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DEVELOPMENT OF A STUB APPROACH LIGHT SYSTEM

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TABLE OF CONTENTS

FIGURE INDEX

DEVELOPMENT OF A STUB APPROACH LIGHT SYSTEM

SUMMARY

This report describes the development of a slope-line stub approach light system designed to take the place of range or threshold lights for clear weather landing conditions, and to give improved direction indication to pilots.

This system has been installed at the west end of Runway 9-27 at Weir Cook Airport, Indianapolis, Indiana. Consisting of three pairs of linear red gaseous tube lights spaced 100 feet between pairs, with the furthest pair 300 feet from the end of the runway, the lights are mounted on the slope-line principle, with the outside ends of the units nearest the ground and the inner ends so elevated as to make a 30-degree angle with the horizontal. They are so arranged that if the axes of the units of any pair were extended the extensions would intersect on a glide path, which makes an angle of approximately 2-1/2 degrees with the horizontal, and intersects the runway 497 feet in from the end.

When a pilot on this glide path looks ahead he sees all of the lights lying in only two lines, one line on each side of the approach. If he deviates from the glide path, the lights break up into echelon in accordance with the direction and amount of deviation.

Various airline pilots and private pilots have been asked to comment on these lights. All comments agree that the pattern is a material improvement on standard range lights as an aid in lining up the runways. The airline pilots report that the pattern gives a good reference to the proper angle of let down, and pilots flying smaller aircraft report that the angle indicated is flatter than they normally use. All pilots agree that the pattern indicates clearly the direction and glide angle for which it is designed.

INTRODUCTION

For some time work has been going on at the Civil Aeronautics Administration Experimental Station toward the development of a slope-line system of approach lights designed particularly for use under conditions of restricted visibility.[1] These lights, of which it takes 30 pairs and 3000 feet to install a full system, make use of clear incandescent lamps that, because of their brightness, require dimming apparatus before they can be used in clear weather. It is obvious that such a system, while its use is

[1] A description of the slope-line approach lighting system is contained in T.D. Report No. 60, "Some Considerations of High Intensity Approach Lighting" by H.J.C. Pearson and M. S. Gilbert, March, 1947.

justified and desirable for the instrument runway, would be far too expensive and impractical for use on all of the approaches. Yet there is a need for some improvement in the present methods of marking runway ends, a need for some type of range or threshold light that would also serve as an approach light for clear weather while not involving unreasonable space requirements or exorbitant expenditures.

In studying the problem of approach lighting for instrument landing runways, it was recognized that some approach lighting aids should be provided for all runway ends. The lights used for non-instrument runways, however, would have much less stringent requirements, as their normal use would be in clear and near clear weather, in which the lights would be visible for a mile or more.

In the development of the principle of slope-line approach lighting, in which linear lights are set in a three-dimensional geometric pattern, and with which the pilot learns to judge his approach by the geometric rearrangement of this pattern, it is obviously of great advantage to have the pilot use such a pattern on as large a proportion of landings as possible in order to familiarize himself with its characteristics. This system of lighting fortunately lends itself very readily to partial or stub requirements and to tubular lighting sources, without changing the basic characteristics of the means of guidance.

Although the high intensity slope-line lights are set at a 45-degree angle from the ground, this practice was not adopted for the stub approach system inasmuch as it is desirable to have the units far enough apart to avoid forming an obstruction while at the same time allowing the touch-down point to be as close to the runway end as is practical. From Figure 1 it can be seen that the touch-down point, glide angle and light position are all interpendent. Where an instrument landing system is available the touch-down point is normally further from the approach end of the runway and the planes pass over the units at a higher altitude.

Figure 2 shows how the lights appear on a proper approach. Pilots can soon learn to look for this characteristic pattern.

Figure 3 was taken from an airplane high and to the left. This illustrates how the left side of the pattern breaks up into an echelon of parallel lines, indicating that the observer is above the plane in which the left side units lie.

Figure 4 was taken from an airplane low and to the left. Here the observer is in the same plane as the left units, but is below the plane containing the units on the right side of the approach.

Figure 5 shows a close-up view of one of the linear light units used.

EQUIPMENT AND INSTALLATION

The basic requirements of the slope-line approach light system are linear light sources which can be set in the geometric pattern to define the two planes which intersect on the path to be marked, and light sources of high enough intensity to be seen under the conditions and from the distances required.

