Characteristics of Some Aircraft Anticollision Lights

by

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TECHNICAL DEVELOPMENT REPORT NO. 284

CIVIL AERONAUTICS ADMINISTRATION
TECHNICAL DEVELOPMENT AND
EVALUATION CENTER
INDIANAPOLIS, INDIANA

June 1956

U S. DEPARTMENT OF COMMERCE
Sinclair Weeks, Secretary

CIVIL AERONAUTICS ADMINISTRATION
C. J. Lowen, Administrator
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CHARACTERISTICS OF SOME AIRCRAFT ANTICOLLISION LIGHTS*

SUMMARY

This report describes laboratory and flight tests of some recently developed external lighting units for aircraft Photometric measurements of the lamps and light units were made in the laboratory All but one of the light units were installed on a DC-3 airplane, and threshold-visibility distances for each unit were obtained in flight during clear night conditions For purposes of comparison, the characteristics of the conventional low-intensity position lights also were measured and are reported

INTRODUCTION

The speed of aircraft has more than doubled in the last decade, and air-traffic densities are continuing to increase Until recently, however, external lighting arrangements for aircraft have remained essentially unchanged This has resulted in a growing need for greatly improved effectiveness, and particularly for increased visible ranges of external aircraft lights

Several manufacturers have recognized this need and have developed a number of different types of high-intensity or anticollision lights The Technical Development Center of the Civil Aeronautics Administration has collaborated in much of this development [1] A number of available lights were tested at the Center during 1953, 1954, and 1955 The physical characteristics of the lights and the maximum airplane-to-airplane distance at which they could be seen on a clear night were measured This report describes those tests and observations

DESCRIPTION OF LIGHTING UNITS

The lighting units, Nos. 1 through 8, were installed on a DC-3 airplane They included

1 A rotating V-reflector light supplied by the Grimes Manufacturing Company, Urbana, Ohio
2 Two sweep-beam lights supplied by the Standard-Thomson Corporation, Dayton, Ohio.
3 Three rotating prismatic-lens lights or "Glitterlites" supplied by the Aero Flash Corporation, Chicago, Illinois.
4 A rotating parabolic-reflector light, the "Pounder," supplied by the Aero Flash Corporation
5. An oscillating four-way-reflector light supplied by the Federal Sign and Signal Corporation, Chicago, Illinois
6 A four-lamp rotating cluster light made at the Technical Development Center for experimental purposes.
7 The standard low-intensity flashing navigation lights
8 A small two-lamp rotating light, made for use on small or executive aircraft, manufactured by the Grimes Manufacturing Company

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*Manuscript received for publication February 1956.

[1] Cecil B. Phillips and Alan L. Morse, "A Review of Aircraft External Lighting Activities," CAA Technical Development Report No. 215, September 1953

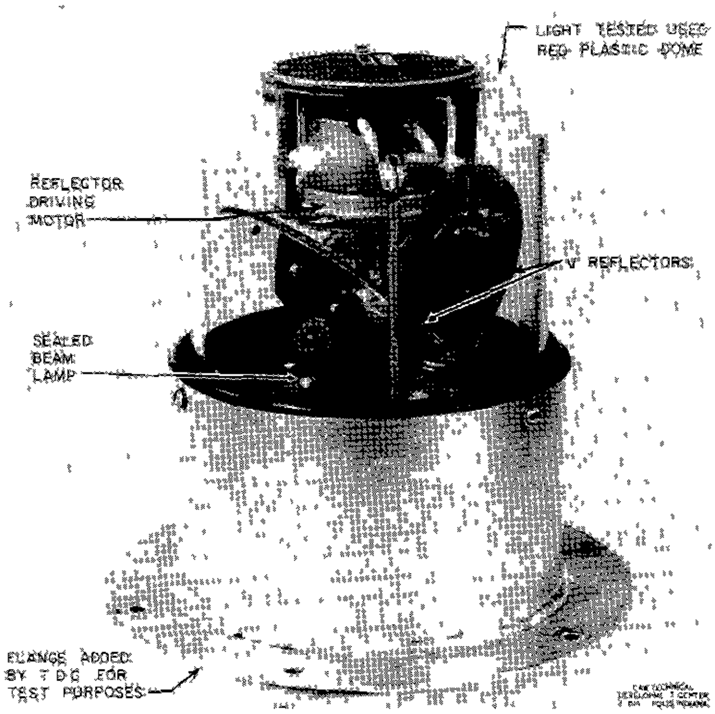

Fig 1 Rotating V-Reflector Light

Another unit, a large two-lamp rotating light developed by the Federal Sign & Signal Corporation, was tested in the laboratory only. It was not installed on the aircraft for flight testing.

A detailed description of these units follows

1 Rotating V-Reflector Light

The Grimes rotating V-reflector light was designed to provide a high degree of coverage and intensity from a single PAR-36 sealed-beam lamp in a compact, lightweight unit This light is shown in Fig. 1 The lamp is submerged in a metal base 4 3/4 inches in diameter and 3 1/4 inches deep. The red plastic dome which covers the two reflectors and their driving motor is 4 1/2 inches in diameter and 3 3/4 inches high The total weight of the unit is 2.5 pounds The beam of light from the lamp is directed upward. Immediately above the lamp are two reflectors in the form of a V which split the beam from the lamp and direct each half outward The reflectors are rotated so that the two high-intensity beams sweep the horizon and from a distance appear as a continuous succession of flashes. One of the reflectors is slightly curved so that the beam it reflects is spread vertically. The beam from the flat reflector is concentrated in a narrow cone. Each beam has a 360° horizontal sweep.

2. Sweep-Beam Light.

The sweep-beam light is designed for submerged mounting within the aircraft structure or within a low drag housing. Also, it is designed to provide wide coverage of high-intensity light. This is accomplished by sweeping a relatively narrow but concentrated beam through a wide arc. This light was designed by the staff at TDC and is shown in Fig. 2 Its design characteristics were determined by previous flight tests of a modified oscillating fire-engine light made by the Carpenter Manufacturing Company, Cambridge, Massachusetts It comprises a cylindrical base and an oscillating lampholder. The base houses the driving motor, the oscillating mechanism, and a radio-noise suppressor. The lampholder a accommodates a PAR-36 sealed-beam lamp which sweeps through an angle of 70°. With the lampholder at its extreme angle of sweep, the light unit is 5 1/8 inches wide, 5 1/8 inches high, and 5 3/8 inches deep Total weight of the unit is 2 2 pounds

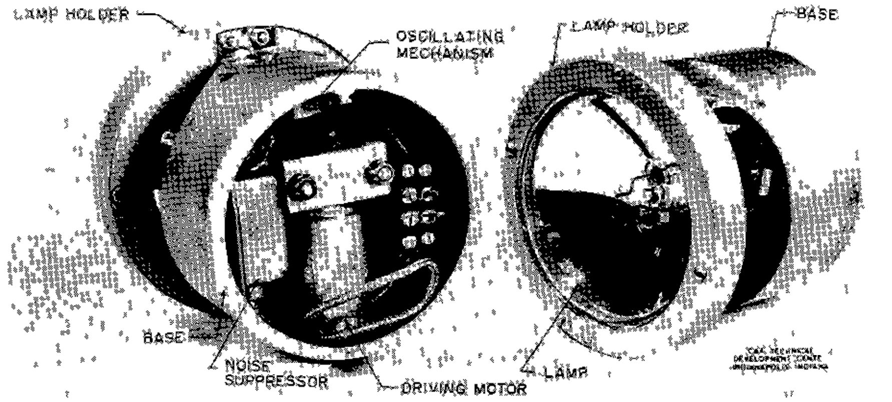

Fig. 2 Sweep-Beam Light

3 Rotating Prismatic-Lens Light.

The rotating prismatic-lens light or "Glitterlite" also is designed for submerged or low drag installation It was believed that the glitter effect would improve attention-getting qualities and would facilitate tracking of the airplane in flight This unit produces an intense, steady light punctuated with flashes of greatly increased intensity at the rate of 600 per minute It was designed by the Aero Flash Corporation, Chicago, Illinois, and is shown in Fig. 3 The light uses a PAR-46 sealed-beam lamp. The lamp is fixed, and a lens consisting of a series of molded glass prisms is rotated in front of the lamp. The lamp and the driving mechanism of the lens are supported by an aluminum casting The lens is rotated at sufficient speed in front of the lamp to cause the light to shimmer or glitter. The light unit is 6 1/2 inches deep and 6 1/2 inches high. Total weight of the unit is 3.7 pounds.

