturday Vehicle Trip Ends			10.1	14.7	6.3		43	292
Peak Hour of Generator		Enter	0.5	1.0	0.4		21	273
		Exit	0.5	0.7	0.3		21	273
		Total	1.0	1.7	0.7		35	296
Sunday Vehicle Trip Ends			8.8	11.7	0.5		38	301
Peak Hour of Generator		Enter	0.5	0.8	0.3		19	252
		Exit	0.5	1.2	0.4		19	252
		Total	1.0	2.0	0.7		34	284

Source Numbers 1, 4, 5, 6, 7, 8, 11, 12, 13, 14, 16, 19, 20, 21, 24, 26, 34, 35, 36, 38, 40, 71, 72 (references appear in the committee's full report, available from ITE).

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unit. The average automobile ownership measured was 1.6 vehicles per unit.

Trip Characteristics. The analysis of correlation between average weekday vehicle trip ends and all measured independent variables is shown in Table 3.

Although the number of vehicles and number of residents have the highest correlations with average weekday trip ends, these variables have limited use. This is because the number of vehicles and residents is difficult to obtain and very few of the studies contained this data, and because the data is also difficult to predict. The number of units has a high correlation with average weekday vehicle trip ends. This variable is best because it is contained in most studies, it is easy to project and convenient to use.

As indicated in Table 4, single family dwellings generate on the average 10 vehicle trip ends per weekday per dwelling unit. Saturday vehicle trip generation is slightly higher; on Sunday, it is lower.

The regression equations developed for calculating the average weekday vehicle trip ends (AWDVTE) are as follows:

$$\begin{aligned} \text{AWDVTE} &= 138 + 8.17 \times \text{Units} \\ &\qquad R = 0.937 \\ &= -100 + 2.55 \times \text{Persons} \\ &\qquad R = 0.995 \\ &= -185 + 6.76 \times \text{Vehicles} \\ &\qquad R = 0.999 \end{aligned}$$

Some data is from studies conducted in the late 1960s and therefore should be updated. Additional data concerning auto occupancy and other modes of transportation is necessary.

Data Limitations

As indicated in the trip generation table, the data presented has limitations. The basic limitation, and one reason for variations in rates, is the sample size of counts at some generators and for peak hours for most generators. Additional data is needed for most generators to state more accurately the peak hour entering and exiting rates.

Another reason for variation in the generation rates is caused by different lengths of count periods and the time of the year the traffic volumes were counted. There exist daily and seasonal variations for most generators. In some cases, full week counts were made to define the average weekday and in other cases, a single day's count was obtained. In almost no case was the generation measurement adjusted for seasonal variations. This is especially true for shopping centers.

Variations in generation rates may also exist because of the location of the generator studied either within a metropolitan area or within the U.S. These locations have been identified in the data sets but no separate analyses have been made to determine if a difference exists because of location.

In all cases, the generation rates presented in this report represent driveway volumes of vehicles entering and exiting the site. For some building types, such as retail establishments, the generation rate could overstate the volume of traffic when assigned to the adjacent street system because some traffic is attracted to the site from the passing stream of traffic. That portion of the total generated traffic attracted to the site would pass on the adjacent street system whether or not the site were developed. It is essential that heavy effort be focused on defining how much of the total generated traffic to all building types would be attracted from the passing adjacent street traffic in order to define more accurately the traffic impact on the street system caused by development of a site.

The data summarized in this report is only for vehicle trip ends and does not include all person trip ends by mode. More data is needed for each building and land use type to define vehicle occupancy rates and person trip generation rates by mode of travel.

More data is also needed to define generation rates for the following types of buildings or land uses:

- water ports
- truck terminals
- railroad terminals
- low- and high-rise apartments
- condominiums
- retirement communities
- residential planned unit developments containing a mixture of duplexes, apartments and/or single family units
- day care centers
- churches
- museums
- libraries
- hospitals
- nursing homes
- clinics
- medical offices
- government buildings
- specialty shopping centers containing a mixture of small specialty shops and restaurants
- building materials retail establishments
- high quality restaurants
- drinking establishments
- banks, savings and loans, real estate offices, insurance offices and other financial services
- recreational uses.

Update Procedure

The Institute is establishing a formal procedure to update this report and to add data for additional land uses or building types not sufficiently covered in the report and to develop information on person trip ends by mode.

It is recommended that all ITE districts and sections be involved in this continual update procedure. These organizations, through their respective technical committees, can collect data from at least one or more sites annually and send it either on keypunch cards or on the trip generation coding sheets to the ITE Technical Council. In many cases, traffic counters, or even personnel, may be available from time to time to conduct a generation study in a given area.

It is also proposed that ITE work with the U.S. Department of Transportation, state, county and city departments of transportation or traffic engineering and with private consultants to obtain additional current data and include it in the updated reports. In this manner, a continual, uniform method of obtaining and summarizing the current trip generation data for all types of special generators, land uses and building types will be produced.

To implement this update procedure, the ITE Technical Council is establishing a permanent committee on trip generation rates for special generators, land uses or building types to update this report at least every two years.