Under visibility conditions of one mile, the intensity requirements are moderate for night use. Under these conditions a light of 300 candles can be seen from 1-1/2 miles distance, and tubular light sources with parabolic reflectors are available with this order of brightness. Under 3/4-mile visibility this light can be seen from approximately 1-1/4 miles and under 1/2-mile visibility from about 3/4 miles. Under daytime conditions, however, these distances are materially reduced.

The characteristic pattern of this method of lighting is not dependent on color, either for identification or for interpretation, so that it is practical to use the red color agreed on for low intensity approaches in the tentative international agreement by the International Civil Aviation Organization. At the same time it should be pointed out that if these lights are to be used in daylight, the greater brightness available in green light sources can be made available.

As a result of earlier experiments with high current low voltage cold cathode tubes, used for two-color boundary lights and described in a previous report,[2] it was decided to use these lights for the experimental installation. Single lengths, approximately six feet long, were installed in the four positions nearest the runway, and double length units were installed at the outermost pair of positions.

This experimental installation was so connected to the runway lighting system, through a transformer and contactor, that the slope-line lights come on with the runway lights. This is shown in Figure 6. In the first experiment all of the lights were supplied with green tubes of 1300 candlepower facing the approach. Pilot reaction indicated that these were too bright. The green tubes were then replaced by red tubes of only 360 candlepower maximum. The pilots reported that the red tubes were much more satisfactory than the green ones.

By increasing the spacing and extending the stub approach light system out to 600 feet in length it is possible to give a pilot a more sensitive tool than the 300-foot system, although 300 feet has been found satisfactory.

[2] M. S. Gilbert, "A Low Cost Boundary Lighting System for Small Airports," T.D. Report No. 53, December, 1946.

OPERATING DATA

The experimental red lamp, which draws approximately 500 milliamperes at 375 volts, consumes approximately 160 watts. The entire system, as installed at Indianapolis, uses 1.28 KWH per hour. At three cents per KWH the energy charges for an average system would be about 3.84 cents per hour of operation. Lamp life of neon tubes in general averages better than 10,000 hours.

APPLICATION

Stub approaches using this configuration are applicable for runway ends on all non-instrument landing runways, and can also be applied to strip landing areas where no runway lights are available.

In this latter case it would be necessary to supplement the stub approach with a range light at the far end of the landing strip, to give the pilot visual guidance after he had passed the approach. For this purpose a red horizontal linear light is suggested. This should be restricted by means of vertical louvers to restrict the visibility to the one approach area.

The 200-foot spacing is recommended for all installations where ground is available, but this spacing can be reduced where necessary, without affecting the characteristic appearance.

The angle used in the experimental installation is 30 degrees from the horizontal. This angle can be varied from 30 degrees to 60 degrees, but the optimum sensitivity is produced by an angle of 45 degrees. If the ground falls off, the lights can be set to compensate for the varying levels.

