NATIONAL BUREAU OF STANDARDS REPORT

5902

AN APPROACH-BEACON SYSTEM

By
Visual Landing Aids Field Laboratory
Photometry and Colorimetry Section
Optics and Metrology Division

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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NATIONAL BUREAU OF STANDARDS

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An Approach-Beacon System

ABSTRACT

A relatively simple, low-cost method of providing improved visual guidance is needed for the approaches to airfields. This guidance is especially needed for circling or radio-range approaches in marginal atmospheric conditions. The approach-beacon systems discussed in this report can provide guidances through 360 degrees of azimuth. The approach beacons consist of continuously burning incandescent lamps which are rotated about a vertical axis to give the appearance of a flashing light. Two beacons located on the extended centerline of the runway provide useful guidance for straight-in and instrument approaches, as well as circling approaches, in visibilities as low as one mile. These beacons also provide good approach and runway identification. The optimum flash rate is approximately 72 flashes per minute, for which the optimum flash duration is from 0.3 to 0.4 second.

1. INTRODUCTION

1.1 Purpose of the System

It has been shown that under low-sun or twilight conditions the distance at which a runway can be seen may be much less than the reported visibility[1/]. At the same time the brightness of the background is often so high that the present runway or approach lights cannot be seen unless the pilot is within the main beam of these lights. In addition, during periods of darkness when there are moderate restrictions to visibility, the intensity settings of the approach- and runway-light systems must be low to prevent excessive glare when the pilot is in the main beam of the lights. This reduction in intensity may reduce the intensity of the light directed away from the runway to a value too low to be useful in circling or off-axis approaches. Thus the pilot may not locate the runway in time to make the required corrections. These considerations indicate a need for marking the approach of the runway so that it can be located and identified from distances at least as great as the reported visibility from the time the pilot is abreast of the system on the downwind leg of the approach until he lines up with the runway. Such a system would also be useful for instrument approaches where a high-intensity approach-light system is not available.

1.2 Historical Background

The National Bureau of Standards proposed in 1947 the installation of two or three approach beacons along the extended centerline of the runway at distances of 1000 to 5000 feet from the threshold as an approach aid. The beacons were to have a horizontal coverage of at least 180 degrees and a flash repetition rate sufficiently rapid to provide adequate guidance. Following this, using design data supplied by the National Bureau of Standards, the Naval Air Test Center constructed and flight tested experimental approach beacons.[2/] Their tests indicated that the concept was a useful one. The approach beacons were then sent to the Landing Aids Experiment Station for further development, but the station was closed before this work was completed. With the establishment of the Visual Landing Aids Field Laboratory, development of the system was continued. To simplify the evaluation of the approach beacons, the development was carried out in two phases. The preferred flash characteristics were determined from tests in low visibility conditions by observers on the ground and the preferred arrangement of the beacons and operational requirements were determined from flight tests of an installation.

2. DEVELOPMENT OF THE APPROACH-BEACON UNIT

2.1 Ground Test Installation and Procedure

Field tests were made by observers on the ground to determine the preferred flash frequency and flash duration, the effective intensity and visual range, and the glare effects of the approach beacon. Since these characteristics are interrelated and depend upon the atmospheric conditions and upon background brightness, the tests were made by observing many possible beacon combinations in operation in restricted visibility conditions.

A prototype beacon was installed at the visibility test site (figure 1) which was located 500 feet beyond the northwest end of the taxiway paralleling runway 13-31. The taxiway provided a test range for observations from 300 to 6300 feet. A beacon base with seven slip rings was used to energize the lamps and provided five control circuits. This beacon base rotated a turntable at 12 revolutions per minute about a vertical axis. Twelve equally spaced lampholders were mounted on the turntable. Relays were mounted on the turntable to energize 1, 2, 3, 4, 6, or 12 lamps as desired. Each set of selected lamps was uniformly spaced.

The observer moved along the taxiway in a two-way-radio-equipped vehicle and reported his observations to the recorder-controller. The observer reported the ranges at which he first noted glow (at night only), the regularly transmitted light, the useful light, glare, and dazzle. He also observed the prevailing visibility, light or object, and made qualitative comments pertinent to his observations. The recorder-controller recorded the observations, comments, time, and the test and selected the number of lamps to be energized. In addition to the observed visibility periodically obtained by the observer, visibility measurements were obtained from four transmissometers located at intervals near the test range. The transmissometers continuously recorded the transmission from which the indicated visibilities were determined.

2.2 Flash Frequency

The tests at the Naval Air Test Center[2/] indicated that 60 and 120 flashes per minute for these beacons provided useful guidance to pilots, but the most effective flash frequency was not determined. To make this determination, observations were made using several flash durations. The observer indicated qualitatively his reaction to the flash frequency being tested.

The results indicated that the preferred flash frequencies were from 48 to 144 flashes per minute. The 144 flashes-per-minute rate was suitable only for the very short flash durations and then this rate was considered too fast, although better than the 72 flashes-per-minute rate. For lamps with more desirable flash durations, the 72 flashes-per-minute rate was preferred.

A few observations were made when one lamp of the selected group of lamps was not lighted, or the energized lamps were not equally spaced. Such irregularities can help to attract attention, especially at the faster flash rates or for longer flash durations, but were distracting, especially when the light was brighter. Since the regular flashes seemed to provide adequate identification and attraction, a non-uniform rate was considered unnecessary, although a single burned-out lamp in a beacon would not be particularly objectionable.

2.3 Flash Duration

The flash duration, as well as the flash frequency, is an important factor of the effectiveness of a flashing light.[3/] Since the turntable was rotated at a constant speed, the duration of the flash was determined by the horizontal beamspread of the lamps. The preferred flash duration was dependent upon the flash frequency. The position of the light was easier to find and keep located when the flash duration was about equal to the "off" time. A rapid change of intensity at the beginning and end of the flash was preferred. When the flash was well above threshold, it was not necessary for the intensity during the "off" part of the cycle to be below threshold. Some visible light from the beacon during the "off" time made the position of the beacon easier to keep located. With the preferred flash frequency of 72 flashes per minute, a flash duration of from 0.3 to 0.4 second appeared optimum, but durations of from 0.2 to 0.5 second were acceptable. An intensity during the "off" time of 5 to 20 percent of the effective intensity of the flash may be desirable.

2.4 Effective Intensity and Visual Range

The effective intensity and visual range of the beacons using two types of lamps were determined.[4/] The method of determining the effective intensity and visual range consisted of the observer finding the visual range of the beacon and having the recorder-controller adjust the current of a comparison lamp to an intensity that provided an equal visual range. The visibility was observed periodically and the indicated visibility was computed from the transmissometer reading for the time of the effective intensity observation.

The average effective intensities of the approach beacon were (1) 30,000 candles for daytime and 22,000 candles for nighttime when the type 400PAR lamps were used, and (2) 18,000 candles for daytime and 13,000 candles for nighttime when the type 300PAR56/NSP lamps were used.

The visual range of the approach beacon using type 400PAR or type 300PAR56/NSP lamps was approximately twice the observed or indicated visibility for visibilities between 500 and 3000 feet. The visual range for a given visibility was about 10 percent greater for the beacon with type 400PAR lamps than with type 300PAR56/NSP lamps. The visual range of the beacon appeared to be independent of the flash frequency.

2.5 Glare

To be effective the beacon must provide adequate intensity to be seen by the pilot at distances sufficient to permit making corrections necessary for aligning the aircraft with the runway. The intensity required for some atmospheric conditions may be so great that excessive glare is produced in clearer weather or as the pilot nears the beacon. To determine when glare could be expected, the observer, while driving a vehicle toward the beacon, reported the ranges at which he considered the beacon to become glaring and blinding. These observations gave the following results. For daytime conditions, glare, often considered objectionable, was not considered blinding. The glare range was normally about one-half or less of the observed visibility, and objectionable glare, if reported, was about one-fourth the observed visibility. For nighttime conditions the glare range averaged about two-thirds of the observed visibility and the ratio varied considerably. The range at which glare became objectionable averaged about one-half of the observed visibility and the dazzle range was about one-third of the observed visibility. The effects of reduced intensity on glare will be discussed in paragraph 3.5.

The glare from a flashing light was found less objectionable than was expected from the effective intensity of the flash. The observations indicated that the effect of glare was reduced when other light sources were visible in the vicinity of the light during the darker part of the flash cycle. The increased glare of flashing lights when other appreciable illumination was absent was markedly demonstrated by observations of a condenser-discharge light and the approach beacon. When the condenser-discharge light and the approach beacon were operating simultaneously, the effect of glare was less noticeable for the condenser-discharge light than for the beacon (as would be expected from the effective intensity of the two lights), but, when each light was operated independently with no other lights in the area, the effect of glare from the beacon was not changed appreciably but the glare of the condenser-discharge light was then much greater than that of either light when the two lights were operating simultaneously. The stray light from the lamps used in the approach beacon provided some illumination that was continuously visible when the viewing distance was short. Thus the glare of the main beams was reduced.

2.6 Comparisons of the Approach Beacon and a Condenser-Discharge Light

To determine the effectiveness of an approach beacon as a lighting unit, comparative observations were made of a condenser-discharge light and the test beacon in the same atmospheric conditions. The condenser-discharge light had a flash duration of 200 microseconds, and a flash frequency of 60 flashes per minute.[4/] This flash frequency was considered too slow and the flash duration too short for single units to be used as approach beacons. Although the peak instantaneous intensity of the flash of the condenser-discharge light was several million candles, the effective intensity was determined to be 5800 candles for nighttime and 15,000 candles for daytime.[4/] These effective intensities are considerably less than those of the approach beacons. Correspondingly, the visual range of the condenser-discharge light was 5 to 10 percent less than that of the beacon. The range of glow of the condenser-discharge light averaged 15 percent greater than that of the beacon. The relation between the visual range of the glow and the visual range of the light depended on several undetermined factors in addition to the background brightness and the transmittance. On dark nights (background brightness less than 0.001 footlambert) the visual range of the glow was at times only slightly greater than that of the light. At other times the visual range of the glow of the approach beacon was as much as 40 percent greater than the visual range of the beacon and the visual range of the glow of the condenser-discharge light was as much as twice the visual range of the light itself. At night the ratio of the visual range of glow to the visual range of the light averaged 1.2 for the beacon and 1.5 for the condenser-discharge light. During daylight the visual range of the glow was, of course, less than the visual range of the direct light from the unit.

3. DEVELOPING THE APPROACH-BEACON SYSTEM

After the basic requirements for the beacon had been established by ground observations, an approach-beacon system was installed for experimental flight testing. From these tests needed changes were made and the usefulness of the system was evaluated. The flight testing of these beacons was performed mostly by commercial airline pilots, business aircraft pilots, and private pilots, in their normal operations at the Arcata Airport. Comments of the pilots were recorded during the approach or immediately after landing, and comments were also obtained from interviews with pilots. A few observation flights were made by the Laboratory personnel. Maintenance information was obtained from records of servicing needed to keep the test installation operating satisfactorily.

One of the approach beacons which was constructed for the flight tests is shown in figure 2.

3.1 Location of the Beacons

The Naval Air Test Center indicated that the location of one beacon at 1000 feet and another at 2000 feet from the end of the runway and on the extended centerline was the most suitable of several arrangements tested.[2/] The chief advantages of locating the beacons on the extended centerline are more effective guidance for aligning the aircraft with the runway during final approach, and easier transition from the beacon guidance to the runway light or runway marking guidance. The major disadvantage of this location is that glare is more of a problem. The Arcata field test installation was made on the extended centerline of the runway as recommended by the Naval Air Test Center, with the intention of making changes to correct for any deficiencies found by flight test. No changes in location were suggested by the pilots. The test system was installed on the approach to runway 31, which also had a high-intensity slopeline approach-light system. Both systems could be energized simultaneously.

3.2 Spacing of the Beacons

The Naval Air Test Center report[2/] indicated that spacing the beacons at 1000-foot intervals from the runway threshold (figure 3) was very satisfactory. However, the use of other spacings and a different number of beacons was not thoroughly investigated. The test installation was made with the inner beacon 1000 feet and the outer beacon 2300 feet from the threshold. The outer beacon was located at this position in order to take advantage of an available 60-foot tower which was needed to put the beacon at runway level.

