An Investigation of Some Means To Improve the Daytime Conspicuity of Aircraft

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TECHNICAL DEVELOPMENT REPORT NO. 344

CIVIL AERONAUTICS ADMINISTRATION

TECHNICAL DEVELOPMENT CENTER

INDIANAPOLIS, INDIANA

July 1958

U. S. DEPARTMENT OF COMMERCE
Sinclair Weeks, Secretary

CIVIL AERONAUTICS ADMINISTRATION
James T. Pyle, Administrator
D. M. Stuart, Director, Technical Development Center

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AN INVESTIGATION OF SOME MEANS TO IMPROVE THE DAYTIME CONSPICUITY OF AIRCRAFT*

SUMMARY

This report covers the results obtained from a preliminary investigation of the use of experimental solar reflectors, sweep-beam high-intensity lights, and fluorescent paint as possible means for improving the daytime conspicuity of aircraft.

The results obtained from the various types of solar reflectors were unsatisfactory because it was not possible to attain a satisfactory flash frequency and effective range and still obtain omnidirectional coverage. Solar reflectors appear to be limited in their ability to improve the conspicuity of aircraft.

The average threshold distances obtained in flight during bright daylight of high-intensity lights mounted in the nose of a DC-3 aircraft were: 8.3 miles for a 250-watt, 127,000-candlepower lamp; 14.7 miles for a 600-watt, 526,000-candlepower lamp; and 20 miles for a 900-watt, 2,240,000-candlepower lamp. The average threshold distances of the aircraft itself were: 17.1 miles during the 250-watt lamp tests; 13.4 miles during the 600-watt lamp tests; and 16.5 miles during the 900-watt lamp tests. The over-all results indicate that a light of an intensity of at least 500,000 candlepower or more improves the head-on conspicuousness of aircraft.

Results obtained from flight observations made of an Ercoupe painted with blaze orange fluorescent paint indicate that the paint is most effective when viewed at short distances (two miles) with the ground as a background. Therefore, it shows some promise in helping the pilot to detect aircraft at low altitudes in the proximity of airports where the majority of past midair collisions have occurred.

INTRODUCTION

The limited conspicuousness of present-day aircraft in the daytime is one of the factors contributing to the difficulty of solving the midair collision problem. Higher speeds require that a pilot be able to see an airplane at greater distances to allow him sufficient time to respond and to maneuver his airplane out of a potential collision situation. Conventional paint schemes, and in some cases, the smallness of profile area, are limiting factors in the probability of detection of aircraft. The need for improving the daytime conspicuity of aircraft was shown by the results obtained in previous studies completed at the Technical Development Center.[1, 2]

The purpose of this study was to make a preliminary investigation of the various possible methods of making aircraft more conspicuous, with the intent of selecting the most promising means for further development and evaluation.

SOLAR REFLECTIONS

General Background.

Since approximately 90 per cent of the past midair collisions occurred during CAVU (ceiling and visibility unlimited) weather, generally when the sun was shining, it was felt that

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*Manuscript submitted for publication March 1958.

[1]Wayne D. Howell, "Determination of the Daytime Conspicuity of Transport Aircraft," CAA Technical Development Report No. 304, April 1957.

[2]R. Byron Fisher and Wayne D. Howell, "Investigation of Some Parameters Related to Midair Collisions," CAA Technical Development Report No. 322, November 1957.

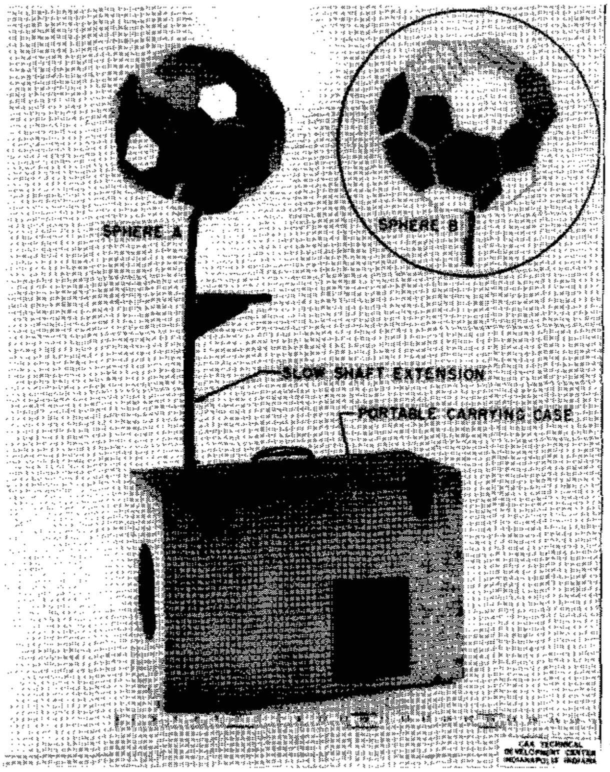

Fig. 1 Spherical-Shaped Solar Reflectors

a device which utilized the sun's rays instead of competing with them should prove to be satisfactory for improving the daytime conspicuity of aircraft. Most pilots, from time to time, while flying during CAVU conditions, have encountered very bright specular reflections of the sun's rays from such objects as metal roof tops, automobile windshields, lakes, rivers, and aluminum surfaces of other aircraft. Solar reflections at times are very annoying, but they do attract the pilot's attention, even when they occur in the peripheral vision. Also, mirrors have been used by pilots who have crashed in remote places to attract the attention of pilots searching for them. These particular phenomena suggested the use of a solar reflector as a device for improving the conspicuousness of an airplane.

Since midair collisions can occur at any angle of convergence, efforts were concentrated on the development of a solar reflector which would give spherical coverage about an aircraft and still provide a reflection which can be seen at a reasonable distance.

Description.

Figure 1, Sphere A, shows a solar reflector which was developed in the early stages of the project. It was the result of the first attempt to design a device which would provide spherical coverage. Two hemispherical plastic bubbles were fabricated and cemented together. Ninety-seven facets were milled on the surface of the globe and polished to a high gloss. The globe then was aluminized, making each facet a front surfaced mirror. The average surface area of each facet is 2.6 square inches, and the total surface area of the globe is 254 square inches.

