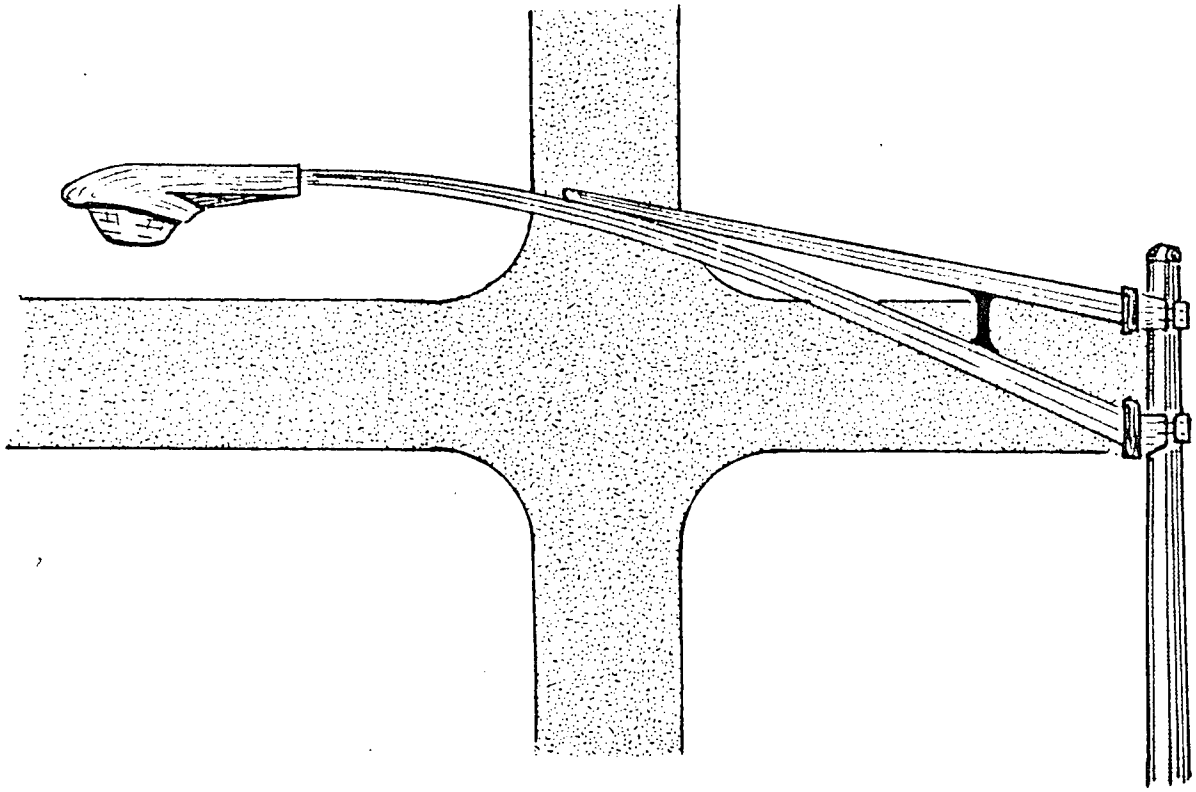
EFFECTS OF
REDUCED INTERSECTION LIGHTING
ON
NIGHTTIME ACCIDENT FREQUENCY



FINAL REPORT

RESEARCH PROJECT HR-1003A

HIGHWAY DIVISION

NOVEMBER 1977

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Materials

Effects of Reduced Intersection Lighting

FINAL REPORT
FOR
RESEARCH PROJECT HR-1003A

EFFECTS OF

REDUCED INTERSECTION LIGHTING

ON

NIGHTTIME ACCIDENT FREQUENCY

BY

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NOVEMBER 1977

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HIGHWAY DIVISION
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TABLE OF CONTENTS

ABSTRACT

The first phase of the study of intersection lighting and accidents conducted using data from 1964 through 1971 yielded the conclusion that the installation of intersection lighting reduced the nighttime accident frequency by 52%.

	Nighttime Accident Rate
Before Intersection Lighting	1.89 per MEV
After Intersection Lighting	0.91 per MEV
Nighttime Accident Reduction	52%

With this conclusion, this project (the second phase), was initiated to determine the relative benefit of a higher level of lighting as opposed to minimum lighting. Twenty pairs of intersections with similar geometrics were selected. Some lights were turned out at one intersection of each pair to produce a lighting level differential. Based on the results of this research, the lighting level of lighted rural at-grade intersections does not have a significant effect on the accident frequency.

	Nighttime Accident Rate
Full lighting level	1.06 per MEV
Reduced lighting level	1.01 per MEV
Differential:	5%

At the nineteen "reduced lighting" intersections, the number of lighted luminaires was reduced from 101 to 46 with a corresponding reduction in energy consumption of over 100,000 Kilowatt hours per year. This energy conservation measure could reduce consumption by an estimated 1,000,000 Kilowatt hours per year if initiated on more than 200 earlier primary, rural installations.

EFFECTS OF REDUCED INTERSECTION LIGHTING ON NIGHTTIME ACCIDENT FREQUENCY

INTRODUCTION

The highway engineer is continually aware of the need for improved highway safety. Traffic accidents are the leading cause of accidental death, killing nearly 50,000 persons a year in the United States. Traffic fatalities for Iowa were 684 in 1974, 674 in 1975 and 785 in 1976. The at-grade intersection accounts for 15 percent of all fatal rural accidents and 25 percent of all rural accidents while constituting a very small portion of the total rural highway mileage (1). Intersection lighting is a method of improving highway safety.

This research is the second phase of a two part study on the relationship of intersection lighting and accident frequency. The first phase was a study of 47 rural at-grade intersection lighting installations constructed from 1967 through 1971. The study was based upon a comparison of the accident data for a period of three years prior to lighting with that of three years after lighting. The composite accident frequency of all 47 intersections in "accidents per million entering vehicles" was determined for both periods. The nighttime accident frequency before lighting was 1.89 and was 0.91 after lighting or 52% reduction due to the illumination.

Another very similar research project was conducted in the State of Illinois with the conclusion that illumination of intersections resulted in a 45 percent reduction in the nighttime accident rate (3). These two independent studies are in complete agreement as to the safety benefit derived from intersection lighting.

The Iowa Department of Transportation (Iowa DOT) lighting designs are based primarily on the American National Standards Institute (ANSI) Manual. These recommended procedures conform closely to American Association of State Highway and Transportation Officials (AASHTO) and are supported by the Federal Highway Administration (FHWA).

The energy crisis of November, 1973, caused many states to reduce the amount of existing highway lighting (4). Iowa reduced lighting levels by turning off some luminaires at various intersections in the following months. After the easing of the energy crisis and facing mounting complaints, lighting was restored at most of these intersections around April of 1974. This energy crisis initiated a need for a re-evaluation of highway lighting policies in Iowa. Safety was a definite consideration for any change of policy and therefore, generated both phase I and this research on different levels of intersection lighting.

OBJECTIVE

The objective of this research is to determine if the level of illumination of lighted rural at-grade intersections affects the accident frequency.

METHOD OF STUDY

Selection of Intersections

Approximately 220 primary road intersections were reviewed and variables such as geometric layout, channelization, traffic controls and major legs were considered. Intersections that were similar with respect to these variables were grouped. From these groups, twenty pairs of intersections were matched for comparison (Table 1).

Level of Illumination

Iowa's intersection illumination varies from 3 lights to 15 lights and the number generally relates to the complexity and channelization of the intersection. During the energy crisis, many of the 3 light installations were reduced to 1 light and an 8 light installation may have been reduced to 4 lights. In a few cases, the original lighting installation on geometrically similar intersections utilized a significantly different number of lights and provided a comparison without lighting reduction. In most cases, however, a request to turn out some lights on one of each pair was necessary to yield a significant difference. The number of lights requested at each of the 40 intersections is shown in Table 1. The lighting layouts for each intersection designating the particular lights to be left "on" or "turned off" are included in Appendix B.

Data Collection Period

Reduction in intersection lighting due to the energy crisis was initiated in November, 1973, but most of the lighting was restored by April, 1974. After selection of the twenty pairs of intersections, the study period was established as July 1, 1974 through June 30, 1977 to obtain a three year period that would yield sufficient data for analysis.

ANALYSIS OF DATA

Data Sources

Even though the layout of these paired intersections was similar, it was impossible to also match them on traffic volume. Traffic volume is one variable that would affect accident frequency. Traffic movement diagrams that have been corrected for seasonal variation and yield an "Average Annual Daily Traffic" were obtained from the Iowa DOT, Office of Transportation Inventory. Most of the data were taken from traffic counts between 1974 and 1977. For the majority of the forty intersections, there were two counts available. Using these two traffic volume figures based upon a uniform or straight line change an "Average Annual Daily Traffic" for January 1, 1976 (the midpoint of the research period) was calculated. There were some intersections where only one recent set of traffic count data was available. In these cases, the value was not adjusted, but used as the best information available. The general Iowa trend shows an increase in traffic volume, but approximately half of the research intersections, where two values are given, exhibited a decrease in traffic flow, so the values were not modified by the State trend percentage. In one case, the most recent data was from 1971. The Office of Transportation Inventory supplied nighttime traffic factor information for the 1974 to 1977 study period. It was interesting to find that if there had been no daylight savings time, 24.5 percent of the traffic volume was during nighttime hours, considered from sunset to sunrise. During the period of daylight savings time with sunset one hour later, the nighttime percentage drops to 22.2 percent. Iowa has six months of daylight savings time during the period when traffic volumes are higher than the daily average. Based upon this data, a 23 percent nighttime traffic factor is used in this research

The accident data was obtained from the Iowa DOT, Motor Vehicle Division. The data for 1974 and 1975 were tabulated from

data processing summaries, but 1976 and 1977 data were taken directly from the accident reports. These accident reports were manually sorted as the summary was not available at the time of this report. The source of this information is the accident reports filed with the state for accidents involving personal injury or property damage in excess of a specified amount. The property damage level was $100.00 at the initation of this project, but was changed to $250.00 in September, 1975. From these state records, there were 91,114 reported accidents in 1974 and 94,396 in 1975. Using this data and a table showing the time of sunrise and sunset for Des Moines (Table 2) the accidents were classified as "daytime" or "nighttime" (Table 3). Nighttime for this research was considered as being from sunset to sunrise. This classification took into account the fact that daylight savings time was in affect for the months of May through October. The accident reports classify light conditions as day, night, dawn and dusk, but for research purposes, the dawn and dusk were classified as day or night based upon the sunrise and sunset criteria.

Evaluation of Results

The original research was established to study 40 (20 pairs) intersections. Because this research is based upon intersections within the highway system, the research is secondary to essential safety and maintenance. Intersection 20A was altered by installation of a 4 way stop during the research period and therefore, 20A and 20B were excluded from the research. There were four other intersections where some lighting was restored at the "reduced lighting" intersections by mistake. This happened due to uninformed individuals efforts to "repair" luminaires that were not "on." Even during the period of restored lighting, the "reduced lighting" intersections had fewer lighted luminaires than their "full lighting" counterpart. The differential during this period, however, was less than planned. Because there was always a lighting differential and most of the research period was as planned, these intersections were retained in the evaluation.

A summary of traffic volumes and accidents for the 38 intersections during the research period is given in Table 3. There is tremendous variation in accident frequency when considering individual intersections. The number of accidents is shown for each calendar year of the research period. The 1974 and 1977 data represent only six months. Intersections 4B and 12B exhibit the greatest accident frequency variation. For intersection 4B there

were no accidents in the last six months of 1974, but there were four in 1975 and none again in 1976. Intersection 12B had four accidents in the last six months of 1974 with none in 1975. Other intersections exhibit large variations when considered individually.

Even though the intersections were paired on the basis of geometrics, it is impossible to completely eliminate the variables. There are two commonly accepted methods of minimizing the effects of the variables. One is to relate the accident frequency to traffic volume. Again, when the traffic volume and accident frequency are compared for individual intersections, there is very little relationship. The correlation coefficient for the "reduced lighting" intersections was 0.38 and the "full lighting" coefficient was 0.56. Both of these values indicate a very poor correlation. This variability emphasizes the need of including a reasonably large number of intersections in the research study. It would be desirable to include more than the 19 pairs, but the geometric matching was a limiting factor. When considering the cummulative data for 19 intersections (Table 4) the totals are primarily related to traffic volume and exhibit little dependence on the level of lighting. The "full lighting" intersections had a nighttime accident frequency of 1.06 accidents per million entering vehicles while the "reduced lighting" frequency was 1.01. This shows no benefit of the higher level of lighting as the frequency is 5 percent greater. The daytime and total accident frequencies are 3 percent and 4 percent higher respectively for the "full lighting" intersections. This would not exhibit a significant difference between the "reduced lighting" and "full lighting" intersections when based on traffic volume.

The second method of minimizing the effects of variables is the night accident/total accident ratio which has been noted as the best method because the only variable not accounted for is the light condition(s). Even though this is claimed, it may not be true as the driver condition, due to drinking or lack of sleep, may deteriorate during the same nighttime hours. In this research, both the traffic volume relationship and this method will be used as valid and meaningful methods of evaluation. The night accident/total accident ratio was 0.290 for the "full lighting" intersections and 0.288 for the "reduced lighting." This difference is less than 1 percent and again, shows an insignificant difference when comparing the level of lighting.

Energy Requirement

The 19 reduced lighting intersections of this research utilize 400 Watt Mercury Vapor luminaires. During this research, the total number of luminaires (19 intersections) was reduced from the original 101 to 46. The luminaires are lighted for an approximate average of 11 hours each day with an energy input of 465 Watts each. Energy consumption at the 19 intersections was reduced 54% amounting to 281 Kilowatt hours per day or 102,684 per year. If these intersections are representative of more than 200 earlier primary, rural installations in Iowa, the possible reduction in energy consumption would amount to 1,080,880 Kilowatt hours per year.

CONCLUSIONS

From the first phase of this study on intersection lighting and accidents (2), the safety benefits of intersection lighting were established. The nighttime accident rate of rural at-grade crossings was reduced by 52%. Based on this phase of the study it can be concluded that:

1. There are large variations in the accident frequency at individual intersections.
2. The accident frequency at individual intersections is not closely related to traffic volume.
3. The lighting level of lighted rural at-grade intersections does not have a significant effect on the accident frequency, as long as the conflict area is sufficiently illuminated.

PROPOSED ACTION

1. Continue the current practice to utilize the minimum number of luminaires that will adequately light the conflict areas.
2. Initiate a program to remove luminaires from overlighted, earlier installations.
3. Continue to light rural at-grade intersections as funding allows within the total highway program.

ACKNOWLEDGMENTS

The assistance of co-workers, other Divisions and Offices of the Iowa Department of Transportation is greatly appreciated. Steve Roberts, Fred Walker, Richard Smith (Office of Materials) and Floyd Christofferson (Office of Road Design) selected and paired the 40 intersections. Traffic volume information was provided by Robert Studer and Leroy Hamilton (Office of Transportation Inventory). John Nervig (Office of Safety Programs) furnished the accident data.

The contents of this report reflect the views of the author and do not necessarily reflect the official views or policy of the Iowa Department of Transportation. This report does not constitute a standard, specification or regulation.

REFERENCES

1. Accident Facts. National Safety Council, Chicago, 1972.

2. Fred W. Walker and Stephen E. Roberts. "Evaluation of Lighting on Accident Frequency at Highway Intersections," Transportation Research Record 562, 1976 pp 73-78.

3. M. E. Lipinski and R. H. Wortman. "Effects of Illumination on Rural At-Grade Intersection Accidents," Transportation Research Record 611, 1976 pp 25-27.

4. "Fixed Highway Lighting Questionnaire No. II Summary," Transportation Research Circular, Number 173, October, 1975.

Appendix A - Tables

Table 1. Intersections as paired for comparison

Reduced Lighting				Full Lighting			
Reference	County	Description	Luminaires requested for research	Reference	County	Description	Luminaires in original installation
1A	Adams	US 34 & Ia 25	2	1B	Hardin	Ia 57 & Ia 299	5
2A	Carroll	EUS 71 & Ia 141	2	2B	Carroll	WUS 71 & Ia 141	7
3A	Clarke	US 34 & Ia 104	2	3B	Butler	Ia 3 & Ia 188	3
4A	Dickinson	EUS 71 & Ia 9	4	4B	Buena Vista	SUS 71 & Ia 7	11
5A	Grundy	Ia 14 & Ia 185	2	5B	Wapello	US 34 & Ia 16	4
6A	Ida	WUS 59 & Ia 175	4	6B	Decatur	US 69 & Ia 2	8
7A	Ida	EUS 20 & US 59	5	7B	Ida	WUS 20 & US 59	9
8A	Jefferson	US 34 & Ia 303	1	8B	Marshall	Ia 14 & Ia 96	3
9A	Jefferson	Ia 1 & Ia 356	1	9B	Chickasaw	US 63 & Ia 289	3
10A	Keokuk	WIa 1 & Ia 78	1	10B	Davis	US 63 & Ia 273	5
11A	Lee	SUS 61 & US 218	3	11B	Lee	NUS 61 & US 218	8
12A	Louisa	US 61 & Ia 92 & Ia 252	2	12B	Clinton	US 61 & Ia 136	6
13A	Page	US 59 & Ia 184	3	13B	Clayton	Ia 13 & Ia 128	6
14A	Poweshiek	Ia 21 & Ia 85	2	14B	Adams	US 34 & Ia 49	4
15A	Sac	NUS 20 & US 71	1	15B	Sac	SUS 20 & US 71	4
16A	Shelby	US 59 & Ia 37	2	16B	Keokuk	Ia 92 and Ia 77	4
17A	Tama	EIa 8 & Ia 21	1	17B	Pocahontas	NIa 4 & Ia 7	4
18A	Worth	US 65 & Ia 9	4	18B	Kossuth	US 18 & US 169	8
19A	Kossuth	EUS 169 & Ia 9	4	19B	Boone	WUS 30 & US 169	6
20A	Shelby	US 59 & Ia 44	8	20B	Lee	US 218 & Ia 103	15

Table 2. Times of Sunrise and Sunset

Times of Sunrise and Sunset at Des Moines, Iowa; Municipal Airport; Latitude, 41° 32'; Longitude, 93° 39'; Field Elevation, 950 Fee

Day	January		February		March		April		May		June		July		August		September		October		November		December	
	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set
1.....	7.41	4.55	7.27	5.31	6.50	6.05	5.59	6.40	5.12	7.12	4.43	7.42	4.44	7.52	5.09	7.32	5.40	6.48	6.11	5.57	6.47	5.10	7.21	4.46
2.....	7.41	4.56	7.26	5.32	6.48	6.06	5.56	6.41	5.10	7.13	4.43	7.43	4.45	7.52	5.09	7.31	5.41	6.47	6.12	5.56	6.48	5.09	7.22	4.45
3.....	7.41	4.57	7.25	5.33	6.47	6.07	5.56	6.42	5.09	7.14	4.42	7.43	4.45	7.52	5.10	7.30	5.42	6.45	6.13	5.54	6.49	5.08	7.23	4.45
4.....	7.41	4.58	7.24	5.35	6.45	6.09	5.53	6.43	5.09	7.16	4.42	7.44	4.46	7.52	5.12	7.29	5.43	6.43	6.14	5.52	6.50	5.07	7.24	4.45
5.....	7.41	4.59	7.23	5.36	6.44	6.10	5.51	6.44	5.07	7.17	4.42	7.45	4.46	7.52	5.13	7.28	5.45	6.42	6.15	5.50	6.51	5.06	7.25	4.45
6.....	7.41	5.00	7.22	5.37	6.42	6.11	5.50	6.45	5.06	7.18	4.41	7.45	4.47	7.51	5.14	7.27	5.45	6.40	6.16	5.49	6.53	5.04	7.26	4.45
7.....	7.41	5.01	7.21	5.38	6.40	6.12	5.48	6.46	5.05	7.19	4.41	7.46	4.48	7.51	5.15	7.26	5.46	6.38	6.17	5.47	6.54	5.03	7.27	4.45
8.....	7.41	5.02	7.20	5.40	6.39	6.13	5.47	6.47	5.04	7.20	4.41	7.47	4.48	7.51	5.16	7.24	5.48	6.37	6.19	5.45	6.55	5.02	7.28	4.45
9.....	7.41	5.03	7.18	5.41	6.37	6.14	5.45	6.48	5.03	7.21	4.41	7.47	4.49	7.50	5.17	7.23	5.48	6.35	6.20	5.44	6.56	5.01	7.29	4.45
10.....	7.41	5.04	7.17	5.42	6.36	6.16	5.43	6.49	5.02	7.22	4.40	7.48	4.50	7.50	5.18	7.22	5.49	6.33	6.21	5.42	6.57	5.00	7.30	4.45
11.....	7.40	5.05	7.15	5.43	6.34	6.17	5.42	6.50	5.01	7.23	4.40	7.48	4.50	7.49	5.19	7.20	5.51	6.32	6.22	5.40	6.58	4.59	7.31	4.45
12.....	7.40	5.06	7.15	5.45	6.32	6.18	5.40	6.52	5.00	7.24	4.40	7.49	4.51	7.49	5.20	7.19	5.52	6.30	6.23	5.39	7.00	4.58	7.31	4.45
13.....	7.40	5.07	7.13	5.46	6.31	6.19	5.39	6.53	4.59	7.25	4.40	7.49	4.52	7.48	5.21	7.18	5.52	6.28	6.24	5.37	7.01	4.57	7.32	4.45
14.....	7.39	5.08	7.12	5.47	6.29	6.20	5.37	6.54	4.58	7.26	4.40	7.50	4.53	7.48	5.22	7.16	5.53	6.26	6.25	5.36	7.02	4.56	7.33	4.45
15.....	7.39	5.10	7.10	5.48	6.27	6.21	5.35	6.55	4.57	7.27	4.40	7.50	4.53	7.47	5.23	7.15	5.55	6.25	6.26	5.34	7.03	4.55	7.34	4.46
16.....	7.39	5.11	7.09	5.49	6.26	6.22	5.34	6.56	4.56	7.28	4.40	7.51	4.54	7.46	5.24	7.13	5.56	6.23	6.28	5.33	7.04	4.54	7.34	4.46
17.....	7.38	5.12	7.08	5.51	6.24	6.24	5.32	6.57	4.55	7.29	4.40	7.51	4.55	7.46	5.25	7.12	5.56	6.21	6.28	5.31	7.06	4.54	7.35	4.46
18.....	7.38	5.13	7.07	5.52	6.22	6.25	5.31	6.58	4.54	7.30	4.40	7.51	4.56	7.45	5.26	7.10	5.58	6.20	6.30	5.30	7.07	4.53	7.36	4.46
19.....	7.37	5.14	7.04	5.53	6.21	6.26	5.29	6.59	4.53	7.31	4.40	7.51	4.57	7.44	5.27	7.09	5.59	6.18	6.31	5.28	7.08	4.52	7.36	4.46
20.....	7.36	5.15	7.03	5.54	6.19	6.27	5.28	7.00	4.51	7.31	4.41	7.52	4.57	7.44	5.28	7.07	6.00	6.16	6.33	5.27	7.09	4.51	7.37	4.47
21.....	7.36	5.16	7.02	5.55	6.17	6.28	5.26	7.02	4.50	7.32	4.41	7.52	4.58	7.43	5.29	7.06	6.01	6.15	6.33	5.25	7.10	4.51	7.37	4.47
22.....	7.35	5.18	7.01	5.57	6.16	6.29	5.25	7.03	4.49	7.33	4.41	7.52	4.59	7.42	5.30	7.04	6.02	6.13	6.35	5.24	7.11	4.50	7.37	4.47
23.....	7.35	5.19	6.59	5.58	6.14	6.30	5.24	7.04	4.49	7.34	4.41	7.52	5.00	7.41	5.31	7.03	6.03	6.11	6.35	5.22	7.13	4.49	7.38	4.48
24.....	7.34	5.20	6.57	5.59	6.12	6.31	5.22	7.05	4.48	7.35	4.42	7.52	5.01	7.40	5.32	7.01	6.04	6.09	6.37	5.21	7.14	4.49	7.39	4.49
25.....	7.33	5.22	6.56	6.00	6.10	6.32	5.21	7.06	4.47	7.36	4.42	7.53	5.02	7.39	5.33	7.00	6.05	6.08	6.37	5.19	7.15	4.48	7.39	4.50
26.....	7.32	5.23	6.54	6.01	6.08	6.33	5.19	7.07	4.47	7.37	4.42	7.53	5.04	7.39	5.34	6.58	6.06	6.06	6.38	5.18	7.16	4.48	7.40	4.51
27.....	7.32	5.24	6.53	6.03	6.06	6.34	5.18	7.08	4.46	7.38	4.43	7.53	5.05	7.38	5.35	6.56	6.07	6.04	6.41	5.17	7.17	4.47	7.40	4.51
28.....	7.31	5.26	6.51	6.04	6.05	6.35	5.16	7.09	4.45	7.39	4.43	7.53	5.06	7.37	5.36	6.55	6.08	6.02	6.41	5.15	7.18	4.47	7.40	4.52
29.....	7.30	5.27	6.50	6.05	6.04	6.37	5.15	7.10	4.45	7.39	4.43	7.53	5.07	7.36	5.37	6.53	6.09	6.01	6.43	5.14	7.19	4.46	7.40	4.53
30.....	7.29	5.28	.....	.....	6.02	6.38	5.14	7.11	4.44	7.40	4.44	7.53	5.08	7.35	5.38	6.52	6.10	5.59	6.44	5.13	7.20	4.46	7.41	4.54
31.....	7.28	5.29	.....	.....	6.01	6.39	.....	.....	4.44	7.41	.....	.....	5.09	7.34	5.39	6.50	.....	.....	6.44	5.11	.....	.....	7.41	4.54