The pilots' comments indicated that this spacing was very satisfactory for guidance and alignment. However, spacing the beacons at equal intervals from the threshold seems preferable. Spacings at intervals of 1000 feet appear adequate for use in visibility conditions down to one mile, but closer spacing (perhaps 500 feet) may be desirable if the results of operational tests indicate lower operating minimums than one mile are practical. If the beacons are used for operations in visibilities of one mile or less, especially with aircraft with higher approach speeds, extension of the system to 3000 feet by installing one or more additional beacons may be necessary.

Reports from other airports, especially airports where the surrounding areas are congested, have indicated a need for a visual aid at distances of 1 to 5 miles or more from the threshold for identification, guidance, and alignment at an early stage of the approach. Although these distances are beyond those normally considered for approach lighting, beacons similar to the approach beacons should be suitable for this purpose. Such beacons should be coded to prevent confusion with the approach-beacon system.

3.3 Elevation for Mounting the Beacons

The test beacons were installed on stands that put the lights at the same elevation as the threshold of the runway. Some of the pilots reported that alignment on the approach would be easier if the beacons were at a higher elevation, but installation at any elevation above the runway would be a potential hazard. Maintenance would be easier if the beacons were mounted at or near ground level. Preferably the lights should be mounted at the runway threshold elevation, but if this is not feasible, they should be installed in a plane which shall not exceed plus two percent or minus one percent from the horizontal plane as required by AGA-NS1a "National Standard for Approach Lighting at Land Aerodromes."[5]

3.4 Selection of the Type of Lamp

Since the approach-beacon system is intended for use in restricted VFR as well as IFR conditions, the beamspread should be such that the lamps provide suitable intensity through wide vertical coverage and provide the required flash duration. For present VFR and radio-range minimums, the lamps in the approach beacons should have a minimum effective intensity of about 15,000 candles at all elevations from near horizontal to an altitude of 1000 feet at one mile. This requires a vertical beam spread of approximately 12 degrees. The specifications for the type 399PAR lamps, Navy stock No. R17-L-6920, require a minimum intensity of 16,000 candles for a vertical beamspread of 10 degrees, and a horizontal beam spread of 30 degrees. With proper aiming, these lamps provide the required vertical coverage except in a region below the minimum glide-slope angle. As the turntable speed is 12 revolutions per minute, these lamps provide a flash duration of 0.5 second and a peak effective intensity of about 20,000 candles, with an effective intensity of about 12,000 candles at 5 degrees above or below the peak. Therefore, lights of this type were included in the test installation. Pilots' reports indicated that these lamps provided the necessary intensity and coverage except for conditions of very low ceilings and visibilities for which use of the beacons was not intended and is not practical.

Type 300PAR56/NSP lamps were also used. This type lamp has higher peak instantaneous intensity and a somewhat narrower vertical beamspread than the type 399PAR lamps. The pilots reported that there was little noticeable difference in the performance of the two types of lamps viewed from a position near the axes of the lamps, but that the type 300PAR56/NSP lamps were less effective for high approaches, especially those involving lower ceilings.

3.5 Intensity Control

Tests by observers on the ground and early pilots' reports indicated that there were conditions at night when the approach guidance could be useful. However the beacons would be too bright if they were operated at full intensity during the final approach. Therefore a lower intensity step was needed. A simple two-step intensity control was tried. The low-intensity step was approximately 15 percent of the intensity at rated voltage and was regarded as satisfactory. Some comments indicated that still lower intensity might be preferred. To provide this low-intensity setting, special autotransformer-contactor units for energizing the beacons and controlling the intensity have been procured, with low-intensity taps for 50, 60, and 75 volts. These voltages provide low-intensity settings at 5, 10, or 20 percent of full intensity. The procedure and conditions for use of intensity control are explained in Appendix B, Use and Operation of Approach Beacons.

3.6 Summary of Pilots' Comments

The flight testing provided enough information for design and indicated the usefulness and limitations of the system. The pilots' reactions are summarized briefly here and representative pertinent comments are quoted in Appendix C. Most reports gave an evaluation of the system as a whole and not of the individual components of the system. Most pilots indicated that the test installation provided adequate guidance for approaches under most atmospheric conditions except for very low ceilings and visibilities. Many especially remarked on the guidance provided on the downwind leg and in directions where runway and other approach lights do not provide adequate intensity.

Without special flight testing, the visual range of the system could not be determined accurately, but the pilots' reports indicated the useful range. Reports were received that the beacons provided useful information in VFR conditions with visibilities of 7 to 10 miles at distances greater than 8 miles in daytime and 12 miles at

but generally were visible at distances suitable to provide useful guidance. During many of the more restricted nighttime conditions (visibility 3 miles or less) approaches were made with the beacons on high intensity without complaints from the pilots. There were no reports of the glare being bothersome when the beacons were operated on low intensity even on very clear, dark nights, but some pilots did express a preference for a lower intensity. For clearer nighttime conditions some pilots suggested using the beacons on high intensity for identification, off-axis guidance, and early alignment, and then switching to low intensity after the pilot has the runway lights in sight. (Of course, where traffic is heavy, the beacons can be operated only on low intensity during clearer nighttime conditions in order to avoid glare to pilots on final approach.)

The usefulness of the beacons was best indicated by the number of requests for installations elsewhere or by the use of the beacons by pilots for special purposes. There were numerous requests for beacon installations to be made on the approach to runway 13 or to other approaches and at other intermediate-type airports. Several pilots requested the operation of the test beacons for approaches to runway 13 (not runway 31) at night in fairly clear conditions. Although this type of operation indicated the usefulness of the beacons, it also indicated a potential hazard because of the possibility of landing beyond the beacons in the wrong direction. If stations find that wrong-way landings may occur, this hazard can be eliminated easily by shielding the beacons through perhaps 30 degrees on the back side without seriously affecting the identification and off-axis guidance of the system. Some pilots wanted the beacons operating for takeoffs because the beacons were useful in keeping the field located and helped on making the climb-out pattern.

3.7 Maintenance and Servicing

The test installation of approach beacons has been in operation for four years. Little routine maintenance has been needed during this period. Most of the non-routine maintenance was caused by temporary test installations and should be eliminated by a permanent installation made according to the instructions in Appendix A. Routine maintenance consisted primarily of replacement of burned-out lamps, checking of lamp alignment, lubrication of the drive mechanism, and painting of stands and equipment. One or two lamps broke in service. About 40 percent of the green filters used on the threshold lights broke during a period of 2 1/2 years.

3.8 Threshold Lights

Pilots' comments and previous experience indicated that the existing runway threshold lights and markings did not provide the needed threshold information during the approach. In some daytime conditions the runway or threshold markings were very difficult to detect until the distance was short, and in some nighttime conditions, usually involving low ceilings and good visibility below the ceiling, the runway lights were operated at low intensity although a higher intensity is needed for the threshold lights. The use of additional threshold lights as part of the approach-beacon system was indicated.

Single, very-high-intensity threshold lights installed 100 feet from the centerline on each side of the runway did not contribute much guidance to the system. Therefore, a number of lights were installed in a row on each side of the threshold to form threshold wing bars (see figure 3). (These lights consisted of type 399PAR lamps with aviation green filters.) The test installation had five lights on each side spaced at 5-foot intervals with the middle light approximately in line with the edge-marking runway lights. Intensity control similar to that of the beacons was used on these lights. The pilots reported that these lights were a very desirable improvement for the system and provided useful information as far out as 3 miles in daytime and 5 miles at night. Later, five more threshold lights were added to each side as part of the runway-light circuits. Each of these systems appears adequate. Glare from the beacon threshold lights, as differentiated from that from the beacons, was never reported as being excessive. Insufficient test information was obtained to determine if special threshold lights will be required as part of each approach-beacon installation. Operational testing may show that special threshold lights are necessary only when the existing threshold lighting consists of low- or medium-intensity runway lights or of a limited number of high-intensity runway lights.

3.9 Stub Approach Beacon

Many airfields report that the terrain of the approach zone is such that a standard approach-beacon installation is not practical. A stub approach-beacon system was installed for testing to try to provide some visual approach aid for such approaches. The stub system consisted of a single beacon and the threshold wing bars. The first installation was made on the approach to runway 13 where a 180-foot bluff prevented placing the beacon further than 500 feet from the runway threshold. This beacon was then located within 80 feet of the

Instrument Landing System (ILS) localizer antenna. The beacon at this location affected the signal from the localizer and had to be removed. Then the stub beacon system was installed on the approach to runway 31 at 500 feet from the threshold. Pilots' comments on the stub beacon system indicated that it was much less effective than the standard approach-beacon system. Because most comments were based on comparison with the standard beacon installation or with the slopeline approach lights, the effectiveness of the stub beacon system was not adequately evaluated. Since the stub beacon provides identification of the approach and runway throughout a circling approach, it may be useful for some approaches even if there is little alignment information. Operational testing of the effectiveness of a stub approach-beacon system is needed.

4. CONCLUSIONS

An approach-beacon system consisting of two beacons located on the extended centerline of the runway at 1000 and 2000 feet from the runway threshold provides the visual guidance needed for approaches in restricted VFR conditions and in many IFR conditions. This system provides excellent approach and runway identification. It provides the visual guidance required for circling and radio-range approaches and, except in very restricted atmospheric conditions, furnishes adequate guidance for straight-in or other type approaches. The system does not provide all the visual guidance needed for GCA and ILS approaches under minimum conditions (ceilings, 200 feet or less; visibility 1/2 mile or less). However, these beacons would be a valuable visual aid for precision instrument approaches where high-intensity approach lights are not installed. The "saves" of aircraft reported in section 3.6 indicate that the approach beacons would also be a useful addition to a high-intensity approach-light system for the approaches made without the use of a precision electronic aid. The approach-beacon system, when provided with intensity control, is effective for both daytime and nighttime conditions.

The approach-beacon system is a relatively low-cost installation which it may be practical to install on several approaches to an airfield. These beacons may also be suitable for uses on approaches to seadromes.

The system is sufficiently flexible to allow modifications to meet unusual conditions or special needs. Threshold wing bars should be installed where the runway-threshold lights are weak. The stub approach beacon can provide some useful information where installation of a standard system is not feasible. A third beacon should be installed 3000 feet from the threshold if earlier guidance on final approach is needed.

5. RECOMMENDATIONS

5.1 Installation
(See Appendix A for detailed instructions.)

1. Install the beacons on the approach to any runway where additional visual guidance is needed. For a given airport, the installation may be completed in stages according to need in a manner similar to the following criteria. First, install the beacons on the approach most used in restricted conditions unless a suitable high-intensity approach-light system is provided. (If a high-intensity approach-light system is installed later, the units of this approach-beacon system may be used in the second or succeeding stages.) Second, or first, if suitable high-intensity approach lights are provided, install the beacons on the approach that most satisfactorily complements the first approach. Continue to install beacon systems on approaches as the need is justified by the number of approaches. At many airports an approach-beacon system for each approach direction may be justified.

2. Install a stub approach beacon with threshold lights on approaches where terrain features make installing a complete system impractical if the need for this limited information is worthwhile.

3. Install additional threshold lights as part of the beacon system wherever additional threshold information is needed. Consider the use of additional threshold lights when the runway-light installation consists of low- or medium-intensity lights or if less than eight high-intensity lights are used in the runway threshold.

4. Consider approach beacons for use as approach lights to seadromes.

5.2 Operation
(See Appendix B for detailed instructions.)

1. Operate the beacons at any time that they may be of assistance to pilots; not when requested only. Pilots are likely to be unaware of the need for additional guidance, especially during daytime and twilight conditions.

2. Operate the beacons on high intensity when they are used in daytime and for all twilight conditions until glare becomes bothersome. DO NOT USE low intensity in daytime or twilight because the need for the beacons is questionable. If the need is questionable at these times, high intensity is required to provide any useful guidance. In general, use high intensity at any time that glare is not objectionable to pilots.

3. Operate the beacons on low intensity at night for standby and to reduce bothersome glare. For the more restricted conditions at night, the high intensity is needed to provide adequate guidance. For clear nights when air traffic will allow, the beacons may be operated on high intensity for early recognition and initial alignment until the runway lights are visible and then changed to low intensity at the pilot's request to avoid glare.

REFERENCES

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3. C. A. Douglas, Computation of the Effective Intensity of Flashing Lights, Ill. Eng. 52, 641 (1957).

