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16. Abstract

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DALLAS CORRIDOR ARTERIAL SUBSYSTEM EVALUATION PLAN

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March 1975

Prepared for
Federal Highway Administration
Department of Transportation
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An evaluation plan for the arterial portion of the Dallas North Central Expressway Corridor is presented. A complete site description is given showing detection locations and intersection layouts. For this study Texas Transportation Institute has built an instrumented vehicle; a description of that vehicle is given in this report.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES (continued)

DALLAS CORRIDOR ARTERIAL EVALUATION PLAN

I. *Background and Objectives*

The overall Dallas Corridor Control Study has three primary control segments or phases: (1) the freeway control subsystem; (2) the frontage road control subsystem; and (3) the arterial control subsystem. The freeway control subsystem has been operational since June of 1971.[1] The frontage road control system became operational in June of 1974. This subsystem included basic control center hardware for overall corridor control. The third phase, the arterial subsystem, will go to contract in the near future.

The objective of this report is to describe studies which will be used in evaluation of the third phase, arterial portion, of the Dallas Corridor Study. Evaluation of control on the arterial system is not unlike evaluation of control on the frontage road system which was reported in a previous document.[2] However, this document will specifically describe the system as now designed and the studies will be performed for before and after evaluation.

II. *Arterial Subsystem Description*

1. *Control Hardware* - Previous project documentation[3] has described in detail the hardware design for the overall control system. Briefly, the system is made up of a central digital minicomputer, with minicomputers in the field at major (multi-phase) intersections. Two-phase intersections will be controlled by causing the existing fixed-time controllers to advance and hold in accordance with the overall control algorithm. Specific detector sampling points are detailed below in the site description.

2. *Study Site* - The study site will be located within two large areas east and southeast of North Central Expressway. The southeast area, (Figure 1), is contained within Mockingbird on the north, North Central Expressway on the west, Hall on the south and Gaston-Abrams on the east. Appendix Figures 4 through 19 show details of intersections included in the arterial study site. Locations of sampling detectors are shown. In addition to the intersections shown in these figures, the following intersections will be connected to the control system:

    1. Gaston/Prospect
    2. Alderson/Paulus
    3. Swiss/Haskell
    4. Swiss/Washington
    5. Swiss/Hall
    6. Junius/Washington
    7. Junius/Hall
    8. McMillan/Henderson

   These intersections will have no detectors, and are included since they are now part of an existing signal system.

   The East Study Site, (Figure 1), is contained within Mockingbird on the south, North Central Expressway on the west, Abrams on the east and Loop 12 on the north. Appendix Figures 20 through 26 cover this area. Within this area there will be no bus detection. There will be, however, an extensive vehicle detection system.

3. *Control Technique* - Several levels of control will be used in the arterial portion of the corridor experiment. The southeast area, as described in section 2 above, will be controlled as four major arterials running from the Dallas CBD to Mockingbird. Most of these intersections are two-phase; this area will also include the Urban Corridor Demonstration Study for giving buses preferential treatment. The control strategy will be a variation of the one being used at present on the frontage road system.[4,5]

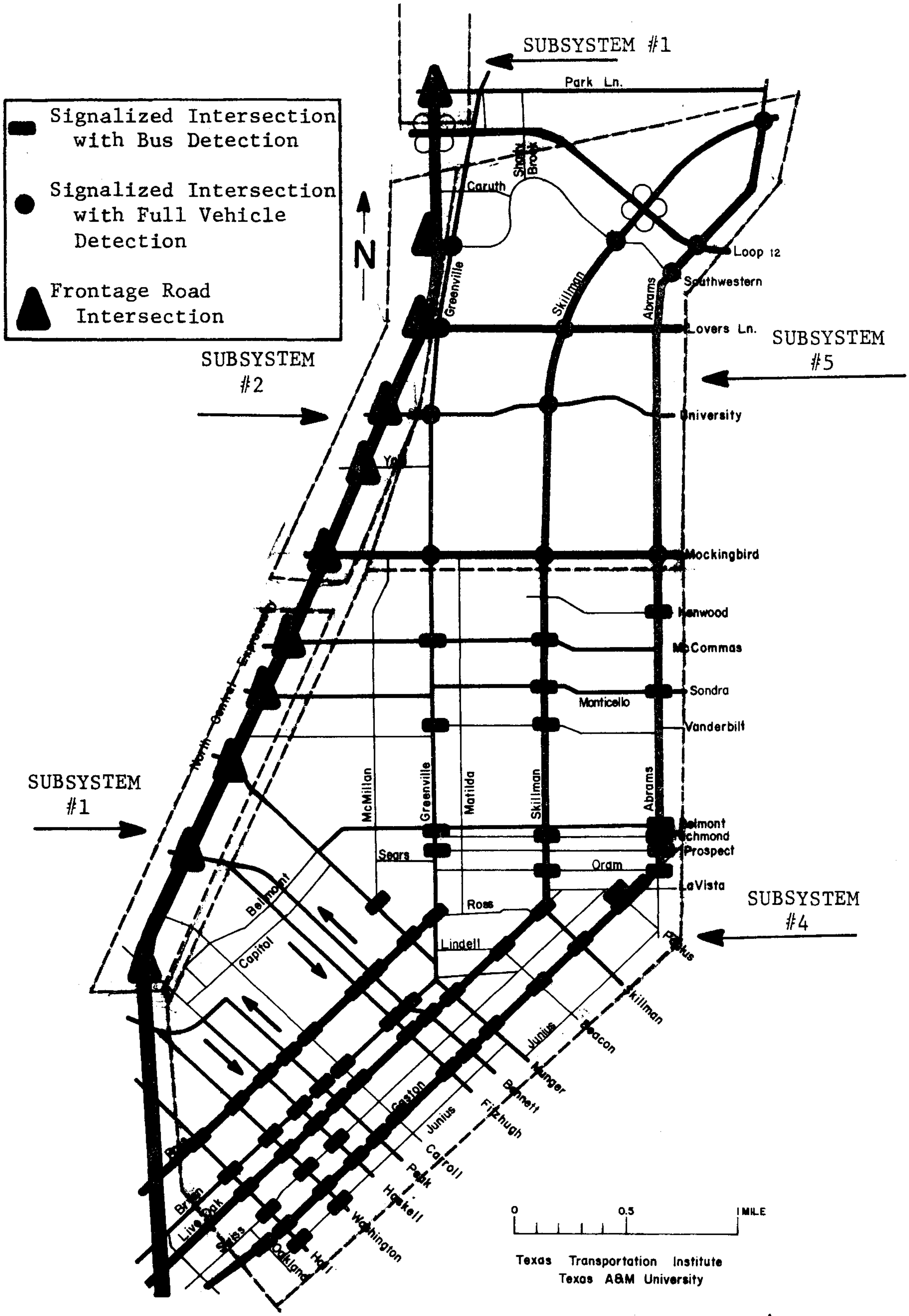


Figure 1. Initial arterial implementation system. (Schematic)

The East Study Site will also be controlled as arterials running north and south. The intersection will, however, be multi-phase with individual lane detection on all approaches. In addition to the control strategy described in references 4 and 5, each multi-phase intersection in this area will have a skip-phase off-peak control scheme.[6]

III. *Evaluation Parameters*

The prime objective of the arterial control system is to improve quality of traffic flow through the use of innovative control hardware and control techniques. Increased usage of the arterial system without degradation of flow efficiency is also desired. Measures of effectiveness will therefore be concentrated on changes in traffic volumes, changes in travel time, and changes in quality of traffic flow. See Figure 2 for work plan.

1. *Traffic Volume Counts* - Locations of detection sampling for the planned control system are shown in the site description above. Dallas Traffic Control Department will make machine counts prior to installation of the control system at the sites to establish a data base. At least two weeks of data will be collected and adjusted for seasonal variations at each detection station. Continuous data collection and logging will be possible with installation of control and surveillance hardware.

2. *Travel Time and Quality of Traffic Flow Measurements* - Travel time changes for roadways in the arterial system will provide measures of effectiveness for the demonstration. Travel time measurements are needed to estimate travel costs (especially cost of commuter travel times). These data also help describe the travel alternatives available to corridor residents. Travel time measurements will generally be confined to those streets with intersections under control.

   The floating-car technique will be used for travel time studies. A test vehicle will be driven along the selected route at the average speed of the traffic stream. During the test run, an observer records general information for the run and specific information on the location, duration, frequency, and cause of delay. Before making travel time measurements, those locations where delay is likely will be identified. These locations will be referenced to objects that can be easily recognized by both driver and recorder and will be recorded before conducting the travel time runs.

   Using detector counts and machine counts for traffic volume data, an estimate of total vehicle miles will be made. Travel time data from "floating-cars" will be used to estimate total vehicle hours.

   Improvements that affect traffic flow for limited sections of roadway, by reducing interactions between vehicles, may not always significantly change travel times or delays. These improvements, however, may considerably influence the smoothness or quality of traffic flow.

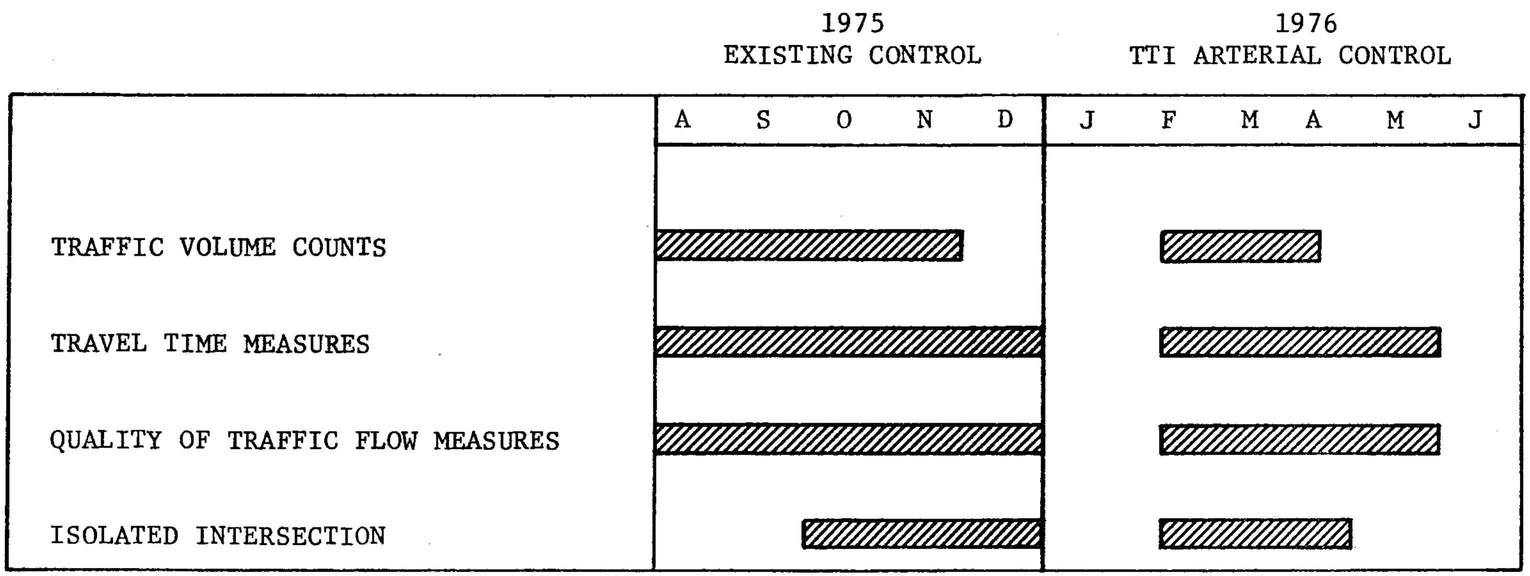


Figure 2. Field work plan. **(Bar Graph)**

(Schedule subject to adjustment depending on field hardware installation schedule)

Quality of traffic flow may be expressed quantitatively by acceleration noise, Greenshield's Index, or other similar measures. Sufficient time distance information will be collected and recorded using a test vehicle. Appendix B gives details of the test vehicle.

The study procedure used in this data collection is designed to produce the maximum information about each individual study. The following data will be obtained for each study:

1. Complete study description.
   Environmental conditions.
   Pavement conditions.
2. Time (sec.).
3. Distance/sec. (feet).
4. Brake applications.
5. Fuel consumption.
6. Manual event records.

3. *Isolated Intersections* - Certain intersections, primarily north of Mockingbird, will be part of the progression control; but due to wide spacing, these intersections will operate in isolated mode much of the time. In these cases, optimization of individual intersection operation will be measured. Overall delay, queue lengths, and other measures of individual operation will be determined at representative multi-phase intersections. These studies are envisioned to be on-site evaluations by field personnel.

4. *Bus Preferential Treatment* - Preferential treatment of buses will be studied in a related contract - The Urban Corridor Demonstration Program. Control algorithms will have an optional feature where bus preferential treatment techniques may be tested within the overall control strategy or may be deleted.