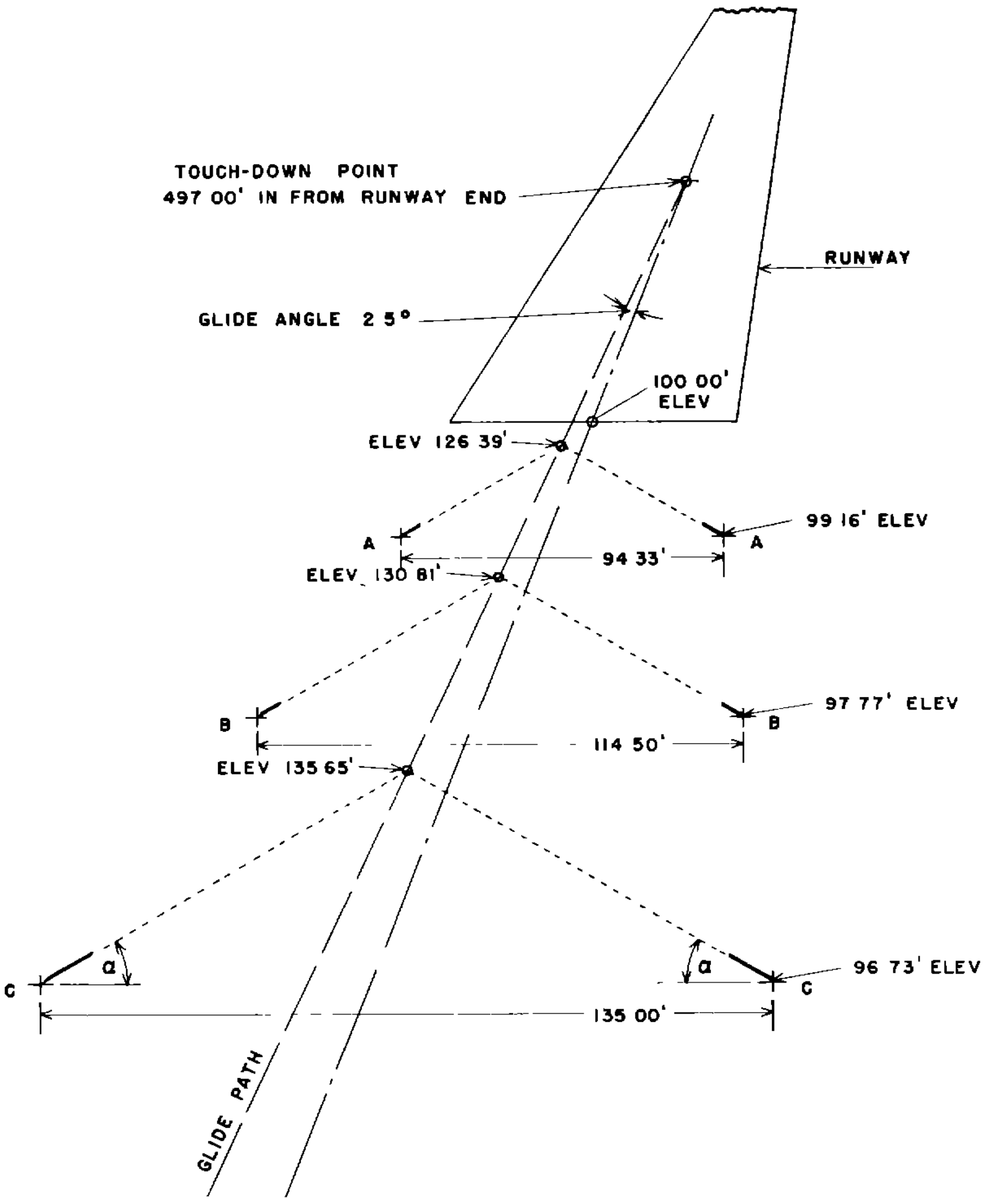
CONCLUSION

Flight tests of the stub approach system have demonstrated that it gives much more effective guidance than the standard range lights.

The visibility is much better than that of range lights, and the improvement becomes more marked under poorer weather, as the pilot is not dependent on seeing the remote range lights, a mile farther away.

The guidance given includes not only lateral guidance, but information on height and let down angle as well, which is not given by standard range lights.

The use of stub slope-line approaches will give the pilot experience on using this method of guidance, and will increase his confidence with experience.



