NATIONAL BUREAU OF STANDARDS REPORT

6846

Proposed Design of a Taxiway Guidance System for Miramar Naval Air Station

By
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U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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Proposed Design of a Taxiway Guidance System for Miramar Naval Air Station

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This report contains design details of a proposed installation of lighting, guidance signs, and markings for the taxiways of the Miramar Naval Air Station. The proposed Miramar installation is planned to serve as an operational test for evaluating the system as a Navy standard for lighting and marking of taxiways. New features included in the proposed installation are lighting and marking of peripheral taxiways in parking apron areas, centerline lights for certain sections of taxiways, taxiway-edge markings, revisions in use of guidance signs, intensity control of taxiway lights integrated with the runway light intensity selection, and taxiway-circuit selection integrated with the runway-circuit selection.

1. INTRODUCTION

The Department of the Navy, Bureau of Naval Weapons, as Project TED NBS SI-5007, requested the National Bureau of Standards to assist in the development of a standard installation of taxiway lighting and taxiway guidance signs. Before requirements for a standard installation are specified, the various components integrated into the system should be evaluated by an operational test. Miramar Naval Air Station was suggested as a representative station at which such a test installation could be made and used to advantage. Drawings of the Miramar installation applicable to taxiway lighting were obtained from the station for use in planning the taxiway lighting and guidance system. Using these drawings for reference, new drawings have been prepared showing the locations of lights, signs, and markings of the proposed system approximately to scale. Figure 1 is a drawing of the field plan of Miramar Naval Air Station.

2. PLANNING OF THE PROPOSED SYSTEM

2.1 General

The proposed system is based on present Navy, Air Force, and Civil aviation standards and specifications except when installations based on these standards and specifications fail to provide adequate guidance. The proposed system disregards the present taxiway lighting installation at Miramar, although many parts of the present installation can be integrated or modified for use in the proposed installation. Three changes in the layout of taxiways are proposed. These changes are shown on Figure 1.

The major change is in the parking apron area. Peripheral taxiways are required, to comply with Code 113 20.1, NAVAER 00-100-503[1] and especially to provide access to the high-speed refueling lanes. To make best use of the parking apron space, the present taxiway across the middle of the apron should be eliminated.

The second change, necessitated by the proposed installation of peripheral taxiways, is the relocation or elimination of the small buildings on the parking apron near the hangars. If the peripheral taxiway on this side of the apron were moved far enough to allow adequate clearance from these structures, the area for parking inside the peripheral taxiways would be substantially reduced. If the taxiway were jogged around these structures, the flow of traffic would be impeded and the accident potential would be significantly increased.

The third construction change is the filleting of the exit from the parking apron going to runway 10. This filleting is necessary to provide suitable access to the peripheral taxiway and is in conformance with drawing SE 111 10-1, NAVAER 00-100-505.[2] Fillets are also needed on two turnoffs of runway 6L-24R in order to meet the requirements of drawing SE 111 10-1, although this filleting is not as important as the filleting of the entry to the parking apron.

The actual operating procedures at the field are not known and have had to be assumed in planning the installation. Thus the proposed installation may require some modification to fit properly the operating procedures. Even after an installation is completed, changes may be required to serve new operating procedures effectively.

2.2 Lighting and Marking Installation Details

The details for location of taxiway lights, signs, and markings are shown on figures 2-I through 2-XVI. The section of the field covered by each of these figures is indicated on figure 1 by the corresponding Roman numeral. Each figure consists of two drawings and the notes to cover each intersection. Locations of lights for the intervening distances are indicated.

(1) One section of each figure shows the locations of all lights, signs, and marking, to the indicated scale. The spacing between the lights and the radius of the curves to the edge of the full strength pavement and to the taxiway centerline markings are indicated. (Since these drawings were not prepared from actual installation drawings, there may be some errors in distances.)

(2) The other drawing for the same area shows the location of and the information to be provided by the taxiway guidance signs. Actual operating procedures may require some changes in information on the signs. The information on the signs is presented to be read from the same position as that from which the pilot will observe the sign.

(3) The notes accompanying these drawings indicate priority for the signs and other pertinent information for planning and installing the system.

3. TAXIWAY LIGHTING

Taxiway lighting for providing guidance at night will be considered in two classes: a) edge-marker lights and b) centerline lights. Edge-marker lights mark the lateral limits of the taxiway and are of the same type as those used for the present taxiway lighting. The centerline lights, a recent development, are proposed for marking the taxiway centerline at those intersections which may be confusing or where the break in the line of edge-marker lights is so wide that satisfactory guidance is not provided in restricted visibility conditions.

3.1 Edge-Marker Lights

Several types of lights have been used in the past for taxiway edge-marker lights. The elevated type M-1 lights (with blue lenses), mounted on clamps (Item 508) instead of cones, are commonly used now and are satisfactory for locations where elevated lights can be used.

These lights with 45-watt lamps are used for edge marking wherever feasible. Class B3 flush lights with blue filters and 45-watt lamps as described in Specification MIL-L-26202[3] are to be used as edge-marker lights in paved areas where interference with aircraft or surface vehicles is likely.

3.2 Centerline Lights

For those intersections where edge-marker lights cannot furnish adequate guidance for taxiing under all operating conditions, use of centerline taxiway lights is proposed. In the past, centerline lights have seldom been used for taxiways because of the cost and the difficulty in maintaining such an installation. With the development of the "pancake" lights[4], the use of centerline lights is justified. In the proposed installation, pancake bi-directional type lights with 45-watt lamps and green filters are used on the centerline of taxiways where additional guidance is required. Centerline taxiway lights may be used at other intersections also if experience or operational procedures justify the cost of installation and maintenance.

3.3 Pancake Lights for Edge Marking

In some existing paved areas, e.g., along the inside edge of peripheral taxiways of the parking apron, where it is not practical to install Class B3 lights, pancake lights are proposed as edge-marker lights. In these locations blue filters should be used instead of green filters. Bi-directional pancake lights with the beams parallel to the axis of the taxiway are used for edge-marker lights along straightaways. Along curved sections in these areas, bi-directional pancake lights with the axis of the beam perpendicular to the radius of the curvature are used. At intersections in paved areas, where the far side of the taxiway needs marking, e.g., from refueling lanes into the peripheral taxiway, mono-directional pancake lights are used with the beam directed down the intersecting taxiway refueling lane.

3.4 Spacing of Taxiway Lights

3.4.1 Spacing of Edge-Marker Lights. The recommended spacing of edge-marker taxiway lights conforms to Code 136 50 NAVAER 00-100-503 and drawings SE 136 50-1 and SE 136 50-2, NAVAER 00-100-505, with the following exceptions.

(1) For straight edges, either single or parallel, 300 feet or less in length, the spacing between lights approaches but does not exceed 50 feet. For parallel straight edges exceeding 300 feet in length, the arrangement of lights is the same as in Detail B of drawing SE 136 50-2 except that there is a minimum of five equally spaced lights (counting the lights at both ends of the group) in addition to

lights at 40 feet from each end of the section. (See figures 2-III and 2-XIII for examples of these exceptions.)

(2) The entrance-exit lights to runways are located opposite the point of tangency with the light nearest the runway located five feet from the edge of the runway rather than at a point where a line five feet from the runway edge and an arc two feet from the edge of the taxiway fillet intersect. (This change is consistent with Air Force and Federal Aviation Agency policies.) (In existing taxiway lighting installations meeting current Navy standards, this change may be satisfactorily accomplished by removing the second light of the present entrance-exit lights and making the new entrance-exit installation opposite the point of tangency. The minor differences resulting in the spacing around the curve will not affect the usefulness of the system.)

(3) Along the curves of large radii at or near intersections and other confusing areas, the distance between lights does not exceed 50 feet and lights are still more closely spaced when necessary to prevent possible confusion. (This change is comparable to the use of close spacing for straight edges where the distance is less than 300 feet in total length.)

(4) When a taxiway intersects but does not cross another taxiway, an edge-marker light is located on the far side of the intersection on the extended centerline of the intersecting taxiway. This light is considered as the dividing point between two segments for the purpose of determining the spacing of the lights on the far side of the intersection. An extra light is installed on either side of this light at the midpoint of the normal space or at 25 feet from the light, whichever is less. (See figure 2-IV.) This arrangement of lights is used to mark more definitely the end of a taxiway and to avoid the possibility of leaving a spacing which may be interpreted as a taxiway continuing ahead, should the light on the extended centerline be burned out.

(5) Where a taxiway crosses a runway threshold area and is used when another runway is the operational runway, taxiway edge-marker lights are installed along that portion of the threshold or edge of the runway where guidance for taxiing is needed. These lights should be flush. They are located five feet from the edge of the runway paving. (See figure 2-VII.)

(6) Where the curvature of a taxiway fillet continues beyond the point at which the edge is parallel to the far side of the taxiway, forming a neck in the taxiway, an edge-marker light is installed at the narrowest point and the increments for spacing should be broken accordingly. (See figure 2-X.)

(7) The spacing on some single straight sections exceeding 300 feet in length is limited to 50 feet (or less) where the alinement of the lights of this section with other more distant lights would present a false appearance of outlining a taxiway had the usual spacing been used. (See figure 2-VIII.)

3.4.2 Spacing of Centerline Lights. The centerline taxiway lights, where used, are spaced at 25-foot intervals along the curved sections and at 50-foot intervals along the straight sections of the taxiway centerline. At intersections these lights extend for a minimum of 100 feet along the centerline beyond the points of tangency of the taxiway. (See figure 2-VIII.) The centerline lights are terminated at a point in line with the edge of the runway paving when the taxiway intersects a runway at the threshold. (See figure 2-X.)

3.5 Hooding and Alining of Lights

Elevated taxiway edge-marker lights should be hooded with the hoods alined so that the lights are visible only where needed for guidance on the taxiways and runways. To the extent possible, a taxiway light should not be visible from the air or from sections of runways, taxiways, or other areas of the field where the particular light is not needed for guidance. The Air Force type hoods (Item 650) may be used along straight sections of taxiways and in some other areas. When these hoods restrict the horizontal beamspread of the light to less than that needed for guidance, the angle of vision may be increased by expanding the slot in the hood with a pair of tin snips. If the light distribution needs to be decreased, the slots may be reduced by attaching strips of thin metal to the hoods as required. (A hood designed for easier modification to fit the location may be feasible.) The hoods may be omitted as required to provide light in all directions where guidance is needed. Usually hoods will not be used on flush edge-marker lights but may be desirable where these lights are installed across runway thresholds.

The pancake lights should be alined to provide the best coverage in the directions where guidance is required. Usually the beams will be alined parallel to the taxiway centerline or to the tangent to the marking at the location of the light.

4. TAXIWAY GUIDANCE SIGNS

Taxiway guidance signs are used as part of the taxiway lighting system to aid the pilot in reaching his taxiing destination as rapidly and as safely as possible and to eliminate unnecessary radio transmissions. These signs are used at runway turnoffs, intersections of

taxiways and of taxiways and runways, and at entrance-exits from parking aprons and other areas. At present no Navy standard for use of taxi guidance signs is in effect and the CAA standard TSO-N23[5] has had rather limited application. The principles described in this standard have been considerably revised for the proposed Miramar installation, particularly in location of destination signs and use of identification signs. The fueling lane signs are not considered as a part of the system of taxi guidance signs and are not treated in this report.

4.1 Type of Sign

The only taxiway guidance signs presently available are those manufactured according to CAA Specification L-829[6]. The type I sign is for operation with 6.6-ampere, series lamps and the type II sign is for operation with 120-volt lamps. These signs are not large enough to provide adequate legibility at the full range desired for guidance in minimum visibility conditions, but satisfactory guidance is provided for most conditions. Because of the limited clearance of some aircraft, the use of larger signs is not considered permissible at this time.

The signs proposed for the Miramar installation are type I signs. The lamps to be used in these signs should be type 6.6A/T10/1P, 30-watt, 6.6-ampere series lamps. The signs are to be energized from a 6.6-ampere series circuit through 200-watt, 6.6/6.6-ampere series-isolating transformers. Only the 200-watt size transformers should be used for taxiway guidance signs in order to simplify supply. Up to six sections of sign can be energized from a single 200-watt transformer. The taxiway guidance signs are connected as part of the taxiway lighting circuit. The letters, numerals, and dashes should be the same as those shown in Specification L-829. The shaft or tail of the single panel arrows should be eliminated because it was found that the specified arrow is easily confused with other letters or numerals. (This is in agreement with the findings of Dunlap Associates.[7])

4.2 Location of Signs

Taxiway guidance signs should be located at all intersections where information other than that provided by other lights and markings is likely to be needed by taxiing pilots in determining their proper route. The need for a sign and the information to be shown frequently is determined by operational procedures and the arrangement of the station. As instructed by the Bureau of Aeronautics in letter Aer-SI-52/112, 3 August 1959, "The inboard edge of the signs shall be 25 feet from the edge of the full strength pavement and --- the elevation of the top of the signs shall be 24 inches above that of the adjacent edge of the full strength pavement." The signs should usually be

positioned at the point of tangency of a fillet. The "HOLD" signs at entrances to runways should be positioned beside the holding post markers to serve the same purpose at night that the holding post markers serve in daytime. Runway turnoff signs beyond the end of the runway should be positioned with a 25-foot clearance from the extended edge of the runway as well as from the edge of the taxiway. The signs should be alined perpendicular to the centerline of that direction of travel for which the information is to be provided.

4.3 Priority Ratings

The Bureau of Naval Weapons has requested that the priority of installation of the various taxiway guidance signs be indicated. The layout of taxiway guidance signs as shown on figures 2-I through 2-XV is for a complete system of signs for the proposed installation. The signs, as used, serve three basic functions: 1) The holding post signs along taxiways at the intersection with runways serve to warn pilots of potential hazards from other aircraft using the runway and provide destination and position information; 2) The destination or routing information signs supply the information needed by the pilot for taxiing to his destination on the field, whether inbound or outbound; and 3) The runway turnoff signs mark the limits of the exit from the runway to the taxiway or from the taxiway to the ramp. Frequently one sign can serve more than one function. For example, one side of a sign may mark the holding post and the back side may indicate the direction to a destination, or the same side of a runway turnoff sign may indicate the direction to a destination and also mark a limit of the runway exit. All of these signs are not of equal importance and the following priority ratings are used for the proposed installation.

Priority A1. All holding post signs, because of the potential hazards they indicate, are assigned this priority. If signs are used to mark any holding posts, then all holding posts should have signs although the amount of traffic involved may differ greatly at different intersections.

Priority A2. The signs at those positions where the use of signs along taxiways to provide direction information is likely to reduce the number of radio communications or where a choice of direction for exit from a runway is involved are assigned priority A2.

Priority B. The signs at positions where destination information will be useful but where lack of the information will not result in excessive radio communications or in too much confusion are assigned priority B.

Priority C. Those runway turnoff signs which are used primarily to mark the far limit of the exits or to indicate destinations where turnoffs in only one direction are involved and those signs which indicate reasonably obvious entrances to ramps are assigned priority C.

Priorities A1 and A2, although serving different basic functions, are both essential to a system of taxiway guidance signs and are required for the initial installation.

Signs of priority B are not essential for initial installation, although additional study may indicate that certain of the signs assigned this priority should have been assigned priority A2. Priority B signs are needed for maximum effectiveness of the taxiway guidance system, especially after pilots become familiar with the use of the signs of priorities A1 and A2.

Most of the information to be furnished by signs of priority C can be obtained from the taxiway lights and markings and by an instruction from the control tower to turn right or left off the runway. The use of runway turnoff signs for marking the limits of the exits of all turnoffs may be valuable in developing the effectiveness of the high-speed runway turnoffs. However, the effectiveness of the signs for this purpose is significantly reduced by the requirement that these signs be located 25 feet from the edge of the pavement.

Signs for which the two sides properly fit into different priorities are rated according to the higher priority.

Table I is a summary of the taxi guidance signs and the priorities assigned to them.

4.4 Billboard Signs

In some areas, such as some runup areas and very complicated intersections, taxiway guidance signs are inadequate for presenting the needed information. In such areas, the use of billboard-type signs (similar to some highway routing signs) showing the configuration of the area is proposed. The precise nature and construction of these signs has not been fully investigated but should be somewhat similar to the following:

A flat sign of light sturdy construction,
Not less than 48 inches by 48 inches in size,
Made of 1/4-inch exterior plywood or of sheet metal painted white,
With the diagram of the area and the routing information shown in black,
Illuminated by exterior floodlighting.

The construction, installation, and lighting should be similar to that for the runway distance markers as given in drawing SE 134 90.2-1, NAVAER 00-100-505. These signs should be located opposite the entrance to the area with the inboard edge 50 feet or more from the edge of the full strength pavement.

5. TAXIWAY MARKINGS

The taxiway markings consist of the centerline, edge, and holding post markings. These markings are to be of retroreflective aviation yellow material.

5.1 Holding Post and Centerline Markings

The holding post markings are the standard markings as given in drawing SE 111 90.2-2, NAVAER 00-100-505. The centerline markings are based on the proposed revision of AGA-NS2 National Standard for the Marking of Serviceable Runways and Taxiways and differ from the present drawings SE 111 90.2-1 and SE 111 90.2-2, NAVAER 00-100-505 as follows.

(1) At intersections of taxiways with runway thresholds, the taxiway centerline terminates in line with the nearest edge of the runway.

(2) At intersections of taxiways with runways other than at thresholds, where the taxiway may serve as an exit from the runway, the taxiway centerline markings are curved into the runway centerline marking in the following manner. The curve of this taxiway turnoff is drawn tangent to a line parallel to and 3 feet from the near side of the runway centerline marking and tangent to the taxiway centerline with the largest radius of curvature which will retain a clearance to the taxiway or runway edge of not less than one-half the width of the taxiway. This marking should be extended parallel to the runway centerline marking for a distance of 200 feet beyond the point of tangency.

(3) When a taxiway crosses a runway, except at the threshold, the taxiway centerline markings continue across the runway but are interrupted for the runway markings. Also the runway turnoff lines should be used as required.

(4) At intersections of taxiways, the taxiway centerline markings intersect and all turns which may be used in normal traffic operations are marked. These turn markings should be similar to the centerline markings and drawn tangent to the taxiway centerlines with the largest radius of curvature which will retain a clearance to the taxiway edges not less than one-half the width of the narrower taxiway.