4. Rotating Parabolic-Reflector Light

The design objectives of the rotating parabolic-reflector light or "Pounder" were to obtain 360° horizontal coverage of high-intensity light and to produce an efficient, reliable unit which would be light in weight and low in cost. These qualities should encourage its use

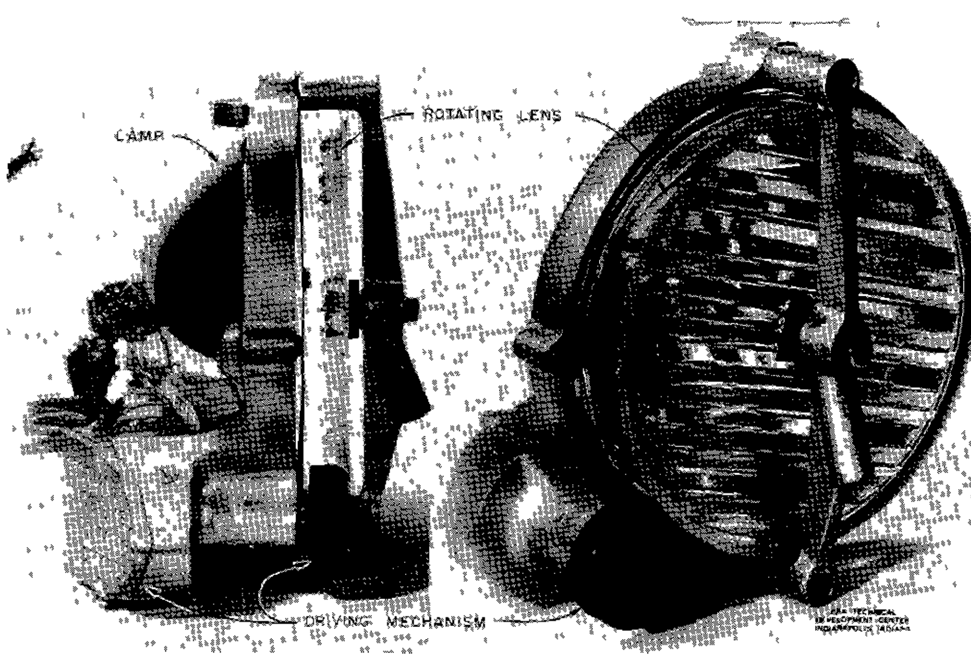

Fig 3 Rotating Prismatic-Lens Light

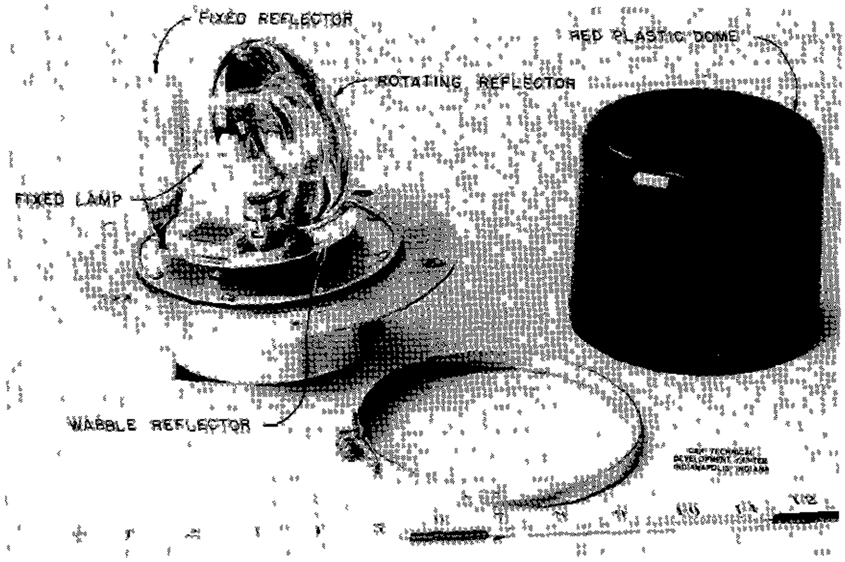

Fig. 4 Rotating Parabolic-Reflector Light

on both transport and personal-type airplanes. The Pounder, shown in Fig. 4, was designed and supplied by the Aero Flash Corporation, Chicago, Illinois. It utilizes a 100-cp incandescent lamp. The unit has three parabolic aluminum reflectors with noncorrosive Alzak surfaces One reflector is fixed, the second reflector rotates around the lamp, thus giving 360° horizontal coverage, the third reflects light upward and rotates with a slight wobbling motion Total weight of the unit is 1 0 pound.

5 Oscillating Four-Way-Reflector Light.

The design objectives of the oscillating four-way-reflector light were to obtain 360° horizontal coverage with sector identification and to produce a lightweight unit which also

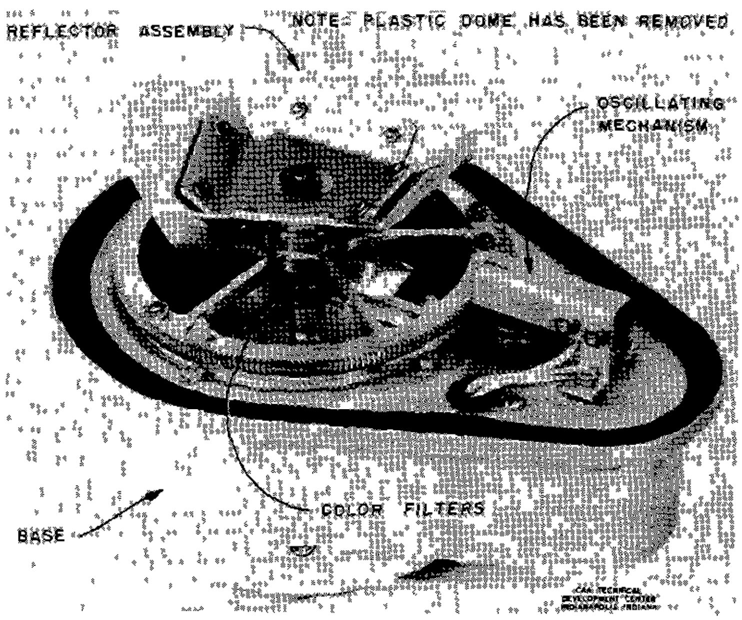

Fig. 5 Oscillating Four-Way-Reflector Light

would be suitable for smaller aircraft This unit, shown in Fig. 5, contains a PAR-36 sealed-beam lamp with its beam directed upward Four reflectors above the lamp divide its beam into four beams which are directed outward The reflector assembly oscillates, causing the four reflected beams to sweep through an arc of 110°. A three-color filter was interposed between the lamp and the reflectors to provide green on the right, red on the left, and clear to the rear A clear plastic streamlined dome covers the oscillating reflectors. The light is 3 inches high, 6 inches wide, and 8 1/4 inches long The aluminum base housing the driving mechanism for the lamp and the color filters is 8 3/4 inches long, 2 3/4 inches deep, and 5 inches wide The weight is 3 0 pounds.

6 Rotating Cluster Light

The main design objective of the rotating cluster light was to increase the effective flash duration while maintaining a flashing frequency of 70 flashes per minute The four lamps in a cluster rotating at 17 1/2 rpm provide 70 flashes per minute, but the flash duration is four times that which would be provided if one lamp were rotated at 70 rpm Other objectives were to obtain high-intensity coverage throughout 360° in the horizontal plane and to obtain sector identification

This light unit, shown in Fig. 6, consists of four sealed-beam lamps which are mounted back-to-back This cluster rotates about a vertical axis so that the four beams sweep in a horizontal plane A metal base, 10 1/4 inches in diameter and 2 3/4 inches high, houses the driving mechanism Each lamp produces a narrow concentrated beam. The lamps are covered by a plastic dome which is 10 1/2 inches in diameter and 5 inches in height The dome is constructed so that red shows to the front and to the left, green to the right, and clear to the rear This provides the conventional sector identification. The weight is 8 2 pounds.

7. Standard Low-Intensity Navigation Lights.

The standard low-intensity flashing navigation lights were the conventional type, that is, the low-intensity wing-tip-light installation and the standard low-intensity red and white flashing-taillight installation

8 Grimes Small Rotating Light

This light, shown in Fig 7, was produced for small aircraft, but it is not necessarily limited to such use because models are available for operation with 12- and 24-volt systems. The unit tested here was the 24-volt light It has two single contact, bayonet, indexing, reflector-type Adler lamps The two lamps, facing away from each other, rotate 360° in a clockwise direction. The beams are more than 30° wide, approximately conical, and are centered slightly above the horizontal plane through the lamp filaments The glass cover is aviation red, and the complete unit weighs 23 ounces

Beacon-Ray Light.