IOWA DEPARTMENT OF PUBLIC SAFETY CP-25994

This chart is applicable to Des Moines. Since the time of sunrise and sunset is earlier in the east, patrolmen operating east of Des Moines should subtract 15 minutes from the times given to arrive at a more accurate figure. Patrolmen operating west of Des Moines should add 15 minutes. For example, if the chart showed sunrise to be at 6:15 A.M., in Des Moines, sunrise in Burlington would be at approximately 6:00 A.M., and sunrise in Sioux City would be at approximately 6:30 A.M., all central standard times.

Table 3. Traffic Volume and Accident Summary

Research Study Reference	Average Annual Daily Traffic	NUMBER OF ACCIDENTS DAY 74	75	76	77	NIGHT 74	75	76	77	DAY	NIGHT	TOTAL
1A	2790				1			1	1	1	2	3
2A	1828	1		1						2	0	2
3A	2069									0	0	0
4A	2842	2	1	2			1			5	1	6
5A	3718						2			0	2	2
6A	2856		1				1			1	1	2
7A	2599		1	1		1	2			2	3	5
8A	4836		3	1	1			1		5	1	6
9A	1863									0	0	0
10A	2803									0	0	0
11A	7496		1		1	1			1	2	2	4
12A	5242	1	1	1			1			3	1	4
13A	1767					1				0	1	1
14A	1745	1	1	2	1					5	0	5
15A	3154	1	3				1			4	1	5
16A	2055		2							2	0	2
17A	2318		1	2						3	0	3
18A	4998	2								2	0	2
19A	1724									0	0	0
*20A												
TOTAL	58703	8	15	10	4	4	7	2	2	37	15	52

Research Study Reference	Average Annual Daily Traffic	NUMBER OF ACCIDENTS DAY 74	75	76	77	NIGHT 74	75	76	77	DAY	NIGHT	TOTAL
1B	1902			2						2	0	2
2B	3077									0	0	0
3B	2492	1					1			1	1	2
4B	3349		4						1	4	1	5
5B	5196	1	1	1				1	1	3	2	5
6B	2850									0	0	0
7B	3656						2			0	2	2
8B	4240		1		1	2		1		2	3	5
9B	2267		2							2	0	2
10B	5292	1			3					4	0	4
11B	4939	1	2	1			2	1		4	3	7
12B	4907	4		2	1					7	0	7
13B	2382							1		0	1	1
14B	2150		1				1			1	1	2
15B	2811		2			1	1			2	2	4
16B	2010	2		1	2					5	0	5
17B	2134		1					1		1	1	2
18B	8716		1	3			1			4	1	5
19B	3167			2						2	0	2
*20B												
TOTAL	67537	10	15	12	7	3	8	5	2	44	18	62

*Pair 20 not included due to installation of 4 Way Stop.

Table 4. Summary of Cummulative Traffic Volume and Accident Data

Item	Reduced Lighting	Full Lighting
Traffic Volume (ADT for 19 Intersections)		
Nighttime (ADT X 0.23)	13,502	15,534
Daytime (ADT X 0.77)	45,201	52,003
TOTAL (ADT)	58,703	67,537
Traffic Volume (for 3 year research period)		
Nighttime (ADT X 0.23 X 365 X 3)	14,784,351	17,009,193
Daytime (ADT X 0.77 X 365 X 3)	49,495,434	56,943,822
TOTAL	64,279,785	73,953,015
Accidents		
Nighttime	15	18
Daytime	37	44
TOTAL	52	62
Accident Rate/MEV		
Nighttime	1.01	1.06
Daytime	0.75	0.77
TOTAL	0.81	0.84
Night Accident/Total Accident Ratio	0.288	0.290

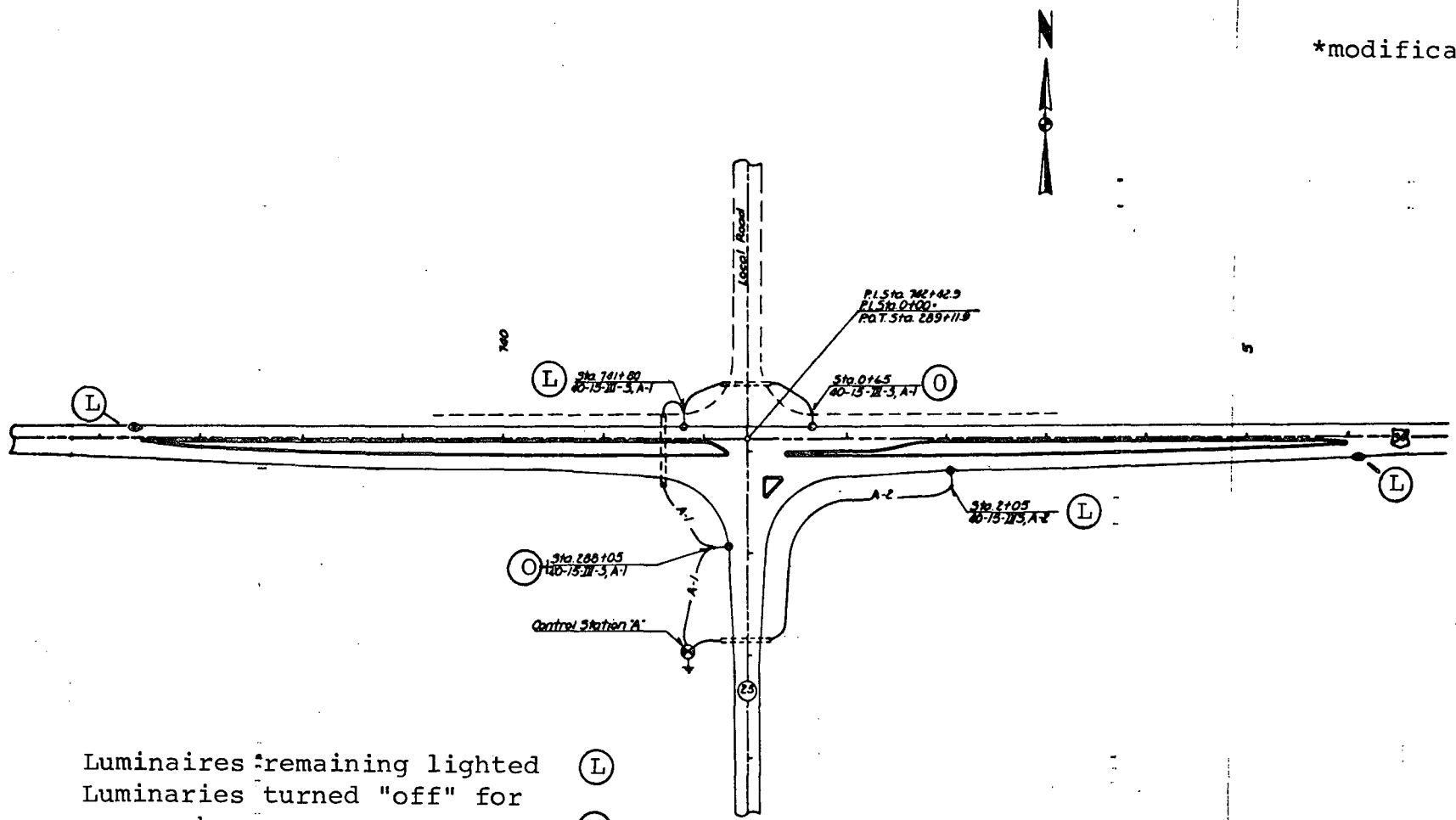
Appendix B - Intersection Layouts

Reference 1 A

Luminaires in original installation 4 6*

Luminaires requested during research 2

*modification



Luminaires remaining lighted (L)

Luminaries turned "off" for research (O)

HIGHWAY LIGHTING LAYOUT

INTERSECTION OF

U. S. NO. 34 & IA. NO. 25

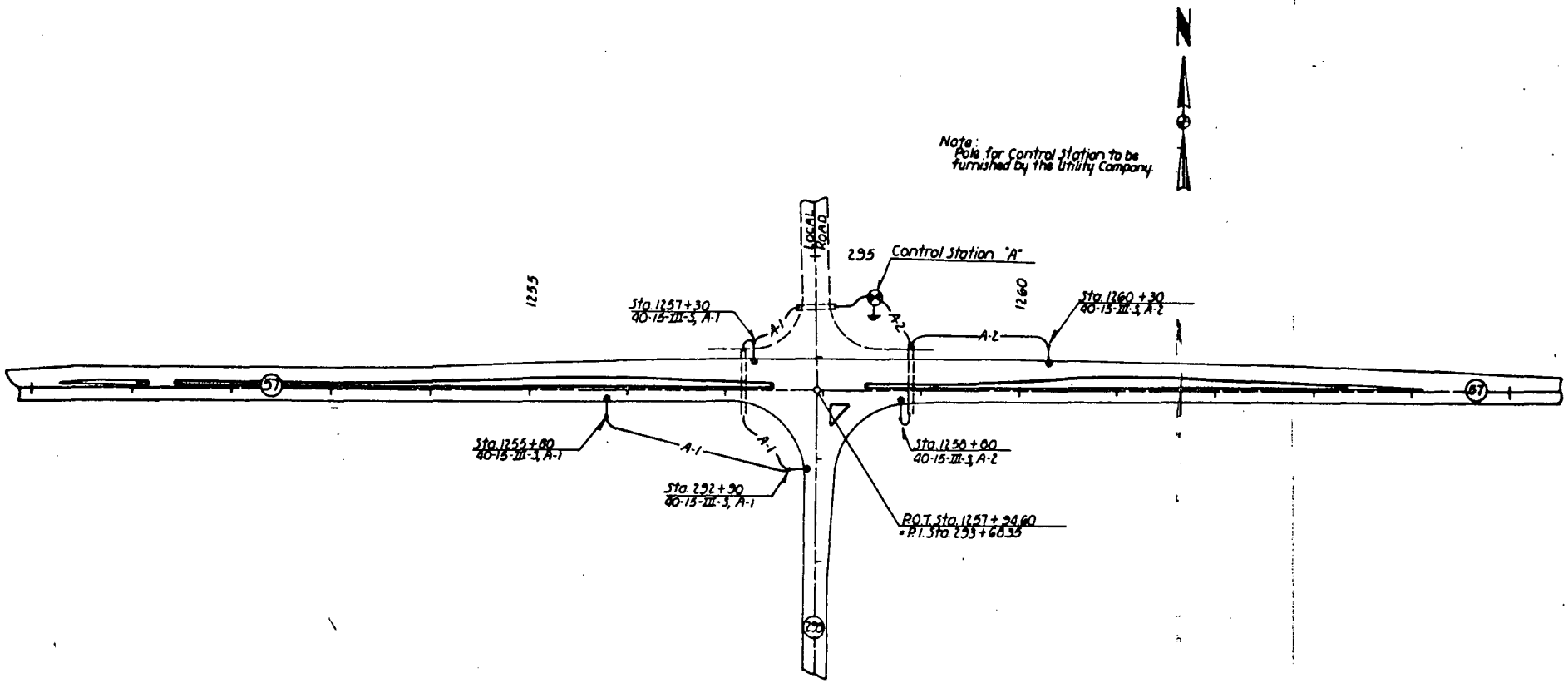
FILE NO. 93

Adams COUNTY

FN-34-3(7)--21-02

Reference 1 B

Luminaires in original installation 5
All luminaires lighted during research



HIGHWAY LIGHTING LAYOUT
INTERSECTION OF
IOWA NO. 57 AND IOWA NO. [illegible]

FILE NO. [illegible]

Hardin COUNTY

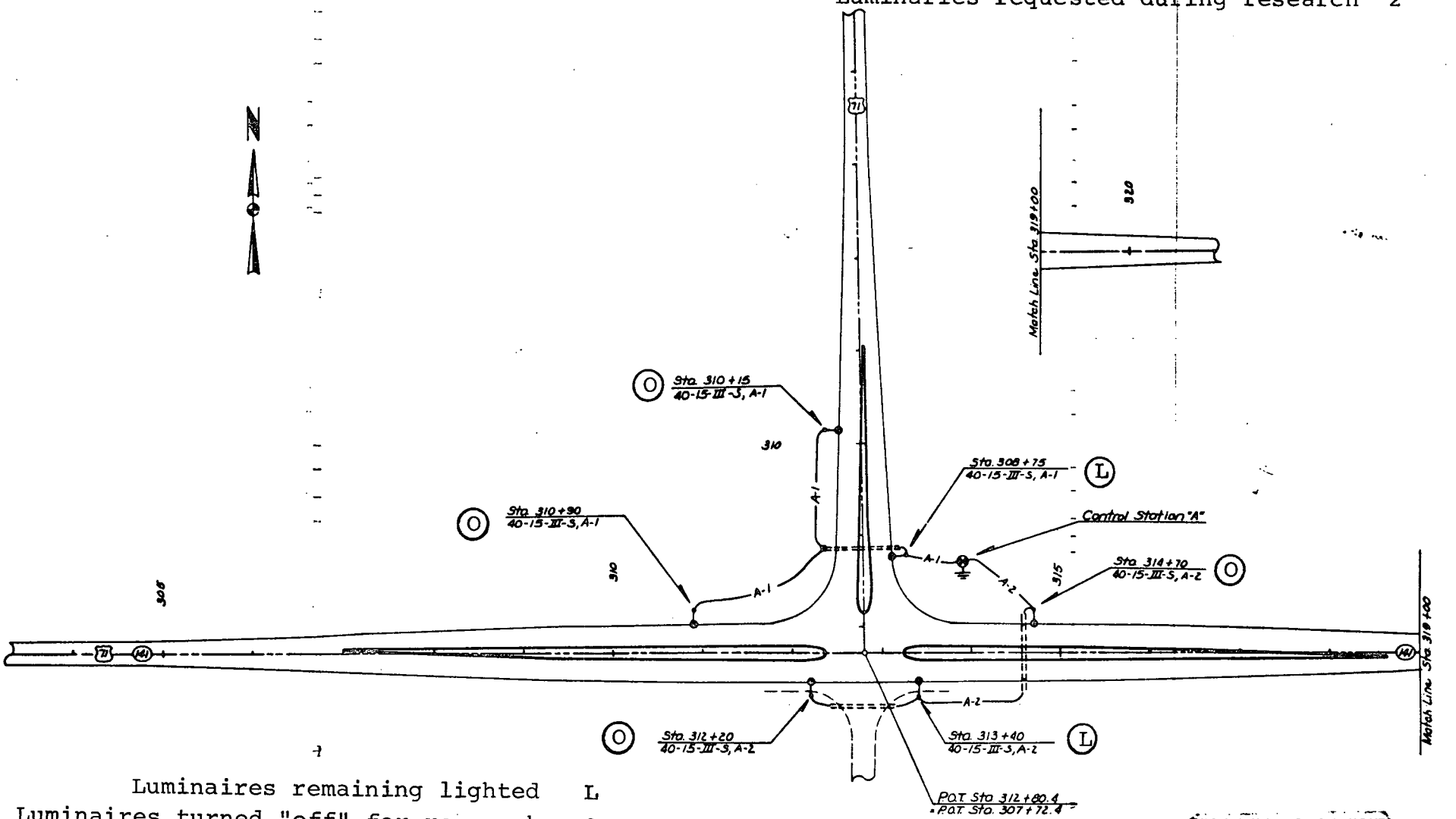
FN-57-1(11)--21-42

-15-

Reference 2 A

Luminaires in original installation 6

Luminaries requested during research 2



Luminaires remaining lighted L

Luminaires turned "off" for research O

HIGHWAY LIGHTING LAYOUT

INTERSECTION OF

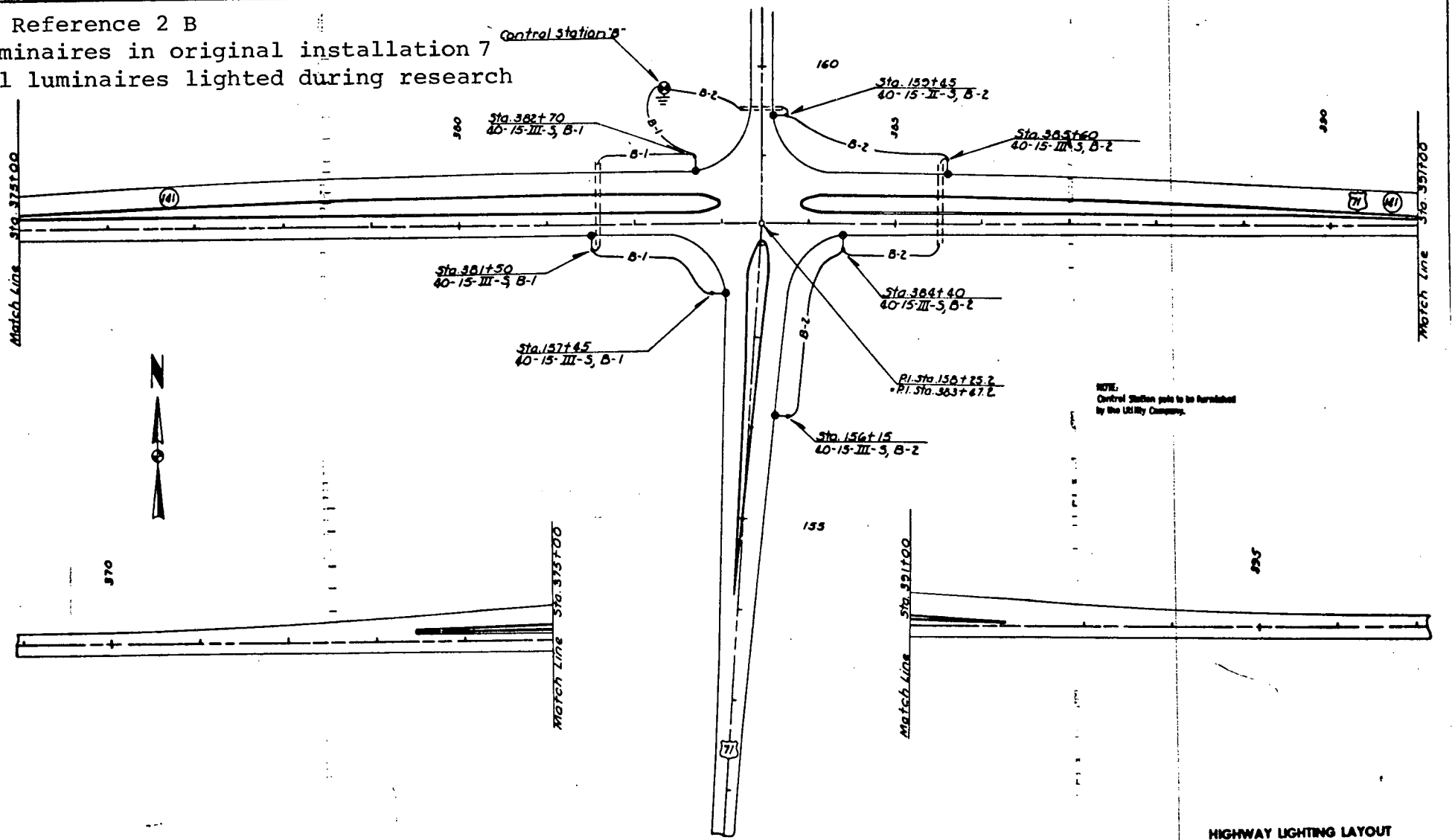
EAST JUNCTION OF U. S. NO. 71 AND IOWA NO. 141

FILE NO. 1778

Carroll COUNTY

FN. 71-3(2)--21-14

Reference 2 B
Luminaires in original installation 7
All luminaires lighted during research



NOTE:
Control Station pole to be furnished by the Utility Company.