5.2 Edge Markings

The taxiway edge markings should be broken lines located on the edge of the full strength paving and should be six inches wide with 10-foot dashes and 10-foot blank spaces. In wide, paved expanses, such as on parking aprons, where only part of the paving is considered as taxiway, the taxiway edge markings should be used to mark the limit of the taxiway area and the taxiway lights should be two feet outside of this line.

6. CONTROL CIRCUITS, REGULATORS AND LIGHTING CIRCUITS

6.1 Intensity Control

As suggested in the project details by the Bureau of Naval Weapons, the intensity of the taxiway lighting and signs should be controlled by using brightness steps 3, 4, and 5 of type NC-3 regulators. The intensity to be used will depend on the visibility conditions and should be matched with the runway lighting brightness steps of 1 through 5 in the vault. One brightness control switch should be used for controlling the brightness of both the taxiway lights and runway lights. When the intensity of the runway lights is set at brightness steps 1, 2, 3, 4, or 5, the regulators for the taxiway lighting should operate at steps 3, 4, 4, 5, or 5, respectively. These settings are based on the use of high-intensity edge-marker lights for the runway lighting. With medium-intensity runway lights, the taxiway lighting should operate at steps 3, 3, 4, 4, or 5, respectively.

6.2 Circuit Selection

As indicated also in the project directive, runway selector cabinets and selector switches are not used for control of taxiway circuits. Instead, the taxiway lighting circuits to be energized are controlled by the runway selection. All sections of taxiway lights which are normally used as access to and from the operational runway are automatically selected by the runway selector switch. In order to reduce any possibility of confusion, those sections of taxiway lights which are not normally used in conjunction with the active runway are not lighted. Since there may be occasions when taxiway lights are needed on sections of taxiways not normally used in conjunction with the active runway, a master taxiway lighting switch which will energize all taxiway lights simultaneously should be installed.

6.3 Control Circuits

The control circuits necessary for the intensity control and circuit selection are shown in figure 3. The control circuits are relatively simple. Except for the regulators, the only major component required for controlling the taxiway lighting is a single type MC-1

pilot relay assembly. All of the connections and wiring are confined to the vault except that the wiring to the taxiway-light main switch and to the taxiway-selection override switch goes to the lighting control panels.

6.4 Regulators

In accordance with the project directive, type NC-3, 15-kilowatt regulators are used to power the taxiway lighting circuits. No runway selector cabinets are used and each regulator supplies power to a specific circuit at any time the regulator is energized. To the extent possible the load on each regulator is kept between 10 and 15 kilowatts when the regulators are operated at brightness step 5. This load includes the taxiway guidance signs and the centerline lights, as well as the edge marker lights. Eight type NC-3 regulators are required for the proposed taxiway lighting system at Miramar. This arrangement will allow for some possible expansion on all circuits. The general layout of the circuits is given on figure 1.

7. DISCUSSION

In making any changes in the layout proposed in this report, the primary consideration should be whether the change will improve the effectiveness of the system for the operations of the station and still will not be a source of confusion to pilots under any condition. In general it is better to have no information than to have information which creates confusion.

The principles involved in the design of the components of the system shown on figures 2-I to 2-XVI have been discussed separately. However, the maximum effectiveness of the system can be obtained only by proper integration of all components.

Table 1. List of Taxiway Guidance Signs

Sign No.	Legend	Priority Rating
10	HOLD 6L	A1
11	——→	C
12	RAMP >	C
20	6L^ ^ RAMP	B
21	HOLD 6L RAMP >	A1
22	——→	C
23	RAMP >	C
30	HOLD 6L 6R^	A1
31	HOLD 6R ^ RAMP	A1
32	——→	C
33	RAMP >	C
40	< 6L	B
41	RAMP >	A2
42	6L^ 6R >	A2
43	< 6R ^ RAMP	A2
44	HOLD 6L	A1
45	< RAMP ——→	C
46	RAMP > ←——	A2
50	HOLD 6L	A1
51	HOLD 6R ^ RAMP	A1
52	——→ < RAMP	C
53	RAMP > ←——	C
60	6L·6R RAMP ^	A2
61	RAMP ^ 6R·6L	A2
62	^ FUEL 6R·6L^	A2
63	FUEL > NO ENTRY	A2
64	NO ENTRY RAMP^	A2
65	HOLD 6L ^ RAMP	A1
66	< RAMP ——→	A2
67	RAMP > ←——	A2
70	HOLD 10 RAMP	A1
71	——→	C
72	RAMP >	A2
73	HOLD 10 6L·6R^	A1
80	HOLD 10 ^ FUEL	A1
81	——→	C
82	FUEL >	A2
83	HOLD 10 6L·6R^	A1
90	HOLD 28	A1
91	< RAMP	C
92	←——	C
100	HOLD 24R 24L·28^	A1
101	HOLD 24L ^ RAMP	A1
102	RAMP	A2
103	←——	C
104	HOLD 24L ^ 28	A1
110	< FUEL ^ 24·28	A2
111	HOLD 24R ^ RAMP	A1
112	< RAMP	A2
113	←——	C
120	10·6 > OPS ^	A2
121	< OPS	B
122	RAMP	C
123	< 10 ^ FUEL	A2
124	10·OPS >	B
125	< 6	B
126	< FUEL RAMP	B
127	< RAMP ^ 6L·6R	A2
128	RAMP > 24·28^	B
129	6 >	A2
129a	< 24·28	A2
130	FUEL RAMP	B
131	< RAMP ^ 6	B
132	RAMP > 24·28^	B
133	6 >	A2
134	< 24·28	A2
140	< HGR	B
141	HGR >	B
142	6 >	A2
143	< 24·28	A2
150	FUEL RAMP	B
151	RAMP	B
152	24·28 > 6·10^	A2

Total Priority	A1	17
	A2	26
	B	14
	C	16
	Total	73

REFERENCES

1. NAVAER 00-100-503 (Conf). U. S. Naval Aeronautical Shore Facilities, Technical Planning Manual (1959)

2. NAVAER 00-100-505. U. S. Naval Aeronautical Shore Facilities, Planning Standards (1959)

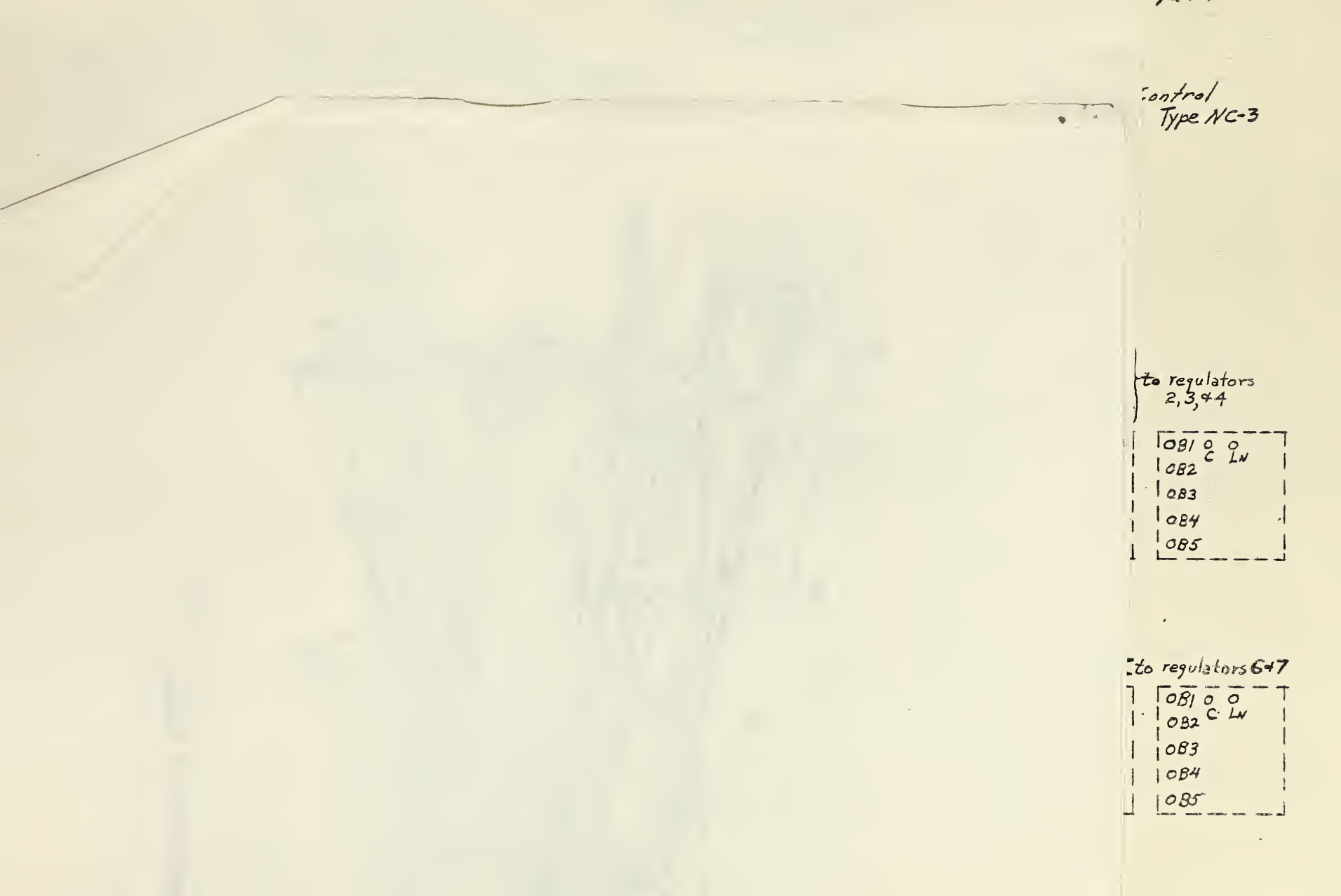
3. Military Specification MIL-26202A. Light, Flush Approach, Runway, and Taxiway, General Requirements for (18 March 1958)

4. Specification for Semiflush "Pancake" Type Runway-Taxiway Light, Federal Aviation Agency, Bureau of Research and Development (20 February 1959)

5. Technical Standard Order TSO-N23. Taxi Sign System, Civil Aeronautics Administration (March 24, 1953)

6. Specification L-829. Specification for Internally Lighted Taxi-Guidance Signs, Civil Aeronautics Administration (Oct. 15, 1955)

7. Taxiway Lighting, Routing and Destination Marking System for Airfields. Prepared for Dept. of Navy, Bureau of Aeronautics, Contract No. NOas 51-1017-C by Dunlap and Associates, Inc., Stamford, Conn. (1952)


Control
Type NC-3
to regulators
2,3,&4
OB1
OB2
OB3
OB4
OB5
C
LW
to regulators 6&7
OB1
OB2
OB3
OB4
OB5
C
LW

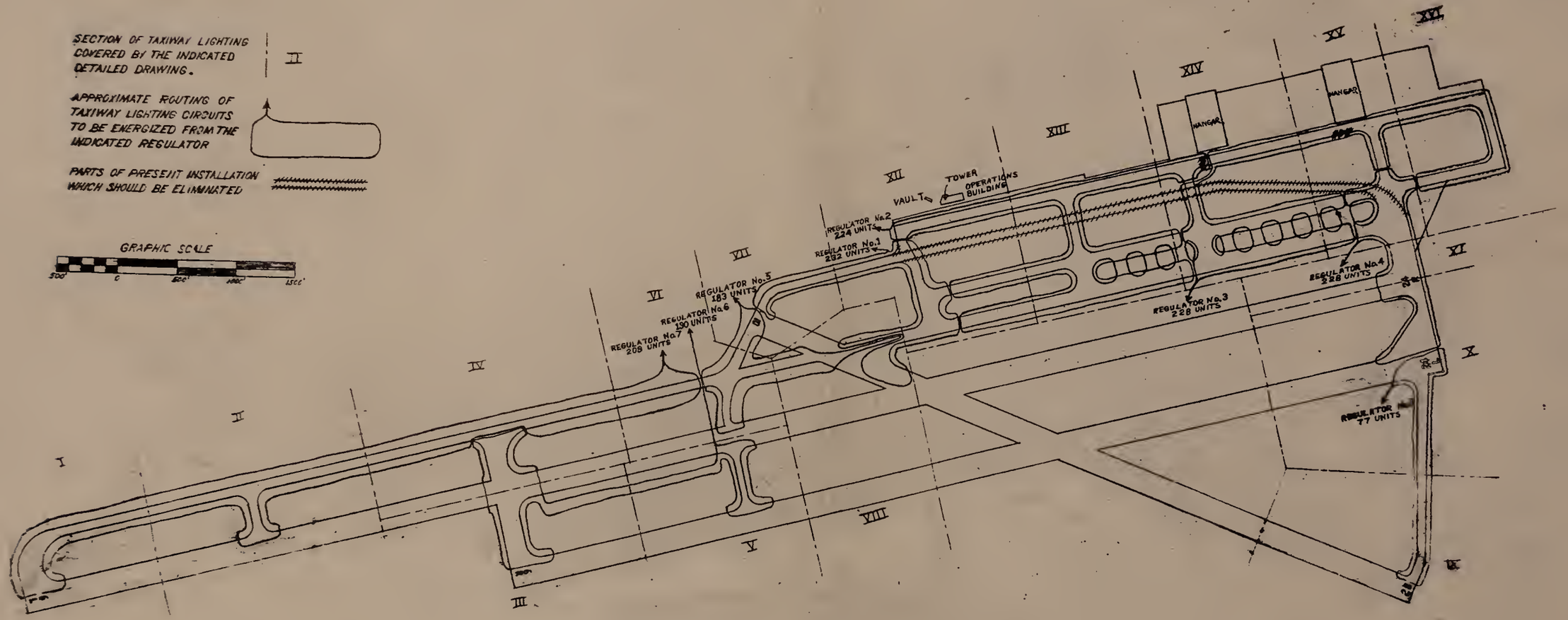


Figure 1. General plan of airfield at Miramar Naval Air Station.

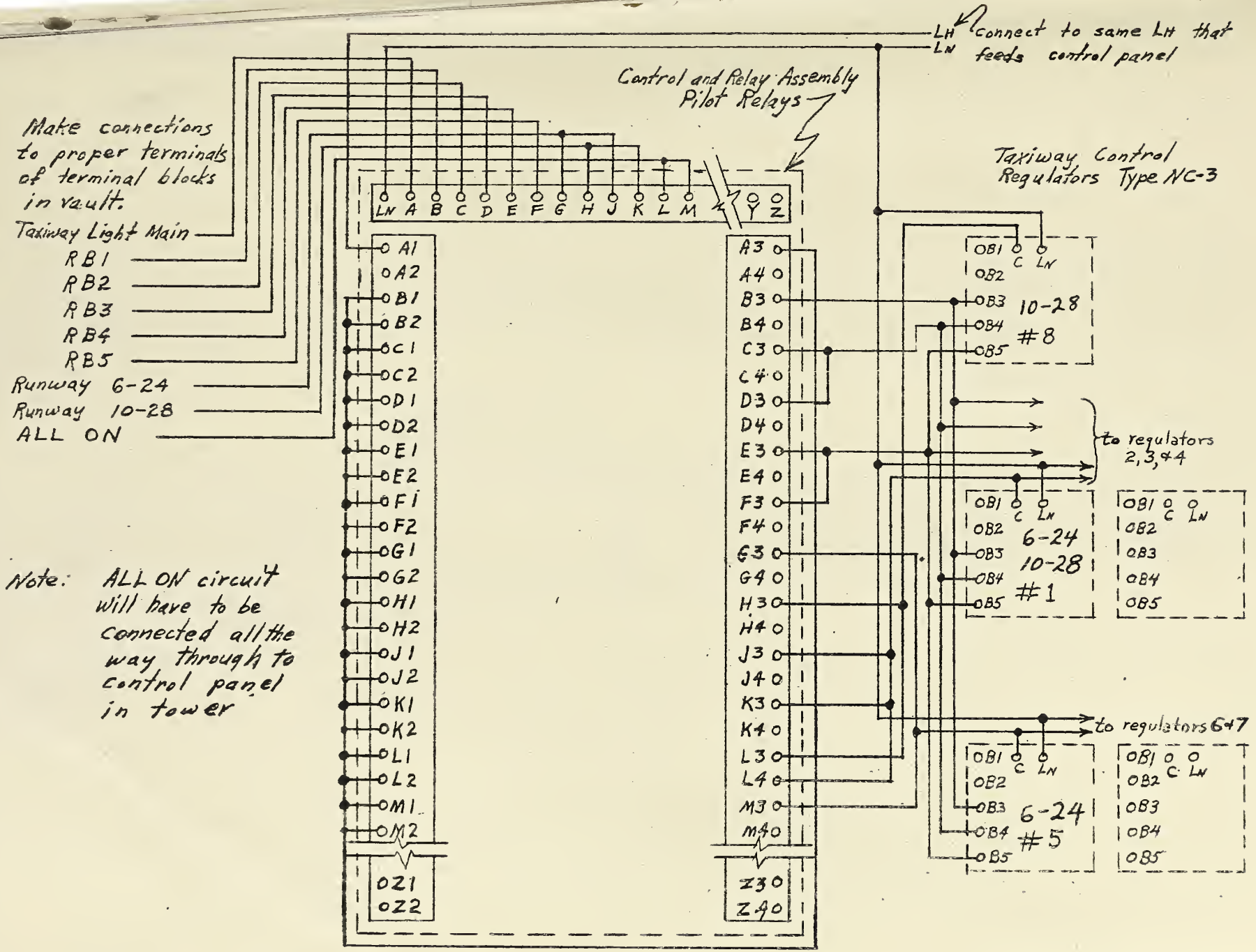


Figure 3. Taxiway lighting control wiring diagram.

