A TRAFFIC STUDY OF THE INTERSECTION IN AGGIEVILLE, MANHATTAN, KANSAS

by

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B. S., Robert College Engineering School,
Istanbul, Turkey, 1957

A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Civil Engineering

KANSAS STATE UNIVERSITY
OF AGRICULTURE AND APPLIED SCIENCE

1959

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INTRODUCTION

The location under study is the offset intersection in Aggieville where Moro Street and Anderson Avenue intersect N. Manhattan Avenue. Bluemont Avenue, which joins N. Manhattan Avenue north of this intersection is also considered part of this discussion. As a single intersection is an integral part of the whole traffic system, some reference will have to be made to traffic conditions and trends in Manhattan.

The existing conditions and suggested corrections will be presented in two sections, the first will involve short-term corrections, which require little expenditure of funds; the second will deal with long-term provisions which will have to be considered over a number of years and will involve considerable funds.

DISCUSSION OF EXISTING AND ESTIMATED FUTURE CONDITIONS

With the tremendous increase in the use of automobiles, the existing highway facilities are quickly becoming overloaded, causing undue delay, fatigue and inconvenience to the driving public. At times, some stop-gap provisions are sufficient to bring relief for a short time; usually, however, long-range predictions and planning are needed for satisfactory solutions. In preparing such a long range plan, its value from the standpoint of City Planning, Traffic Engineering, economical feasibility, and impact upon the public should be carefully evaluated, and the most appropriate plan adopted. Thus, we can reason that a traffic improvement suggested by a Traffic Engineer will have to be complemented by the other interests. Only then can the public be insured of the proper treatment of their problems, and an efficient solution of them.

Prevailing Conditions at the Intersection

The offset intersection under discussion is bounded by various business establishments on the SE, SW, and NE corners. On the NW lies the Kansas State University campus (Figure 1). On N. Manhattan Avenue, business extends north as far as Bluemont Avenue, and south as far as Laramie Street. Anderson Avenue also has a few businesses between N. Manhattan Avenue and N. 16th Street. The most heavily developed approach, however, is Moro Street between N. Manhattan Avenue and N. 11th Street. All types of businesses have flourished in this area and gained the name of "Aggieville Shopping Center." This area generally serves the University community and the nearby residential areas. The complex and inefficient traffic pattern and the lack of a long-range development plan for the area, however, do not promise a healthy and satisfactory improvement of the area as a "Shopping Center" in the generally conceived sense.

The streets within the area are narrow (Figure 2), and they have to carry a great traffic load (Figure 3). The capacities fall short of demand, especially during peak hours. This, coupled with the confusion caused by the offset of the intersection, accounts for the great number of loaded cycles[1] on the leg with the heavier traffic volume, during the peak hours (Table 1).

Traffic at the Area

A survey made in November 1955 showed that the 24-hour traffic volume on the legs of the intersection is 8215 vehicles on Anderson Avenue, 7000

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[1] A cycle is considered to be loaded, when the last car in line cannot clear the intersection during the first green time on the leg at which he has been stopped.

vehicles on the N. Manhattan Avenue north leg, 4200 vehicles on Bluemont Avenue, 6850 vehicles on Moro Street, and 3940 vehicles on the N. Manhattan Avenue south leg. It also showed that traffic on Moro Street between N. 12th Street and N. 11th Street dropped to 5400 vehicles, and between N. 11th Street and N. 10th Street it dropped to 2775 vehicles. From the same counts we see that 3820 vehicles use N. 11th Street between Moro Street and Laramie Street (Figure 3). N. 11th Street is the first link between the Aggieville area and Poyntz Avenue. It is also the first straight route east of N. 17th Street which provides uninterrupted access to Poyntz Avenue whereas all the N-S roads between Anderson Avenue and Poyntz Avenue are posted with stop signs at their intersections with the E-W roads. N. 11th Street is guarded by some signs, all E-W roads joining it having been posted with stop signs at their intersections with the N. 11th Street. Even without any counts taken to verify such an argument, we can safely assume that considerable amount of traffic would use this link for its trip to Poyntz Avenue. This is also evident from a study of the traffic count figures.

Field manual counts were taken at the intersection at a peak hour, to determine the turning movements, peak load, pedestrian load, and factors that have an adverse effect on the efficiency of movement at the intersection. The Eastbound traffic on Anderson Avenue accounted for 32.7 per cent of the total. Of this load 46 per cent turned left to N. Manhattan Avenue, 14 per cent turned right to N. Manhattan Avenue, and 40 per cent were through movements on to Moro Street. During that one hour period, there were 792 vehicular, and 311 pedestrian movements through the intersection. Of the total 20 loaded cycles, 9 were on N. Manhattan Avenue southbound, 6 were on Anderson Avenue eastbound, and 5 were on Moro Street westbound (Table 1). According to the field notes, the loaded cycles were not due to the heaviness of the traffic, but to the conflicting movements, such as left turns, pedestrian movement and cyclists.

Control of the Intersection

With the existing traffic control, that is signals, there exists eight conflict points at the intersection: four of the diverging, two merging, and two crossing type (Figure 4). However, with two seconds of clearance time, the vehicles entrapped at the intersection increase the number of conflict points, by four if one vehicle, by eight if two cars are entrapped. Despite this fact, there has been only one property damage accident during a year. This low rate constitutes no accident problem, and can be attributed to the caution of the drivers who use this intersection.

The signals work on a 60-second cycle. The N-W movements have 20 seconds of green, and 28 seconds of red, and E-W movements have 26 seconds of green, and 22 seconds of red, with 2 seconds of amber following green on each phase, and 10 seconds of pedestrian walk signs (Figure 5). Each lane of traffic is faced with only one traffic signal, and only three of the eight pedestrian cross-walks have directly facing walk signs (Figure 5). Both of these conditions are below the recommended standards. "In urban areas there shall be two or more signal faces visible to traffic on each approach to the intersection."[1] The pedestrians need to have a signal indication directly before them, while proceeding through the intersection.[2] This substandard signalization adds to the confusion caused by the geometric lay-out of the intersection.

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1 "Manual on Uniform Traffic Control Devices for Streets and Highways," Public Roads Administration, August 1948, p. 110.

2 Ibid., p. 111.

Capacity of the Intersection

Capacities of each leg of the intersection will have to be known for a better appreciation of the efficiency of the intersection. For traffic analysis purposes, several capacities are used. Design capacity "represents a volume of traffic that will pass through an intersection with few drivers having to wait longer than the first green period; possible capacity represents the maximum volume of traffic that can pass through the intersection with a continual backlog of waiting vehicles."[1] Practical capacity is the expression for the average maximum volumes.[2] There is another factor, called the "local factor", that has a great influence on the intersection capacity. This factor is dependent on the driving habits of the people of a community.

As explained earlier, the area around the intersection is developed as a business center. The heavy development on the Moro Street and the south approach of N. Manhattan Avenue classify these legs as "downtown areas."[3] Because of the Kansas State University campus, only one side of the other two approaches is lined with business establishments, and hence, they are classified as "intermediate areas."[4] On that basis, and using

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[1] "Design Capacity Charts for Signalized Street and Highway Intersections," Reprinted from <u>Public Roads</u>, vol. 26, No. 6, p. 106.

[2] Ibid., p. 106.

[3] "Downtown area is that portion of a municipality in and surrounding a business development where ordinarily there are large numbers of pedestrians and a heavy demand for parking space during periods of peak traffic or a sustained high pedestrian volume and a continuously heavy demand for parking space during business and industrial employment hours," from <u>Highway Capacity Manual</u>, Bureau of Public Roads, Washington, 1950, p. 19.

[4] "Intermediate area is that portion of a municipality which is outside of a downtown area but generally within the zone of influence of a business development, characterized by moderately heavy pedestrian traffic and a somewhat lower parking turn-over than is found in a downtown area," from, ibid, p. 20.

the field count data, capacities of the four approaches of the intersection were found as indicated in Table 2.

