1930

A Traffic Survey of the City of Sioux Falls, South Dakota

George Everett Thompson

A TRAFFIC SURVEY OF THE CITY OF SIOUX FALLS, SOUTH DAKOTA

By

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Acknowledgement

The increase in street congestion in Sioux Falls, South Dakota the past few years has placed before the city an important municipal problem. The major objective of this thesis is to help solve the problem of traffic control in Sioux Falls.

The writer is indebted to the City Engineer's Office and the Police Department of Sioux Falls and the Senior Civil Engineers of South Dakota State College for their help in obtaining data for the survey. Also the assistance received from the National Safety Council of Chicago, Illinois through their reports on traffic surveys.

The writer wishes to thank Professor H. S. Carter, Head of the Civil Engineering Department at South Dakota State College for his many helpful suggestions, and Miss Jane Mullenbach, Professor of English, South Dakota State College, who read the original copy for grammatical construction.

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INTRODUCTION

How to control the traffic on the streets of our cities is becoming one of the most important municipal problems of the present day. An urban community depends for its existence upon the transportation facilities both internal and external. The external transportation is necessary for a city's growth because food supplies and raw materials must be brought into the city and the commodities which are produced in the cities must be distributed to other places.

The internal traffic is also equally important in that commodities transported to and from a city do not originate or end at the city limits. The incoming traffic must serve the whole community and the streets are means by which inter-communication is made possible within a city. Without streets no city could exist long. It is equally true that when the streets fail to meet the increased demand which is placed upon them the growth of the community will be limited.

The street traffic problem is by no means a new one; ancient cities, as well as modern, suffered from street congestion. In Rome, Caesar found it necessary to issue an order prohibiting the passage of wagons through the central streets for ten hours after sunrise. The modern traffic problem arose in the latter part of the past century and is a by-product of the phenomenal growth of metropolitan districts. Increase in population alone is not the important cause, but the motor vehicle and the sky scrappers are playing an important part in street congestion. The situation is graphically expressed by an eminent engineer, "We have built forty story cities on a street plan designed for a three story town."

The cities have not kept pace with the increase in automobile industry in regard to the control of traffic in their city planning. It has been only in the past few years that extensive traffic surveys have been made in our cities to determine the best means of controlling traffic and what improvements are needed on the street to better facilitate the flow of traffic.

It is the purpose of this survey to help solve, in part at least, the problems of traffic control in the city of Sioux Falls, South Dakota, and also suggest city improvements wherein they apply to the betterment of traffic flow within the city.

Population and Motor Vehicle Registration

To obtain safer and more expedious movement of traffic and to secure greater freedom of access to the curb at important points for receiving and discharging passengers and merchandise is the major objective of the survey in solving the traffic problem in the city.

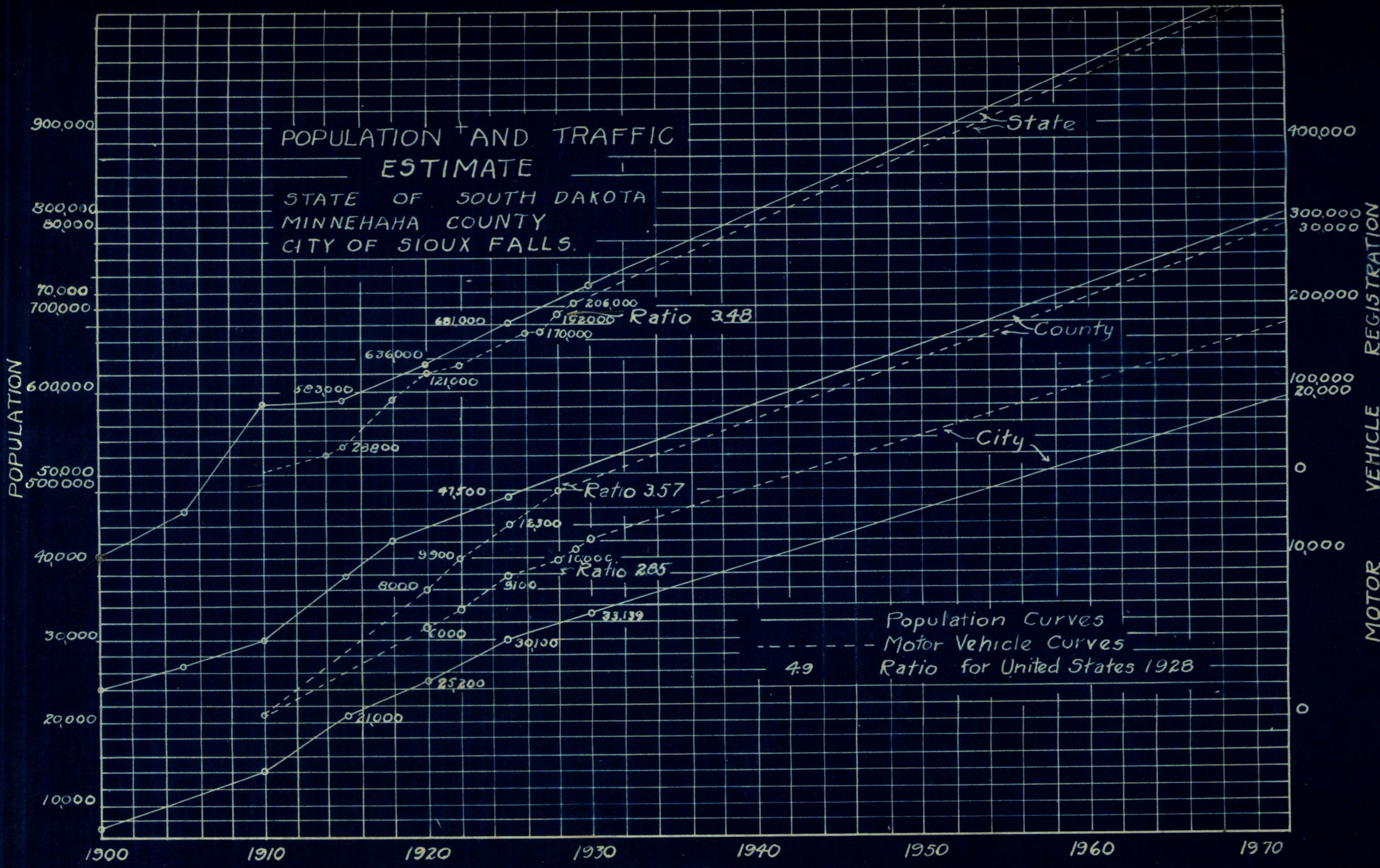
The traffic system must serve not only the present needs of the community but should be so planned in advance that growth in traffic may be controlled in the most efficient manner.

It is believed that when the saturation point of automobile ownership is reached the growth in total traffic volume will increase in the same proportion as population increases. While it is hazardous to forecast the saturation point, the most widely accepted estimate of the saturation point is 3 to 1, that is, 3 persons per motor vehicle.

According to the booklet, "Facts and Figures in Automobile Industry," published by the National Automobile Chamber of Commerce, the growth of the automobile industry dates back to the year 1895 when four motor vehicles were produced as against 4,601,134 in 1928, and the registration for the two dates are 4 in 1895 and 24,493,124 in 1928. The ratio of motor vehicles to population in the United States for 1928 was 4.9. The saturation point for South Dakota, Minnehaha County, and the City of Sioux Falls has been assumed as reached in 1928 and an estimate of future registration of motor vehicles may be seen in Figure 1.

The future population of the State, County, and City was estimated on the basis of present growth. The future motor vehicle registration estimate was determined by finding the ratio of motor vehicles to person in 1928 and accepting the general opinion that traffic growth will be proportional to population growth, the future traffic curves were constructed. As seen in Figure 1 the ratio for the State is 3.48, County 3.57, and City 2.85, all having a lower ratio than for the whole United States.

It has been estimated that the city will have a population of approximately 60,000 in 1970 and a vehicle registration of approximately 22,000. Will the present system of traffic control handle the problems satisfactorily? How will the city meet the demands placed upon its streets now and also in the future?



POPULATION AND TRAFFIC ESTIMATE
STATE OF SOUTH DAKOTA
MINNEHAHA COUNTY
CITY OF SIOUX FALLS
State
County
City
Ratio 3.48
Ratio 3.57
Ratio 2.85
206,000
192,000
170,000
681,000
636,000
121,000
583,000
28,800
47,500
12,300
9900
10,000
8000
9100
8000
33,139
30,100
25,200
21,000
Population Curves
Motor Vehicle Curves
4.9 Ratio for United States 1928
POPULATION
900,000
800,000
80,000
70,000
700,000
600,000
50,000
500,000
40,000
30,000
20,000
10,000
MOTOR VEHICLE REGISTRATION
400,000
300,000
30,000
200,000
100,000
20,000
0
10,000
0
YEARS
1900
1910
1920
1930
1940
1950
1960
1970

FIG. 1.