OF SIGN
ALLATION

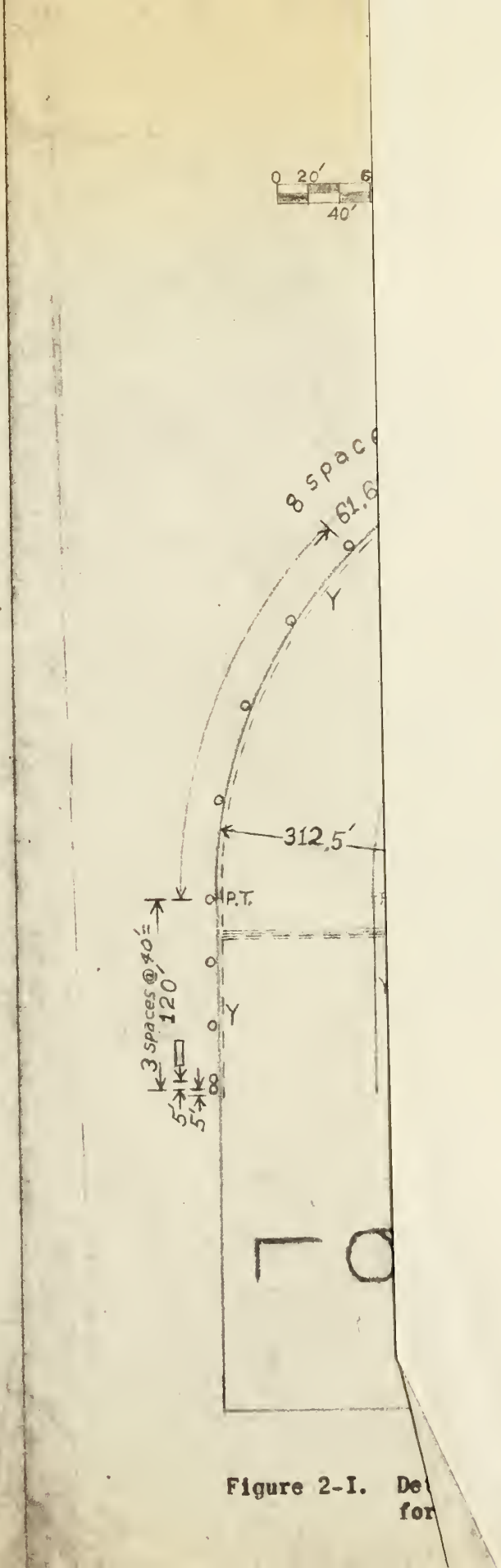


Figure 2-I. De
for

GENERAL NOTES (Figures 2-I through 2-XVI):

1. The symbols of the legend apply to figures 2-I through 2-XVI.

2. Elevated taxiway lights, type M-1, should be equipped with hoods. Air Force Item No. 650 may be used. The hoods may be modified to increase or decrease the angular distribution of the light when required.

3. The entrance-exit lights at the runways should be located opposite the point of tangency of the fillet with the nearest light five feet from the edge of the full strength pavement of the runway.

4. The taxiway edge-marker lights should be located in a straight line or along a smooth curve approximately two feet from the edge of the full strength pavement of taxiways and approximately five feet from the edge of the full strength pavement of runways.

5. The taxiway guidance signs should be located with the in-board edge of the sign 25 feet from the edge of the full strength pavement of the taxiway or runway and with the faces of the sign perpendicular to the centerline of the runway or taxiway.

6. The information to be provided by the signs should be the same as that indicated in the drawings. The lettering on the drawing is read from the direction corresponding to that at which the sign in the actual installation is observed.

7. A taxiway guidance sign reading "HOLD----" and the number of the nearest runway threshold should be installed in line with the holding post markers. These signs mark the holding post at night and supplement the painted markings during the daytime.

8. The details for installation of the taxiway markings are described in Section 5 of the text.

SPECIAL NOTES (Figure 2-I):

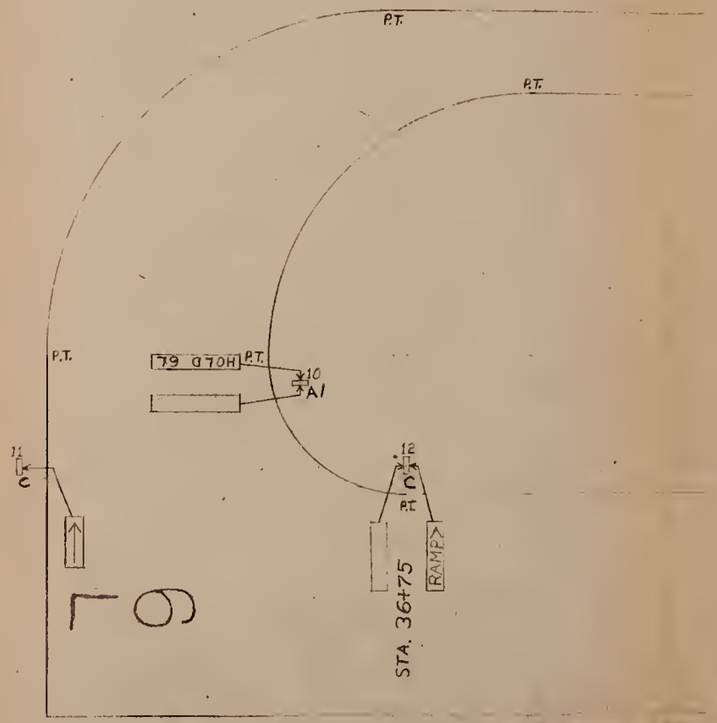
1. Sign 10, as a holding post sign, is priority A1.

2. Signs 11 and 12, marking the exit from the runway, are priority C.

I

Legend

- ELEVATED TAXIWAY LIGHT
- FLUSH OR SEMI-FLUSH TAXIWAY LIGHT
- PANCAKE TYPE CENTERLINE LIGHT
- PARTITION ACCORDING TO SECTION OF CIRCUIT ON DIFFERENT REGULATORS.
- 10 / A1 — TAXIWAY GUIDANCE SIGN; 10 IDENTIFICATION NUMBER OF SIGN; A1 PRIORITY RATING FOR INSTALLATION
- Y — TAXIWAY MARKING, YELLOW
- P.T. — POINT OF TANGENCY



I

GRAPHI SCALE

0 20' 40' 60' 80' 100' 200' 300' 400' 500'

REGULATOR No.7

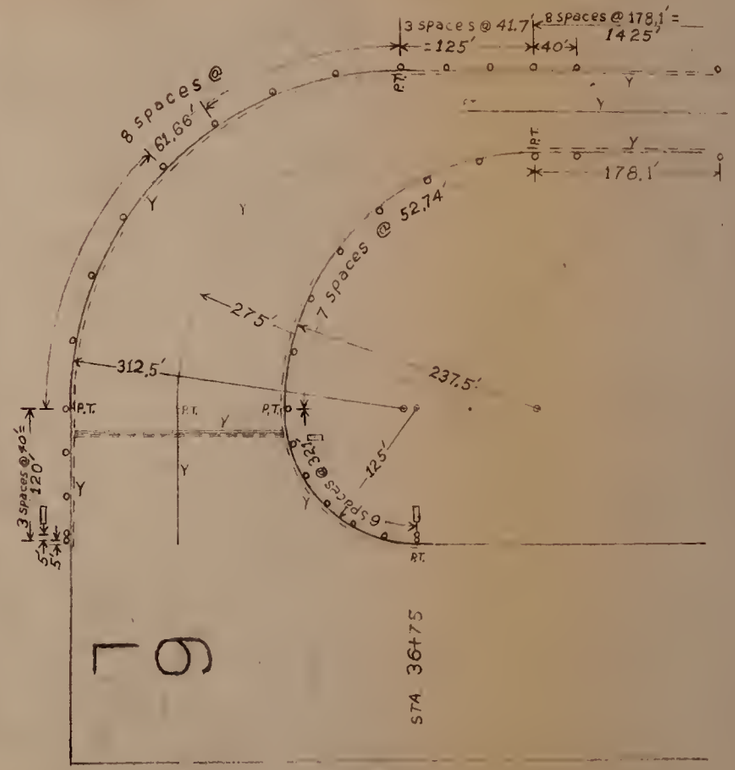


Figure 2-I. Detailed drawing for location of lights, signs, and markings for taxiways in area I.

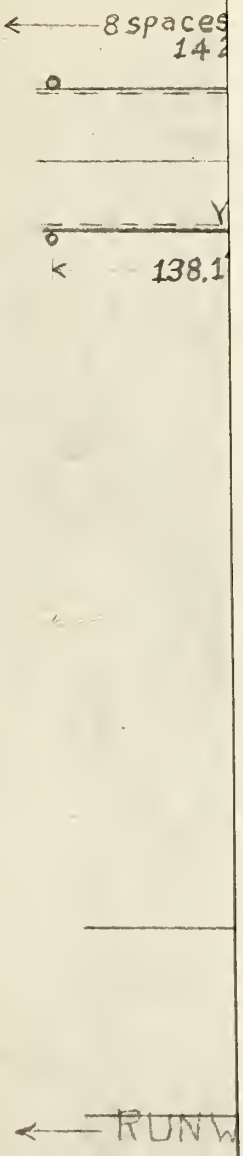
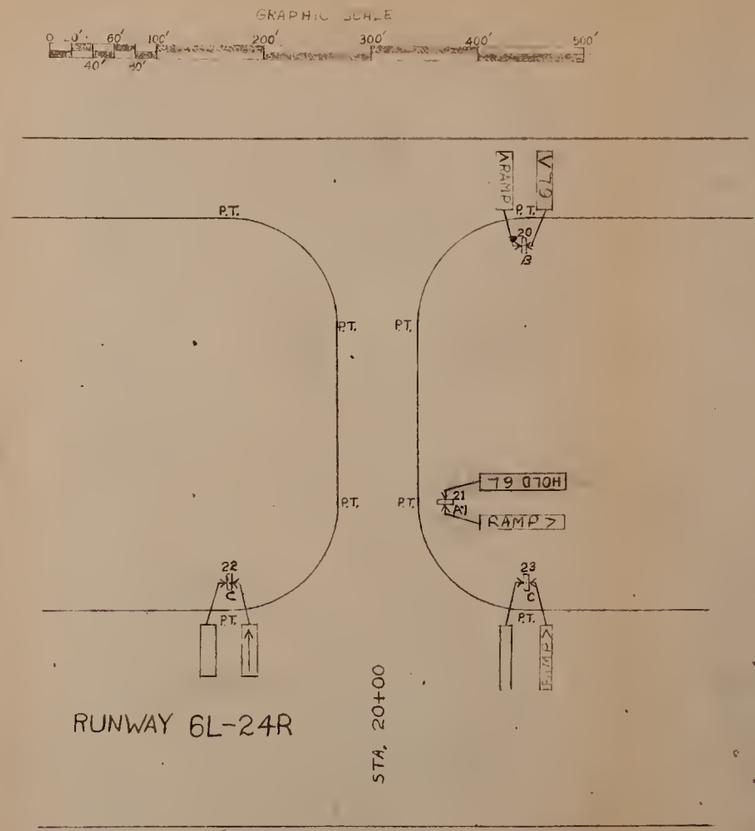


Figure 2-1

NOTES:

1. Sign 21, as a holding post sign, is priority A1.
2. Sign 20, indicating the destination at an intersection where there is little likelihood of confusion, is priority B.
3. Signs 22 and 23, marking the limit of a runway exit in which a choice of direction to turn is not involved, is priority C.
4. Since this stub taxiway will be used almost exclusively for turnoff from the runway, additional destination signs are unnecessary.

II



II

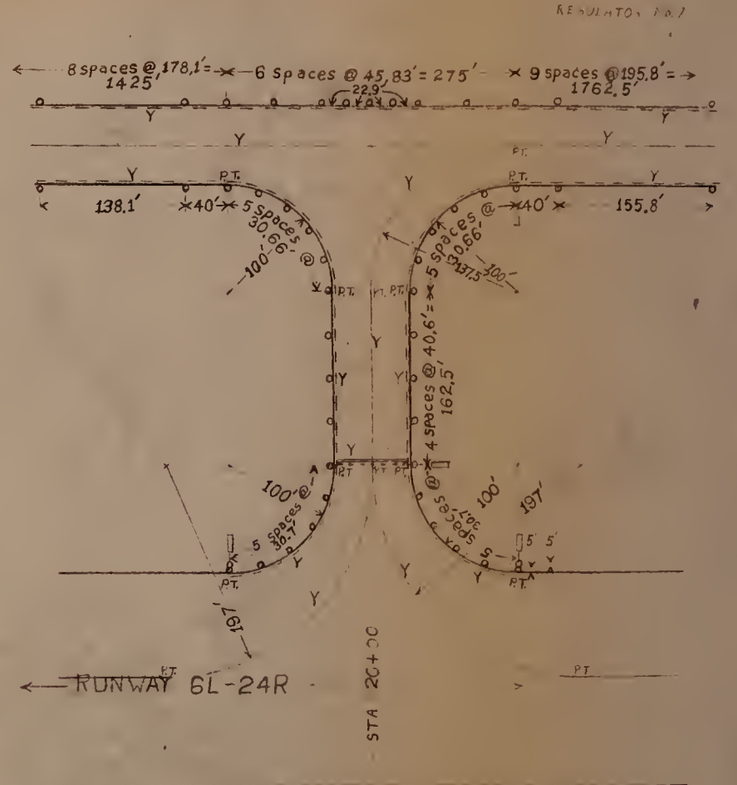


Figure 2-II. Detailed drawing for location of lights, signs, and markings for taxiways in area II.

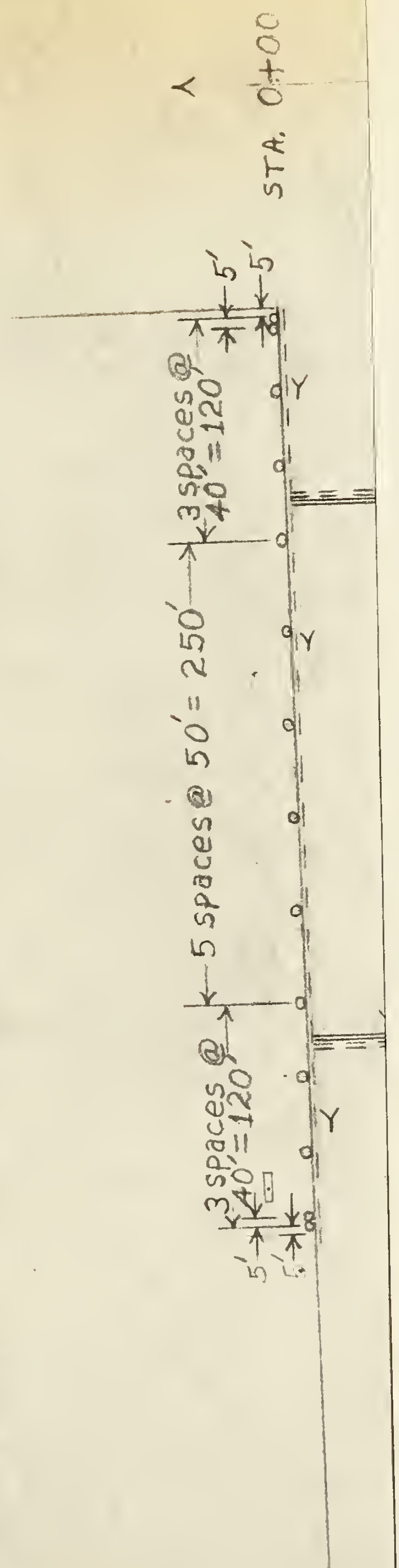
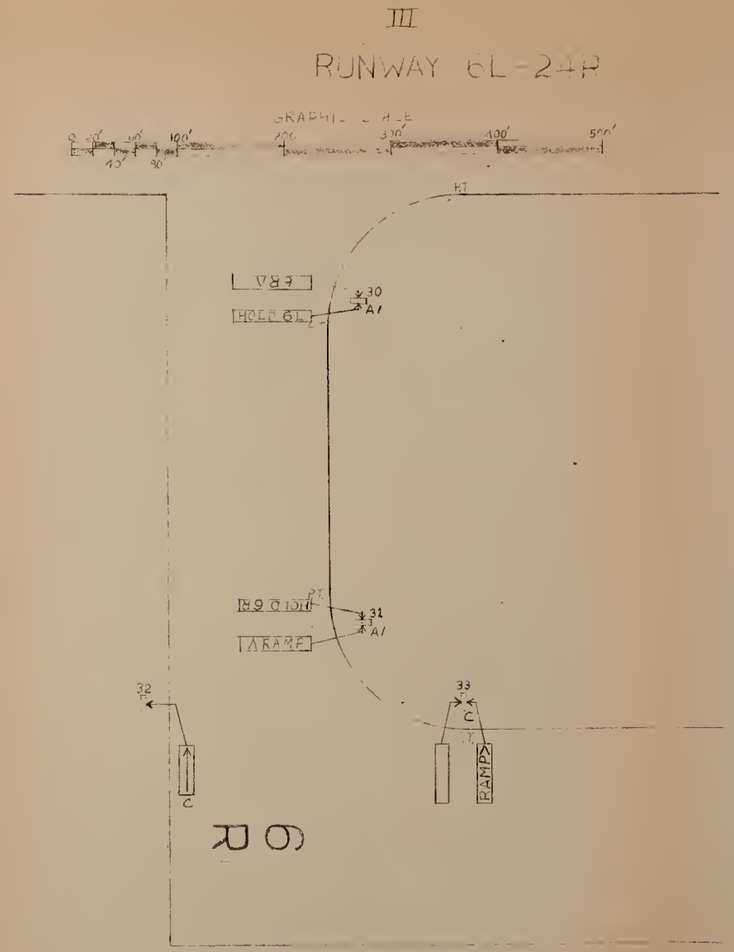


Figure 2-II

NOTES:

1. Signs 30 and 31, as holding post signs, are priority A1.
2. Signs 32 and 33, marking the exit from runway 24L, are priority C.
3. Since this taxiway is not normally used as an exit from runway 6L-24R, runway turnoff signs are not used at the intersection with this runway.
4. The centerline lights are spaced at 50-foot intervals along the taxiway centerline with the spacing starting at the first light from the end of the curvature of the centerline in figure 2-IV.