IV. *Sample Selection and Statistical Design*

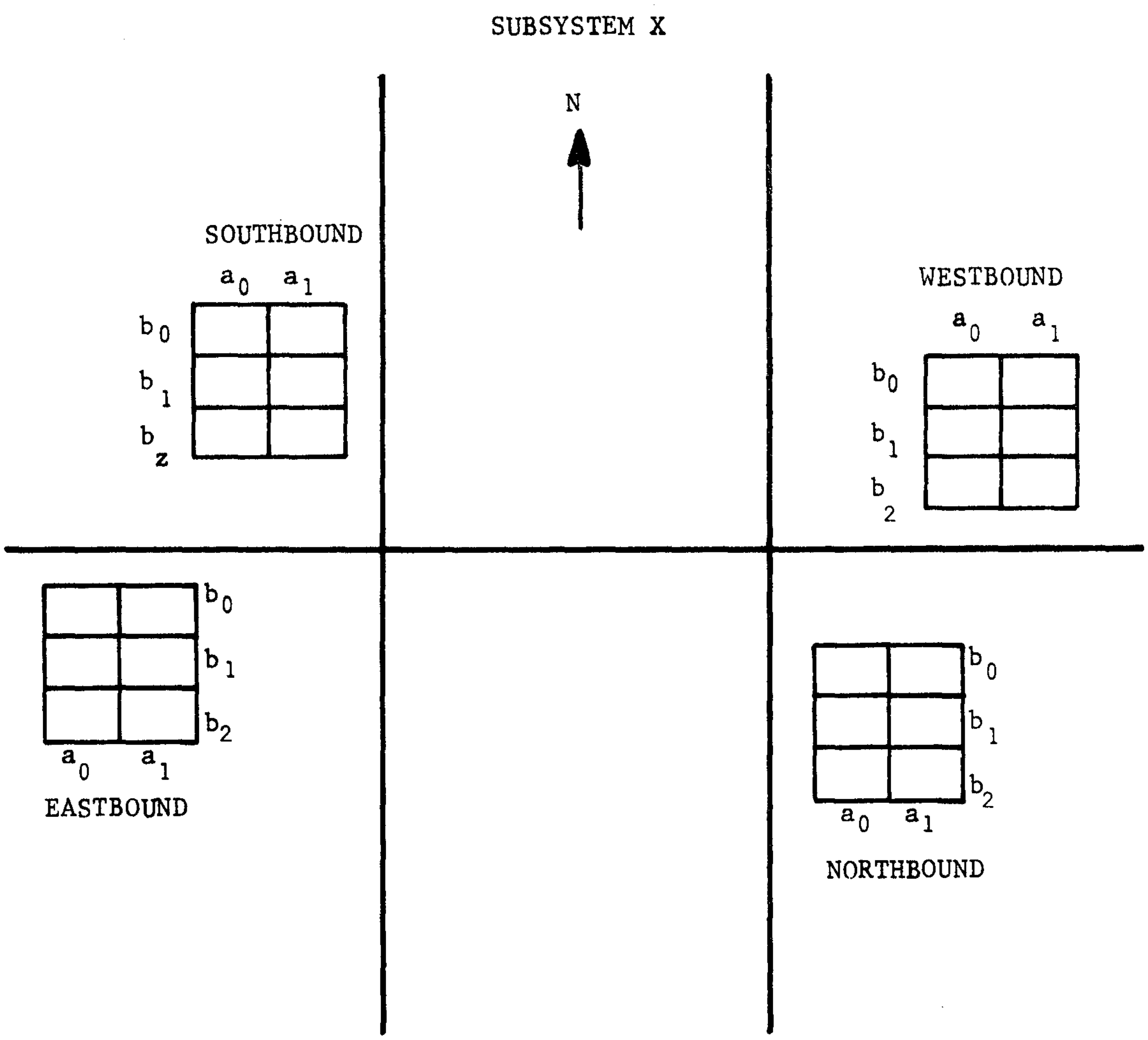
1. *Sample Selection* - The determination of sample size for evaluation parameters is extremely important. Due to increased inflationary costs for manpower and equipment, a minimum number of collection activities consistent with statistical soundness is mandatory. There is neither time nor funds for an "over-kill" data collection program.

   The number of travel time and quality of flow samples required to adequately measure changes on a section of roadway depends on the length of the section and the variability of traffic flow. A definitive study for determination of the number of travel time runs for statistically significant comparisons[7] was developed by the Los Angeles Bureau of Traffic Research. It is proposed that this technique be used for sample size selection.

   Under this approach, coefficient of variation ($s/\bar{x}$) is estimated to be 0.14 in the major direction for a study of eleven (11) links, approximately 2.5 miles. At 95 percent level of confidence, a minimum sample size of eight (8) runs per major arterial is estimated for measuring changes of 15 percent or greater. If the computed coefficient of variation $s/\bar{x}$ is highly variable from the estimate, more runs will be required.

2. *Experimental Statistical Design and Evaluation* - The proposed experimental statistical design for evaluating the arterial roadway operation will follow sound statistical procedures consistent with available data collection capabilities and operational objectives. Several approaches will be used in analyzing a measure of effectiveness. These will range from simple composite averages, displayed in graphic and tabular form, to detailed factorial treatment combination statistical designs using analysis of variance techniques[8] to determine whether significant effects and changes have occurred in a measure of effectiveness of frontage road control.

   Factorial Design - The factorial structure of the experimental statistical design is complex but logical. Basically, a factor is something in the study that might cause a change in the measure of effectiveness being considered. Those factors which will be considered are type of control, time of day, direction of flow, and subsystem location. Thus, a 2 (control) x 3 (time) x 2 (direction) x 3 (subsystem) factorial treatment study design results. Figure 3 shows a matrix of the proposed factorial design.



a_0 = local fixed time control

a_1 = system control

b_0 = a.m. peak period

b_1 = p.m. peak period

b_2 = off-peak

Figure 3. Factorial design. (Schematic)

The factorial design combined with the analysis of variance technique will permit an in-depth evaluation of the success of the arterial computer control implementation phase of the research project. Any significant improvements that may result due to control on either an overall system or individual subsystem basis can be determined. These capabilities far outweigh any negative consequences that might arise from using a somewhat complex statistical analysis procedure. Computer programs are available at the Texas A&M Computer Facility for making analysis of variance studies.

A factorial design analysis will be conducted for each of several of the measures of effectiveness previously described. An analysis will be performed for each of the utilization measures - arterial volume, screenline volume, and arterial to screenline ratio. Similarly, a factorial analysis will be performed on selected quality of flow measures and travel time.

Mean Differences - For some of the evaluation studies, it may not be possible to collect sufficient data to perform a factorial design analysis. Some subsystems may not be included, and certain times may be missed or not appropriate for analysis. In these cases where it is necessary to pool the "before" data to get sufficient "before" and "after" sample sizes, the mean difference statistical test can be used. The test is basically one of forming a hypothesis that the "before" and "after" means are the same versus the alternate hypothesis that the means are statistically significantly different. The results of the test reveal the appropriate hypothesis.

REFERENCES

1. Evaluation of Ramp Control Operation on North Central Expressway. Texas Transportation Institute. March 1972.

2. Messer, C. J. and Whitson, R. H. Dallas Corridor Frontage Road Evaluation Plan. Texas Transportation Institute Report RF 953-12. August 1973.

3. Optimizing Flow in an Urban Freeway Corridor. Texas Transportation Institute Report RF 590-F. November 1971.

4. Whitson, R. H., White, B., and Messer, C. J. Arterial Progression Control as Developed on the Mockingbird Pilot Study. Texas Transportation Institute Report RF 953-3. February 1972.

5. Whitson, R. H. and Carvell, J. D. A Variable Phase Sequence Progression Optimization System. IFAC, IFIP, IFORS 2nd Word Symposium. September 1974.

6. White, B. Actuator Program Documentation for Frontage Road Control. Texas Transportation Institute Report RF 953-6. March 1975.

7. Terry, D. S., Hernandez, V. L., and Taylor, S. S. Minimum Number of Travel Time Runs Required to Obtain Statistically Significant Results. Bureau of Traffic Research, City of Los Angeles, May 1971.

8. Ostle, B. Statistics in Research. Iowa State University Press. 1964.

APPENDIX A

GASTON (PAULUS TO OAKLAND) SCHEMATIC (PART I)
ARTERIAL CONTROL
SUBSYSTEM

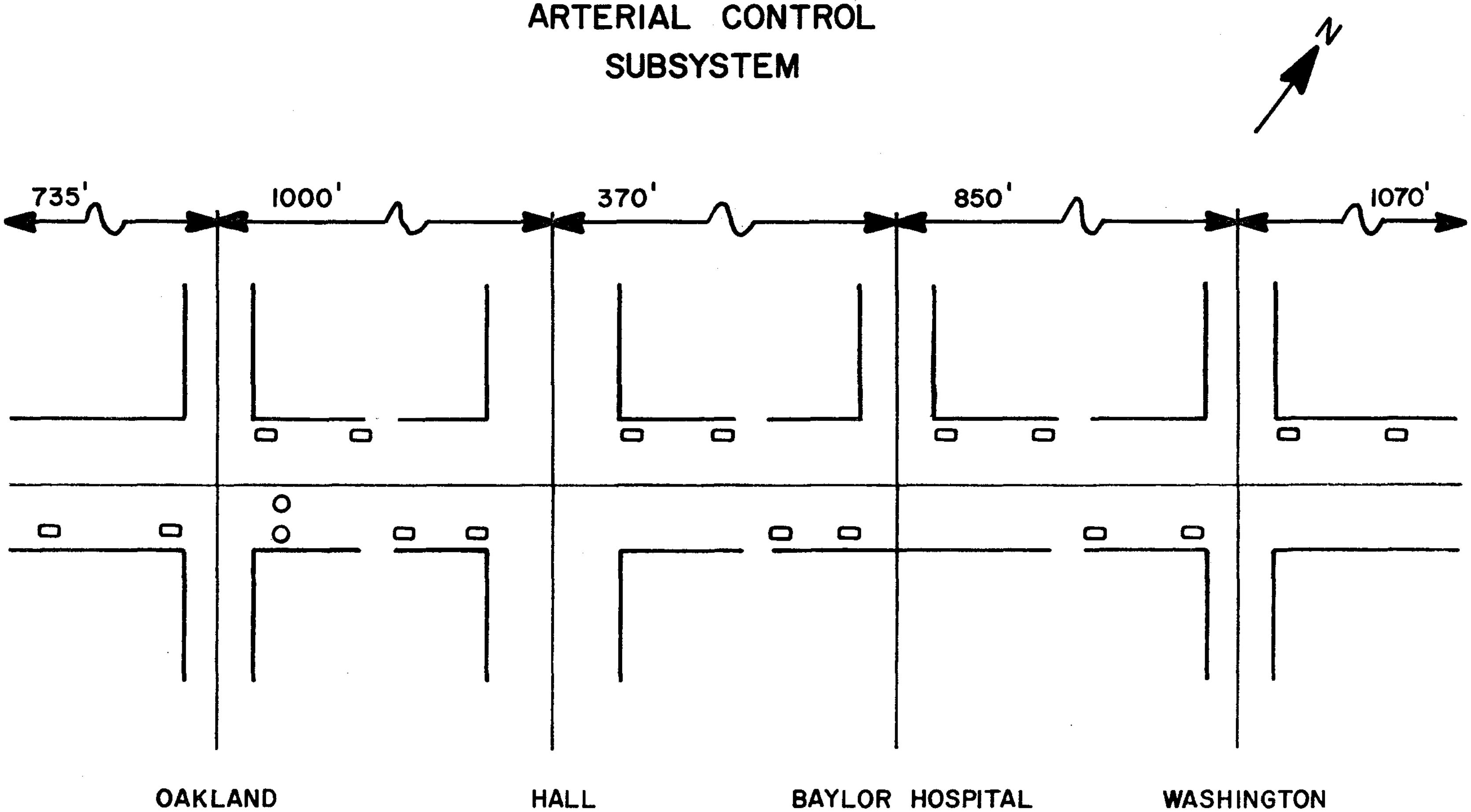


Figure 4

GASTON (PAULUS TO HALL) SCHEMATIC (PART 2)
ARTERIAL CONTROL
SUBSYSTEM

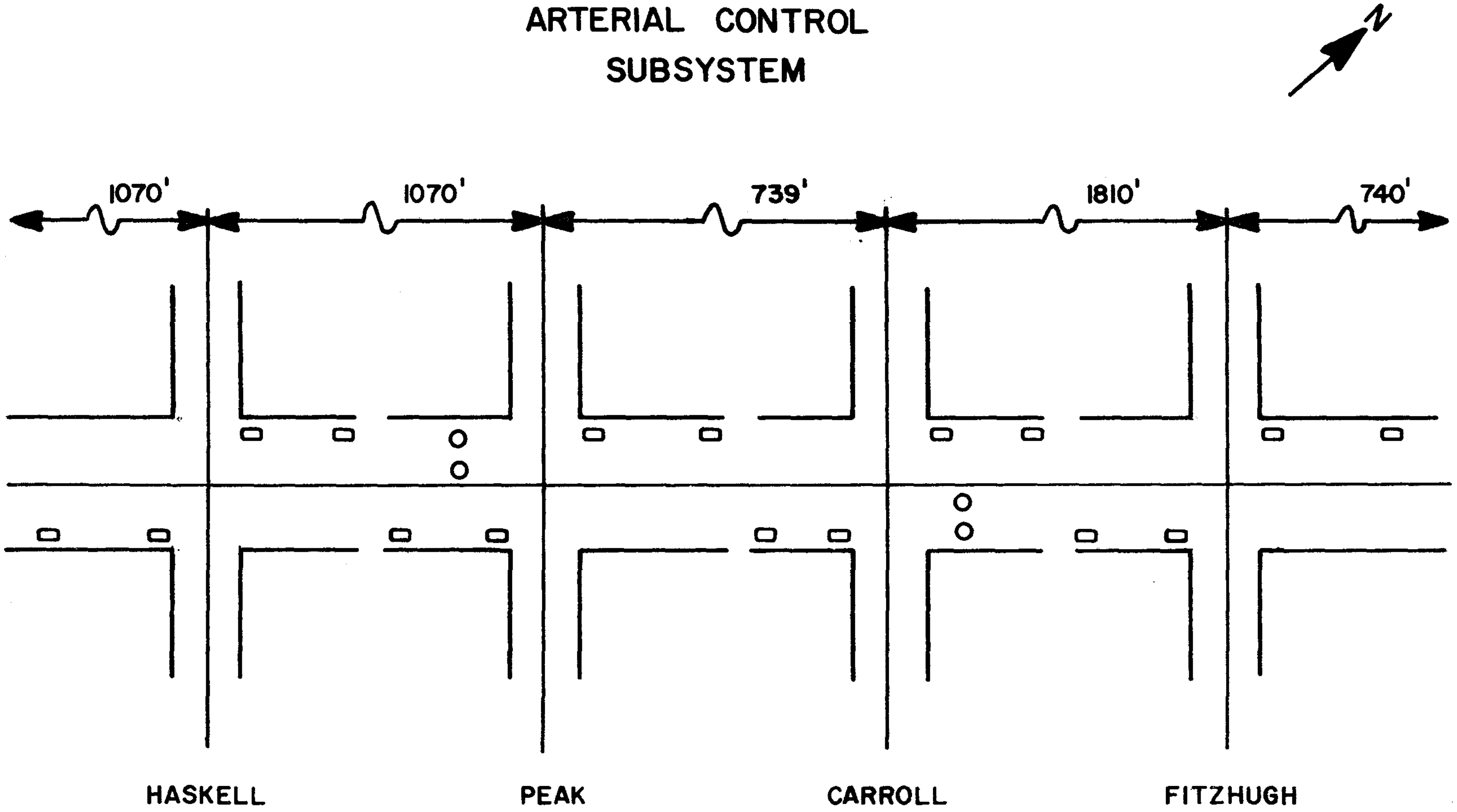


Figure 5

GASTON (PAULUS TO HALL) SCHEMATIC (PART 3)