The Federal Sign and Signal Corporation designed this light to provide a suitably strong anticollision light for large, high-speed aircraft. The two General Electric 50-watt, PAR-36 sealed-beam lamps are mounted back-to-back, and they rotate in an aircraft-red transparent glass dome One of these lamps, No. 4505, produces a concentrated conical beam which is centered on the horizontal. The other, No. 4502, incorporates a prismatic lens which provides

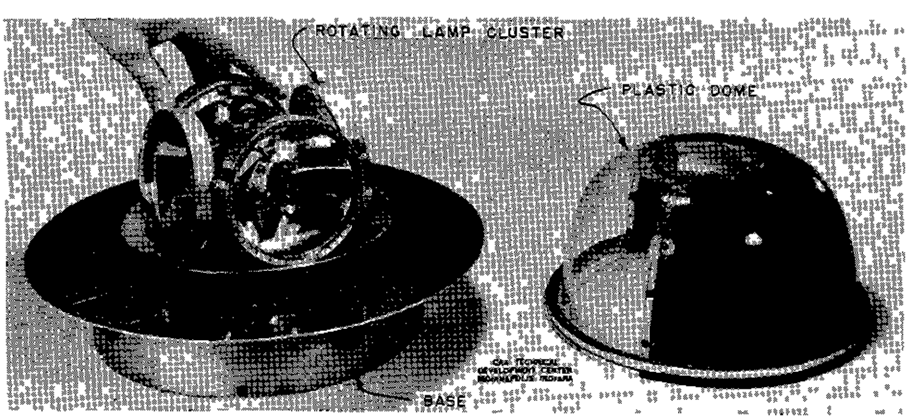

Fig. 6 Rotating Cluster Light

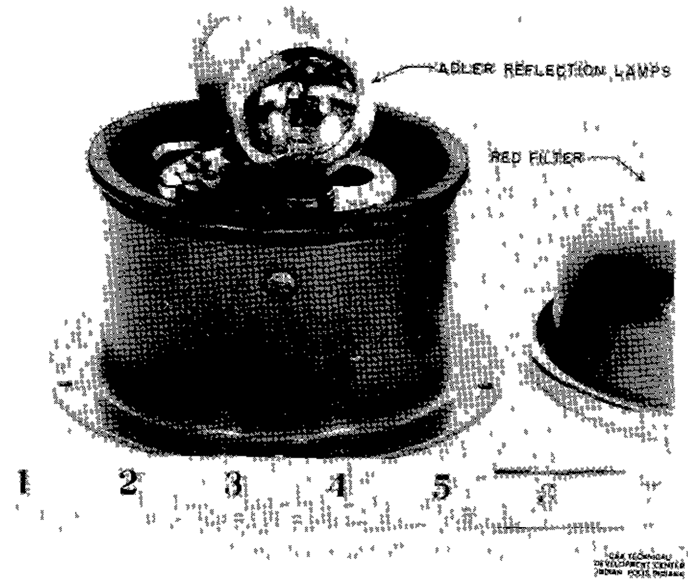

Fig 7 Small Grimes Rotating Light, Filter Off

wider vertical coverage but lower intensity. This lamp is aimed slightly above the horizontal to afford more complete vertical coverage. The unit weighs 8.8 pounds, and it is shown in Fig. 8.

Lamps.

A detailed description of each of the various lamps used is presented in Table I. The two special types of high-intensity lamps for use in flashing-taillight units are PAR-36 sealed-beam lamps, but each embodies a different design principle.

The principle upon which the Westinghouse lamp is based was conceived by Mr. Charles Adler, Jr , Baltimore, Maryland. It involves the use of a spherical reflector or other means to obtain a wider distribution of light than is obtained when the lamp filament is at the focal point of a parabolic reflector The wider distribution is obtained through sacrifice of intensity.

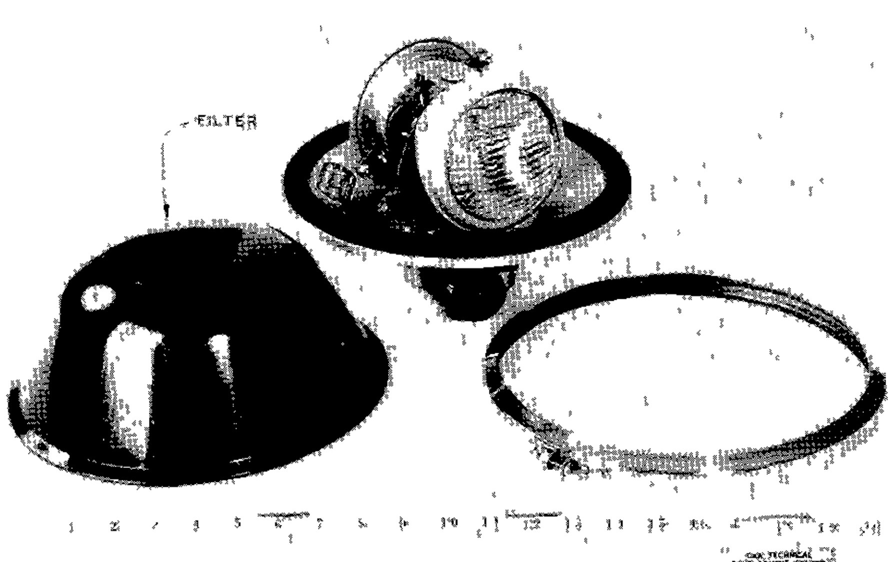

Fig. 8 TWA Constellation Beacon-Ray Light, Filter Off

TABLE I

LAMP DATA

Light Unit	Lamp No	Manufacturer	Type*	Size**	Rating	Filament Type***	Remarks
Flashing taillight	Experimental	Westinghouse	PAR	36	28 volts, 100 watts	Single Radial CC	Wide beam
Flashing taillight	4501	General Electric	PAR	36	26 volts, 5 3 amperes	Four parallel CC	Provides sharp eclipse when flashed electrically
Sweep-beam	4591	Westinghouse	PAR	36	28 volts, 100 watts	Single CC	
Rotating V-reflector	4594	General Electric	PAR	36	28 volts, 100 watts	Single CC	Filament shield used
Rotating prismatic-lens	5190	General Electric	PAR	46	28 volts, 250 watts	Single CC	
Rotating parabolic-reflector	988	General Electric	D.C. Bay	G-16 1/2	28 volts, 100 candlepower	Single C	
Low-intensity flashing wing-tip	1524	Grimes	S.C. Ind	GG-10	28 volts, 24 candlepower	Single CC	
Low-intensity flashing taillight	308	General Electric	D.C. Bay	S-8	28 volts, 21 candlepower	Single C	
Small rotating	A-7079-24	Grimes	S.C. Ind Bay	GG-10	24 volts, 65 watts	Single C	Silvered back
Beacon-ray-type	4502	General Electric	PAR	36	28 volts, 50 watts	Single CC	Prism front
	4505	General Electric	PAR	36	28 volts, 50 watts	Single CC	

*PAR denotes sealed-beam lamp; D.C Bay, double-contact, bayonet; S C Ind, single-contact, indexing.
**Figures refer to the approximate bulb diameter, in eighths of an inch Letters denote bulb shape
***CC means coiled coil. Wire is wound into a helical coil, and this coiled wire again is wound into a helical coil.

The principle upon which the General Electric lamp is based was conceived by Mr A. D. Dircksen, Dayton, Ohio. It involves the use of several filaments connected in parallel. This arrangement produces a sharp eclipse when the light is flashed electrically and thereby improves its conspicuity

LABORATORY TESTS

Lamps

In addition to measurements of electrical and light-intensity characteristics of lamps, the filament temperatures were measured to provide an indication of probable lamp life

The equipment used for photometric measurements consisted of a standard goniometer and photometer The goniometer allowed horizontal and vertical angular adjustments about the lamp's center The photometer included a color-corrected, barrier-layer (dry disc) photocell, Weston Model 856RR. The cell housing was baffled to eliminate any stray light, and the cell was located a sufficient distance from the lamp to insure validity of the measurements. The output of the photoelectric cell was indicated by a sensitive low-resistance galvanometer. A standard calibrated 1000-cp lamp was used as a reference for calibrating the photocell and combination

Prior to measurement of their characteristics, the lamps were operated at their design voltage for approximately 16 hours to season and stabilize the filaments They then were mounted on the table of the goniometer and were positioned so that the points of maximum intensity were sensed with the goniometer at 0° in the horizontal and vertical directions. Measurements of the light intensity were recorded for points along the horizontal and vertical planes which intersected at 0° or the photometric center of the beam. These measurements of light intensity were made without filters. Curves showing the light intensities are shown in Figs. 9, 10, and 11. These curves represent the candlepower distributions, they also show the horizontal and vertical spreads of the beams. These data, together with electrical characteristics and beam widths, are listed in Table II. The two values of maximum beam intensity listed for lamp No. 4591 and shown in Fig. 11 illustrate the variation between lamps of the same type. Several No. 4591 lamps were tested to obtain the range of maximum beam intensity which might be expected in actual practice.

