NATIONAL BUREAU OF STANDARDS REPORT

9045

A Stub Approach Beacon

By

James E. Davis and J. W. Simeroth

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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NBS PROJECT		NBS REPORT
2120414	February 1966	9045

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For
Bureau of Naval Weapons
Department of the Navy
Washington, D. C.

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1. INTRODUCTION

At many airports there is continuing need for a simple, economical visual approach aid. This type of aid is especially needed at secondary airports where high intensity approach lights are not economically feasible. Even at major airports which have high intensity approach lights, the approaches to runways without approach lights often need additional visual aids. Visual approach slope indicators (VASI) provide needed glide slope information, and when used in conjunction with a precision electronic approach aid such as the instrument landing system (ILS), may furnish the required visual guidance. In many cases, the runways do not have precision electronic aids. In these cases, visual orientation may be difficult, especially when circling or pattern type approaches are used, even if VASI is installed, because of the narrow horizontal beamspread of the VASI and the runway lights.

An approach beacon system was developed to aid approaches in such conditions. As was pointed out in the report describing this system[(1)] at many runways the terrain or other conditions may make it impractical to install the complete approach beacon system. A "stub" approach beacon system on the approach to runway 31 at the Arcata Airport in California was installed and tested. The comments on this installation indicate that useful information was furnished, but effectiveness was much less than that of the complete approach beacon system or of the high intensity approach lights to which the stub system was usually compared. A stub approach beacon installation was attempted on the approach to runway 13 at Arcata, but the initial installation had to be removed without testing because of its effect on the ILS localizer signal.

(1) National Bureau of Standards Report 5902, "An Approach-Beacon System" February 1959.

Since the earlier work, the Federal Aviation Agency has replaced the ILS localizer antenna building for Arcata Airport with the low-profile antennas located nearer the threshold of runway 13. The FAA has also installed the VASI system for the approach to runway 13. These changes, plus the fact that the back course of the ILS localizer is not authorized as an approach aid, made it possible to install a stub approach beacon installation on the approach to runway 13 for testing. Now a test could also determine if the stub approach beacon would furnish useful guidance to supplement the VASI.

2. THE TEST INSTALLATION

2.1 The Approach Beacon

The approach beacon used for the tests was one of the beacons used in the tests of a complete approach beacon system.(1) It consists of an airway beacon base which has a turntable rotating at a speed of 12 revolutions per minute. A steel plate 24 inches in diameter was mounted on the turntable of the beacon base. Type MB-2 lampholders were equally spaced around the outer edge of this plate, with the lamps directed outward from the beacon. Initially six lamps were used which provided a flash frequency of 72 flashes per minute. Later five lamps were used which provided 60 flashes per minute.

The beacon was driven by a motor operating from 115 volts alternating current. The lamps were operated at two intensity settings: at 100 percent intensity for daytime, and at a lower intensity for nighttime. Four types of PAR-56 lamps were used in these tests, to study the effects of different flash characteristics. These types were as follows:

1. Type 399PAR; 115-volt, 399-watt, 100-hour—life approach light lamps which produced flashes having a flash duration of 0.5 seconds with an effective intensity of about 20,000 candelas at the elevation of the peak. The vertical beam spread at 50% of peak was 12 degrees.

2. Type 300PAR56/NSP; 120-volt, 300-watt, 2000-hour-life general service lamps which produced flashes having a duration of 0.3 seconds with an effective intensity of about 23,000 candelas at the elevation of the peak. The vertical beam spread at 50% of peak was 7 degrees.

3. Type 20A/PAR56Q/1; 20-ampere, 500-watt, 500-hour-life approach light lamps which produced flashes having a duration of 0.5 seconds with an effective intensity of about 28,000 candelas at the elevation of the peak. The vertical beam spread at 50% of peak was 12 degrees.

4. Type 20A/PAR56Q/3; 20-ampere, 500-watt, 500-hour-life approach light lamps which produced flashes having a duration of 0.14 second with an effective intensity of about 100,000 candelas at the elevation of the peak. The vertical beam spread at 50% of peak was 6 degrees.

The 115- and 120-volt types of lamps were operated with the energizing voltage supplied through the sliprings of the beacon base directly to the lamps. The 20-ampere-type lamps were energized with 115 volts applied through the sliprings to 115/22.5-volt transformers mounted on the turntable to which the lamps were connected.

2.2 Installation Details

Preferably the stub approach beacon should be placed in the approach zone on the extended runway centerline at a sufficient distance from the threshold so that the light will not be an obstruction and so that it will not cause distortion of the localizer beam of the instrument landing system (ILS) if the antenna of such a system is located in the area. This was not possible at the end of runway 13 at Arcata because of a bluff some 400 feet from the threshold. Therefore, an underground installation with only the lamps extending above the ground surface was required. Fortunately there was a conveniently prepared site on the approach to runway 13 on the extended runway centerline 380 feet from the threshold at the entrance to the underground vault beneath the concrete slab for the old dismantled localizer antenna shelter. The beacon base was suspended in this entrance by hangers prepared from strap steel, at a height such that the lamps and lampholders were the only parts of the beacon above the surface of the concrete slab, as shown in figure 1. The beacon was only 75 feet beyond the ILS localizer antennas.