A careful study should be made of a city in regard to population, growth, and distribution--traffic flow, its volume, character, origin and destination--standing vehicles--street hazards, location and causes--existing street plan and future changes required to meet increasing volume of traffic--methods of regulating and effect on traffic flow. before improvements are made This was done in so far as possible.

The matter of population and vehicle growth has been discussed and graphically shown in Figure 1. As to the distribution of population, no definite information was obtained, but the estimate as to the future growth of the city as to territory and population distribution is based on three major points: tendency at present, topographic features, and industrial plant locations. The present trend of growth is in a southward direction although considerable progress is being made toward the east. The business district is limited in its direction of territorial expansion to the south and southwest. The Sioux River and trackage on the east make expansion impossible in that direction; trackage and steep grades to the north and northwest make business locations undesirable. The trend of the business district to the southwest has been foreseen and provided for in the zoning plan of the city as adopted July 20, 1928. See Figure 5. Assuming that the conclusions drawn from what information was obtainable are correct, future planning as to street improvements must take this into consideration.

Traffic Distribution

In determining the traffic flow ~~in the~~ city, traffic census ~~was~~ taken at various observation points throughout the city. The results of the traffic counts ~~taken April 10, 1930 from 8 A. M. to 12 P. M.~~ gives an estimate of the kind and volume of traffic flowing to and from the city on an average business day. This may be below the average, ~~due to the fact~~, ~~that~~ when the census ~~was~~ taken ~~the highways were~~ in poor condition, and heavy truck traffic was restricted in some places. A study of Figure 2 will show that the heaviest traffic into the city is from the south and west over U. S. Highways No. 16 and 77. The truck traffic into the city is fairly well distributed over the six main routes into the city.

The stockyards and packing plant in Sioux Falls is the destination for considerable of the heavier trucking as shown by the following figures which were obtained at the stockyards. The average number of truck per day into the yards for the week April 2nd. to April 9th., 1930 was as follows:

U. S. Highway 77 from south	40
U. S. Highway 77 from north	31
State 38 northwest	25
State 38 east	24
U. S. Highway 16 from west	39
U. S. Highway 16 from east	33

The origin of the trucks were known and the route into Sioux Falls figured accordingly. Besides the trucking to the yards, considerable trucking is done direct to the Packing Plant.

TRAFFIC CENSUS

LOCATION		1924 15 hrs.	1925 24 hrs.	1926 24 hrs.	1927 24 hrs.	1929 15 hrs.
U.S. 16	4 mi. E of S.F.					800
	4 mi W of S.F.	1195	1421	1480	1512	2431
U.S. 77	3 mi. N of S.F.	1157	1923	1397	1323	1245
	4 mi. S of S.F.					1342
State 38	3½ mi. E of S.F.	924			1326	1307
	5 mi. N.W. of S.F.	924	1156	1311	2122	1588
Jct. 38 & 16	On 38 in S.F.				1184	608
	On 16 in S.F.				2240	1038

Traffic Counts on Highways Leading into Sioux Falls
State Highway Commission

TYPE AND DISTRIBUTION OF TRAFFIC

KIND OF TRAFFIC			U.S. 16 12th & Western	U.S. 16 Cliff & Rice	State 38 6th & No West	State 38 10th Van Epps	U.S. 77 At State Pen.	U.S. 77 Minn & 26th
HORSE DRAWN		IN	4	4	2	0	0	2
		OUT	2	7	0	2	0	2
HEAVY TRUCKS	INTER STATE	IN	2	22	0	5	1	0
		OUT	0	16	1	3	0	1
	INTER COUNTY	IN	33	16	8	2	20	33
		OUT	15	5	4	3	6	15
	CITY & COUNTY	IN	27	51	27	17	36	13
		OUT	20	33	16	14	4	20
LIGHT TRUCKS	INTER STATE	IN	0	3	0	2	3	0
		OUT	1	0	0	2	1	0
	INTER COUNTY	IN	8	1	2	1	6	9
		OUT	9	3	0	1	1	4
	CITY & COUNTY	IN	21	9	33	36	45	31
		OUT	29	17	30	15	23	43
PASS CARS	INTER STATE	IN	21	30	5	45	45	21
		OUT	15	23	12	19	16	33
	INTER COUNTY	IN	70	17	19	19	60	101
		OUT	38	9	17	13	16	51
	CITY & COUNTY	IN	107	90	82	93	122	192
		OUT	120	51	97	79	92	174
BUSSES	INTER CITY	IN	3	1	4	0	3	2
		OUT	1	1	3	0	1	3
	CITY	IN	0	4	0	17	17	18
		OUT	9	5	0	0	17	18

Traffic census taken for a period of 4 hours on highways indicated on table - April 10, 1930 - 8:00 A.M. to 12:00 P.M.

FIG. 2

The Wilson Transportation Company at the present time is running 49 two and three ton trucks regularly from the city over the six main highways. Other regular traffic on the highway that must use the streets to reach its destination comes from the Union Truck Depot which is operating thirty lines from the city.

Sioux Falls being the largest city in South Dakota and situated where 43% of the population of South Dakota is tributary to it, adds to the traffic demands of its street .

The traffic flow at the present time in the business district is best represented by Figure 3. Observers were stationed on the intersections shown in the diagram for hour periods throughout the day, April 10, 1930 from 8 A. M. to 4:30 P. M. -- the diagram showing the average hourly flow of traffic in what might be called the congested district. Other points of heavy traffic in the city are shown in Figure 4 and the following figures taken on April 10, 1930:

Location	Time	Vehicles Passing Through Intersection
Minnesota and 12th.	10:15 A. M. - 12:15 P. M.	878
Minnesota and 10th.	10:15 A. M. - 12:15 P. M.	943
Minnesota and 8th.	10:15 A. M. - 12:15 P. M.	761
Main and 8th.	4:30 P. M. - 6:00 P. M.	672

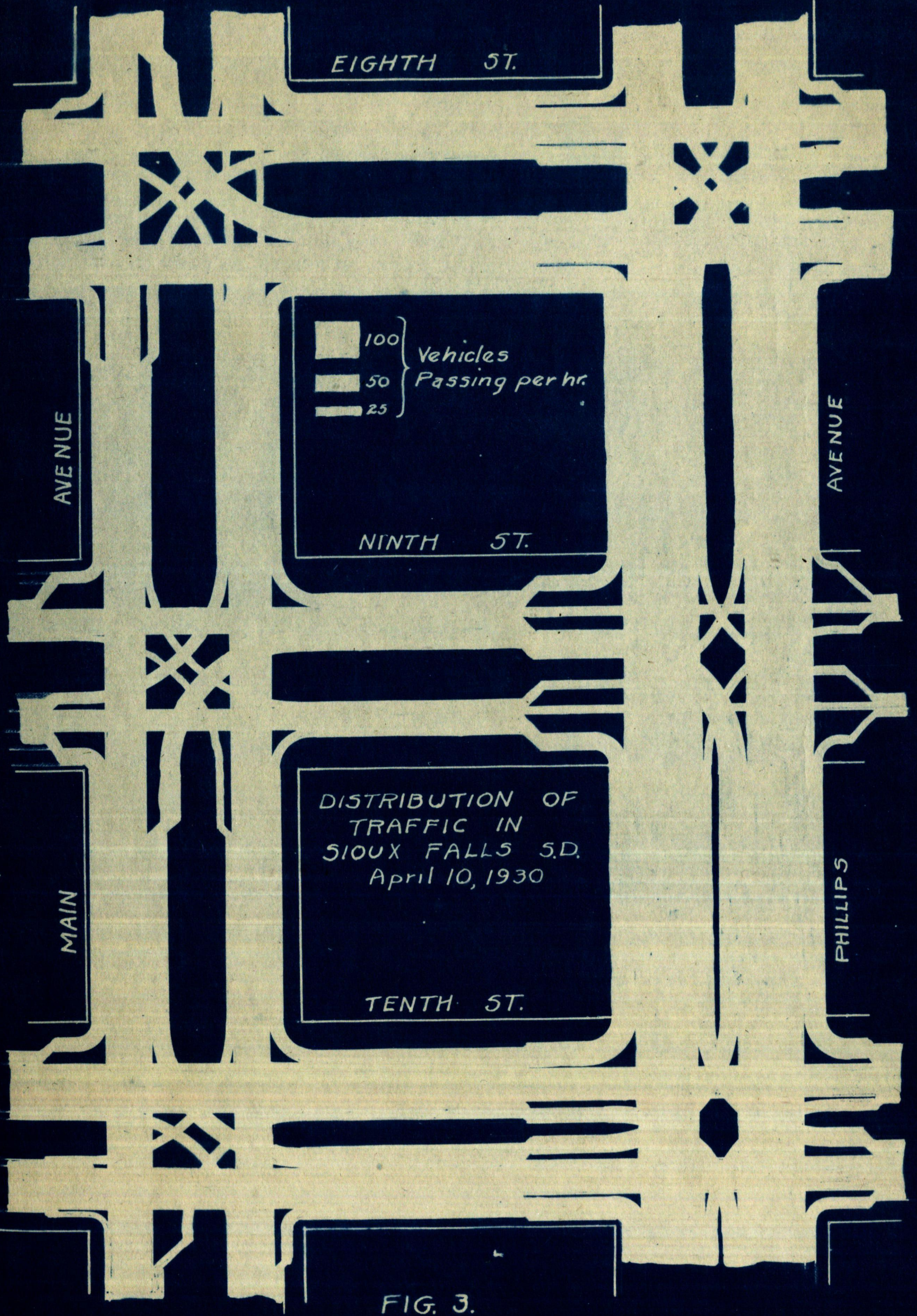

EIGHTH ST.
100
50
25
Vehicles
Passing per hr.
AVENUE
AVENUE
NINTH ST.
DISTRIBUTION OF
TRAFFIC IN
SIOUX FALLS S.D.
April 10, 1930
MAIN
PHILLIPS
TENTH ST.