Lamp life is an important factor in evaluating the lamps used in aircraft lighting A major factor in lamp life is the operating temperature of the filament Other factors being equal, high filament temperatures will indicate short lamp life An optical pyrometer, Leeds and Northrup Company No. 8622, was used to measure filament temperatures These are listed in Table II. All are relatively low, indicating that the lights should not require excessive maintenance because of unusually frequent lamp replacements.

Covers and Filters

The transmission characteristics of the covers or filters used on the various light units were compared to determine effectiveness of the units This also made it possible to estimate the effect of substituting other lamps having greater or lesser intensities than those used during the tests All of the filters were made of acrylic resin, and the tests were conducted at room temperature

The equipment used to obtain transmissivity data was a No. 10-210 Aminco photomultiplier microphotometer manufactured by the American Instrument Company, Inc , Silver Spring, Maryland. The multiplier phototube, No. 1P22, in the pickup unit was the high-sensitivity type, with a spectral response similar to that of the human eye The microphotometer was adjusted to give a deflection of 100 while sensing the light from an incandescent lamp. It was then adjusted to read zero when the lamp was turned off. The lamp was operated at constant voltage Next, the light filter or cover to be measured was inserted between the lamp and the photometer pickup. This procedure resulted in a reading of the instrument in terms of per cent transmission of the filter. The results of these tests are listed in Table III

Operating Characteristics of Lighting Units.

In order to provide an additional basis for analyzing and comparing the flight-test results, and particularly to permit an appreciation of the effectiveness of the various lighting units as influenced by both flash duration and intensity, it was considered desirable to obtain records of their time-intensity characteristics while they were in operation Records and measurements were made of the lighting units as mounted on the airplane, including the covers or filters. On the airplane, the filters of the submerged installations and the high-intensity flashing taillights comprised a part of the mounting arrangement.

TABLE II

LAMP CHARACTERISTICS

Lamp No.	Test Conditions (volts)	(amperes)	(watts)	Maximum Beam Intensity (candlepower)	Beam Width* (degrees horizontal)	(degrees vertical)	Filament Temperature (degrees F)	Remarks
Experimental**	28 0	3 2	90	9,000	24	25	4,000	
4501	28 0	5 6	157	80,000	12	11	4,450	
4591	28 0	3 6	100	29,000 to 84,000	14	9	4,500	
4594	28 0	3 5	98	45,000	8	13	Not measured***	Filament shield
4594	28 0	3.45	97	52,200	14	7	4,400	No filament shield
5190	28 0	8 9	250	150,000	13	15	4,450	
988	28 0	2 0	56	120		****	4,250	
1524	28 0	0 72	20	330		****	3,800	
308	28.0	0 68	19	25		****	3,900	
A-7079-24	26 0	1.34	34 8	2,200	36	33	3,860	
4502	27.8	3.7	102 8	2,160	7	40	4,045	
4505	27.8	3 7	102.8	10,150	10	6	4,155	

*Beam width is measured at that portion of the beam where its intensity has dropped to 10 per cent of the maximum
**Experimental lamp had a radially extended filament to increase width of beam
***Unable to measure because of filament shield of lamp.
****Lamp does not include reflector to provide concentrated beam.

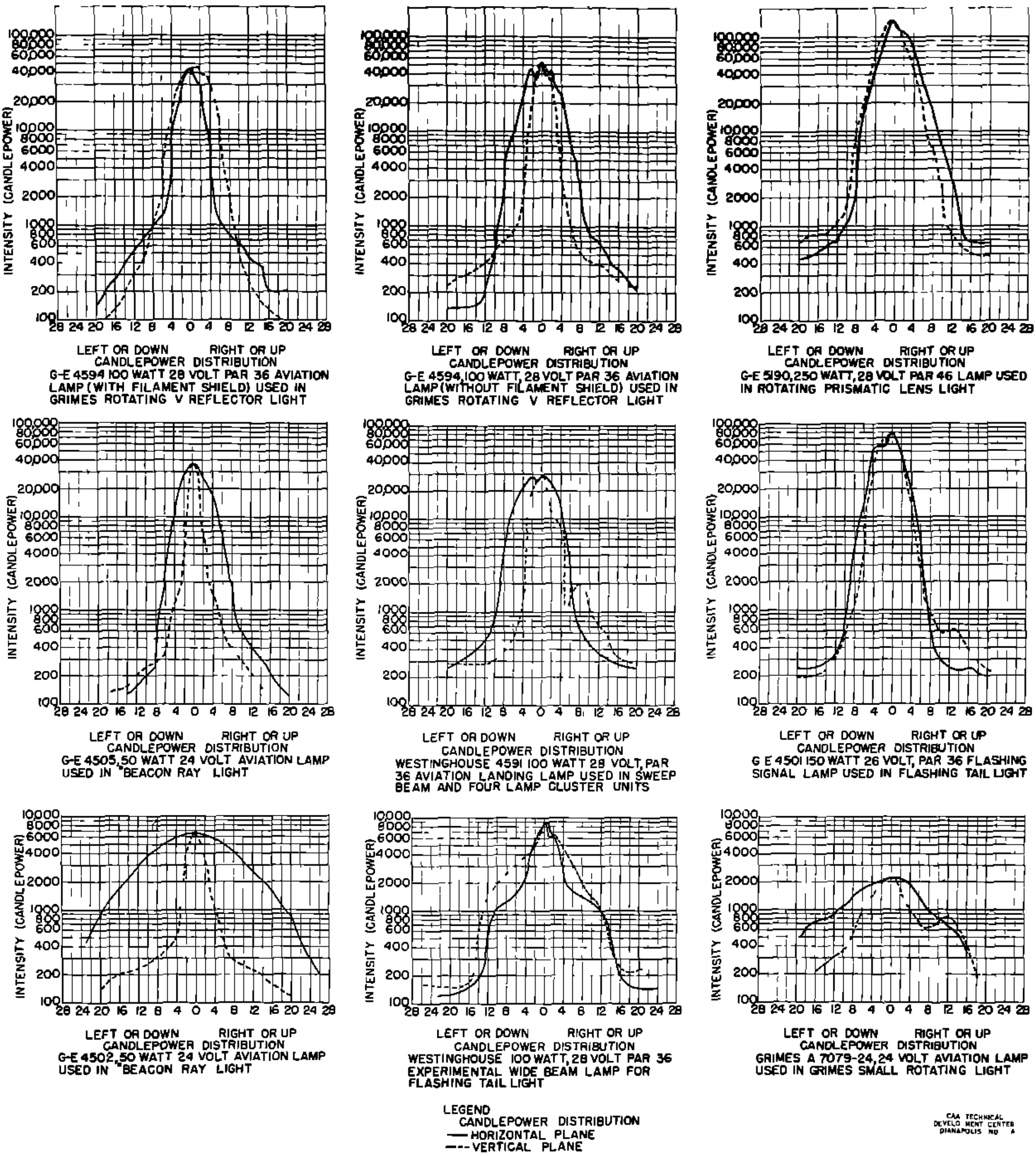

Fig 9 Candlepower Distribution of High-Intensity Lamps

No additional filters were used in the flight installations of the rotating V-reflector light, Fig 1, the rotating parabolic-reflector light, Fig 4, the oscillating four-way-reflector light, Fig 5, or the rotating cluster light, Fig 6. These were mounted on top of the fuselage and were equipped with filters or filter domes

Two sweep-beam units, Fig. 2, were incorporated in streamlined housings mounted on the wing tips of the DC-3 airplane as shown in Fig 12 Essentially, these are high-intensity versions of the standard wing-tip lights because a green plastic nose is used on the right wing tip and a red cover is used on the left wing tip. As shown in the cutaway view, Fig 13, a