A similar reflector, Sphere B, shown in the upper right-hand corner of Fig. 1, was fabricated by bonding hexagonal and pentagonal glass mirrors to similarly shaped facets on a hollow aluminum globe. Each pentagonal mirror has a surface area of 4.5 square inches, and each hexagonal mirror has a surface area of 7 square inches. There are 31 facets on this globe having a total surface area of 187 square inches.

For test and observation purposes, these globes were mounted on an extension of the shaft of a reversible, variable-speed, direct-current (d-c) motor. The speed could be varied from 15 to 230 revolutions per minute (rpm). The motor and speed-control rectifier unit were mounted in a case, shown in Fig. 1.

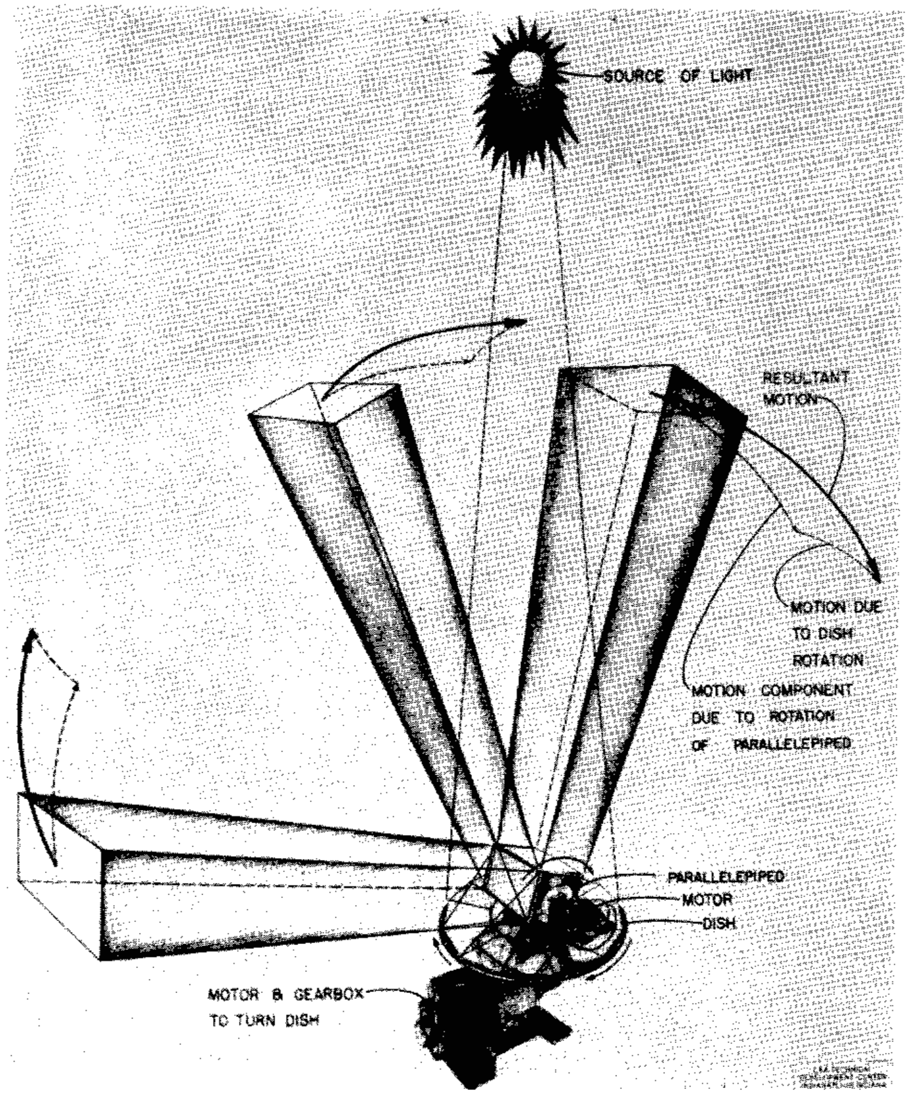

Fig. 2 Parallelepiped Solar Reflector Showing Principle of Operation

Since the solar reflectors shown in Fig. 1 proved to be unsatisfactory, a third test model was developed. See Fig. 2. The complete unit comprises a mirrored dish 16 inches in diameter revolving about its vertical axis and a rectangular parallelepiped 7 1/2 inches by 4 3/4 inches by 4 3/4 inches above the mirrored dish simultaneously revolves about its own horizontal axis. The rotational speeds of the dish and the parallelepiped can be varied independently to achieve various flash frequencies. The dish which has its perimeter mirrors sloping upward at an angle of 10° is used to collect sunlight and reflect it upon the faces of the parallelepiped which, in turn, reflect this light back into the sky. Effectively, both direct and indirect sunlight are reflected off the faces of the parallelepiped. The dish is driven by the output shaft of a Graham variable-speed transmission. The transmission input speed is 3,600 rpm and the output can be varied from 0 to 55 rpm.

A 115-volt, one-half horsepower, continuous-duty, alternating-current (a-c) motor supplies power to the input shaft. The parallelepiped is driven by a 27-volt d-c motor. By varying the input voltage and the gear ratio, the parallelepiped can be rotated at speeds varying from 100 to 320 rpm.