There is no commercial traffic at the intersection, and the busses are too few to be represented in percentages. The only bus line runs west on Moro Street as far as N. Manhattan Avenue and then turns north, to form a ring service between the University and downtown Manhattan. During the hour of field count, only two busses were counted.

The capacities computed are for normal intersections. The intersection under study, with its offset, will normally have less capacity. The pedestrian movement, and the short amber clearance time also will have reducing effects on the capacity. Due to lack of information, however, no attempt is made to estimate a reduction factor, and the capacities computed for normal intersections will be used as the basis of study.

In the past, no attempt has been made to determine the "local factor". Observations on the Manhattan intersections indicate that the driving habits of the citizens would not have an appreciable effect on the capacities. As such, the "local factor" for the intersection under study is assumed to be unity, and no adjustments are made.

Traffic Trends

It is an established fact that the automobile ownership of U. S. citizens is increasing every year. With the increase in population, and dependence on the car for daily use, this factor grows at a fast pace. It is evident that, the already overloaded facilities will soon become obsolete with increased ownership and the use of automobiles. The public officials and highway engineers face the challenging task of bringing the highway facilities up to date, and also provide for the increasing demand.

Any improvement will have to be planned for the future, if it is expected to serve its purpose.

The trends in Manhattan closely follow the U. S. pattern. The population of the city has about tripled over the past thirty years (Figure 6), and car registration has similarly increased as fast. In about twenty years from now, population is estimated to reach some 28 thousand people, and the motor vehicle ownership is expected to follow the same upward surge. In the same manner, the enrollment at the Kansas State University, which has a direct influence on the city of Manhattan, has been increasing, and it is expected to increase at a steady pace over the years to come (Figure 7). The vehicle registration at the University has remained somewhat constant the past several years at about four thousand. With a continuous increase in student enrollment, and faculty, however, it can be assumed that the number of cars operated by the members of the University community will also increase. This will, no doubt, be reflected on the highway facilities in the city of Manhattan.

The Kansas State University has begun a large housing project. Some married student dwellings have recently been completed, and a dormitory for 600 men students is soon to be finished. There is to be further construction on the west campus area of dormitories and apartment houses. Since most of the residents of these units will use the Aggieville and downtown Manhattan shopping facilities, the routes leading to those areas will be increasingly utilized. The roads around Aggieville will be influenced by both the traffic going to this area, and by the traffic using that link to get to downtown Manhattan. Therefore, any long range plan will have to consider a by-pass for through traffic around Aggieville, to relieve the congestion in that area.

DISCUSSION OF FINDINGS AND SHORT-TERM SUGGESTIONS

The foregoing discussion gives the existing traffic conditions at the intersection in Aggieville, and indicates some future developments.

A comparison of the capacity of the intersection with the load it now carries shows that it is now operating nearly at its design capacity. With the existing adverse factors, and with the present signal system, it cannot be expected to carry any load which is considerably greater than the design capacity. Already the road user finds this intersection congested.

Since the distribution of load between the N-S and E-W approaches remains somewhat constant, a fixed time signal will be appropriate to use. The present green time for N-S and E-W movements is in proportion to the traffic load. However, there are no provisions for turning movements. In view of the fact that total turning movements are about the same number as, or more than, through movements, it is felt that some means of separating these movements will decrease confusion, and conflict points, and also increase capacity.

One provision might be elimination of left-turn movements on all approaches during the peak hours. This will eliminate six conflict points (Figure 4), and hence provide for safer and faster movement of traffic. This will, however, inconvenience some 35 per cent of E-W, and some 18 per cent of N-S, or some 28 per cent of the total number of drivers who use this intersection. In view of the fact that this is such a high ratio, this provision will not find much public acceptance, and will probably have to be strictly enforced if it is to work at all.

Another means of separating the through from the turning movements will be to provide for separate signal indications. A suggested system could be, permitting right turn for southbound traffic, and all movements for eastbound traffic on one phase, right turn for northbound and all movements for west bound traffic on the second, and all N-S movements on the third phase (Figure 8). This will eliminate all conflicts on the first and second phases, and by accommodating the heavier right-turn movement of the southbound traffic, conflicting movements of N-S traffic will be minimized. For such a system to work, however, there will have to be two approach lanes for the north and the southbound traffic. One of these lanes will be for only right-turn on N-S approaches. This brings us to the third way of separating turning and through movements, which can be used with the existing signal timing, or may be more effectively applied by combining with the above suggested signal set-up. This third way is providing two approach lanes to each and every leg of the intersection. The widths of the legs are suitable for such a change, provided some parking is removed on the approach side of each leg. The minimum distance which should be provided for turning lanes are found to be: Anderson Avenue 100 feet, Moro Street 70 feet, and N. Manhattan Avenue north approach 90 feet (Figure 9)[1]. This will mean the elimination of five parking stalls on Anderson Avenue, four on N. Manhattan Avenue north approach, and two stalls on Moro Street. Then the lanes will have to be properly marked and signed (Figure 9), and for a short time after the change is put in effect, the enforcement crew will have to direct traffic

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1 "Design Capacity Charts for Signalized Street and Highway Intersections," Reprinted from <u>Public Roads</u>, Vol. 26, No. 6, Chart 10-B, p. 134.

until the drivers get accustomed to the new system. Since in this way the vehicles desiring to make a turn, but waiting for an acceptable gap in the oncoming traffic will not be blocking the path of the vehicles in line, there will be less strain on the drivers, and the capacity of the intersection can be expected to increase by the elimination of one turning movement from the traffic stream, even with the existing signal timing (Table 3). If providing separate turning lanes were incorporated with the signal timing as suggested above (Figure 8), the capacity of the intersection will be considerably higher (Table 3).

Another factor that will have to be considered in applying the above improvements is redesigning the signal locations to comply with the recommended standards (Figure 10).

A suggestion for improvement of the performance of the intersection has been to have one-way westbound operation on Anderson Avenue, three traffic lanes on Moro Street, and provide 4-lane operation on N. Manhattan Avenue.[1] Though this system has its merits, it will be eliminating a vital feeder road for the Aggieville area. It is felt that the business at the Aggieville shopping center will be adversely affected by the one-way operation on Anderson Avenue.

Of the proposals discussed above, the one involving provision of separate turning lanes for all approaches supplemented by new signal timing is likely to give the best results. In addition to eliminating most of the

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1 "Traffic Study for the City of Manhattan, Kansas," Burgwin and Martin, Consulting Engineers, Topeka, Kansas, July 1958, pp. 30-31.

conflicting movements, providing for ease and continuous traffic flow, the increased capacity will keep the intersection efficiently in service for some more years. This will give the city officials enough time to evaluate some long range plans and take the necessary financial provisions. It should be emphasized that this is only a "stop-gap" proposal to relieve the existing conditions, and give the officials enough time to plan on realistic future improvements.

LONG-RANGE PROPOSALS

Many people have realized the fact that the final solution to the traffic problem existing at this intersection will have to be a consideration of a new geometric lay-out. A proposal which has found acceptance among the interested people suggests connecting N. 14th Street with Bluemont Avenue by a street to be constructed on the SE corner of the Kansas State University campus, then closing Anderson Avenue between N. Manhattan Avenue and N. 14th Street and using this abandoned section for off-street parking, and improving N. 14th Street between Anderson Avenue and Poyntz Avenue. This plan will provide for right-angle intersections at N. 14th Street and Anderson Avenue, and also at N. Manhattan Avenue and Bluemont Avenue (Figure 11). It will eliminate confusion, relieve the Aggieville area of through traffic, provide for some much needed off-street parking for the area, and accomodate pedestrians and traffic efficiently. The closure of Anderson Avenue will make the Moro Street, N. Manhattan Avenue intersection a T-intersection. Under this type of operation, the capacity and efficiency of the intersection will definitely increase.