TABLE III

TRANSMISSION CHARACTERISTICS OF LIGHTING-UNIT COVERS OR FILTERS

Used in Light Unit	Shape	Size (inches)	Thickness (inches)	Color	Transmission (per cent)	Remarks
Rotating V-reflector	Hemisphere	4 1/2 high, 4 1/2 diameter	1/8	Red	30	Red dome or cover was used, however, clear and amber covers also are available from Grimes Manufacturing Company
Sweep-beam	Streamlined nose	7 front to rear, 7 3/4 diameter		Red Green	20-32* 32-60*	Red nose on left wing, green nose on right wing
Rotating prismatic-lens	Flat	7 diameter	3/16 3/16 3/16	Clear Red Green	92 15 16	Designed for use with clear cover Red and green covers also were used
High-intensity taillights	Hemisphere	2 1/2 high, 4 1/2 diameter	1/8 1/8	Clear Red	92 24-35*	Clear cover for upper lamp, red cover for lower lamp
Rotating parabolic-reflector	Hemisphere	4 1/4 high, 4 5/8 diameter	1/8	Red	30	Red cover used
Oscillating four-way-reflector	Streamlined dome	3 high, 6 wide, 8 long	1/16 to 3/32	Clear	80-95*	Clear plastic dome used, color filters between lamp and dome
	Flat		3/32	Red Green	32 32	
Rotating cluster	Hemisphere	5 1/2 high, 10 1/4 diameter	1/8	Clear Red Green	92 15-28 18-40	Constructed of three colors and arranged to show red in the front and to the left, green to the right, and clear to the rear
Small rotating	Rounded dome	2 1/2 high, 5 diameter	3/16	Red	30	Red glass
Beacon-ray-type	Truncated cone	5 high (approx) 10 7/8 diameter	1/4	Red	31	Red glass

*A range of transmissivity values results from variation in thickness of plastic filters

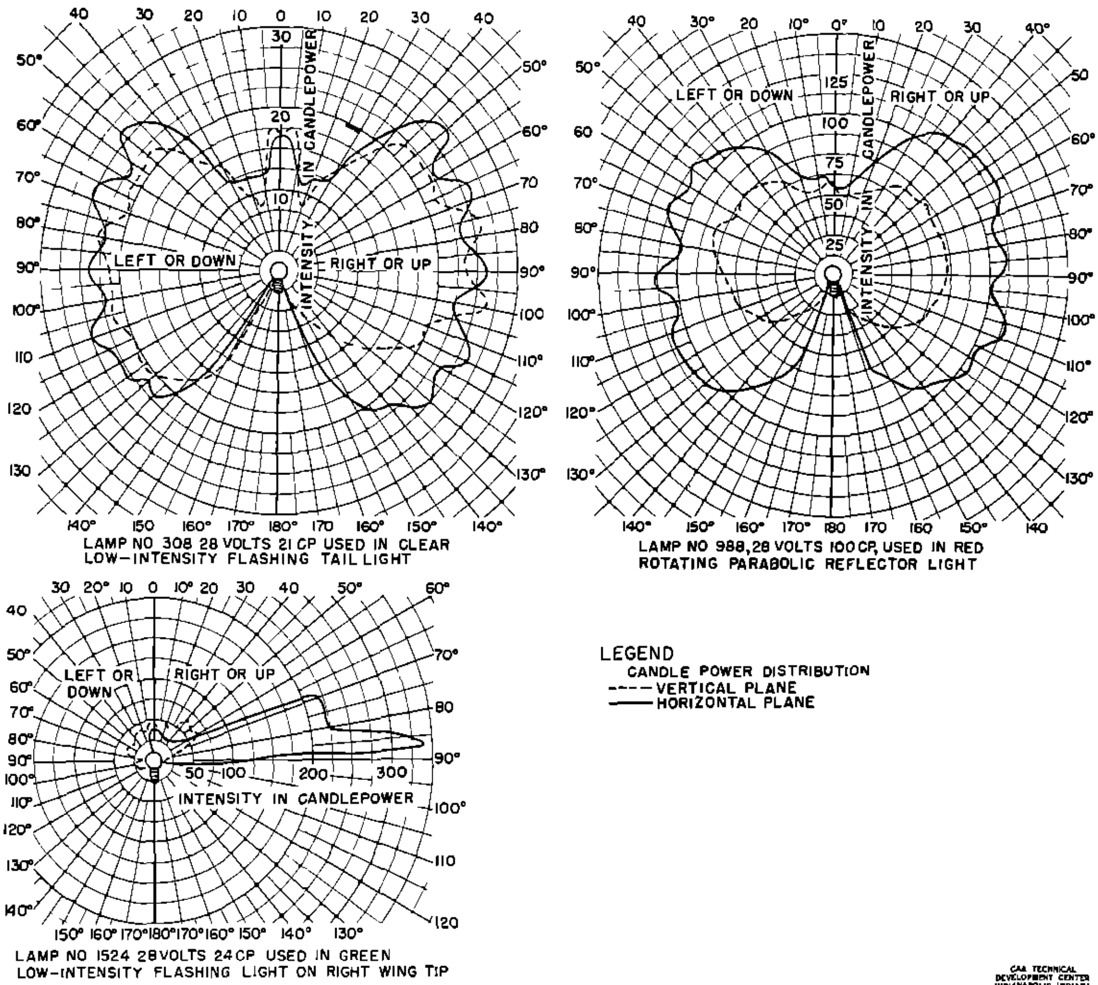

Fig 10 Candlepower Distribution of Low-Intensity Lamps

half-nose of metal on the inboard side of the plastic nose shields the lights from the pilot Fig 13 also shows the 45° reflector which intercepts half of the light beam when the unit is in the straight-ahead position This beam is reflected outboard so that the horizontal sweep angle of 70°, provided by the sweep-beam unit alone, is supplemented by a sweeping reflected beam, making a total sweep of 110°. This combination of direct and reflected beams from each of the wing-tip units sweeps from straight ahead to 110° outboard The beams do not sweep across the pilot's line of vision, however, as he looks out and ahead

The wing-tip sweep-beam installations actually are a part of a basic wing-tip and taillight configuration, but they accommodate high-intensity lighting units The taillight component of this system is shown in Fig 14 Essentially, this is the standard type of red and white flashing-taillight arrangement The high-intensity unit will accommodate two PAR-36 sealed-beam lamps, however Both the wide-angle experimental (Westinghouse) and the multifilament (General Electric No. 4501) lamps were tested

Three Glitterlites were submerged in the fuselage, one in the nose and one in each side The nose unit was covered with clear plastic, and the right and left side units were covered with green and red plastic covers, respectively This arrangement of the three Glitterlites was not intended to represent a lighting system, rather, it provided convenient mounting arrangements and permitted flight measurements of threshold-visibility distances to be made for each color

The small rotating light was not mounted on an airplane, but its operating characteristics are much the same as the rotating V-reflector light Both beams of this light are narrow spot

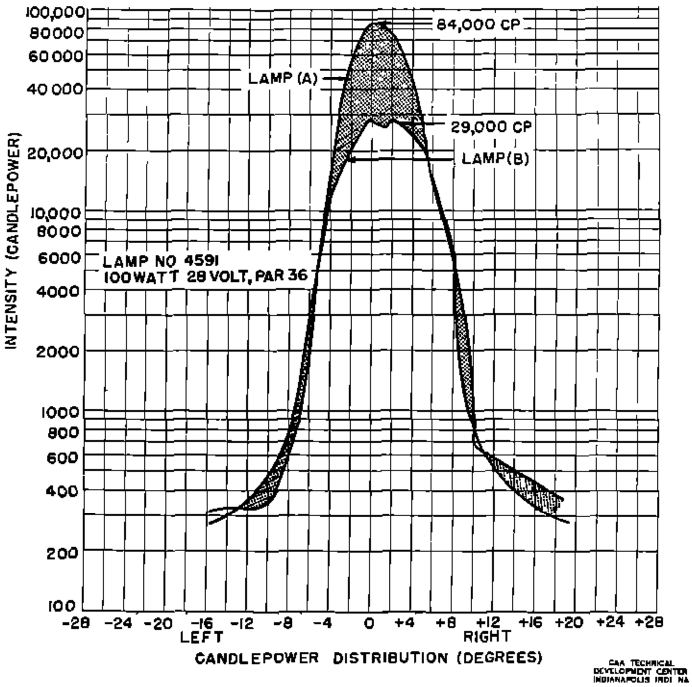

Fig 11 Variations in Maximum Candlepower of Lamp No. 4591

beams with about 35° coverage, and they revolve slightly above the horizontal plane The unit may be mounted on the fuselage, dorsally, behind the cockpit, or on the vertical stabilizer

The beacon-ray-type light operates in the same manner as the small rotating unit The beacon-ray light employs two lamps, much larger in size One throws a spot beam of about 6°, the other, which is set slightly above the horizontal, throws a wide vertical beam of about 40° by 7° horizontal