With the approach beacon located so close to the localizer antennas, there was a possibility that it might affect the localizer signal, not so much from the exposed mass of the beacon as from the reflectors of the lamps if the turntable should be stopped in certain positions. To eliminate the possibility of interference, a simple shield was installed. The shield consisted of a 1-inch by 12-inch board five feet long, wrapped in fine-mesh chicken wire. The shield was placed very near the beacon on the runway side. The top was tilted back toward the beacon approximately 20 degrees. Then earth was smoothly mounded up against the shield on the localizer side. The length of this shield was selected to screen the outer antennas of the localizer from any exposed part of the beacon. The shield, in addition to protecting from localizer interference, served as a glare shield for the runway and taxiway. The length of the shield was kept to the minimum

Figure 1. The stub approach beacon and shield.

needed to prevent glare and ILS interference in order to provide the maximum feasible horizontal coverage.

A standard VASI system is installed on runway 13. The lights for the VASI are located 750 feet and 1250 feet down the runway from the threshold on each side of the runway.

The test installation of the stub approach beacon was made in 1962.

3. TEST PROCEDURES

The edge of the bluff prevented evaluation of the system by observers on the ground. Therefore, the results of these tests are based entirely on observations made during flight, from 1962 through 1965. Some observations were made by NBS personnel flying in visual flight regulation (VFR) conditions for the purpose of evaluating this system. Most of the observations and evaluations were made by pilots during approaches for landing on this runway. The atmospheric conditions ranged from clear and unlimited to minimums for circling and instrument approaches in both day and nighttime. Pilots participating were light plane pilots with private licences, business executive pilots, airline pilots, and a few FAA and military pilots. Most comments were obtained from scheduled airline pilots.

In asking for comments, the following information was requested: the pilot's position when the beacon was first sighted; his opinion of the suitability of the intensity, flash rate, and flash duration; and any general comments. Additional specific information was requested on occasions. The weather conditions for the time of the approach were recorded. Many unsolicited comments were received. These were either reported directly to the FAA Flight Service Station communicators or reported personally to NBS personnel after the landing.

During the winter and spring seasons when winds favoring use of runway 13 were probable, the beacon was sometimes operated continuously for several days because remote control circuits were not available. The lamps were operated at or near rated intensity during daytime and were switched to low intensity at night by a time switch.

A direct comparison of the effectiveness of different types and numbers of lamps was impractical. A given type of lamp was evaluated for its effectiveness as determined from the comments received. Then it was replaced with another type lamp or with another number of lamps for evaluation.

4. RESULTS

The stub approach beacon was considered a useful visual aid by nearly all pilots who observed it during pattern or circling type approaches. This was especially true for nighttime approaches because, when the pilot was out of the beam of the runway lights and after he had passed the airport beacon on the downwind leg, there were virtually no lights in this approach area to identify the runway unless the taxiway lights were energized. In daytime there was less need for additional visual aids in this area but the pilots' comments were favorable, nevertheless, especially when visibility and ceilings were near approach minimums for the runway.

On straight-in approaches to runway 13, a majority of pilots indicated that the stub approach beacon was effective when the intensity was adequate. When the visual range of the beacon was considerably less than that of the VASI installations, the comments were less favorable. The pilots seemed to find a comparison of the stub approach beacon with the VASI unavoidable for these approaches because operating procedures require using the VASI when runway 13 is the operational runway. At the request of the pilots, higher intensities were used in the beacon to match more nearly the intensities of the VASI.

Many pilots considered the stub approach beacon to be a useful addition to the VASI for straight-in approaches. Apparently the location of the beacon on runway centerline provided an aiming point for alinement between the VASI units. In addition, in some cases the wider vertical beamspread of the beacon helped in locating the end of the runway when the pilot was above the vertical cutoff of the VASI.

Although most comments were favorable, one airline pilot objected to the use of the stub approach beacon. He stated that looking directly toward the flashing light tended to cause a fixation and could cause disorientation or vertigo. He felt that if the stub approach beacon is to be used at all, remote control by the tower or flight service station is mandatory. Other pilots, asked to check for the fixation tendency, did not consider it a problem.

During the tests, in accordance with the pilots' suggestions for improving the performance of the beacon, the duration of the lighted part of the flash was increased and the flash rate was decreased from 72 to 60 flashes per minute to conform with ICAO recommendations for approach light beacons. Apparently the single beacon, as compared to the two-beacon regular approach beacon system, requires a longer flash duration to fix the location of the beacon, but a definite off period is desired for easy recognition and identification.