STUB APPROACH SLOPE-LINE LIGHTS
A & B - SINGLE LENGTH UNITS
C - DOUBLE LENGTH UNITS
$a = 30 0°$

FIGURE I DIAGRAM SHOWING RELATIONSHIP BETWEEN GLIDE PATH, SLOPE-LINE LIGHT POSITION AND TOUCH-DOWN POINT

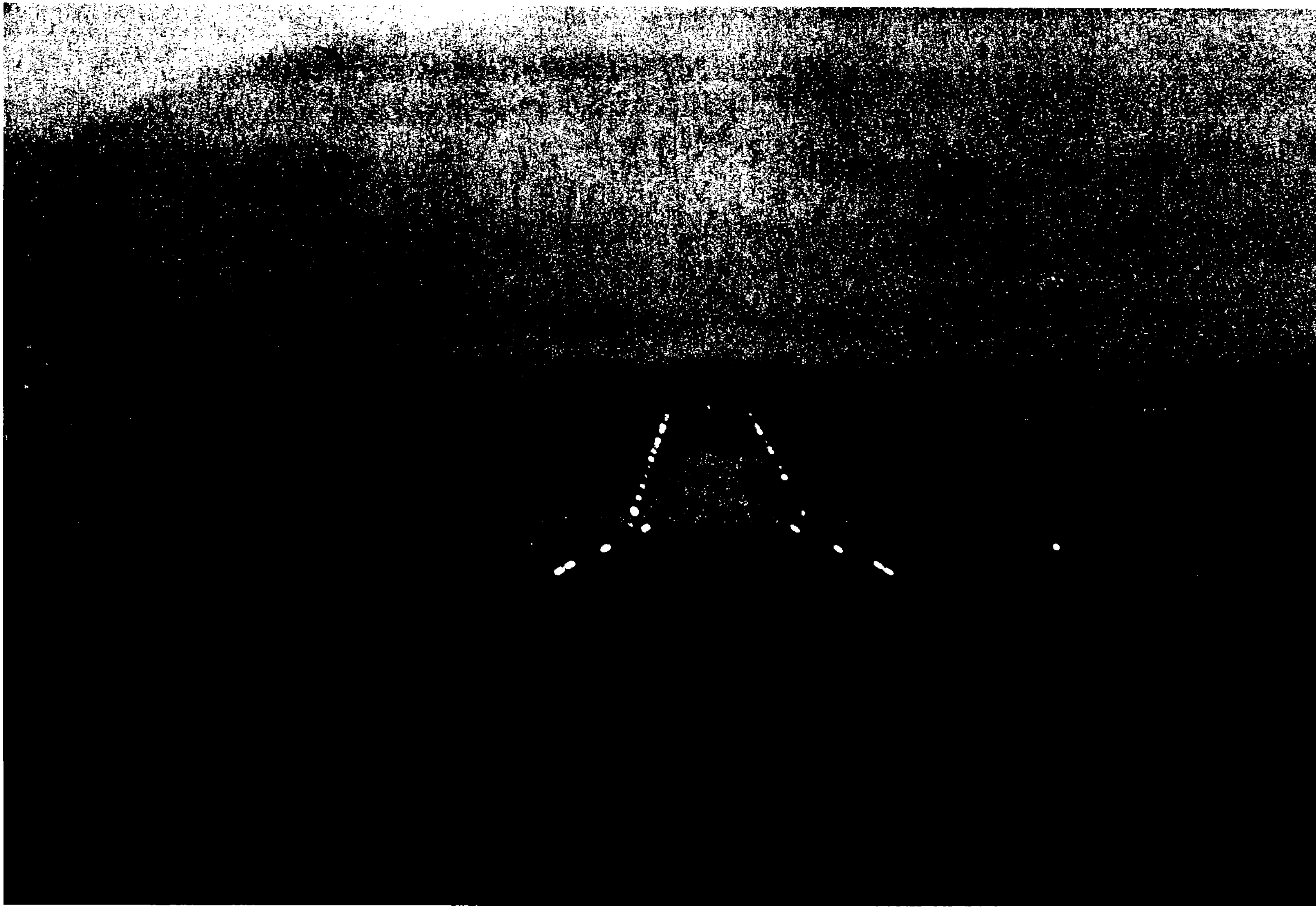


FIGURE 2. DRYPHOTO REPRODUCTION OF AN UNRETOUCHED AERIAL PHOTOGRAPH OF STUB APPROACH AND RUNWAY LIGHTS, AIRPLANE ON PROPER GLIDE PATH.
DATE: APRIL 22, 1948. TIME: 7:00 PM
WEATHER CONDITIONS: HIGH, THIN, SCATTERED CLOUDS, VISIBILITY 20 MILES, WIND 10-15 MILES PER HOUR EAST.