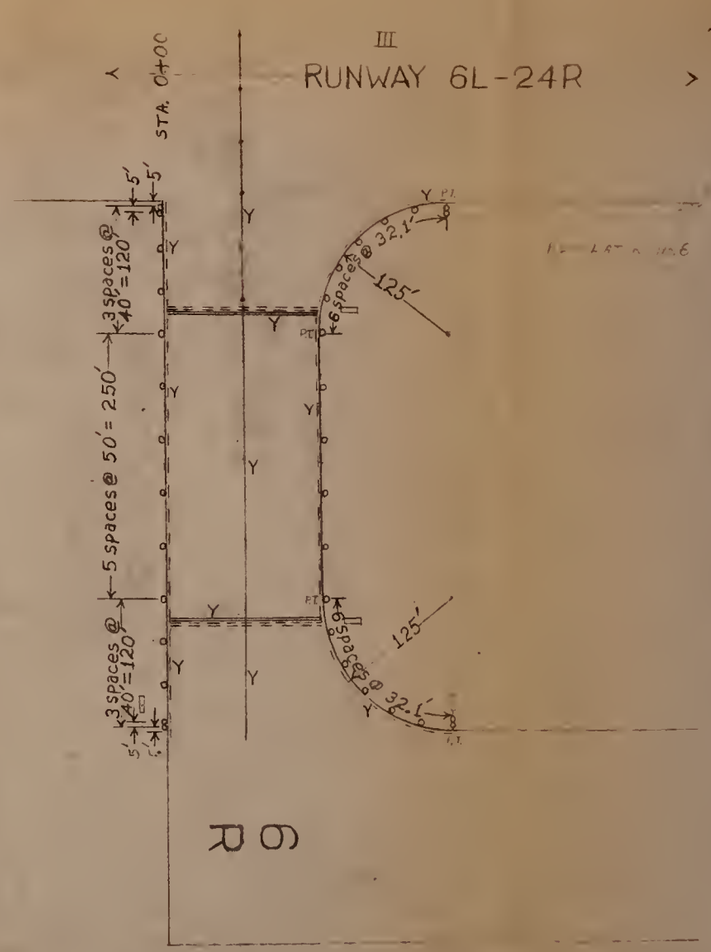
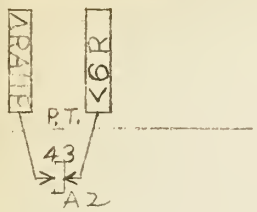
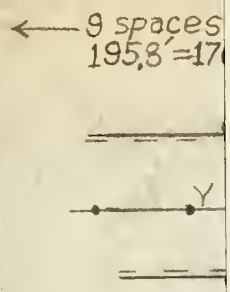


Figure 2-III. Detailed drawing for location of lights, signs, and markings for taxiways in area III.





24R

Fig

NOTES:

1. Sign 44, as a holding post sign, is priority A1. Note that the back side of this siga is not used because any turn indication may be interpreted to meaa turn ahead of the sign rather than behiad the sign.

2. Sigas 41, 42, aad 43, indicating importaat destinations at an iatersection where a choice of directions is reqaired, are priority A2.

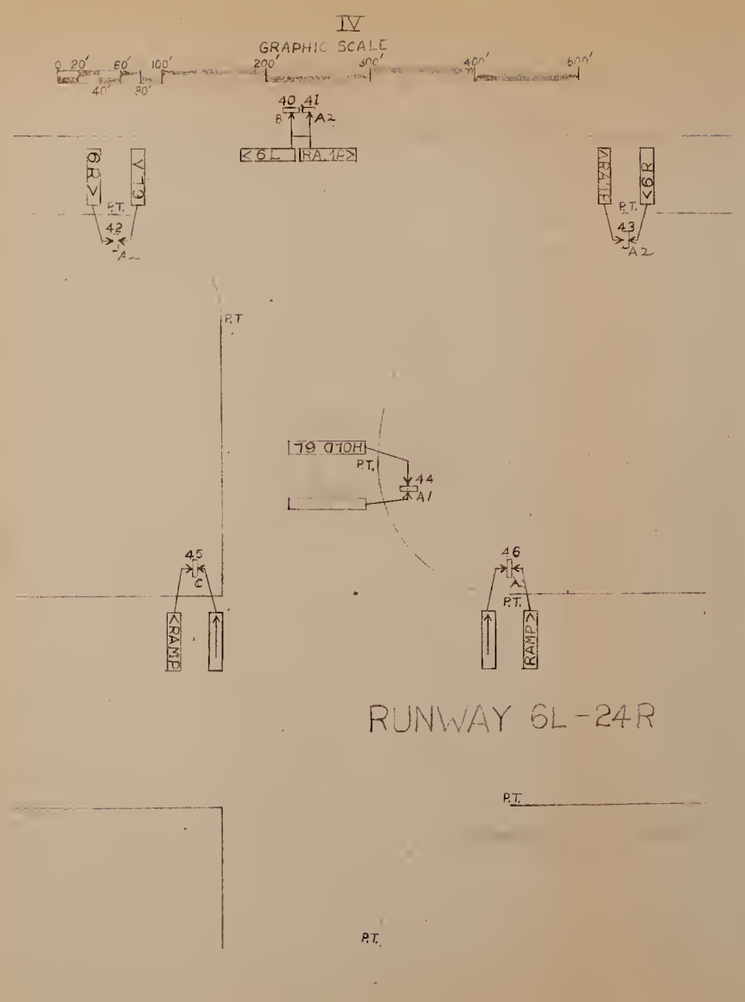
3. Sign 46, marking a possible choice of direction for exit, is priority A2.

4. Siga 40, iadicating a destination of lesser importance, is priority B.

5. Sign 45, markiag the limit of the turnoff, is priority C. There is little likelihood of pilots unfamiliar with the field layout neediag to make a tura at this point after landing on 6L.

6. The centerliae lights are spaced at 25-foot intervals oa the carved section aad at 50-foot iatervals oa the straight sections. The refereace poiat for these spaciags is at the point of taagency oa the taxiway paralleling the ruaway.

7. All the lights, includiag the destination sigas and the centerline lights, aloag the straight sectioas of the paralleling taxiway are powered by regulator #7. All the lights and signs, includiag the centerline lights oa the curved section of centerliae aad the edge marker lights on the fillets, are powered by regulator #6.



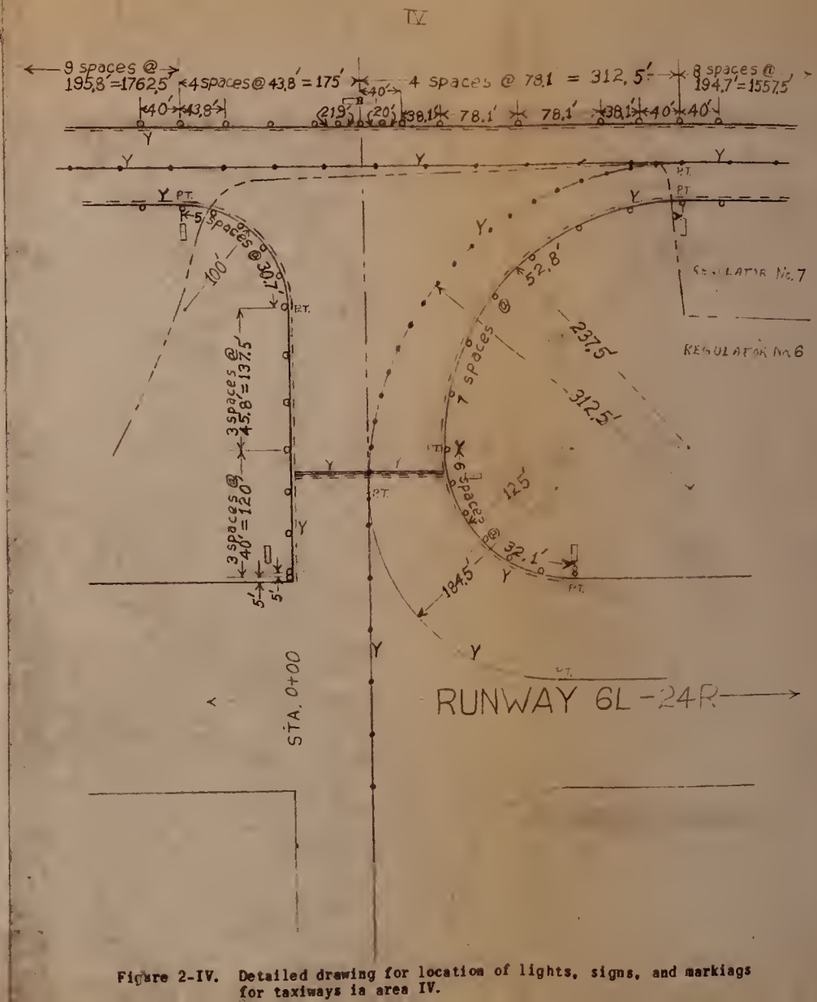


Figure 2-IV. Detailed drawing for locatioa of lights, signs, and markiags for taxiways ia area IV.

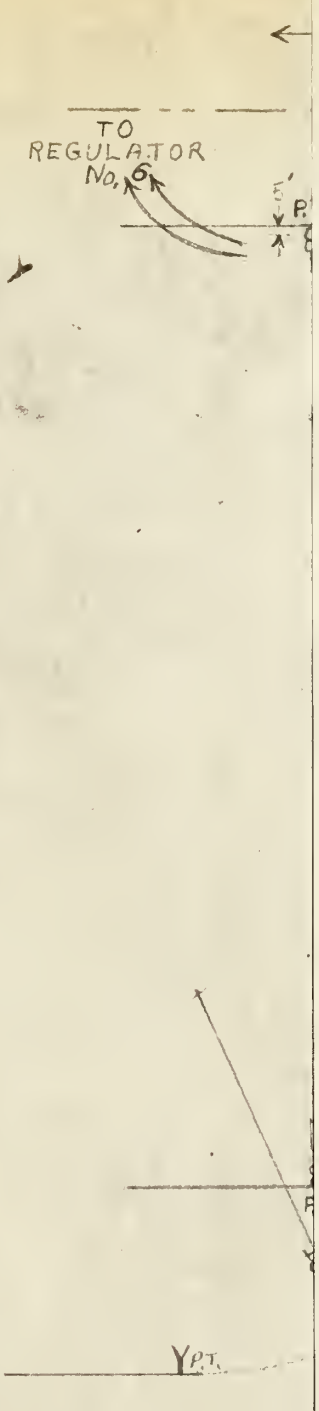
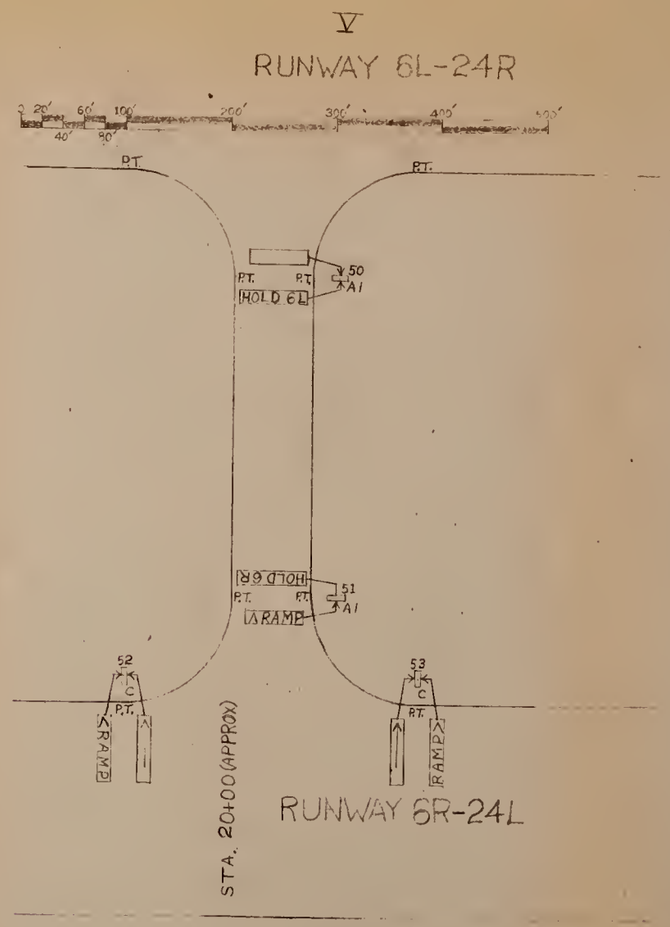


Figure 2-V.

NOTES:

1. Signs 50 and 51, as holding post signs, are priority A1.
2. Signs 52 and 53, marking the limit of this runway exit, are priority C.
3. Since this taxiway is not normally used as an exit from runway 6L-24R, runway turnoff signs are not used at the intersection with this runway.



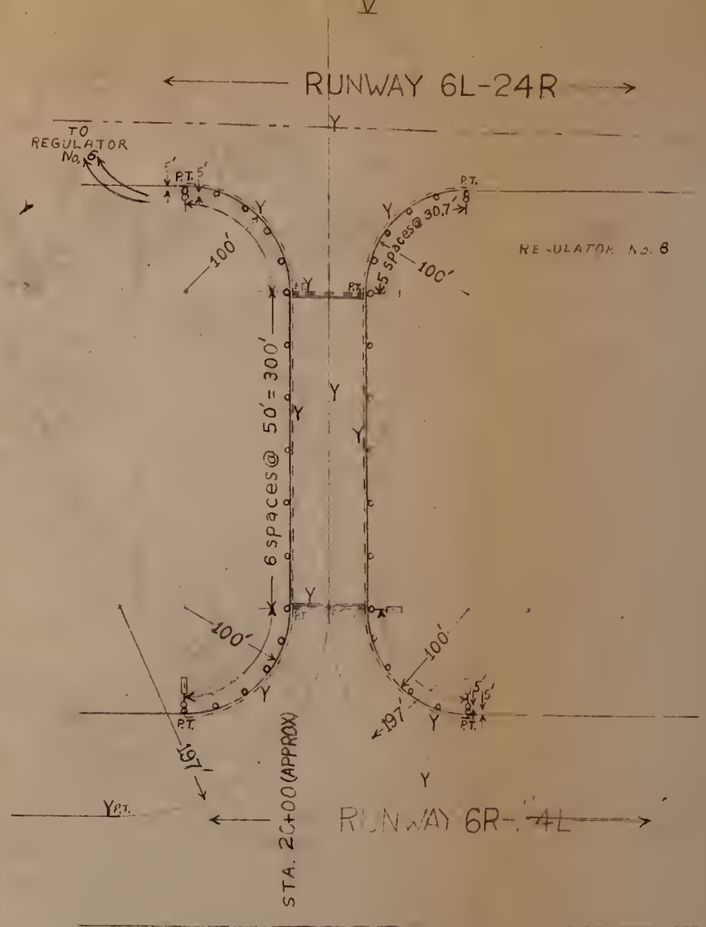


Figure 2-V. Detailed drawing for location of lights, signs, and markings for taxiways in area V.

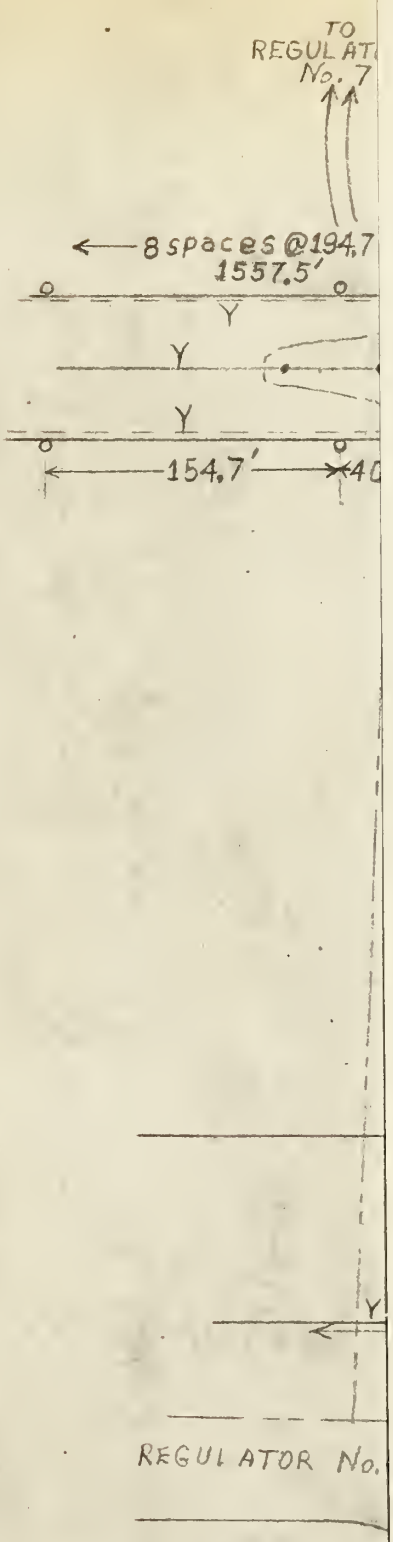
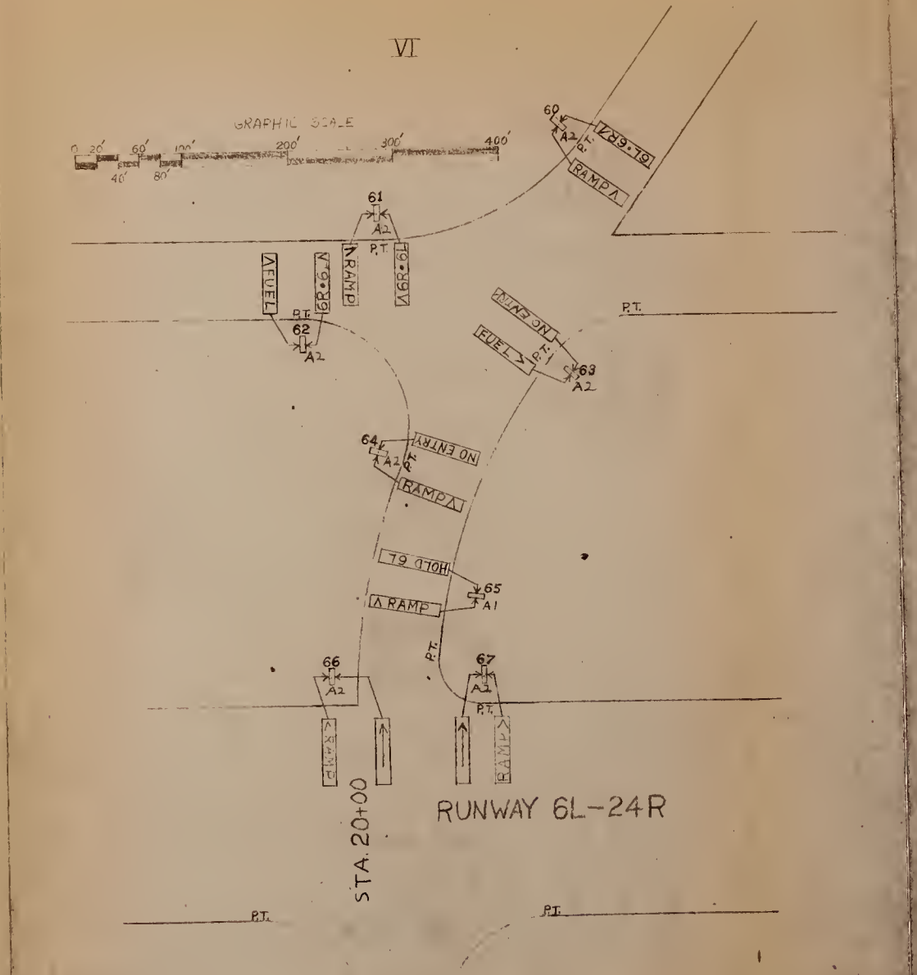


Figure 2-VI.