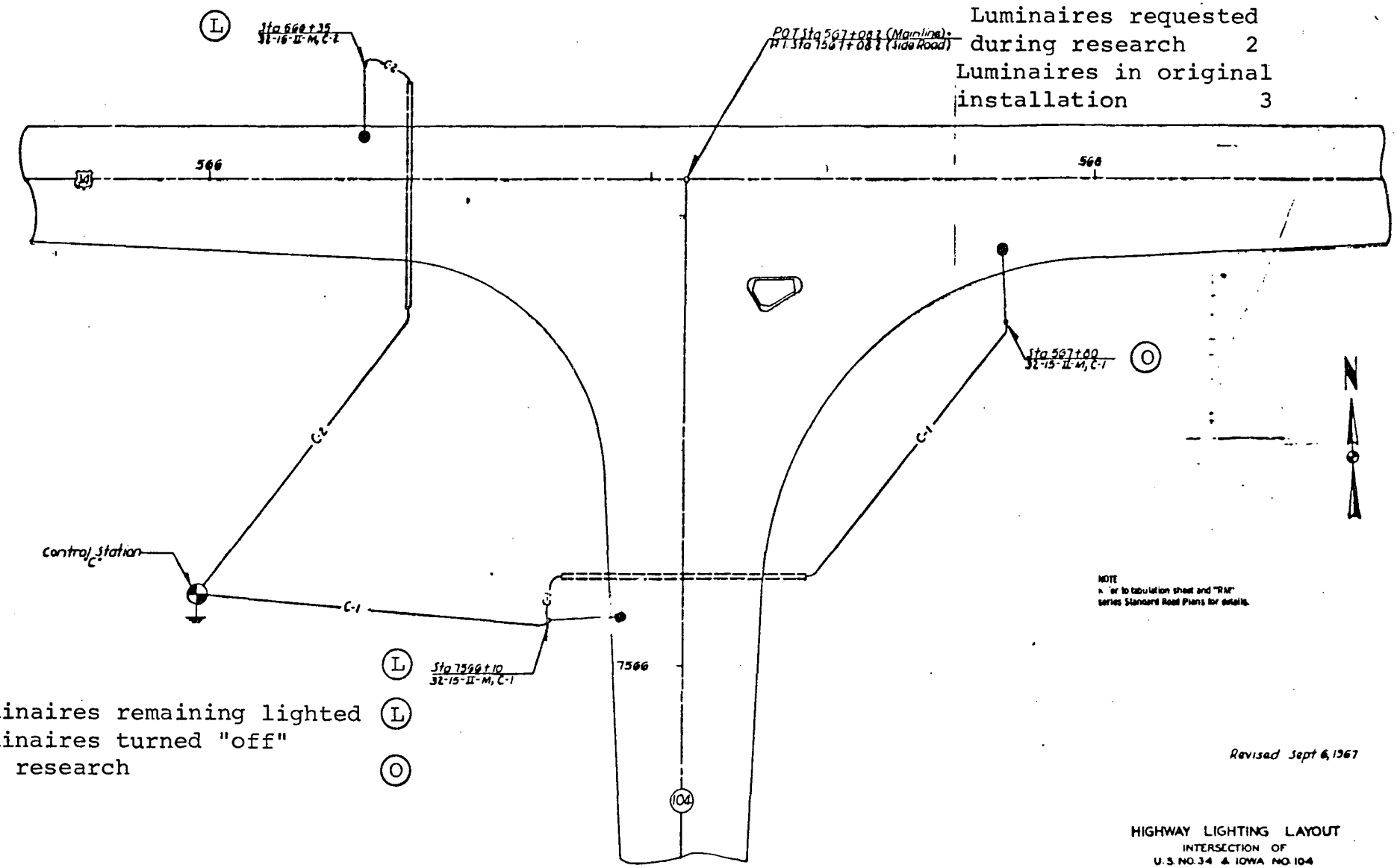
HIGHWAY LIGHTING LAYOUT
INTERSECTION OF
WEST JUNCTION OF U. S. NO. 71 AND IOWA NO. 141

FILE NO. 177A

Carroll COUNTY

FN-71-S(2)--21-14

Reference 3 A
Luminaires requested during research 2
Luminaires in original installation 3



NOTE
Refer to tabulation sheet and "RM" series Standard Road Plans for details.

Luminaires remaining lighted (L)
Luminaires turned "off" for research (O)

Revised Sept 6, 1967

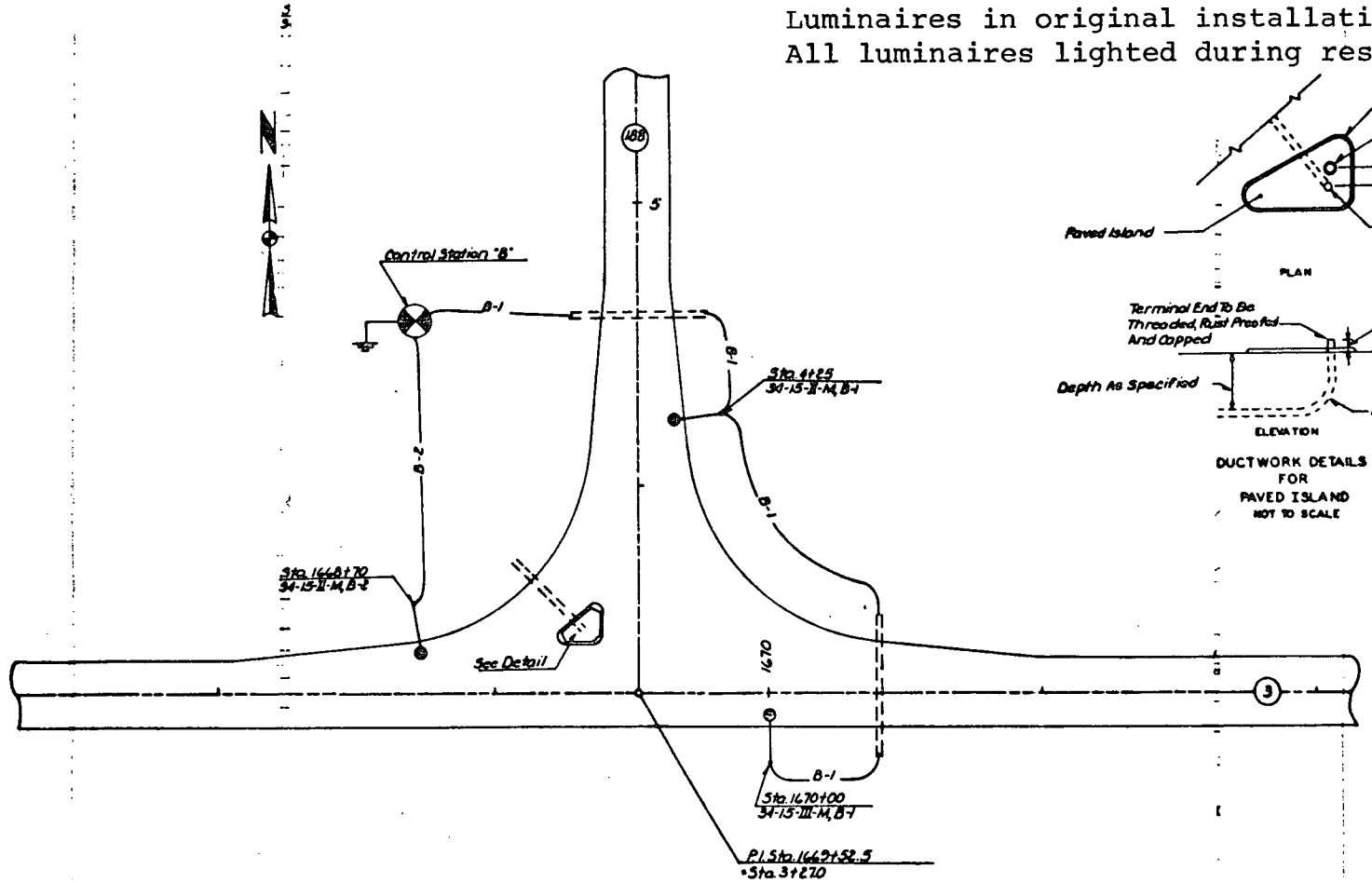
HIGHWAY LIGHTING LAYOUT
INTERSECTION OF
U.S. NO. 34 & IOWA NO. 104

Clarke COUNTY F-FG-34-5(1)--24-20 FILE NO. 23C

Reference 3 B

Luminaires in original installation 3

All luminaires lighted during research



DUCTWORK DETAILS
FOR
PAVED ISLAND
NOT TO SCALE

HIGHWAY LIGHTING LAYOUT

INTERSECTION OF

1A, NO. 3 AND 1A, NO. 188

FILE NO. 52

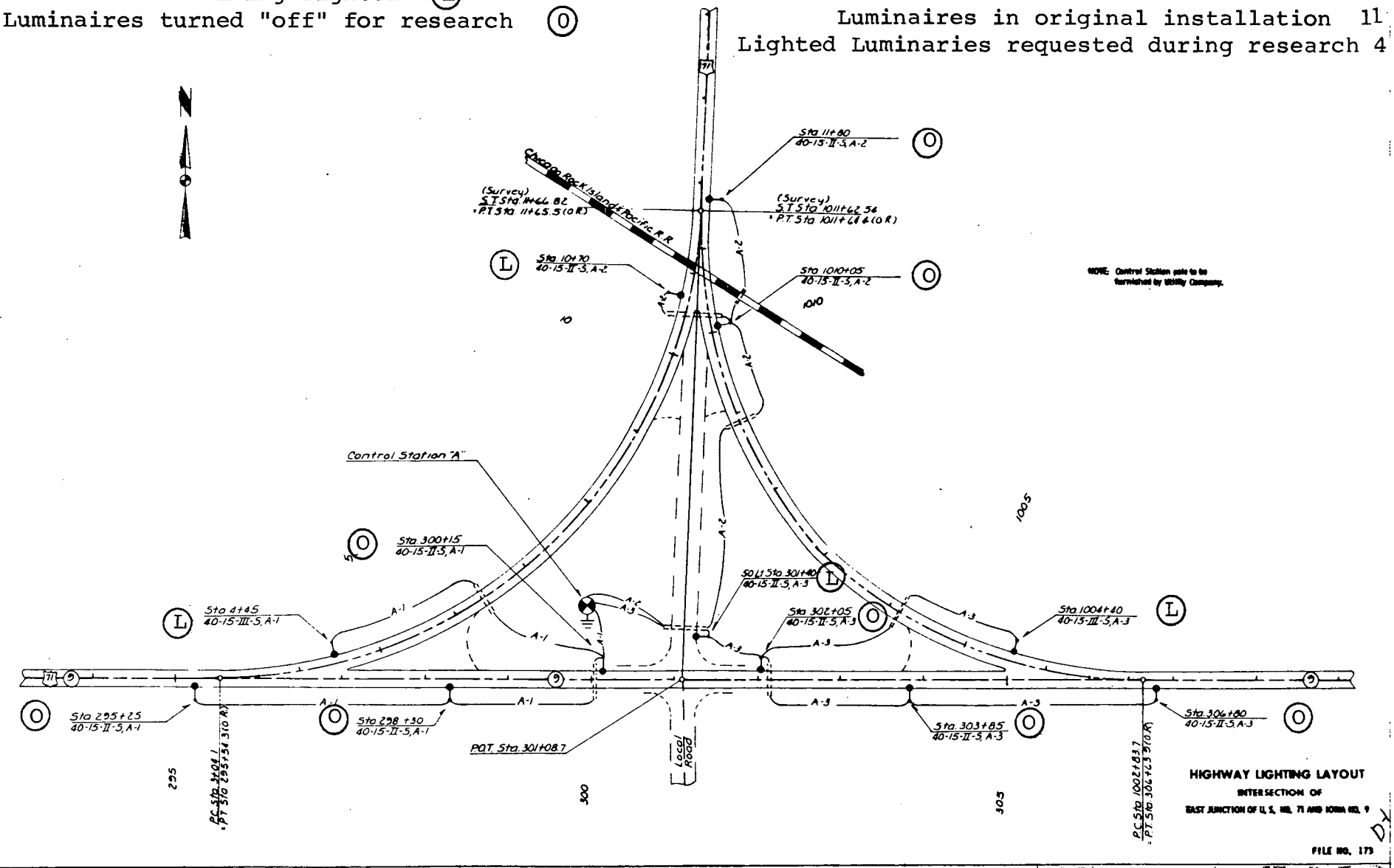
Butler COUNTY

F-3-8(6)--20-12

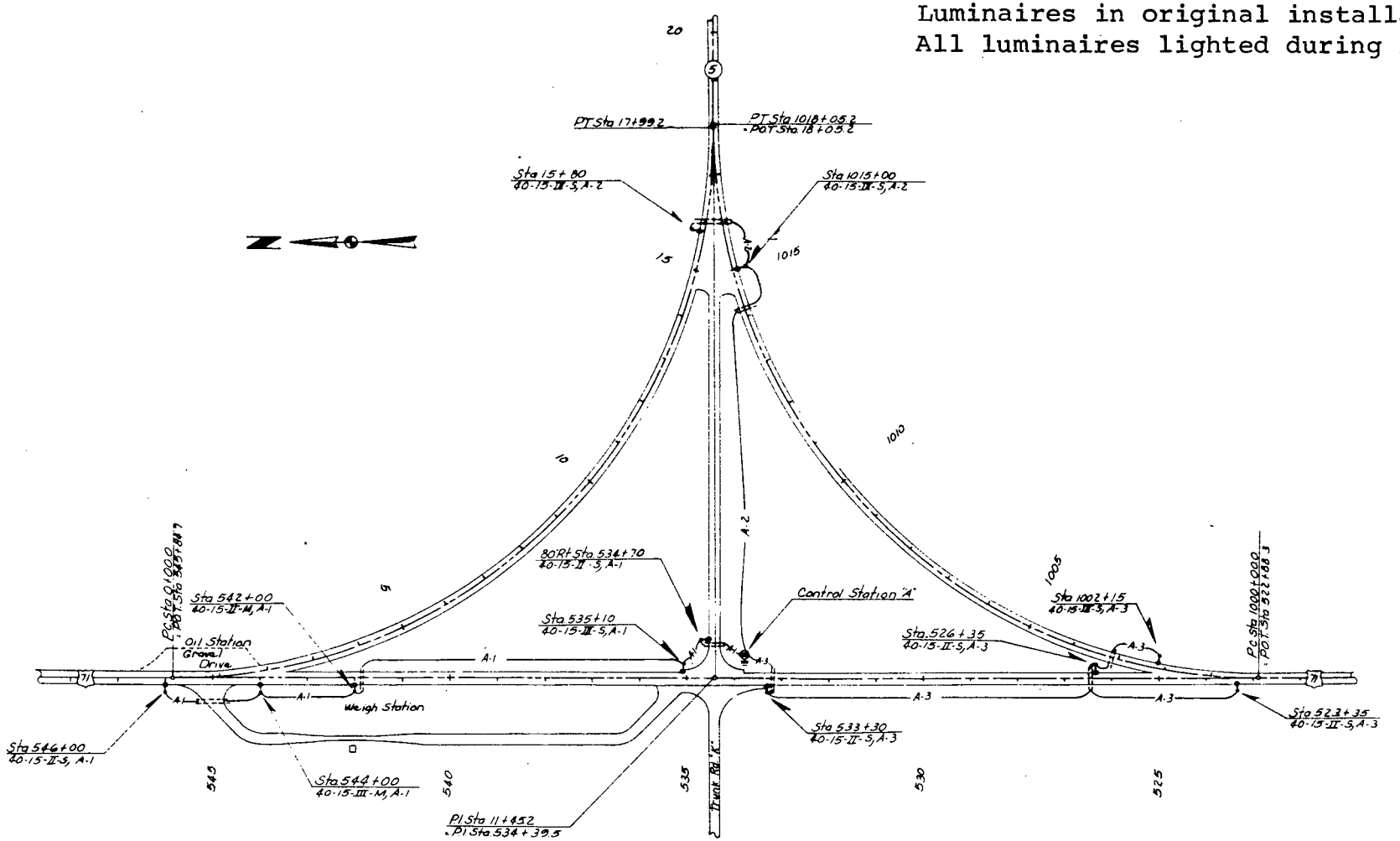
87-3 206

Luminaires remaining lighted (L)
Luminaires turned "off" for research (O)

Reference 4 A
Luminaires in original installation 11
Lighted Luminaries requested during research 4



Reference 4 B
Luminaires in original installation 11
All luminaires lighted during research



Note: Control Station pole to be furnished by Utility Company.

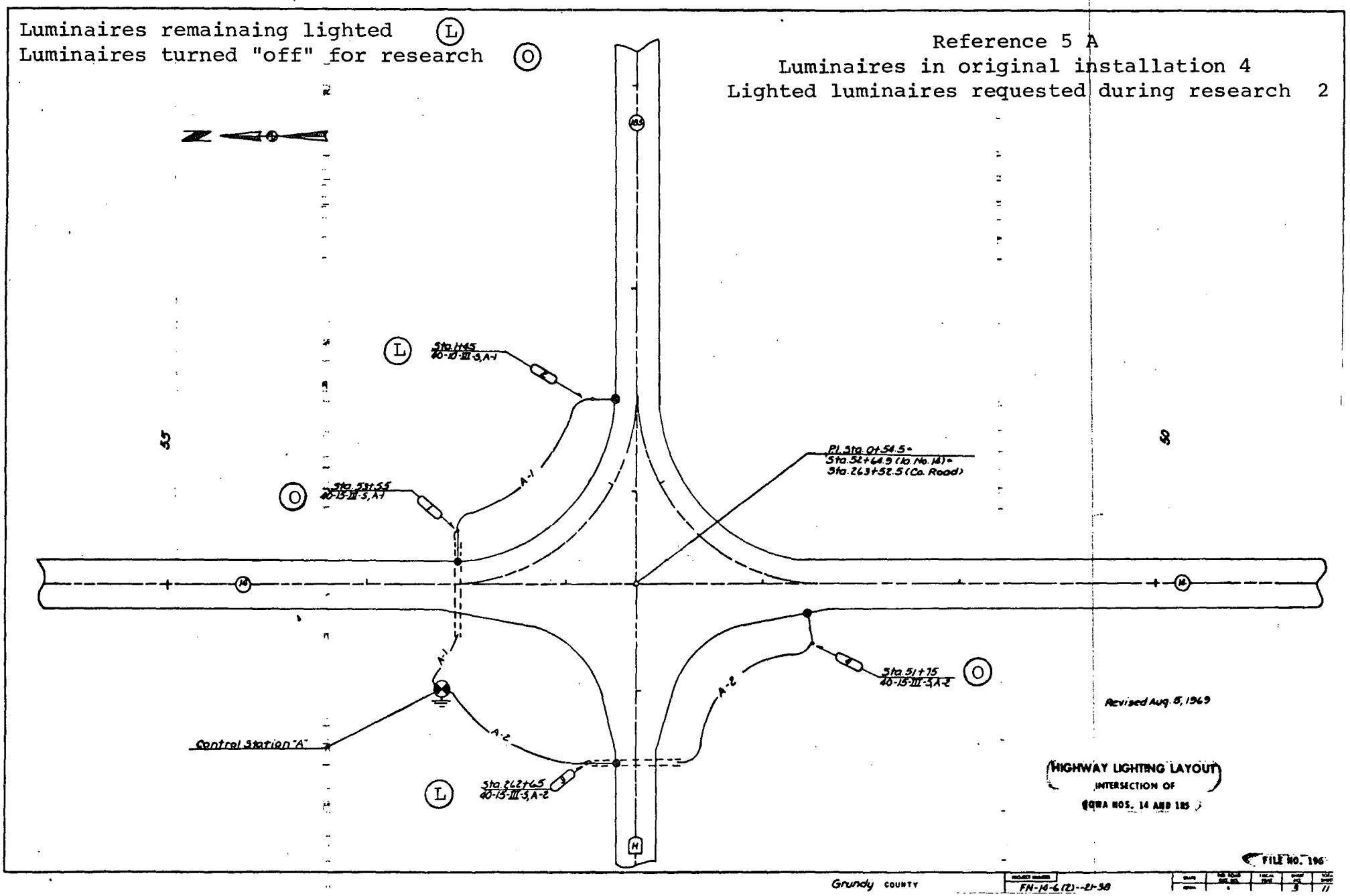
HIGHWAY LIGHTING LAYOUT
INTERSECTION OF U. S. NO. 71
AND IA. NO. 5

D-2

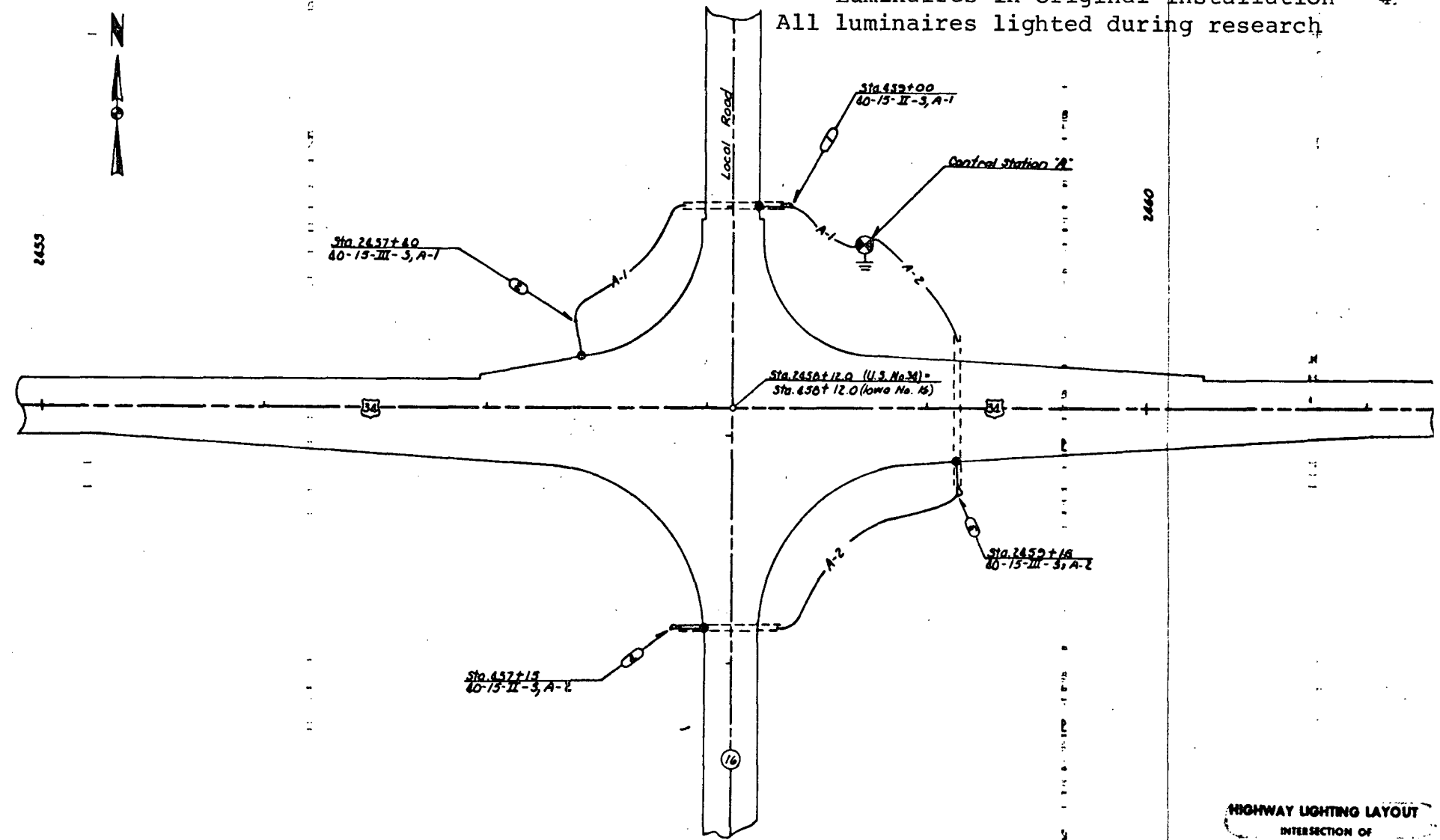
FILE NO. 172

Buena Vista COUNTY

FAI-71-7(8)--21-11


Luminaires remainaing lighted (L)
Luminaires turned "off" for research (O)
Reference 5 A
Luminaires in original installation 4
Lighted luminaires requested during research 2
Sta. 1+45
40-10-III-3, A-1
Sta. 53+55
40-15-III-3, A-1
Pl. Sta. 01+54.5 =
Sta. 52+64.9 (to No. 14) =
Sta. 263+52.5 (Co. Road)
A-1
A-1
A-2
A-2
Sta. 51+75
40-15-III-3, A-2
Sta. 262+65
40-15-III-3, A-2
Control Station "A"
55
80
Revised Aug. 5, 1969
HIGHWAY LIGHTING LAYOUT
INTERSECTION OF
IOWA NOS. 14 AND 185
FILE NO. 196
Grundy COUNTY
FN-14-6(12)--21-38