4. NBS Report 5905, Determination of the Effective Intensity and the Visual Range of Flashing Lights in Restricted Visibility (August 1958).

5. AGA-NSla, National Standard for Approach Lighting at Land Aerodromes (August 4, 1953).

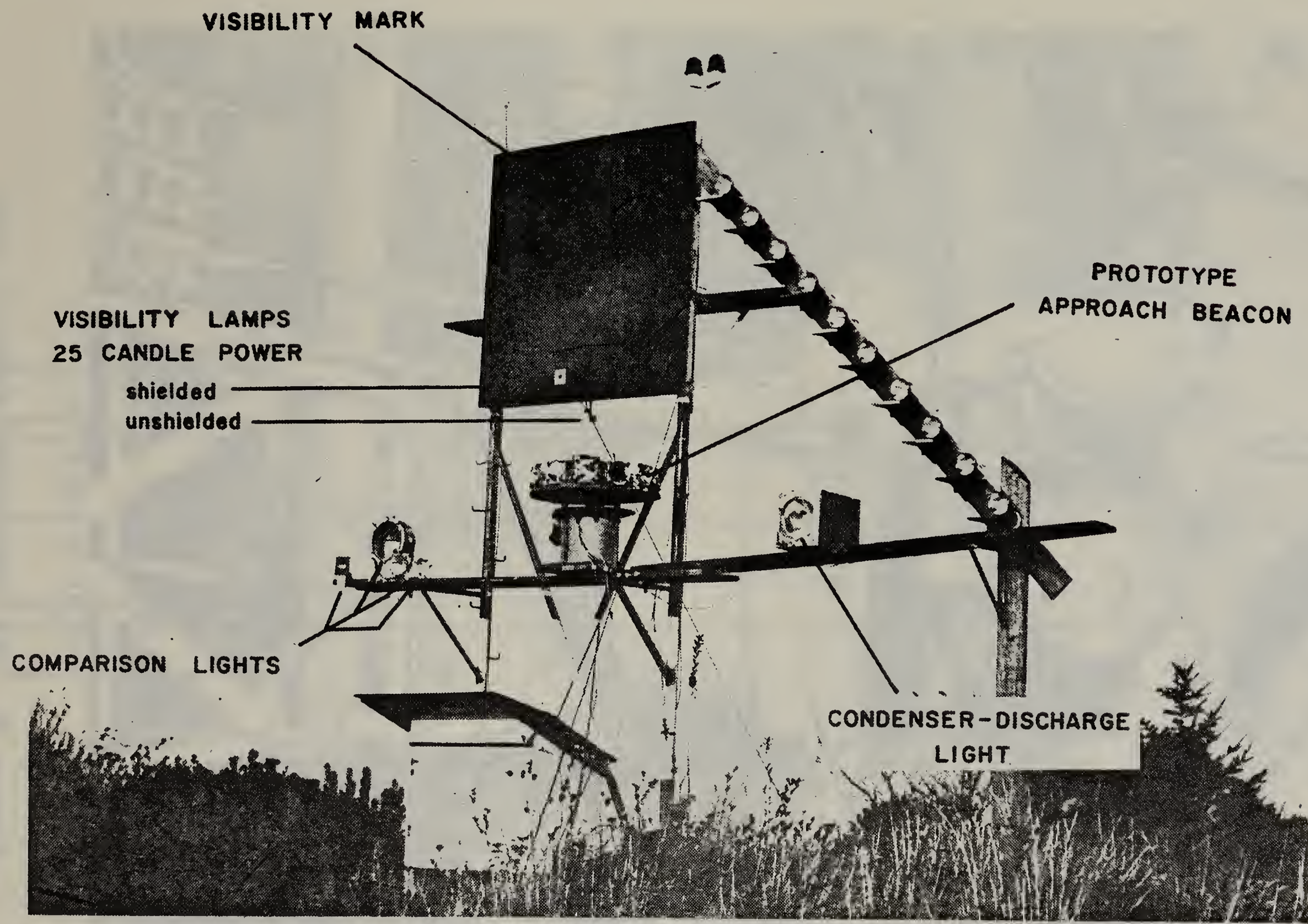

Figure I Visibility test site for tests of approach-beacon components by observers on ground

Figure 2 An approach-beacon unit

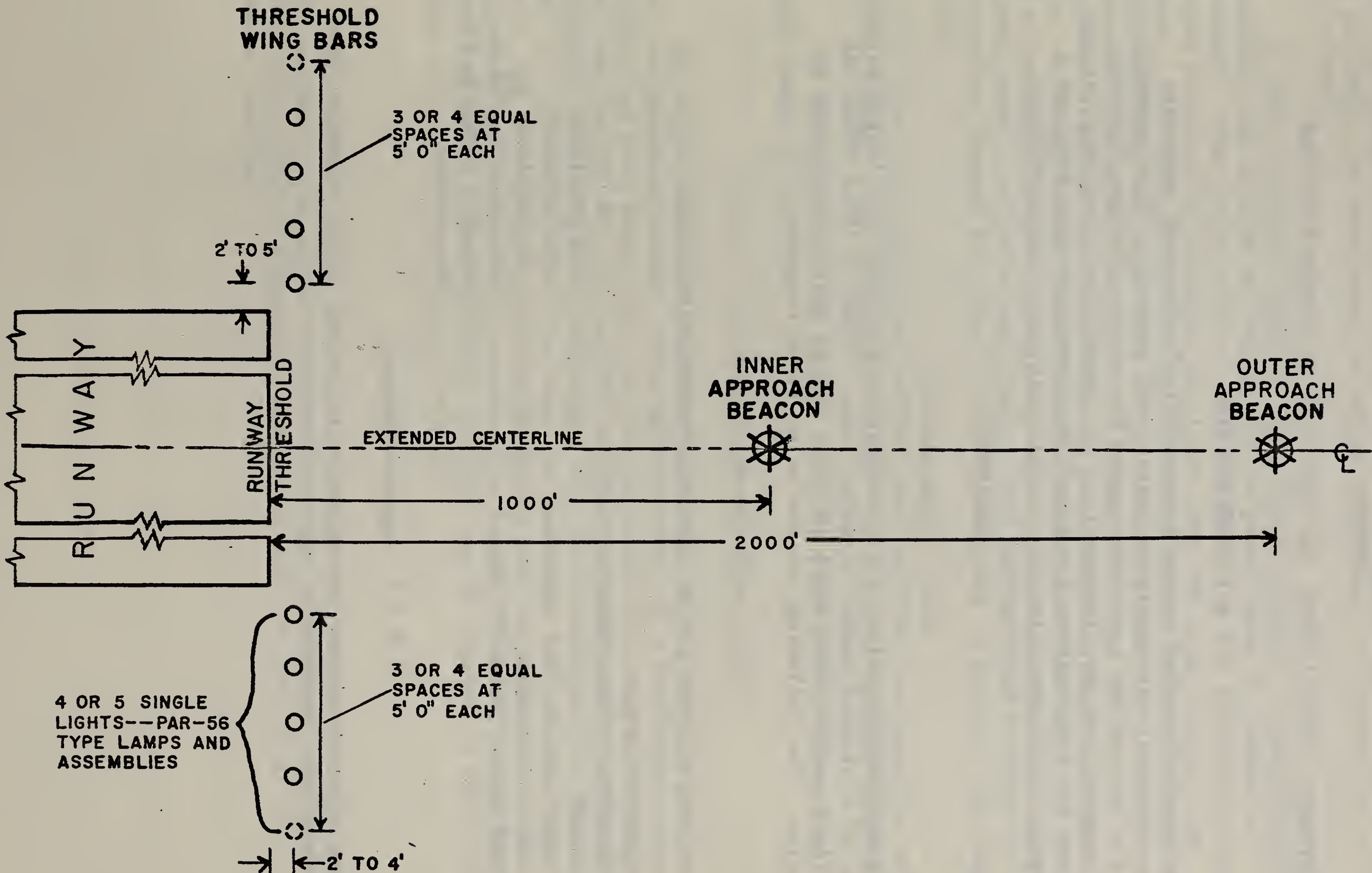

Figure 3 A standard approach-beacon installation with threshold wing bars.

APPENDIX A

EQUIPMENT, INSTALLATION, AND SERVICING OF APPROACH BEACONS

A.1 INTRODUCTION

The approach-beacon system is a relatively low-cost approach-light system and it is simple to install and maintain. This appendix contains a list of the equipment needed for an installation, and possible sources of supply; instructions for installing a standard system, as well as the instructions for installing threshold wing bars and a stub system; and instructions for normal maintenace and servicing.

A.2 EQUIPMENT

A.2.1 Requirements

The equipment required for a standard approach-beacon installation consists of a limited number of major items. Most of these items can be readily assembled from stock parts or may be easily fabricated at the station. The following are the major items required.

Table A-1

Major Items for an Approach-Beacon Installation

Approach beacon	2
Autotransformer-contactor unit	2
Stands	As required
Power circuits and equipment	As required
Control circuits	As required
Additional threshold lights	Not required, but a valuable addition to the system.

A.2.1.1 Approach Beacon

Each approach beacon (see figure A-1) is made up of a beacon base, a turntable, six lampholders, and six lamps.

a. The beacon base is a 12-rpm drive assembly similar to that used for airway beacons. The base for an airport beacon may be used by replacing the worm gears to obtain 12 instead of 6 revolutions per minute.

b. The turntable should be fabricated locally. A satisfactory turntable may be made of 1/4-inch-thick steel plate 24 inches in diameter. Make holes in this plate for mounting the turntable on the beacon base and for bringing the leads from the slip rings to the lamps. Also make six holes for 3/8-inch diameter bolts at 60-degree intervals near the outer edge of the plate for mounting the lampholders. Construct a weatherproof compartment over the wiring entrance from the base for enclosing and protecting the connections from the lamps to the leads from the beacon-base slip rings. A section of 6-inch pipe welded to the plate with a gasketed cover fastened by screws makes a suitable compartment. Use weatherproof bushings or connectors through the sides of the compartment to bring in the lamp leads.

c. The lampholders for PAR-56 lamps shall be the stock No. R6210-322-6617-D446, light assembly, PAR-56. (Old No. R17-MUEL-D-476-MU).

d. The lamps for the beacon shall be type 399PAR lamps, Navy stock number R17-L-6920.

A.2.1.2 Autotransformer-Contactor Unit

The autotransformer-contactor unit is a unit specially designed for the approach beacons. This unit consists of a 3-kilowatt autotransformer with input taps for 200, 220, and 240 volts and with output taps for 50, 60, 75, and 120 volts and a double-pole, double-throw contactor with a 120-volt actuating coil which connects the lamps to the 75- (60- or 50-) volt tap when the contactor coil is not energized or to the 120-volt tap when the contactor coil is energized. (When received, the contactor is connected to supply 75 volts to the lamps when the coil is not energized, but this may be changed to 60 or 50 volts if a lower intensity is needed.)

A.2.1.3 Stands

The beacons should be mounted at or near runway level. To put the beacons at the proper height, use stands as required (figure A-2). These stands may be fabricated locally to fit the terrain at the beacon location.

A.2.1.4 Power Circuits

The power required at each beacon site is 3 kilowatts, at 240 volts, 60 cycles, single phase. The equipment and cables for the power will be supplied by the station. A satisfactory circuit is shown in figure A-3. However, the arrangement may be modified as required. The cable may be installed by direct burial. Electrical duct is not required except under paved areas.

A.2.1.5 Control Circuits

The control circuits and equipment for energizing the remote-controlled oil switches and the intensity-control coils of the autotransformer-contactor units will be supplied by the base. The arrangement shown in figure A-4 is satisfactory. This arrangement requires two switches or circuit breakers on the lighting-control panels in both the control tower and the airfield-lighting vault and 120-volt, 60-cycle, control voltage controlled by the switches or circuit breakers on the lighting panel for energizing the oil switches and contactor coils. If approach lighting is installed on more than one approach, a type II airport-lighting-control panel is needed in order to prevent simultaneous lighting of more than one approach system.

A.2.2 Detailed List of Equipment

A detailed list of the equipment needed for the standard approach-beacon system is given in table A-2, page 23.

A.3 INSTALLATION

The installation of the approach-beacon system is relatively simple and there are no particularly critical requirements.