ARTERIAL CONTROL SUBSYSTEM

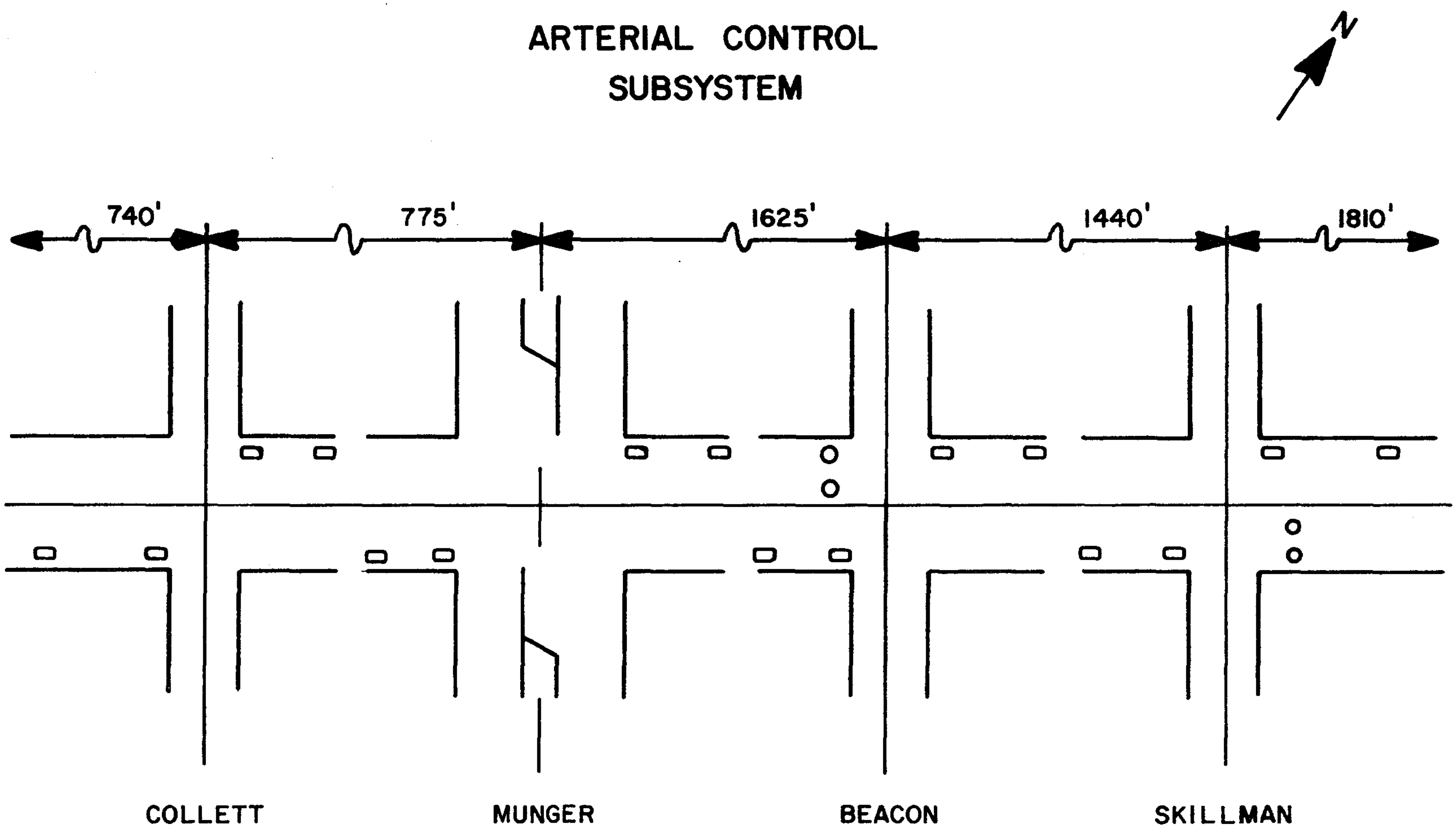


Figure 6

GASTON (PAULUS TO HALL) SCHEMATIC (PART 4)
ARTERIAL CONTROL
SUBSYSTEM

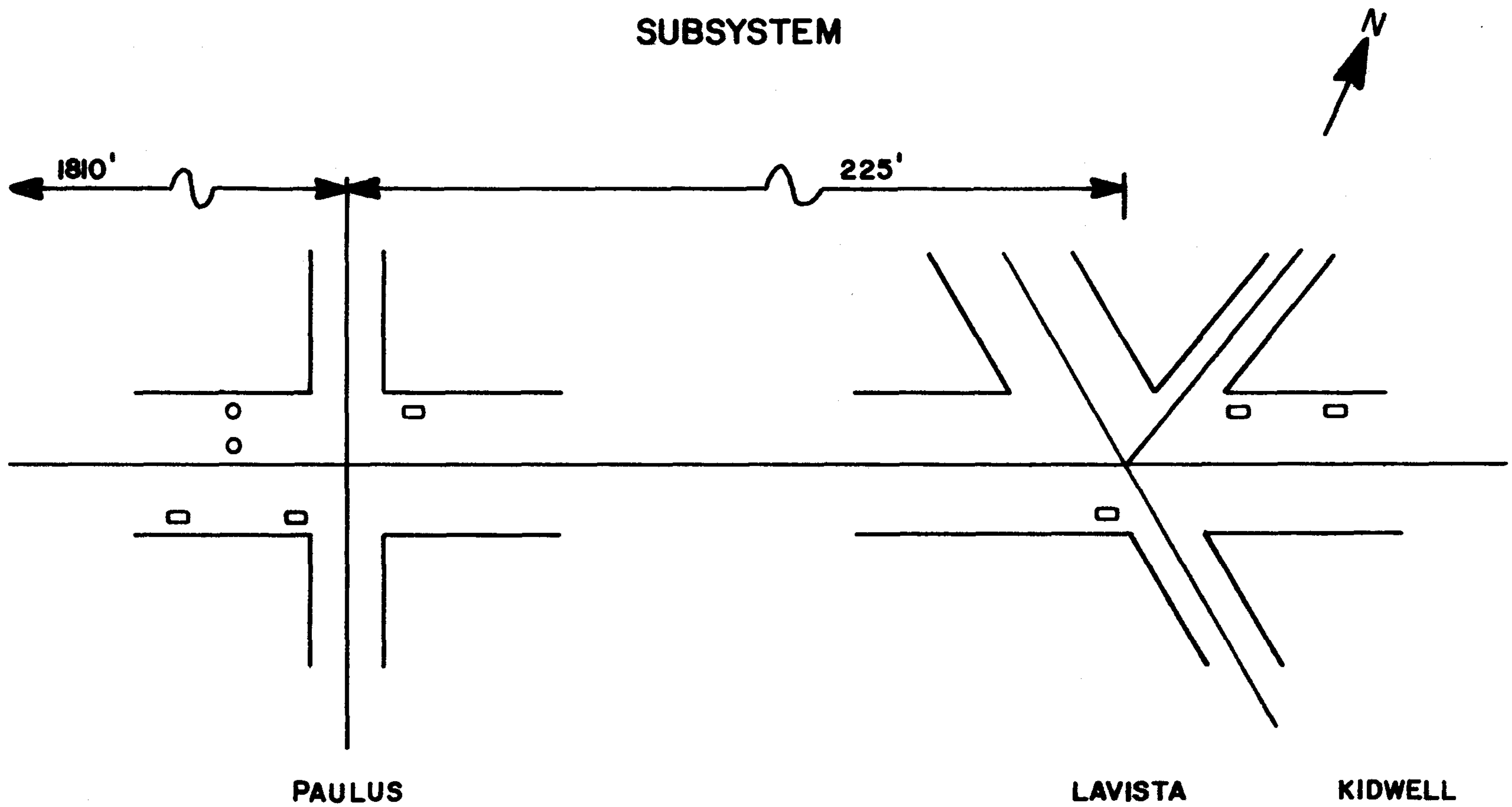


Figure 7

ABRAMS (KENWOOD TO GASTON) SCHEMATIC (PART I)
ARTERIAL CONTROL
SUBSYSTEM

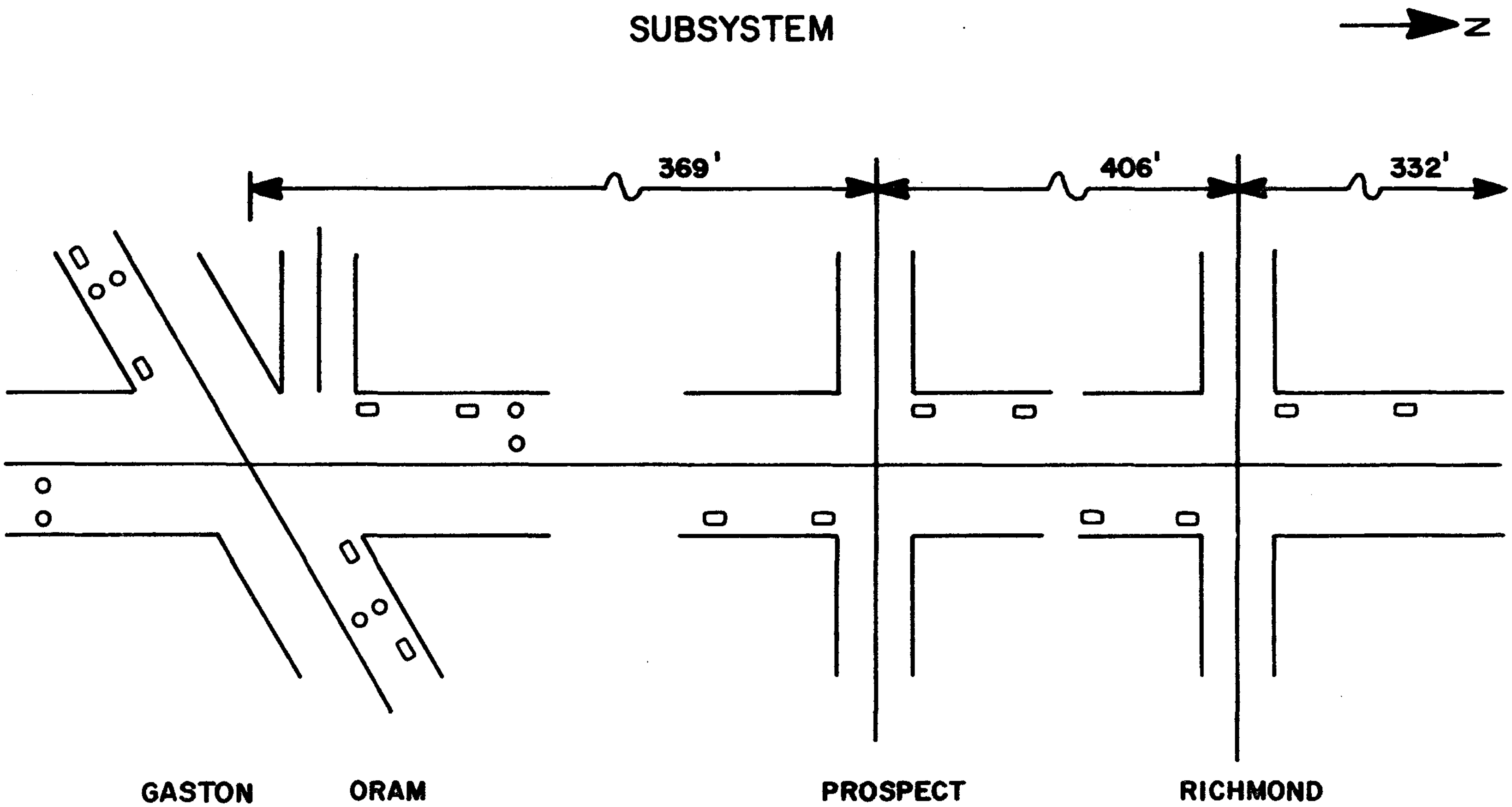


Figure 8

ABRAMS (KENWOOD TO GASTON) SCHEMATIC (PART 2)
ARTERIAL CONTROL
SUBSYSTEM