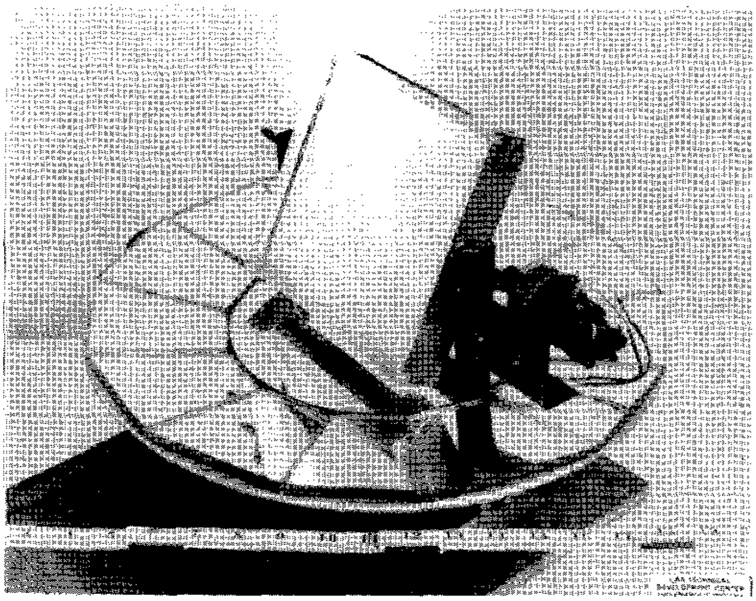

Fig. 3 Large Plate-Glass Mirror Reflector

Three different types of mirrors were tested on the parallelopiped. A slightly convex plastic mirror was fabricated by aluminizing the back surface of a section cut from a Lucite bubble whose radius of curvature was approximately 69 inches. In another configuration and to obtain a greater flash intensity, 2 plate-glass mirrors 7 1/2 inches by 6 3/4 inches were mounted back to back on the trunion, as shown in Fig. 3.

Test Procedure.

The various types of solar reflectors were placed on top of a 40-foot building or an 80-foot radar tower on clear days and observed from both the ground and the air. They were viewed from an airplane from various angles and at various distances to determine their coverage and effective range. Communication was maintained between ground personnel and the flight observer so that rapid changes in mirror rotational speeds could be made as desired.

Discussion of Results.

Results obtained from the spheres shown in Fig. 1 were unsatisfactory. Spherical coverage obtained from Sphere A was poor and the flash intensity of the reflected sun's rays from the facets was so low that the flashes could be seen effectively at a maximum distance of only 1/2-mile when rotational speeds were varied between 15 and 100 rpm. This was attributed to the fact that the facets were too small in surface area. The intensity of light reflected from a mirrored surface is directly proportional to the reflecting surface area. In an attempt to increase the flash intensity, larger mirrors were fabricated, as shown on Sphere B. Although the coverage was less than that obtained from Sphere A, due to the fewer number of facets, effective range was increased to approximately one mile.

The dish-parallelepiped device then was built and tested. Results obtained from this device also were unsatisfactory. When the flat plate-glass mirrors were mounted on the 4 faces of the parallelepiped, the flashes could be seen effectively up to 3 miles when the dish was rotating at 30 rpm and the parallelepiped was rotating at 150 rpm. This produced a desirable frequency of 60 flashes per minute,[3] since 2 flashes were received from the parallelepiped for each revolution of the dish. However, the omnidirectional coverage was poor. Coverage was improved by slowing down the rotational speed of the dish but this reduced the flash frequency which, in turn, reduced the attention-getting features of the device. Therefore,

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[3] Aircraft anticollision lights flash at approximately 80 flashes per minute.

in order to achieve the desired frequency of 60 flashes per minute, the speed of the dish had to be maintained at 30 rpm. The optimum speed at which the parallelepiped could be rotated was determined to be 150 rpm. At rotational speeds higher than 150 rpm, the flashes occurred too rapidly to allow sufficient time for the eye to respond properly to the stimulus. At speeds lower than 150 rpm, coverage was sacrificed.

In order to improve the coverage at these selected rotational speeds of the dish and parallelepiped, slightly convex plastic mirrors were used to spread the reflected rays over a greater angle. Since the plastic convex mirrors were spherical in shape, they tended to spread the reflected rays in all directions and consequently, reduced the flash intensity. Flat rectangular sections of Alclad aluminum were experimented with since they could be bent at varying degrees of curvature in the shape of a cylindrical section where the curvature was in only one direction. The Alclad aluminum mirrors bent in this manner then spread the sun's rays in the horizontal plane only. In this case, coverage was slightly increased but the maximum effective range was only 1.5 miles.

The final model that was tested is shown in Fig. 3. In this model, the parallelepiped was replaced with two large, flat, plate-glass mirrors mounted back to back. The effective range was four miles but the coverage was unsatisfactory.

Although a variety of solar reflector devices were fabricated and tested, none provided a satisfactory combination of flash frequency, range, and coverage despite their size and complexity. Another factor which might hinder the use of solar reflectors on aircraft is the necessity for using small mirrors when mounting a device of this sort in a streamlined section.

HIGH-INTENSITY LIGHTS

General Background.

Aircraft are most inconspicuous when they are approaching each other head-on due to their small frontal area. This situation, of course, is aggravated by the high closing speeds which are encountered. In this type of situation, aircraft need to be seen or detected at the greatest possible distance in order to allow a pilot sufficient time to react and maneuver his aircraft off a potential collision course. The relative inconspicuousness of present-day aircraft approaching head-on was indicated by the results obtained from a recent study conducted at this Center.[4] Although the majority of past midair collisions were in the overtaking and not the head-on category, it does not follow that the head-on situation will not become more critical as more and more aircraft fly the airways and as the speeds at which they fly increase. Therefore, high-intensity lights have been flight-tested to determine their value in providing the pilot a greater margin of safety when approaching another aircraft head-on.

Description.

Three high-intensity lights were installed in the nose of a DC-3 aircraft for flight-observation and test purposes.

A General Electric No. 5044, 250-watt, 28-volt, PAR-36, sealed-beam lamp was the first light tested. This particular lamp has a maximum beam candlepower of 127,000. See Fig. 4. The lamp was attached to an oscillating unit manufactured by the Standard-Thompson Corporation, Dayton, Ohio. This unit would oscillate or sweep the lamp back and forth through a horizontal arc of 60°; that is, 30° to either side of straight-ahead at a rate of 40 oscillations per minute. The oscillating unit was attached to a mounting bracket to facilitate installation in the nose of the aircraft. A view of this arrangement disassembled is shown in Fig. 5. Attached to the side of the mounting bracket is a No. 2 Torrington air blower to prevent the heat of the lamp from warping or distorting the transparent plastic cover on the nose of the aircraft.