A.3.1 Standard Approach-Beacon System

1. Locate the inner beacon on the extended centerline of the runway 1000 feet from the threshold and locate the outer beacon on the extended centerline 2000 feet from the threshold (see figure A-5). Where terrain or other physical features make it impractical to locate the approach beacons at distances of 1000 and 2000 feet, some variations in these distances may be allowed. In all cases the beacons should be located on the extended centerline and the inner beacon should be located one-half the distance between the outer beacon and the runway threshold. The outer beacon should be not closer than 1500 feet or farther than 3000 feet from the runway threshold.

Table A-2

Equipment List For An Approach-Beacon System

Stock Number or Other Identification	Description of Item	Quantity	Source of Supply
CAA Cat. No. B-23	Beacon base with motor and 12-rpm worm	2	CAA Supply or surplus
or	Or		
6210-299-5829 (for complete beacon) (Old #R17-L-11100-401)	Rotating beacon, base assembly only	2	ASO
	and		
	Worm, 12-rpm, for rotating beacon	2	Manufacturer
	and		
	Gear, worm, 12-rpm, for rotating beacon	2	Manufacturer
None	Turntable, for mounting on beacon base	2	Fabricate locally
R6210-322-6617-D446 (Old #R17-MUEL-D-476-MU)	Light assembly, PAR-56, six for each beacon (lampholder)	12	ASO
R17-L-6920	Lamp, PAR-56, type 399PAR, 115-volt, 399-watt, approach-light, six for each beacon	12	GSSO
None	Autotransformer-contactor unit, 3-kilowatt, input taps for 200, 220, and 240 volts; output taps for 50, 60, 75, and 120 volts; 120-volt coil for operating contactor	2	Manufacturer (Hevi-Duty)
None	Stands, as required	2, as required	Fabricate locally
R5945-573-7185-0334 (Old #R17-C-42750-631)	Cutout, primary expulsion fuse, 5000-volt, 50-ampere	1, or as required	ASO
RS-5930-432-6983-D336 (Old #R17-S-19015-672)	Switch, remote-control oil, RCCC, two-pole, single-throw, 4600-volt, 35-ampere, 120-volt, 60-cycle operating coil	1, or as required	ASO
R17-T-7510-593	Transformer, distribution, 10-kva, 1-phase 60-cycle, 2300 - 115/230 volt	1, or as required	ASO
	Disconnect, fused	1, or as required	ASO
R6145-323-8516-DAMN	Cable, 5000-volt, #8, suitable for direct burial, for primary circuits	As required	ASO
	Cable, 600-volt, single- or two-conductor, suitable for secondary wiring	As required	ASO
R6145-506-1680-D336	Cable, control, 2-conductor, suitable for direct burial, for intensity-control circuits	As required	ASO
[illegible]10-610-2298-D336 (Old #R17-P-580-545)	Panel, airport-lighting control, type II, Spec. AN-P-59	2, if not already installed	ASO
	Miscellaneous hardware, conduit, and obstruction lights	As required	ASO

2. Construct foundations and stands as required for each beacon. The stands shall be tall enough for the beacons to be at the same elevation as the end of the runway. If necessary, the units may be above the elevation of the runway. The outer beacon shall be at least as high as the inner beacon or any intervening obstructions. The stands shall be strong enough to support stably the beacon and two technicians. Suitable access to the beacon for servicing and installing shall be provided. The top of the stand shall provide a suitable platform for mounting the beacon and the autotransformer-contactor unit and include sufficient working space and adequate safety rails.

3. Mount the beacons on the stands and adjust for level as indicated by a level on the leveling bosses of the beacon bases. Install the autotransformer-contactor units.

4. Adjust the lampholders so the axis of the beam is radially away from the axis of rotation and at an angle above the horizontal plane of 7 degrees for the outer beacon and 5 degrees for the inner beacon. (Before installing the lamps check this angle of each lampholder with a protractor level, or other suitable device, with the lampholder facing in the direction of the approach path.)

5. Carefully install the lamps in the lampholders with the wide beam spread horizontal (the lamp terminals in a horizontal plane).

6. Connect the output of the autotransformer-contactor units to the proper terminals of the terminal blocks of the beacon-base assemblies. The leads for the drive motor shall be connected directly across the 120-volt output tap. The leads for the lamps, which may be labeled "LAMP CHANGER" on the terminal block, shall be connected to the terminals of the intensity-control contactors.

7. Provide power to each beacon (see figure A-3). The capacity shall be at least 3 kilowatts at 200-240 volts at the site when the beacon is energized on high intensity. Adjust the voltage to the lamps for rated lamp voltage when the lamps are energized at high intensity by using the taps of the distribution transformer or the input taps of the autotransformer-contactor unit.

8. Connect the control circuits to the switches on each lighting-control panel and to the contactor and oil-switch operating coils. (See figure A-4 for the control circuits.) One switch will energize the beacons to drive the turntables and operate the lamps at low intensity (about 20 percent of rated intensity, normally the 75-volt tap).

The other switch energizes the intensity-control contactor to operate the lamps at rated voltage when the high intensity is desired. Label these switches "APPROACH BEACONS RUNWAY ---" and "APPROACH BEACONS HIGH INTENSITY." If more than one approach has approach lights, the first switch will be labeled "APPROACH BEACONS" only and the desired circuit will be selected by the runway-selector switch (see figure A-4).

9. Obstruction light and mark the approach beacons and stands as specified in BuAer Instruction 11012.1, if required.

10. Usually the beacons will be visible through 360 degrees, but at some locations shielding of the light from certain areas may be required. Shielding of the back side of the approach beacons (the side away from the approach) through 90 degrees will not seriously affect the performance of the system; but, because of the circling guidance provided, shielding within 135 degrees either side of the centerline of the approach path should be avoided if such shielding will interfere with aircraft viewing the beacons during an approach. Keep any shielding to the minimum area required.

11. The low-intensity setting for the beacons is required to reduce glare at night. If operational experience indicates that the 75-volt tap provides too high intensity for normal nighttime operations, connect the lamps to the 60- or 50-volt taps for the low-intensity setting.

A.3.2 Installation of Threshold Wing Bars

To improve the guidance of the approach-beacon system, especially in the final part of the approach, and to provide better transition for landing, the installation of threshold wing bars is desirable especially if the runway-threshold lights are low-intensity semiflush lights or are not installed as corner group lights as specified in BuAer Instruction 11012.1, drawing S. E. 129. Even if high-intensity runway threshold lights are used, additional guidance in this area is often desirable.

The additional threshold lights should be located at the runway threshold as two bars of four or five lights each, with the lights spaced at 5-foot intervals and extending outboard of the runway lights with the inner light of each bar in line with the runway lights (figure A-5). The lights in these bars should be sealed-reflector approach lights with green filters. These lights consist of a lampholder for PAR-56 lamps, stock No. R6210-322-6617-D446 (old No. R17-MUEL-D-476-MU); an upper cable assembly, stock No. R6210-395-9998-D446; a frangible coupling, stock No. R6210-396-0010-D336; an aviation green filter, stock No. R5950-505-8977-D446 (old stock No. R17-CGW-17623-G); and a PAR-56, sealed-reflector approach-light lamp. Three types of suitable lamps are available:

a. Type 399PAR, stock No. R17-L-6920, a 115-volt, 399-watt lamp. Use this lamp if the power for the wing bars is to be supplied from the approach-beacon circuit. (An intensity control unit of the autotransformer-contactor unit type used for the approach beacons will be required. Use only four lights in each bar to keep the power requirements within the capacity of the autotransformer-contactor unit.)

b. Type 6.6A/PAR56/2, Air Force stock No. 6240-283-9391, a 200-watt lamp with a 6.6-ampere series filament. Use this lamp if the power for the threshold wing bars is to be supplied by a 6.6-ampere runway-lighting circuit.

c. Type 20A/PAR56, a 300-watt lamp with a 20-ampere series filament. Use this lamp if the power for the wing bars is to be supplied from a 20-ampere series circuit.

Since the lamps listed under b and c are used in circuits that are not an integral part of the approach-beacon system and may be operated at lower intensity settings, the lamps and circuits of a are preferred.

Make the installation as follows:

1. Install the tube-base adapters, conduit, or flat surfaces suitable for mounting the PAR-56 lampholders at the specified positions. Since these lights will be elevated, the lampholders must be mounted on frangible couplings.

2. Install the lampholders for the PAR-56 lamps. Adjust each light so that its optical axis is 5° outboard of the runway centerline. The axis of the light will be elevated 5 degrees, as determined with a protractor level or other suitable device.

3. Carefully install a suitable lamp in each holder taking care not to change the setting of the lampholder.

4. Connect the leads from the lamp to the power circuit. For the type 399PAR lamps, connect to the contactor terminals of an autotransformer-contactor unit. Connect the contactor actuating coil in parallel with the control circuit for the beacons. For the series-type lamps, connect the lamps to the series circuit through the proper transformers.

5. Install the filter in the clips of each lampholder.

All equipment, lights, cables, etc., for installation of the threshold wing bars will be procured by the station.

A.3.3 Modification of the Approach-Beacon System

Because of terrain features, a system using a single beacon may be necessary. When installation of a two-beacon system is definitely impractical and there is serious need for a visual approach aid or for runway identification, use a stub approach-beacon system. For this stub system install a single beacon on the extended centerline of the runway as far from the threshold as practical up to 1000 feet. Make the beacon installation the same as that of a standard beacon with the lamps aimed up at an elevation angle of 7 degrees. The threshold wing-bar lights are more necessary in the stub beacon system than in the standard beacon system and the power for these wing bars should be supplied from the approach-beacon circuit.

Three beacons may be desirable for some approaches having a large number of operations in visibility conditions of one mile or less. If a third beacon is needed, locate it 3000 feet from the runway threshold. Install the beacon and aim the lights in the same manner as the outer beacon of the standard system.

A.4 MAINTENANCE AND SERVICING

A.4.1 General

The maintenance and servicing of the approach beacons is relatively simple. The schedule of inspection and servicing shall consist of: a daily visual check of the beacons while they are operating; replacement of the lamps as outages occur; periodic inspection; and lubrication servicing of the beacons. Malfunctions should seldom occur and the troubleshooting is not complicated.

A.4.2 Servicing of Lamps

Make a daily visual check of the beacons (and threshold wing bars if installed as part of the approach-beacon system) for burned out lamps or other malfunctions. Check the operation on both high- and low-intensity settings. This check may be made from any location from which the beacons are clearly visible, but a position at or above threshold elevation is preferred because then any serious misalignment of a lamp will be noticeable.

Replace any burned out lamps. The replacement of a single lamp in a beacon may be delayed for a day or two because an outage will not reduce the effective range of the beacon. The replacement of lamps should not be delayed unnecessarily because more than one lamp failure may seriously affect identification and the pilot's ability to keep the beacons located. When lamps are being replaced, or if misalignment is observed, check the alignment of all lamps in the unit. Realign the lamps to the proper direction.

If the beacons operate on one intensity setting only, check for failure and repair the autotransformer-contactor unit and the intensity-control circuit.

A.4.3 General Inspection and Lubrication Servicing

A general inspection of the approach beacons and lubrication servicing schedule should be established. Probably this servicing can best be scheduled to coincide with the lubrication of the airfield beacon. The following items of servicing should be included.

a. Inspect the brushes and slip rings for wear, dirt, and pitting. Clean slip rings with carbon tetrachloride. Use size 00 sandpaper to smooth out moderate pitting. Apply sandpaper or cloth wetted with carbon tetrachloride to the brushes while they rotate, using finger pressure only. Replace worn out brushes with new ones as furnished by the depot.

b. Inspect the beacons, especially the turntables and lampholders, thoroughly for rust or corrosion. Clean and repaint as required.

c. Check the pans and weatherproof compartments on the turntables for accumulation of water. Replace gaskets and bushings as required.

d. Lubricate the rotating mechanism parts as necessary with the following lubricants:

Motor bearings.	Use lubricating oil, class D, SAE 20, Federal Specification No. VV-O-496.
Vertical main shaft.	For the two bearings supporting the rotating shaft, lubricate with grease grade 375, USAF Specification No. 3560.
Worm gear.	Use oil, lubricating, transmission, U.S. Army Specification No. 2-28, or oil, lubricating, mineral, steam cylinder, grade 2, Army Specification No. 2-32.

e. Inspect stands. Repair, clean, and repaint as required.