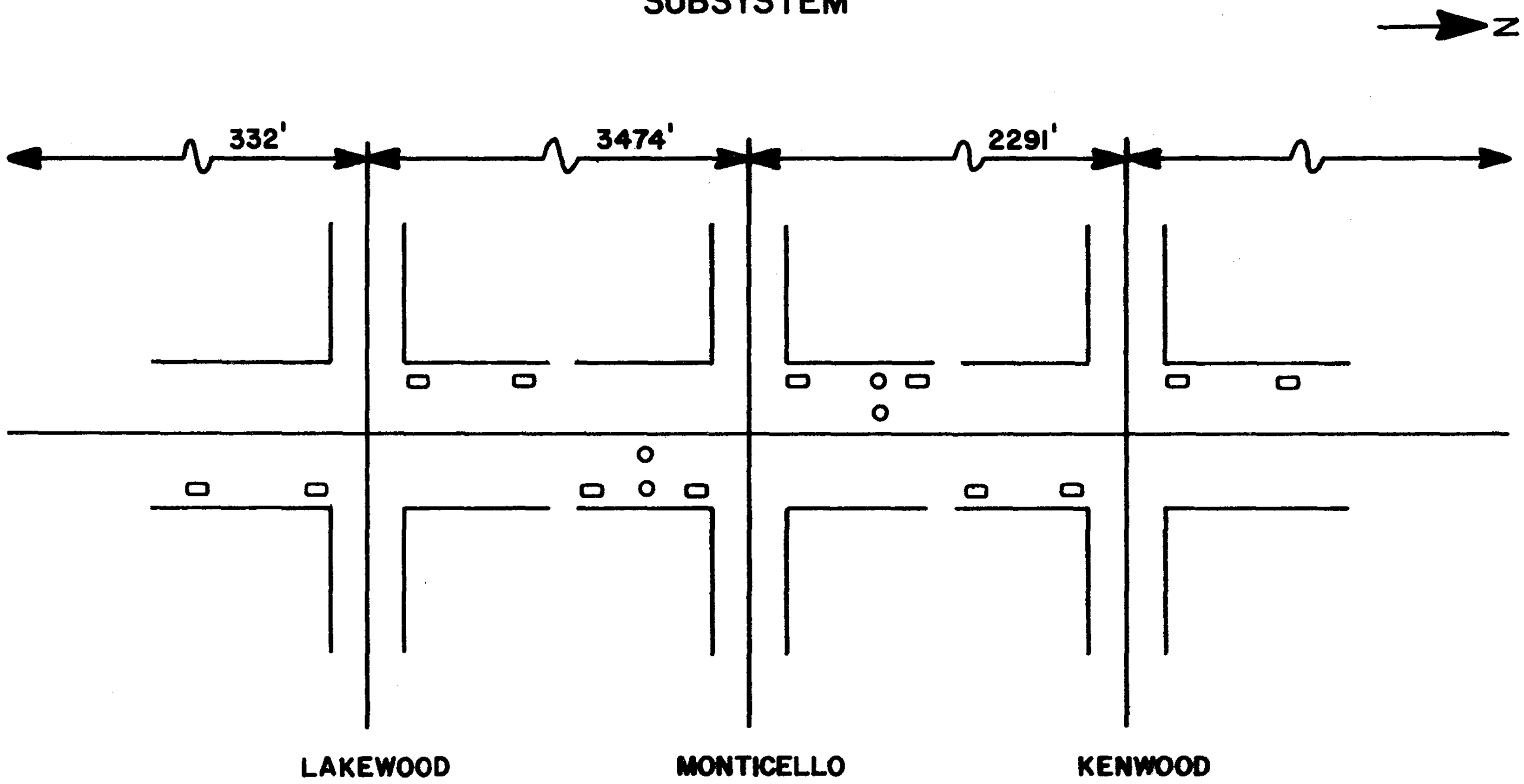


Figure 9

LIVE OAK SOUTH SCHEMATIC (PART I)
ARTERIAL CONTROL
SUBSYSTEM

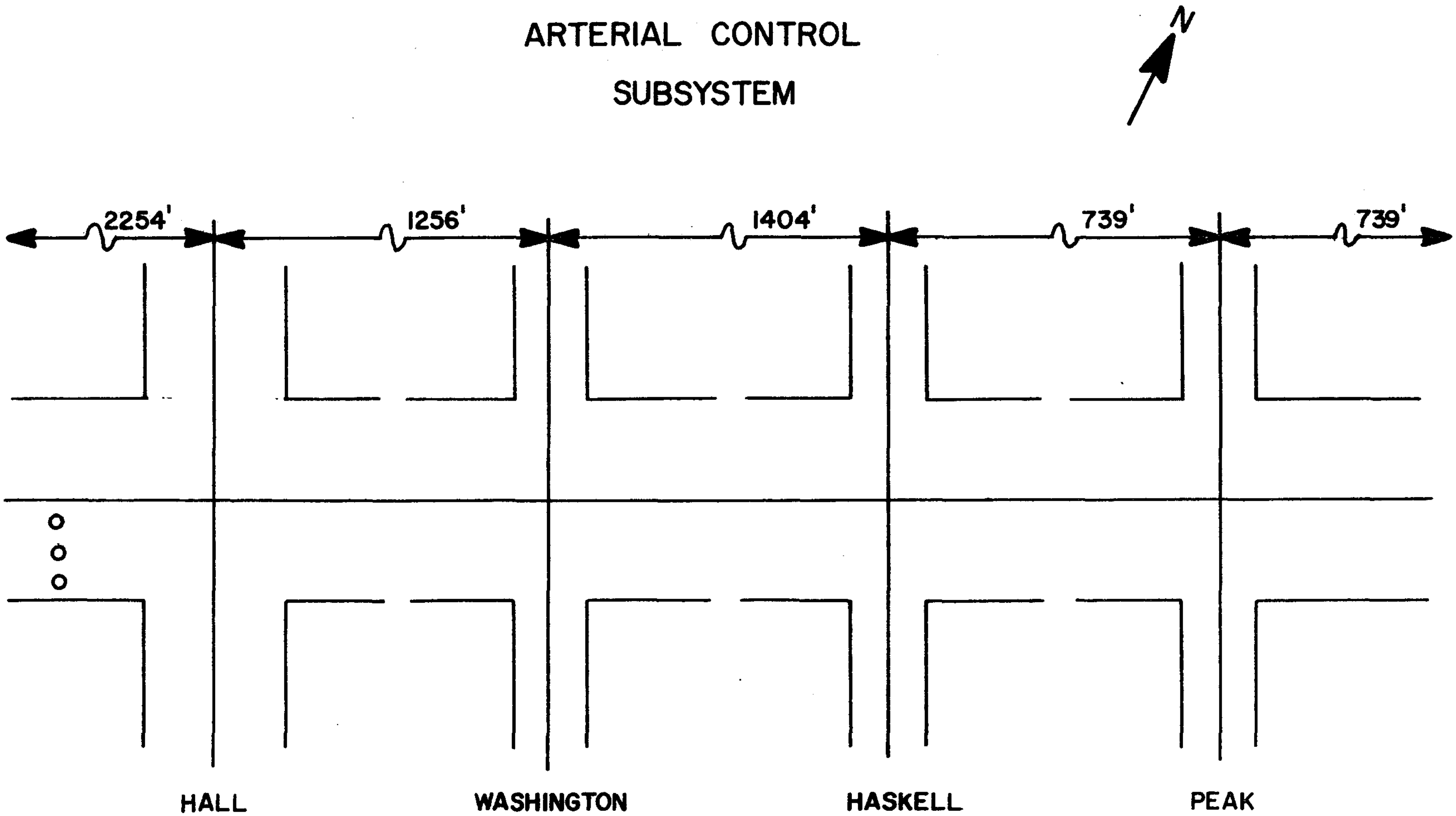


Figure 10

LIVE OAK SOUTH SCHEMATIC (PART 2)
ARTERIAL CONTROL
SUBSYSTEM

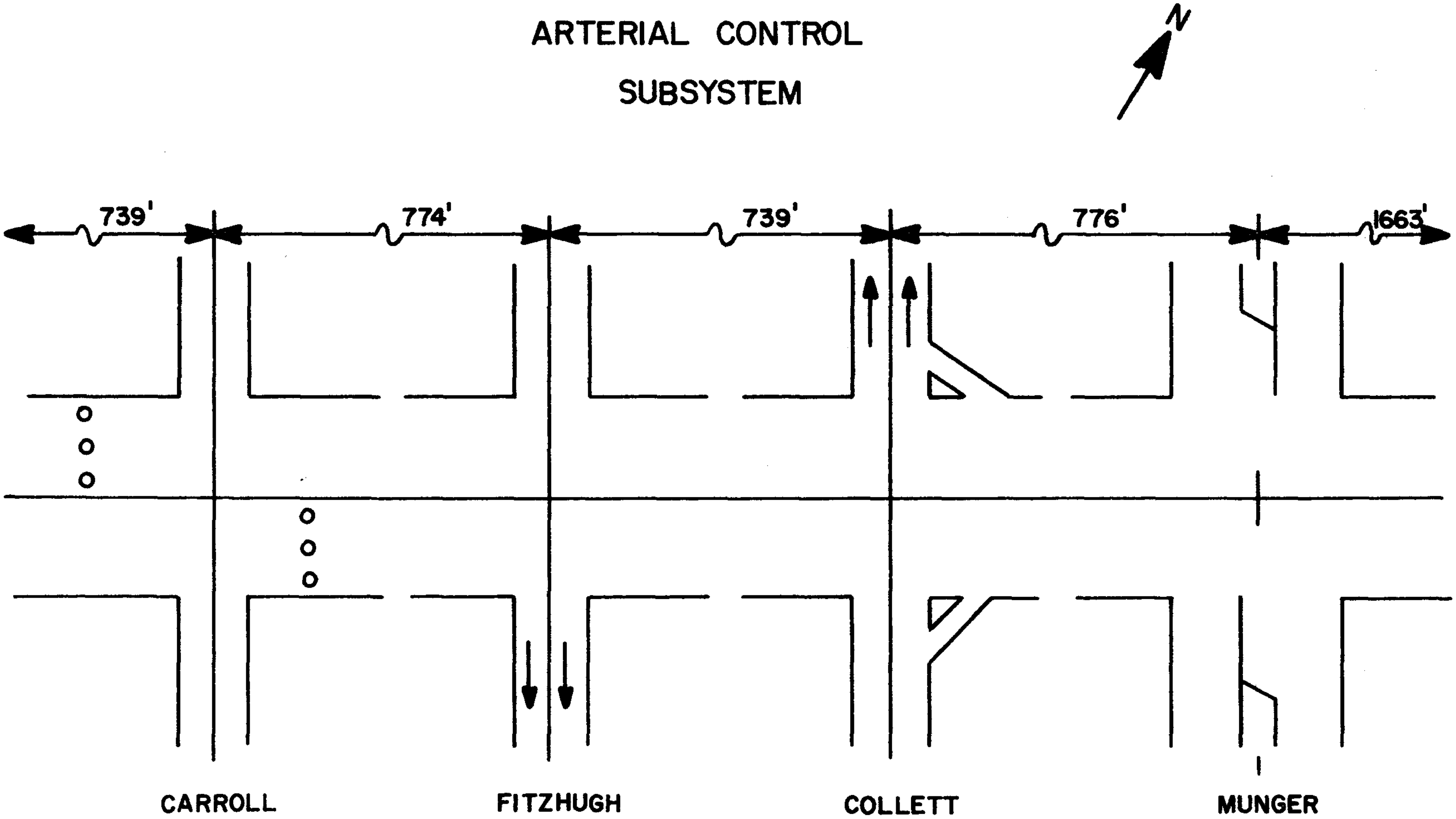


Figure 11

LIVE OAK SOUTH SCHEMATIC (PART 3)
ARTERIAL CONTROL
SUBSYSTEM

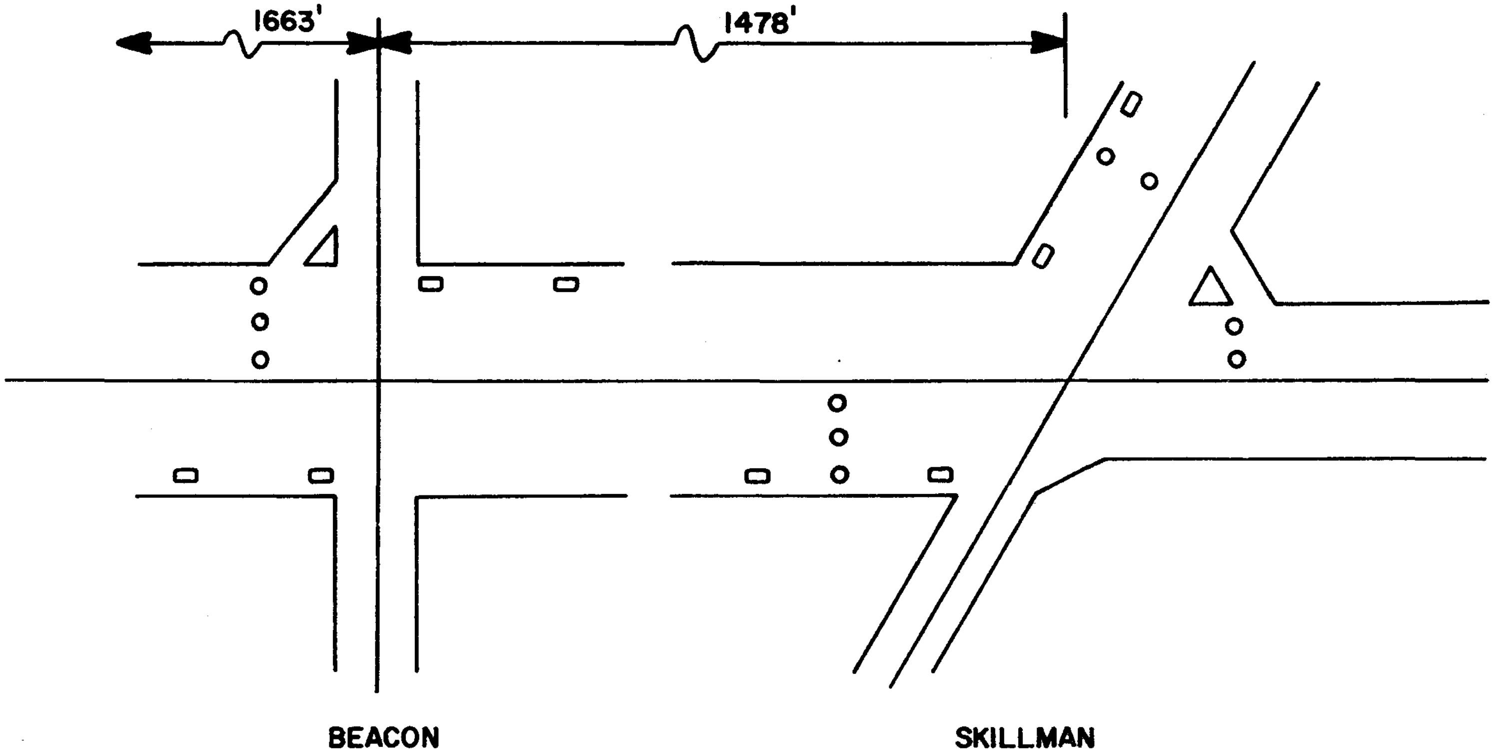


Figure 12