The second light tested was a General Electric No. 4559, 600-watt, 28-volt, PAR-64 lamp which normally is used as a landing light. The maximum beam candlepower of this lamp is 526,000. Candlepower distribution curves are shown in Fig. 6. By means of two adaptor rings, this lamp was attached to the same oscillating unit and mounting bracket that was used for the 250-watt lamp. Figures 7 and 8 show the 600-watt light installed in the nose of the DC-3 aircraft. This was the mounting arrangement that was used to flight-test all of the high-intensity lights covered by this study.

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[4] Wayne D. Howell, op. cit.

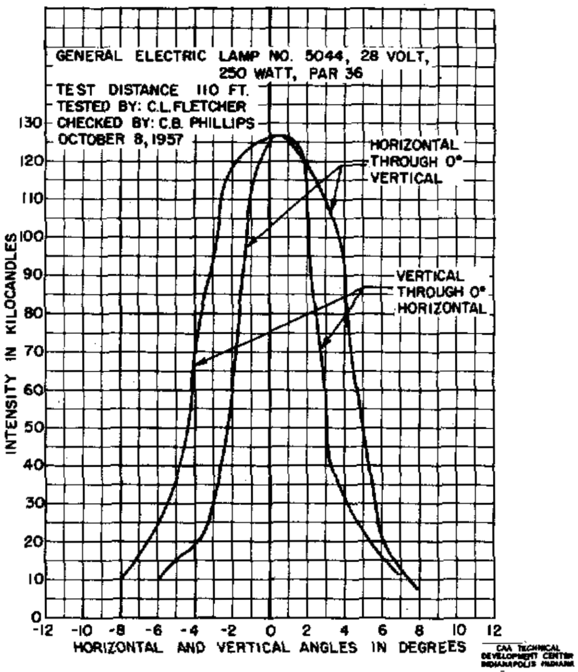

Fig. 4 Candlepower Distribution Curves of the 250-Watt Lamp

The third light tested was a Grimes B-H6, 900-watt, mercury-vapor lamp. The maximum beam candlepower of this lamp is 2,240,000. Candlepower distribution curves are shown in Fig. 9. Disassembled and assembled views of the lamp installation are shown in Figs. 10 and 11. A blast of air flowing at the rate of 6 cubic feet per minute had to be supplied to the light for cooling. A schematic diagram of the electrical circuit and air supply is shown in Fig. 12.

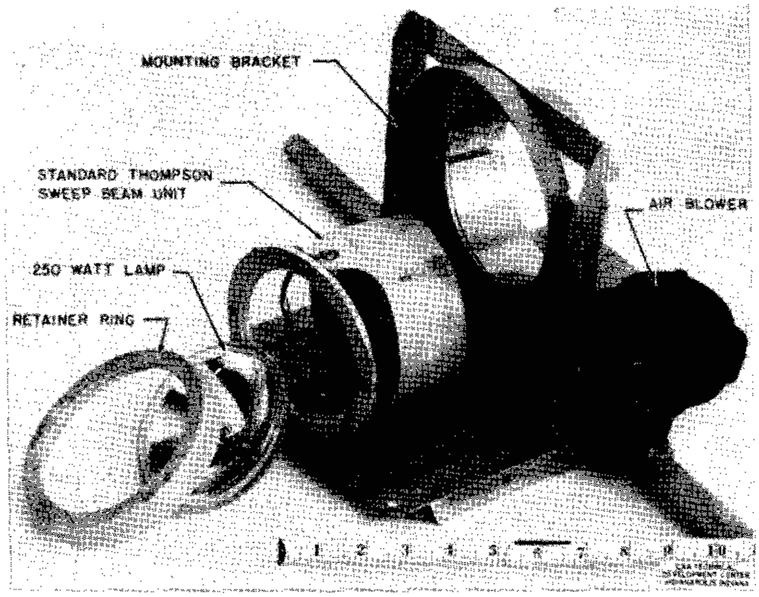

Fig. 5 Disassembled View of the 250-Watt Sweep-Beam Installation

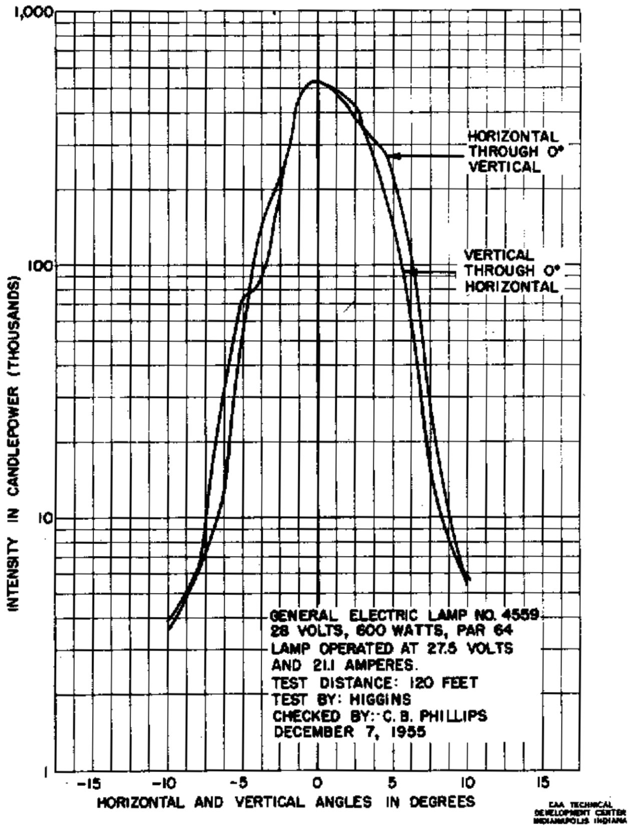

Fig. 6 Candlepower Distribution Curves of the 600-Watt Lamp

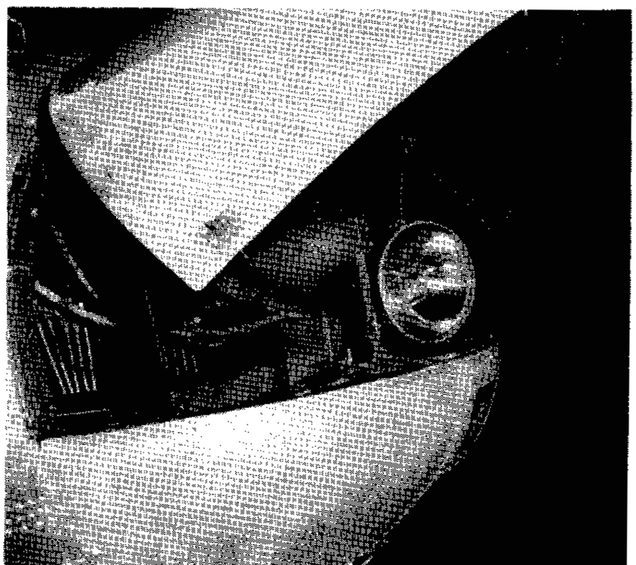

Fig. 7 600-Watt Lamp Installed in the Nose of a DC-3 (Nose Door Open)