A.4.4 Troubleshooting

Operating malfunctions other than lamp burnouts and lampholder misalignment should seldom occur. For troubleshooting and repair of the drive mechanisms, see T. O. No. 08-20-66. If malfunctions of the autotransformer-contactor units occur, the fault should be easily located by inspection and testing for presence of voltage when the units are energized.

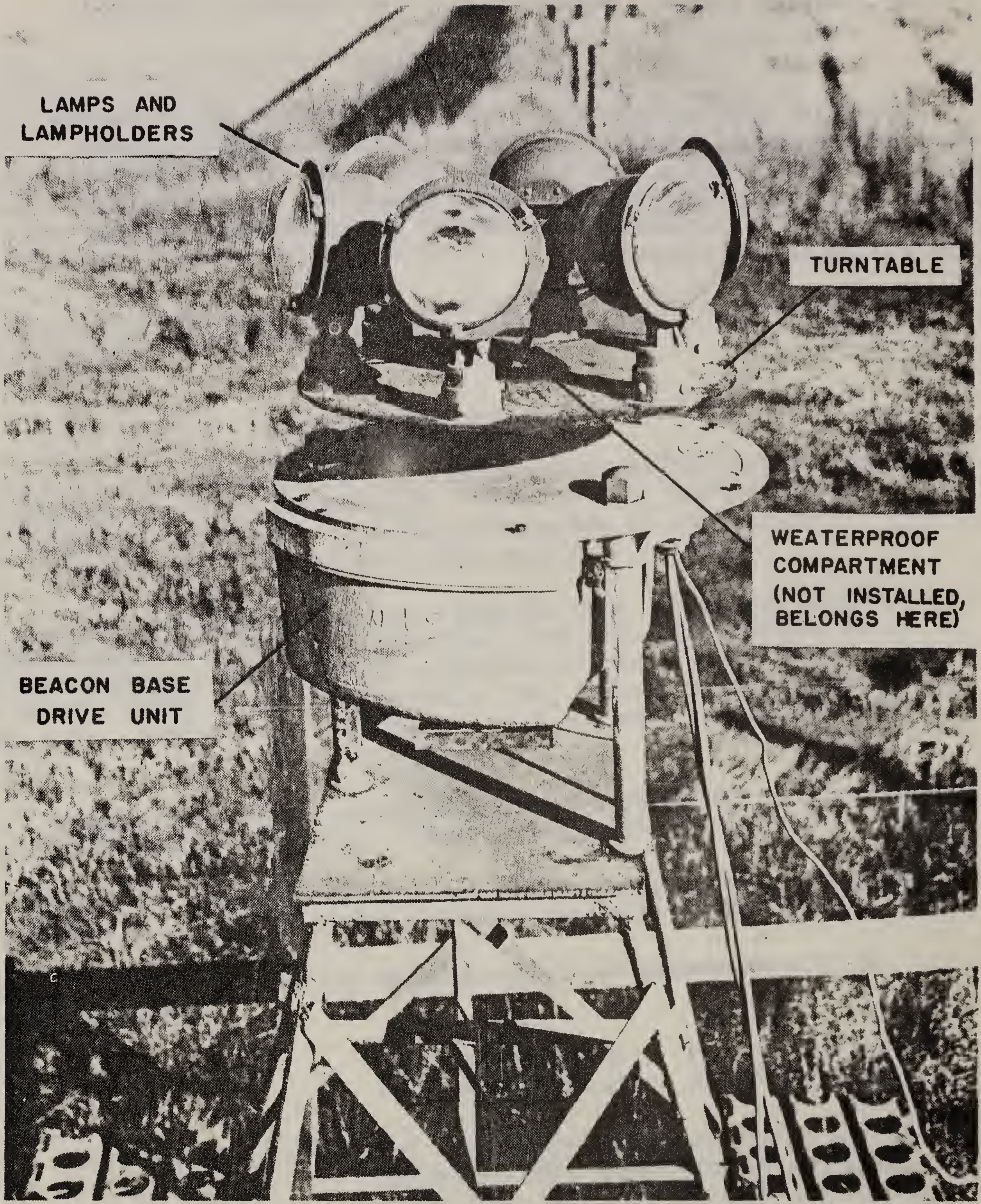

Figure A-1 An approach-beacon unit
showing major components

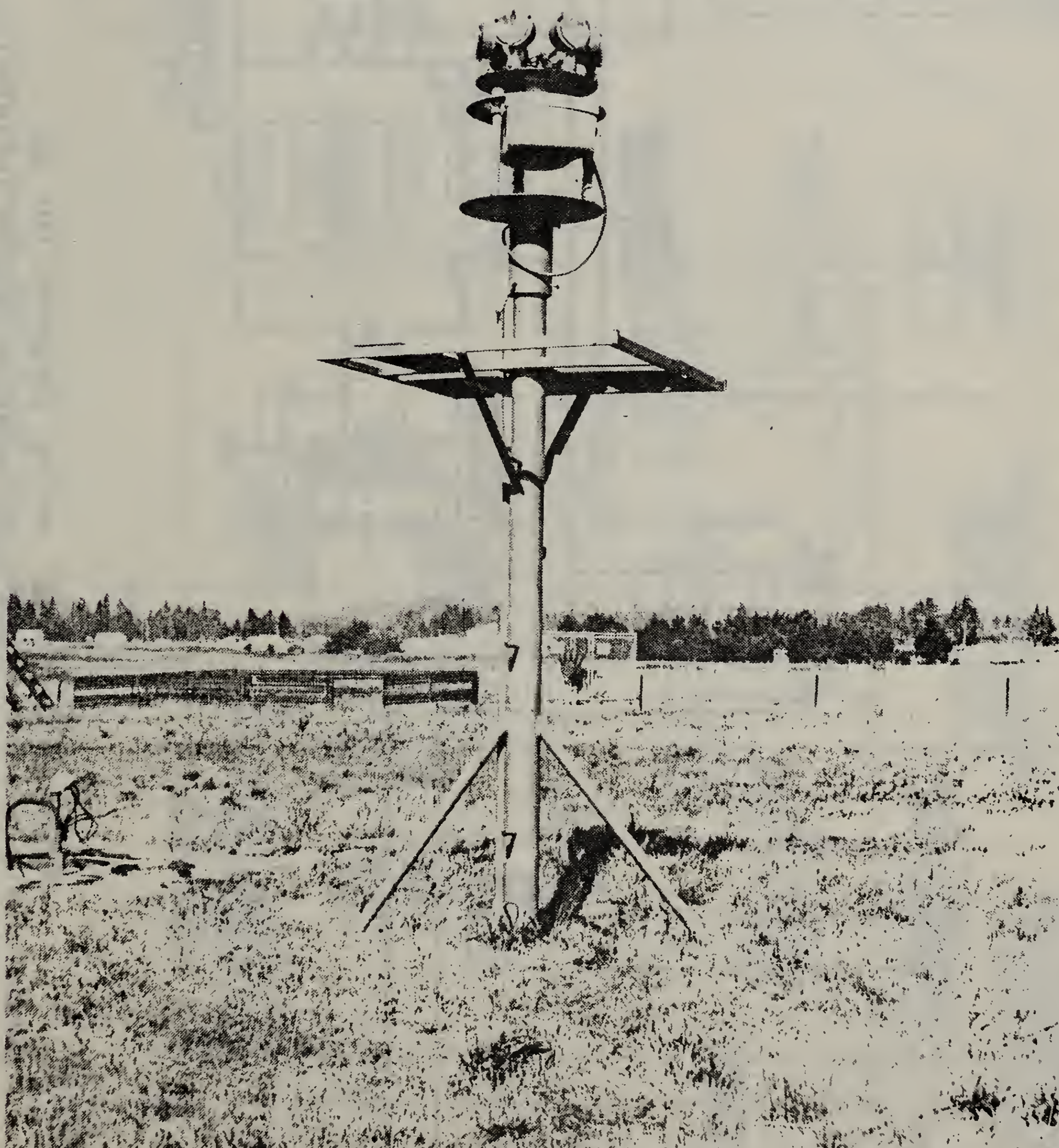

Figure A-2 An approach-beacon unit installed on a stand

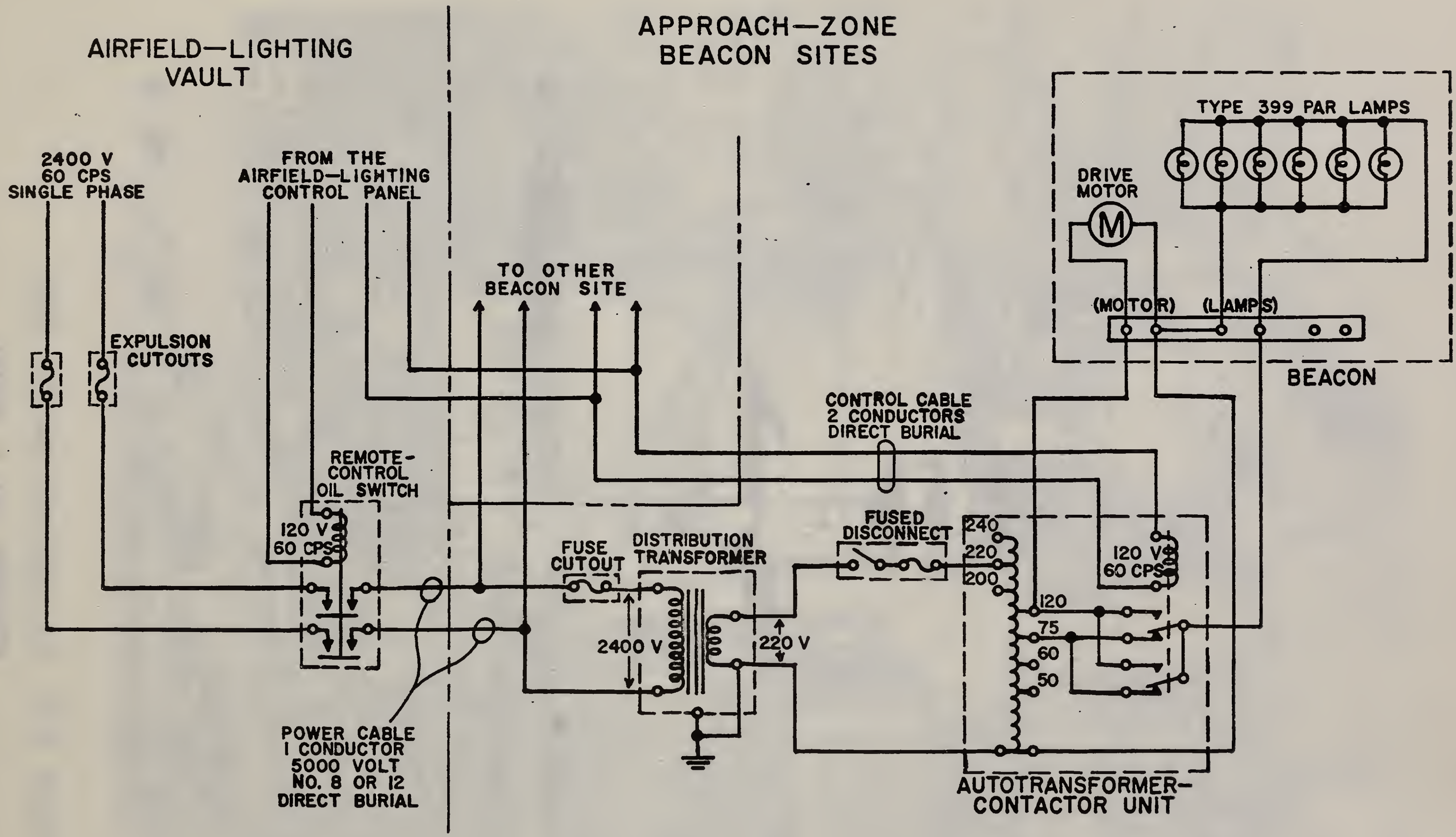

Figure A-3 Power wiring diagram for an approach-beacon system installation

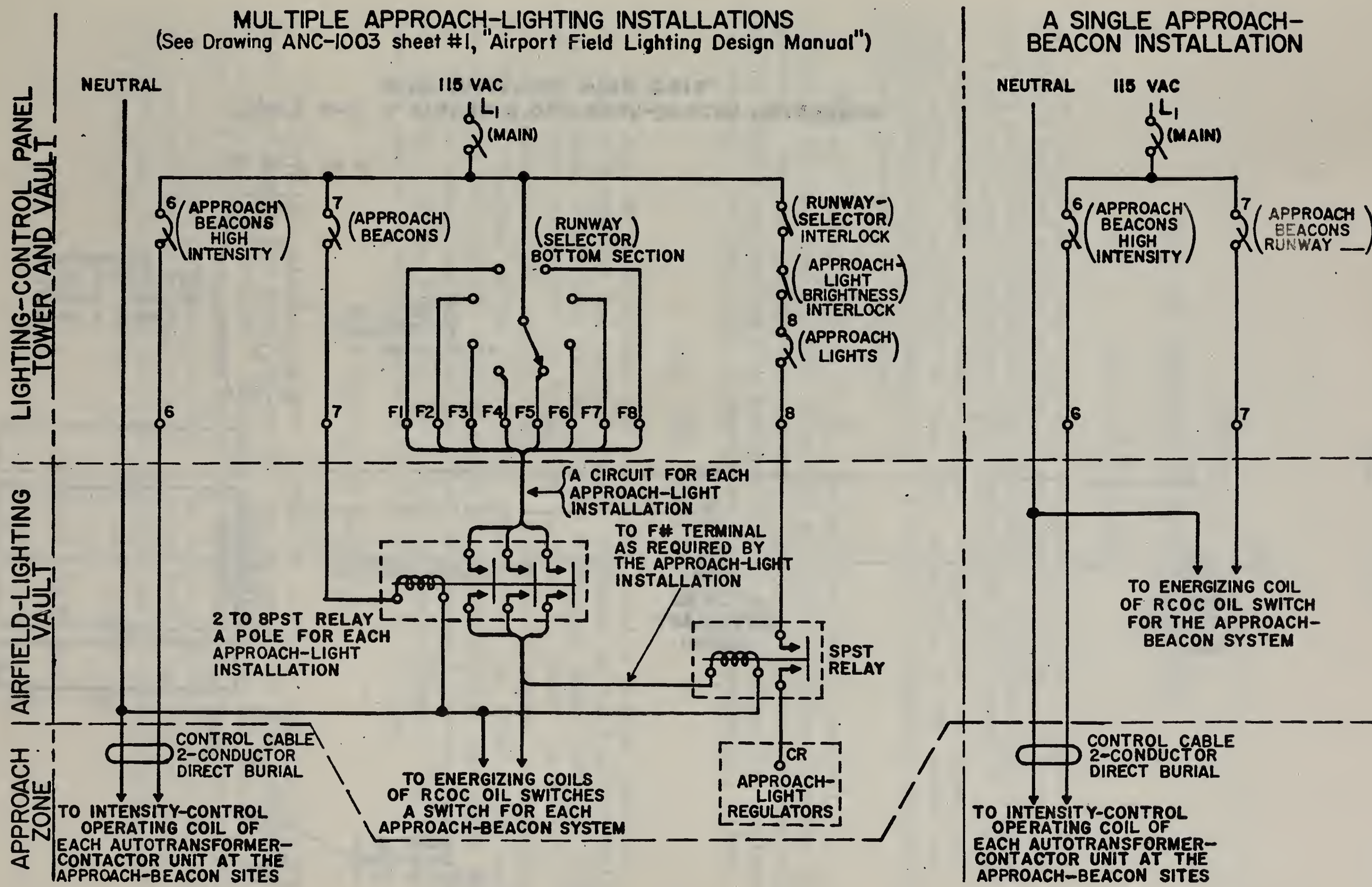

Figure A-4 Control wiring diagrams for approach-beacon systems

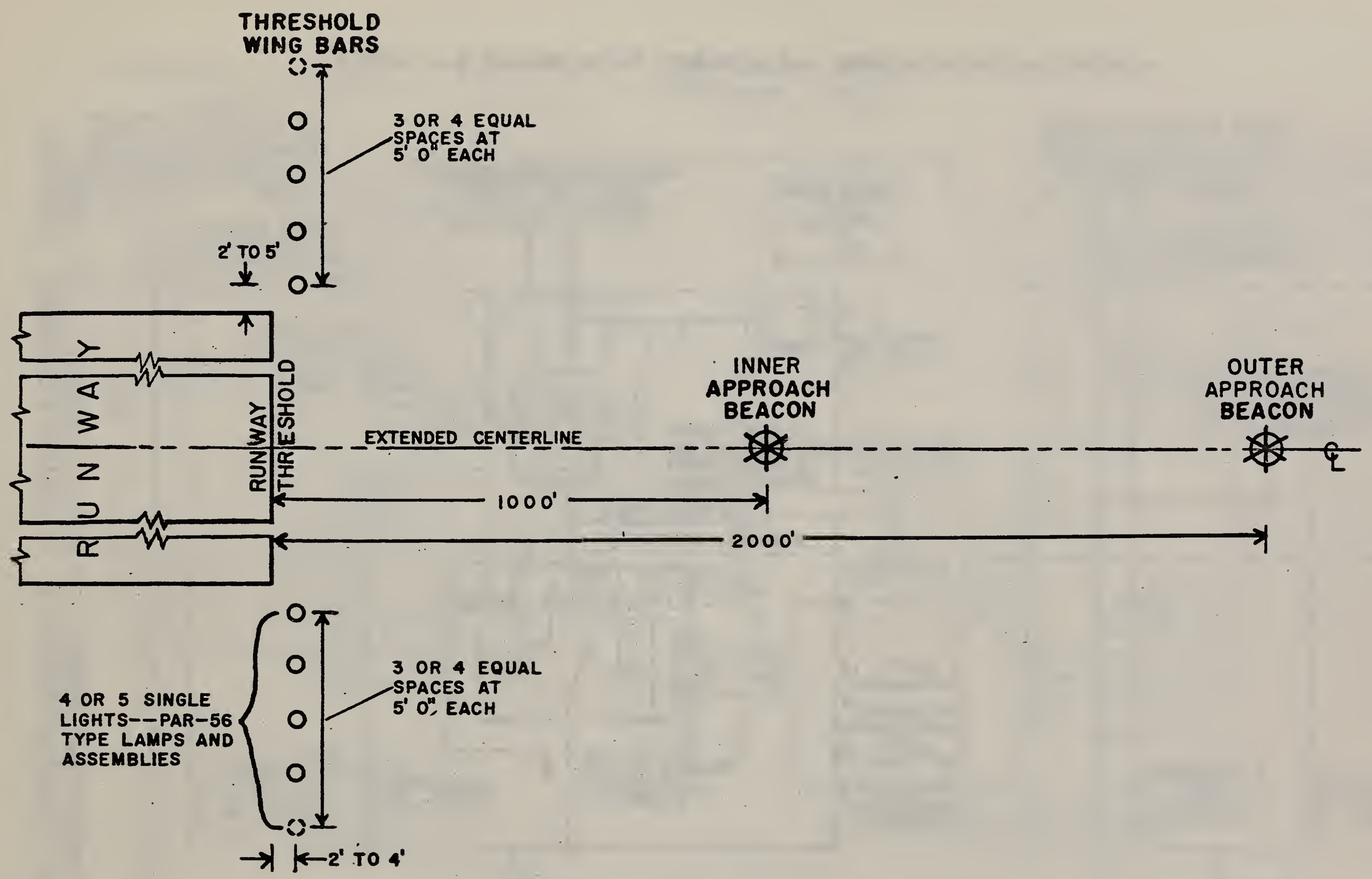

Figure A-5 A standard approach-beacon installation with threshold wing bars.

APPENDIX B

USE AND OPERATION OF APPROACH BEACONS

B.1 INTRODUCTION

The operation of the approach beacons is simple. Place the APPROACH BEACONS switch or circuit breaker in the ON position. The beacons will then operate on low intensity. To operate the beacons on high intensity, place the APPROACH BEACONS HIGH INTENSITY switch or circuit breaker in the ON position. If more than one approach-light system is installed for use, then selection of the proper approach system with the runway-selector switch is necessary before the approach beacons are energized.

The use and operation of the approach beacons is primarily a question of when and at what intensity to operate rather than how to operate. When to use the beacons will depend on the ceiling and visibility conditions and on the horizon and sky brightness. The preference of intensity settings will probably vary with the individual pilot.

B.2 USE IN DAYTIME

For daytime conditions, the following results may be expected. The approach beacons can provide useful guidance up to 5 miles during clear, bright conditions and at greater distances under overcast conditions when the visibility below the ceiling is good. In low visibility conditions the visual range of an approach beacon is approximately twice the observed visibility. Thus, because of the extra range and because the beacons are located ahead of the threshold, the pilot will be able to obtain useful guidance from the approach beacons before he can obtain guidance from the runway and runway markings. The approach beacons should be used only on high intensity in daytime.

B.3 USE DURING TWILIGHT

Twilight for pilots, as for automobile drivers, is the time when many visual aids are least effective and often pilots are unaware of the reduced effectiveness. During the transition period between daylight and dark, the guidance obtained from runways and runway markings, and the circling guidance obtained from runway lights is usually poor. The approach beacons should always be used during periods of dusk. During twilight, use the beacons on high intensity at all times except when the sky brightness is so low that glare becomes excessive.

B.4 USE AT NIGHTTIME

For nighttime conditions the following results may be expected. The visual range of the beacons on high intensity is approximately equal to that of the main beam of the type C-1 runway lights on brightness step 5 (100 percent intensity). The beacons will provide much better guidance at "off-axis" angles of view than any of the present runway lights. The circling guidance and runway and approach identification provided by these beacons should make the use of approach beacons worthwhile for most nighttime operations. The operational problem is to control properly the intensity in order to provide the maximum guidance and prevent bothersome glare. The proper intensity of the beacons to use will be determined by the atmospheric conditions and the traffic.