The time-intensity records of these units were obtained by mounting the flight arrangement of each unit, including filter, on the goniometer Figure 15 shows one of the wing-tip

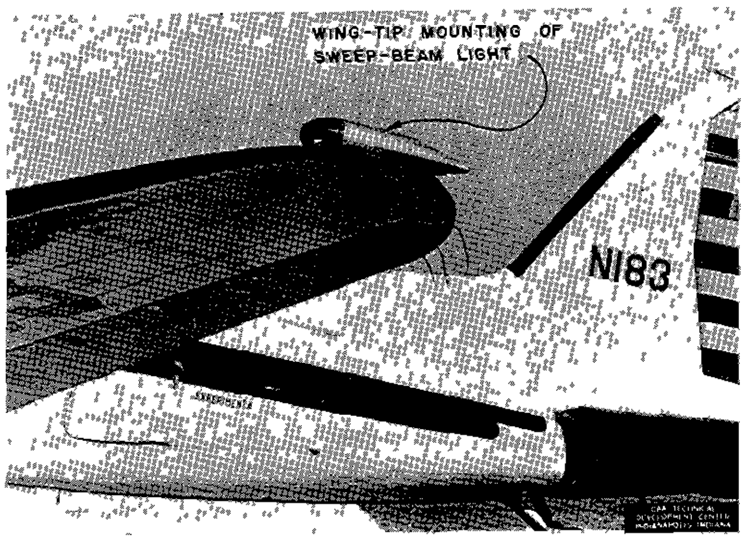

Fig 12 Installation of Sweep-Beam Light

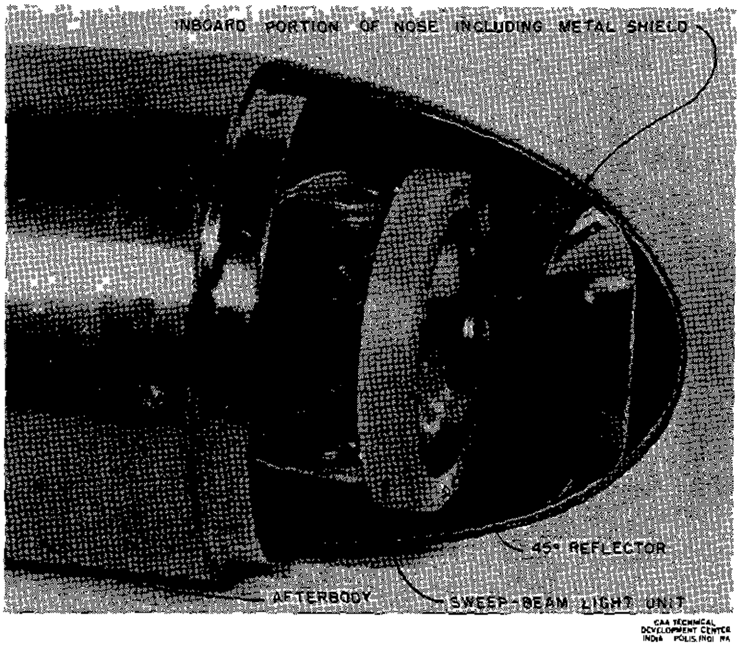

Fig 13 Cutaway View of Wing-Tip Sweep-Beam Light

sweep-beam installations so mounted The units were operated at 27 4 volts dc while the time-intensity records were obtained This is the voltage supplied to the units by the airplane's electrical system during flight.

The sensing and recording instrumentation comprised a system of light baffles, a sensing element, and a recorder. The sensing element is a color-corrected Weston No. 856RR photoelectric cell The recorder is a Model 127 manufactured by the Sanborn Company, Cambridge, Massachusetts. The recorder includes a Type MR-61A micro-microammeter manufactured by the Millivac Instrument Corporation, New Haven, Connecticut, an amplifier, D'Arsonval moving coil galvanometers, and electrically heated styli operating against heat-sensitive paper

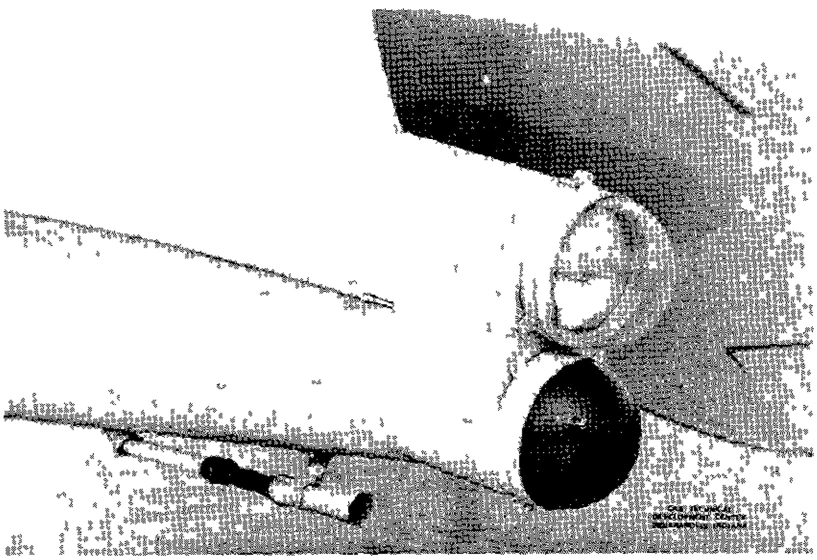

Fig 14 High-Intensity-Taillight Installation

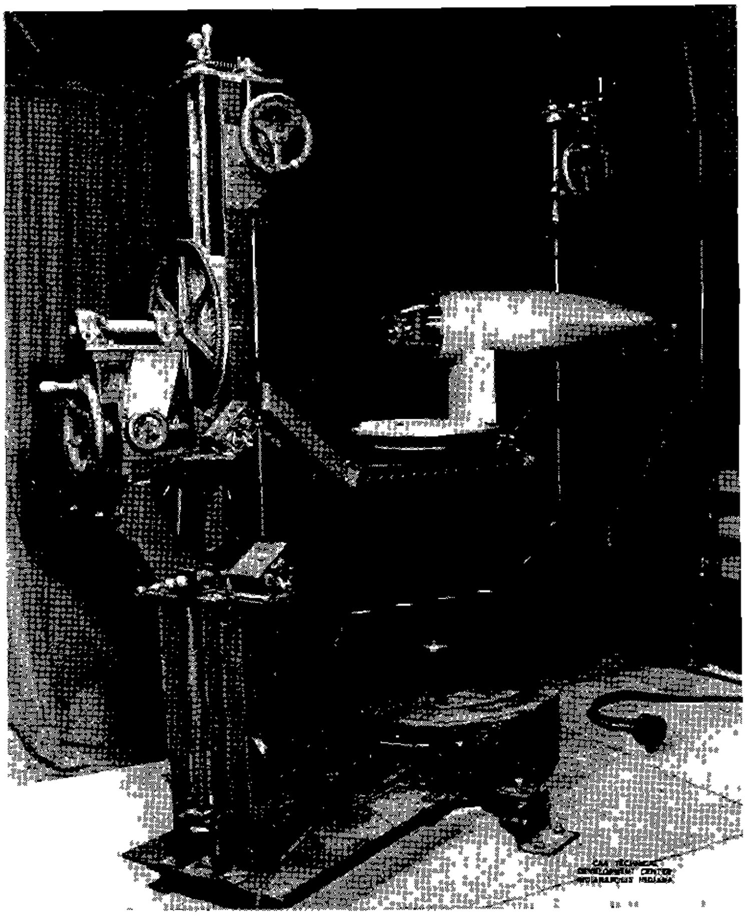

Fig 15 Lighting Unit Mounted on Goniometer

The baffle arrangement used for mounting the sensing element eliminated stray reflections Care was taken to locate the sensing element at sufficient distance from the light being measured to insure validity of the measurements

The accurately predetermined intensities of standard incandescent lamps also were recorded to provide "yardsticks" for analyzing similar records of the various lighting units A 100-cp standard lamp was used as a reference when measuring the time-intensity characteristics of the units of lower candlepowers For the more intense units, a 1000-cp standard lamp was used Neutral-density filters, with accurately predetermined transmission values, also were used as yardsticks of convenient magnitude