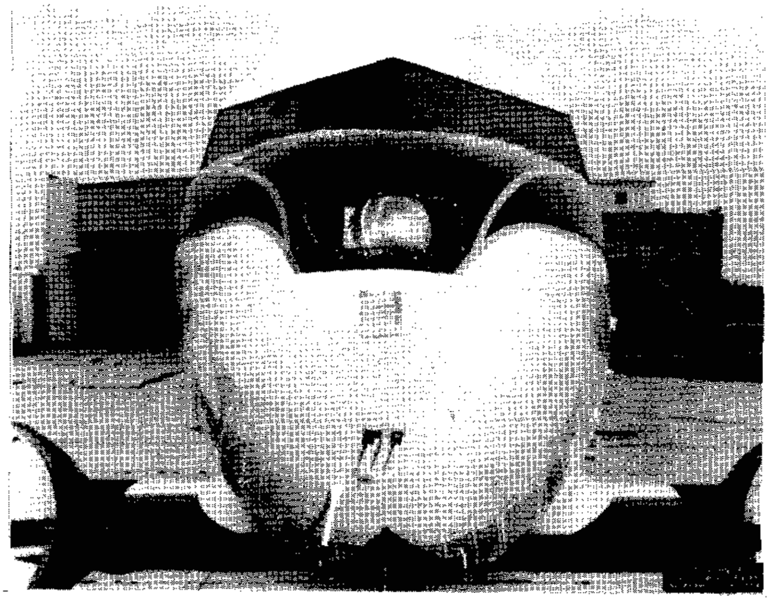

Fig. 8 600-Watt Lamp Installed in the Nose of a DC-3 (Head-On View)

Test Procedure.

In-flight observations were made of each of the three experimental lights mounted in the nose of a DC-3 airplane from another aircraft which approached on head-on collision courses. Each aircraft flew directly opposite radial courses toward the Indianapolis VOR-DME station which was the probable point of collision. Communication was maintained between the two aircraft so that when the observer spotted the light or aircraft at its threshold

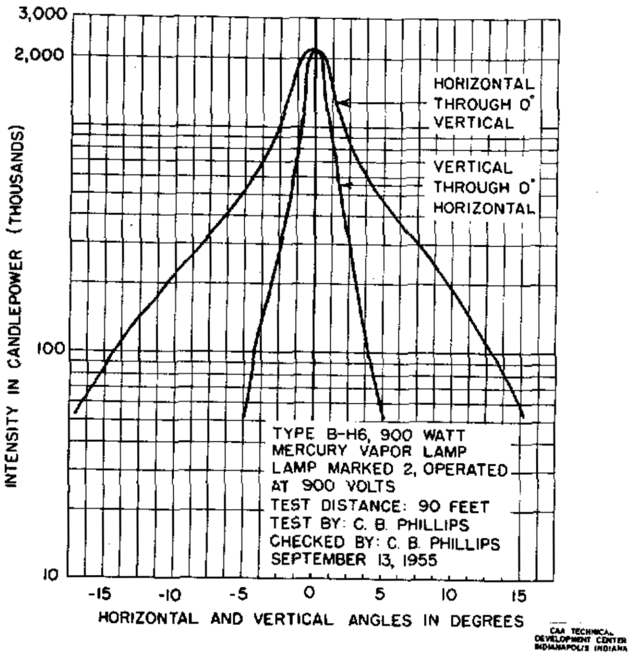

Fig. 9 Candlepower Distribution Curves of the 900-Watt Mercury-Vapor Lamp

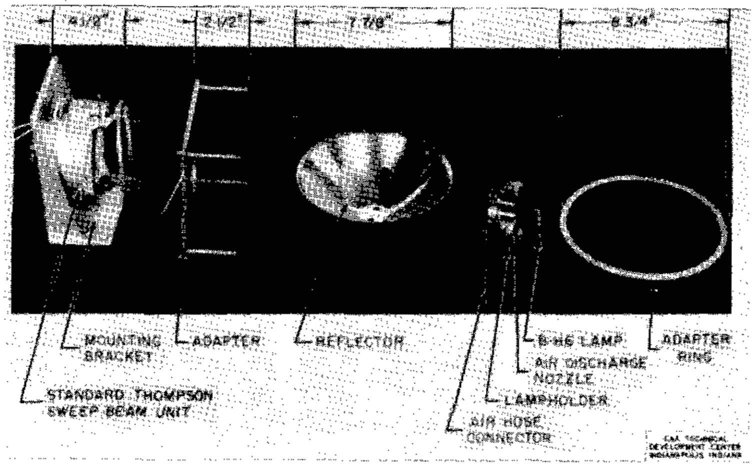

Fig. 10 Disassembled View of the 900-Watt Mercury-Vapor Lamp Installation

he would notify the other aircraft immediately and simultaneous readings of distance were obtained from the DME indicators. By adding the two readings, the aircraft separation distance was obtained.

The majority of the flight tests were made during relatively clear weather conditions in a generally east-west direction. First, the aircraft with the experimental light mounted in its nose would be flying away from the sun, which would require the observer to look in the direction of the sun while searching for the light. In a second flight, the directions were reversed.