SKILLMAN (McCOMMAS TO ORAM) SCHEMATIC
ARTERIAL CONTROL
SUBSYSTEM

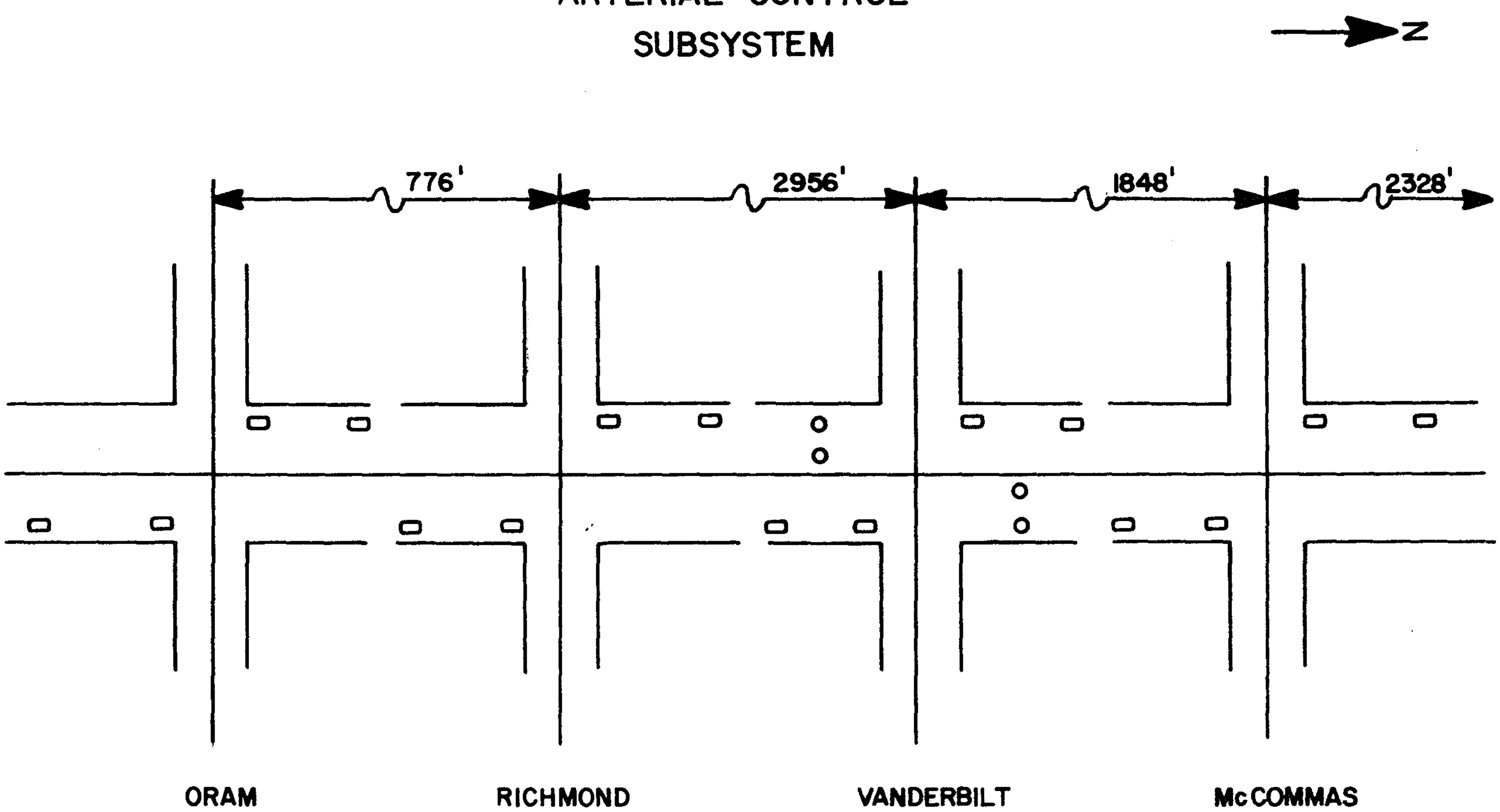


Figure 13

BRYAN (BENNETT TO HALL) SCHEMATIC (PART I)
ARTERIAL CONTROL SUBSYSTEM

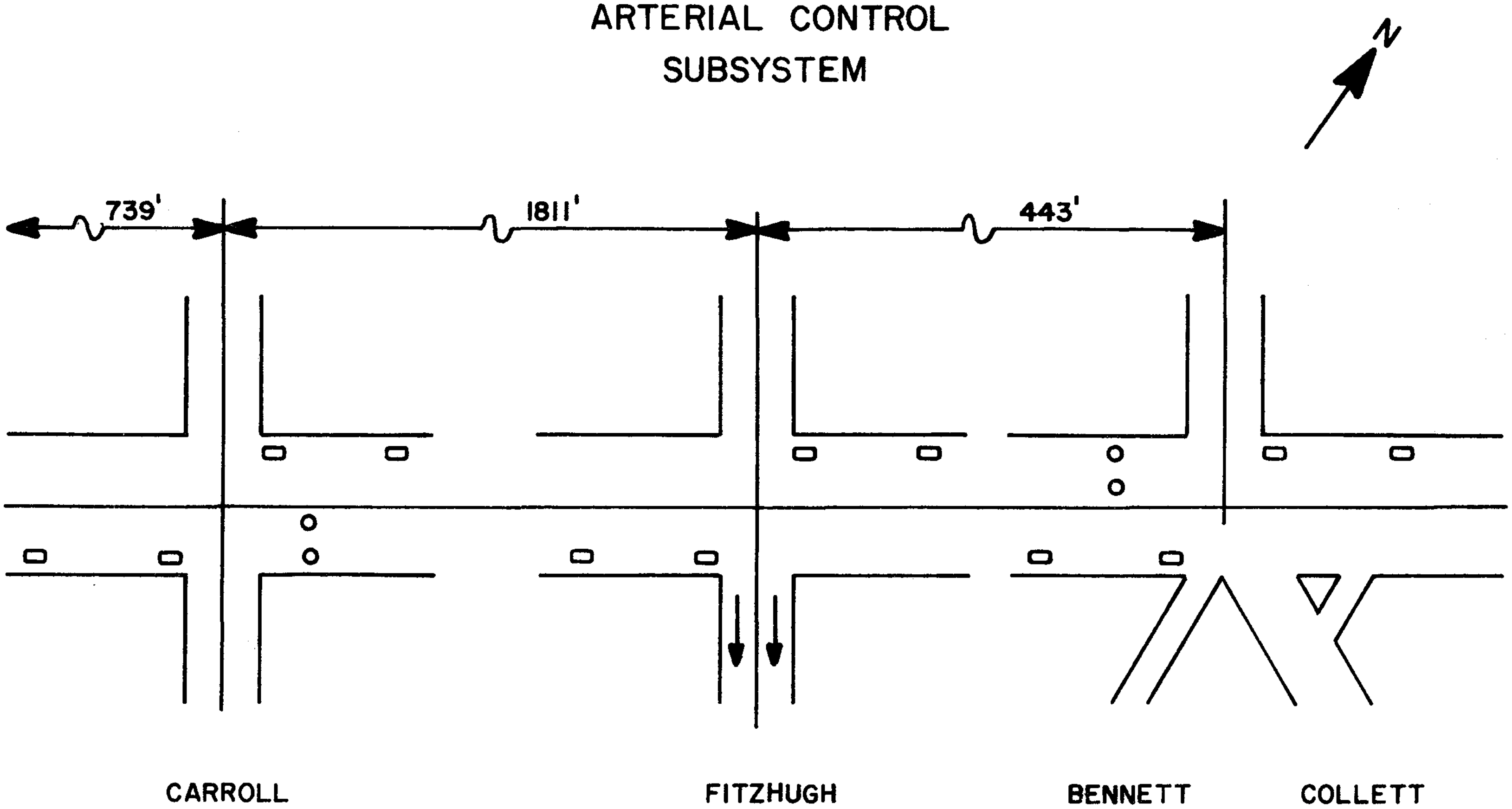


Figure 14

BRYAN (BENNETT TO HALL) SCHEMATIC (PART 2)
ARTERIAL CONTROL SUBSYSTEM

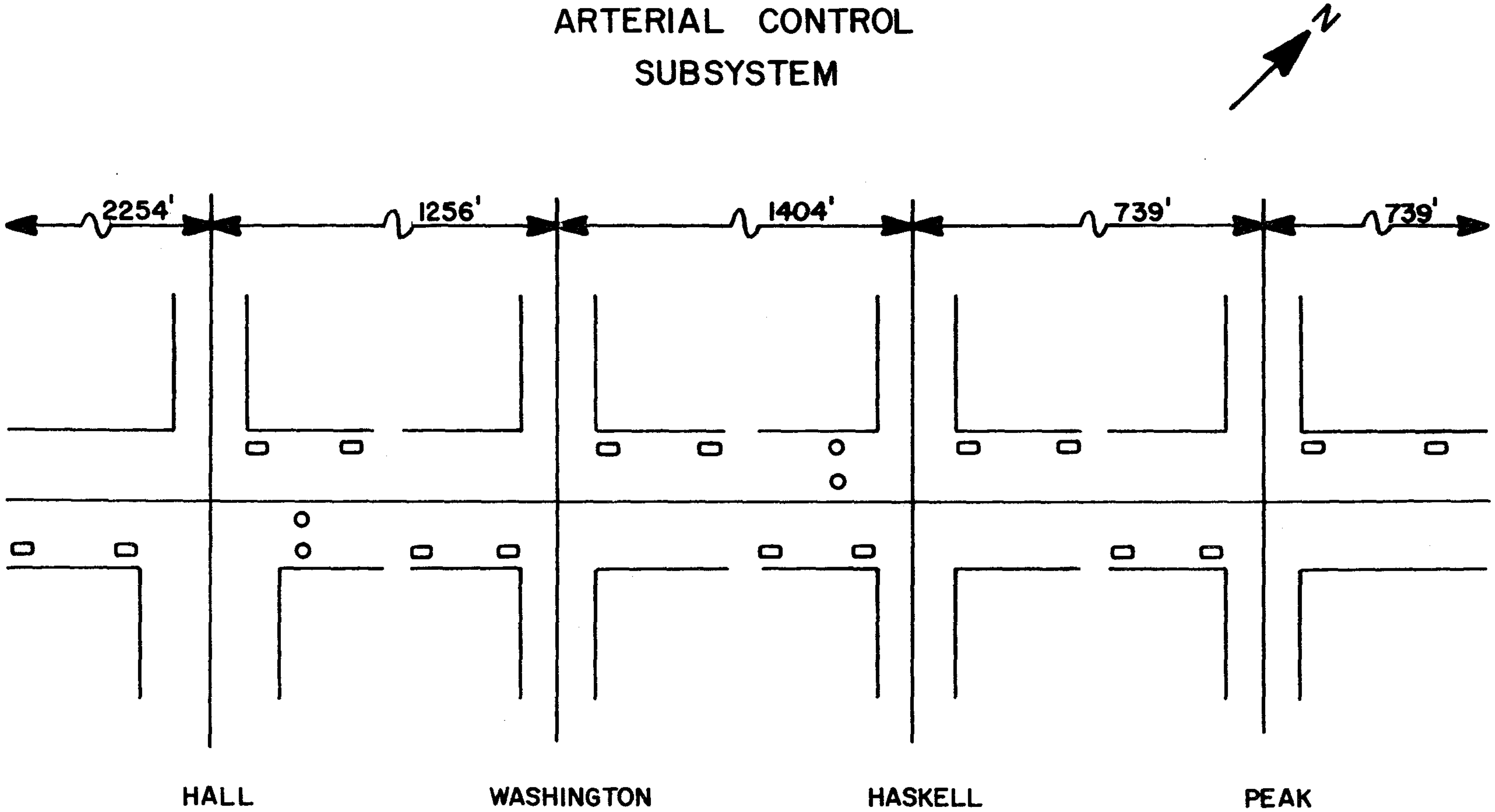


Figure 15

ROSS (GREENVILLE TO HALL) SCHEMATIC (PART I)