FIG. 3.

TRAFFIC CENSUS

KIND OF TRAFFIC		Direction of Travel	6th St. Bridge	8th St Bridge	10th St Bridge
HORSE DRAWN		EAST	0	0	3
		WEST	0	2	4
HEAVY TRUCKS	INTER STATE	EAST	1	4	0
		WEST	2	2	2
	INTER COUNTY	EAST	6	3	2
		WEST	4	2	1
	COUNTY & CITY	EAST	33	43	62
		WEST	41	46	49
LIGHT TRUCKS	INTER STATE	EAST	0	0	0
		WEST	0	0	0
	INTER COUNTY	EAST	1	2	0
		WEST	2	2.	0
	COUNTY & CITY	EAST	47	60	46
		WEST	51	49	53
PASSENGER	INTER STATE	EAST	13	25	23
		WEST	12	21	24
	INTER COUNTY	EAST	12	9	11
		WEST	14	15	8
	COUNTY & CITY	EAST	93	183	201
		WEST	91	166	209
BUSSES		EAST	0	17	0
		WEST	1	18	0

Traffic census taken for a 2 hr. period on April 10, 1930 - 8:00 A.M. to 10:00 AM.

Light Trucks - 1 Ton and less.
Heavy Trucks Over 1 Ton.

FIG. 4.

Traffic Congestion

The term congestion as generally applied to street traffic is used to designate almost every type of undesirable condition. Congestion should not be confused with density, or that condition which exists when there is a large number of vehicles or pedestrians in a limited street area. Congestion does not result from mere numbers of cars unless they block the freedom of movement. Density of the traffic stream is usually a concomitant of congestion, sometimes the cause and sometimes the effect. Congestion in street traffic may be defined as a condition resulting from retardation of movement below that normally necessary for contemporary street users. Congestion is due to three general causes:

1. The inability of streets to hold a sufficient number of vehicles and to pass them at an adequate speed.

2. The inclusion in the traffic stream of elements which hamper its freedom of flow.

3. The improper or inadequate direction and control of traffic.

Street Capacity

As regulated at the present time, the traffic demands upon the street capacities in Sioux Falls are rapidly approaching the saturation point. Better ways of handling the traffic situation must be devised to prevent the problem from becoming serious. The width of the streets has too frequently been determined by some standardized plan and not by the character of traffic which it is to carry. Street capacity is determined by volume or effective lanes and speed in the same manner as capacity of water mains. The volume of traffic which a street can satisfactorily handle is not determined by the gross width of roadway but by the number of vehicle lanes that it provides. The speed of flow, the second factor in figuring street capacity, will vary according to the average speed which can be maintained, as determined by the character of the traffic, the surface of the roadway, and the amount of cross traffic interference.

An interesting study as to traffic speed in its relation to street capacity is that made by Herbert S. Swan#, in which he determines the discharge capacity of a single lane of traffic by calculation of the necessary headway between cars on the basis of the number of feet covered in stopping at various speeds. In commenting on his conclusions Mr. Swan says: "An increase in speed by no means increases the capacity of a roadway. Paradoxical as it may seem, the direct opposite is true, for though a fast car may travel between two points more rapidly than a slow one, it does so when the roadway is used to capacity only by driving other cars off the highway.

The speed that will pass the maximum number of cars with equal safety is not one of 50 miles an hour, nor one of 40 miles an hour, nor even one of 30 or 20 miles an hour; it is the prosaic gait of 10 miles

"Automobile Control, City Planning, and Traffic Regulation," Engineering News Record. February, 1923.

an hour. A uniform speed of 10 miles an hour will pass a third more vehicles than one of 25 miles, and half again as many as one of 30 miles. A speed of 60 miles will pass scarcely more than a third as many vehicles as one of 10 miles. Even a speed of 5 miles an hour will pass more vehicles than one of 30 and twice as many as one of 60........... The common impression is that the faster the speed the greater is the number of vehicles which can pass a point in a given length of time. This is true of quite low speeds. Each increase in speed up to a certain point does increase the capacity of a roadway, but after a certain speed has been attained, each unit of increased speed requires such an increased spacing of machines that the roadway capacity is dimished. If accidents are to be avoided, machines should certainly not follow each other any closer than the distance it takes to stop."

In computing street capacity the rate of speed which is deemed reasonably necessary and not that which results in the greatest discharge capacity must be used. The use of four-wheel brakes and faster acceleration on motor cars seems to increase the discharge capacity per lane at high speeds by decreasing the time and distance required for stopping and thus reducing the headway which must be used. A test by the Thermoid Rubber Company indicates that at 25 miles per hour the four-wheel brake reduces the stopping distance from 58 feet to 38 feet 6 inches.

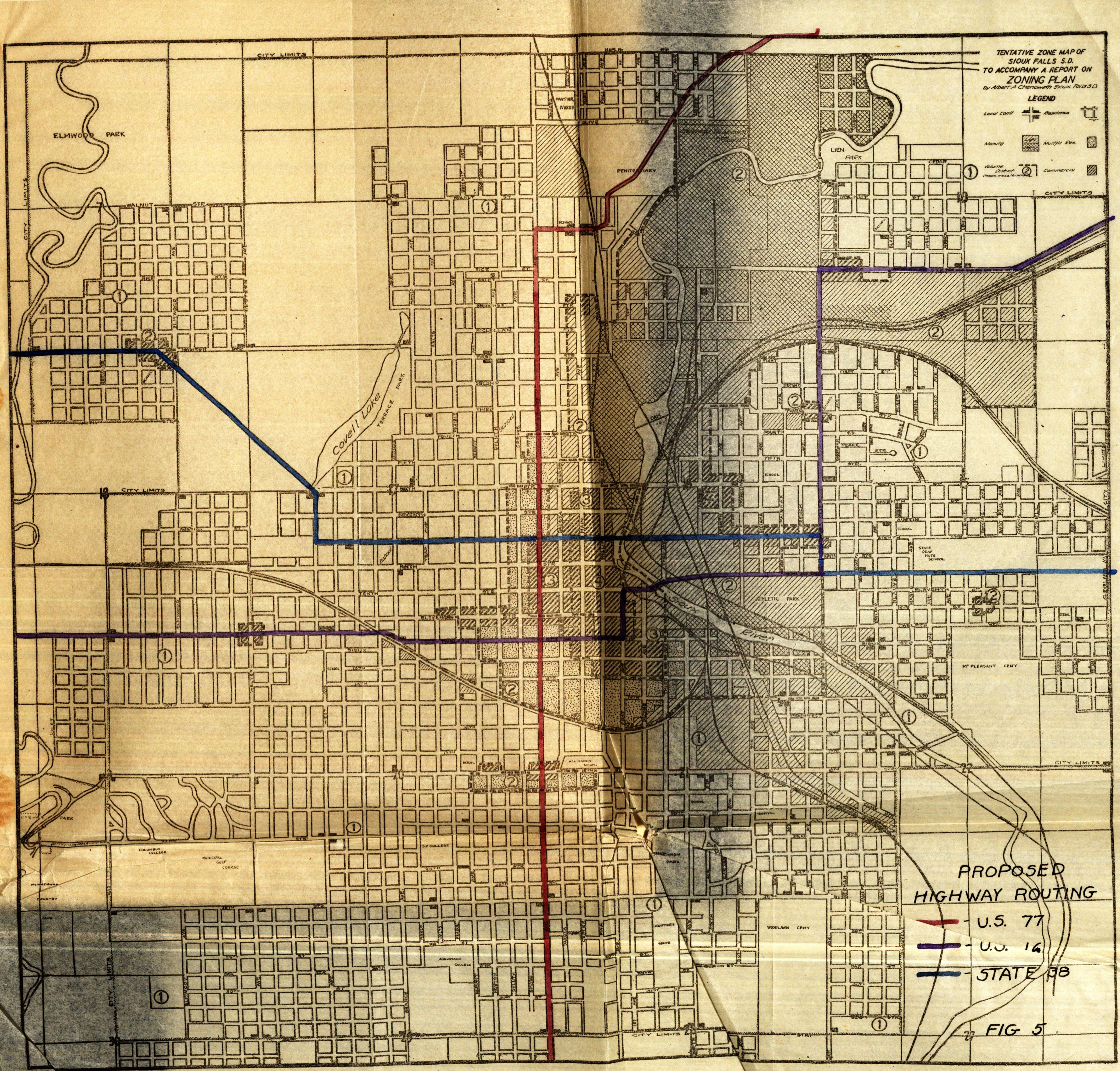
Observation of traffic speed on streets may be made in several ways. Perhaps the simplest method is to have a motor car drive over a measured distance on a congested street and to record the time elapsing; this would make possible a computation of the average rate of speed maintained on the street. The speed of flow on the Sioux Falls Streets was not determined in this survey.