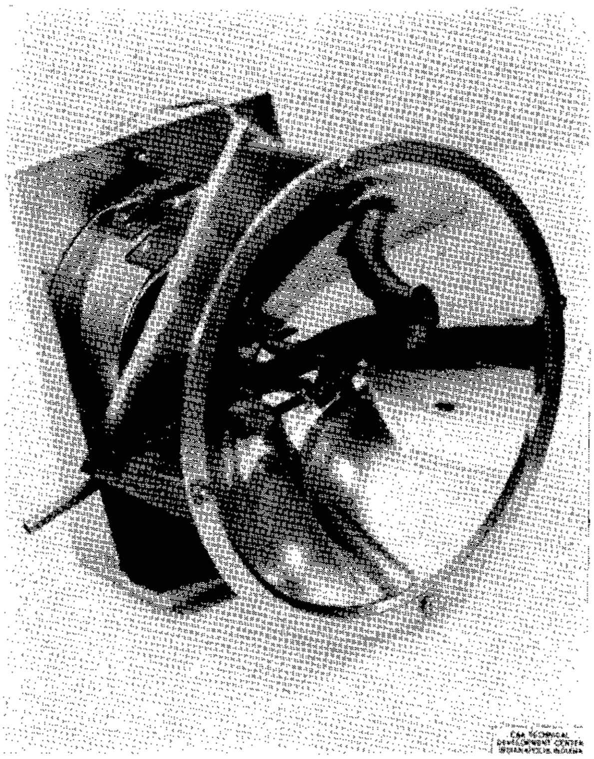

Fig. 11 Assembled View of the 900-Watt Mercury-Vapor Lamp Installation

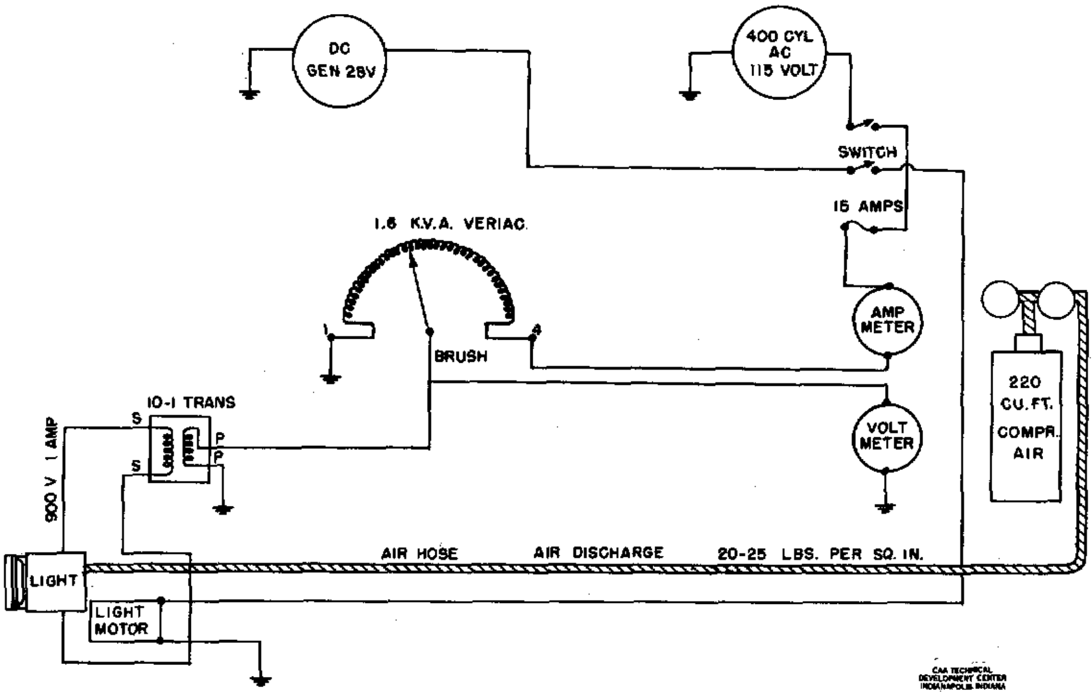

Fig. 12 Schematic Diagram of the 900-Watt Mercury-Vapor Lamp Installation

Discussion of Results.

Table I shows results obtained from the flight tests of the three different lights. The ultimate distance that the 250-watt light could be seen was 10.4 miles when the threshold distance of the aircraft itself was 17.5 miles. The average threshold distance obtained from this light was 8.3 miles. Although this light was ineffective at the aircraft threshold distances, it still had attention-getting features at close range, and it was especially effective when the ambient light level was low.

The 600-watt light was sighted at a maximum distance of 16.5 miles when the aircraft threshold was 18 miles. During test runs Nos. 5, 6, 7, and 8, the threshold of the aircraft was less than that obtained from the other runs. This is accounted for by the fact that, during these runs, there were dark clouds in the background. Since an aircraft at threshold appears black, it is more difficult to distinguish against such a dark background. During these runs, the 600-watt light was seen farther than the aircraft. The average threshold distances obtained (aircraft - 13.4 miles; light - 14.7 miles) indicate that the 600-watt lamp had effectively increased the average visibility distance of the aircraft 1.3 miles.

The 900-watt light was sighted at a maximum distance of 23 miles when the aircraft was visible at 18 miles. The average threshold distances obtained (aircraft - 16.5 miles; light - 20 miles) indicate that the 900-watt light effectively increased the average visibility distance of the aircraft 3.5 miles. This light was very effective even during high ambient light levels. Although the 900-watt lamp proved most effective, the use of this type of light would entail an appreciable weight and power penalty, particularly since a constant supply of compressed air is required to cool the lamp. During these tests, the objective was to study the effect of intensity or quantity of light emitted from each lamp rather than to develop a practical installation.