ARTERIAL CONTROL

SUBSYSTEM

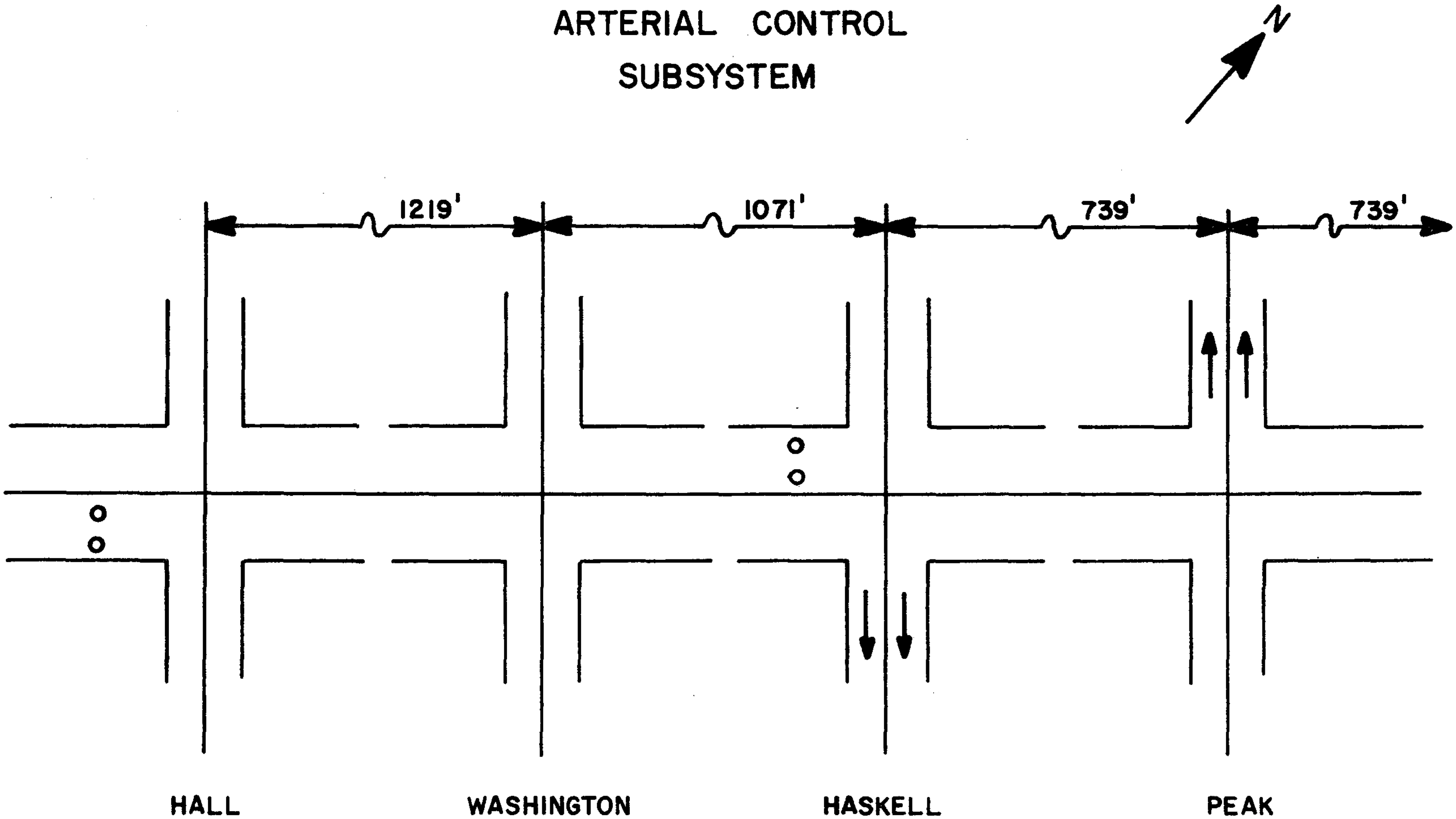


Figure 16

ROSS (GREENVILLE TO HALL) SCHEMATIC (PART 2)

ARTERIAL CONTROL

SUBSYSTEM

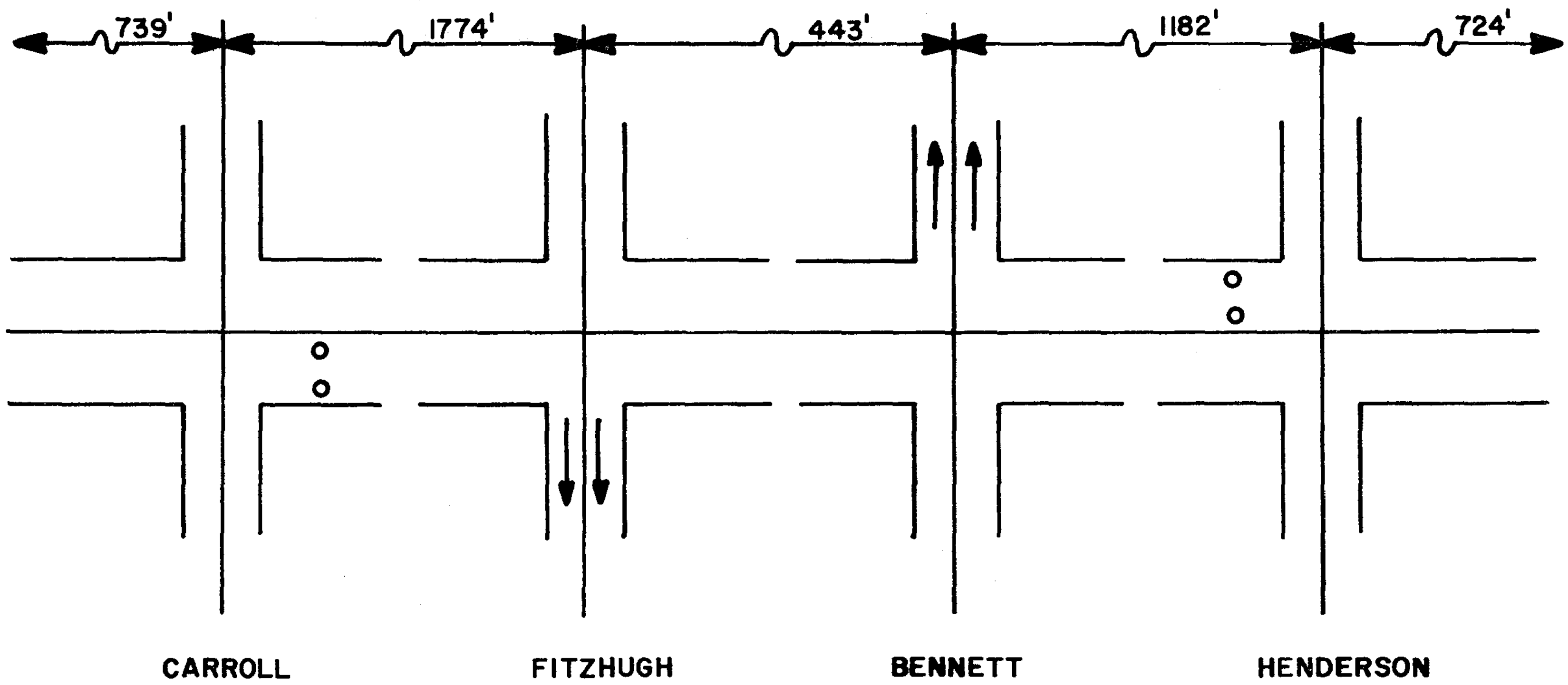


Figure 17

ROSS (GREENVILLE TO HALL) SCHEMATIC (PART 3)
ARTERIAL CONTROL
SUBSYSTEM

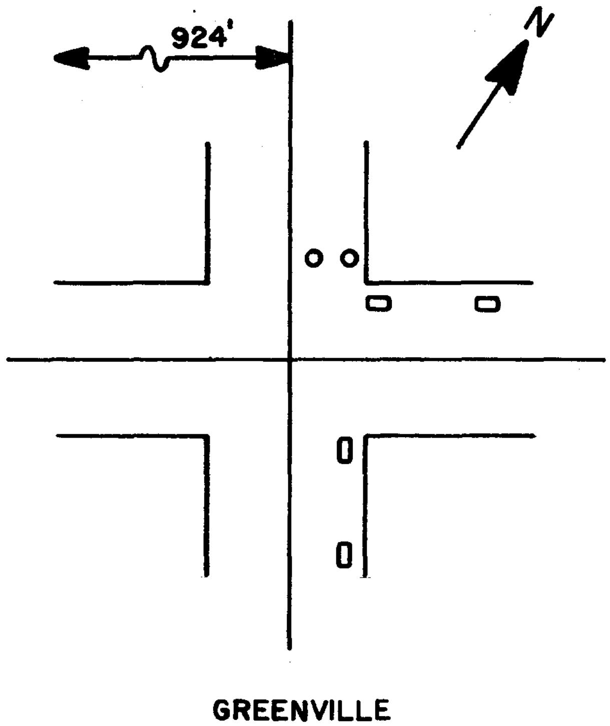


Figure 18

GREENVILLE (McCOMMAS TO SEARS) SCHEMATIC
ARTERIAL CONTROL SUBSYSTEM

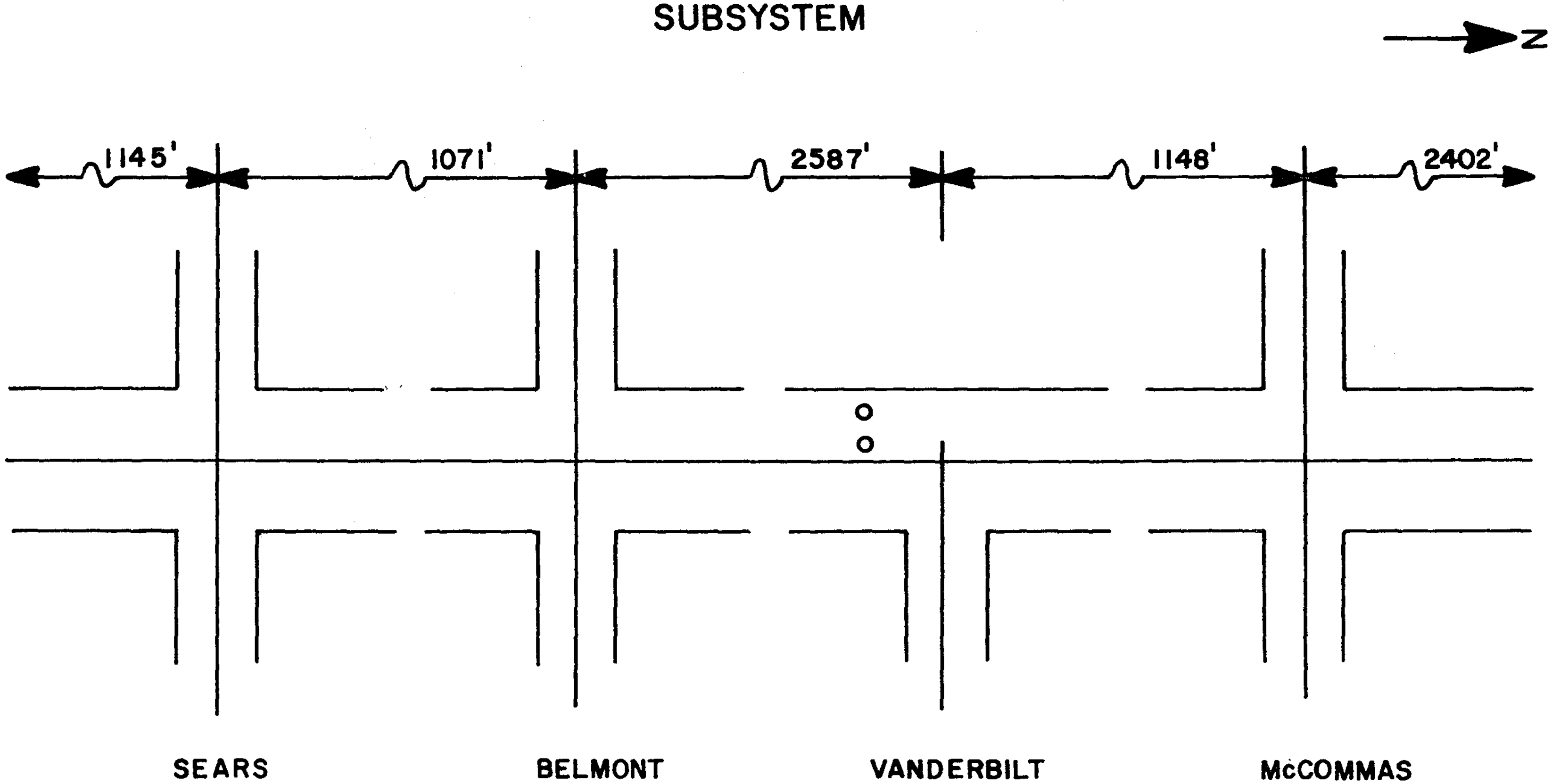


Figure 19

ABRAMS NORTH SCHEMATIC (PART I)