Research 5 B
Luminaires in original installation 4.
All luminaires lighted during research

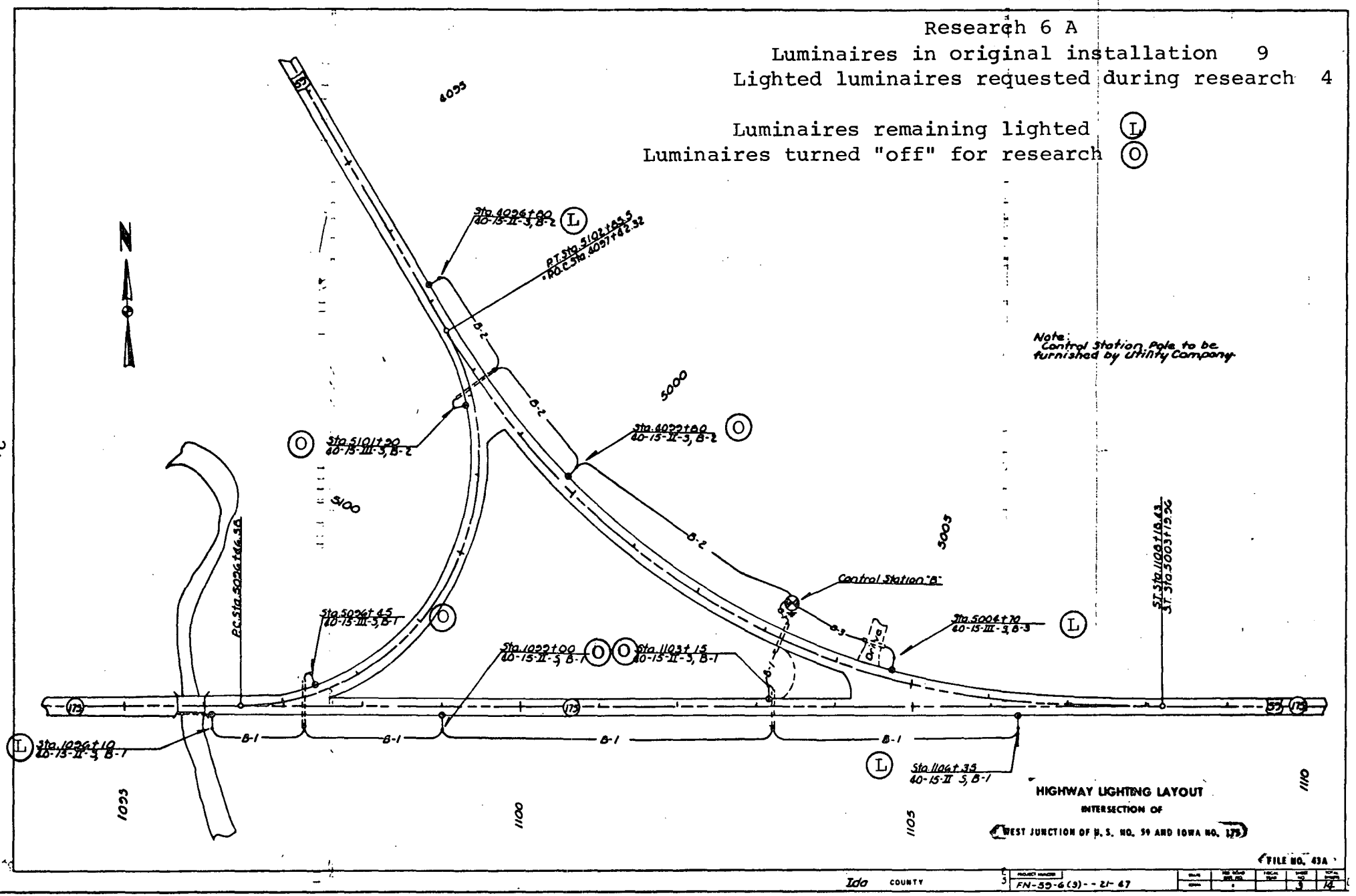


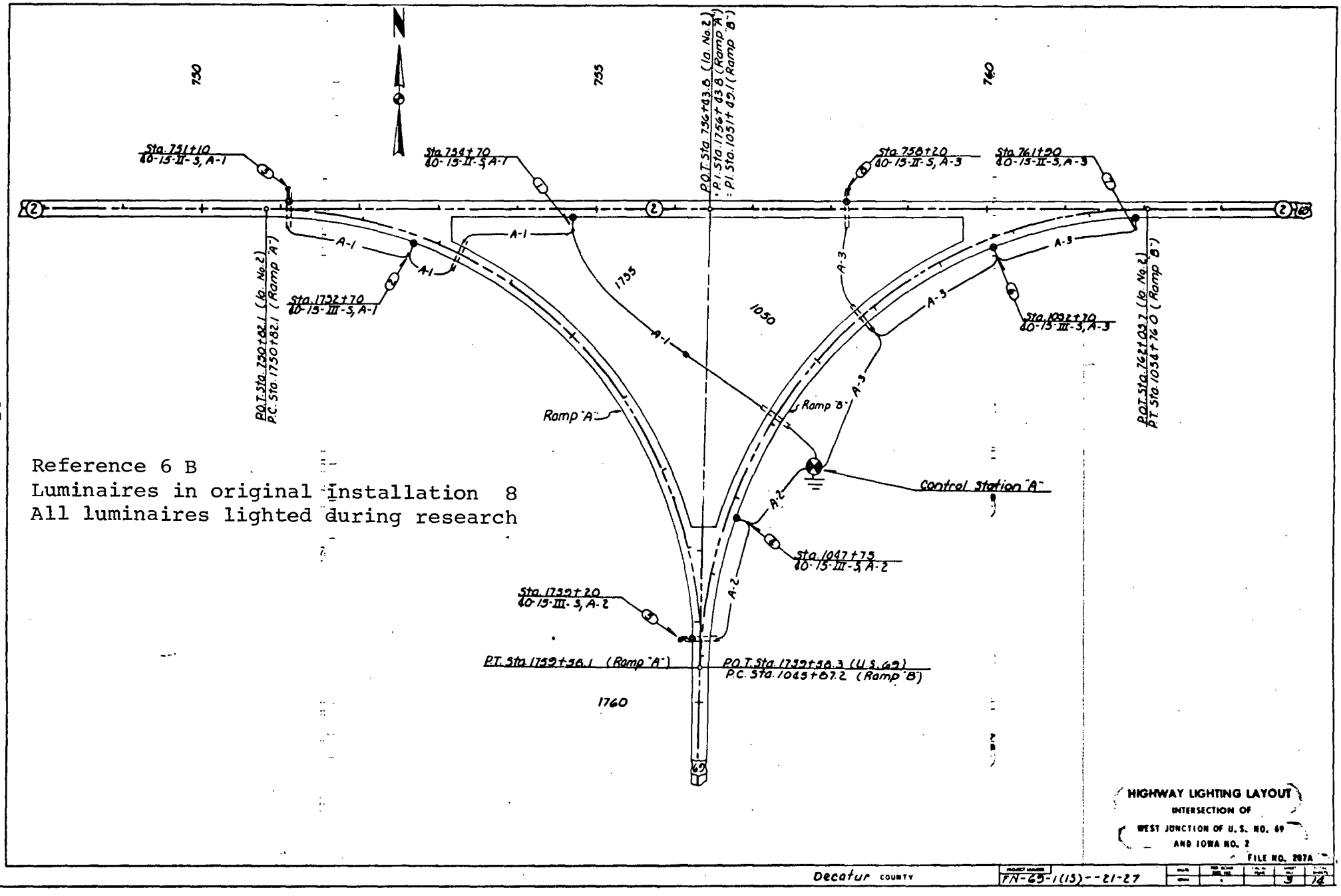
HIGHWAY LIGHTING LAYOUT
INTERSECTION OF
U.S. NO. 34 AND IOWA NO. 16

FILE NO. 217

Wapello COUNTY

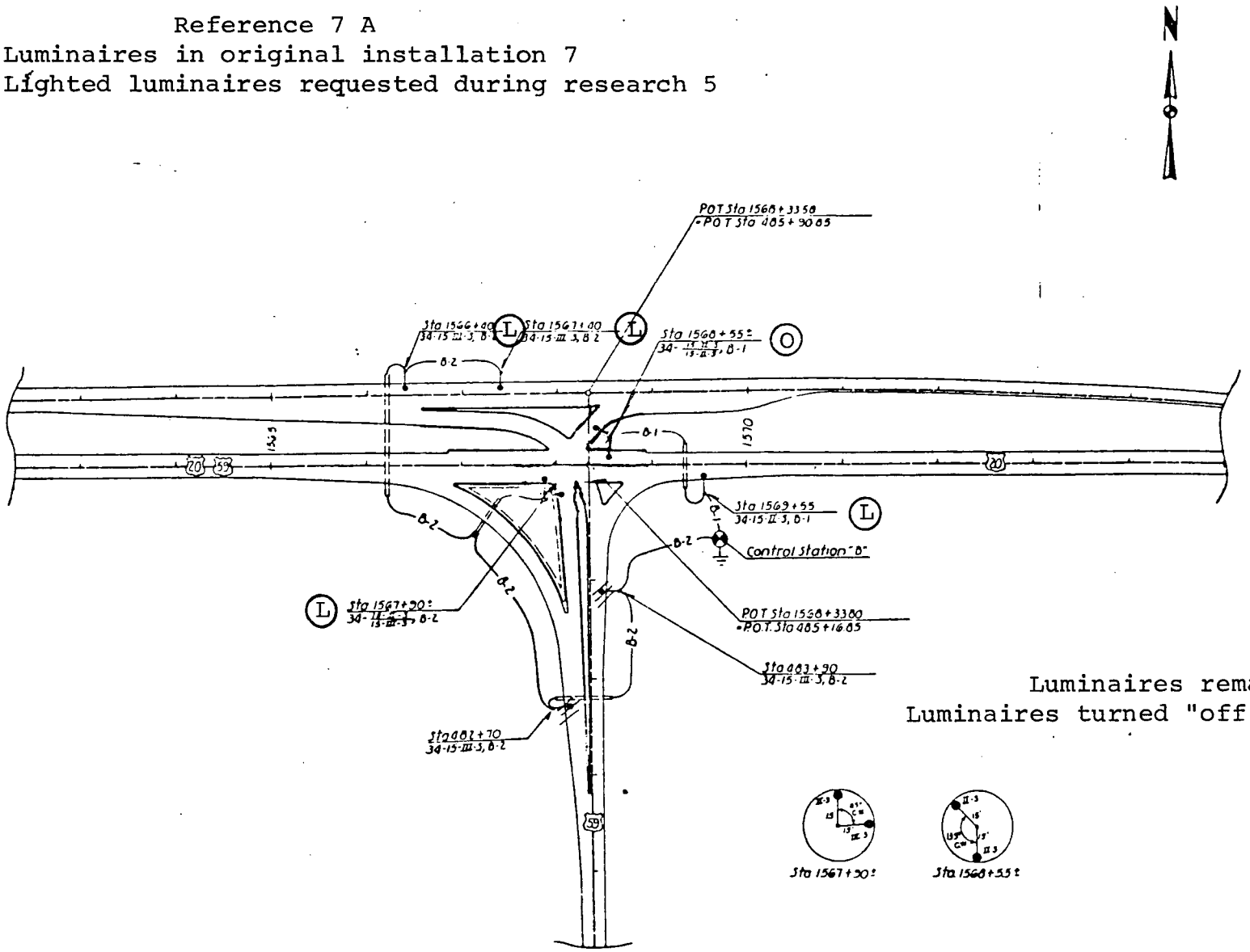
FN-34-7(13)--81-50


Research 6 A
Luminaires in original installation 9
Lighted luminaires requested during research 4
Luminaires remaining lighted (L)
Luminaires turned "off" for research (O)
Sta. 4026+00 40-15-II-3, B-2
P.T. Sta. 5102+66.5
P.O.C. Sta. 4097+82.32
Note: Control Station Pole to be furnished by Utility Company
Sta. 5101+20 40-15-III-3, B-2
Sta. 4022+00 40-15-II-3, B-2
P.C. Sta. 5026+46.50
Sta. 5026+45 40-15-III-3, B-1
Control Station "B"
Sta. 5004+70 40-15-III-3, B-3
ST. Sta. 1108+19.43
ST. Sta. 5003+19.56
Sta. 1022+00 40-15-II-5, B-1
Sta. 1103+15 40-15-II-5, B-1
Sta. 1026+10 40-15-II-5, B-1
Sta. 1104+35 40-15-II-5, B-1
B-1
B-2
B-3
4035
5000
5100
5005
1095
1100
1105
1110
HIGHWAY LIGHTING LAYOUT
INTERSECTION OF
WEST JUNCTION OF U.S. NO. 59 AND IOWA NO. 175
FILE NO. 43A
Ida COUNTY
FN-59-6(3)--21-47
3
14



Reference 6 B
Luminaires in original installation 8
All luminaires lighted during research

Reference 7 A
Luminaires in original installation 7
Lighted luminaires requested during research 5



Luminaires remaining lighted (L)
Luminaires turned "off" for research (O)

HIGHWAY LIGHTING LAYOUT
INTERSECTION OF
EAST JCT. OF U.S. NO. 20 AND U.S. NO. 59

Revised Aug. 31, 1967

FILE NO. 958

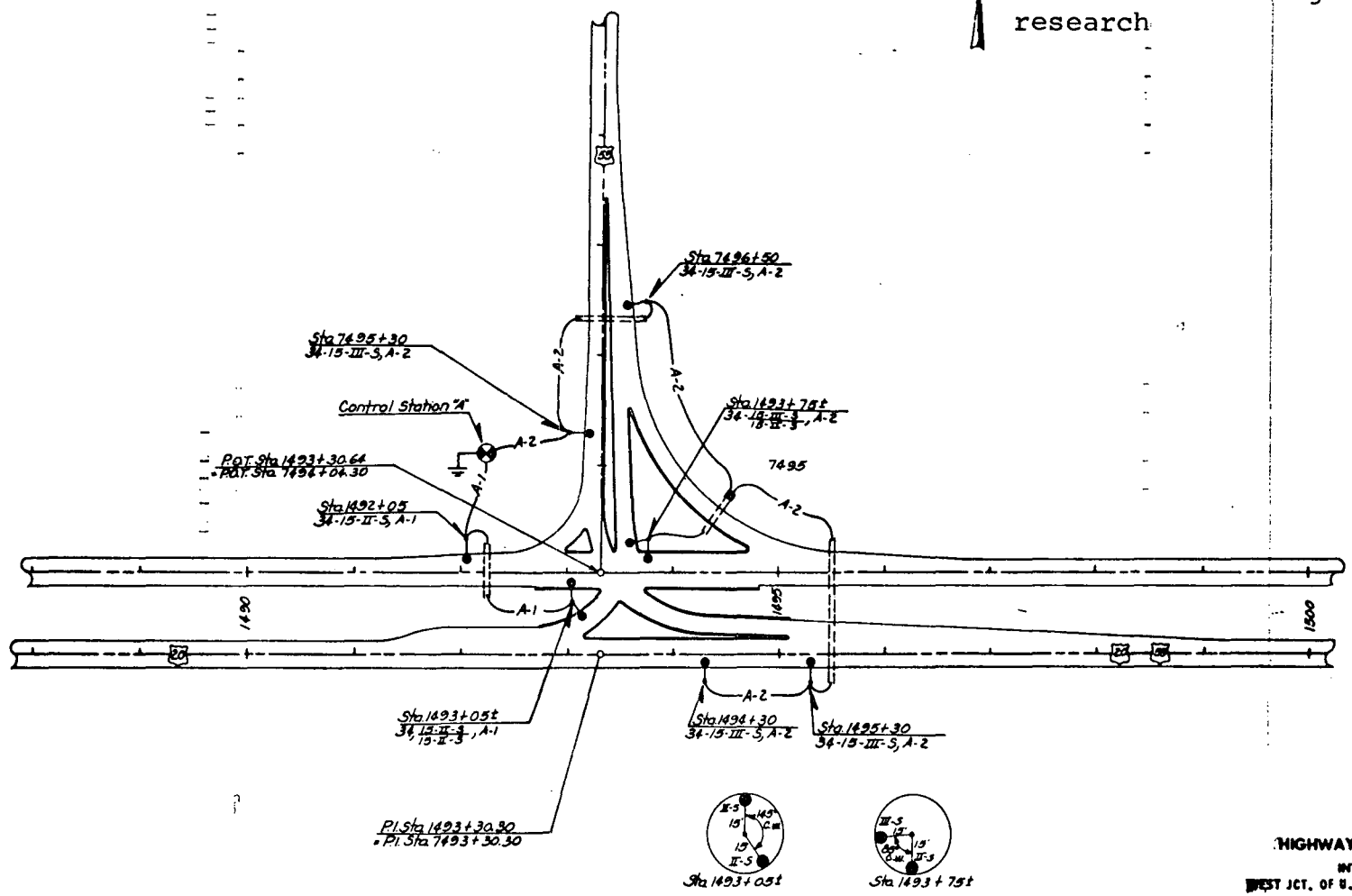
Ida COUNTY

F.A.-20-2(6)--21-07

5 15

Reference 7 B
Luminaires in original installation 9

All luminaires lighted during research



HIGHWAY LIGHTING LAYOUT
INTERSECTION OF
WEST JCT. OF U.S. NO. 20 AND U.S. NO.
Revised Aug. 31, 1967

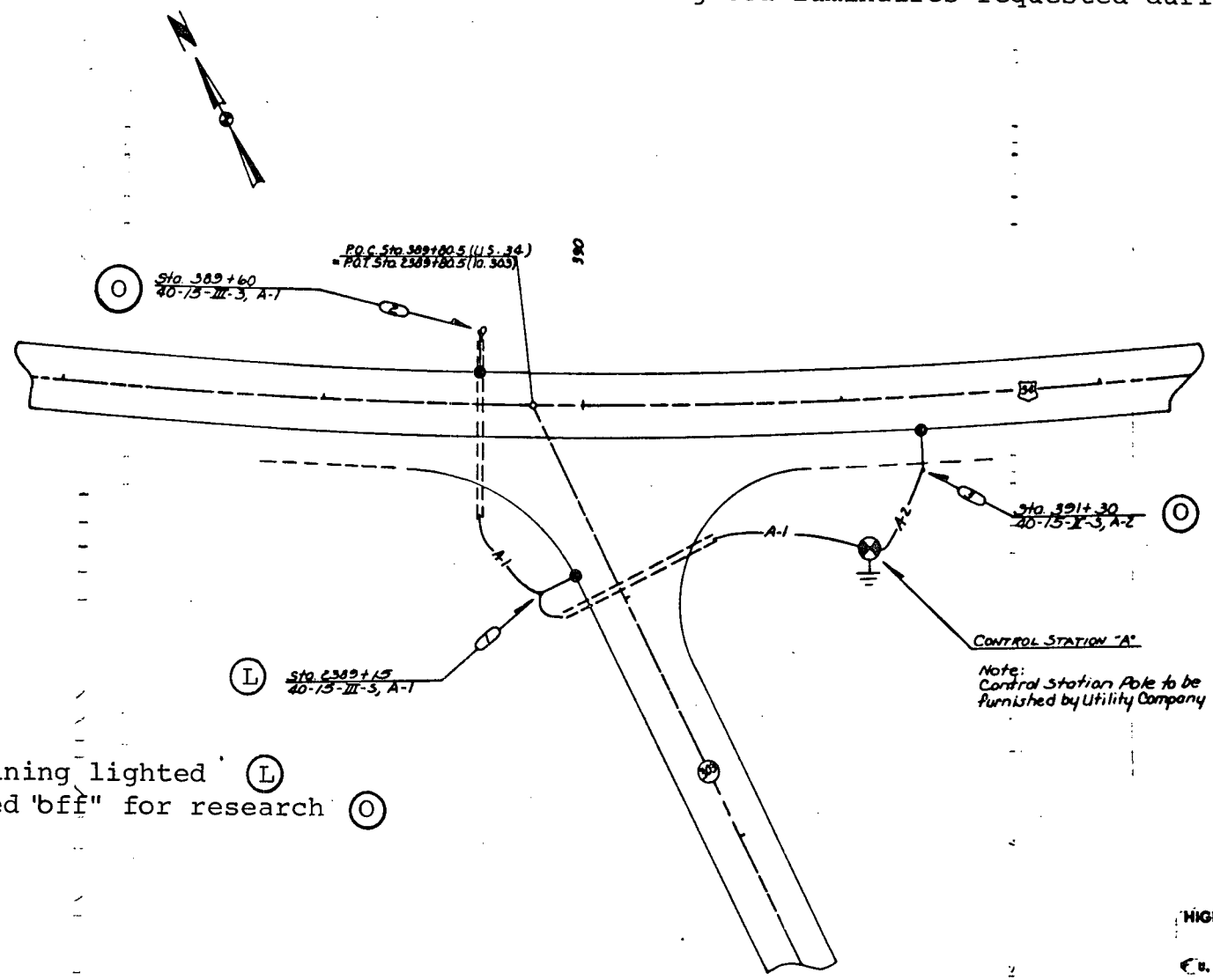
FILE NO. 958

Ida COUNTY

FN-20-2(6)--21-47

- 27 -

Reference 8 A
Luminaires in original installation 3
Lighted luminaires requested during research 1