Traffic Routing

Congestion, which is caused by the inclusion in the traffic stream elements which hamper its freedom of flow, may include interference by cross traffic - interference by left turns - and by the slow moving vehicle in the stream itself. Traffic moves no faster than its slowest vehicle. By routing through traffic around the congested district is one way of removing a large volume of traffic which does not necessarily belong there.

This re-routing is not only a removal of vehicles from the congested district but also a convenience to the through traffic in that it saves the vehicles considerable time by being routed on to streets where traffic flow is more rapid because of less interference from cross traffic. The re-routing of the highways through the city would aid in the relief of the congestion in the business district. Figure 5 shows a proposed routing of the three major highways through the city --U. S. 77 and 16, and State 38.

Figure 5.


TENTATIVE ZONE MAP OF
SIOUX FALLS S.D.
TO ACCOMPANY A REPORT ON
ZONING PLAN
by Albert A Chenoweth Sioux Falls S.D.
LEGEND
Local Com'l
Residence
Manufg
Multiple Res.
Volume District
Commercial
CITY LIMITS
ELMWOOD PARK
WALNUT STR.
PENITENTIARY
Covell Lake
TERRACE PARK
ATHLETIC PARK
MT PLEASANT CEMY
WOODLAWN CEMY
PROPOSED
HIGHWAY ROUTING
U.S. 77
U.S. 16
STATE 38
FIG 5

Direction and Control of Traffic

The third major factor causing congestion; namely, the inadequate direction and control of traffic is an important one and may be corrected at a small cost as compared to widening and constructing new streets.

The demand which traffic makes upon the street system is not constant. The volume fluctuates from minute to minute, hour to hour, day to day, and season to season. The minor fluctuation may be observed on any street, the tendency of vehicles is to move in waves instead of distributing themselves at equal intervals over the length of the street. This grouping of vehicles increases the density of traffic at different points and tends to cause retardation in the movement of the entire group when the leading vehicle slackens its speed. The grouping lessens the headway between vehicles which condition is a frequent cause of accidents. This natural tendency to move in groups is emphasized by the generally prevailing block control method used in our cities.

Every city experiences the hourly fluctuation of its traffic: the peak loads caused by the morning in-rush to the city and the evening out-rush of traffic. Likewise cities have heavy traffic days; in some cities it is Saturday as is the case of Sioux Falls.

Finally there is a seasonal fluctuation in traffic demands. In the winter time street conditions due to snow and ice tends to keep cars off the streets, while in the summer the tourist traffic is added to the street system in addition to the local traffic. Since it is located on three national highways--The Atlantic Yellowstone Pacific Highway, The Custer Battlefield Highway, and the King of Trails, Sioux Falls receives considerable tourist traffic. In the 1928 season approximately 3,300 tourist cars registered at the Sherman Park camp. To estimate the number of tourist cars that passed through the city without stopping at Sherman Park would be hazardous.

Pedestrians and Vehicle Traffic

Pedestrians at present retard the movement of the traffic both by jay walking and by moving against signals at the intersections. The encroachment of pedestrians into street at intersections hinders vehicles from making proper right turns and causes vehicles to slow down and otherwise retard traffic. To expect a driver of a motor car to maintain a rate of speed necessary to avoid undue congestion and at the same time weave through masses of pedestrians is an impossible demand. The amount of jay walking in Sioux Falls is shown by a count on May 3, 1930 for a half hour period, between 10th. and 11th. Street on Phillips Avenue, fifty-seven people crossed the street at points other than the designated crosswalks, while 28 crossed between 8th. and 9th. streets for a like period, and 97 between 9th. and 10th. streets for a one hour period.

This is the cause of a large number of accidents. Accidents defeat the purpose of traffic and their prevention is imperative. The following figure gives the number of accidents reported in Sioux Falls for 1926, 1927, and 1928:

	1927			1928		
Month	Automobile	Personal Injuries	Fatalities	Automobile	Personal Injuries	Fatalities
January	73	8		106	6	1
February	57	7		115	4	1
March	52	7		82	7	1
April	66	6		101	9	
May	65	4		118	12	
June	97	8		132	7	
July	86	15	1	145	14	
August	104	15		130	7	1
September	107	6		136	6	1
October	124	9		146	18	
November	129	15		158	12	1
December	127	13		160	4	1
TOTALS	1087	113	1	1529	106	7
Totals for 1926	566	76	3			

Under the heading automobiles is the number of accidents occuring in which one or more automobiles was involved. The personal injury column is the personal injuries which resulted from the automobile accidents, while in the column fatalities is the number of deaths resulting from the automobile accidents.

Parking of Vehicles

The parking of vehicles is one of the most serious causes of congestion. If drivers of motor vehicles did not need to stop when they reached their destination but could proceed immediately, traffic movement would be simplified, and a large amount of space would be released for the use of moving vehicles. Drivers must stop and provisions must be made for such stops. The normal traffic over the streets is not an end in itself but a means to an end. The end is not accomplished by travel alone but the opportunity to stop long enough to transact that part of the driver's business which is immediately connected with the act of transportation.

Angle versus Parallel Parking

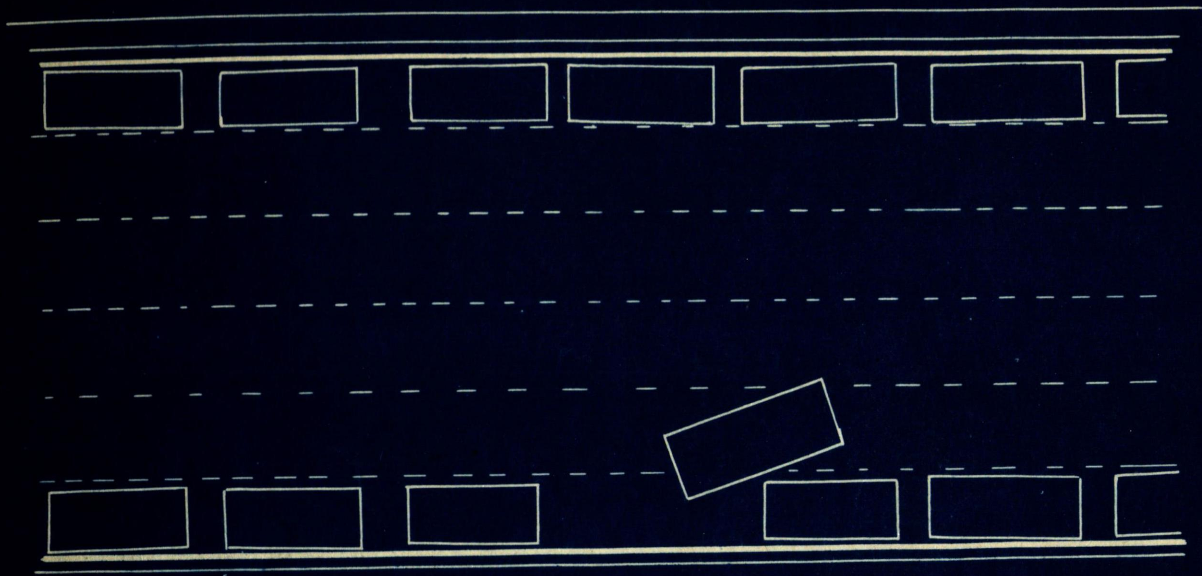
The methods or practices of parking vehicles in cities vary, but in the final analysis the two most common methods used are the angle parking at curb and the parallel parking at curb. The method of parking parallel to curb removes one lane of moving traffic from the street while angle parking removes one lane and part of another. The average extension of a vehicle parked 45 degrees with curb is 15 feet into the street, but while parking, the greatest extension is much greater, which results in at least 26 feet of the streets width being blocked while vehicles are approaching or leaving the curb.