ARTERIAL CONTROL SUBSYSTEM

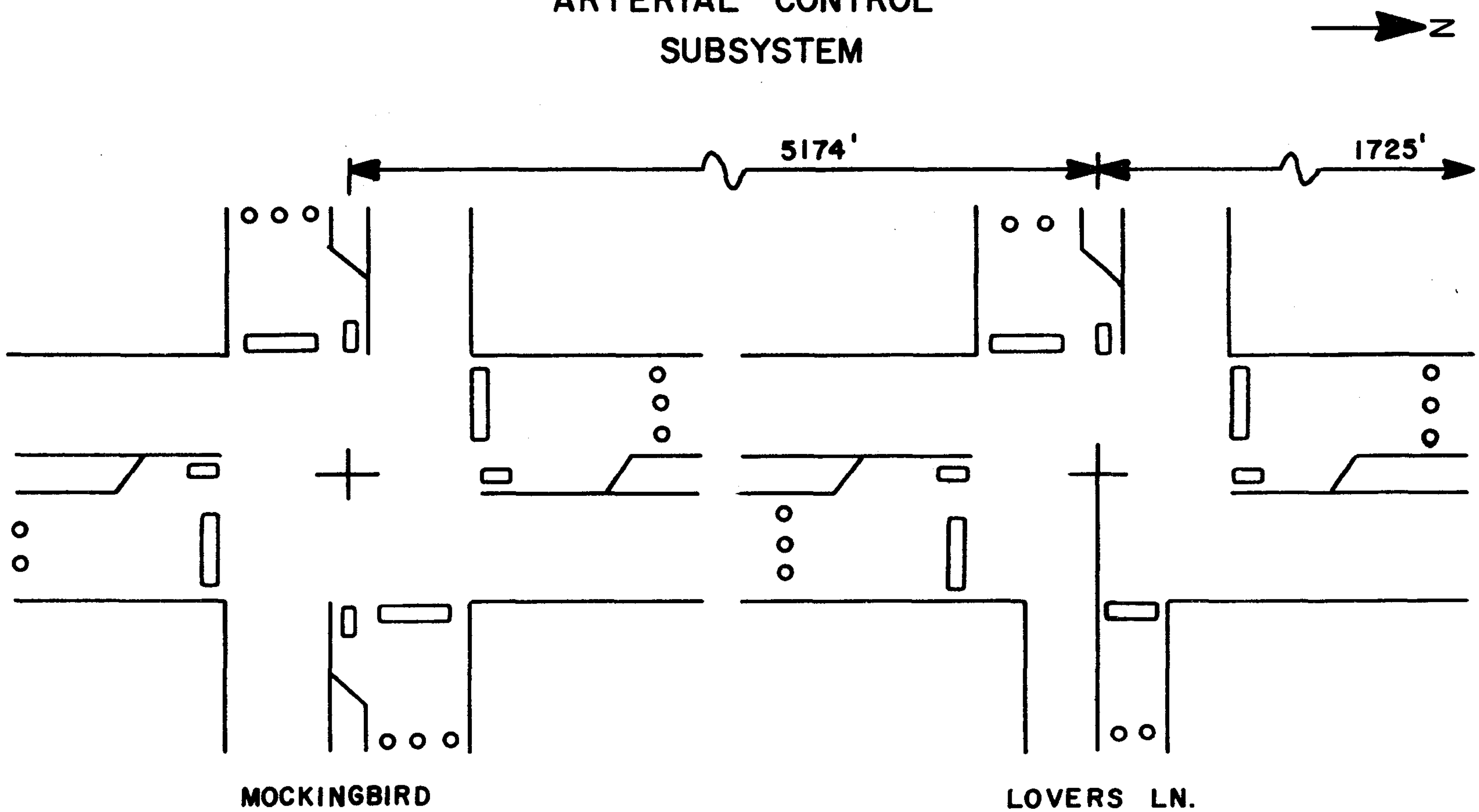


Figure 20

ABRAMS NORTH SCHEMATIC (PART 2)
ARTERIAL CONTROL
SUBSYSTEM

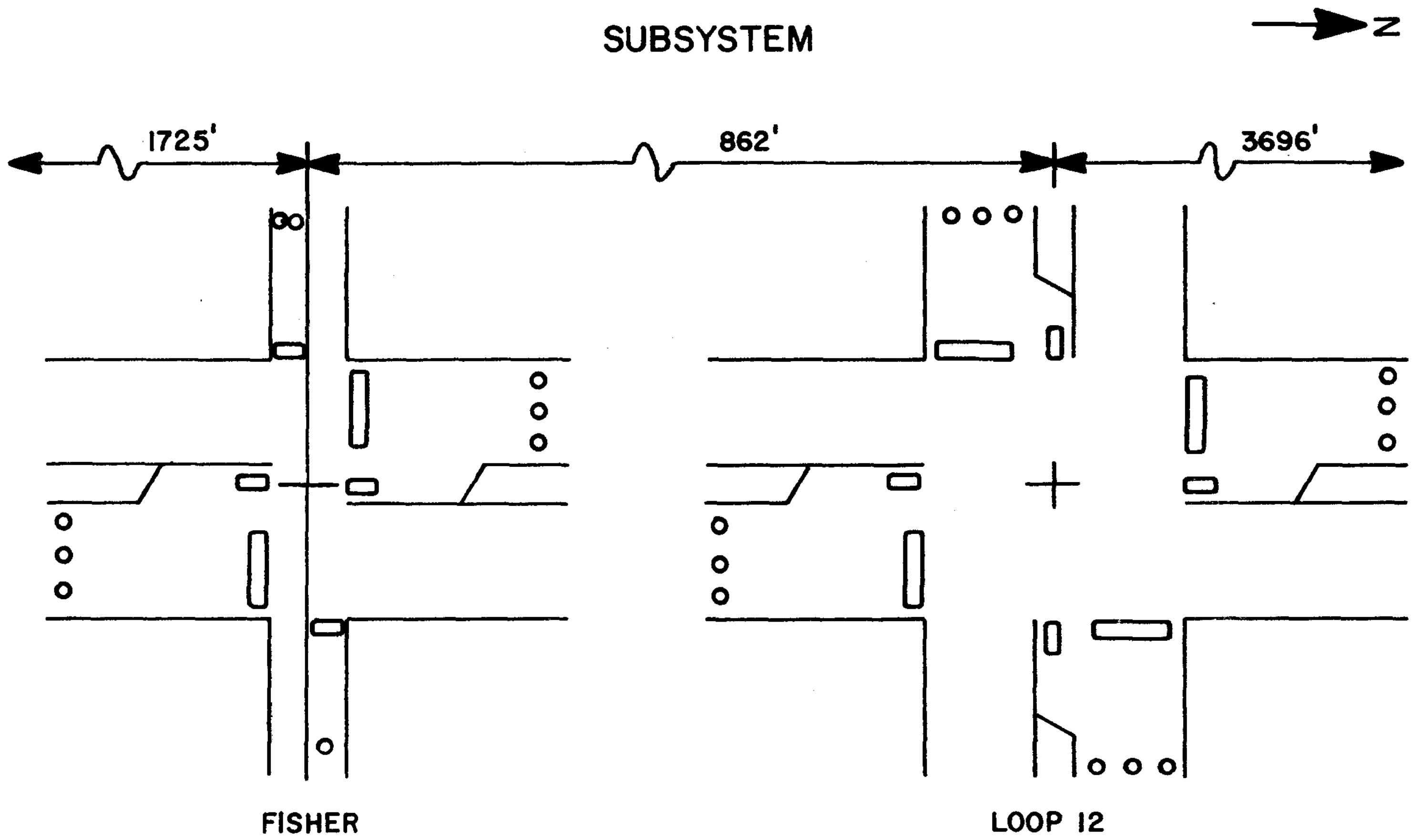


Figure 21

ABRAMS NORTH SCHEMATIC (PART 3) ARTERIAL CONTROL SUBSYSTEM

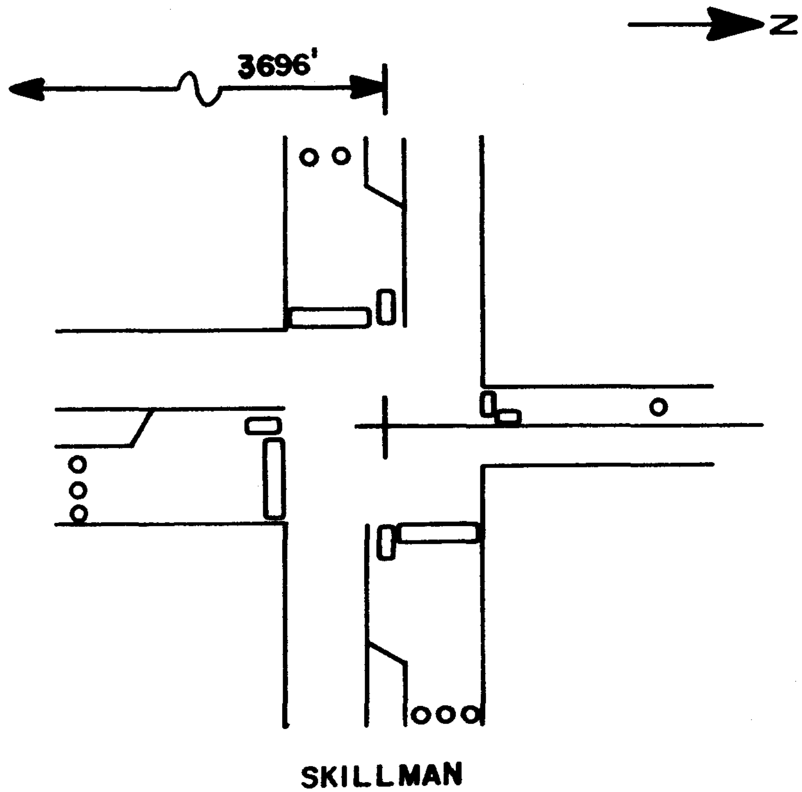


Figure 22

SKILLMAN NORTH SCHEMATIC (PART I)
ARTERIAL CONTROL
SUBSYSTEM

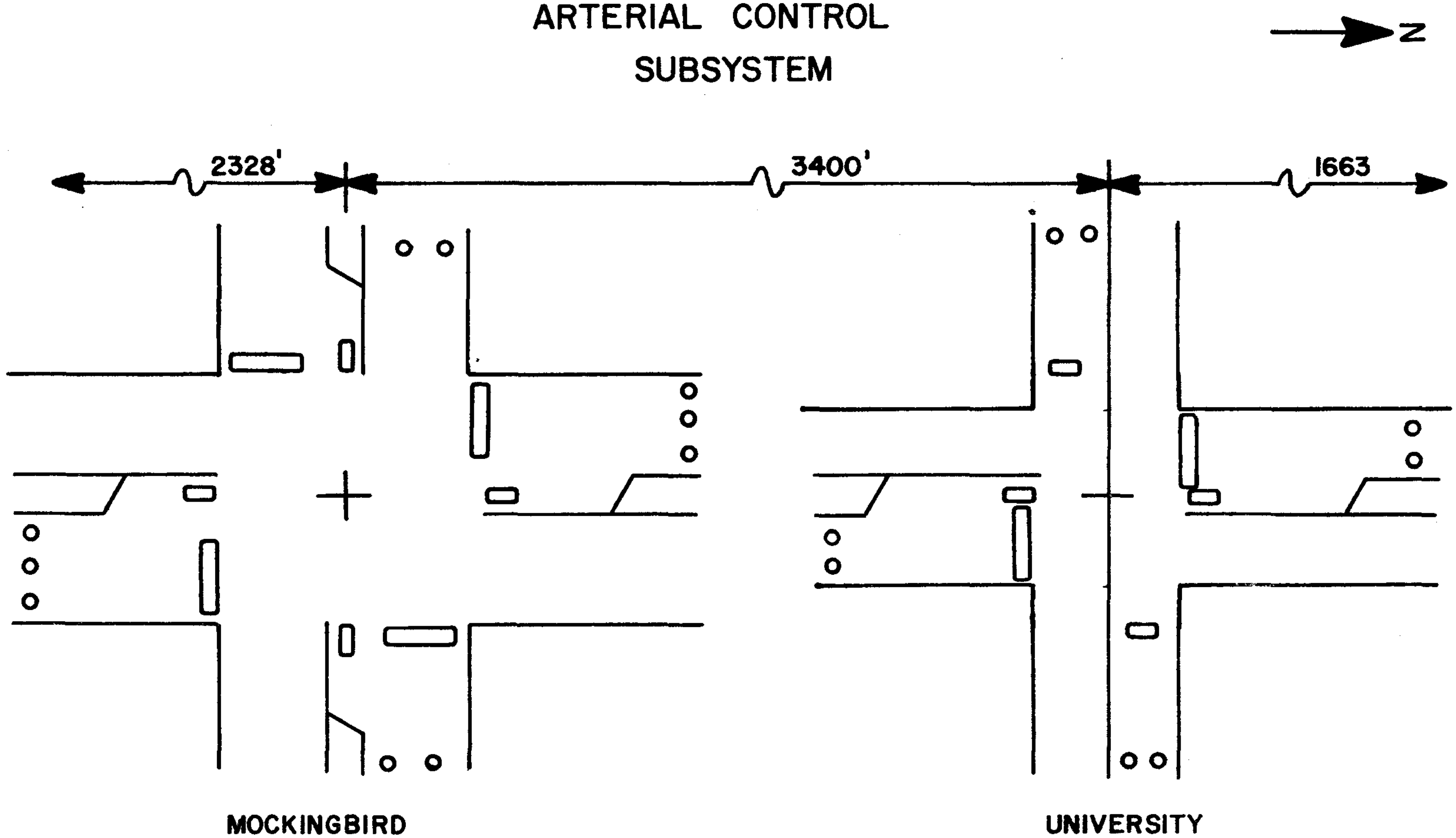


Figure 23

SKILLMAN NORTH SCHEMATIC (PART 2)
ARTERIAL CONTROL
SUBSYSTEM

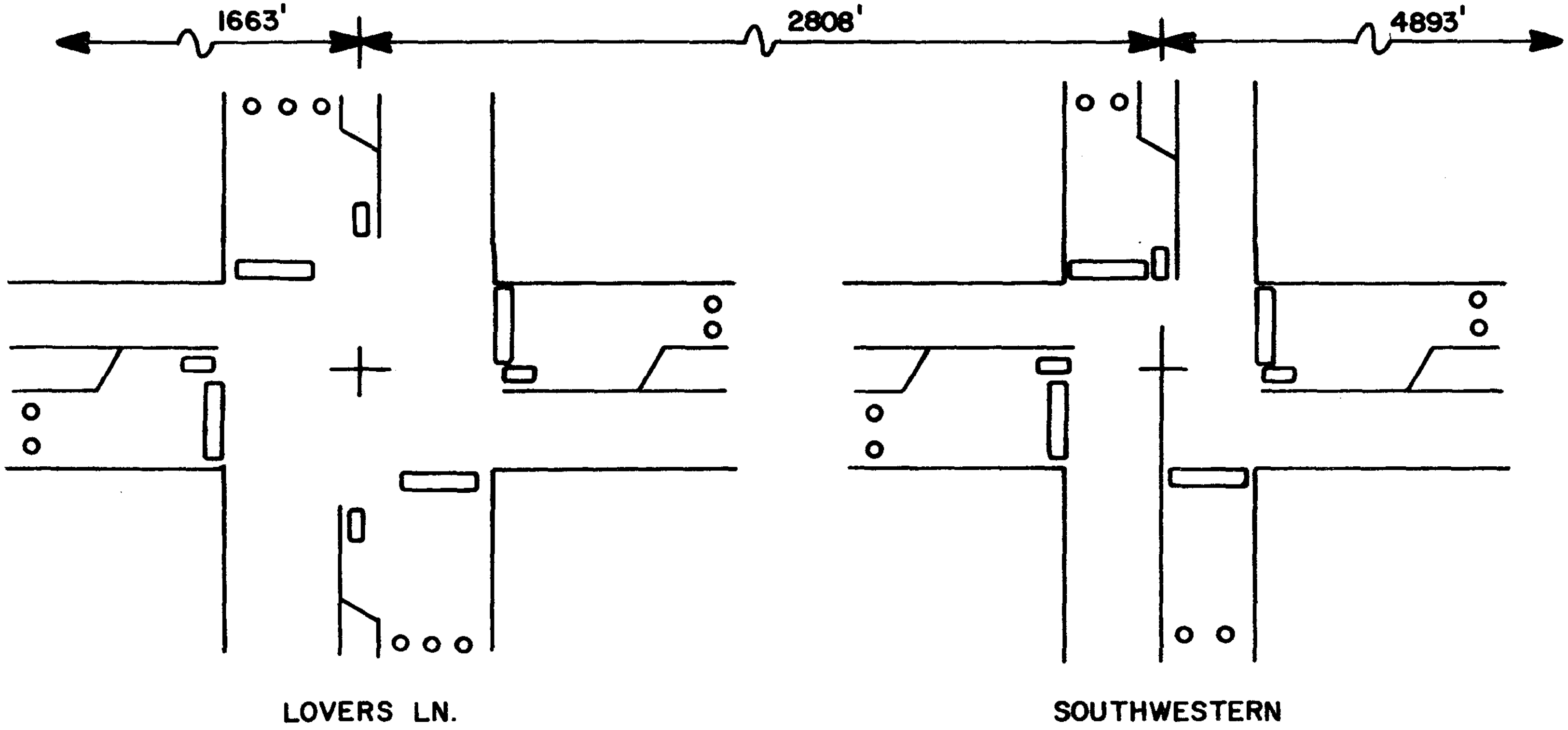


Figure 24

GREENVILLE NORTH SCHEMATIC (PART I)
ARTERIAL CONTROL
SUBSYSTEM

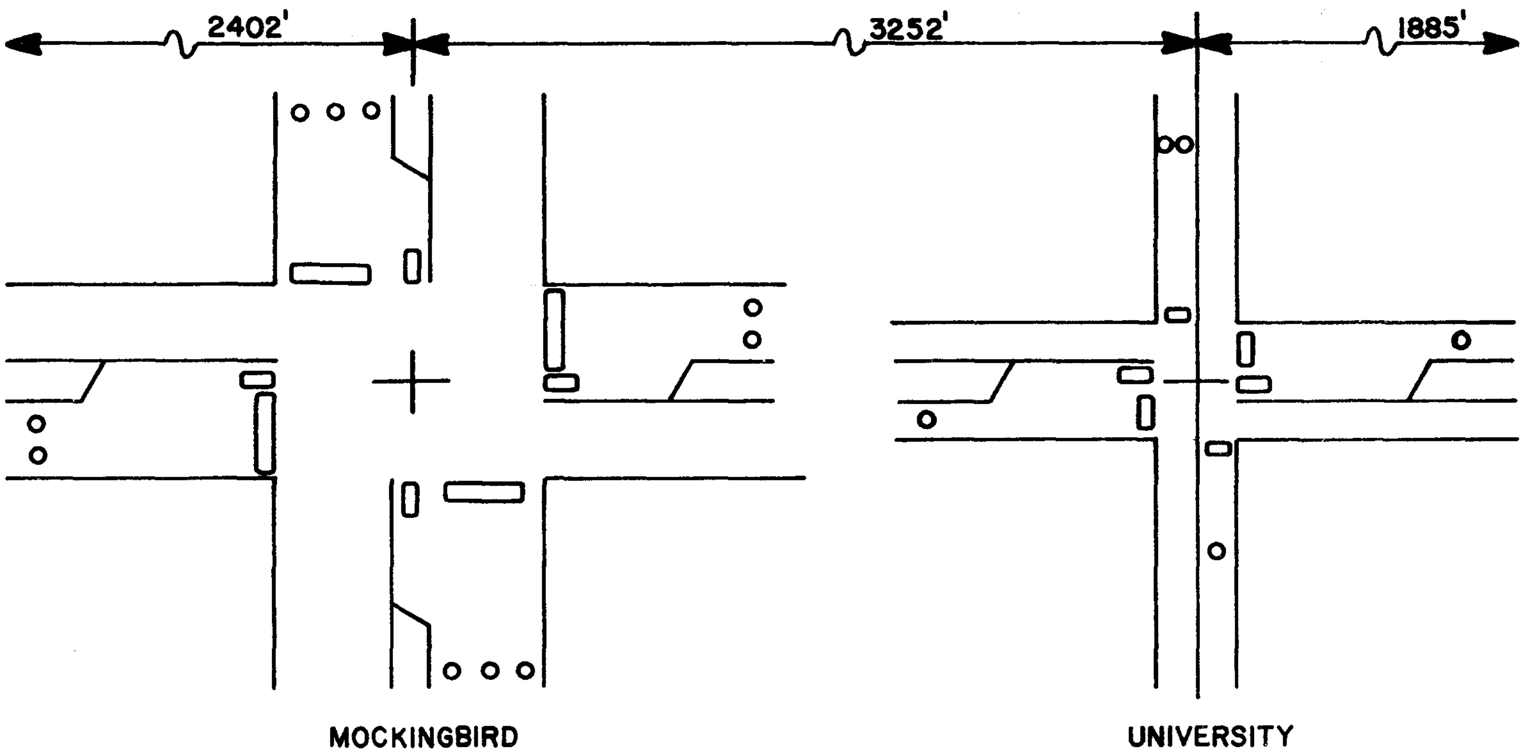


Figure 25

GREENVILLE NORTH SCHEMATIC (PART 2)
ARTERIAL CONTROL
SUBSYSTEM

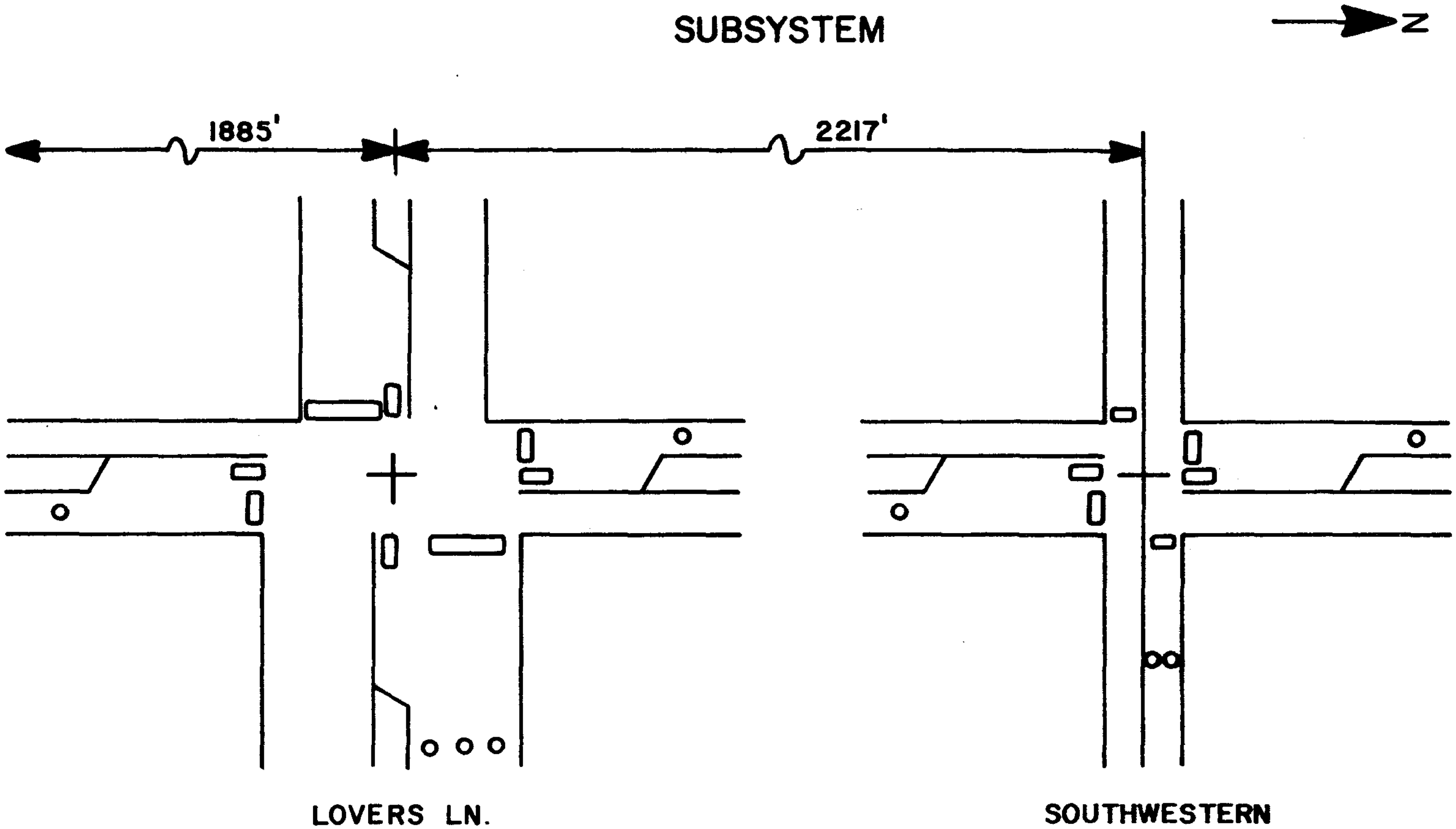


Figure 26

APPENDIX B

APPENDIX B

Instrumented Vehicle

In order to serve current and future needs of transportation research in the area of vehicle-driver-environment interactions, an automobile has been designed at Texas A&M University to measure and record the actions of the car and its driver throughout various specified driving tests.

The automobile selected for instrumenting is a 4-door Dodge Monaco. The car has the following equipment:

1. Air conditioner
2. Radiator, heavy duty with coolant recovery system
3. Radio, AM
4. Remote control left and right, outside mirrors.
5. H.D. shocks
6. Tinted windows
7. Cruise control
8. H.D. transistorized electrical system
    a) 80 amp battery
    b) 100 amp alternator