NOTES:

1. Sign 65, as a holding post sign, is priority A1.
2. Signs 60, 61, 62, 63, and 64, indicating important destinations at an intersection, are priority A2.
3. Signs 66 and 67, marking a possible choice of direction for exit, are priority A2.
4. The centerline lights are spaced at 25-foot intervals on the curved section and at 50-foot intervals on the straight sections. The reference point for spacing is at the point of tangency on the taxiway paralleling the runway.
5. All the lights on this drawing are powered from regulator #5 except for the edge marker lights beyond the last guidance sign which are powered by regulator #7.



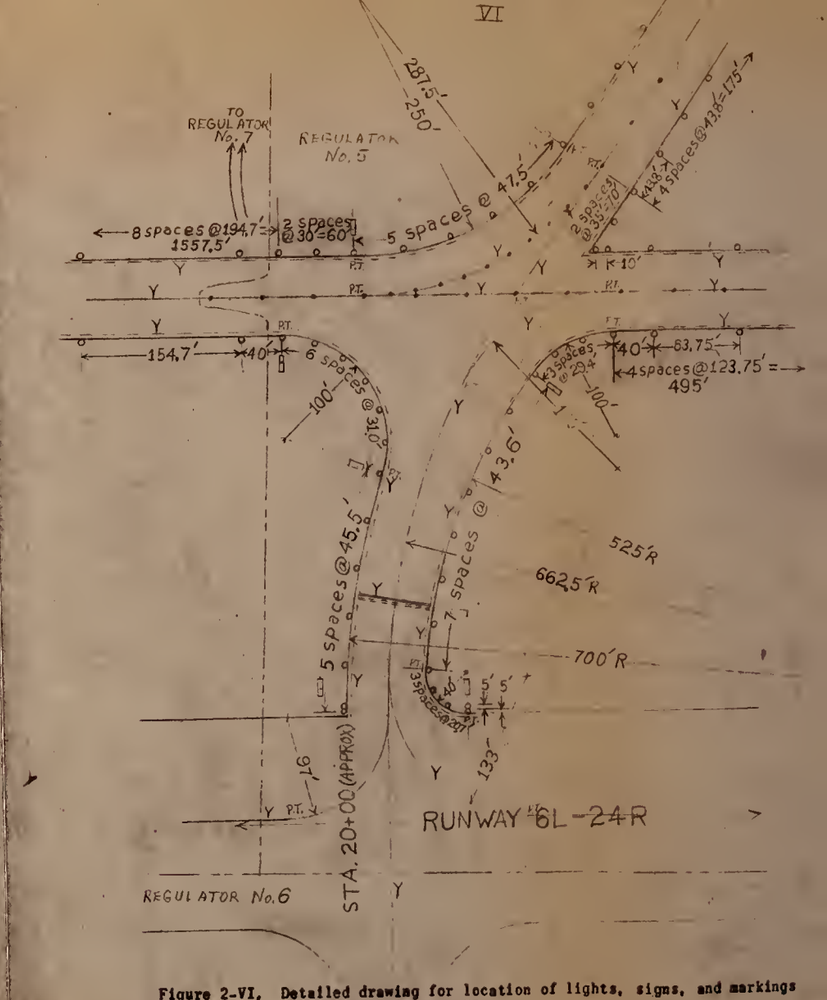
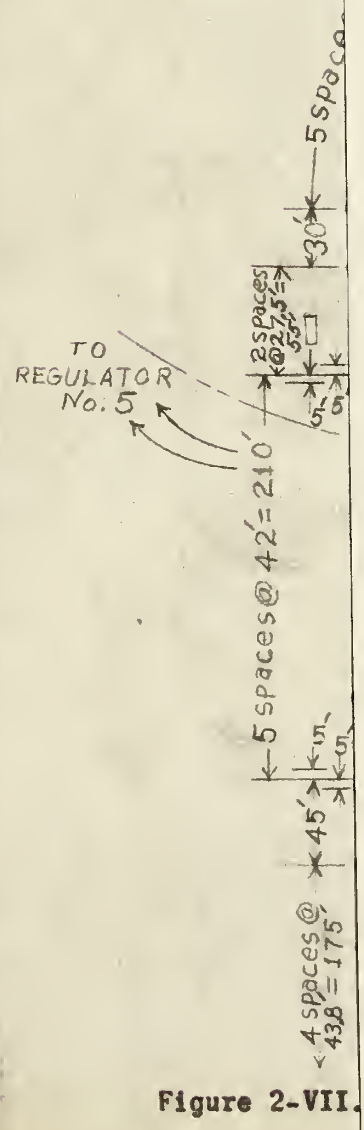
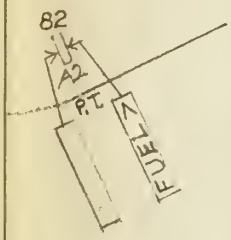


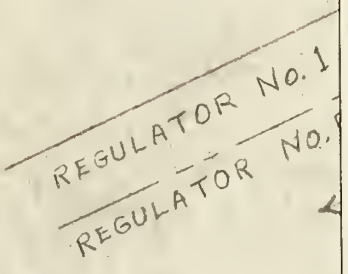
Figure 2-VI. Detailed drawing for location of lights, signs, and markings for taxiways in area VI.



TO
REGULATOR
No. 5
5 spaces @ 42' = 210'
2 spaces @27.5' = 55'
30'
45'
4 spaces @ 43.8' = 175'

Figure 2-VII.





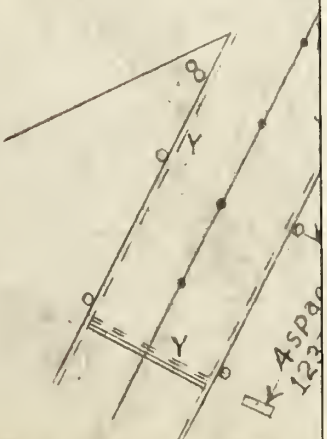
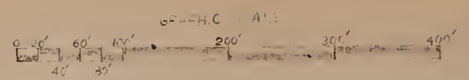
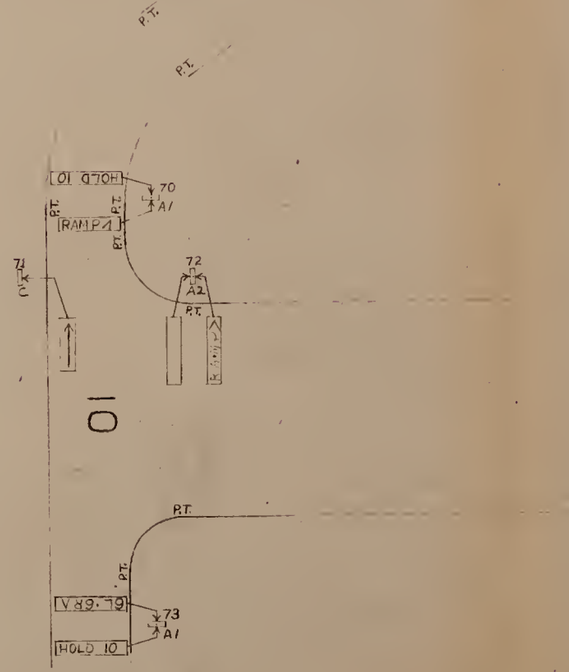


Figure 2-VIII.

NOTES:

1. Signs 70 and 73, as holding post signs, are priority A1.
2. Sign 72, marking a possible choice of direction for exit, is priority A2.
3. Sign 71, marking the limit of the turnoff, is priority C.
4. Since a left turn is not normally made after landing on runway 28, runway turnoff signs are not required on the left side of this runway.
5. The flush taxiway lights across the threshold side of runway 10 may be type M-1 lights instead of flush lights if the use of elevated lights is permissible.
6. All the lights between the near edge of runway 10-28 and the ramp are powered by regulator #1. All the other lights are powered by regulator #5.





VII

Figure 2-VII. Detailed drawing for location of lights, signs, and markings for taxiways in area VII.

REGULATOR

Figure 2-IX.

NOTES:

1. Signs 80 and 83, as holding post signs, are priority A1.
2. Sign 82, marking a possible choice of direction for exit, is priority A2.
3. Sign 81, marking the limit of the turnoff, is priority C.
4. Since a left turn is not normally made after landing on runway 28, runway turnoff signs are not required on the left side of this runway.
5. The centerline lights are spaced at 25-foot intervals on the curved section and at 50-foot intervals on the straight sections.
6. The centerline lights up to the point of tangency and on the curved section to runway 10-28 and the edge marker lights on the side of the runway nearest the ramp are powered from regulator #1. The centerline lights beyond the point of tangency and the edge marker lights on the far side of the runway are powered from regulator #5.

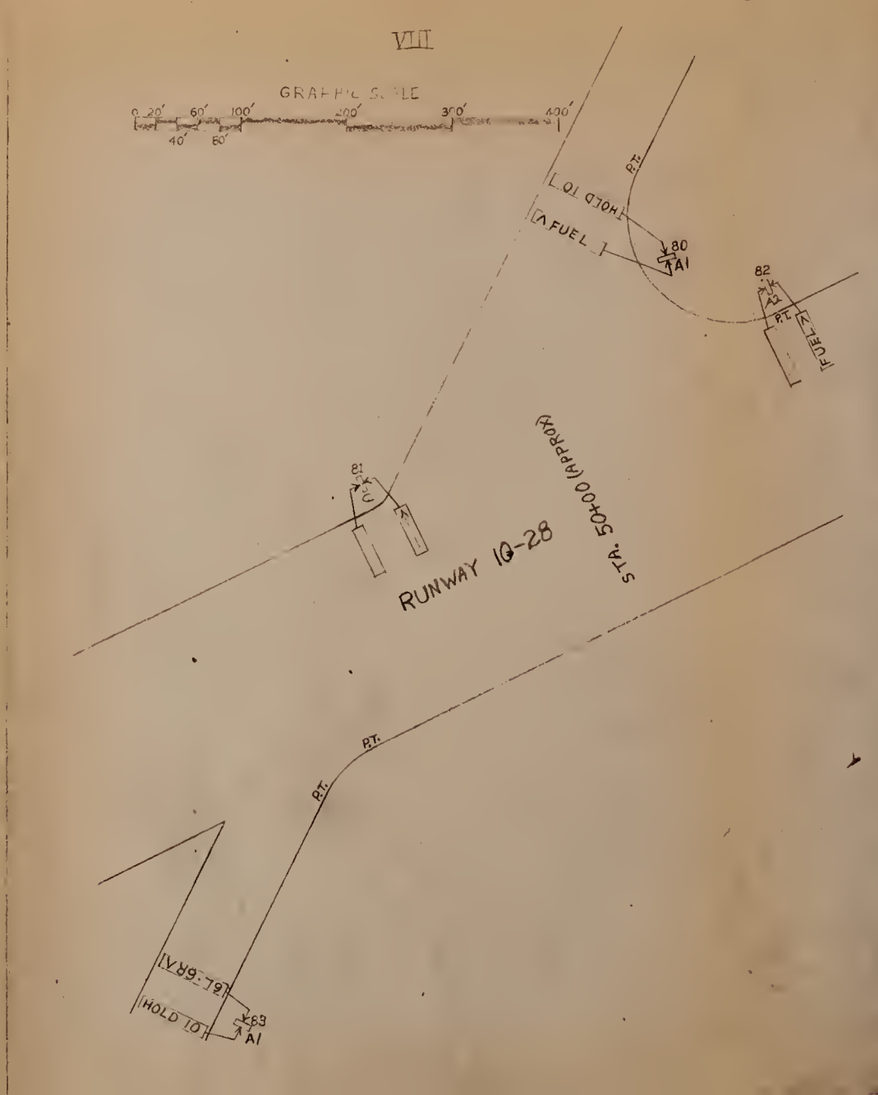


Figure 2-VIII. Detailed drawing for location of lights, signs, and markings for taxiways in area VIII.

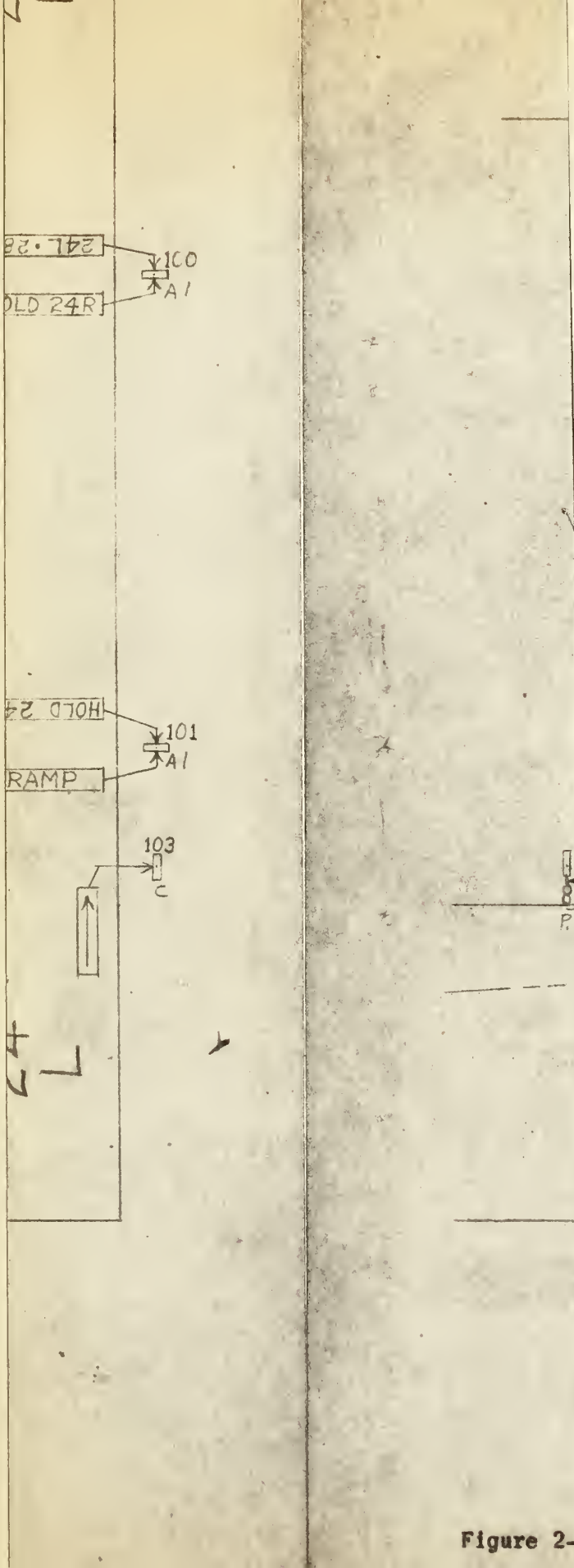


Figure 2-X

NOTES:

1. Sign 90, as a holding post sign, is priority A1.

2. Sigas 91 and 92, marking the limits of tha runway turnoff, are priority C.

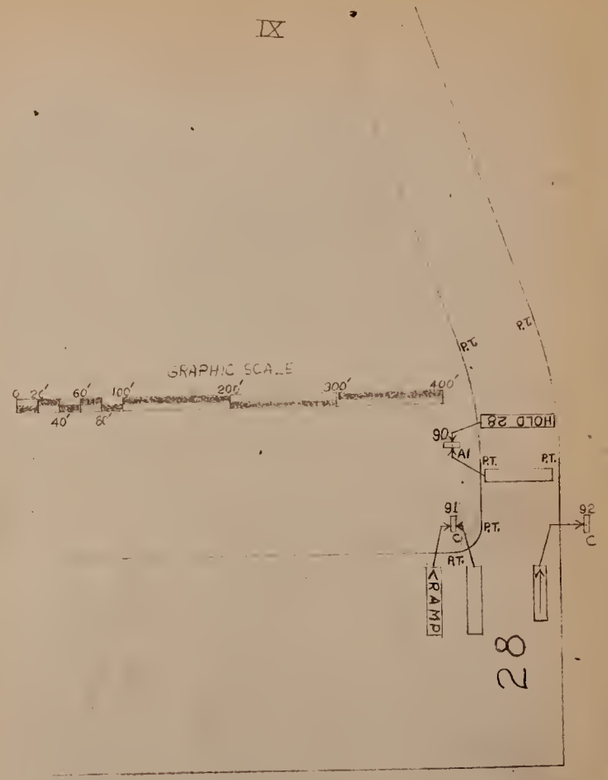
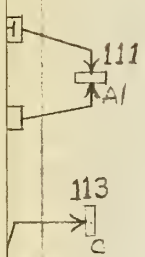


Figure 2-IX. Detailed drawing for location of lights, signs, and markings in area IX.