A passenger vehicle parked parallel with the curb and the right front wheel as much as one foot from the curb, extends a maximum of seven feet into the street. The greatest extension into the street while approaching to and leaving the curb is approximately 16 feet. Figure 6 shows the effect of angle and parallel parking on a 50 foot street. It has been said that parallel parking at its worst is better than angle parking at its best. Angle parking accommodates more cars per foot of curb space but at the expense of moving traffic, and moving traffic is our cities major problem.

Double Parking

The practice of parking vehicles in the second lane from curb, known as double parking is a sign of the super-saturation of the streets. Double parking in many cases is, the results of drivers being unwilling to find a place to stop which would cause less inconvenience to the public.

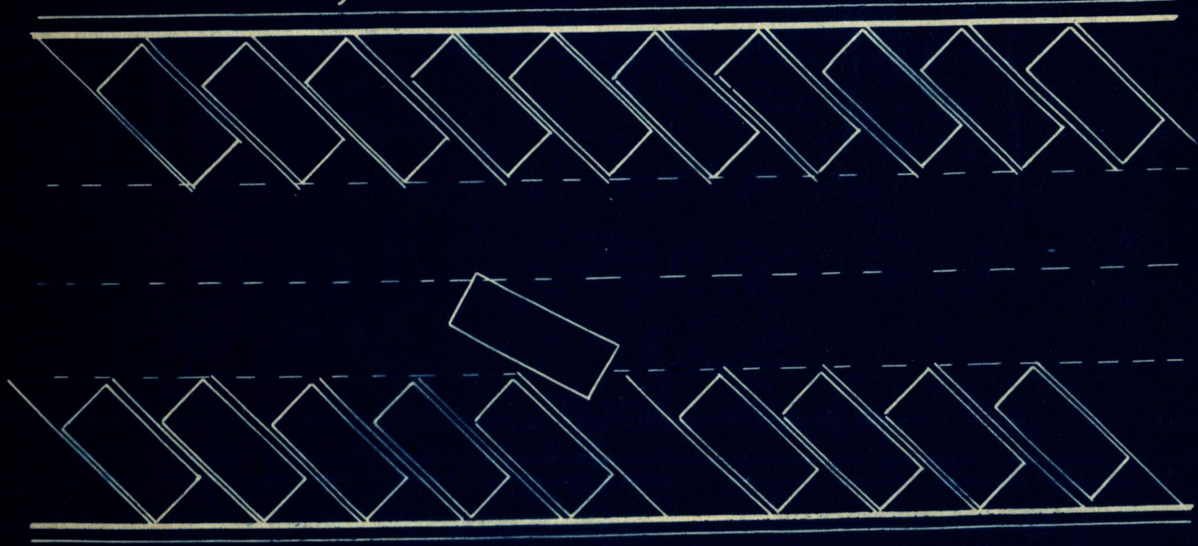
In many cases, however double parking is an actual necessity. A truck driver, for example, has heavy packages to be delivered at a business store. The curb is filled with parked cars for blocks. He has several alternatives. He can return the goods to the sender, which defeats a desirable and necessary economic service; he may drive around the block until such time an opening is made at the desired place, which adds unnecessarily to the density of the traffic stream; or he may double park and deliver his goods.



PARALLEL PARKING

50-Foot Roadway Four Lanes of Moving Traffic

Maneuvering Vehicle Takes 1/4 of Roadway



ANGLE PARKING

50-Foot Roadway Two Lanes of Moving Traffic

Maneuvering Vehicles Takes 1/2 of Roadway

12 Cars Parked Parallel 20 Cars Parked Angle

COMPARISON OF
ANGLE AND PARALLEL PARKING

FIG. 6.

Occupancy of Parking Spaces

The parking problem in Sioux Falls may be attributed to several causes; one, the lack of enforcement of the present parking restrictions, and the abuse of the courtesy given visitors of the city, which does not require visitors to obey parking restrictions as to time limits. A survey made in a portion of the restricted area in Sioux Falls shows that approximately 30% of the vehicles parked in the 30 minute parking zone parked for approximately 55% of the total car parking hours. The excess parking hours amounted to nearly 33% of the total parking time. The excess parking is the amount of time in excess of the parking time limit for each over-parked car. In the one hour parking zone observed, 30% of the vehicles parked for approximately 50% of the total car hours. The excess parking amounted to 38% of the total parking time.

Had the excess parking been prevented in the 30 minute zone, 90.2% more vehicles might have parked in the same parking space during the same time, based on the average time which was .322 hours or approximately 20 minutes, of those vehicles that parked less than 30 minutes. The increase in the one hour zone observed was 80.8% and the average time for those that parked less than one hour was .493 or approximately 30 minutes as computed from data in Figure 7. Figure 8 shows that increased parking could be obtained by strict enforcement

OCCUPANCY OF PARKING SPACES IN BUSINESS DISTRICT.

	Location	Present Time Restrictions	Parked 30 min. or less			Parked over 30 min.			Total Parking		Car Hours Capacity	Occupancy Ratio	Possible Increase in Vehicles Accommodated	
			Vehicles	Hours	Average Time A	Vehicles V	Hours H	Hours Excess $H-\frac{1}{2}V=E$	Vehicles V_t	Hours H_t	C	$H_t \div C$	Vehicles $E \div A = V_i$	Per cent $V_i \div V_t \cdot 100$
1	Phillips Ave 7th to 12th	30 min.	628	190	.303	266	320¾	187¾	894	510¾	640	.78	617	68.9
2	Phillips Ave 7th to 12	30 min.	303	95	.313	137	156	87½	440	251	320	.78	279	63.6
3	Main Ave 7th to 12	30 min	451	152¼	.337	218	376½	267½	669	528¾	728	.72	793	118.5
4	Main Ave 7th to 12th	30 min	214	81¾	.382	121	146¼	85¾	335	228	364	.62	224	70.0
	Totals 1+3		1079	342¼	.320	484	697¼	455¼	1563	1039½	1368	.76	1410	90.2
	Totals 2+4		517	176¾	.345	258	302¼	173¼	775	479	684	.70	503	64.9
5	Phillips + Main 6th to 7th	None	72	43¼	.600	131	203	137½	203	246¼	270	.91	229	112.8
			Parked 1 hr. or less			Parked over 1 hour		$H-V=E$						
6	9th Street Dak to River	1hr.	129	68¾	.533	82	172¼	90¼	211	241	304	.79	175	82.9
7	10th Street Dak. to 1st.	1hr.	176	82	.466	69	161	92	245	243	372	.65	197	80.4
8	8th Street Dak. to Bridge	1hr.	162	79½	.490	48	121½	73½	210	201	292	.69	150	71.3
	Totals -		467	230¼	.493	199	454¾	265¾	666	685	968	.71	538	80.8
9	Dak. Ave. 7th to 12th.	2hr.	82	76	.926	91	138	47	173	214	280	.76	52	29.8

2 and 4 - 9:30 AM to 11:30 A.M.
1 and 3 - 12:30 P.M. to 4:30 P.M.

5, 6, 7 and 8 - 12:30 P.M. to 4:30 P.M.
9 - 12:30 P.M. to 2:30 P.M.

FIG. 7.

OCCUPANCY OF PARKING SPACES IN BUSINESS DISTRICT.

	Location	Present Time Restrictions	Parked 1 hr. or less			Parked over 1 hour			Total Parking		Car Hours Capacity	Occupancy Ratio	Possible Increase in Vehicles Accommodated	
			Vehicles	Hours	Average Time	Vehicles	Hours	Hours Excess	Vehicles	Hours			Vehicles	Percent
					A	V	H	H - V = E	V_t	H_t	C	$H_t \div C$	$E \div A = V_i$	$V_i \div V_t \cdot 100$
1	Phillips Ave 7th to 12th	30 min.	701	309 3/4	.443	193	201	8	894	510 3/4	640	.78	18	2.0
2	Phillips Ave 7th to 12	30 min.	384	163	.436	56	89	33	440	251	320	.78	76	17.3
3	Main Ave 7th to 12	30 min.	502	191 1/4	.381	167	337 1/2	170 1/2	669	528 3/4	728	.72	448	66.9
4	Main Ave 7th to 12th	30 min.	239	102 1/2	.427	96	125 1/2	30 1/2	335	228	364	.62	70	20.9
	Totals 1-3		1203	501	.411	360	538 1/2	178 1/2	1563	1039 1/2	1368	.76	466	34.0
	Totals 2-4		623	265 1/2	.431	152	214 1/2	63 1/2	775	479	684	.70	146	19.1
5	Phillips + Main 6th to 7th	None	109	72 1/4	.663	94	184	90	203	246 1/4	270	.91	136	66.9
			Parked 1½ hrs or less			Parked over 1½ hours		H - 1½V = E						
6	9th Street Oak to River	1 hr	163	109	.668	48	132	60	211	241	304	.79	90	42.6
7	10th Street Oak to 1st	1 hr	221	141	.637	24	102	66	245	243	372	.65	103	42.1
8	8th Street Oak to Bridge	1 hr	196	121 1/2	.562	14	89 1/2	68 1/2	210	201	292	.69	122	58.1
	Totals		580	371 1/2	.641	86	324 1/2	195 1/2	666	685	968	.71	340	46.1
9	Oak Ave 7th to 12th	2 hr	103	102	.99	70	112	7	173	214	280	.76	7	4.0

2 and 4 - 9:30 AM. to 11:30 A.M.
1 and 3 12:30 P.M. to 4:30 P.M.