A more ambitious, yet a more far-sighted plan is the one developed by the City Planning class of the Kansas State University, Department of Architecture and Allied Arts, under the guidance of Professor M. R. Hodgell. This plan considers the development of the area bounded by the N. 11th Street, Bluemont Avenue, N. 14th Street, and Laramie Street as a "Shopping Center" in the generally accepted meaning of the term. Sufficient off-street parking, and a connecting link between N. 14th Street and Bluemont Avenue is provided. The plans are devised with the idea of preserving almost all the existing business establishments, but proposing a development scheme to be carried out systematically over a number of years. This plan, no doubt, is keeping in pace with the progress of the City of Manhattan, as an ever flourishing neighborhood.

CONCLUSION

In conclusion it should again be pointed out that only traffic conditions are considered in this paper. It was shown that some improvements are needed, and needed at present. In carrying out these improvements, however, close consideration will have to be given so business conditions of the area are not to be adversely affected by these changes. The overall development of the area as a "Shopping Center" will draw many new customers, relieve other roads of traffic, and provide a pleasant business area. If traffic planning is not done along with this improvement, however, more serious traffic problems might develop. Therefore, serious consideration of this plan may be the final answer to the problem that now faces the citizens and the officials of the City. However, some stop-gap improvements should be made before trying any long-range plans, if the traffic is to use this intersection effectively.

ACKNOWLEDGMENT

In compiling the necessary data for this paper, the cooperation of the Manhattan City Engineer's Office, and the Highway Planning Department of the State Highway Commission of Kansas in furnishing all available information is gratefully acknowledged. Close interest and suggestions of some long range plans for the intersection by Professor M. R. Hodgell of the Architecture and Allied Arts Department of the Kansas State University was greatly appreciated. The Registrar and the Director of the Housing Office of the University furnished the information as to the present and estimated future developments in this area in relation to the student enrollment and future housing plans. Lastly, appreciation and thanks is expressed to Professor Walter Robohn of the Civil Engineering Department for his constructive suggestions, close cooperation and painstaking efforts in reviewing the thesis.

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APPENDIX

Table 1. Field count data*.

	Through movement	Right turn	Left turn	Pedestrians	Loaded cycles	Total vehicles	%R	%L
WESTBOUND								
1st 15 min.	21	13	8	12	4	42	31	19
2nd 15 min.	25	12	10	5	-	47	25	21
3rd 15 min.	27	20	10	7	-	57	35	17
4th 15 min.	24	12	8	8	1	44	27	18
Total 1 hr.	97	57	36	32		190	30	19
EASTBOUND								
1st 15 min.	35	7	19	23	-	61	11	31
2nd 15 min.	22	8	26	34	-	56	14	46
3rd 15 min.	15	9	38	46	2	62	14	61
4th 15 min.	30	13	37	28	4	80	16	46
Total 1 hr.	102	37	120	131		259	14	46
NORTHBOUND								
1st 15 min.	13	11	7	14	-	31	35	22
2nd 15 min.	11	6	5	9	-	22	27	22
3rd 15 min.	20	2	7	5	-	29	7	24
4th 15 min.	15	4	6	13	-	25	16	24
Total 1 hr.	59	23	25	41		107	21	23
SOUTHBOUND								
1st 15 min.	20	25	7	14	2	52	48	13
2nd 15 min.	18	17	7	27	-	42	40	17
3rd 15 min.	38	33	10	37	3	81	41	12
4th 15 min.	30	18	13	29	4	61	29	21
Total 1 hr.	106	93	37	107		236	39	16

* Counts taken on Monday, May 18, 1959 between 11:15 - 12:15 AM.

Table 2. Capacity[1] of the intersection under existing conditions (in vehicles per hour).

	Moro St.	Anderson Ave.	N. Manhattan Ave.	
	(Westbound)	(Eastbound)	(Southbound)	(Northbound)
Design capacity	210	275	230	180
Practical "	235	308	258	202
Possible "	336	440	368	288

Table 3. Capacity[1] of the intersection after improvements (in vehicles per hour).

	Moro St.	Anderson Ave.	N. Manhattan Ave.	
	(Westbound)	(Eastbound)	(Southbound)	(Northbound)
	Separate turning lanes and existing signal timing.			
Design capacity	300	350	330	185
	Separate turning lanes and suggested signal timing.			
Design capacity	325	400	360	225

1 "Design Capacity Charts for Signalized Street and Highway Intersections," Reprinted from Public Roads, Vol. 26, No. 6, used for capacity computations in Tables 2 and 3.

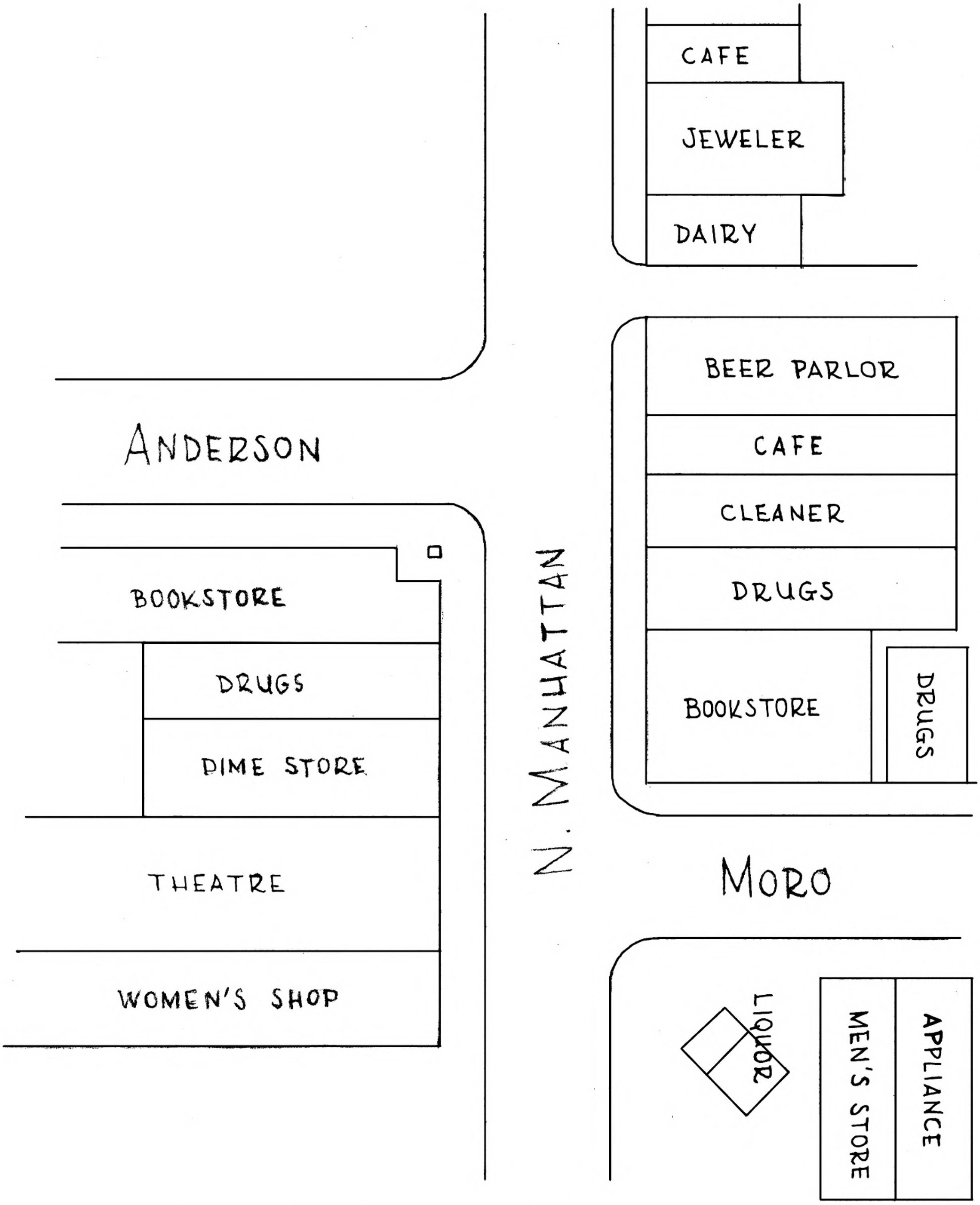


Figure 1. Business establishments around the intersection. (From a plan furnished by Prof.M.R.Hodgell.)