Luminaires remaining lighted (L)
Luminaires turned "off" for research (O)

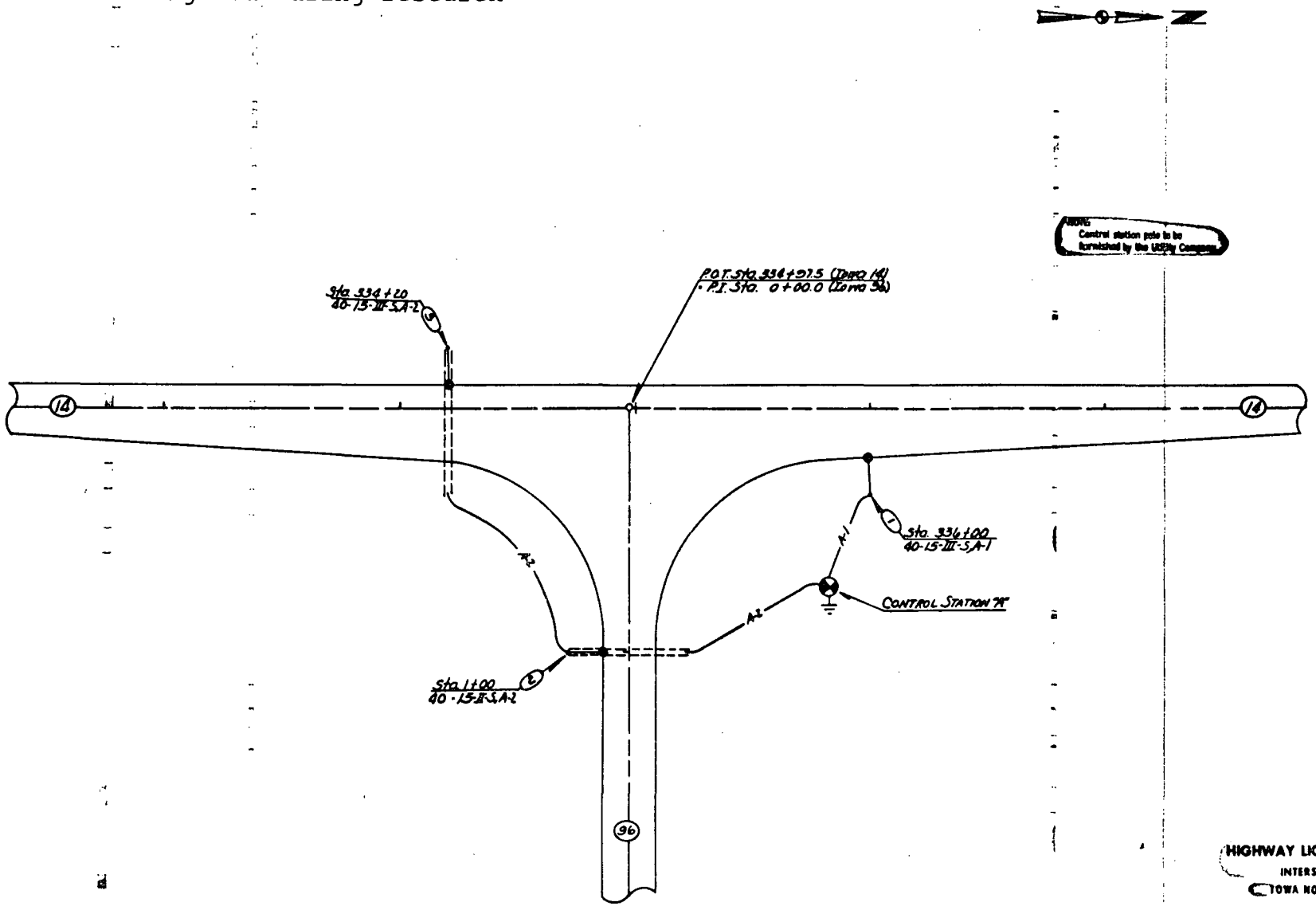
HIGHWAY LIGHTING LAYOUT
INTERSECTION OF
U.S. NO. 34 AND IOWA NO. 303

FILE NO. 219

Jefferson COUNTY

FN-34-8(5)--21-51

Reference 8 B
Luminaires in original installation 3
All luminaires lighted during research

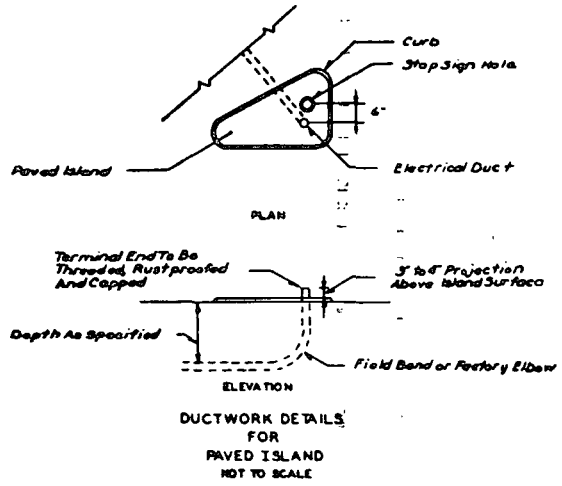


HIGHWAY LIGHTING LAYOUT
INTERSECTION OF
IOWA NO. 14 AND 96

FILE NO. 224

Marshall COUNTY

FN-16-9(15)--21-64



DUCTWORK DETAILS FOR PAVED ISLAND NOT TO SCALE

Reference 9 A
Luminaires in original installation 3
Lighted luminaires requested during research 1

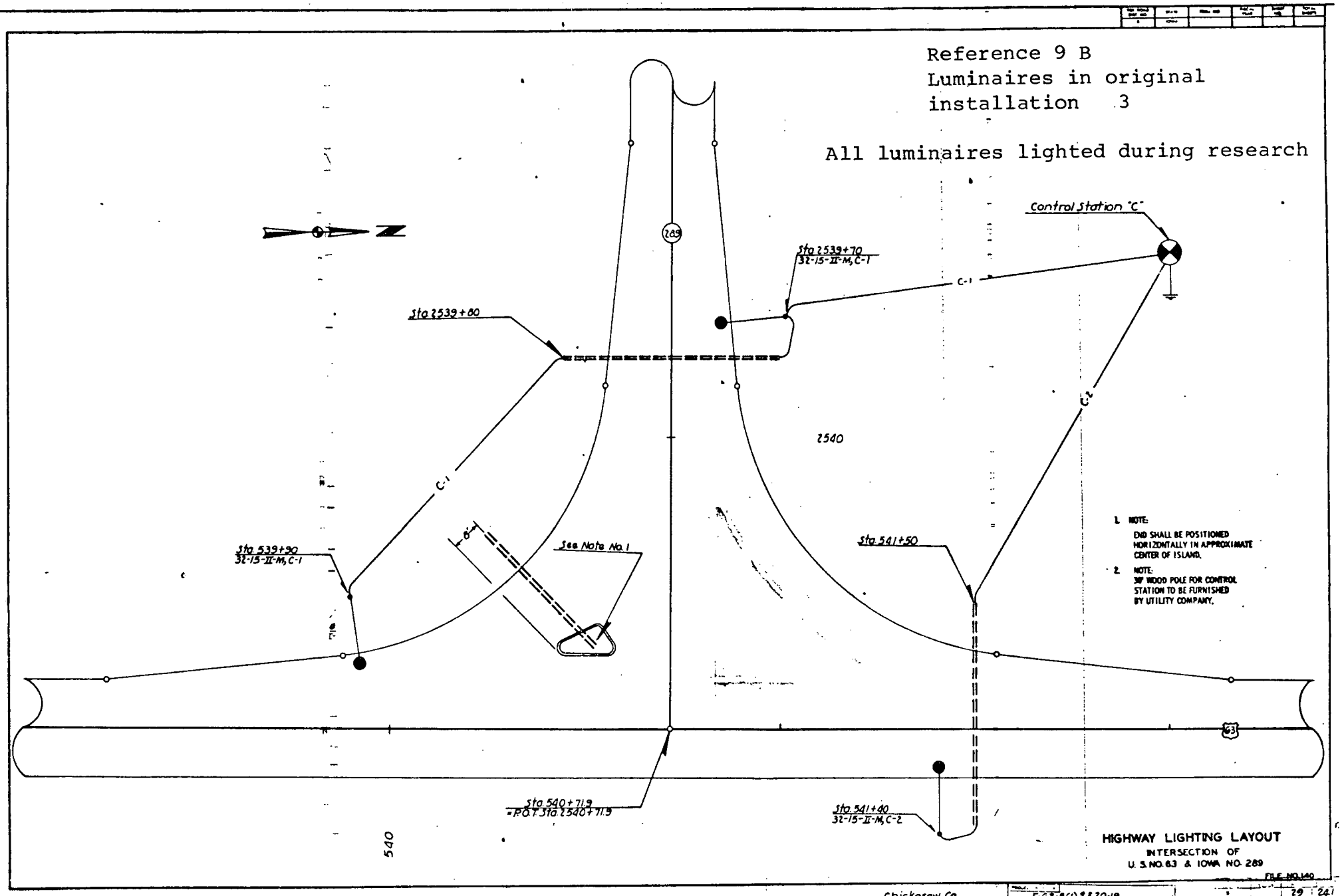
Luminaires remaining lighted (L)
Luminaires turned "off" for research (O)

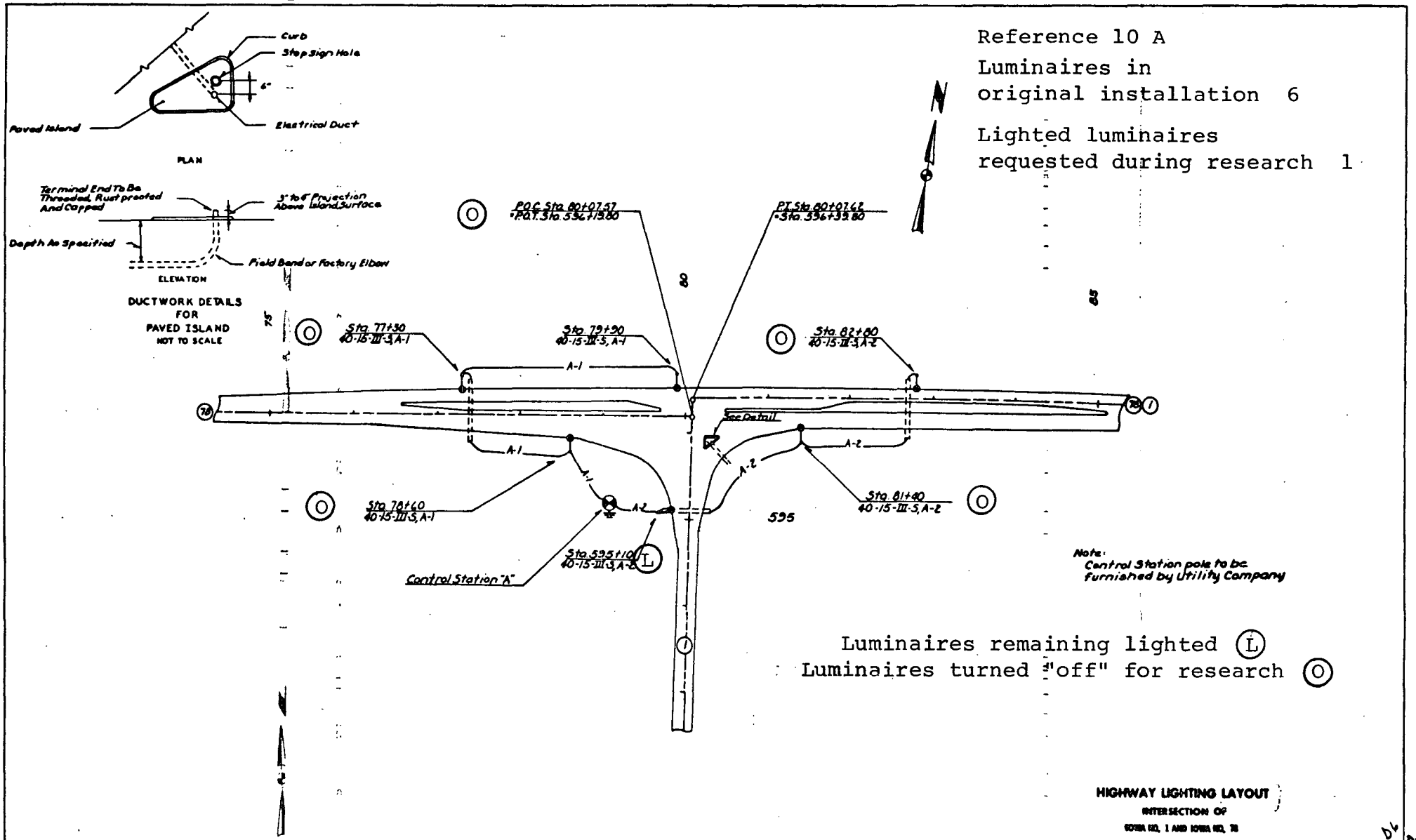
HIGHWAY LIGHTING LAYOUT
INTERSECTION OF
IOWA NO.] AND 356

FILE NO. 188

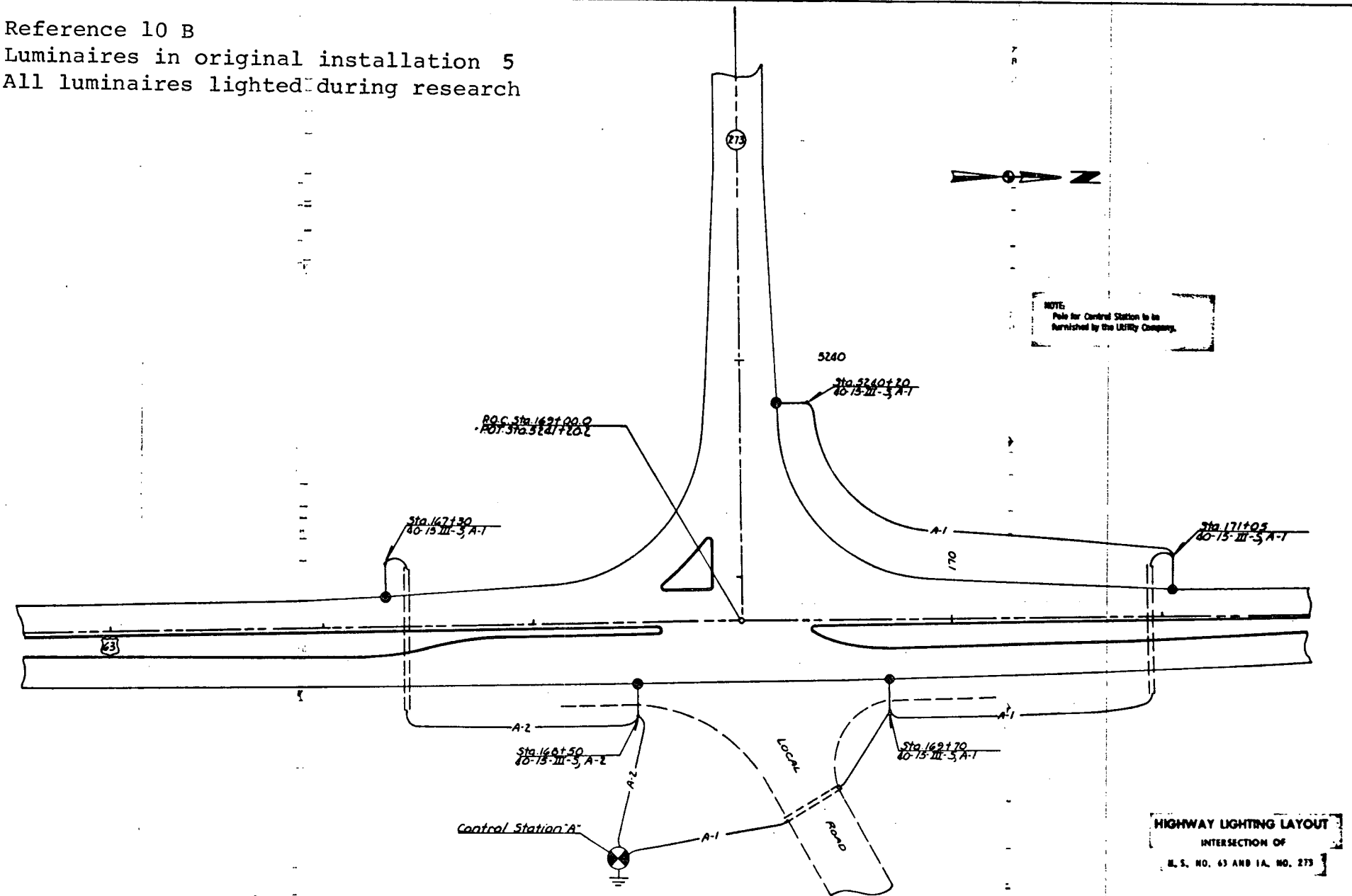
Jefferson COUNTY

F -1-2(2)--20-91


Reference 9 B
Luminaires in original installation 3
All luminaires lighted during research
Control Station "C"
Sta 2539+70
32-15-II-M, C-1
C-1
Sta 2539+60
C-1
C-2
2540
Sta 539+90
32-15-II-M, C-1
See Note No. 1
Sta 541+50
1. NOTE:
END SHALL BE POSITIONED HORIZONTALLY IN APPROXIMATE CENTER OF ISLAND.
2. NOTE:
30' WOOD POLE FOR CONTROL STATION TO BE FURNISHED BY UTILITY COMPANY.
Sta 540+71.9
= P.O.T. Sta 2540+71.9
Sta 541+60
32-15-II-M, C-2
HIGHWAY LIGHTING LAYOUT
INTERSECTION OF
U. S. NO. 63 & IOWA NO. 289
FILE NO. 140
Chickasaw Co.
F-63-6(1)--20-19
29
241


Curb
Stop Sign Hole
6"
Paved Island
Electrical Duct
PLAN
Terminal End To Be Threaded, Rust proofed And Capped
3" to 6" Projection Above Island Surface
Depth As Specified
Field Bend or Factory Elbow
ELEVATION
DUCTWORK DETAILS FOR PAVED ISLAND
NOT TO SCALE
POC Sta 80+07.67
POT Sta 556+15.80
PT Sta 80+07.42
Sta 556+35.80
Sta 77+30
40-15-III-S, A-1
Sta 79+90
40-15-III-S, A-1
Sta 82+60
40-15-III-S, A-2
A-1
A-2
See Detail
Sta 78+40
40-15-III-S, A-1
Sta 81+40
40-15-III-S, A-2
595
Sta 595+10
40-15-III-S, A-2
Control Station "A"
Note:
Control Station pole to be furnished by Utility Company
Reference 10 A
Luminaires in original installation 6
Lighted luminaires requested during research 1
Luminaires remaining lighted (L)
Luminaires turned "off" for research (O)
HIGHWAY LIGHTING LAYOUT
INTERSECTION OF
IOWA NO. 1 AND IOWA NO. 78
Revised April 14, 1969
Keokuk COUNTY
F-1-2(5)--00-56
FILE NO. 185

Reference 10 B
Luminaires in original installation 5
All luminaires lighted during research



HIGHWAY LIGHTING LAYOUT
INTERSECTION OF
U. S. NO. 63 AND I.A. NO. 273

FILE NO. 89 D-3

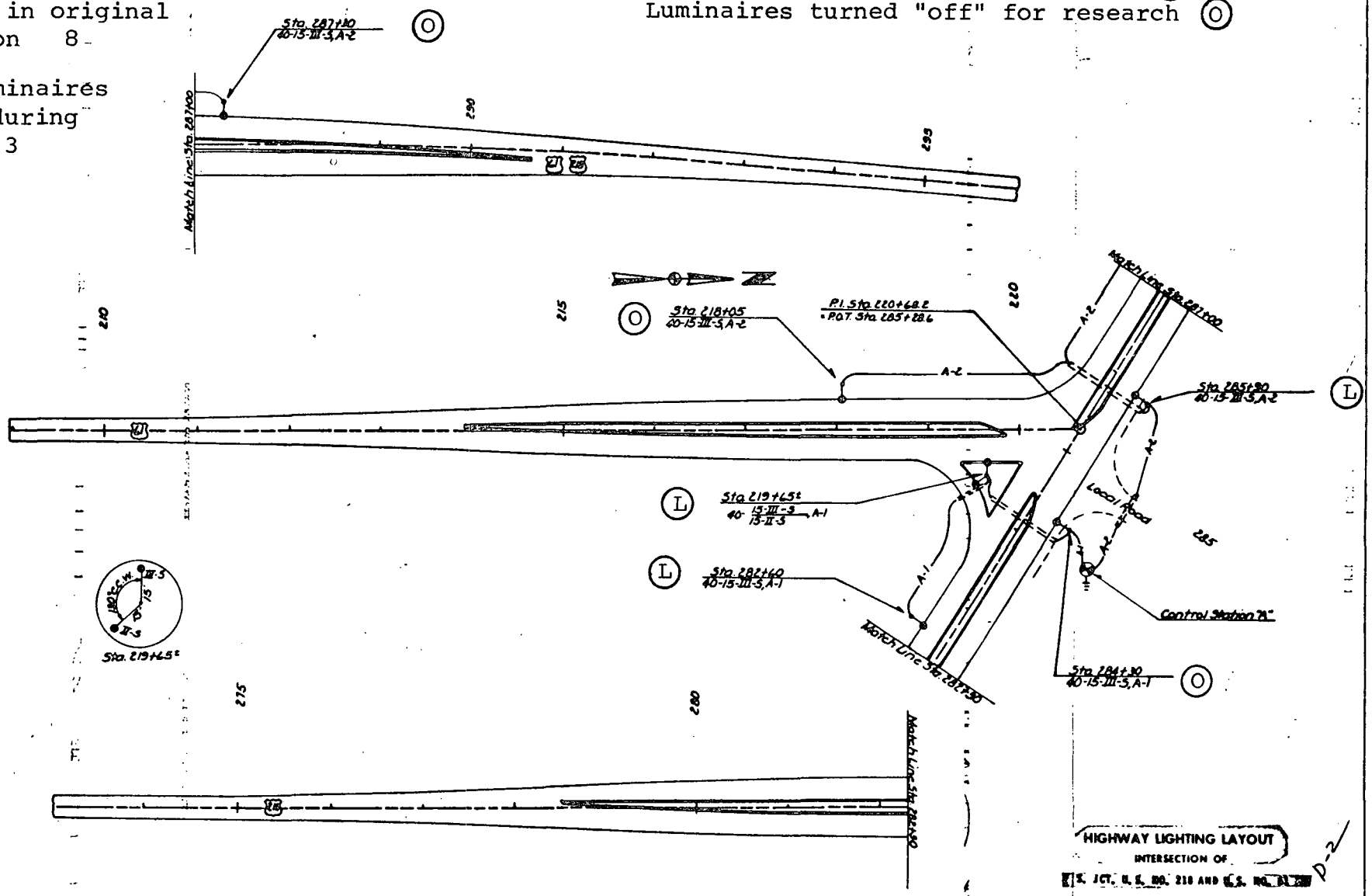
Davis COUNTY

PROJECT NUMBER
FN-63-1(6)--21-26

Reference 11 A
Luminaires in original installation 8

Lighted luminaires requested during research 3

Luminaires remaining lighted (L)
Luminaires turned "off" for research (O)