9. Transmission coolant package
10. H.D. springs - H.D. suspension - front and rear H.D. stabilizer
11. Calibrated speedometer
12. Rear window defogger
13. 400 CID/2BBL V8
14. Radial tires

The data collection-recording computer system has the following equipment:

1. Four thousand-word memory 1200 NOVA central processing unit - Data General Model No. 8182
2. Automatic program loader - Data General Model No. 8108
3. Input/output interface unit - Data General Model No. 4007
4. Real-time clock - Data General Model No. 4008
5. Input/output sub-assembly with D.G. connector No. 4192 - Data General Model No. 4191
6. Input/output interface - Data General Model No. 4066
7. Punch-read combination Remex Machine Model No. RAB 6375
8. Remex computer interface for NOVA 1200 - Model No. RIA/DG-1/2
9. RCA Numitron - Three, 7-digit displays, 0-9 with one decimal
10. One, 10-key keyboard with 0-9 industry standard and format, plus one extra key for keyboard entry with 4-bit encoder (Micro-switch 12NW43-3)

The quantities that the system will initially monitor and record are:

1. Time (real-time computer clock)
2. Distance (magnetic system on the wheels)
3. Brake applications
4. Fuel consumption
5. Manual input

Provisions have also been made for future installation of physiological sensors such as heart-rate.

The output signals from several measuring transducers will be recorded simultaneously on paper tape. This tape may be played back through any teletype type paper tape read unit.