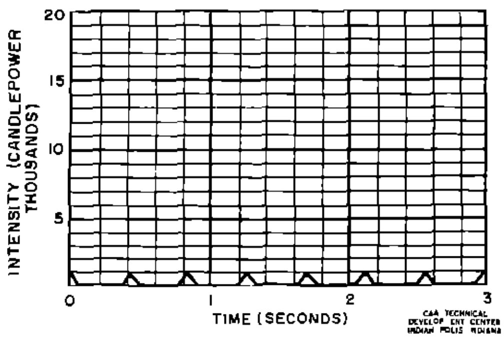

Fig. 16 Time-Intensity Characteristics of Standard 1000-Candlepower Lamp

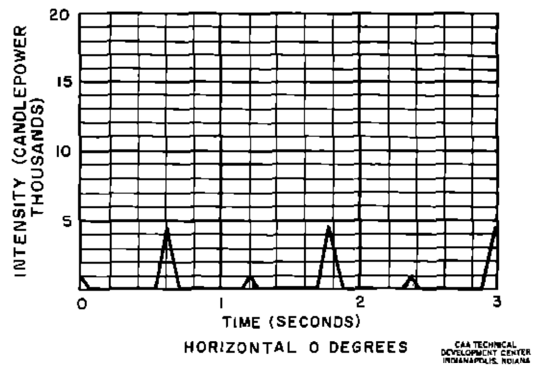

Fig. 17 Time-Intensity Characteristics of Grimes Rotating V-Reflector Light

In recording the intensities of the standard calibrated lamps, a sector disc was rotated between the lamp and the sensing element. Its speed of rotation and angular aperture were adjusted to provide a light duration and flashing frequency approximately equal to the effective flash duration and flashing frequency of the unit being measured.

Time-intensity records of the various units are presented in Figs. 16 through 25 Figure 16 is an oscillogram of the interrupted light output of a standard 1000-cp lamp Figure 17 shows a portion of the oscillogram of the time-intensity characteristics of the rotating V-reflector light Figure 18 shows oscillograms of the left-hand (red) wing-tip unit which incorporates the sweep-beam unit. These were measured from 5° inboard, straight ahead, and 10°, 45°, 90°, and 95° outboard. Oscillograms of the right-hand (green) wing-tip unit are identical except for a slight difference in intensities Measurements of static intensities of both the red and green wing-tip units at various approach angles were made and are discussed later in this report. Measurements at various angles were made to provide a basis for