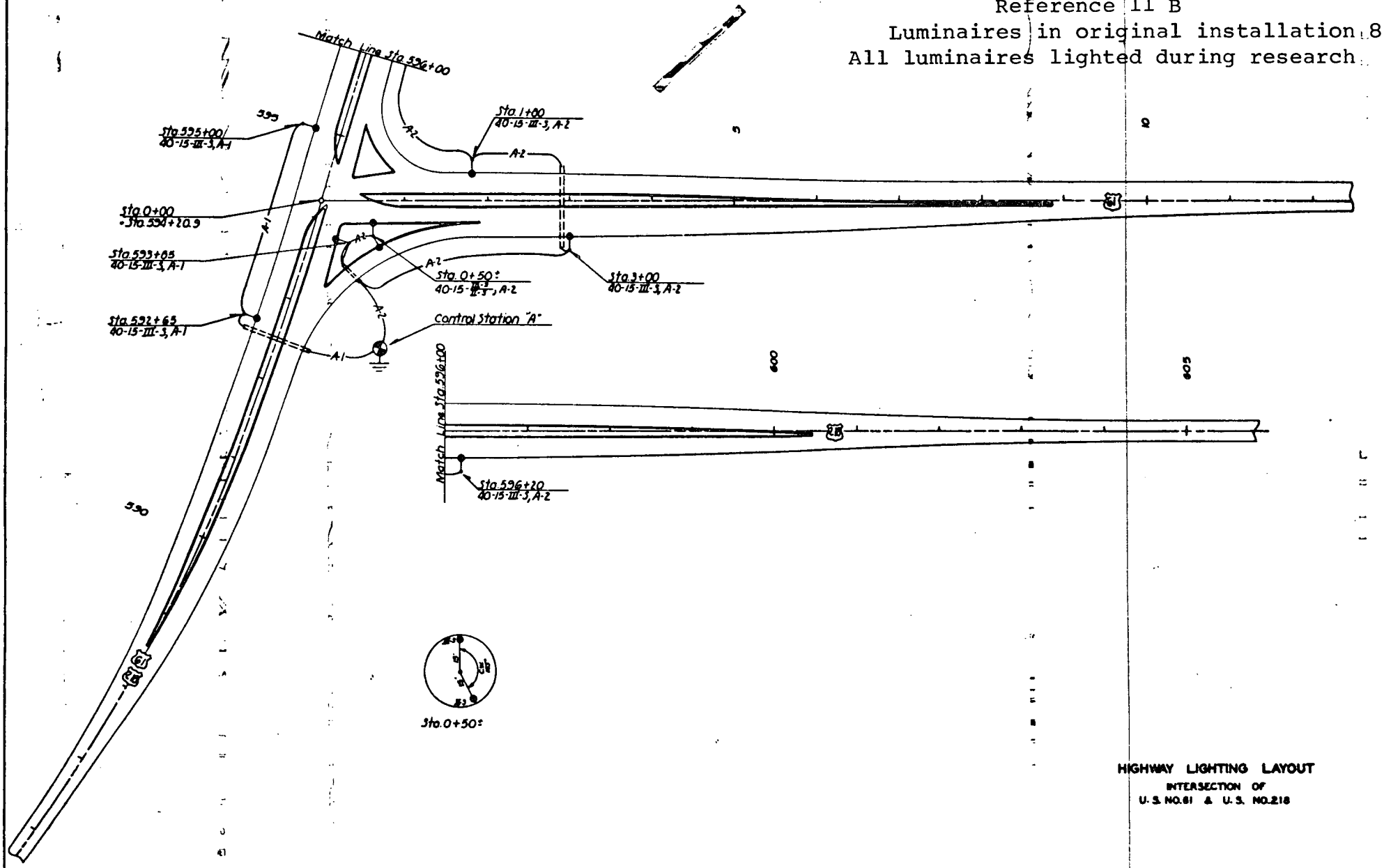


FILE NO. 170

Lee COUNTY

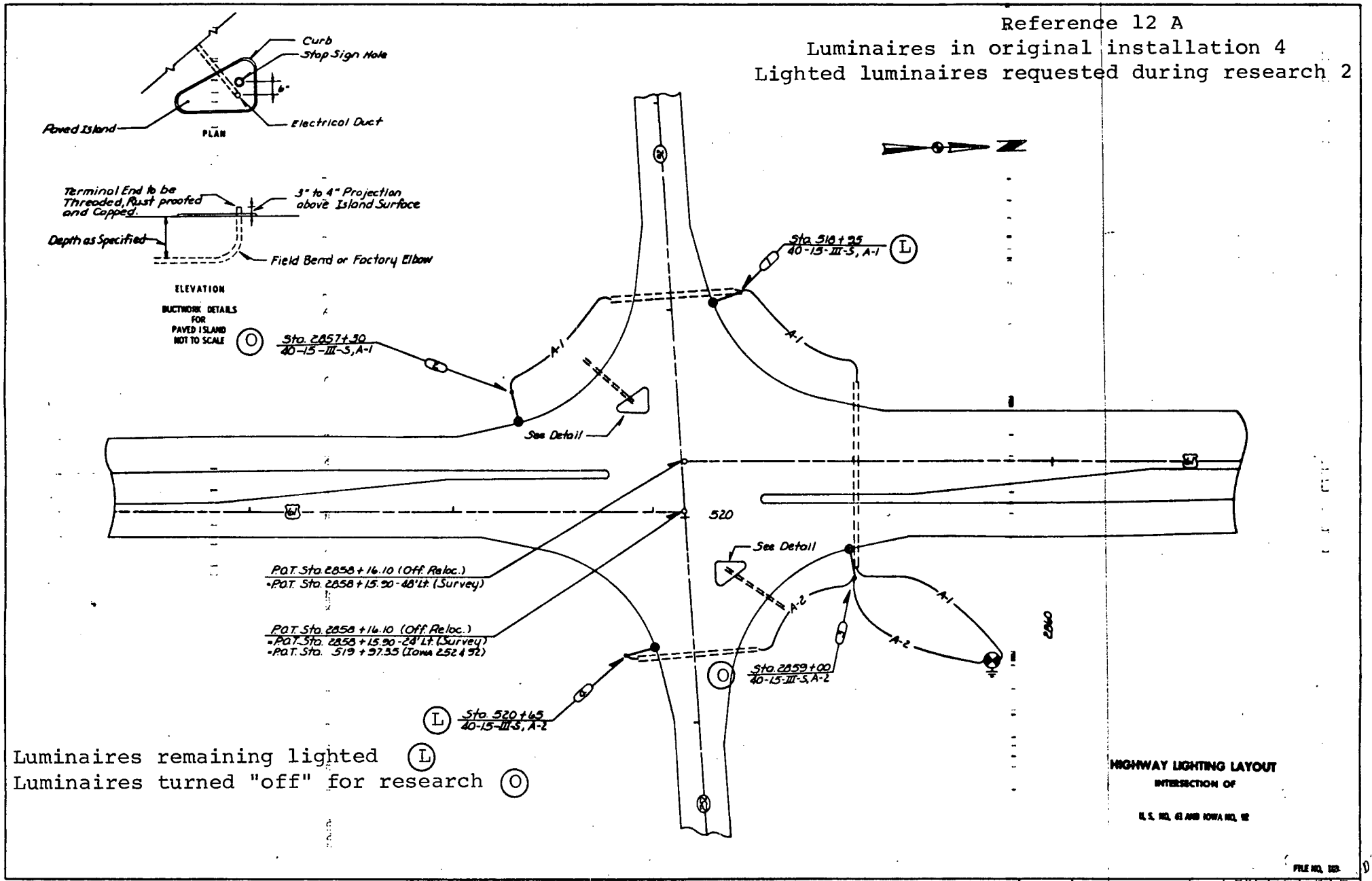
FN-61-1(8)--21-56

Reference 11 B
Luminaires in original installation 8
All luminaires lighted during research

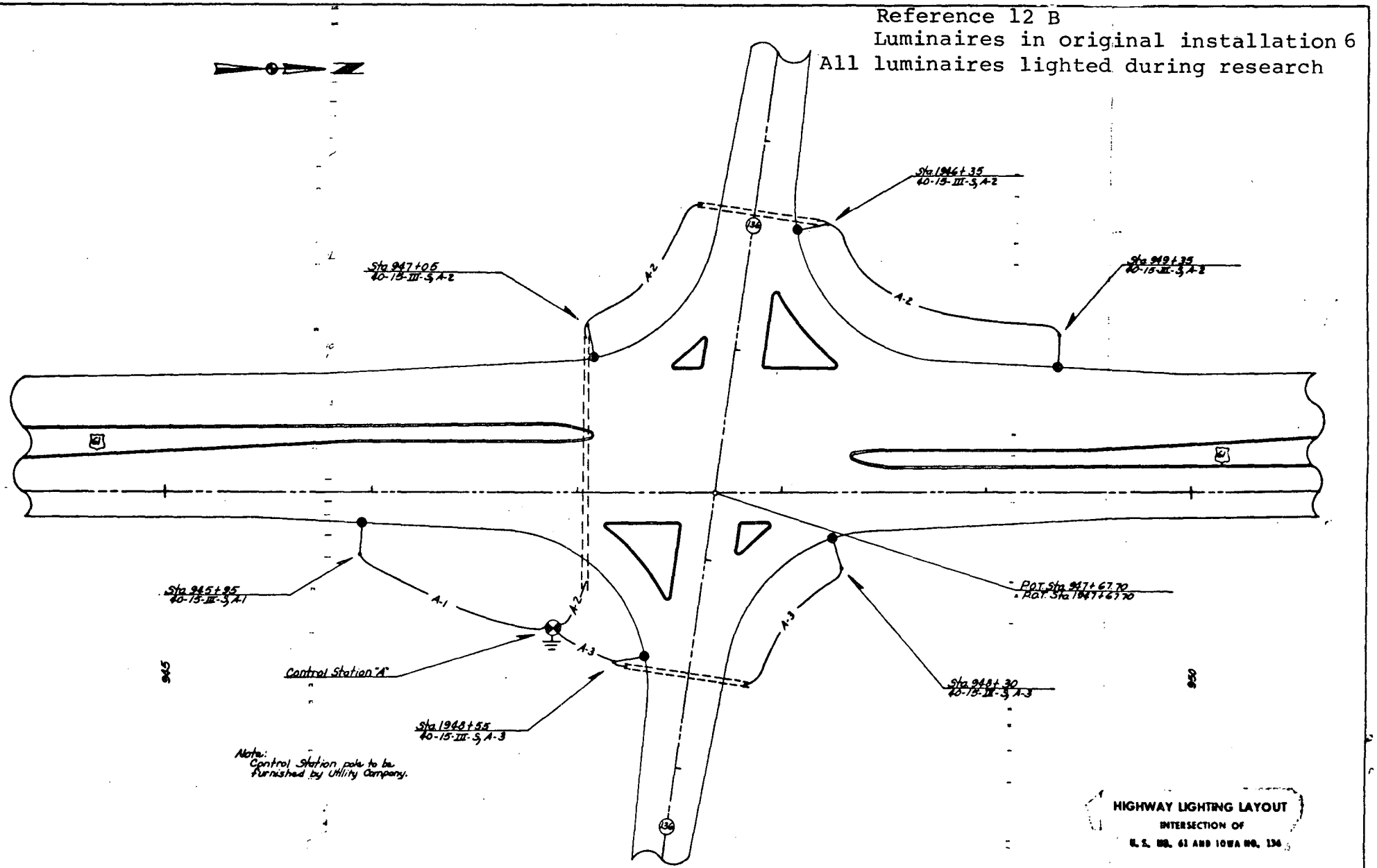


HIGHWAY LIGHTING LAYOUT
INTERSECTION OF
U. S. NO. 61 & U. S. NO. 218

Lee Co.
FN-61-1(4)--21-56


Reference 12 A
Luminaires in original installation 4
Lighted luminaires requested during research 2
Curb
Stop Sign Hole
6"
Paved Island
Electrical Duct
PLAN
Terminal End to be Threaded, Rust proofed and Capped.
3" to 4" Projection above Island Surface
Depth as Specified
Field Bend or Factory Elbow
ELEVATION
DUCTWORK DETAILS FOR PAVED ISLAND NOT TO SCALE
Sta. 2857+30 40-15-III-S, A-1
Sta. 518+25 40-15-III-S, A-1
A-1
See Detail
520
P.O.T. Sta. 2858+16.10 (Off. Reloc.)
•P.O.T. Sta. 2858+15.90-48'Lt. (Survey)
P.O.T. Sta. 2858+16.10 (Off. Reloc.)
•P.O.T. Sta. 2858+15.90-28'Lt. (Survey)
•P.O.T. Sta. 519+97.35 (Iowa 252 & 92)
See Detail
A-2
A-1
Sta. 2859+00 40-15-III-S, A-2
Sta. 520+65 40-15-III-S, A-2
2860
Luminaires remaining lighted (L)
Luminaires turned "off" for research (O)
HIGHWAY LIGHTING LAYOUT
INTERSECTION OF
U. S. NO. 60 AND IOWA NO. 92
FILE NO. 1223
Louisa COUNTY
F-61-3(2)--20-58
26
91

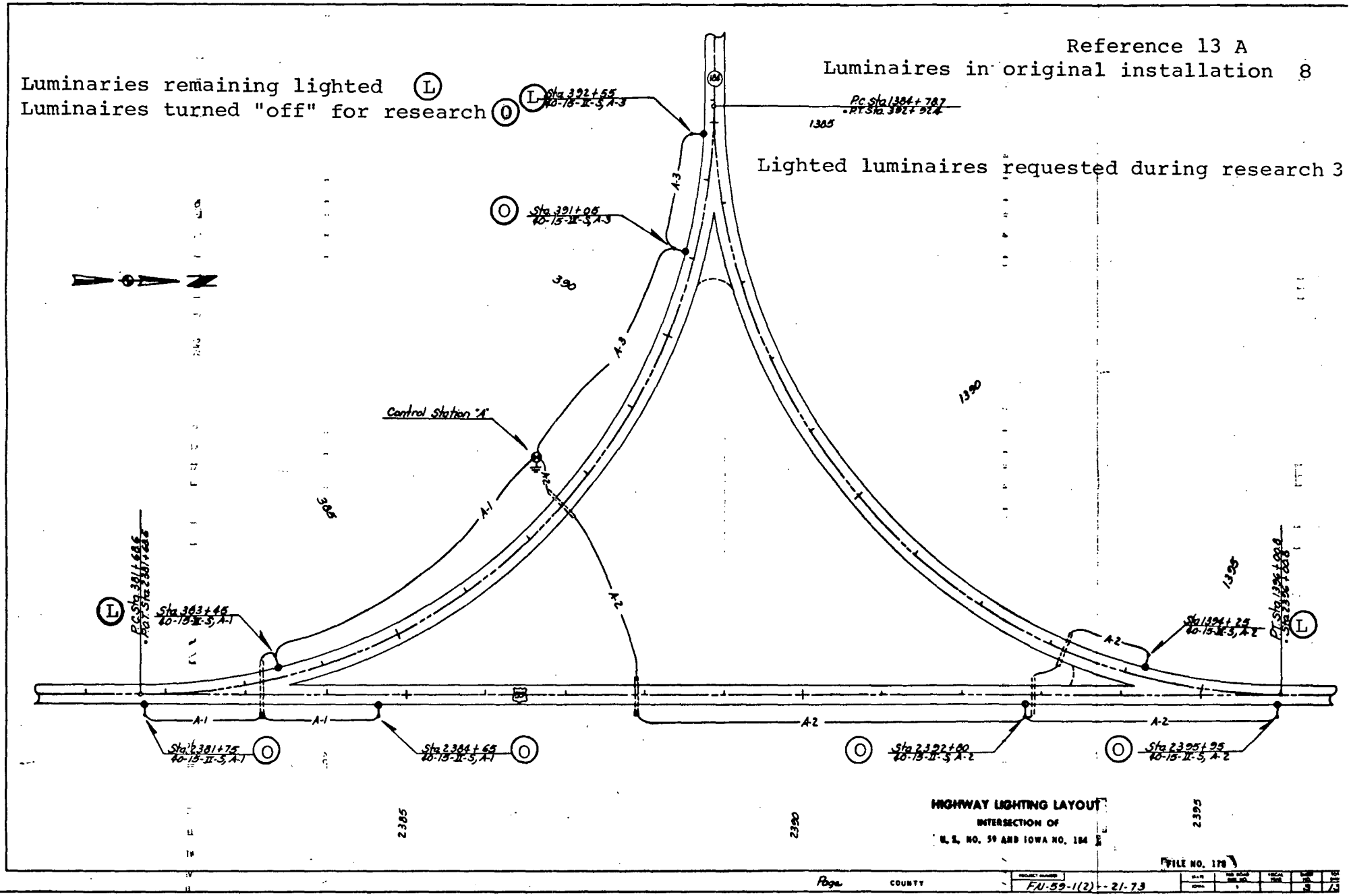
Reference 12 B
Luminaires in original installation 6
All luminaires lighted during research



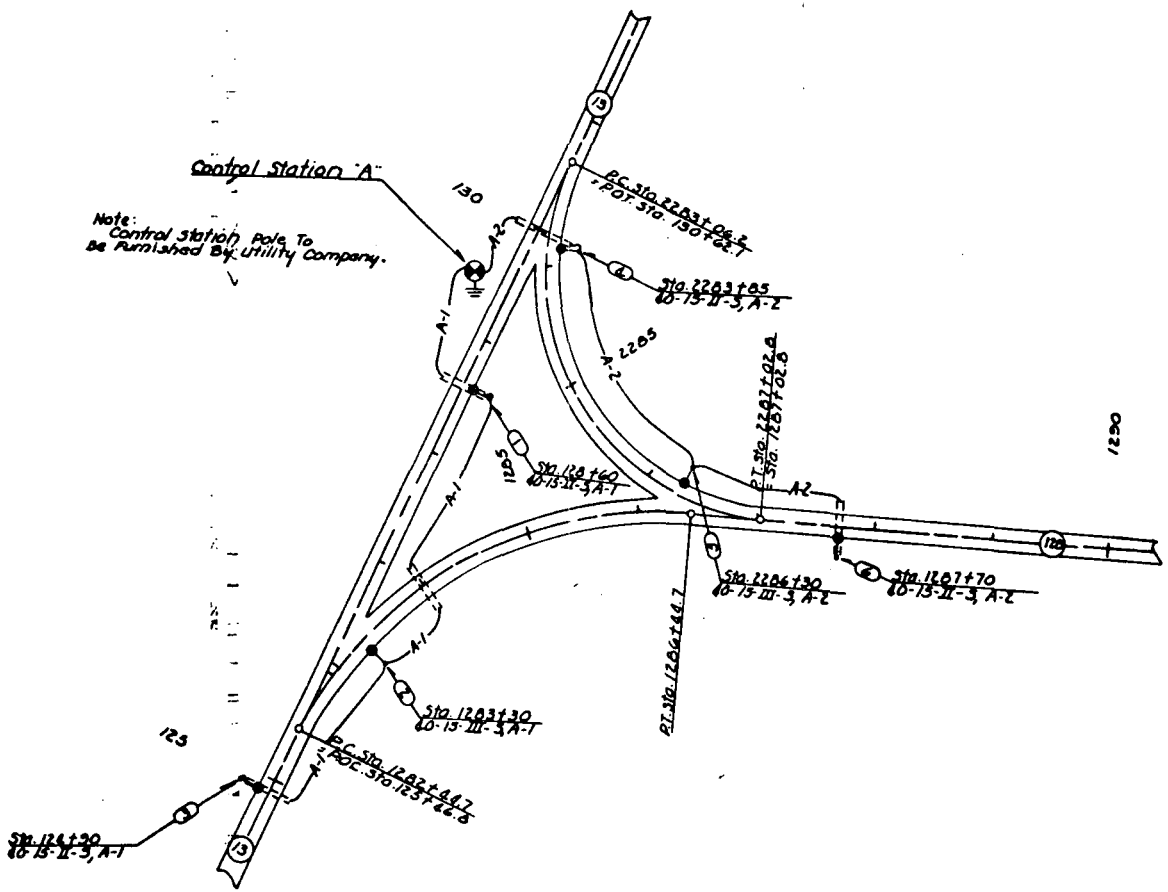
FILE NO. 57

Clinton COUNTY

FN-61-6(4)--21-23


Reference 13 A
Luminaires in original installation 8
Luminaries remaining lighted (L)
Luminaires turned "off" for research (O)
Lighted luminaires requested during research 3
Sta 392+55
40-15-II-S, A-3
PC Sta 1384+787
PT Sta 392+924
1385
Sta 391+05
40-15-II-S, A-3
390
A-3
Control Station "A"
A-1
A-2
1390
Sta 363+46
40-15-II-S, A-1
PC Sta 391+646
PT Sta 2387+686
Sta 1394+29
40-15-II-S, A-2
PT Sta 1394+828
PC Sta 2392+814
1395
A-1
A-1
A-2
A-2
Sta 2381+75
40-15-II-S, A-1
Sta 2384+65
40-15-II-S, A-1
Sta 2392+60
40-15-II-S, A-2
Sta 2395+95
40-15-II-S, A-2
2385
2390
2395
HIGHWAY LIGHTING LAYOUT
INTERSECTION OF
U. S. NO. 59 AND IOWA NO. 184
FILE NO. 178
Page
COUNTY
FAI-59-1(2)--21-73

Reference 13 B
Luminaires in original installation 6
All luminaires lighted during research