5, 6, 7 and 8 from 12:30 P.M. to 4:30 P.M.
9 - from 12:30 P.M. to 2:30 P.M.

FIG. 8.

of a one hour limit in place of the present 30 minute limit. With a one hour limit enforced on Phillips Avenue and Main from 7th. to 12th. Streets, 34% more vehicles could be parked than now are accomodated with the 30 minute partial restriction. Similiarly, the use of a one and one-half hour limit where the present one hour limits are on 8th., 9th., and 10th. streets would allow a 46.1% increase in vehicles accommodated.

Suggested Restricted Area and Capacity

In computing the data for the two Figures 7 and 8 no account was taken of the double parked cars. If a portion of the excess hours were used in absorbing all double and illegally parked vehicles the percentages would be reduced considerably. No definite data was obtained as to the amount of double parking in the restricted areas. Because of this and the fact that considerable of the over-time parking was due to out of city visitors a 30 minute limit on Phillips and Main Avenues seems desirable. Figure 9 shows a proposed new restricted area, while Figure 10 tabulates the parking capacity in the restricted area under a proposed new restriction. The 30 minute limit on Phillips, 12th. to 13th. streets and Main, 7th., 8th., and 12th. to 13th. streets were changed to one hour. While the one hour limit on 7th., 8th., 9th., 10th., 11th., and 12th. streets from Dakota Avenue to Minnesota Avenue were changed to 2 hours. A one hour parking limit was placed on Phillips Avenue from 6th. to 7th. Streets.

Streets are never parked to capacity during an entire business day. The ratio between the actual car hours of parking and the total possible capacity was found to be .73 on April 10, 1930 as may be observed in Figure 7 and Figure 8. The average parking time was computed also for data in Figure 7 and Figure 8, thus with the total car hours the estimated number of vehicles which may be accommodated can be computed by multiplying the total car-hours by the occupancy ratio and dividing the result which is the probable occupancy by the average parking time. The two hour parking limit on Dakota and on 7th. to 12th. streets, inclusive, and Minnesota Avenue was placed for the convenience of those people who find it necessary to park longer than the 30 minute limit on Phillips Avenue and Main Avenue or the one hour limit in the remainder of the restricted district. Without this two hour limit on these streets the parking space would be filled with long period parkers, which would make it difficult for a person who knew he must park longer than one hour to find space a convenient distance from the business place he wished to visit.

SUGGESTED PARKING LIMITS IN RESTRICTED AREA

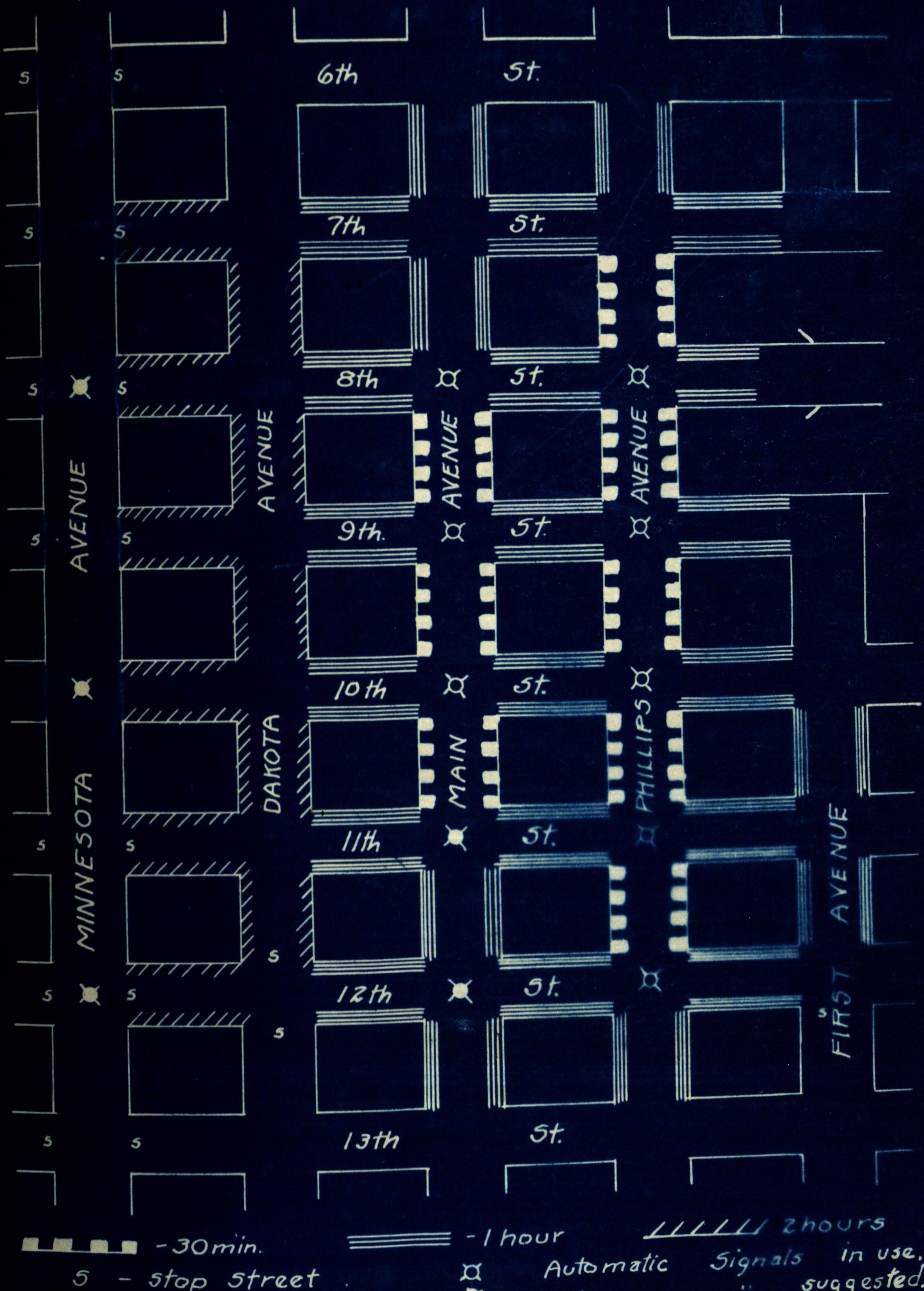


FIG. 9.

PARKING CAPACITY IN RESTRICTED AREA UNDER PROPOSED NEW RESTRICTIONS.

Location	Proposed Restrictions	Total Capacity Car-Hours			Average Parking Time Hours	Estimated Number of Vehicles Accommodated
		Total 9:00 A.M. to 6:00 P.M.	Occupancy Ratio	Probable Occupancy		
Phillips Avenue 7th to 12th	30 min.	1440	.73	1052	.332	3164
Main Avenue 8th to 11th	30 min.	945	.73	690	.332	2079
Dakota to First 7, 8, 9, 10, 11, and 12th Sts.	1 hour	4374	.73	3262	.493	6640
Phillips - 6th to 7th + 11th to 13th Main - 6th to 8th + 11th to 13th	1 hour	1413	.73	1059	.493	2082
Dakota - 6th to 12th. First - 10th to 12th	2 hours	2169	.73	1582	.795	7992
Dakota to Minnesota 7, 8, 9, 10, 11, and 12th. Sts.	2 hours	1674	.73	1222	.795	1539
Total Estimated Vehicle Capacity						23,498