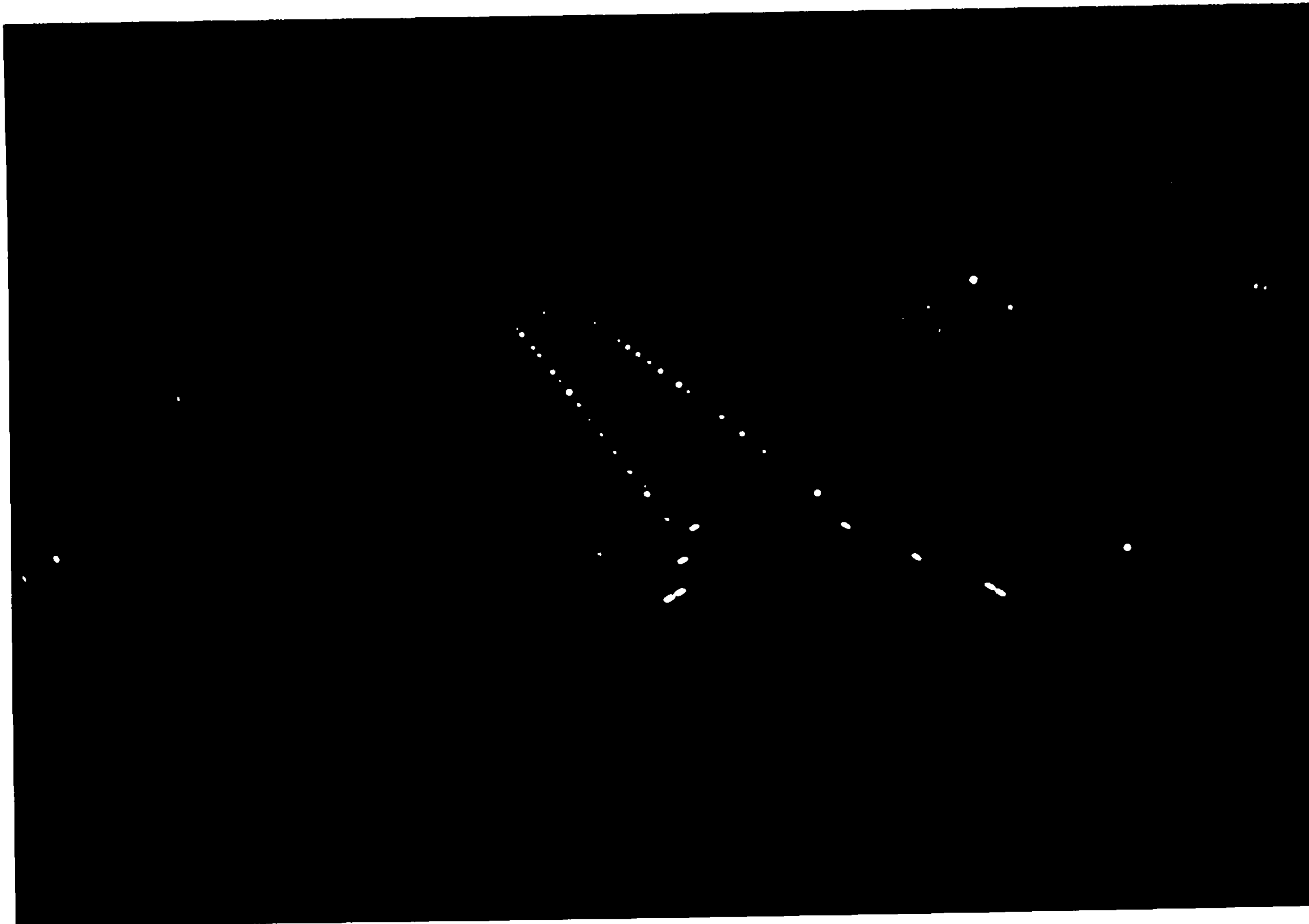


FIGURE 3. DRYPHOTO REPRODUCTION OF AN UNRETOUCHED AERIAL PHOTOGRAPH OF STUB APPROACH AND RUNWAY LIGHTS, AIRPLANE ABOVE AND TO THE LEFT OF PROPER GLIDE PATH.
DATE: APRIL 22, 1948. TIME: 7:05 PM
WEATHER CONDITIONS: HIGH, THIN, SCATTERED CLOUDS, VISIBILITY 20 MILES, WIND 10-15 MILES PER HOUR EAST.