HIGHWAY LIGHTING LAYOUT
INTERSECTION OF
IOWA NOS. 13 AND 128

FILE NO. 213

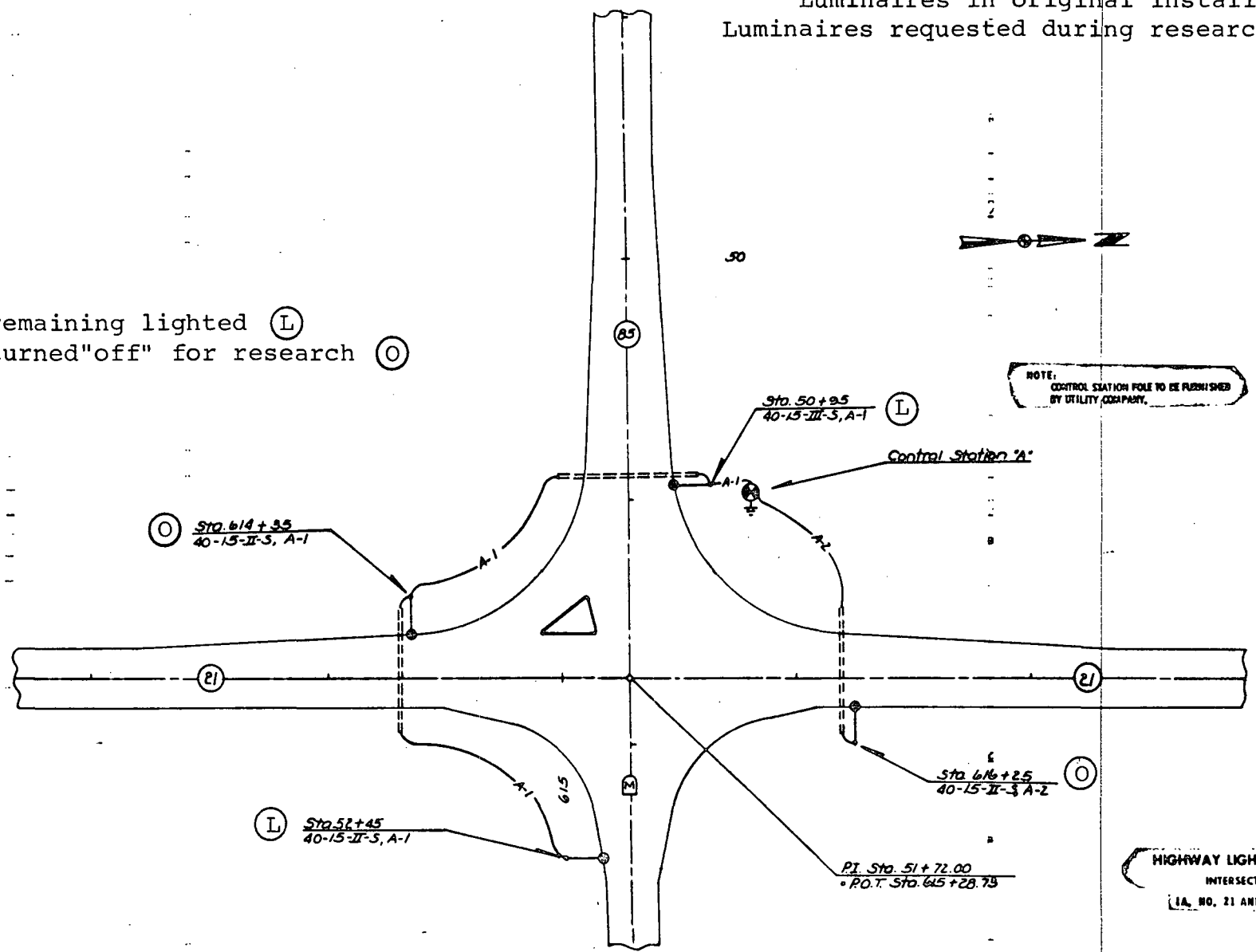
Clayton COUNTY

FN-13-9(4)--21-22

			3	11

Reference 14 A
Luminaires in original installation 4
Luminaires requested during research 2

Luminaires remaining lighted (L)
Luminaires turned"off" for research (O)



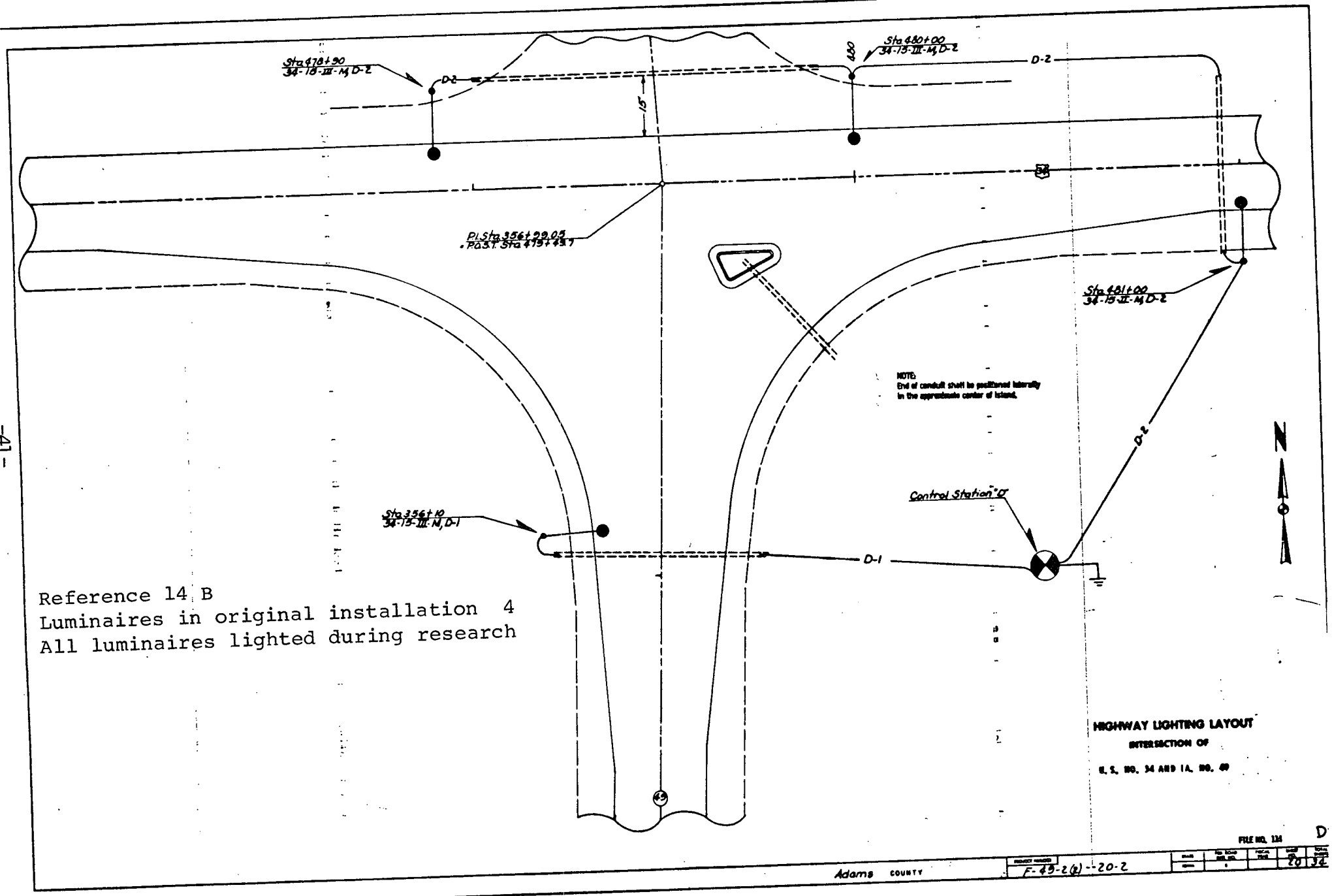
HIGHWAY LIGHTING LAYOUT
INTERSECTION OF
IA. NO. 21 AND IA. NO. 85

FILE NO. 171

Poweshiek COUNTY

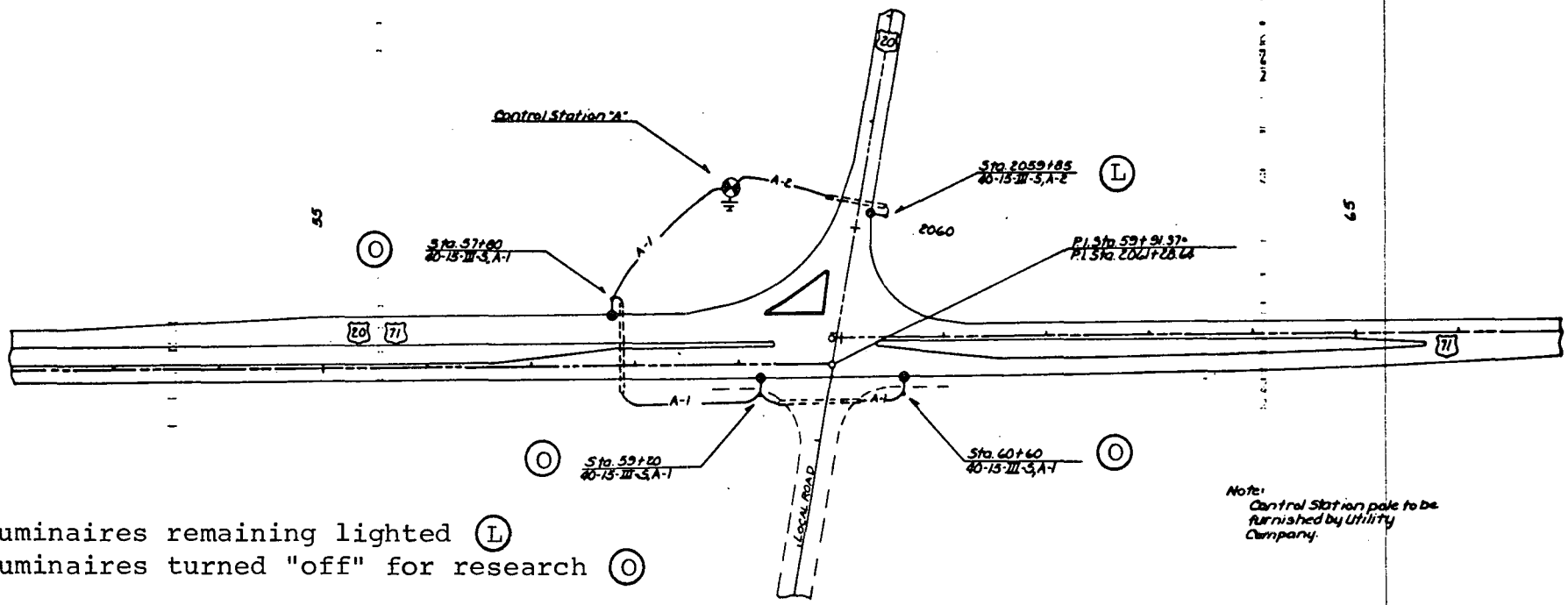
FN-21-2(4)--21-79

SHEET NO. 3 TOTAL SHEETS 10



Reference 14 B
Luminaires in original installation 4
All luminaires lighted during research

Reference 15 A
Luminaires in original installation 4
Lighted luminaires requested during research 1



Note:
Control Station pole to be furnished by Utility Company.

Luminaires remaining lighted (L)
Luminaires turned "off" for research (O)

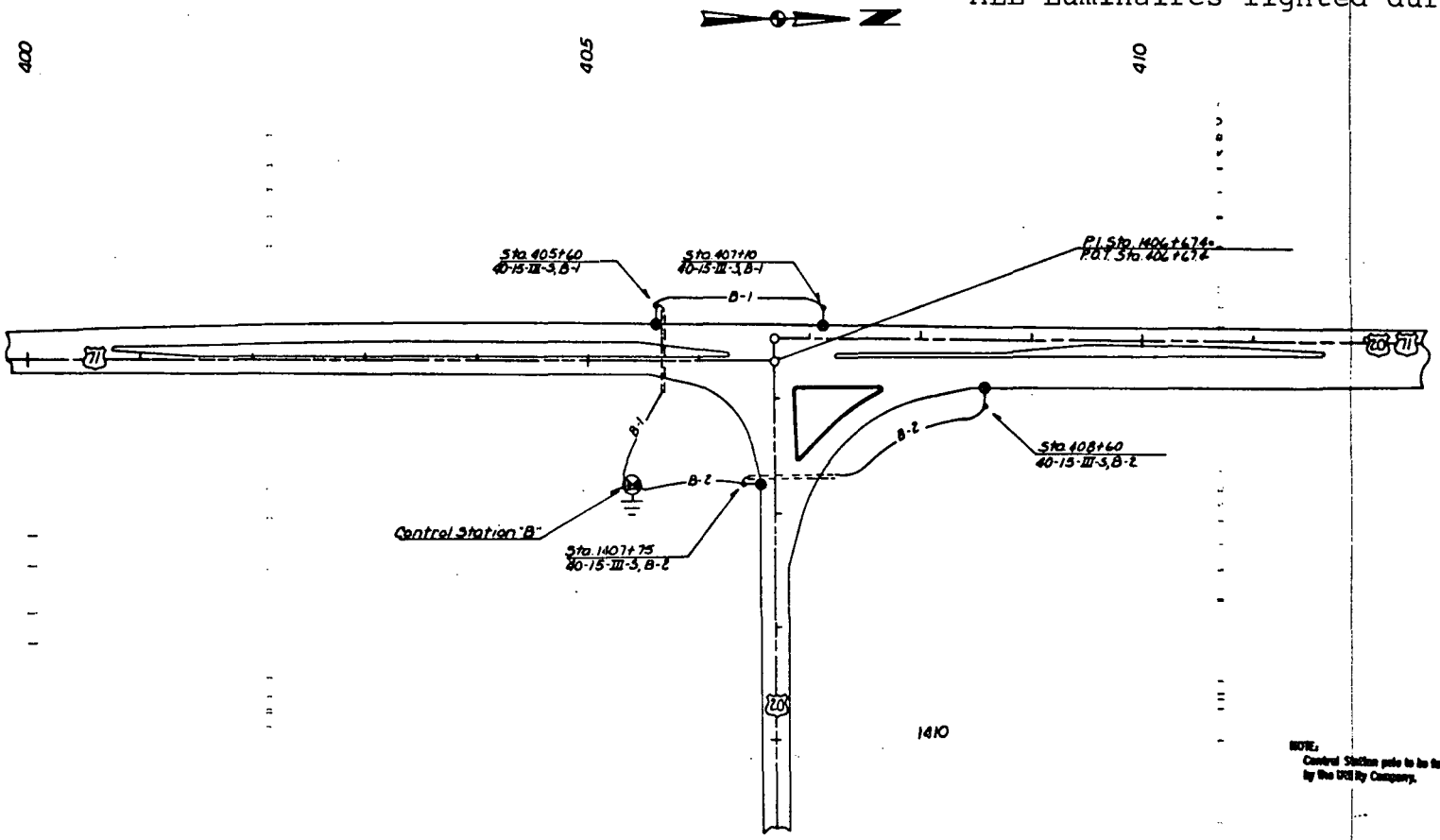
HIGHWAY LIGHTING LAYOUT
INTERSECTION OF
NORTH JUNCTION OF U. S. NO. 20 AND 71

FILE NO. 9A

Sac COUNTY

F-20-2(1)--20-B1

Reference 15 B
Luminaires in original installation 4
ALL Luminaires lighted during research



NOTE:
Control Station pole to be furnished by the Utility Company.

HIGHWAY LIGHTING LAYOUT
INTERSECTION OF
SOUTH JUNCTION OF U. S. NO. 20 AND 71

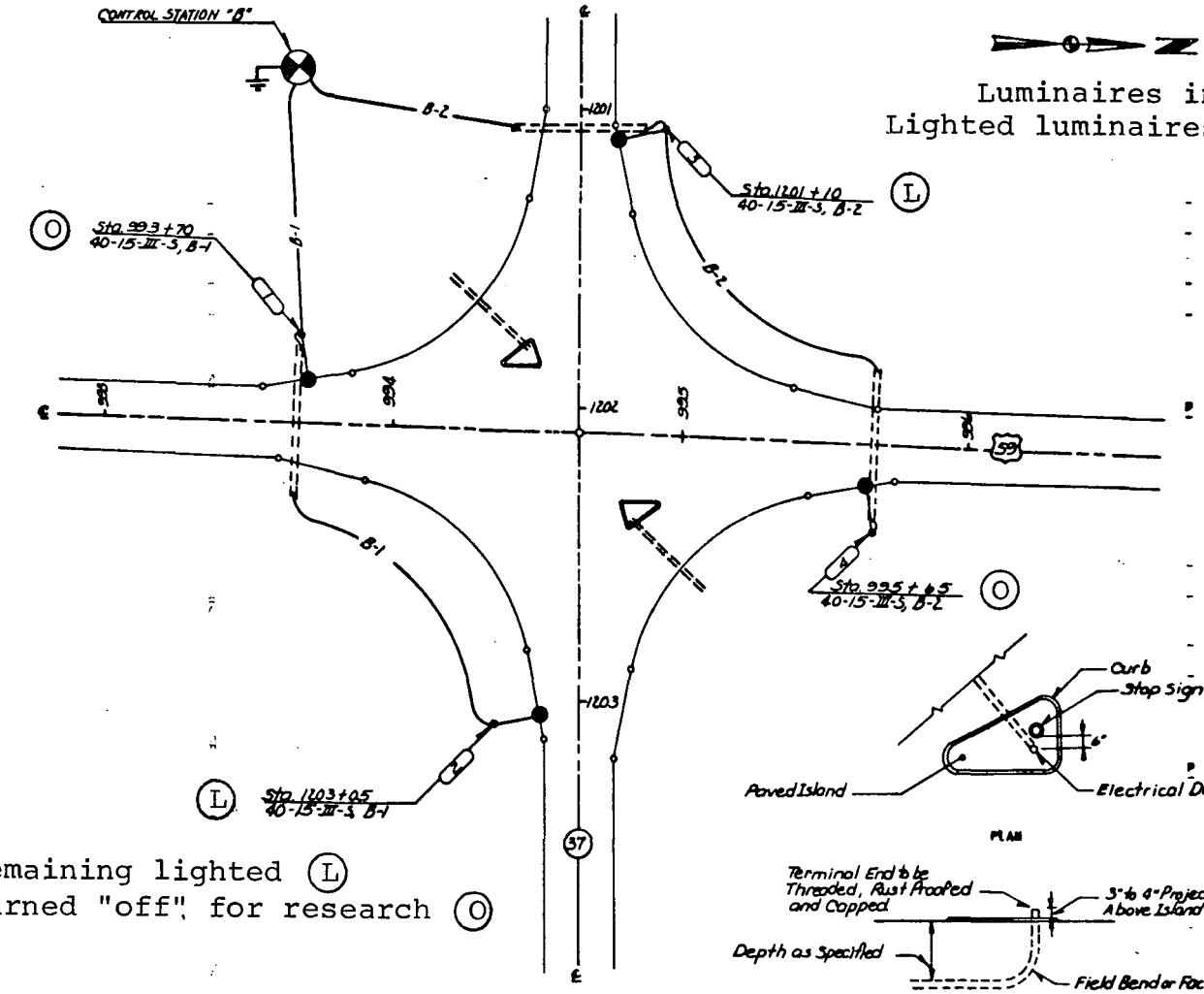
FILE NO. 98

SOC COUNTY

F-20-2(1)--20-81

87 131

Reference 16 A



Luminaires in original installation 4
Lighted luminaires requested for research 2

Luminaires remaining lighted (L)
Luminaires turned "off" for research (O)

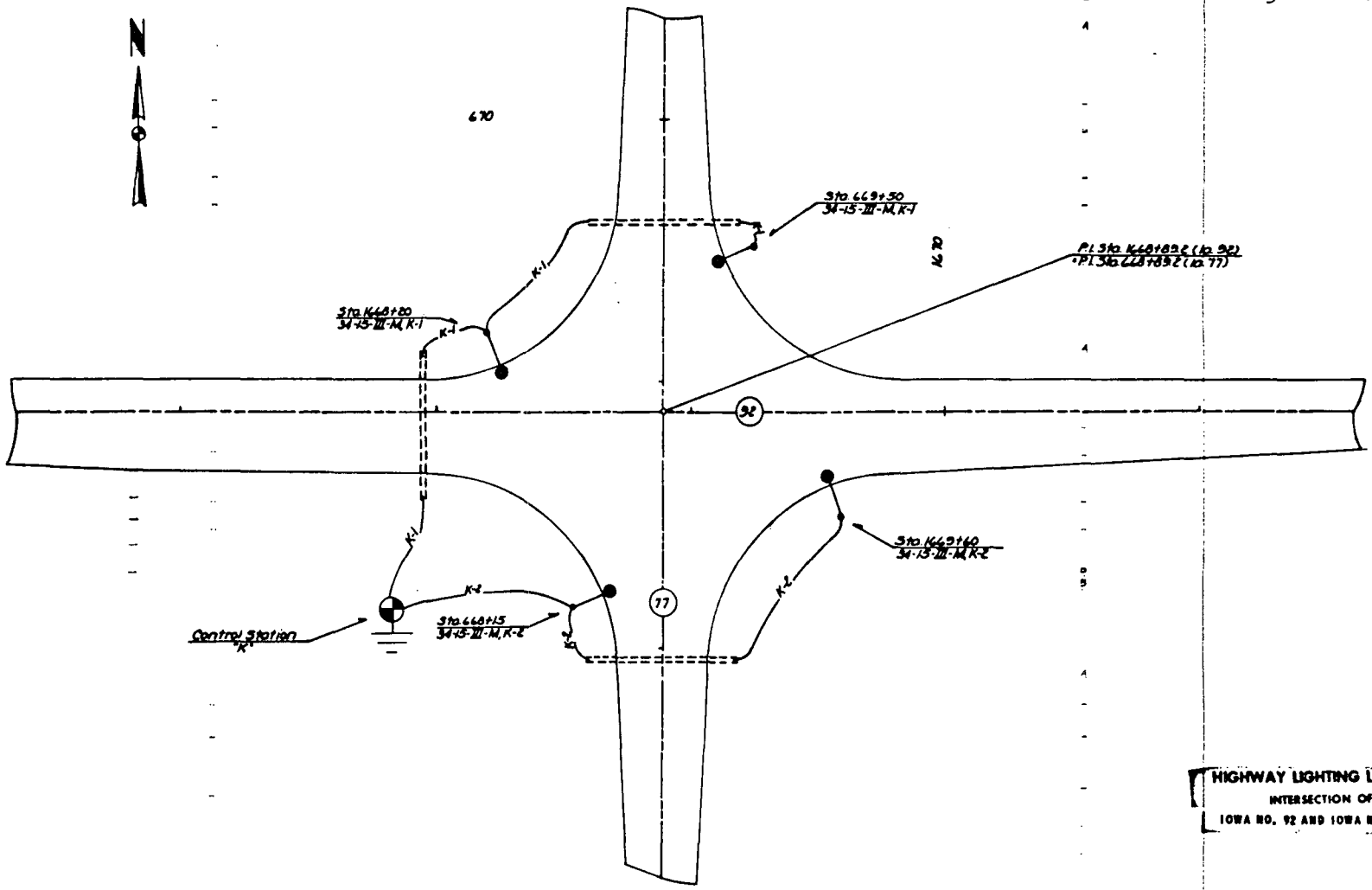
HIGHWAY LIGHTING LAYOUT
INTERSECTION OF
I.A. 37 & U.S. 59