A need for higher effective intensity was indicated and probably was never completely met because the pilots wanted the visual range of the beacon to nearly match that of the VASI. If the approach beacon is not used in conjunction with a VASI installation, a lower effective intensity may be satisfactory.

Comments indicated that two intensities, one for daytime and one for nighttime, are a minimum requirement. The preference was for at least three intensities with a low setting for clearer nighttime conditions of about 5 percent of the high intensity setting, a medium intensity of about 20 percent of the high intensity setting for lower visibilities at night, and the rated intensity for daytime, and perhaps for use at night in near minimum conditions until the pilot is alined on final approach, if remote control is available to dim the beacon on request. The pilots preferred to be able to see the stub approach beacon at least from the time they were abreast the airport beacon on the downwind leg until about the time they started the landing flare, although a lower intensity was often preferred after alinement on the final approach.

Of the equipment combinations tried, the most satisfactory consisted of five lights symmetrically spaced on the turntable (which was rotated at 12 revolutions per minute about a vertical axis). The beams of the lamps were directed outward with the wider beamspread horizontal and the axis of the lamps elevated eight degrees above the horizontal. The most satisfactory lamps tried were the type 20A/PAR56Q/1, 20-ampere, 500-watt, PAR56 lamps. These lamps were operated at approximately 80 percent of rated intensity on the high intensity because of the limits of the components available for this feasibility test (although a higher intensity was desired) and at approximately 15 percent intensity on the low intensity setting.

The only malfunction encountered in the tests that was significant to the performance of the beacon was the failure of lamps during rain. Two sets of type 20A/PAR56Q/1 lamps failed from breakage of the cover glass. This breakage always occurred in moderate to heavy rain. No breakage was found from rain in other type lamps of similar wattage. The deficiency may be limited to one particular group of lamps and may not be a characteristic of the type of lamp.

The stub approach beacon installation did not seriously affect the ILS localizer at any time.

No tests were made comparing the effectiveness of runway identification lights with the stub approach beacon system since pilot comments indicated that the intensity of the runway identification lights would not be adequate for use in daylight.

5. RECOMMENDATIONS

The stub approach beacon system is recommended for use for approaches to runways where additional visual guidance is required and the use of approach lights, a complete approach beacon system, or circling guidance lights is not feasible.

The beacon should be located on the extended runway centerline within 1000 feet of the threshold, preferably 500 feet ahead of the runway threshold. Terrain features, other installations, or obstruction clearances are some of the things that may prevent location at the preferred position. If it is necessary to locate the beacon much more than 1000 feet from the end of the runway, a complete approach beacon system may be required for adequate guidance.

The beacon should be at or near the same elevation as the end of the runway. The beacon shall not be more than five feet below the elevation of the end of the runway or the elevation of a physical obstruction between the beacon and the end of the runway. It is more economical to mount the beacon at or above ground level, but if this would create a physical obstruction or interference with other installations, e.g., the ILS localizer, the beacon may be installed below the surface with only the lamps projecting above ground level.

The flash rate should be 60 flashes per minute, with a flash duration of at least one-half second. This may be accomplished by mounting five equally spaced lamps with suitable horizontal beamspreads around a turntable rotated at 12 revolutions per minute. An airways beacon base with a 12 rpm drive may be used for the drive mechanism and mounting base.

The effective intensity of the lamps used should be at least 25,000 candelas and the lamps should have a vertical beamspread at 50 percent of peak intensity of 8 degrees or more. The center of the beam should be elevated six to eight degrees above the horizontal. If five steady burning lamps on a rotating turntable are used, the horizontal beamspread of the lamps at 50 percent of peak intensity should be about 35 degrees to obtain the desired flash duration. The lamps should have a life of 1000 hours or more.

Intensity control is required. Preferably the intensity control should be remoted to the control tower or other control center for the airfield. For daylight approaches to this runway the lamps should be operated at rated intensity, unless a lower intensity is requested by the pilot. If remote control is not feasible, a nighttime intensity of approximately 20 percent of rated intensity should be used. The switching may be accomplished by a day-night photoelectric switch or by a 24-hour timing switch. If the beacon is used in conjunction

with a VASI installation, three intensity steps of 5, 20, and 100 percent are needed, to correspond with the intensity steps of the VASI. If continuous remote control can be provided, either the two or three intensity steps may be used, with the latter preferred.

The light from the beacon should be visible throughout all permissible horizontal angles. A light shield may be required on the back side toward the runway and nearby taxiways to prevent objectionable glare. The size of the shield should be the minimum required. An electromagnetic shield may be required for some installations to prevent interference with electronic signals such as the ILS localizer. This may require installing the beacon below ground, with only the light sources above the surface, and placing a shield between the beacon and the electronic signal source. The shield should be the minimum size required to prevent interference.

NBS Report 9045
February 1966
JEDavis, JWSimeroth:ew

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