TABLE I

FLIGHT OBSERVATIONS OF HIGH-INTENSITY LIGHTS

250-Watt Lamp (127,000 Candlepower)

Test No.	Aircraft Threshold (miles)	Light Threshold (miles)	Aircraft Heading: Observer's Aircraft	Aircraft Heading: Aircraft with Light	Time	Weather
1	17.5	10.4	East	West	10:00 a.m.	Widely
2	15.1	8.5	West	East	10:20 a.m.	Scattered
3	18.8	6.3	East	West	10:40 a.m.	Clouds
4	16.8	8.0	West	East	11:00 a.m.	
Average	17.1	8.3				
600-Watt Lamp (526,000 Candlepower)						
5	6.4	13.0	East	West	2:15 p.m.	Scattered
6	12.0	13.1	West	East	2:35 p.m.	Clouds
7	11.0	15.2	East	West	2:55 p.m.	Scattered
8	13.7	15.4	West	East	3:15 p.m.	Clouds
9	18	16.5	West	East	2:00 p.m.	CAVU
10	19	15.0	East	West	2:20 p.m.	CAVU
Average	13.4	14.7				
900-Watt Lamp (2,240,000 Candlepower)						
11	18	20	East	West	2:30 p.m.	CAVU
12	16	19	West	East	2:50 p.m.	CAVU
13	18	23	East	West	3:00 p.m.	CAVU
14	14	18	West	East	3:20 p.m.	CAVU
Average	16.5	20				

FLUORESCENT PAINT

General Background.

A survey of past accidents shows that more than 50 per cent of the midair collisions occurred within 1 mile of airports in visual-flight-rule (VFR) conditions.[5] A majority of these collisions occurred when one aircraft descended upon and overtook another during final approach. In this particular situation, the pilot of the overtaking aircraft has to look below the horizon with the ground as a background to be able to detect the aircraft he is overtaking. Present-day paint schemes of most aircraft tend to blend in with the ground or do not produce a contrast, thereby making the aircraft difficult to spot. Also, in this collision condition, the overtaken aircraft is in such a position that the cockpit visual limits prevent the pilot from seeing the overtaking aircraft. Therefore, in order to help remedy this situation, the use of fluorescent paint to make aircraft more conspicuous was investigated.

Description.

For flight evaluation, an Ercoupe aircraft was painted with blaze orange Day-Glo paint manufactured by Switzer Brothers, Inc., Cleveland, Ohio. The paint scheme utilized on the Ercoupe is shown in Fig. 13. This scheme was selected as the most conspicuous of several

[5] Fisher and Howell, op. cit.

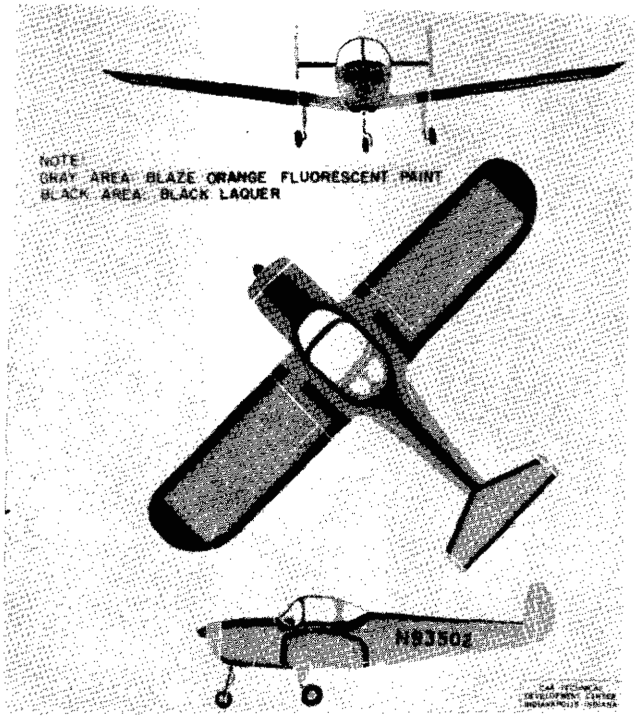

Fig. 13 Fluorescent Paint Scheme Flight-Tested on an Ercoupe Aircraft

schemes which were painted on models and observed against various backgrounds. The top of the engine cowling was painted dull black to prevent the sun's rays from reflecting into the pilot's eyes. The black outline served to make the aircraft conspicuous against light backgrounds where the fluorescent blaze orange was less conspicuous. Blaze orange was selected as the most conspicuous of the following fluorescent colors: fire orange, arc yellow, signal green, neon red, and Saturn yellow.

In applying the paint, the Ercoupe first was thoroughly cleaned and in some areas, the aluminum was etched with an acid solution to allow proper adhesion of the primer coat. Two spray coats of white vinyl primer were applied, followed by two spray coats of blaze orange. The blaze orange then was outlined with black lacquer. Two spray coats of Filteray, a clear nitrocellulose alkyd lacquer sealer, were applied last.

The white undercoat is an essential part of the fluorescent paint process. Nonfluorescent pigments are essentially opaque in nature, and light falling on the paint surface is reflected from the pigment particles, whereas fluorescent pigments are semitransparent and the majority of the light falling on the painted surface passes on through the pigment. Therefore, the white undercoat reflects this light back through the pigment. During this process, the fluorescent conversion takes place. In the case of blaze orange fluorescent paint, the various colors or wavelengths of light that combine in daylight are transformed into an orange light of exceptional purity and radiance. The Filteray was applied according to the manufacturer's instructions in order to lengthen the effective life of the paint.

To study the aging characteristics of the paint, two discarded aircraft upper nose sections were painted with blaze orange and fire orange fluorescent paint and faced south for maximum sun exposure. See Fig. 14. The application procedure was identical to that followed in painting the Ercoupe.

Test Procedure.

The Ercoupe painted blaze orange was tested in flight by comparing it visually with another unpainted aluminum Ercoupe against various backgrounds such as clouds, clear sky, ground, and water. The two Ercoupes flew very close formation while a DC-3 aircraft maneuvered around them in such a manner as to enable an observer to view the Ercoupes

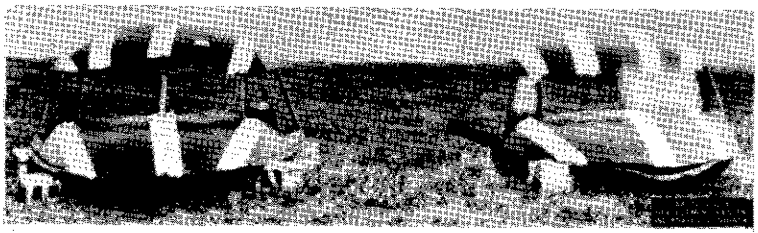

Fig. 14 Aircraft Upper Nose Sections Utilized for Fluorescent Paint Aging Tests

from different angles and at varying distances. The two Ercoupes also were observed by a control tower operator while they were being flown in a prescribed pattern around the Indianapolis Weir Cook Airport.