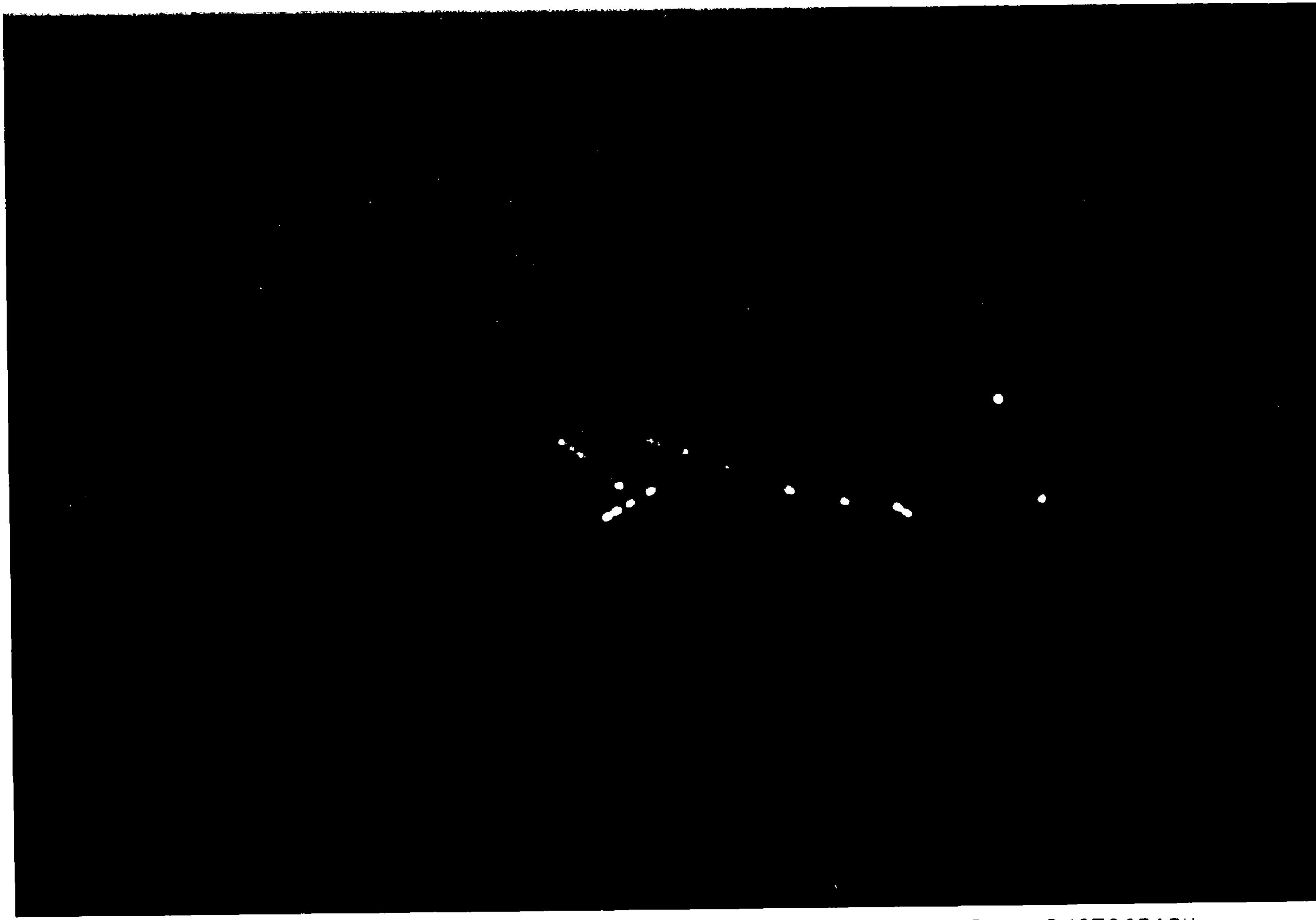


FIGURE 4. DRYPHOTO REPRODUCTION OF AN UNRETOUCHED AERIAL PHOTOGRAPH OF STUB APPROACH AND RUNWAY LIGHTS, AIRPLANE BELOW AND TO THE LEFT OF PROPER GLIDE PATH.
DATE: APRIL 22, 1948. TIME: 7:10 PM
WEATHER CONDITIONS: HIGH, THIN, SCATTERED CLOUDS, VISIBILITY 20 MILES, WIND 10-15 MILES PER HOUR EAST.