The function of this committee will be to:

1. Store all trip generation data.
2. Coordinate with ITE district and section technical committees, government agencies and private consultants for the collection of additional data.
3. Distribute trip generation coding sheets and instructions to those collecting data.
4. Maintain computer program for trip generation analyses and summarization.
5. Maintain and modify when necessary a uniform procedure for collecting data.
6. Summarize trip generation data.
7. Conduct special trip generation analyses when appropriate.
8. Revise trip generation rate tables and appropriate text of report on basis of the additional data.
9. Establish data collection needs in areas where deficiencies exist or where little information is available.

The following procedure is presented to obtain new generation data from actual traffic volume counts. It is recommended that it be followed when collecting data and to transmit it on the coding sheets shown in the full report or on keypunch cards.

- Count a special generator where automatic counts can be made on drives without double-counting turning vehicles and without counting through traffic. Preferably, directional counts should be made. The site should be self-contained with adequate parking not shared by other activities.

• Conduct seven-day automatic counts during a typical week of the year to provide data concerning the average weekday, Saturday and Sunday and peak hours.
• Supplement automatic counts with a manual count for several hours on a weekday to record hourly inbound and outbound vehicular traffic by classification and vehicle occupancy and to compare with corresponding automatic counters to determine a counter factor for adjusting the raw automatic counts.
• Where recording or directional counts cannot be made automatically, manual counts should be made on a typical weekday during the A.M. and P.M. peak two-hour periods of the special generator being counted and that of the adjacent street traffic to record the peak-hour entering and exiting volumes.
• Where recording or directional counts cannot be made automatically, manual counts should be made on a typical weekday during the A.M. and P.M. peak two-hour periods of the special generator being counted and that of the adjacent street traffic to record the peak-hour entering and exiting volumes.
• Where possible, supplement the above work with manual counts or controlled interviews to determine average weekday person trip ends by mode and determine how many trips were actually generated by the site and how many trips were attracted to the site from the adjacent street traffic normally passing the site.
• Data concerning the site should be obtained through interviews with the site owner or manager and through physical measurements, if necessary. Information on the maximum number of related variables should be obtained to determine which is the best related to trip generation. In all cases, it is essential to obtain the number of employees, the gross building area, the number of occupied rooms or dwelling units, the population and the acreage of development.
• Code data on coding forms by following instructions contained in the full report.
• Obtain trip generation bibliography number from permanent committee and, if necessary, a new land use or building type code if one does not already exist.
• Transmit data to Technical Council.

APPENDIX

Trip Generation Land Use Code

000 Port and Terminal
010 Water Port
020 Airport
021 Commercial Airport
022 General Aviation Airport
030 Truck Terminal
040 Railroad Terminal

100 Industrial/Agricultural
110 General Light Industrial
120 General Heavy Industrial
130 Industrial Park
140 Manufacturing
150 Warehousing
160 Construction
170 Utility
180 Agricultural

200 Residential
210 Single Family Detached Housing
220 Apartment
221 Low-Rise Apartment
230 Condominium
231 Low-Rise Condominium
232 High-Rise Condominium
240 Mobile Home
250 Retirement Community
260 Recreational Home
270 Planned Unit Development

300 Lodging
310 Hotel
320 Motel
330 Resort Hotel

400 Recreational
410 Park
411 City Park
412 County Park
413 State Park
420 Marina
430 Golf Course
440 Theater
441 Live Theater
442 Music Theater
443 Movie-Theater (sit down)
444 Drive-In Theater
450 Stadium
451 Baseball/Football
452 Horse Race
453 Auto Race
454 Dog Race
460 Camp
480 Amusement Park

500 Institutional
501 Military Base
510 Preschool
520 Elementary School
530 High School
540 Junior/Community College
550 University
560 Church
570 Court
580 Museums/Gallery
590 Library

600 Medical
610 Hospital
620 Nursing Home
630 Clinic

700 Office
710 General Office Building
720 Medical Office Building
730 Government Office Building
740 Civic Center
750 Office Park
760 Research Center

800 Retail
810 Retail/General Merchandise
820 Shopping Center
821 Regional Shopping Center—over 500,000 G.L.F.A.
822 Community Shopping Center—100,000 to 500,000 G.L.F.A.
823 Neighborhood Shopping Center—under 100,000 G.L.F.A.
824 Discount Shopping Center
825 Specialty Retail Center
826 Specialty Store
827 Building Material
830 Restaurant
831 Quality Restaurant
832 High Turnover Sit-Down Restaurant
833 Drive-In Restaurant
834 Drinking Place
840 Auto
841 New Car Sale
842 Used Car Sale
843 Auto Parts Sale
844 Service Station
845 Tire, Battery and Accessory
846 Car Wash
847 Auto Repair
848 Highway Oasis (including truck fuel, minimal trucker and mechanical services)
849 Truck Stop (including food, auto and truck mechanical services, trucker supplies and trucker overnight sleeping accommodations)
850 Food Store
851 Convenience Market
860 Wholesale
870 Apparel
890 Furniture

900 Services
910 Financial
911 Bank (walk-in)
912 Drive-In Bank
913 Savings and Loan (walk-in)
914 Drive-In Savings and Loan
915 Stock Broker
916 Lending Agency
920 Real Estate
930 Insurance