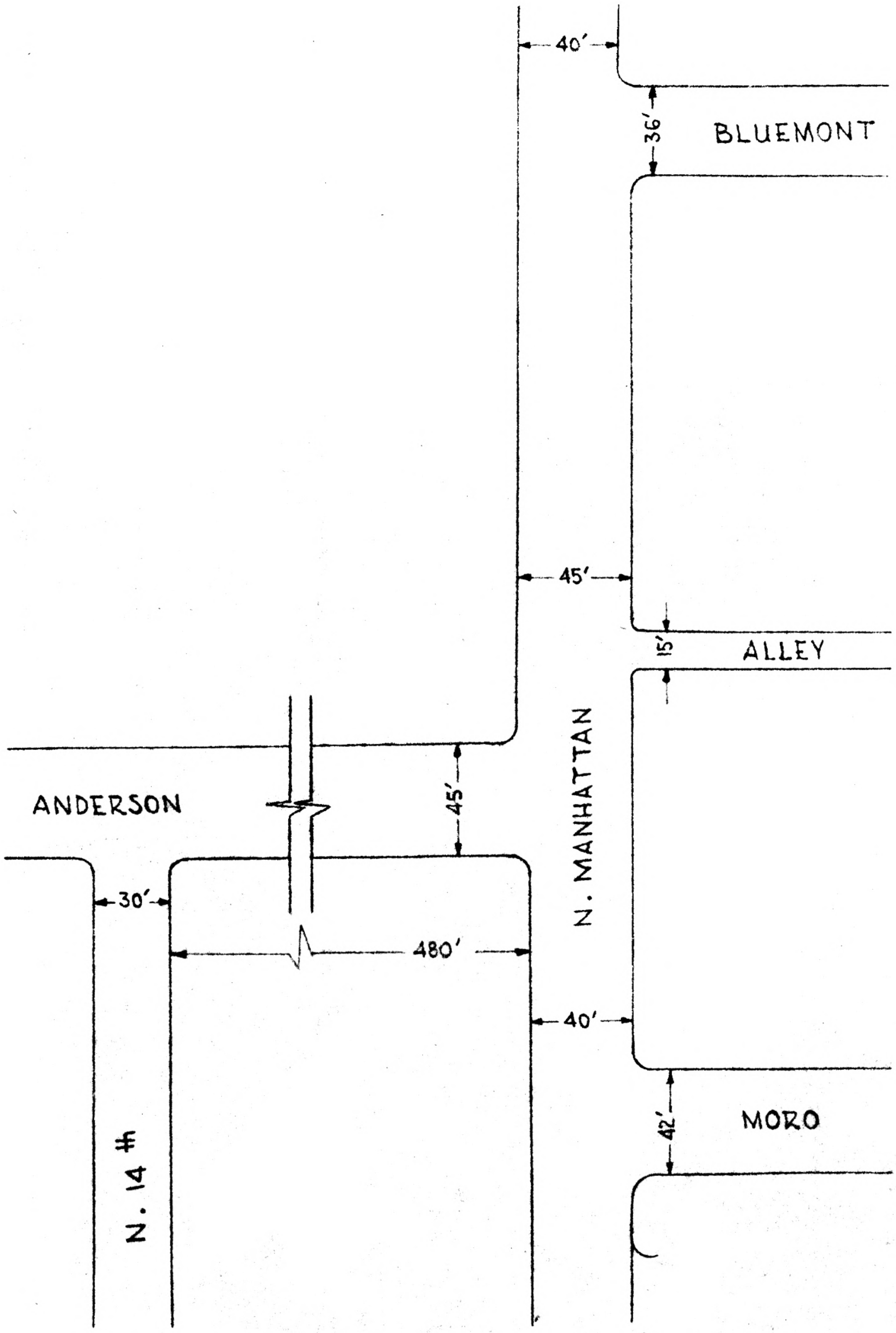


Figure 2. Lay-out and dimensions of the intersection.