FILE NO. 210

Shelby COUNTY

F-59-4(10)--20-69

Reference 16 B
Luminaires in original installation 4
All luminaires lighted during research



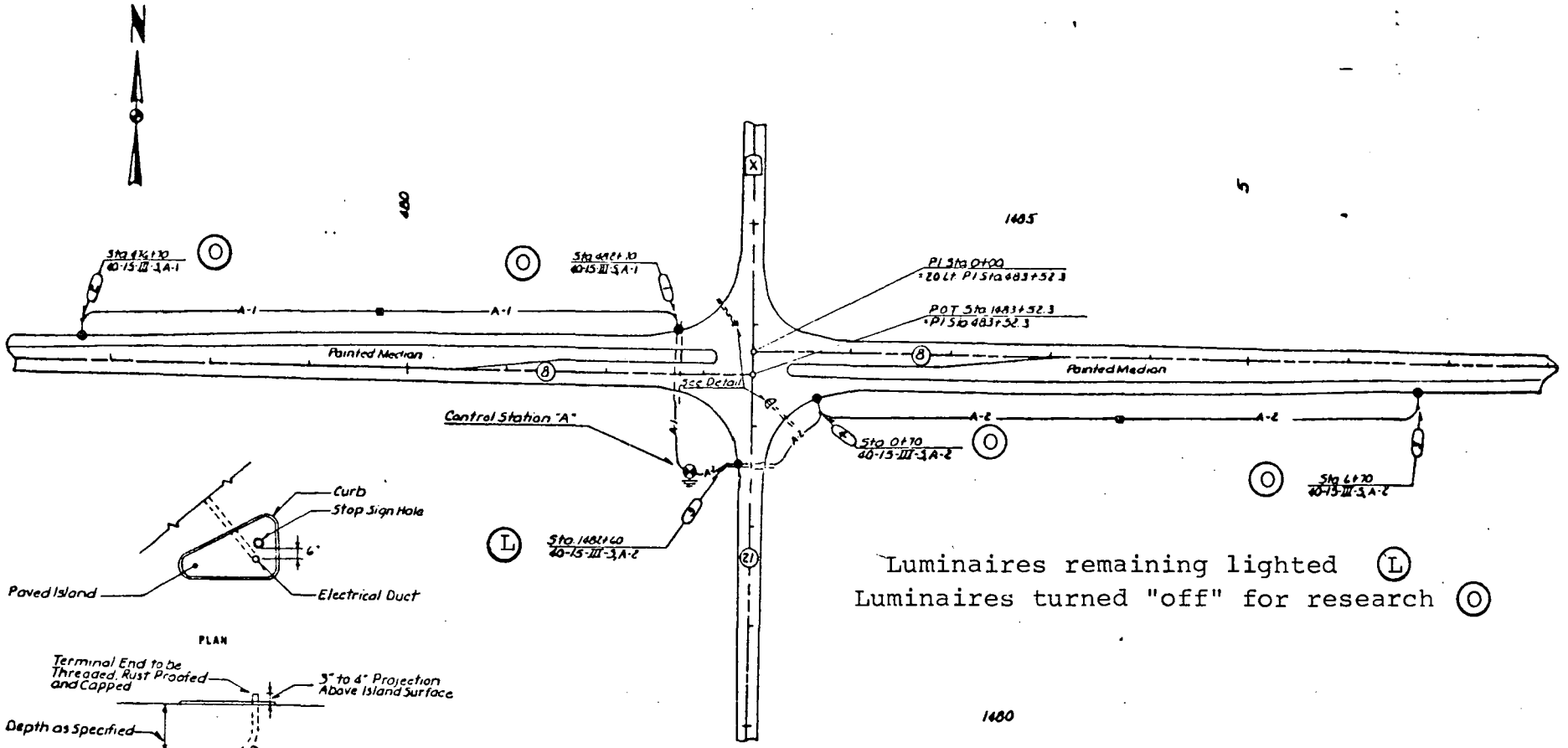
HIGHWAY LIGHTING LAYOUT
INTERSECTION OF
IOWA NO. 92 AND IOWA NO. 77

FILE NO. 161 044

KeoKuK COUNTY

FN-92-8(5)--21-56

Reference 17 A
Luminaires in original installation 5
Lighted luminaires requested during research 1



Luminaires remaining lighted (L)
Luminaires turned "off" for research (O)

PLAN

ELEVATION

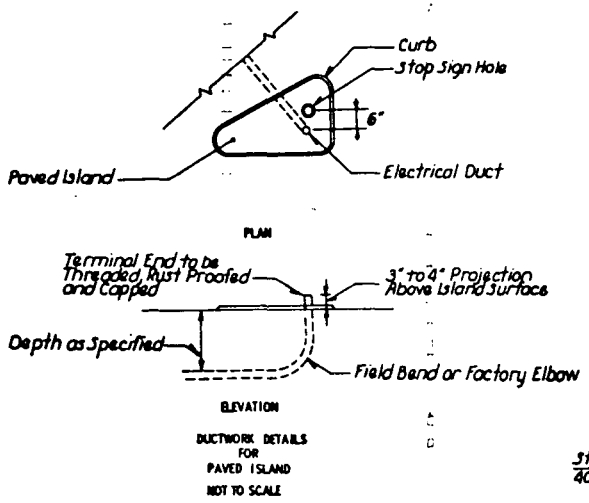
DUCTWORK DETAILS
FOR
PAVED ISLAND
NOT TO SCALE

HIGHWAY LIGHTING LAYOUT
INTERSECTION OF
IOWA NOS. 8 AND 21
SCALE: 1"=50'

FILE NO. 196

Tama COUNTY FN-8-1(6)--21--86

Reference 17 B



Luminaires in original installation 4
All luminaires lighted during research

HIGHWAY LIGHTING LAYOUT
INTERSECTION OF
IOWA NOS. 4 & 7

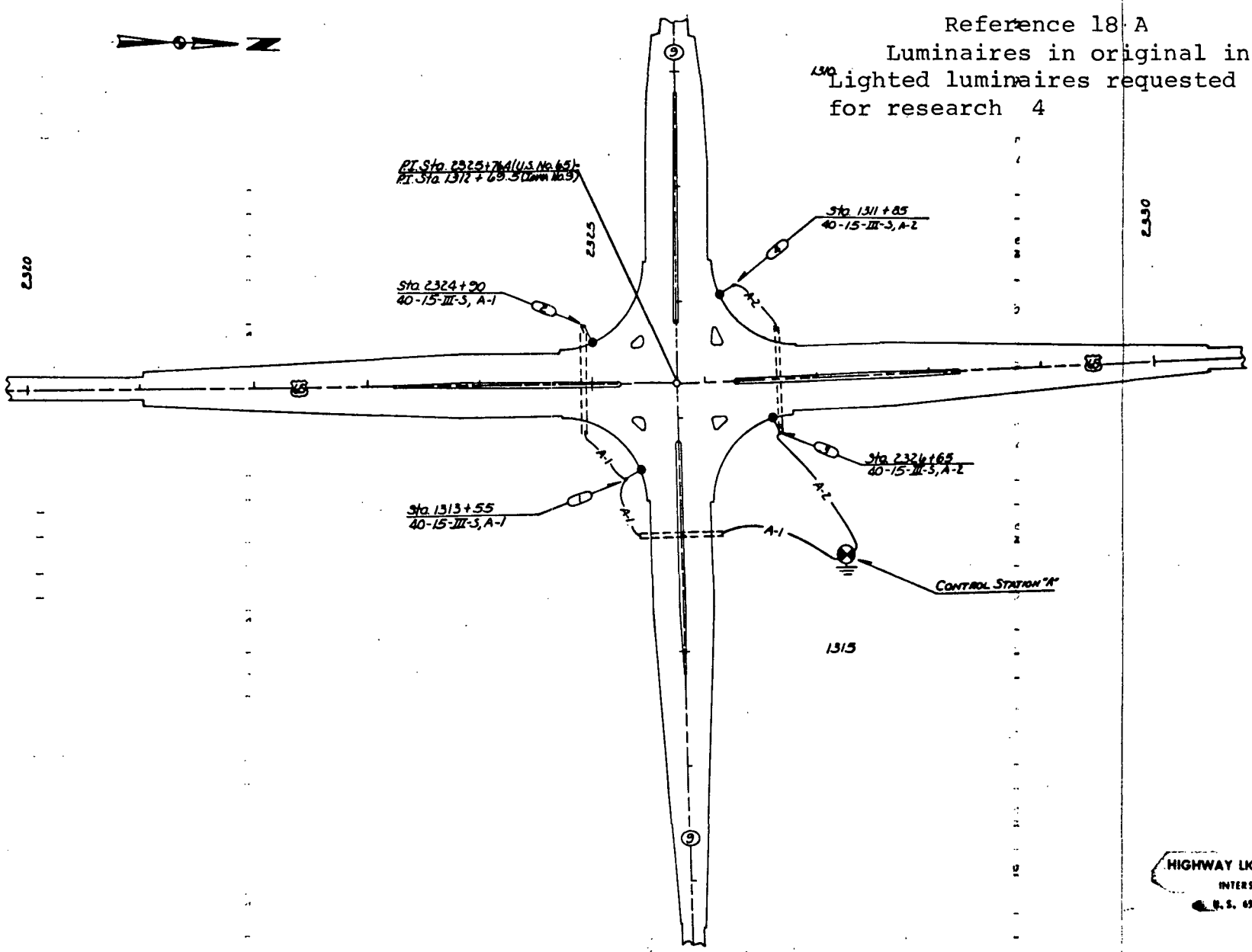
FILE NO. 17

Pocahontas COUNTY

FN-4-4(1)--21-76

			16	73

Reference 18 A
Luminaires in original installation 4
Lighted luminaires requested
for research 4



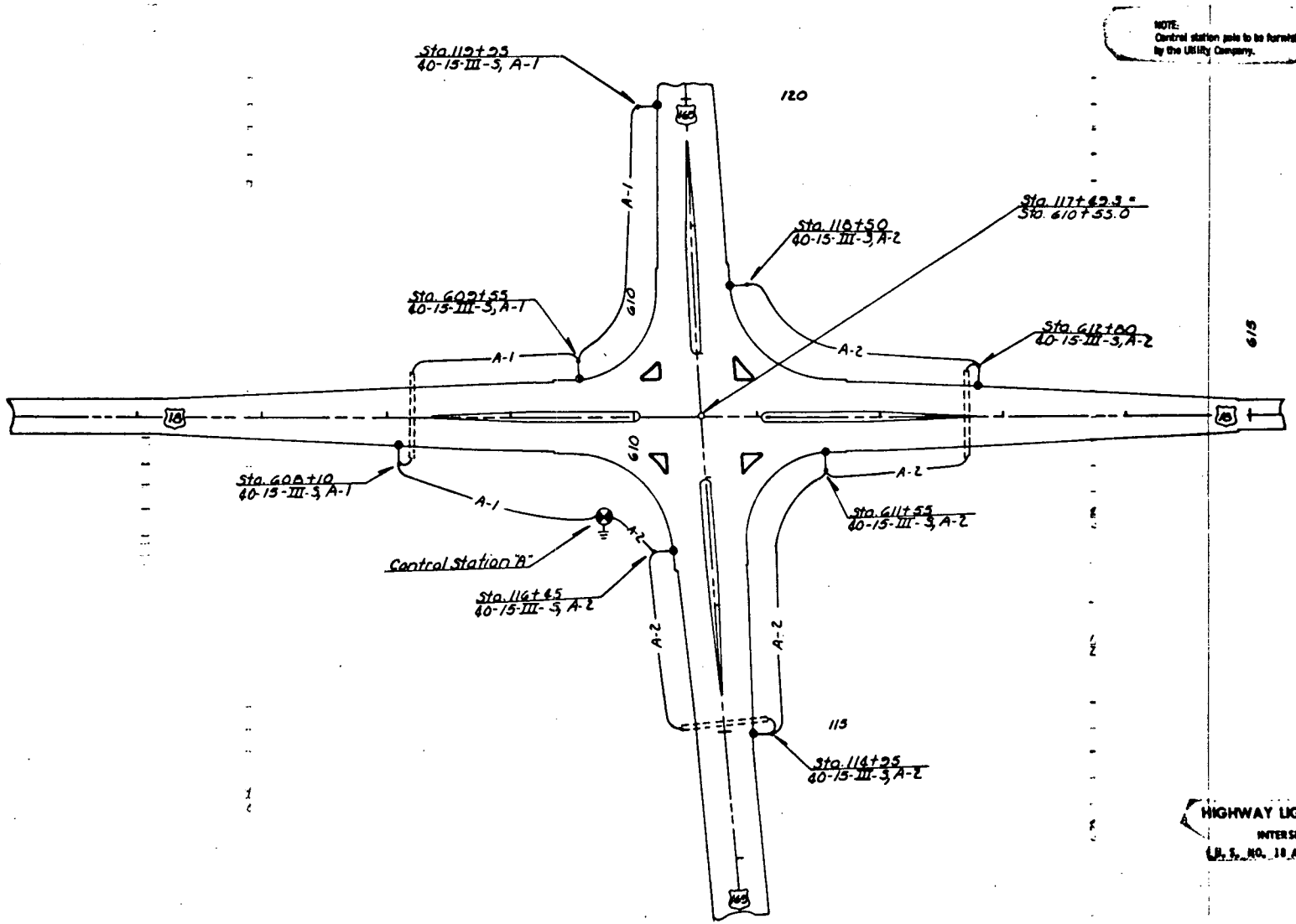
HIGHWAY LIGHTING LAYOUT
INTERSECTION OF
U. S. 65 AND IOWA 9

FILE NO. 214

Worth COUNTY

FN-65-9(1)—21-38

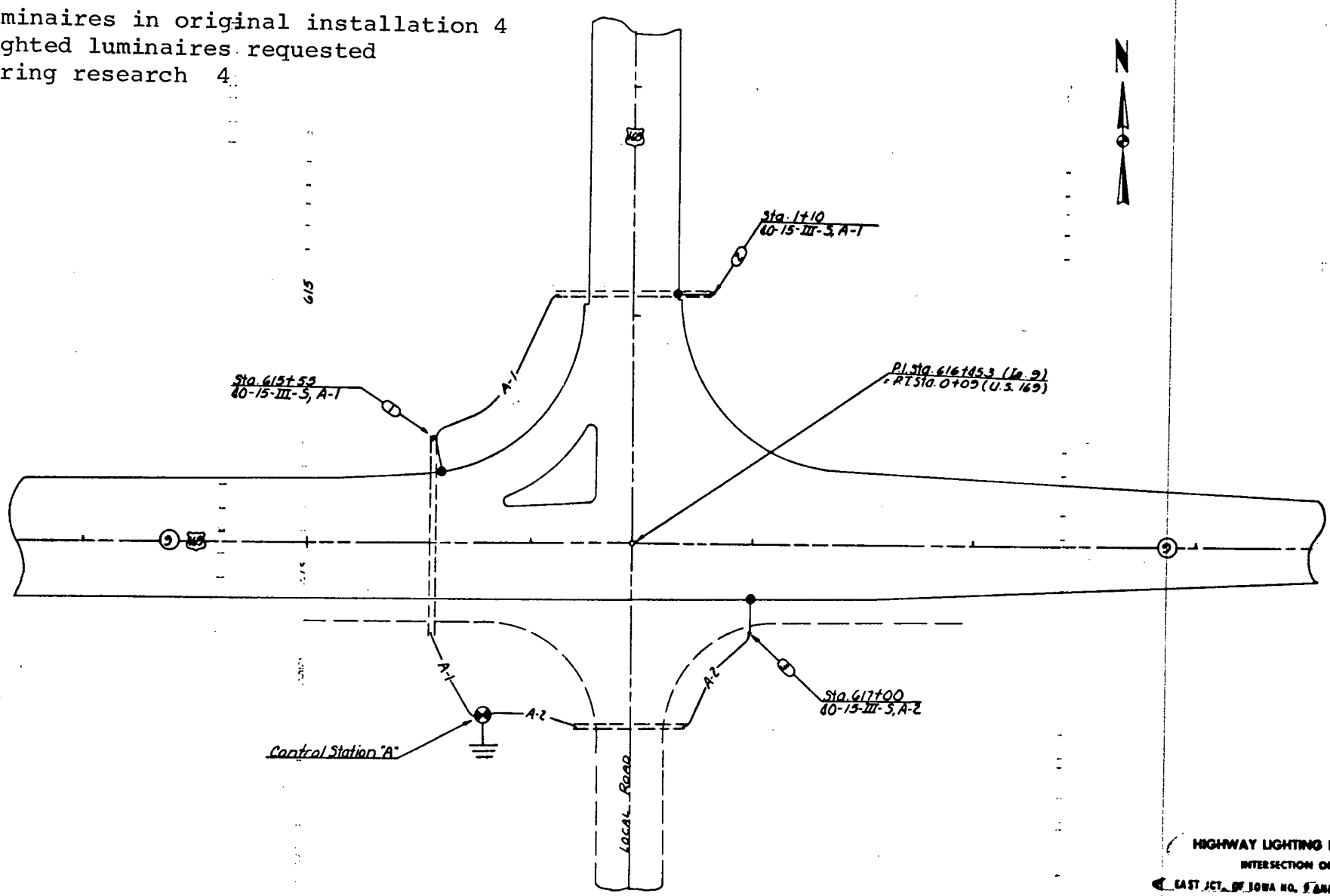
Reference 18 B
Luminaires in original installation 8
All luminaires lighted during research



TYLE NO. 179

Kossuth COUNTY | FN-18-3(12)--21-55 | SHEET NO. 3 | TOTAL SHEETS 10

Reference 19 A
Luminaires in original installation 4
Lighted luminaires requested
during research 4



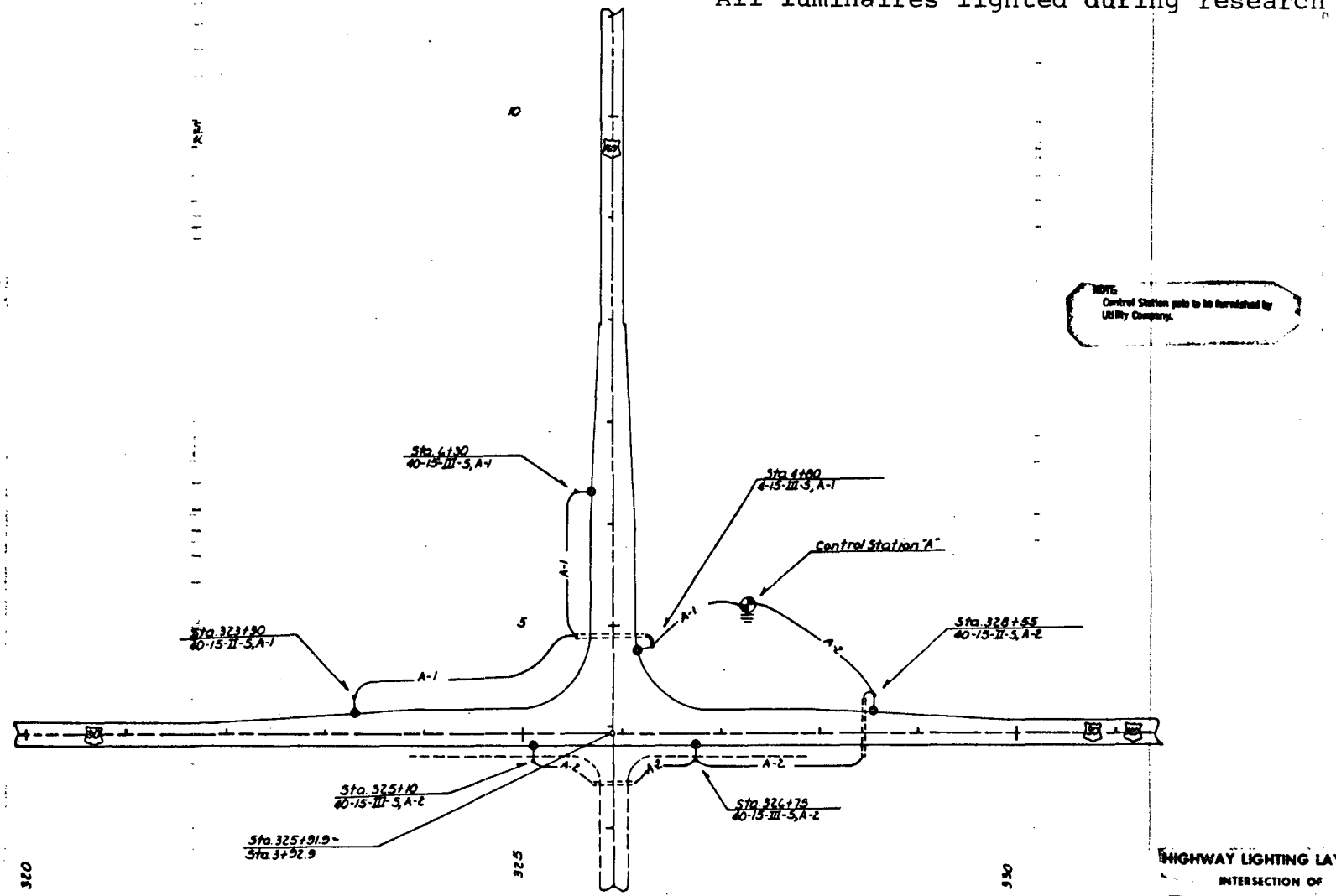
HIGHWAY LIGHTING LAYOUT
INTERSECTION OF
℄ EAST JCT. OF IOWA NO. 9 AND U.S. NO. 169

FILE NO. 2448

Kossuth COUNTY

PROJECT NUMBER	PRE. ROAD REF. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
FN-9-4(10)--21-55			9	10

Reference 19 B
Luminaires in original installation 6
All luminaires lighted during research



HIGHWAY LIGHTING LAYOUT
INTERSECTION OF
U. S. NO. 30 AND U. S. NO. 169

FILE NO. 168

Boone COUNTY

PROJECT NUMBER FN-30-4(16)--21-8