B.5 SUMMARY

Use the approach beacons for any approach when they may provide useful guidance. Table B-1 below gives the criteria for the use and intensity control of the beacons.

Table B-1

OPERATIONAL CRITERIA FOR APPROACH BEACONS

Daytime*

1. IFR Conditions.

   a. For all approaches.

2. VFR Conditions.

   a. When visibility is less than 5 miles.
   b. When low overcast, fog, smoke, or haze conditions exist.
   c. When landing toward the sun or very bright horizon sky.

*For daytime the approach beacons are operated on high intensity only.

Twilight**

1. Use High Intensity Setting:

   a. For IFR conditions throughout the period except when pilots request low intensity.
   b. For VFR conditions throughout the period except when glare is bothersome. (Bothersome glare is indicated by numerous pilots' requests for reduced intensity.)

**Use the approach beacons for all approaches during the period from 30 minutes to 1 hour before sunset until 30 minutes to 1 hour after sunrise.

2. Use Low Intensity Setting:

   a. For VFR conditions when brightness is very low or nearly dark.
   b. At pilot's request.

Nighttime

1. Use High Intensity Setting:

   a. For all IFR approaches when visibility is below 1-1/2 miles.
   b. For the initial stages of all other IFR approaches when visibility is below 3 to 5 miles or ceiling is below 500 to 1000 feet and then switch to low intensity at the pilot's request.
   c. Perhaps for the initial stages of other approaches until the runway lights are in view. (Use this criterion when traffic and control will conveniently allow switching to low intensity at the pilots' requests.)

2. Use Low Intensity Setting:

   a. For all VFR approaches when control for individual approaches is not convenient.
   b. At the pilot's request.
   c. For standby.

APPENDIX C

PILOTS' COMMENTS ON THE APPROACH BEACONS

C.1 INTRODUCTION

The performance of the approach beacons was evaluated by obtaining comments on the test installation from pilots making approaches to the Arcata Airport. These approaches were a part of normal operations and were not part of a flight-test program. The pilots included airline pilots, pilots for private business firms, private pilots, and military pilots, many of whom were unfamiliar with this airport at the time of the approach. Many types of conventional aircraft were used. No comments could be obtained regarding approaches in jet aircraft.

Representative pertinent comments of the pilots on these approaches are given below. They are arranged in chronological order, but are separated into approaches in daytime, nighttime, and twilight conditions.

In the data describing the approach conditions tabulated preceding the comments, the time is based on the 24-hour clock using Pacific Standard time. For twilight conditions the data indicate whether it was relatively light or dark. The ceiling, as observed or reported by the CAA INSAC station, is given. The sky coverage is indicated by Ø for scattered, by Ø̸ for broken, and by ⊕ for overcast. When a value is unknown it is indicated by (??) marks. The comments enclosed by parentheses are identification or explanatory data that are not a part of the direct comment.