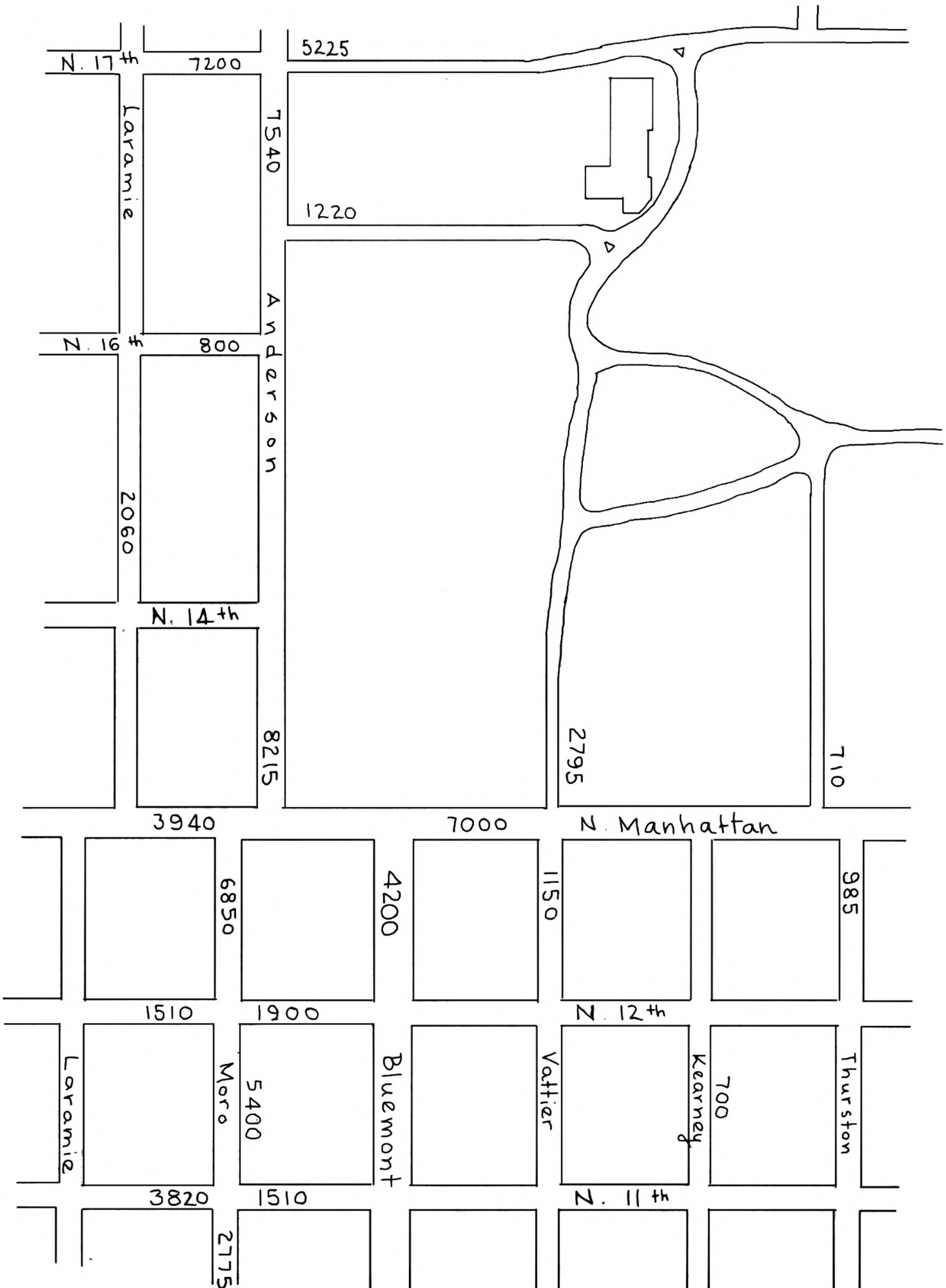
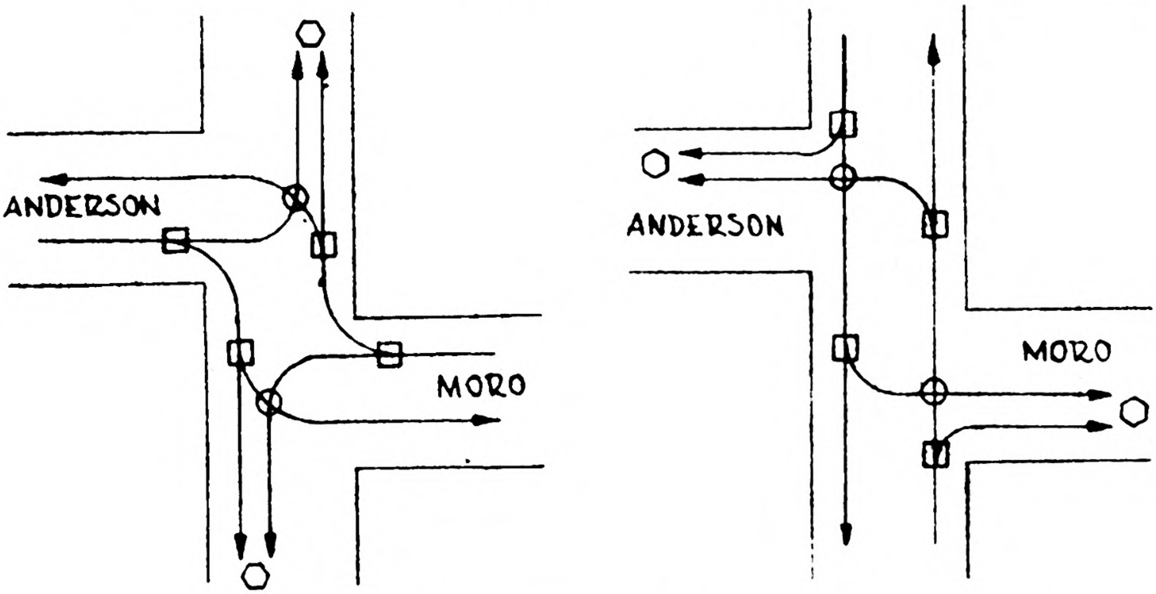
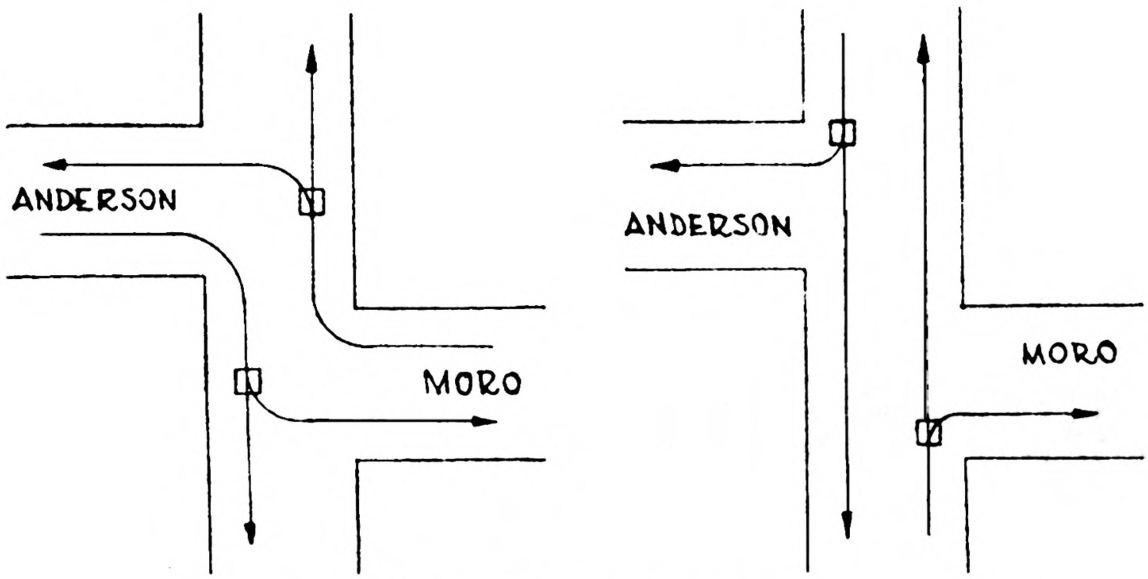


Figure 3. Traffic volume on the streets around the intersection. (Counts taken in November 1955.)

Green for E-W traffic   Green for N-S traffic



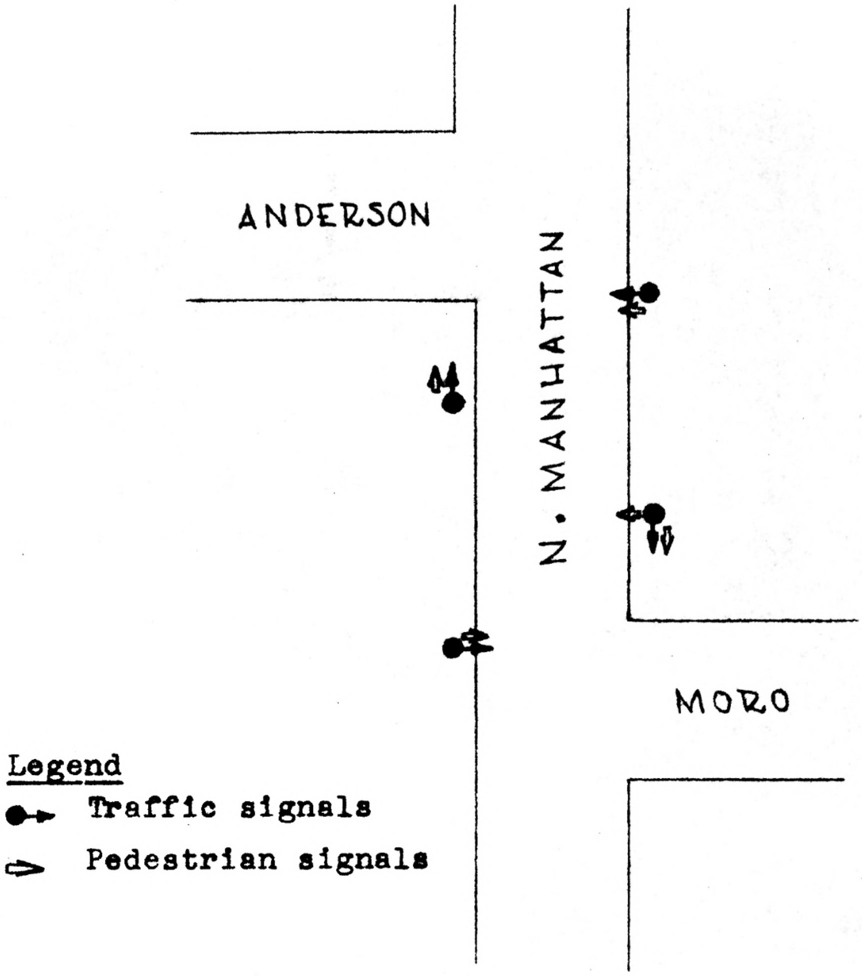
A. Existing conditions.