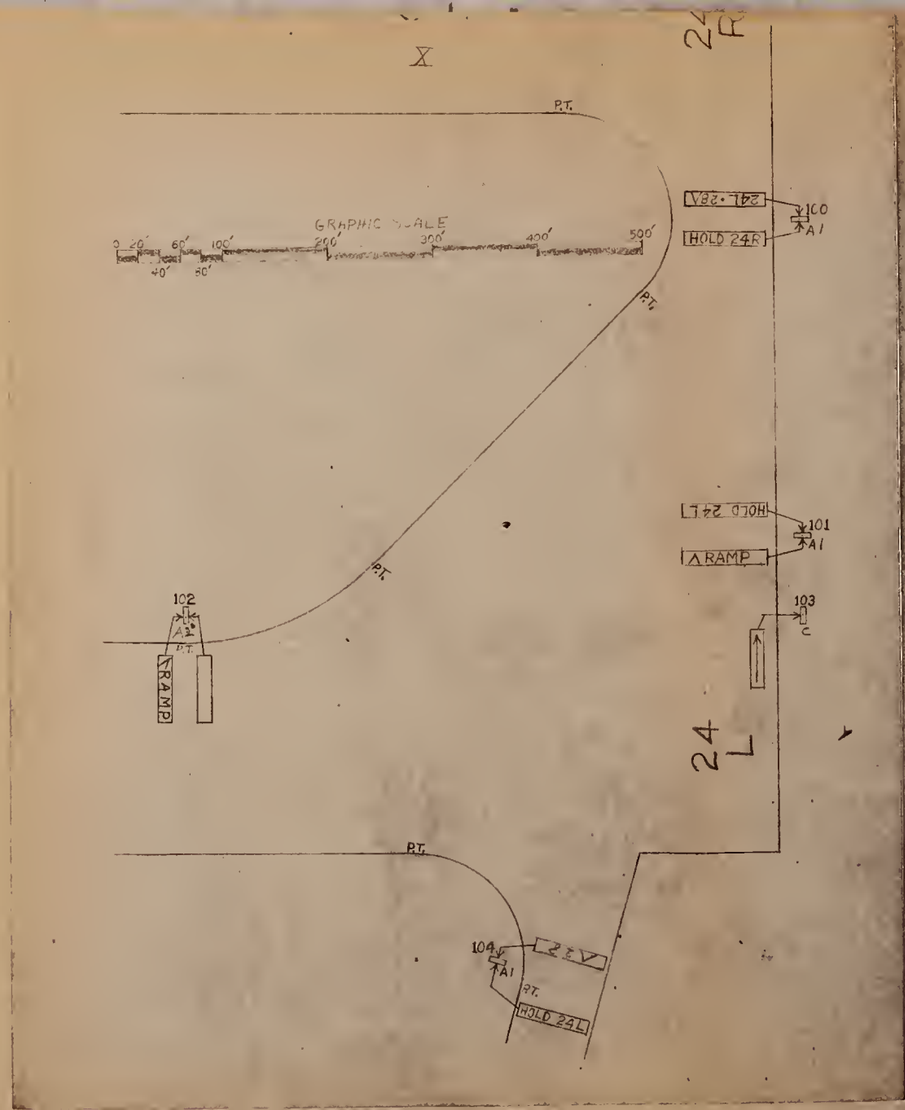


REGULATO

Figure 2-X

NOTES:

1. Signs 100, 101, and 104, as holding post signs, are priority A1.
2. Sign 102, marking a possible choice of direction for exit, is priority A2.
3. Sign 103, marking the limit of the exit, is priority C.
4. Since a right turn is not normally made after landing on runway 6L, runway turnoff signs are not required on the right side of this runway.
5. The flush taxiway lights across the threshold side of runways 24L and 24R may be type M-1 lights instead of flush lights if the use of elevated lights is permissible.
6. The centerline lights are spaced at 50-foot intervals.
7. All the lights between the near edge of runway 24L and the ramp are powered by regulator #4. The taxiway lights across the threshold and on the far side of runway 24L are powered by regulator #8.



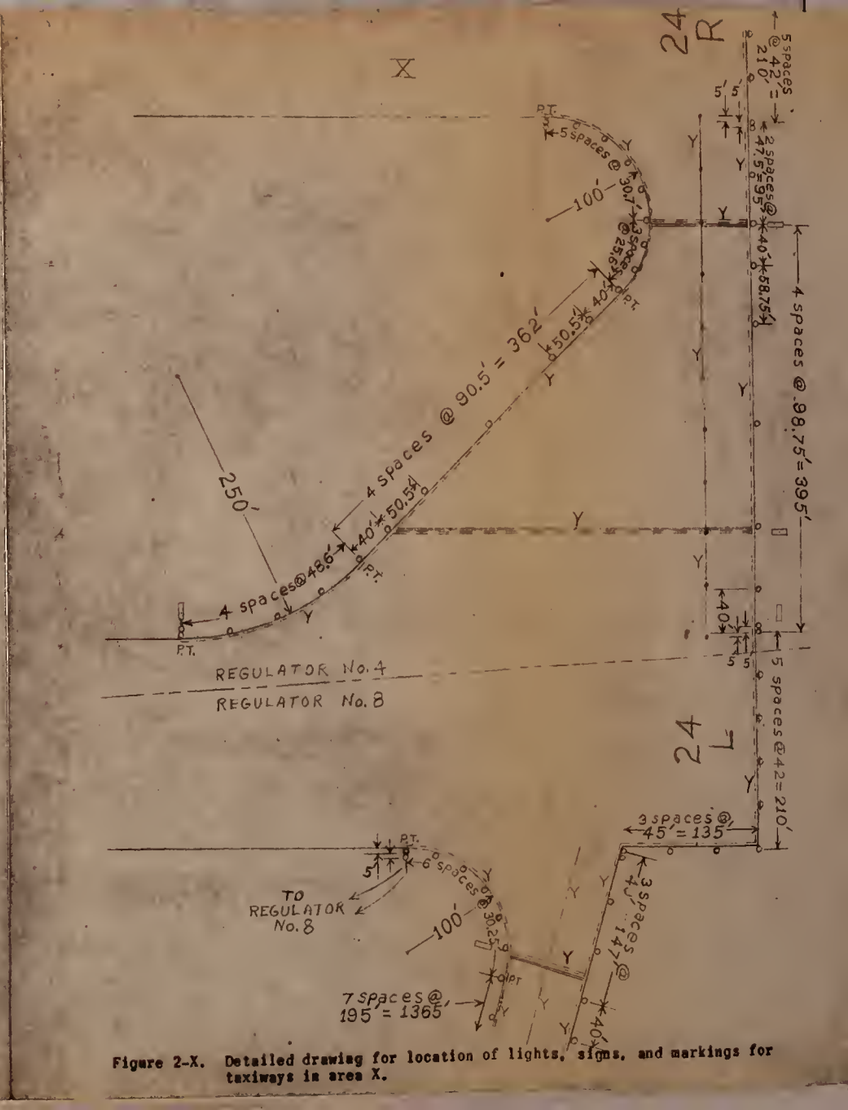


Figure 2-X. Detailed drawing for location of lights, signs, and markings for taxiways in area X.

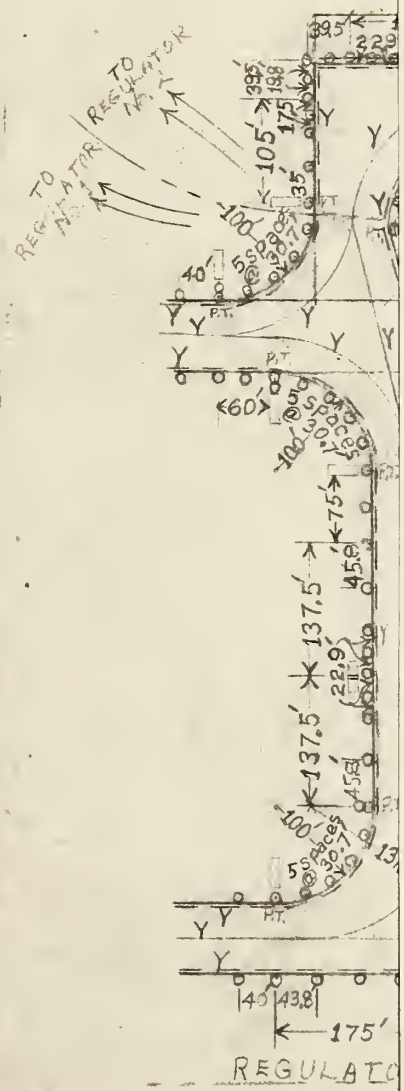
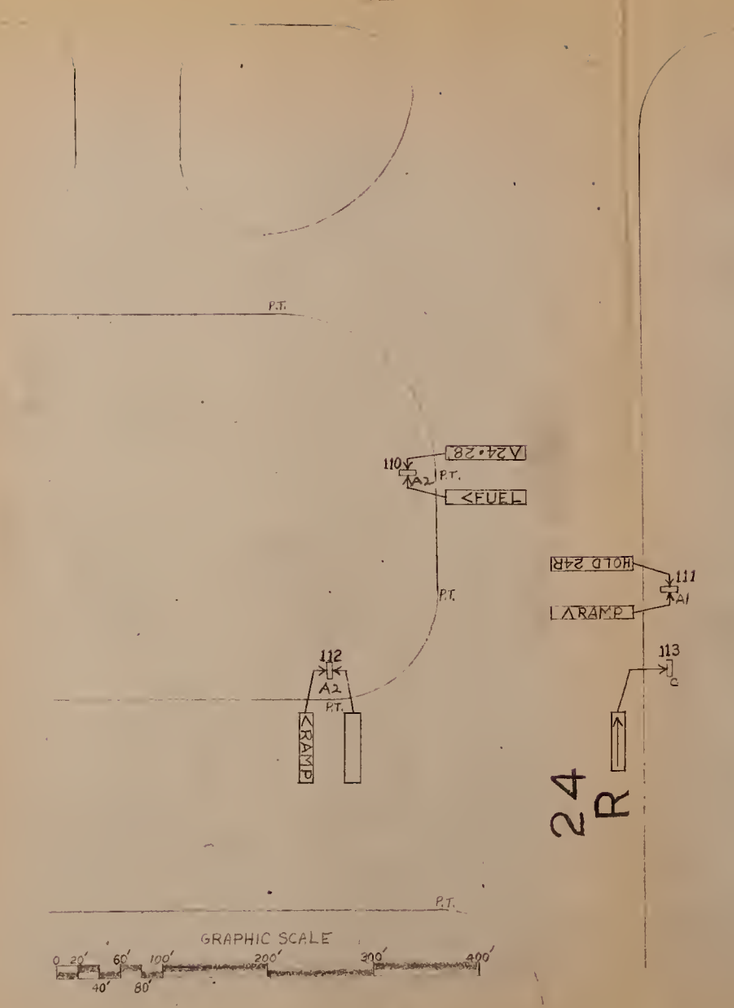

REG TO REGULATOR
REG TO REGULATOR
105'
175'
100'
40'
60'
75'
137.5'
137.5'
22.9'
45.8'
45.8'
43.8'
175'
REGULATO

Figure 2-XII.

NOTES:

1. Sign 111, as a holding post sign, is priority A1.
2. Sign 110, indicating an important destination at an intersection where a choice of directions is required, is priority A2.
3. Sign 112, marking a possible choice of direction for exit, is priority A2.
4. Sign 113, marking the limit of the turnoff, is priority C.
5. The flush taxiway lights across the threshold of runway 24R may be type M-1 lights instead of flush lights if the use of elevated lights is permissible.
6. The centerline lights on the straight section of centerline are spaced at 50-foot intervals.
7. The lighting details toward the ramp are continued on figure 2-XV.



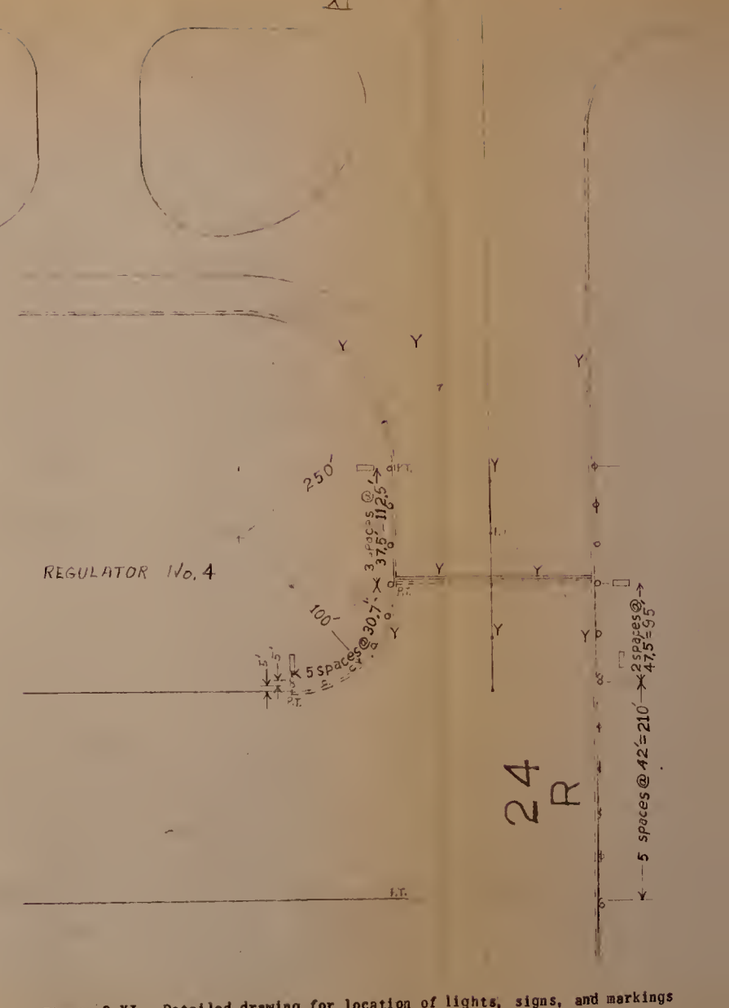


Figure 2-XI. Detailed drawing for location of lights, signs, and markings for taxiways in area XI.

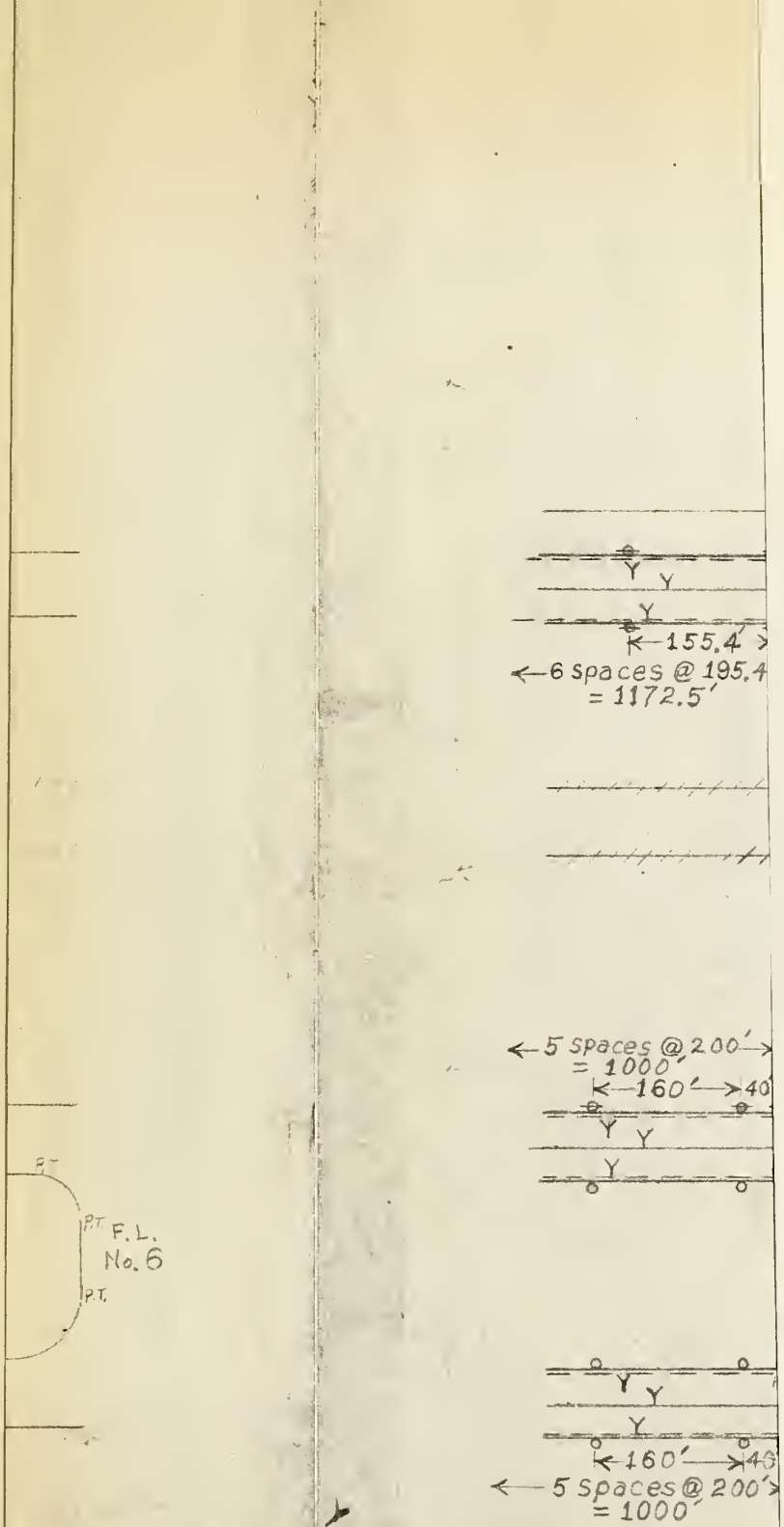


Figure 2-XIII.

NOTES:

1. Signs 120, 123, 127, 129, and 129a, indicating important destinations at intersections where a choice of directions is required, are priority A2.

2. Signs 121, 124, 125, 126, and 128, giving less critical information, are priority B.

3. Sign 122, marking the entrance to the ramp, is priority C.

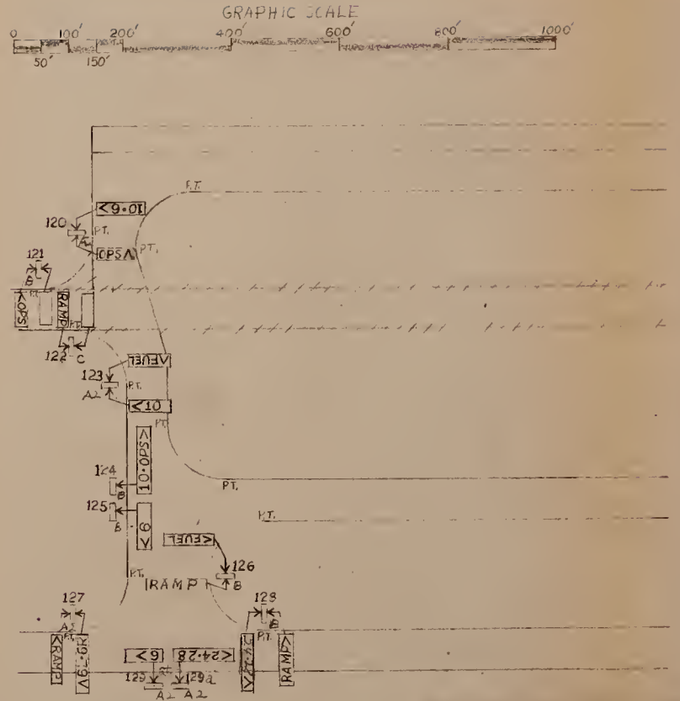
4. No taxiway guidance signs are placed on the parking apron pavement, although signs at such locations may be desirable.