The aging characteristics of the fluorescent-painted nose sections were determined by measuring the loss in visible light radiation during approximately one year of exposure. These measurements were made periodically during approximately like ambient light conditions; that is, when the sun was in the same relative location and the sky was clear. The maximum radiated light energy from each nose section was measured by means of a Weston Model 856 RR Photronic cell and a Weston low-resistance d-c milliameter. The photoelectric cell was color-corrected with a Viscor filter which made its spectral sensitivity similar to that of the human eye. The reflected light from a foot-square surface of magnesium carbonate was used as a standard.

Discussion of Results.

During the air-to-air observations in bright daylight conditions, it was noted that the fluorescent blaze orange was effective at distances up to 2 to 2 1/2 miles when the area of the Ercoupe being viewed was in direct sunlight and against a sky background. Beyond this distance the fluorescent color faded into a gray or black, and both Ercoupes appeared to be equally visible out to a distance of approximately six miles where they completely disappeared. In some instances, however, the unpainted Ercoupe appeared to be slightly more conspicuous. This occurred at sighting distances of 2 1/2 to 6 miles. When the area of the Ercoupes being viewed was not in direct sunlight, the effective visibility distance of the fluorescent-painted Ercoupe was reduced to approximately one mile.

When the Ercoupes were viewed against the ground, water, and cities from a separation distance of 1,000 feet, the fluorescent-painted Ercoupe proved to be considerably more conspicuous than the unpainted Ercoupe. In some cases, the unpainted Ercoupe would be almost invisible against the background while the fluorescent-painted Ercoupe stood out vividly and attracted the observer's attention very readily.

It was noted during the air-to-air observations that the fluorescent-painted Ercoupe was more conspicuous than the unpainted Ercoupe especially during overcast conditions. Although the sun's rays were partially filtered through the overcast, the blaze orange paint still was fluorescing, thereby providing a much greater contrast against the various backgrounds, especially those which were dark. Also, since the ambient light level was low during these conditions, the unpainted Ercoupe was more difficult to see than during brighter conditions.

The results obtained during the ground-to-air observations are brought out in the following comments of an airport tower controller after he had witnessed the two Ercoupes maneuver in the vicinity of Weir Cook Airport:

Engineer : "In your opinion as a controller, did you find any advantage in the fluorescent paint?

Controller: "If there was an advantage, it was when the aircraft was close to the field. The orange Ercoupe stood out, close in. That would be true of any bright-colored airplane. To spot the two of them and turn away and see which one I would again spot first, it would be the silver one first.

Engineer : "At 2 or 2 1/2 miles, color on an aircraft fades into either gray or black. At a greater distance, did the fluorescent orange paint help any?

Controller: "The silver Ercoupe could be picked up before the orange one. I could not tell the orange color at any great distance even though it had more color to it than the other one. The painted one definitely had some sort of a bright color but you could not tell what color.

TABLE II

RADIANCE FACTORS EXPRESSED AS PER CENT OF LIGHT RADIATED FROM FLUORESCENT-PAINTED AIRCRAFT NOSE SECTIONS AS COMPARED TO THE REFLECTED LIGHT FROM A MAGNESIUM CARBONATE STANDARD

Nose Section	1956 Sept.	1957 April	1957 Oct.	Total Loss
Blaze Orange	186	122	89	97
Fire Orange	141	106	77	64

Engineer : "Did the sunlight help any?
Controller: "Definitely. When they were northwest of the field, the painted Ercoupe stood out real well. It took direct light to make the color stand out.
Engineer : "At maximum visual range, was there any noticeable difference in detection?
Controller: "We actually lost the silver Ercoupe first. It was almost simultaneous. We tried looking away and looking back and there was no difference. When the orange one had direct light, it stood out more than the silver one."

Table II shows the results obtained from the aging tests performed on the aircraft nose sections which were painted with fire orange and blaze orange fluorescent paint. Although the radiated light energy from the painted surfaces was reduced considerably over a period of one year, the nose sections still were very conspicuous. There appeared to be no severe loss in fluorescence.

It will be noted in Table II that radiance factors of more than 100 per cent were obtained from the nose sections. For example, 186 per cent was measured initially from the blaze orange. This means that 186 per cent as much radiant light energy was obtained from the blaze orange fluorescent paint as that obtained from the near-perfect reflecting surface of the magnesium carbonate block. As stated before, fluorescent pigments are semitransparent; consequently, the natural light from the sun or sky which is reflected from the surface (unaffected by the fluorescent paint) combines with that light which is radiated from the fluorescent pigment.

Excessive peeling was noted on both the nose sections and on the Ercoupe. This was caused by poor adhesion between the aluminum surface and the white vinyl primer. This possibly could be overcome by the application of a zinc chromate primer coat underneath the white vinyl, an alternate application method recommended by Switzer Brothers, Inc.

CONCLUSIONS

It is concluded that:

1. Solar reflectors appear to be limited in their ability to improve the daytime conspicuity of aircraft.
2. A high-intensity light, when mounted on the nose of an aircraft in a sweep-beam installation and which emits a light intensity of approximately 500,000 candlepower or more, improves the head-on conspicuousness of aircraft.
3. Fluorescent paint improves daytime conspicuity appreciably and helps the pilot detect aircraft at low altitudes in the proximity of airports, particularly when the aircraft are viewed at short distances and with the ground as a background.
4. Further evaluation of promising means to improve the daytime conspicuity is needed. This evaluation should include the determination of subject pilot response to these means and the distance at which they are detected during simulated collision courses when the subject pilot is unaware that he is flying a collision course.
5. Further study is needed to determine the comparison of fluorescent paint with standard paints, and the effect of various painted patterns.

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