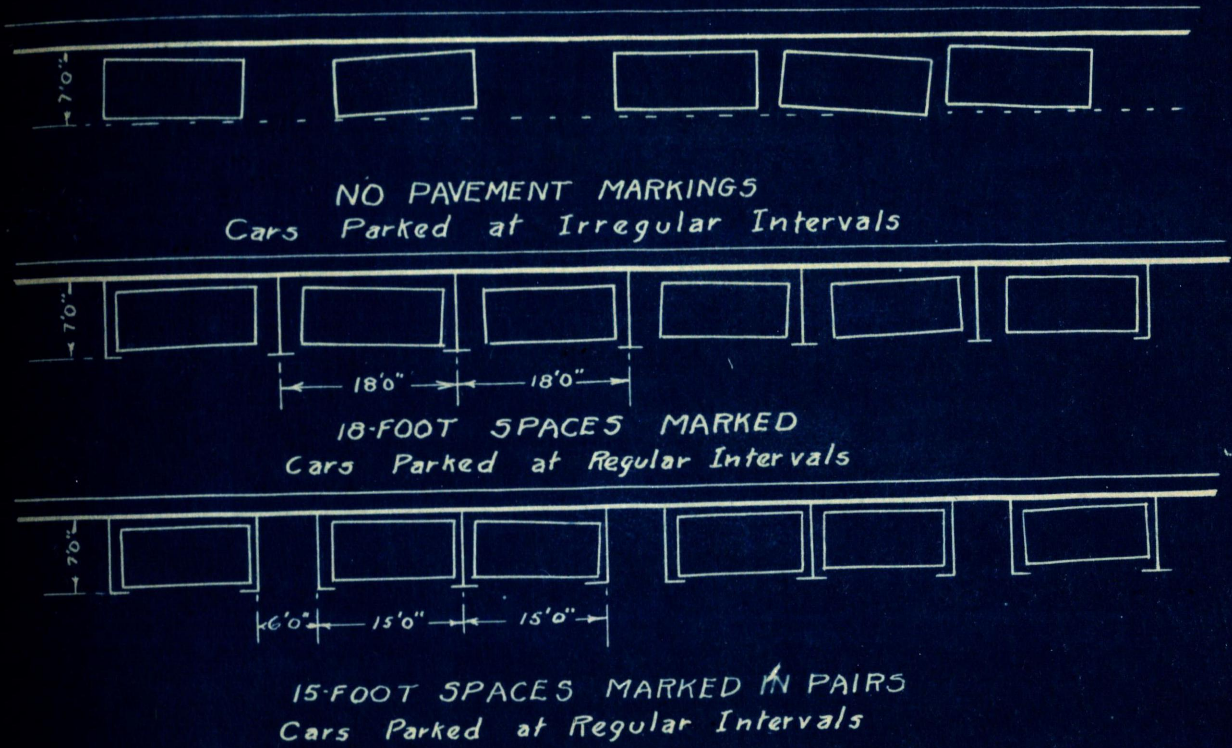
The ratio between the actual car-hours of parking and the total possible capacity was .73 for Phillips and Main Avenues as shown in Figs. 7 and 8 For the other streets it was slightly less, but .73 was assumed approximate for entire area. The average parking time for vehicles parked less than 30 min. was .332 hrs. - less than 1 hr. - .493 hrs and for less than 2 hrs .795

The probable occupancy in car-hours divided by average parking time gives the estimated vehicles that can be accommodated.

FIG. 10.

Marking of Parking Stalls

A city is obligated to make as much parking space at curb as possible for the public convenience, but this space should not be used for free storage space. Since parking is a convenience, the space made available for this convenience, should be arranged so as to accommodate the most vehicles in the most economical way, and to give proper protection to the vehicle parked legally. To provide space at the curb does not fulfill the city's obligation. The space may be available but due to improper spacing of cars the total capacity of a block or area may not be reached, although all cars are legally parked. Figure 11 shows clearly what is meant by this statement. With no pavement markings, cars park at irregular intervals, reduce the capacity, or the vehicles are bunched so closely together that while the capacity may be increased slightly, it is done at the expense of the public because enough space is not left between vehicles for the convenient parking or leaving of a parking space. Considerable damage is done to vehicles parked in this way; in addition a driver often loses much time in maneuvering to leave the curb. Pavement markings as shown in Figure 11 may help considerably in the proper spacing of vehicles. The 18 foot space marked at regular intervals, gives the vehicle ample space to maneuver while approaching or leaving the curb. The 15 foot spaces marked in pairs with 6 foot space between pairs gives the same space as the above mentioned method



PAVEMENT MARKINGS

The marking of individual parallel parking stalls on the pavement insures more efficient use of parking area.

The convienence in approaching to and leaving curb is another great factor in favor of marking stalls on pavement.

Parkers know when they are properly parked when in a stall, it also avoids damage to vehicles which occur when a driver must hit cars in front and to rear of him in order that he may leave parking space.

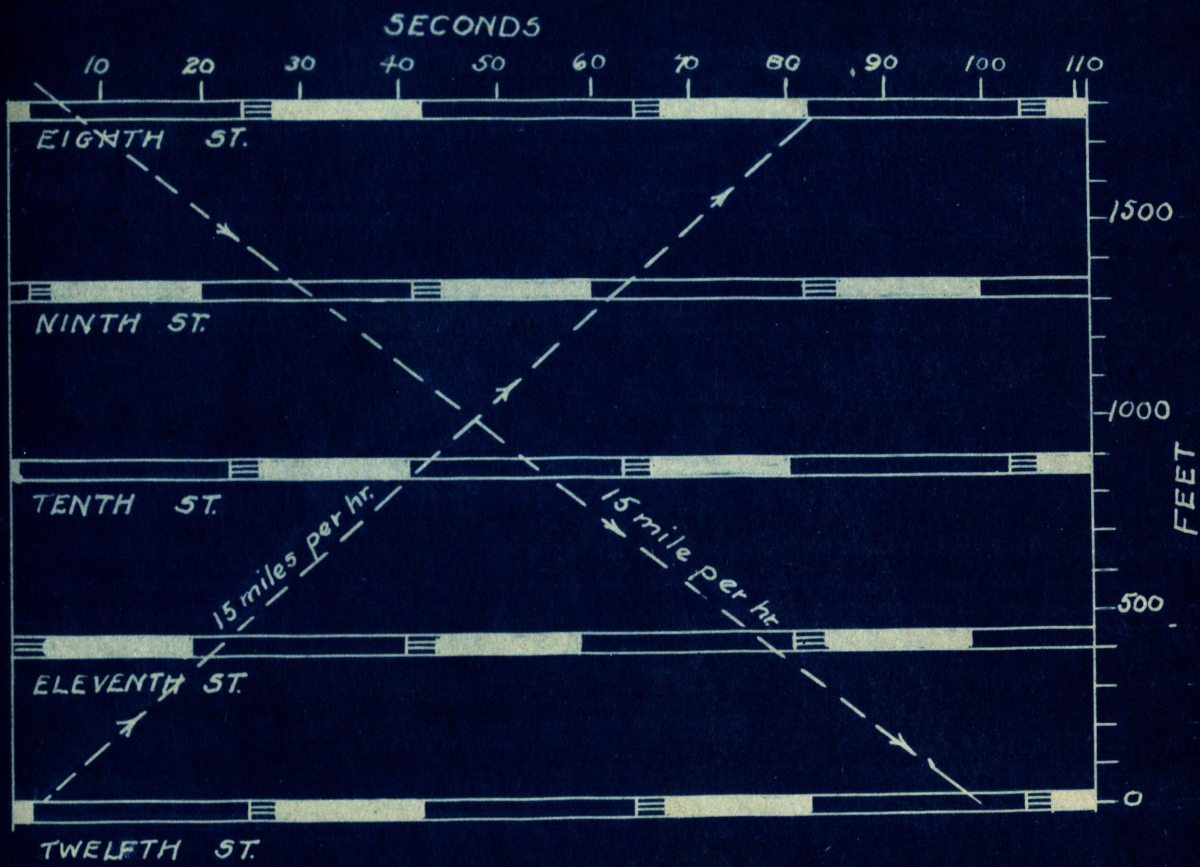
FIG. 11.

of marking pavements. While the cost of painting the street parking spaces is an added expense to the handling of traffic, the reward in moving traffic in and out from curb, more than pays for this small expense and the public is benefitted in time saved while parking and the probability of damage to parked cars is greatly reduced.