B. Left-turns prohibited.

○ Crossing   □ Converging   ⬡ Merging

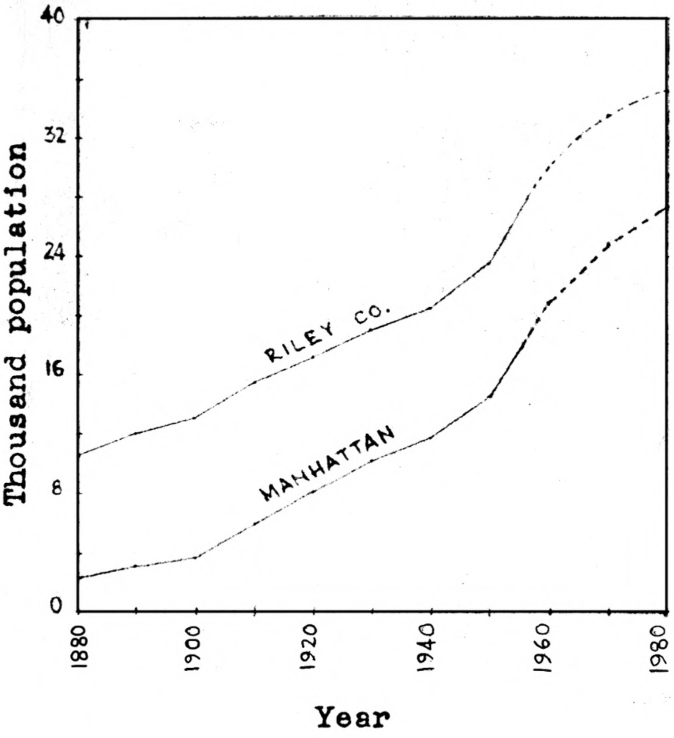
Figure 4. Conflict points at the intersection.



E-W traffic	
R-W	10 sec
G	26 sec
Y	2 sec
R	22 sec

N-S traffic	
R-W	10 sec
R	28 sec
G	20 sec
Y	2 sec

Figure 5. Existing signal locations and timing.



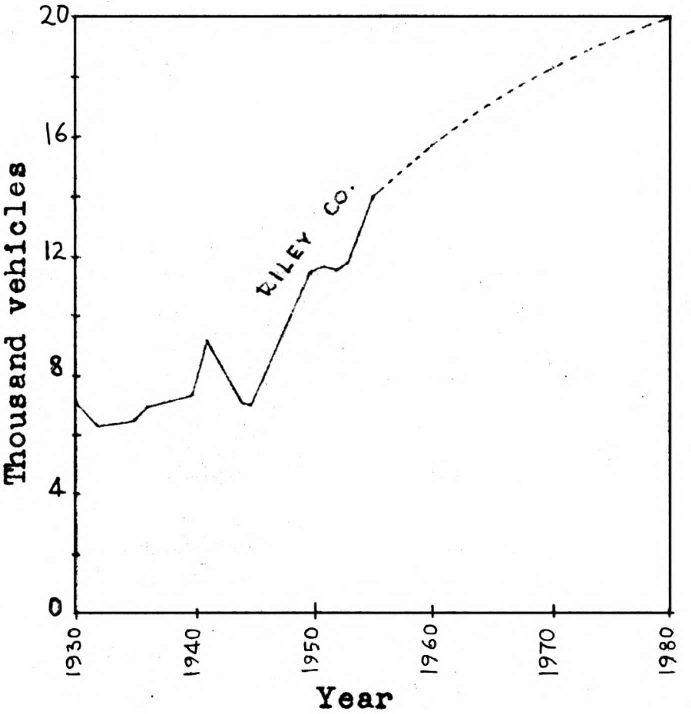


Figure 6. Population and vehicle registration trends. (From "Traffic Study for the City of Manhattan, Kansas", Burgwin and Martin, Consulting Engineers, Topeka, Kansas, 1958.)

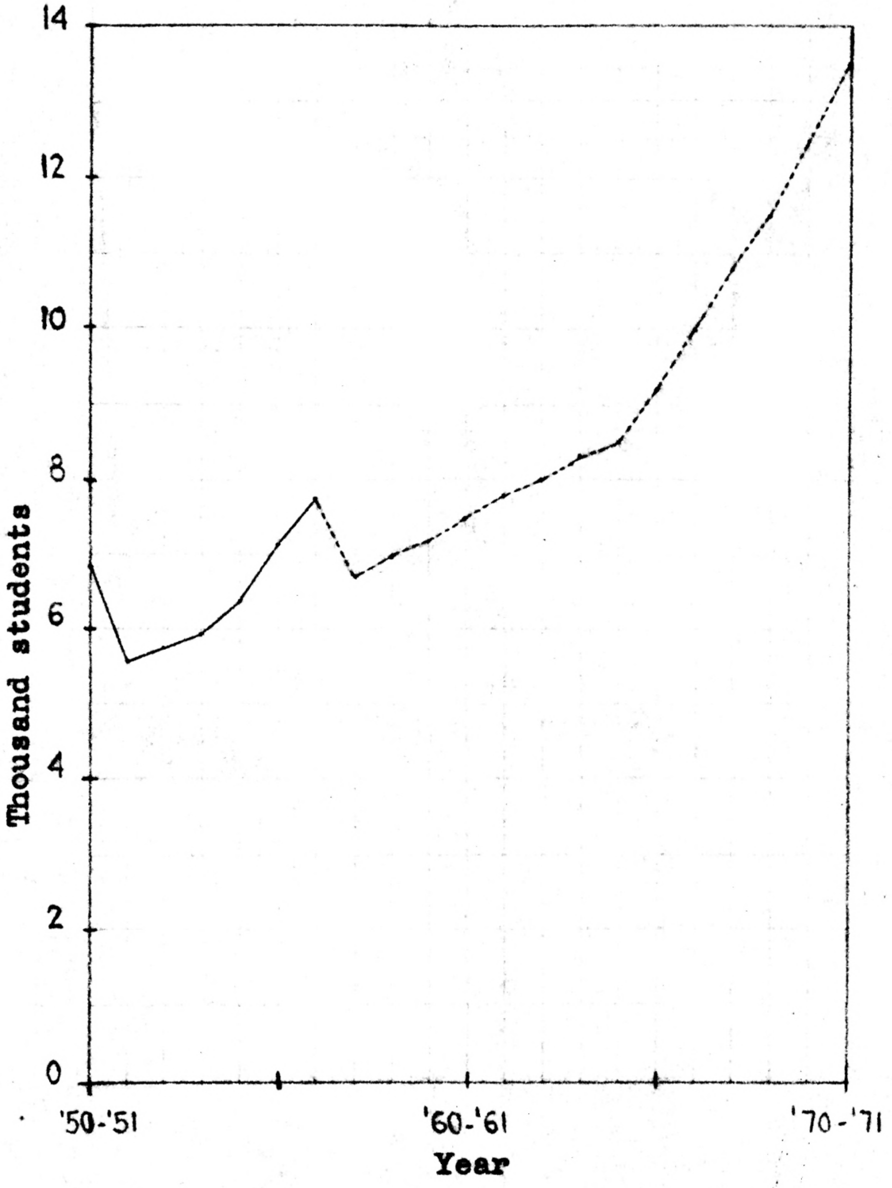


Figure 7. Enrollment at Kansas State University.