5. For the peripheral taxiway, the lights on the paved areas should be omni-directional flush lights. If installation of standard flush lights in existing paving cannot be justified, the pancake type lights may be used but the performance will be less satisfactory, especially at turns and intersections.

6. The light circuits should be separated and connected to regulators 1 and 2 as indicated.

7. The present taxiway across the center of the ramp should be eliminated.

8. The corner at the turn from the Operations Building to the taxiway to runway 10 should be filleted with a radius not less than 100 feet.



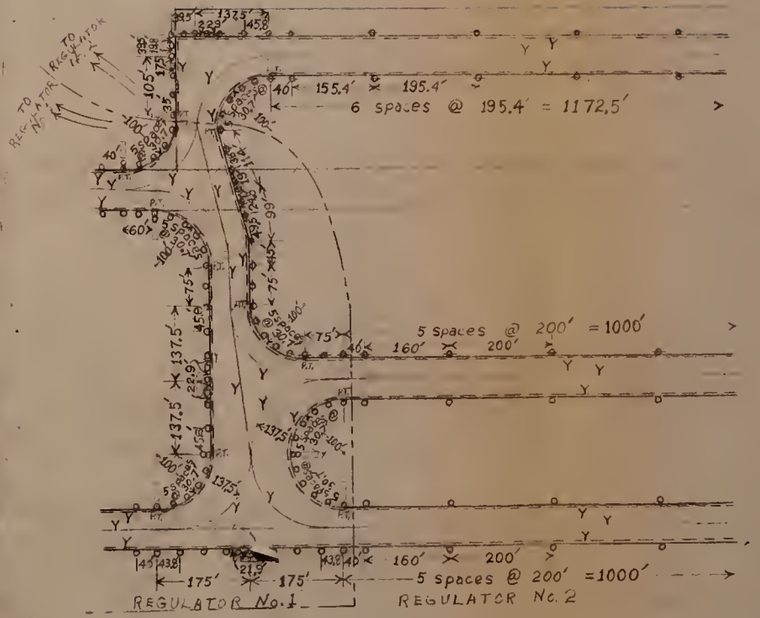


Figure 2-XII. Detailed drawing for location of lights, signs, and markings for taxiways in area XII.

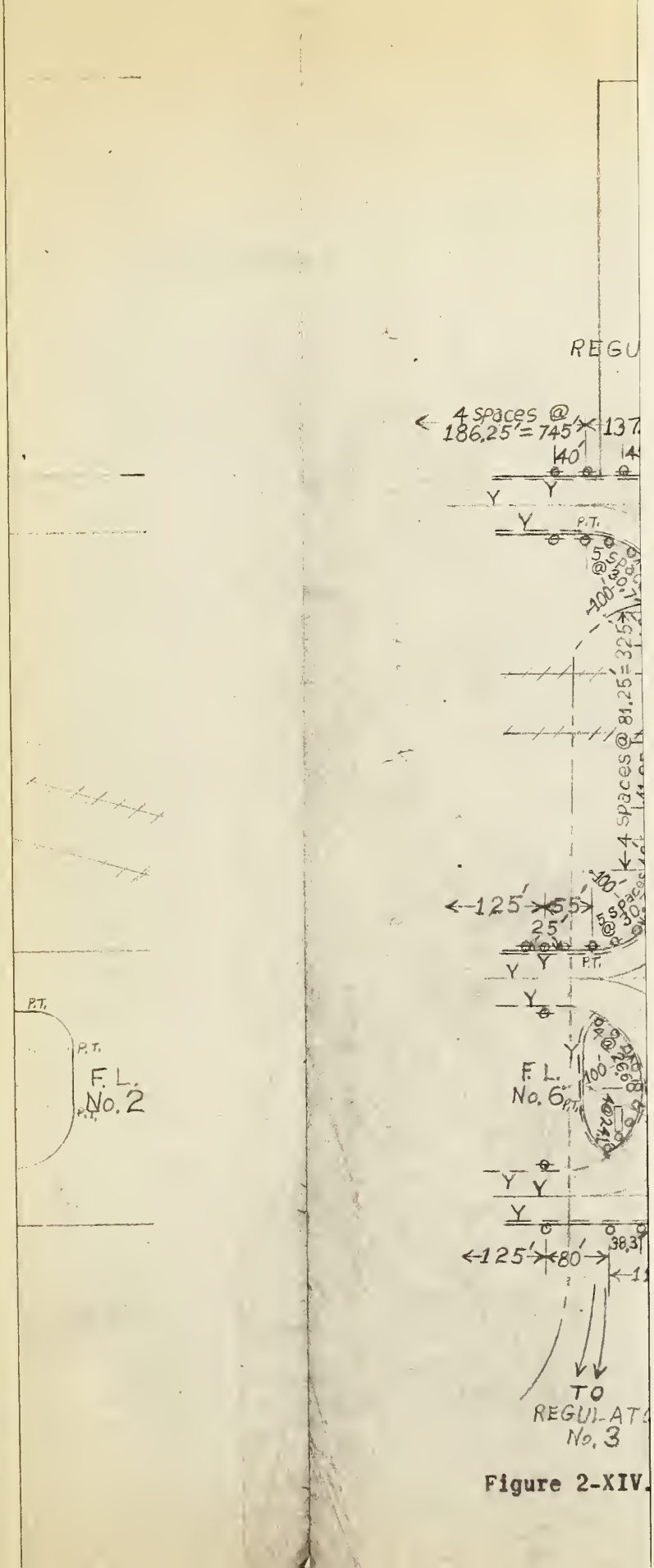

REGU
4 spaces @ 186.25' = 745'
140'
Y
P.T.
5 @ 80'
400'
4 spaces @ 81.25' = 325'
125'
55'
25'
5 @ 80'
100'
P.T.
F. L. No. 2
F. L. No. 6
125'
80'
38.3
TO
REGULATS
No. 3

Figure 2-XIV.

NOTES:

1. Signs 133 and 134, indicating important destinations at an intersection where a choice of directions is required, are priority A2.

2. Signs 130, 131, and 132, indicating destinations at intersections where there is little likelihood of confusion, are priority B.

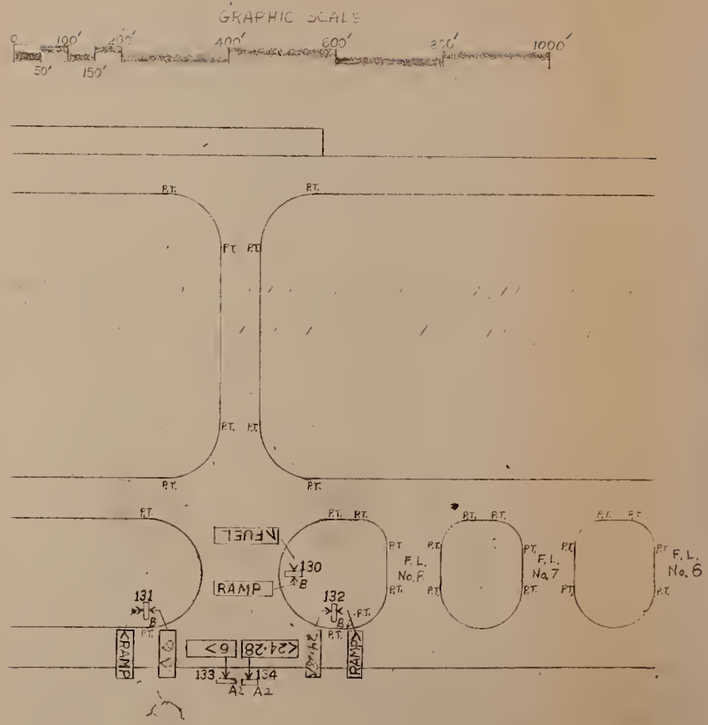
3. No taxiway guidance signs are placed on the parking apron pavement although signs at such locations may be desirable.

4. For the peripheral taxiway, the lights on the paved areas should be omni-directional flush lights. If installation of standard flush lights in existing paving cannot be justified, the pancake type lights may be used but the performance will be less satisfactory, especially at turns and intersections.

5. The taxiway light in the entrance to each refueling lane should not be lighted when the lane is available for refueling. This switching is controlled by the lights of each refueling lane.

6. The refueling lane lighting, except for the taxiway light in the entrance, is not shown on this drawing.

7. The present taxiway across the center of the ramp should be eliminated.



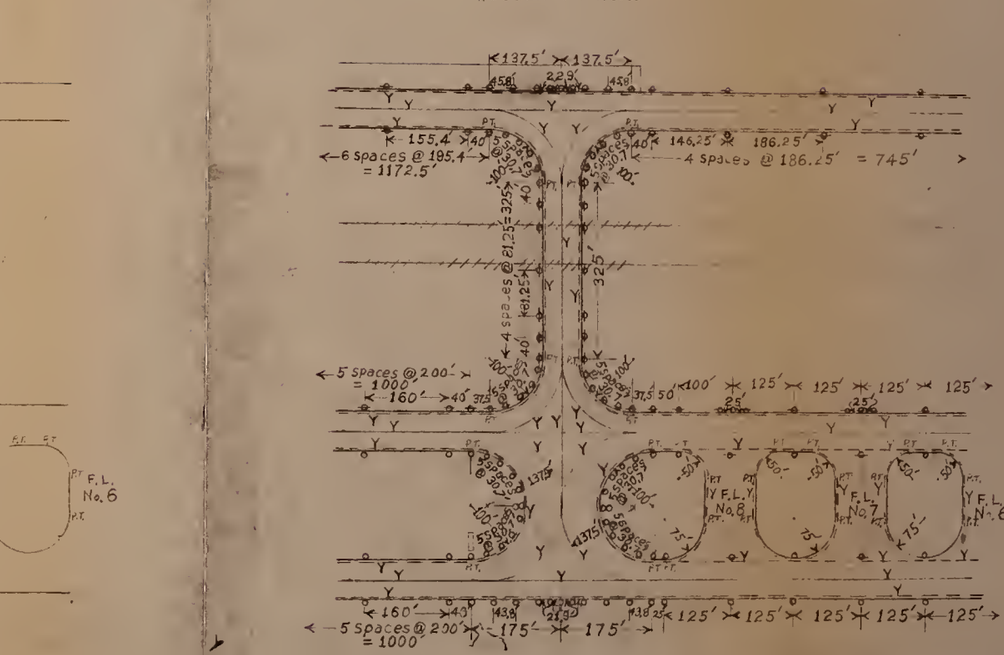


Figure 2-XIII. Detailed drawing for location of lights, signs, and markings for taxiways in area XIII.

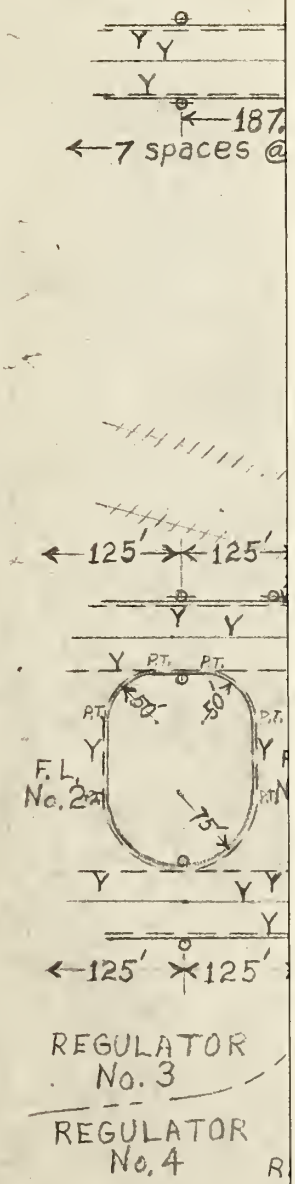

←187
←7 spaces @
←125'→←125'→
P.T.
P.T.
P.T.
P.T.
50'
50'
F.L.
No. 2
125'
125'
REGULATOR
No. 3
REGULATOR
No. 4

Figure 2-XV.

NOTES:

1. Signs 142 and 143, indicating important destinations at an intersection where a choice of direction is required, are priority A2.

2. Signs 140 and 141, indicating direction to the hangar area, are priority B.

3. No taxiway guidance signs are placed on the parking apron pavement although signs at such locations may be desirable.

4. For the peripheral taxiway, the light on the paved areas should be omni-directional flush lights. If installation of standard flush lights in existing paving cannot be justified, the pancake type lights may be used but the performance will be less satisfactory, especially at turns and intersections.

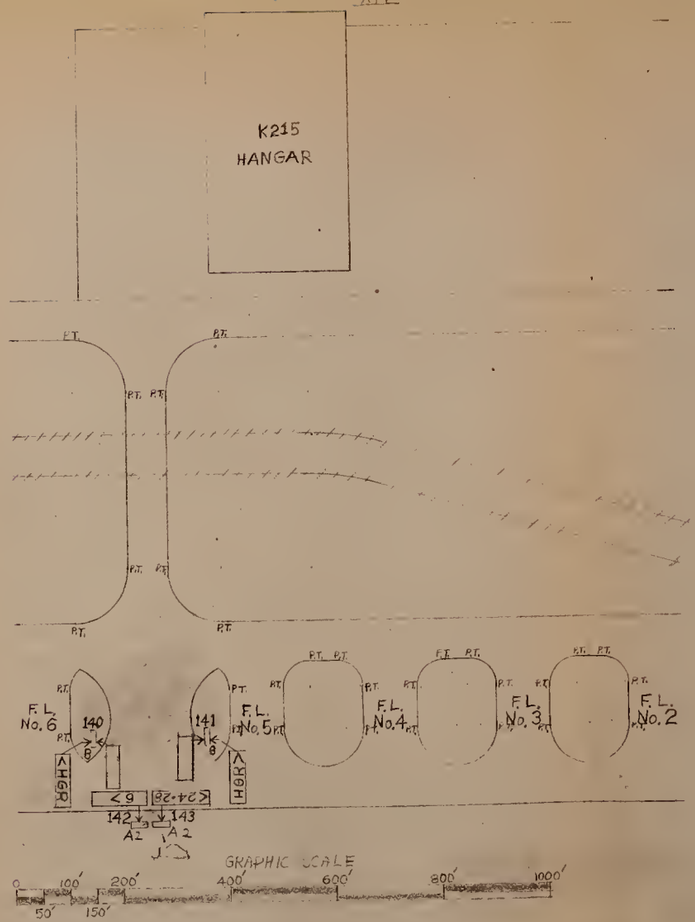
5. The taxiway light in the entrance to each refueling lane should not be lighted when the lane is available for refueling. This switching is controlled by the lights of each refueling lane.

6. The light circuits should be separated and connected to regulators 2 and 3 as indicated.

7. The refneling lane lighting, except for the taxiway light in the entrance, is not shown on this drawing.

8. The present taxiway across the center of the ramp should be eliminated.

9. The small buildings, K805, K806, K807, and K808, should be moved or eliminated in order to provide maximum parking area inside the peripheral taxiway and to keep the taxiway reasonably straight for more effective movement of traffic.



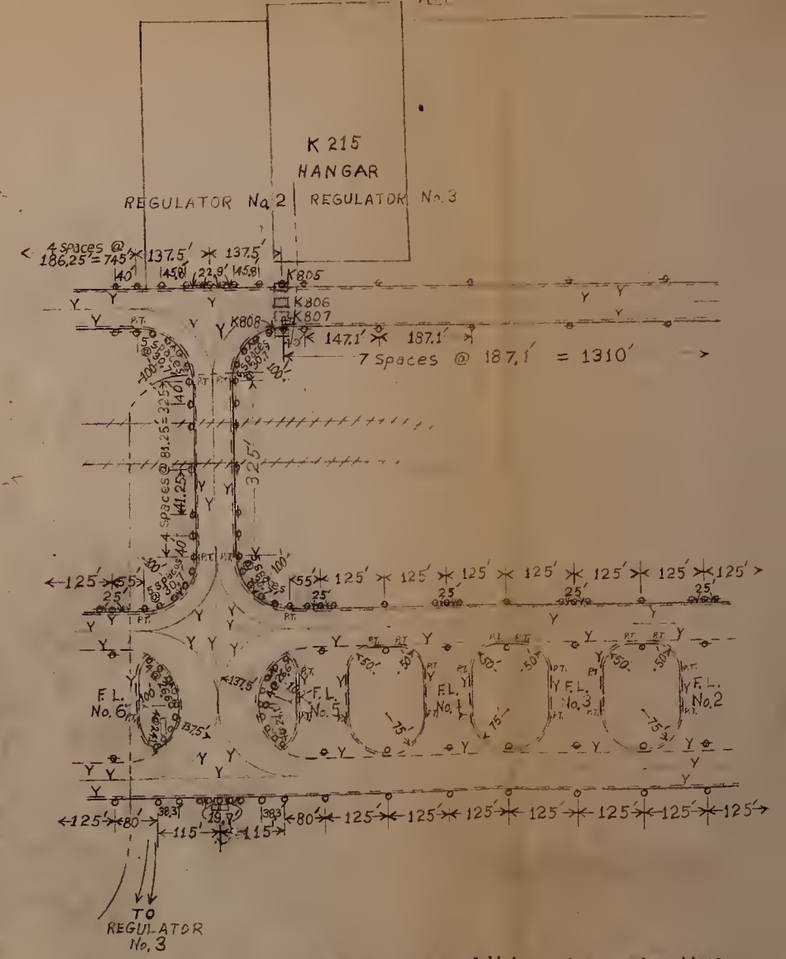


Figure 2-XIV. Detailed drawing for location of lights, signs, and markings for taxiways in area XIV.