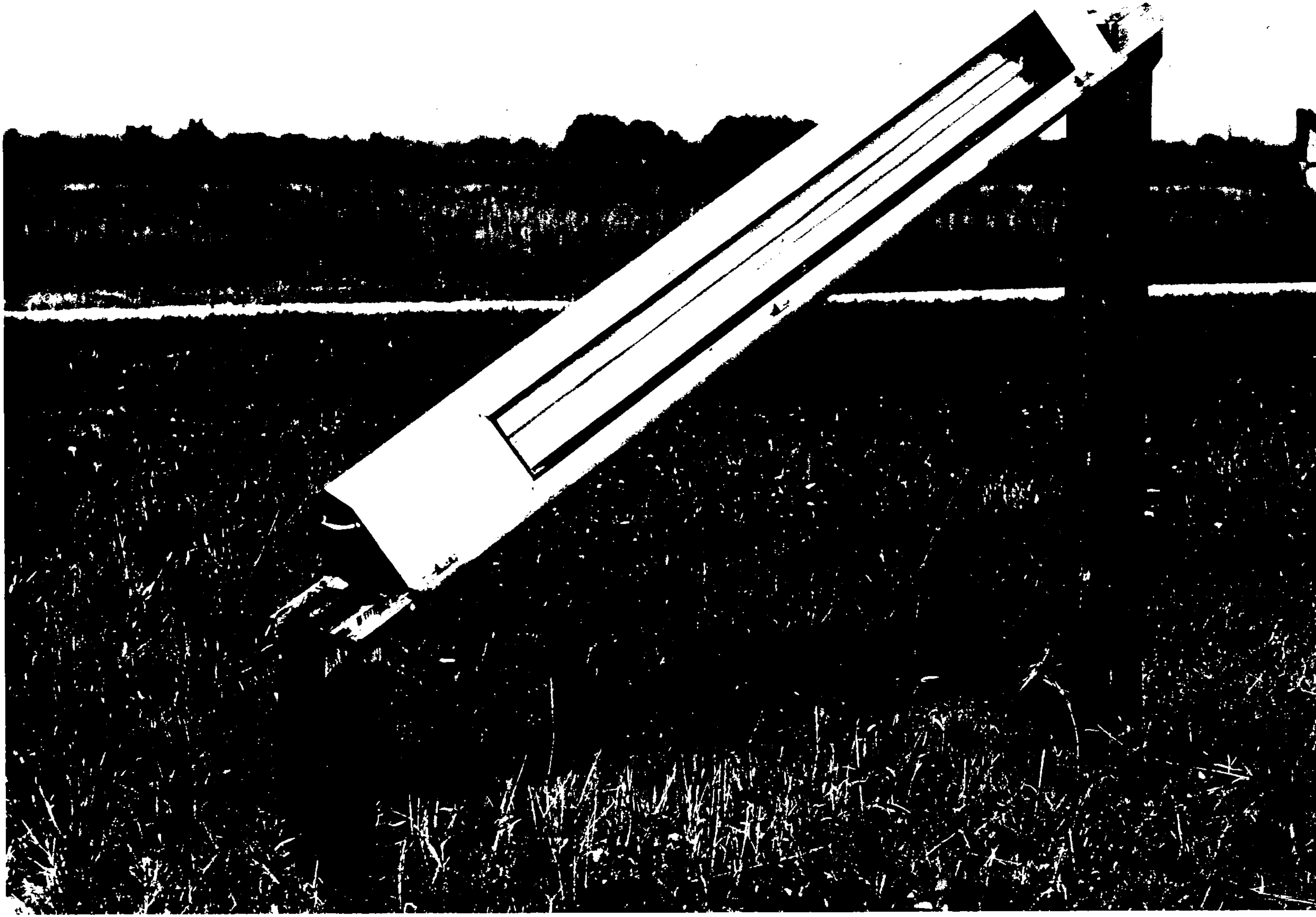
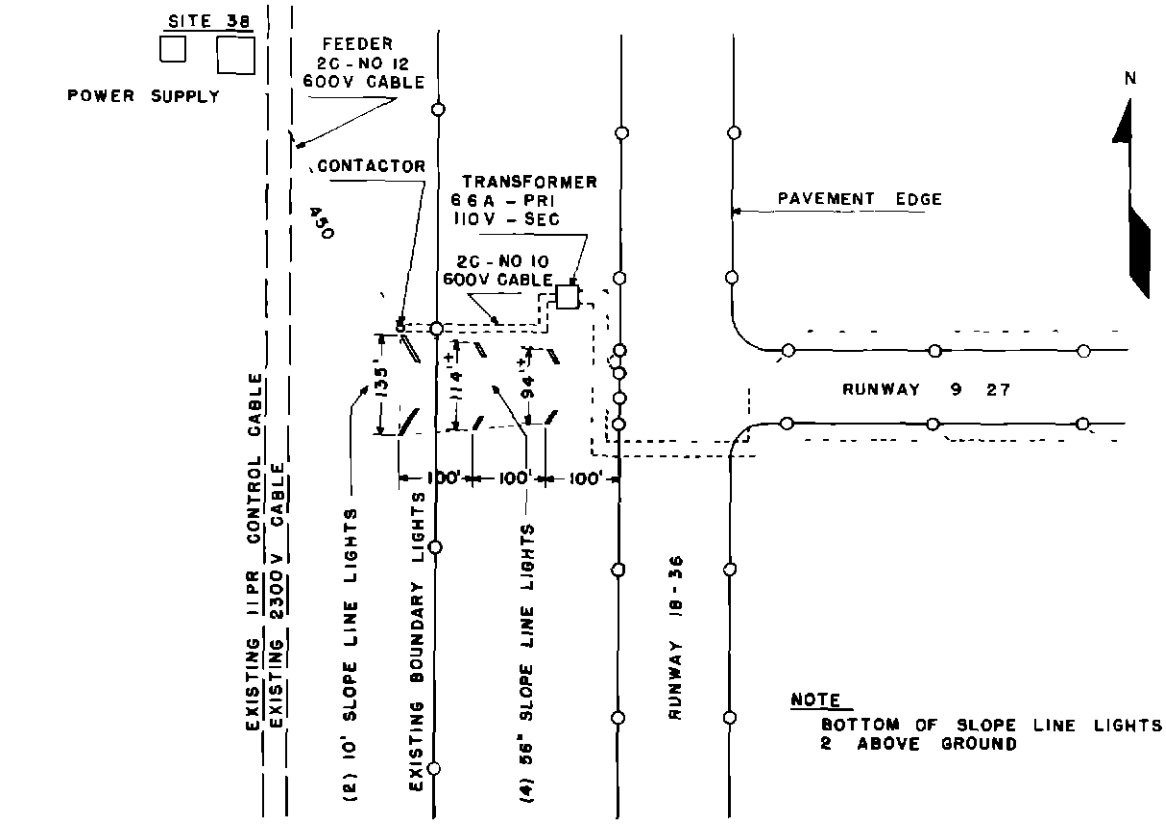
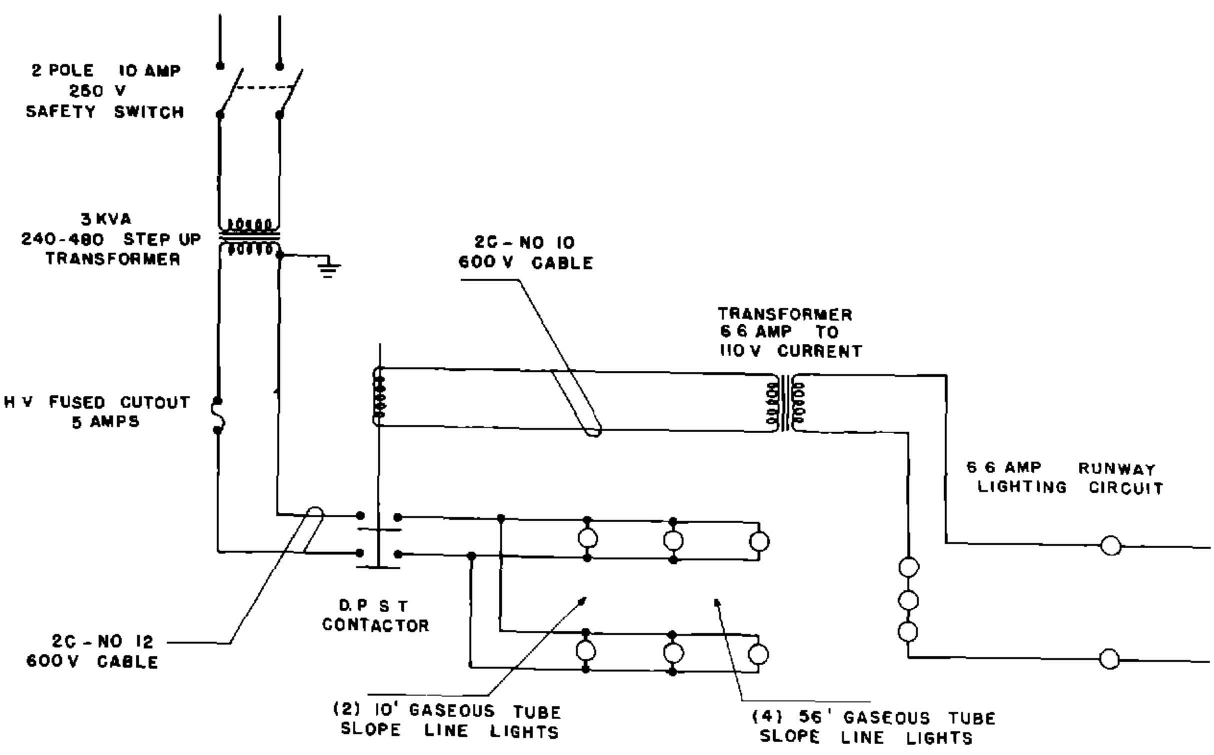


FIGURE 5. GROUND VIEW OF STUB APPROACH LIGHT



PLAN VIEW



WIRING DIAGRAM

FIGURE 6 LAYOUT AND WIRING DIAGRAM OF EXPERIMENTAL STUB APPROACH LIGHT SYSTEM