We wish to acknowledge the fine cooperation of the pilots, especially the pilots of Southwest Airways and local pilots, in making observations and comments. Also we wish to acknowledge the assistance of the CAA INSAC station personnel in providing the communications with the pilots and the weather observations. This cooperation was on a voluntary basis.

C.2 DAYTIME APPROACHES

Date:	3/3/54	Ceiling:	800' Ø	Special conditions:
Time:	0852	Visibility:	5 F	Inner beacon only.
Aircraft:	DC-3	Intensity--		
Service:	Airline	Beacons:	High	
		Slopeline:	??	

(Pilot) We picked up the flashing beacon at about 900 feet (altitude) and about 3 miles out. I think that it would be quite an assistance if one (the aircraft) was off to either side. It didn't seem to be blinding at any time; of course it got more intense as we got farther in. It appears that it would be quite an assistance if it will penetrate the lower visibilities.

Date:	3/4/54	Ceiling:	1000' Ø	Special conditions:
Time:	0844	Visibility:	4 KH	Lamps aimed at 3 and
Aircraft:	DC-3	Intensity--		5 degrees above
Service:	Airline	Beacons:	High	vertical.
		Slopeline:	??	

(Pilot) I think they would come in very handy when flying a pattern in low visibility. We broke out at around 900 feet. Have them put one out on the end of runway 13. Our biggest problem is flying a downwind pattern for runway 13. When we have to circle the field to make a range approach in low visibility, it is awfully hard to tell when to turn. If we had one right on the end - near the bluff - it would be out far enough so that we could turn on base leg right there. At least it would give us some idea of where the end of the runway is. You can't see the runway (lights) when you aren't lined up with it. When you are flying downwind you can't see the (runway) lights at all. The beacons look very good.

Date:	4/23/54	Ceiling:	300' Ø	Special conditions:
Time:	0852	Visibility:	3/8 F	The approach was too
Aircraft:	DC-3	Intensity--		high for the best
Service:	Airline	Beacons:	High	intensity of the beacons
		Slopeline:	100%	

(Co-Pilot) We broke clear at the middle marker at 400 feet. The beacons may be pretty good at night but are not bright enough for daytime.

Date:	7/30/54	Ceiling:	600' Ø	Special conditions:
Time:	1601	Visibility:	3 F	Single landing light
Aircraft:	Beech D18	Intensity--		on each side as bea-
Service:	Business	Beacons:	High	con threshold lights.
		Slopeline:	100%	

(Pilot) (Had missed two approaches from troubles with ILS and compass and had requested permission for a circling approach.) On this approach I picked up the beacons on the downwind leg but had trouble keeping them in view. The intensity is quite satisfactory and I definitely would not want a lower intensity. Glare was no bother. The frequency was satisfactory. The green threshold lights were picked up before the slopeline lights and were very helpful. This beamspread seemed very good (for threshold lights).

Date:	9/2/54	Ceiling:	200' Ø	Special conditions:
Time:	0819	Visibility:	1/2 F	Broken cloudiness
Aircraft:	DC-3	Intensity--		on the approach.
Service:	Airline	Beacons:	High	
		Slopeline:	100%	
		Runway:	30%	

(Pilot) Actually saw the slopeline lights first but could see the beacons immediately afterwards. Frequency seems pretty good but may be a little slow. We could not tell definitely which were the beacon threshold lights when the night before they were so definite. (The night before the slopeline lights were not used and only the semiflush runway lights were used.)

Date:	10/13/54	Ceiling:	800' Ø	Special conditions:
Time:	1130	Visibility:	1 1/4 F	Straight-in approach.
Aircraft:	DC-3	Intensity		600-watt landing lights
Service:	Airline	Beacons:	High	used for threshold.
		Slopeline:	100%	

(Pilot) We saw both beacons halfway down the glidepath. The rotation speed is OK, slow enough to give on and off effect. The contrast of the slopeline lights was not too good; the approach beacons may give better contrast. We could see the slopeline threshold lights quite a bit before we could see the two individual green lights (threshold lights).

Date:	1/21/55	Ceiling:	800' Ø	Special conditions:
Time:	1329	Visibility:	1 1/2 R-F	18-inch course lights
Aircraft:	Martin 202	Intensity--		were the threshold
Service:	Airline	Beacons:	High	lights. Beacon lamps
		Slopeline:	4%	aimed at 5 and 7 degrees
		Runway:	3%	above vertical.

(Pilot) We broke out of the overcast about 1/4 mile before the beginning of the slopeline system and the beacons were just about as distinctive as the slopeline lights. ---- The approach beacons were very nearly as useful as the slopeline system.

Date:	1/24/55	Ceiling:	??	Special conditions:
Time:	1430	Visibility:	1 1/4 F	18-inch course lights
Aircraft:	Martin 202	Intensity--		for threshold.
Service:	Airline	Beacons:	High	
		Slopeline:	100%	

(Pilot) We picked up the beacons at exactly the same time as we located the slopeline lights. The beacons help quite a bit in finding the slopeline and in getting lined up. We did not notice the threshold lights.

Date:	2/3/55	Ceiling:	None	Special conditions:
Time:	1409	Visibility:	15	18-inch course lights
Aircraft:	DC-3	Intensity--		for threshold. Very
Service:	Airline	Beacons:	High	bright, clear day.
		Slopeline:	Not used	

(Pilot) We picked up the beacons about 4 miles out over the water (west) by looking for the flashes, but they are not particularly noticeable at this point. As we turned on final approach we could not see the threshold lights although the beacons were clearly visible. The beacons seem to be pretty good but the flashes could be speeded up some for best use in low visibility operations. We did not see the threshold lights until we were very nearly over them..

Date:	2/7/55	Ceiling:	2000' Ø 3000' Ø	Special conditions:
Time:	1408	Visibility:	10	Overhead circling
Aircraft:	Martin 202	Intensity--		approach, no request
Service:	Airline	Beacons:	High	for observations.
		Slopeline:	Not used	

(Pilot) We picked up the beacons before coming over the field and had them in sight well during the pattern. They looked very good today with the flash rate about right.

Date:	2/7/55	Ceiling	2000' Ø 3000' Ø	Special conditions:
Time:	1421	Visibility:	10	Circling approach
Aircraft:	DC-3	Intensity--		from north to 31.
Service:	Airline	Beacons:	High	
		Slopeline:	Not used	

(Pilot) We picked up the beacons about 4 miles west of the field. The beacons look very good but they really help on these black, inky nights. These lights (beacons) are some help on any approach but they are the greatest aid on low-frequency range approaches when they can be picked up on the downwind leg at about 600 or 700 feet altitude and kept in sight throughout. They also help on approaches at night to runway 13.

Date:	2/8/55	Ceiling:	3000' Ø	Special conditions:
Time:	1100	Visibility:	10	Smoky in the approach
Aircraft:	Cessna 195	Intensity--		zone.
Service:	Business	Beacons:	High	
		Slopeline:	Not used	

(Pilot) You can see these lights (beacons) through the smoke better than you can see the objects at the field.

Date:	2/16/55	Ceiling:	6000' Ø	Special conditions:
Time:	0829	Visibility:	5 R--	This approach was
Aircraft:	DC-3	Intensity--		made to runway 13.
Service:	Airline	Beacons:	High	
		Slopeline:	Not used	

(Pilot) We are over Trinidad Head (7 miles from the beacons) and the beacons are beginning to come in now but are still pretty dim. These beacons are pretty good. The flash rate seems quite satisfactory for this condition and the beacons gave useful information in lining up with the runway. There is one point on this flash rate. It is about the same as the headlights on some trains. Of course here it is not likely to be confusing and with two beacons it may not be confusing anywhere.

Date:	3/25/55	Ceiling:	150' Ø	Special conditions:
Time:	1126	Visibility:	3/8 F	14-inch course lights
Aircraft:	DC-3	Intensity--		for threshold.
Service:	Airline	Beacons:	High	
		Slopeline:	100%	

(Pilot) The slopeline were more useful than the beacons for this approach. When visibility is better, the approach beacons are easier to use. The threshold lights were visible but we were so close in that they were of little use.

Date:	3/25/55	Ceiling:	None	Special conditions:
Time:	1430	Visibility:	15	14-inch course lights
Aircraft:	Martin 202	Intensity--		for threshold; no
Service:	Airline	Beacons:	High	spread lenses; filters
		Slopeline:	Not used	are not the same.

(Pilot) We saw the beacons over Arcata (7 miles) when they were first turned on. Probably could have seen them farther. We first saw the threshold lights over the outer marker. The left light was brighter. They look pretty good.

Date:	6/20/55	Ceiling:	800' Ø	Special conditions:
Time:	1347	Visibility:	10	None
Aircraft:	DC-3	Intensity--		
Service:	Airline	Beacons:	High	
		Slopeline:	100%	

(Pilot) We saw the slopeline lights and then in about 5 seconds saw the approach beacons. Probably the beacons would have been very useful if there had been no slopeline lights.

Date:	10/10/55	Ceiling:	200' Ø	Special conditions:
Time:	0830	Visibility:	3/8 F	May have had holes
Aircraft:	DC-3	Intensity--		in clouds on approach.
Service:	Airline	Beacons:	High	
		Slopeline:	100%	
		Runway:	100%	

(Pilot) We saw the beacons at least as soon as the slopeline and they were a real help. The beacons would really be a lot of help at Crescent City.

Date:	10/17/55	Ceiling	200' Ø 400' Ø	Special conditions:
Time:	0812	Visibility:	3 F	Two lamps burned
Aircraft:	DC-3	Intensity--		out in outer bea-
Service:	Airline	Beacons:	High	con. One out in
		Slopeline:	100%	inner beacon.

(Pilot) We saw the beacons at about the same time as the slopeline. The regular flashes are much easier to locate than the occasional flashes. (The impression of irregular or occasional flashing was the result of the burned out lamps.)

Date:	4/20/56	Ceiling:	100'-200' Ø	Special conditions:
Time:	0840	Visibility	3/16 F	Ceiling and visibil-
Aircraft:	DC-3	Intensity--		ity lower in the
Service:	Airline	Beacons:	High	approach zone.
		Slopeline:	100%	

(Pilot) We did not see the beacons. We saw the slopeline lights at about the middle marker. (The approach-zone transmissometer and the slant-visibility meter indicated that the visibility was about 1/8 mile and the ceiling was about 100 feet in the approach zone.)

Date:	3/28/57	Ceiling:	7000' Ø	Special conditions:
Time:	1125	Visibility:	10 R--	Practice ILS approaches
Aircraft:	DC-6	Intensity--		and observation of
Service:	Coast Guard	Beacons:	High	approach lights.
		Slopeline:	4%	

(Pilot) We could see the glaring (approach beacon) lights at the outer marker but didn't see the others (slopeline) until we were in a little closer. The beacons looked very good.

C.3 NIGHTTIME APPROACHES

Date:	3/4/54	Ceiling:	1200' Ø	Special conditions:
Time:	??	Visibility	7	Lamps aimed at 3
Aircraft:	DC-3	Intensity--		and 5 degrees above
Service:	Airline	Beacons:	High	vertical.
		Slopeline:	Not used	

(Pilot) We broke out at about 1350 feet and are now (just past the outer marker) picking up the beacon. It doesn't seem to be at all glaring. ---- They show up much brighter than any of the other lights around there. They seem to be of definite assistance as near as we can tell now. We can't see anything at all wrong. We are getting in towards the middle marker now and there is a little glare from them. I imagine it will continue to get more glaring as we get in close. They are not so bad that they are bothering anything. Now at the middle marker they are getting a little too bright. (Turned off, no low intensity at this time.)

Date:	8/30/54	Ceiling:	200' Ø	Special conditions:
Time:	??	Visibility:	6 F	Good visibility under
Aircraft:	DC-3	Intensity--		a low ceiling. Land-
Service:	Airline	Beacons:	High	ing lights for the
		Slopeline:	100%	threshold.
		Runway:	4%	

(Pilot) We picked up the beacons at just about the same time as individual lights of the slopeline. The flashes made these beacons show up very well and it was easily identified. The flash rate was much better than a few nights ago when it flashed much slower. (Two lamps were out then in each beacon.) Flash rate and spacing seemed very good. We did not notice the threshold lights.