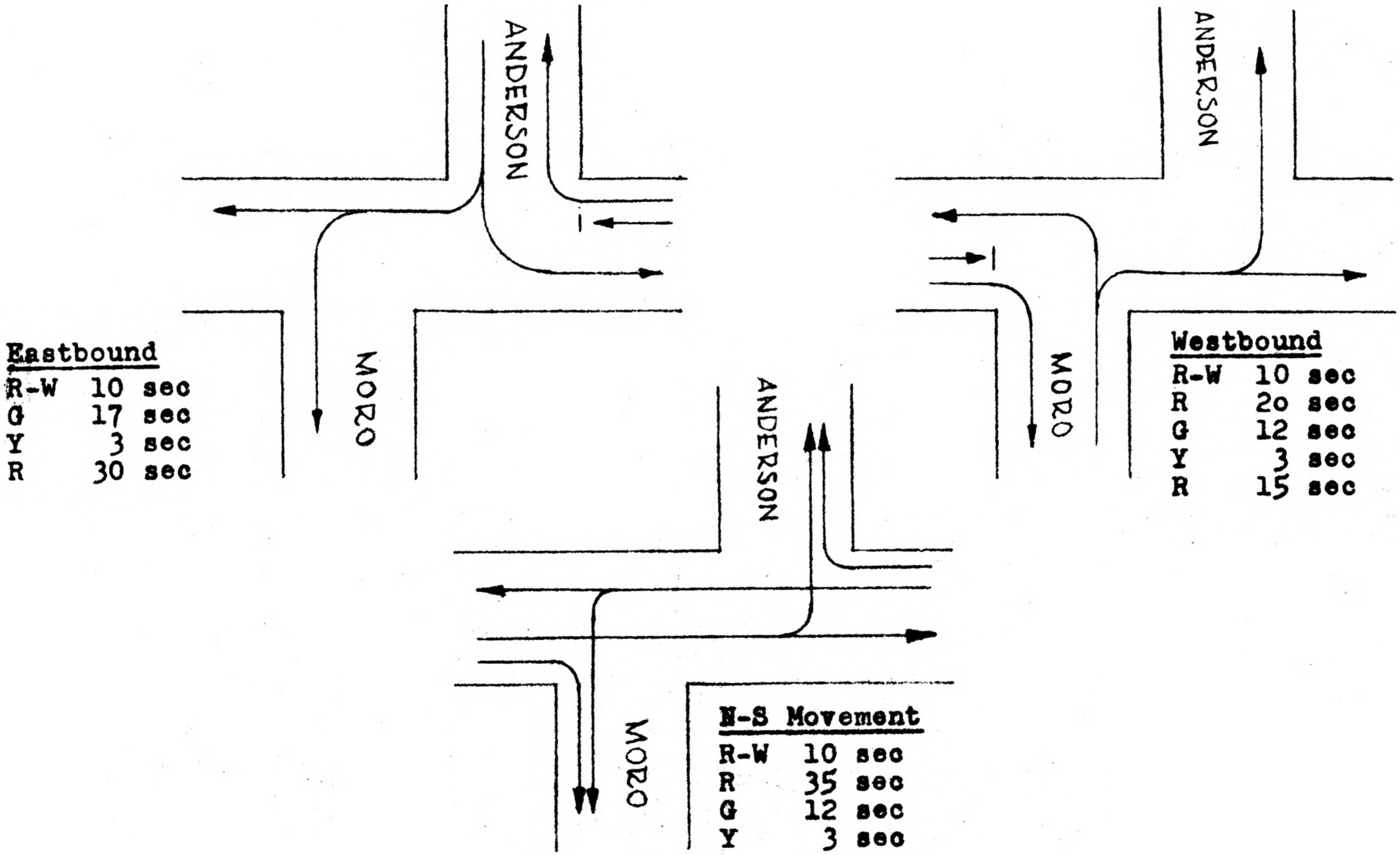


Figure 8. Suggested traffic movements and signal timing.

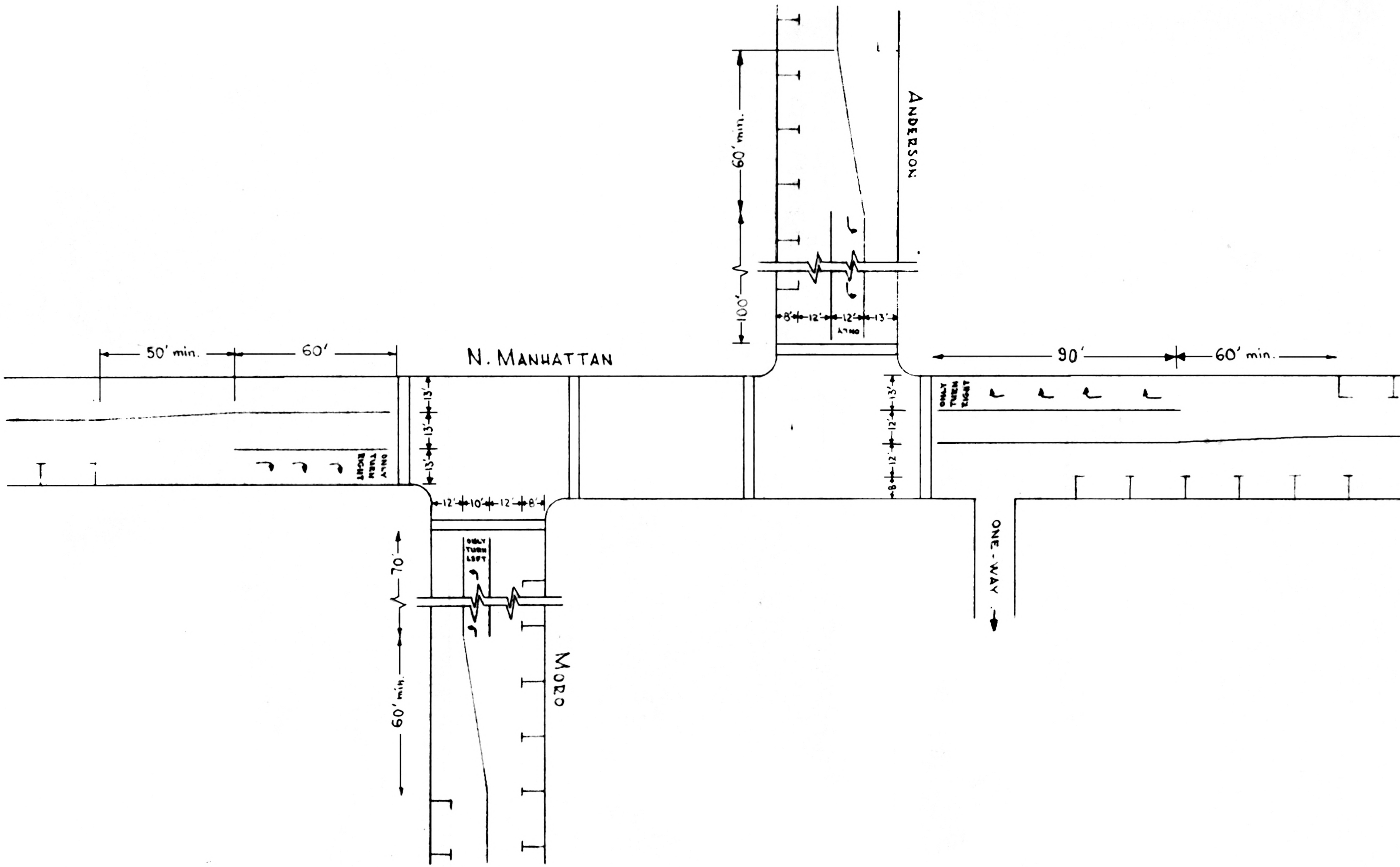


Figure 9. Proposed traffic lane markings.