Automatic Signals

Careful regulation of the automatic signals in the business area is an easy means by which the traffic flow may be increased. At the present time the block signals on Phillips Avenue and Main Avenue change at the same time. The period of Green or "Go" is the same length as the period of Red or "Stop" for all signals in all directions. A study of Figure 3 again will show that more traffic is moving up and down Phillips Avenue than crosses it at any intersection, therefore, the traffic flow on Phillips Avenue should be given major consideration in the regulation of the automatic signals. The present 50 seconds cycle is divided 22 seconds Green "Go," 3 seconds Yellow "Change," 22 seconds Red "Stop," and 3 seconds Yellow "Change." Figure 12 was computed on a 40 second cycle with the division of time as follows: 22 seconds Green "Go," 3 seconds Yellow "Change," and 15 seconds Red "Stop." The yellow flash is not recommended before the "Go" because of the tendency of drivers to start their vehicle in motion before the intersection is clear of vehicles and pedestrians. Pedestrians are often stranded in

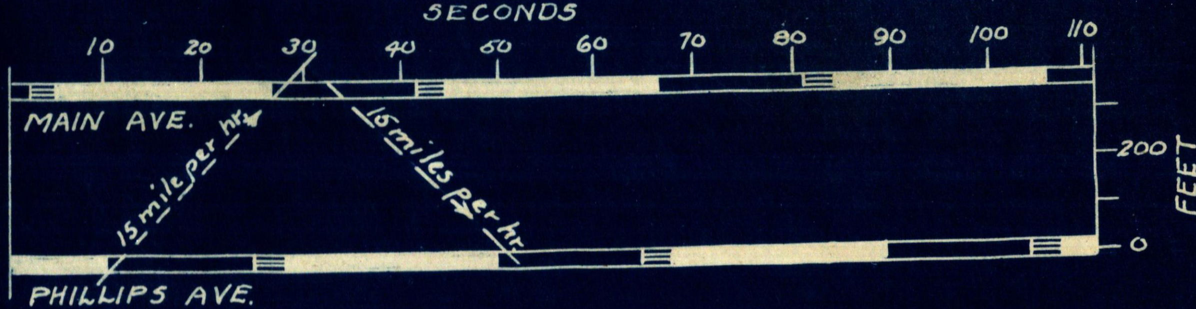
TIMING DIAGRAM FOR AUTOMATIC SIGNALS



PHILLIPS AVENUE

Same timing for Main Ave. from 8th. to 11th Sts.

Green "GO" Yellow "CHANGE" Red "STOP"



FOR ALL STREETS - 8th. to 11th. -

FIG. 12.

The following photographs were taken in Sioux Falls May 3, 1930 and represent some of the problems of traffic control.

Figure 13

This photo shows pedestrians moving across 10th. street at Phillips Avenue against the traffic signal. The driver in car in intersection was required to come to a complete stop to allow the pedestrians to pass. Car coming from West on 10th. Street would have been unable to make a left turn .

Figure 14

Another view of Phillips Avenue and 10th. Street. Pedestrians crossing Phillips Avenue against signal. Photo also shows vehicles crowding the sidewalk crossing. Painted crosswalk should help to prevent this tendency of drivers.

Figure 15.

A good example of pedestrians crowding into the street and preventing vehicles from making a proper right turn. Picture taken on corner of 8th. street and Main Avenue.

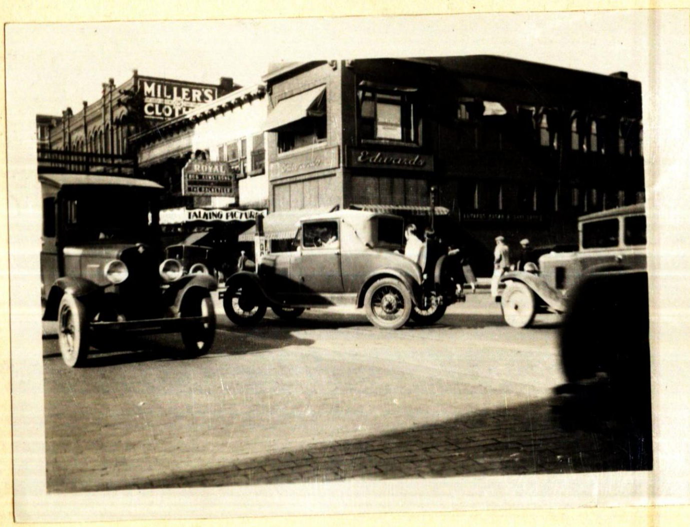


Figure 16.

Phillips Avenue and 10th. Street shows the effect of the inside left turn. The coupe in the picture is pulled into position so that the first break in the line of traffic behind the truck it may proceed. The lane of traffic behind coupe was not interferred with as shown from vehicle going through intersection on right.

Figure 17.

Phillips Avenue as a storage place for vehicles. Two lanes of traffic on a street where four could be used if prohibited double parking. Parking for the convenience of individual at the expense of many.

Figure 18.

The vehicle on left occuping space enough for two vehicles causing the car on the right to double park thus reducing the street volume by one traffic lane. Street markings will reduce this to minimum.

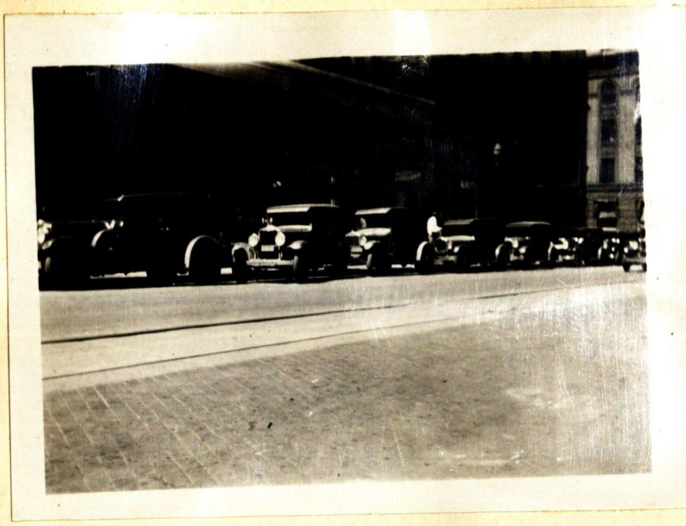


Figure 19.

Vehicle maneuvering to park in space shown in Figure 18. Space not large enough. Vehicle in photo after trying for 15 minutes, blocking traffic, bumping vehicles on side of space doing slight damage to cars, had reached a point as shown in photo.

Figure 20.

Taxi stand occupying approximately 24 feet of curb space. Space is not big enough for two taxis and is more than is necessary for one taxi. Such stands should be reduced to a minimum.

Figure 21.

Dakota Avenue using sidewalk for the purpose of displaying of motor vehicles. The garages at the time this photo was taken were half filled. Street should be used as a means of communication and not as storage spaces.

Figure 22.

Another view of Dakota Avenue where triple parking is practiced. The opening between truck and vehicle on right is not enough to allow two lanes of traffic to pass safely at a speed which should be maintained on this street.

Figure 23.

Double parking near bus zone keeping bus from properly drawing up to curb. Rear end extending into moving traffic lane. Six vehicles on the right are parked within one foot of each other, hardly enough space in which to maneuver when leaving curb.

Figure 24.

Truck loading and unloading merchandise on Main Avenue. The effect of parallel and angle parking on street width is shown. One vehicle parked this way or double parked effects the entire block as shown in Figure 15.

Figure 25.

A privilege offered to one merchant at the expense of the public. Such practice in restricted area should not be allowed.

Figure 26.

Angle parking in the second row. The street effective width being reduced to the minimum. More efficient parking at curbs will provide spaces for such vehicles.

Figure 27.

A car which is double parked effects the street width the entire block. Phillips Avenue capacity is nearly reached with present practices. Prohibiting of double parking and stopping in traffic lane whould more than double street capacity.

Figure 28.

A truck parked unloading merchandise. Having regular hours for deliveries to business houses, when parking at curb is prohibited as 7 A. M. to 9 A. M., is one method of preventing above situation.

Suggested Improvements

In the planning of the city's street system, due consideration should be given the traffic demands of the present and future.

Suggested Improvements and changes in the city's street system and traffic rules to better facilitate traffic, present and future are based on the survey data:

A. Parking

1. Restrict area with time limits as shown in Figure 9.
2. Provide cheap parking space in vacant lots near business district.
3. Create a more rapid turn-over of curb space, by enforcement of parking limit regulations.
4. Prohibit double parking where it reduces effective width less than the number of traffic lanes which is demanded of the street.
5. Limit taxi stands to meet the immediate public demands.
6. Paint parking stalls and crosswalks.
7. Replace all angle parking by parallel parking.

B. Increase Street Capacity

1. Increase speed of all traffic
   a. Proper regulation of automatic signals.

b. Routing of traffic.

1. By-paths for U. S. Highways 16 and 77, and State Highway 38 around congested district.

2. Route truck traffic from industrial centers to highways.

3. Place adequate signs and signals for such routes.

c. Elimination of obstacles which hamper traffic flow and causes accidents.

1. Railroad grade crossings.

2. Blind and sharp corners.

3. Street constriction or bottlenecks.

4. Cross traffic interference.

5. Require pedestrians to obey traffic signals.

2. Increase effective width of street.

a. Prohibit stopping in moving traffic lanes.

b. Prohibit double parking.

c. Widening of streets to meet demands of traffic.

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APPROVAL

This thesis is approved as a study of sufficient merit to be accepted for the Masters Degree. Approval of particular statements made or conclusions drawn herein is not to be inferred.

H. S. Carter
In charge of thesis

G. L. Brown
For Committee on Advanced Degrees