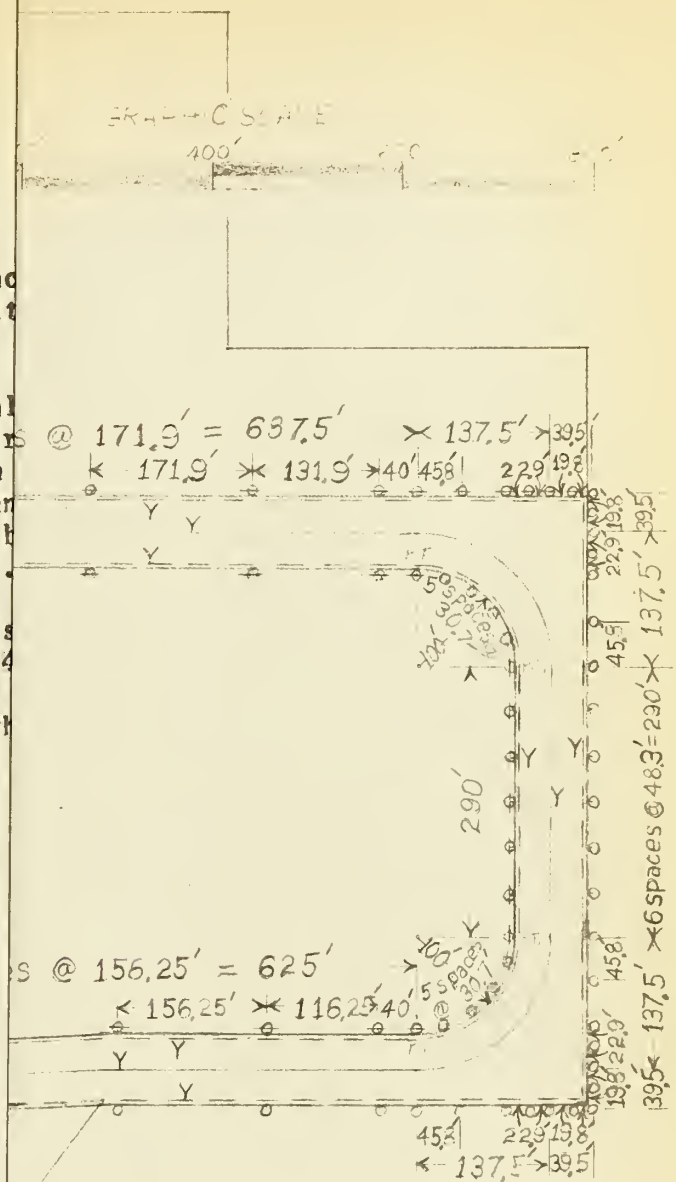
NOTES:

1. No taxiway guidanc
   apron pavement alt
   desirable.

2. For the peripheral
   should be omni-dir
   of standard flush
   justified, the par
   performance will b
   and intersections.

3. The light circuits
   regulators 3 and 4

4. Note that the ligh
   figure 2-XV.



location of lights, signs, and markings
XVI.

NOTES:

1. Sign 152, marking an important destination at an intersection requiring a change in direction, is priority A2.

2. Signs 150 and 151, indicating destinations at intersections where there is little likelihood of confusion, are priority B.

3. No taxiway guidance signs are placed on the parking apron pavement although signs at such locations may be desirable.

4. For the peripheral taxiway, the lights on the paved areas should be omni-directional flush lights. If installation of standard flush lights in existing paving cannot be justified, the pancake type lights may be used but the performance will be less satisfactory, especially at turns and intersections.

5. The taxiway light in the entrances to each refueling lane should not be lighted when the lane is available for refueling. This switching is controlled by the lights of each refueling lane.

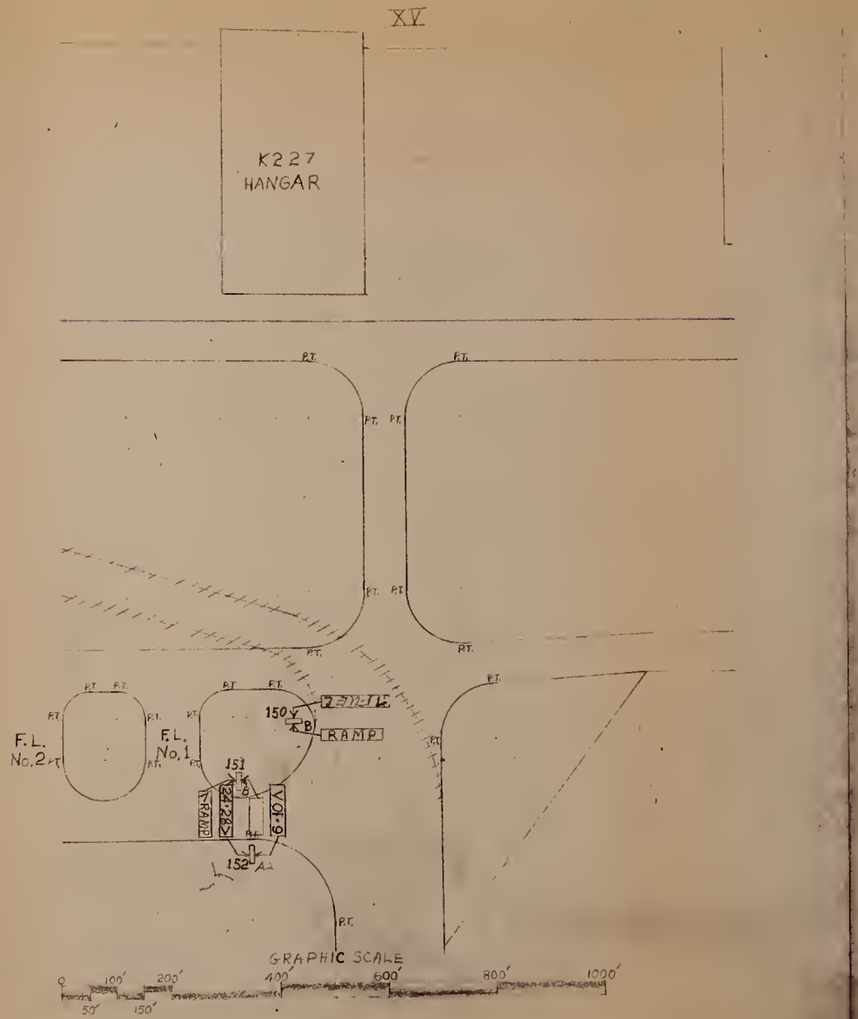
6. The light circuits should be separated and connected to regulators 3 and 4 as indicated.

7. The refueling lane lighting, except for the taxiway light in the entrance, is not shown on this drawing.

8. The present taxiway across the center of the ramp should be eliminated.

9. The small buildings, K811, K814, and K816, should be moved or eliminated in order to provide maximum parking area inside the peripheral taxiway and to keep the taxiway reasonably straight for more effective movement of traffic.

10. The centerline lights are spaced at 25-foot intervals on the curved sections and at 50-foot intervals on the straight sections.



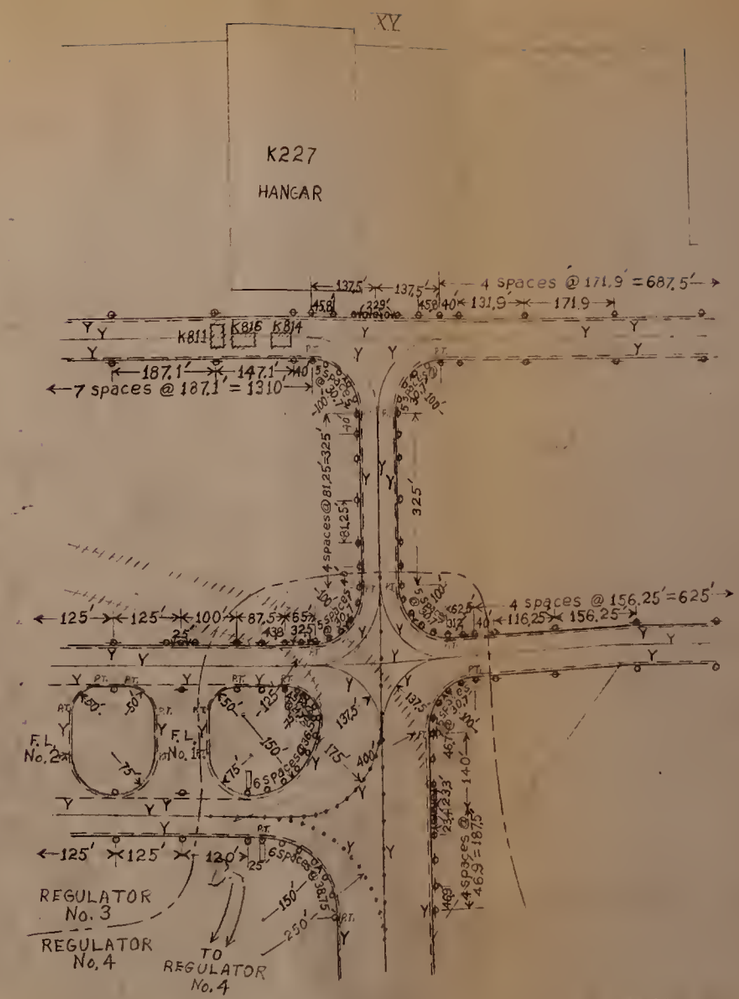


Figure 2-XV. Detailed drawing for location of lights, signs, and markings for taxiways in area XV.

NOTES:

1. No taxiway guidance signs are placed on the parking apron pavement although signs at such locations may be desirable.

2. For the peripheral taxiway the lights on the paved areas should be omni-directional flush lights. If installation of standard flush lights in existing paving cannot be justified, the pancake type lights may be used but the performance will be less satisfactory, especially at turns and intersections.

3. The light circuits should be separated and connected to regulators 3 and 4 as indicated.

4. Note that the lights on this drawing overlap those on figure 2-XV.

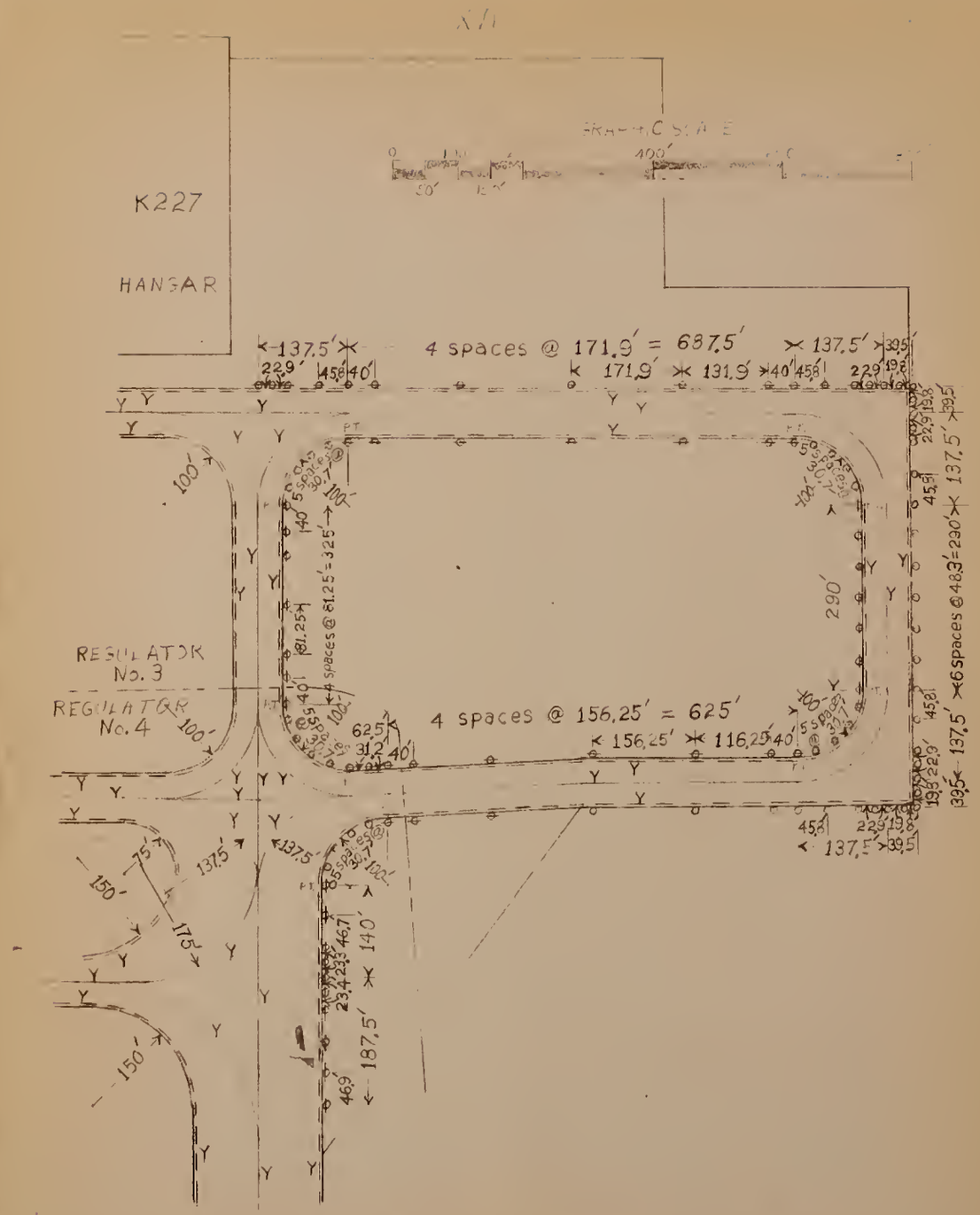


Figure 2-XVI. Detailed drawing for location of lights, signs, and markings for taxiways in area XVI.

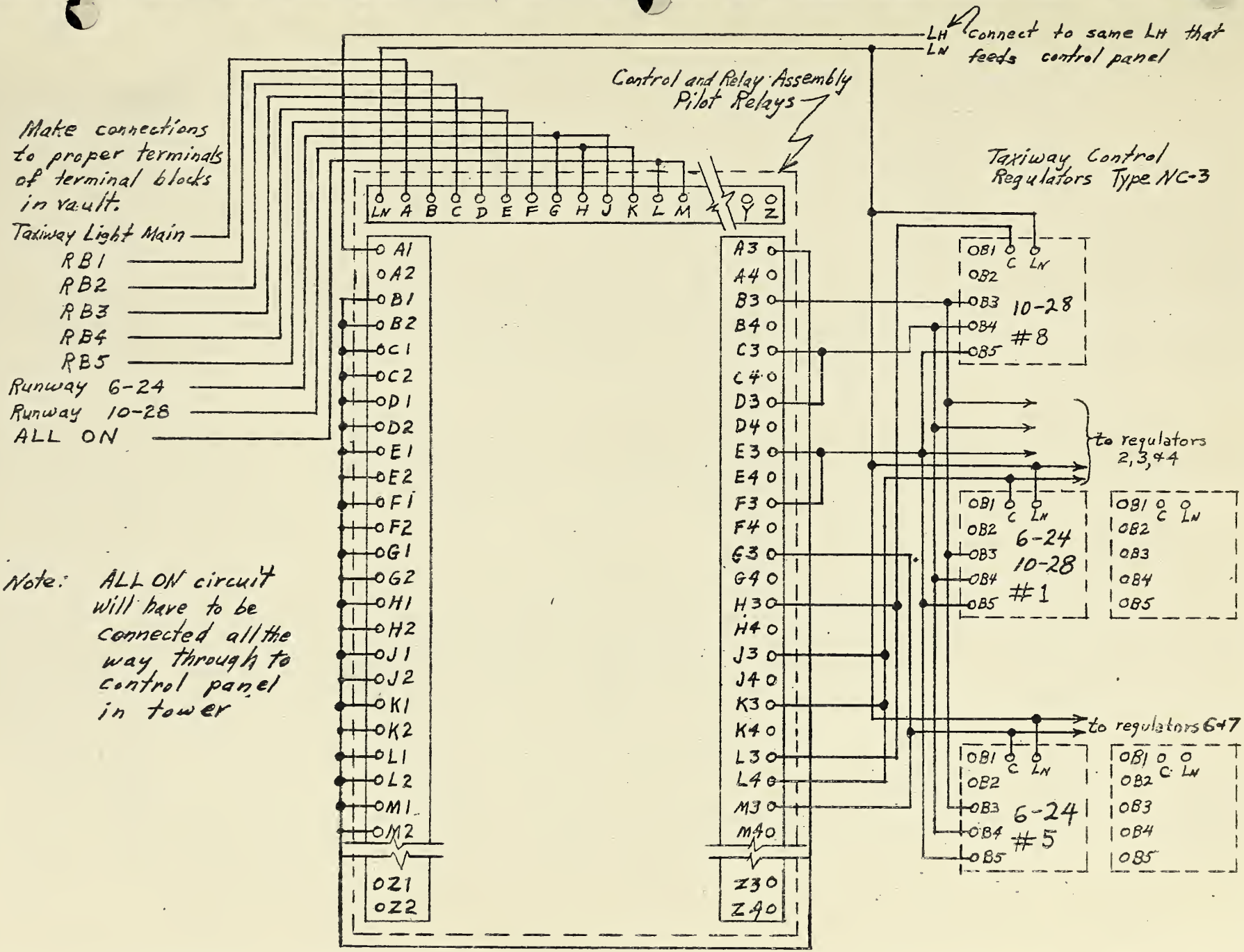


Figure 3. Taxiway lighting control wiring diagram.

U.S. DEPARTMENT OF COMMERCE
Frederick H. Mueller, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

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Radio Propagation Engineering. Data Reduction Instrumentation. Modulation Research. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Propagation Obstacles Engineering. Radio-Meteorology. Lower Atmosphere Physics.

Radio Standards. High Frequency Electrical Standards. Radio Broadcast Service. High Frequency Impedance Standards. Electronic Calibration Center. Microwave Physics. Microwave Circuit Standards.

Radio Communication and Systems. Low Frequency and Very Low Frequency Research. High Frequency and Very High Frequency Research. Ultra High Frequency and Super High Frequency Research. Modulation Research. Antenna Research. Navigation Systems. Systems Analysis. Field Operations.


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