Date:	10/22/54	Ceiling:	None	Special conditions:
Time:	??	Visibility:	10	A strange pilot in a
Aircraft:	Lancaster	Intensity		large aircraft had
Service:	RCAF	Beacons:	High	not been able to
		Slopeline:	Not used	land.

(CAA Communicator) This aircraft was having serious difficulty in finding the field and getting lined up properly. The slopeline lights helped him find the field but he had missed several approaches because he could not get lined up. Upon use of the beacons the pilot reported that he was aided very much in getting lined up and made a successful approach without further difficulty.

Date:	1/21/55	Ceiling:	1000' Ø	Special conditions:
Time:	2024	Visibility:	1 1/2 L--	18-inch course lights
Aircraft:	DC-3	Intensity--		for the threshold.
Service:	Airline	Beacons:	Low	Beacon lamps aimed at
		Slopeline:	20%	5 and 7 degrees above
		Runway:	AN-L-9	vertical.

(Pilot) We saw the slopeline before the beacons this time. The beacons were located about 15 seconds after the slopeline. The beacons do not seem to be at the same intensity as this afternoon. The beacons are a definite help. The threshold lights were OK. (The threshold lights referred to may have been the slopeline threshold.)

Date:	1/23/55	Ceiling:	800' Ø	Special conditions:
Time:	2023	Visibility:	3 L F	None
Aircraft:	DC-3	Intensity--		
Service:	Airline	Beacons:	High	
		Slopeline:	20% then 1%	
		Runway:	1%	

(Pilot) The glow of the slopeline was picked up first, then we were able to pick up the beacons at about the same time as the direct light from the slopeline lights. These beacons give some help on lining up with the runway and are a valuable assistance to the slopeline system, although they can not be as important an aid as the slopeline.

Date:	1/31/55	Ceiling:	1500' Ø 2500' Ø	Special conditions:
Time:	1956	Visibility:	8	18-inch course
Aircraft:	DC-3	Intensity--		light for
Service:	Airline	Beacons:	High	threshold.
		Slopeline:	Not used	

(Pilot) (Requested beacons.) The beacons are very useful on circling approaches because the runway lights are too low intensity on the sides to be of any help. Except in very low visibilities, I think the beacons would be better than the slopeline. We looked for and saw the threshold lights but could not see them on an earlier flight in lower visibility and in daylight.

Date:	2/7/55	Ceiling:	300' Ø 2800' Ø	Special conditions:
Time:	2009	Visibility:	10	Approach was to
Aircraft:	DC-3	Intensity--		runway 13 (not
Service:	Airline	Beacons:	High and low	runway 31).
		Slopeline:	Not used	
		Runway:	AN-L-9	

(Pilot) We picked up the beacons easily near Rocky Point (15 miles). At this distance the beacons are easily seen when on high intensity but are not visible when on low intensity. We are over Trinidad Head (7 miles) and see the beacons (on low intensity) very well before we could see the runway lights or the obstruction lights. These beacons are better for lining up than are the runway lights. Since these beacons can be picked up high and off to the side of the runway, they are a big help. --- The low intensity (of the beacons) is better than these runway lights but is not nearly so useful as the high intensity (of the beacons). The high intensity lights are very useful and should be used until lined up with the runway and the runway lights are in view. Then the low intensity is useful to keep in view and they do not blind. This high, wide beam of light is very useful and the flashes are easily recognized. (After takeoff) The beacons really give a lot of information on the location of the field when flying off to the side parallel to the runway. I think they are worthwhile even after takeoff.

Date:	2/8/55	Ceiling:	200' Ø	Special conditions:
Time:	2027	Visibility:	1 F	None.
Aircraft:	DC-3	Intensity--		
Service:	Airline	Beacons:	High	
		Slopeline:	100%	
		Runway:	100% (?)	

(Pilot) The approach beacons would certainly work at fields where no other (approach) lights were available. They help in lining up.

Date:	2/55	Ceiling:	300' Ø	Special conditions:
Time:	??	Visibility:	1 R- F	Strange pilot of
Aircraft:	Lancaster	Intensity--		large military air-
Service:	RCAF	Beacons:	High	craft. After two
		Slopeline:	Not used (?)	missed approaches.
		Runway:	??	

(Airport manager) (The approach beacons were not used on first two approaches (which resulted in missed approaches) because it was considered that they may add confusion to the slopeline system. On the second try the aircraft almost hit the control tower and the pilot was not aware that he was not aligned with the runway but went around because he thought he was too high. Then the approach beacons were used and the pilot was told how to use them.) The next approach was completed very satisfactorily. From now on we will use the beacons for the Canadians.

Date:	3/25/55	Ceiling:	2000' Ø	Special conditions:
Time:	2042	Visibility:	10	14-inch course lights
Aircraft:	DC-3	Intensity--		at threshold. New
Service:	Airline	Beacons:	High and low	pilots on this run.
		Slopeline:	Not used	

(Pilot) We saw the flashing beacons easily over Eureka (15 miles). They look pretty good. Over Arcata (7 miles) the beacons are looking good. There is quite a bit of smoke here and the beacons are coming in fine and are pretty useful. We noticed the threshold lights over Arcata. They came through good but weren't blinding at any point. (Reduced to low intensity when the aircraft was at about the middle marker.)

Date:	4/11/56	Ceiling:	None	Special conditions:
Time:	2030	Visibility:	7	The wing bars were
Aircraft:	DC-3	Intensity--		at the threshold.
Service:	Airline	Beacons:	High and low	No low intensity on
		Slopeline:	Not used	threshold wing bars.
		Runway:	0.2%	

(Pilot) We picked up the beacons a long way out under this condition. The beacons are bright (just after crossing the outer marker and were switched to low intensity). Just perfect. The beacons are fine for this clear condition but would need the higher intensity for low visibility. The threshold lights were very bright a long way out and requested that they be dimmed about the middle marker (they were turned off). The intensity of both beacons appeared the same. (One beacon had the PAR 399 lamps and the other had the 300PAR56/NSP lamps.)

Date:	4/14/56	Ceiling:	2000' ø	Special conditions:
Time:	2107	Visibility:	6-8	LF range approach.
Aircraft:	DC-3	Intensity--		
Service:	Airline	Beacons:	High then low	
		Slopeline:	Not used	
		Runway:	0.2%, 4%, then 0.2%	

(Pilot) We were not looking for these beacons and had never seen them before. They are pretty bright. I saw them as soon as I broke out. They seemed brighter than the airfield beacon-- at least I saw them before I saw the airfield beacon. After breaking out it was so clear that I did not need them, but they looked like they would be all right with less visibility. I would say they were OK.

Date:	4/16/56	Ceiling:	None	Special conditions:
Time:	2033	Visibility:	8-10	Outer beacon has 399PAR
Aircraft:	DC-3	Intensity--		lamps and the inner
Service:	Airline	Beacons:	High and low	beacon has 300PAR56/NSP
		Slopeline:	Not used	lamps.
		Runway:	??	

(Pilot) We could see the beacons just after crossing the Fortuna VOR range (20 miles out). There does not appear to be any difference in the intensity of the beacons.

Date:	10/24/56	Ceiling:	2500' Ø 4000' Ø	Special conditions:
Time:	2015	Visibility:	7	None.
Aircraft:	DC-3	Intensity--		
Service:	Airline	Beacons:	High then low	
		Slopeline:	Not used	
		Runway:	??	

(Pilot) We had the beacons easily in sight as we turned on final. Are the beacons intended for IFR conditions? (Yes, primarily for circling and range approaches.) They look good. (Requested a lower intensity at about 3 miles out.) The low intensity is about right for present conditions.

Date:	11/5/56	Ceiling:	300' Ø	Special conditions:
Time:	2021	Visibility:	3/4-1 F	ILS approach.
Aircraft:	DC-3	Intensity--		
Service:	Airline	Beacons:	High	
		Slopeline:	100%	
		Runway:	20%	

(Pilot) With the slopeline and the approach beacons both on top intensity, we could see the beacons easily but they were not of appreciable assistance.

Date:	11/5/56	Ceiling:	200' Ø	Special conditions:
Time:	2115	Visibility:	1/2 F	ILS approach. Com-
Aircraft:	Martin 202	Intensity--		ments and observa-
Service:	Airline	Beacons:	High	tions were not
		Slopeline:	100%	requested.
		Runway:	100%	

(CAA communicator) The pilot said that the approach beacons were really fine for this approach. If the beacons had not been on he would have missed this approach. He could not see the runway lights early enough but judged the distance by the beacons. He stated that he did not care for the beacons in clear weather but they were fine for restricted conditions.

Date:	57	Ceiling:	??	Special conditions:
Time:	??	Visibility:	1 F	A strange pilot
Aircraft:	??	Intensity--		seriously needing
Service:	Private	Beacons:	High	to land.
		Slopeline:	??	
		Runway:	??	

(CAA communicator) The aircraft had missed two approaches using the slopeline lights only. He was not familiar with the slopeline system. He completed the landing safely on the first pass using the approach beacons. The pilot thought the beacons were very good although he had never seen them before.

C.4 TWILIGHT APPROACHES

Date:	3/3/54	Ceiling:	1200' ø	Special conditions:
Time:	1845 dark	Visibility:	7	Both beacons. Lamps
Aircraft:	DC-3	Intensity--		aimed at 3 and 5 de-
Service:	Airline	Beacons:	High	grees above vertical.
		Slopeline:	Not used	

(Pilot) We have had the beacons in sight ever since we broke out at 1200 feet. You can turn them down now if you would. (They were turned out since there was no intensity control.) The beacons were nice back there but we had good visibility tonight.

Date:	8/19/54	Ceiling:	200' ø	Special conditions:
Time:	1848 light	Visibility:	1/4-2 F	None
Aircraft:	DC-3	Intensity--		
Service:	Airline	Beacons:	High	
		Slopeline:	100%	
		Runway:	20%	

(Pilot) The approach beacons looked very good. Visibility was better in the approach zone. We sighted the outer beacon shortly after finding the first slopeline lights and the beacons were very helpful in knowing that we were properly lined up and not off to one side on the slopeline lights. There was no glare with the beacons on bright. The frequency may be better if it was somewhat faster.

Date:	8/19/54	Ceiling:	300' Ø	Special conditions:
Time:	1925 dark	Visibility:	1 F	None. (Clearer on the
Aircraft:	DC-3	Intensity--		field than in the
Service:	Airline	Beacons:	High	approach zone.)
		Slopeline:	100%	
		Runway:	20%	

(Pilot) We did not see the approach beacons until well after we had picked up the slopeline lights. The beacons did not appear very bright. The beacons seemed to be turning very slow. A faster flash rate and wider spacing between flashes would give better identification.

Date:	10/1-7/55	Ceiling:	??	Special conditions:
Time:	Not dark	Visibility:	2 K F	VFR approach using
Aircraft:	Cessna 170	Intensity--		ILS localizer for
Service:	Business	Beacons:	High	initial aligning.
		Slopeline:	Not used	
		Runway:	??	

(Pilot) I was coming in just before dark as visibility was lowering to IFR conditions. A layer of smoke was up to 2000 feet. I lined up on the localizer and spotted the beacons just about the outer marker. The beacons were very useful and keeping the beacons lined up made the approach easy. The beacons appeared very red in color (caused by the smoke). I did not pick up the runway or runway lights until I was over the middle marker. I feel that the beacons are easily adequate for approaches in one-mile visibility. They can be used operationally for range approaches in one mile visibility and probably much less than this with ILS. It may be useful to have the beacons operating at different flash rates so the pilot can make certain which way the beacons are from the runway. Perhaps make the inner beacon much faster and then if the beacons were turned on for the wrong end of the runway the pilot could determine this.

Date:	12/7/55	Ceiling:	5000' Ø	Special conditions:
Time:	1643 dark	Visibility:	1 1/2 K	Clear above 200-foot
Aircraft:	Cessna 170	Intensity--		layer of smoke. Made
Service:	Business	Beacons:	High	as a VFR approach.
		Slopeline:	Not used	
		Runway:	20%	

(Pilot) I picked up the beacons over the outer marker but the beacons looked red. If a person was expecting white lights, he might overlook the beacons. The two beacons were fine for aligning with the runway. I was about to the middle marker before seeing the threshold lights. They were adequate for the conditions but would probably show up much better at night.

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