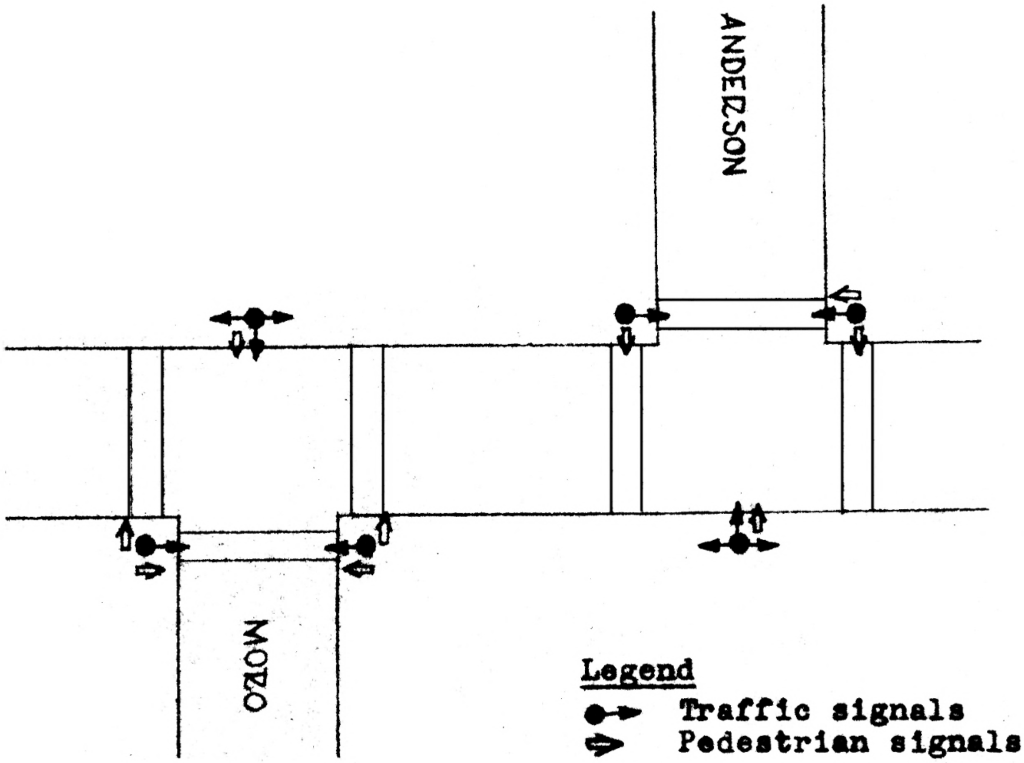


Figure 10. Suggested relocation of signals.

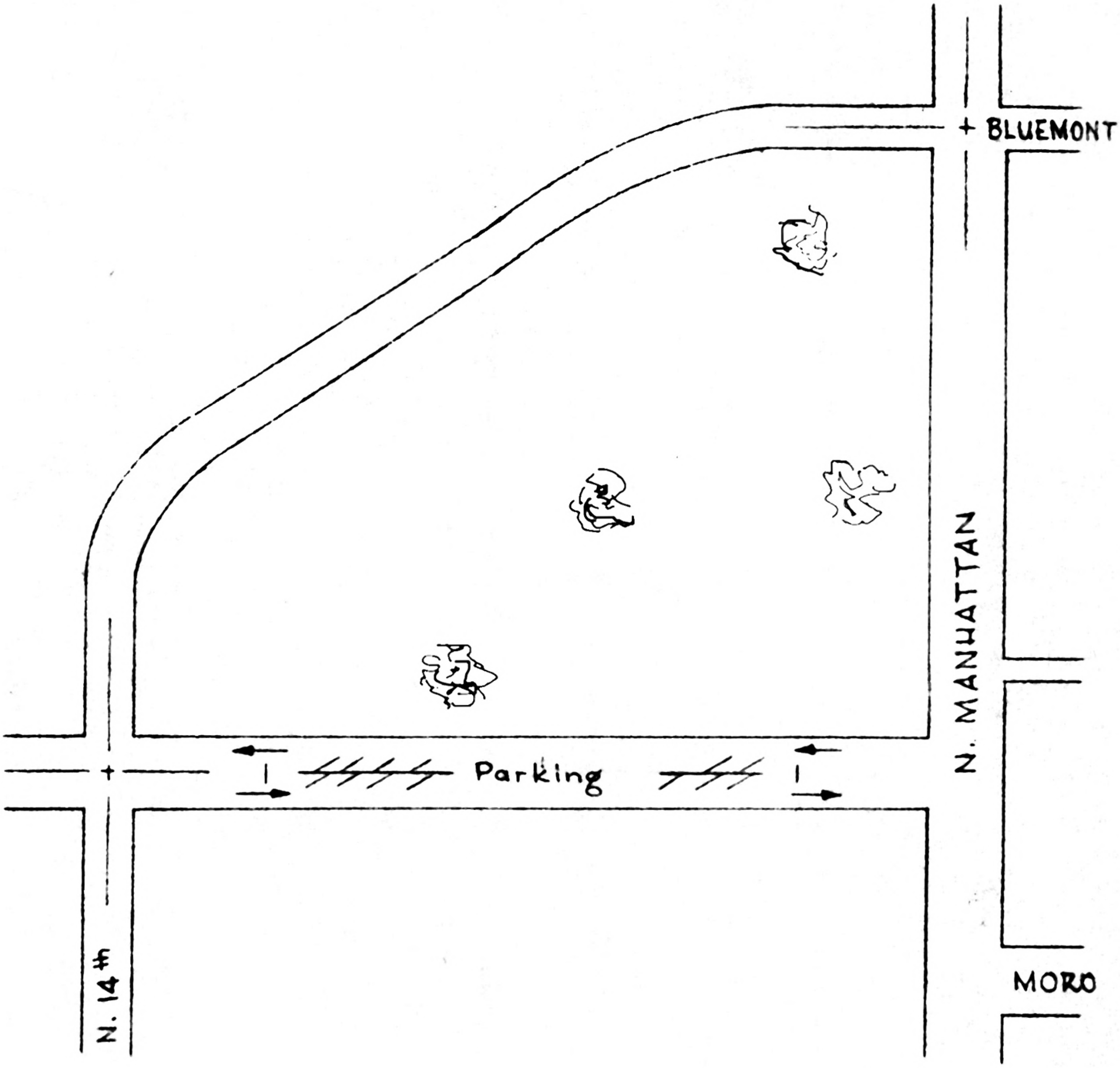


Figure 11. Proposed link between N. 14 th St. and Bluemont Ave.

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This study deals with the offset intersection at Aggieville, at which Anderson Avenue and Moro Street intersect N. Manhattan Avenue.

The existing facilities and traffic is evaluated and it is found that the intersection is operating at its design capacity. Due to the geometric lay-out, it is not expected that the intersection can handle much more traffic than its design capacity. Traffic, however, is estimated to continue to increase steadily. This will add to the confusion and congestion that already exists at this intersection.

It is proposed to develop ways of improving the performance characteristics of the intersection and to increase efficiency and capacity. Since any drastic change will inevitably take a long time, some stop-gap improvements are suggested to relieve conditions, and provide for efficient operation of the intersection until that time when major improvements can be made.

In the way of short-term improvements, the idea of having one-way operation on any of the intersection approaches is dismissed with the feeling that it will adversely affect the businesses of the area. Two approach lanes, one being for the heavier-turning movement, on each and every leg of the intersection, with or without any changes in the signal timing, is felt to be the best solution until changes in geometric lay-out can be realized.

For long-range improvements, the idea of developing the area bounded by N. 11th Street, N. 14th Street, Laramie Street and Bluemont Avenue as a Shopping Center, should be given serious thought. In any event, a link connecting N. 14th Street with Bluemont Avenue through the SE corner of the Kansas State University campus offers a realistic solution to the intersection problem. In this plan, which is a part of the Shopping Center idea, Anderson Avenue is closed to traffic between N. 14th Street and N. Manhattan Avenue, and this area is used for off-street parking.

Some short-term improvements are needed at this intersection to reduce confusion and interference of movements, and increase capacity. This not only will facilitate movement of traffic at the intersection but will also give the officials enough time to plan and decide on long-range improvements.