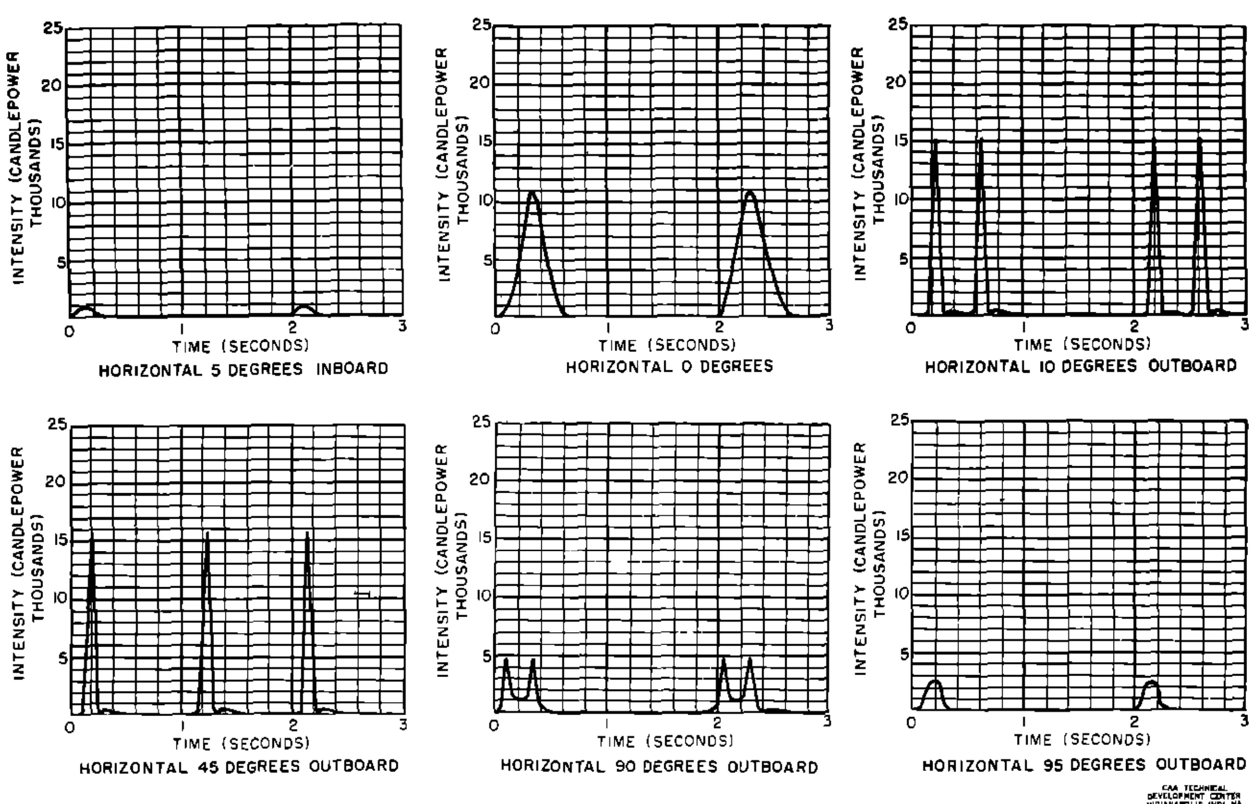

Fig 18 Time-Intensity Characteristics of Red Sweep-Beam Light

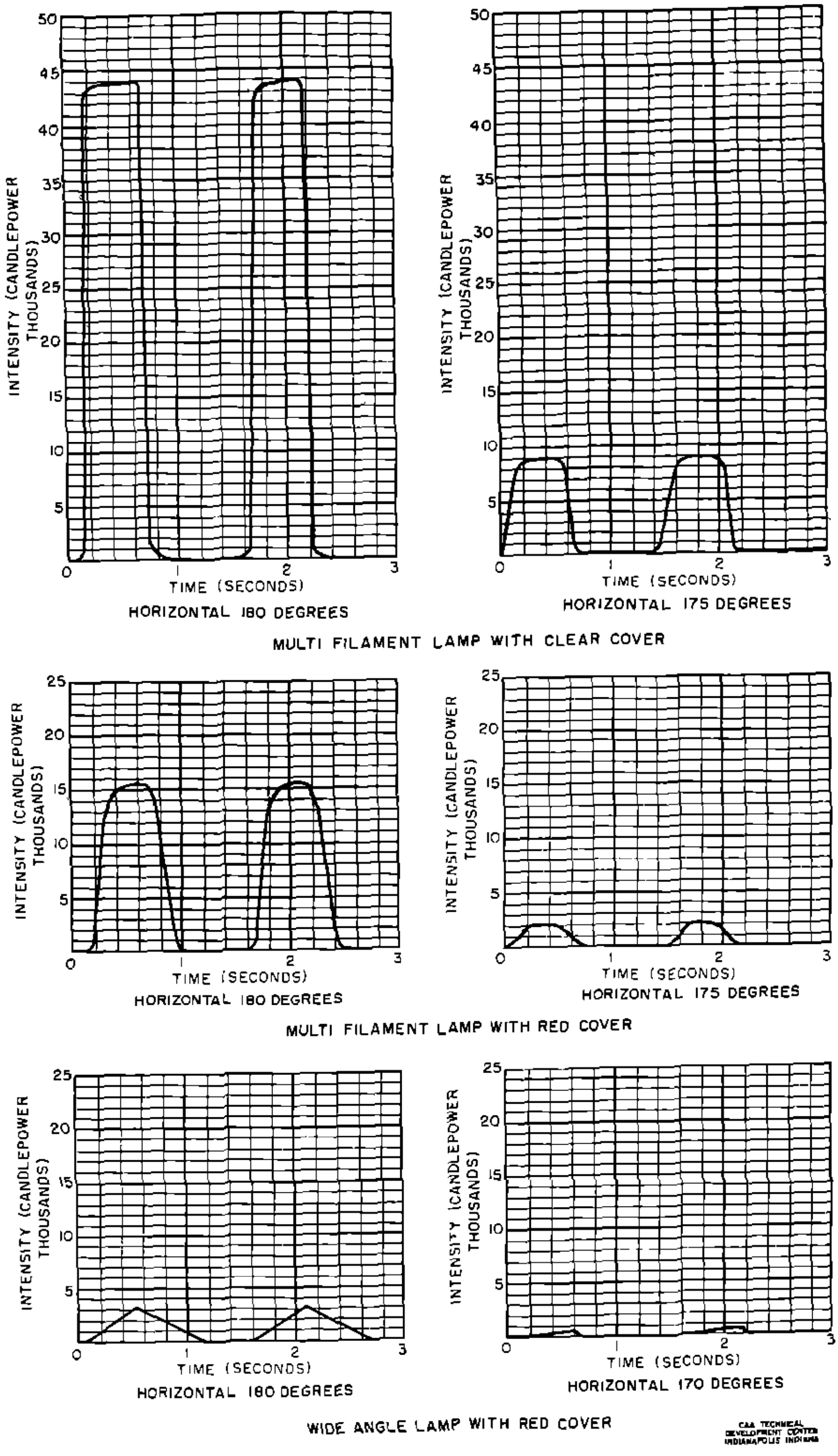

Fig 19 Time-Intensity Characteristics of High-Intensity Taillights

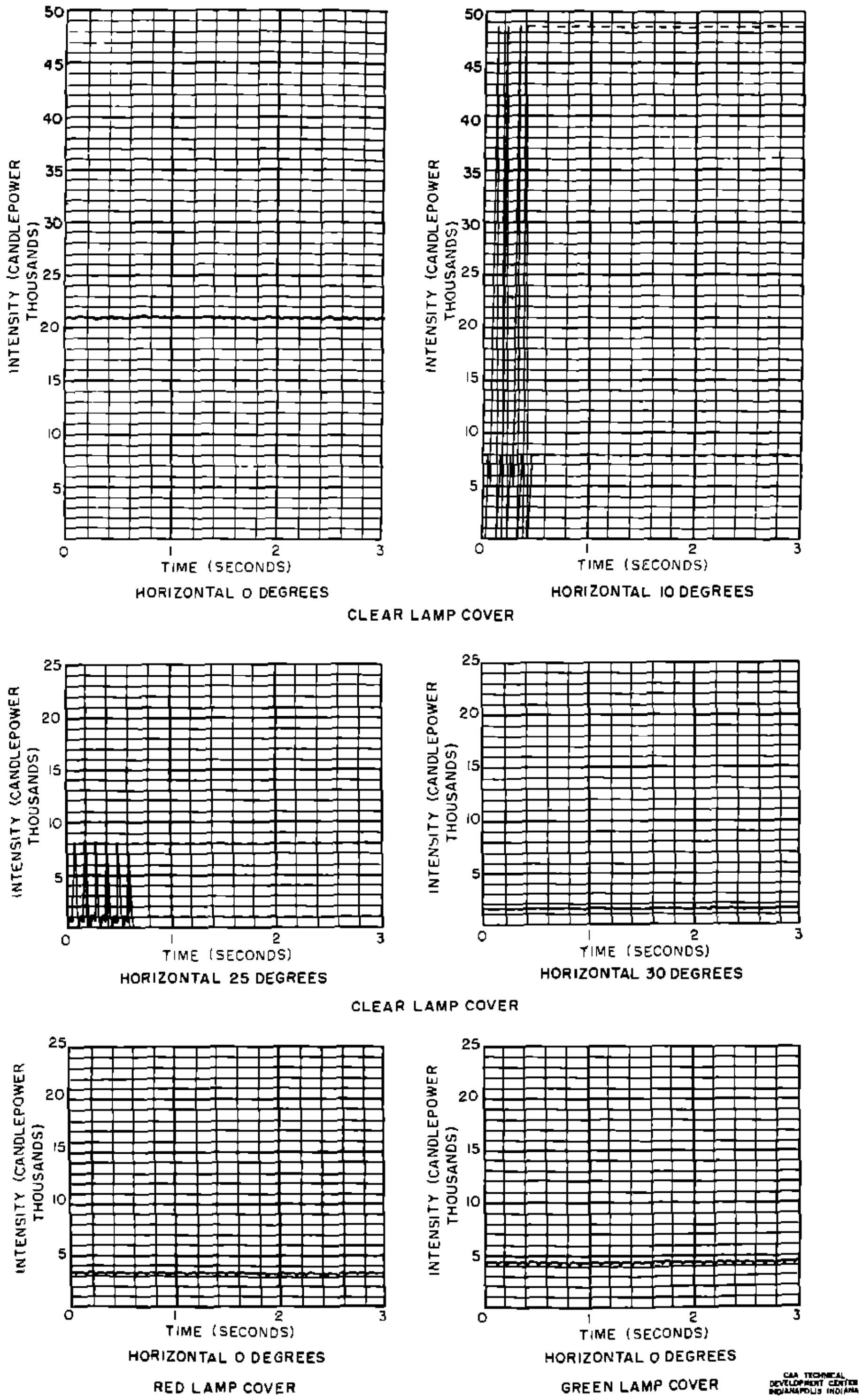

Fig 20 Time-Intensity Characteristics of Rotating Prismatic-Lens Light

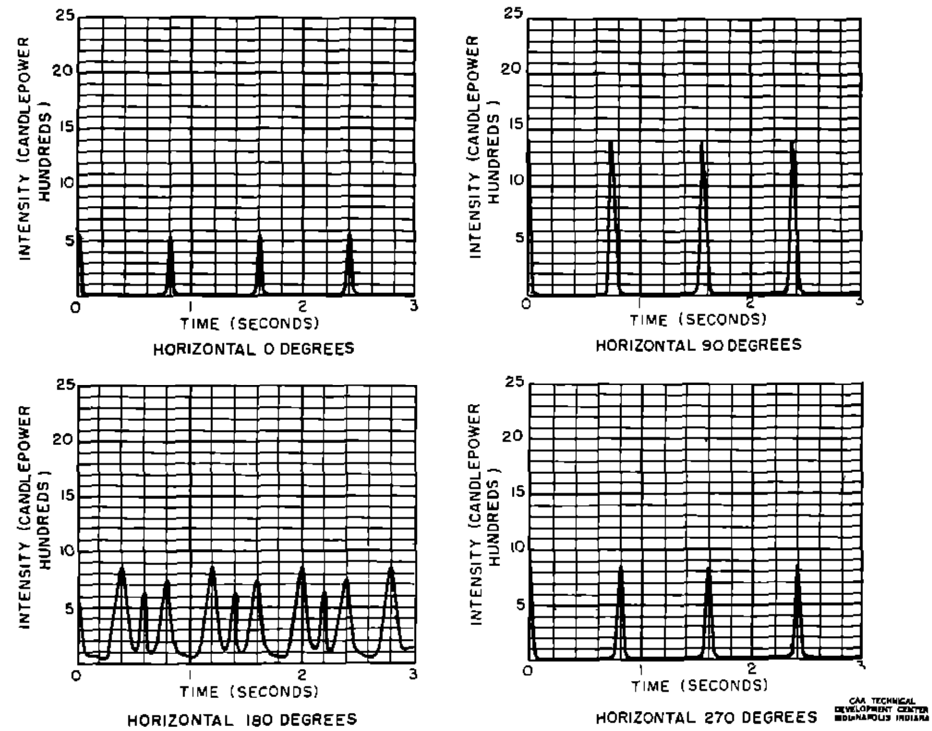

Fig. 21 Time-Intensity Characteristics of Rotating Parabolic-Reflector Light

comparing the effectiveness of the units as seen by the pilot of an approaching airplane from various angles of approach An oscillogram of a standard light was obtained to provide a yardstick for analyzing the oscillograms of the wing-tip sweep-beam units.

Figure 19 shows the time-intensity characteristics of the high-intensity taillights with both the multifilament lamp (General Electric No. 4501) and the wide-angle lamp (Westinghouse) These characteristics were measured from a rearward position (180°) and from a side position which roughly corresponded to a 90 per cent drop in maximum intensity of the beam This angle is 175° for the multifilament lamp and 168° for the wide-angle lamp

Oscillograms showing the time-intensity characteristics of the Glitterlite, the rotating parabolic-reflector light, the oscillating four-way-reflector light, the rotating cluster unit, the small Grimes light, and the beacon-ray unit are shown in Figs 20, 21, 22, 23, 24, and 25, respectively Figure 26 compares the incandescence and nigrescence times of the experimental Westinghouse wide-angle lamp and the General Electric multifilament lamp. Because the ON-OFF times of the standard low-intensity navigation lights are essentially the same as those of the high-intensity-taillight unit, the oscillograms are not shown. The intensitites of the standard navigation lights were measured, however, and are listed elsewhere in this report

A knowledge of the distribution and magnitude of maximum light intensities around the airplane, as provided by the various units or lighting systems using those units, should aid further in their evaluation and should facilitate a better appreciation of the flight-test results Values of those intensities were obtained mainly from the time-intensity data previously discussed In some cases, however, intensity measurements were necessary with the unit-actuating mechanism inoperative They are presented in graphic form in Figs 27 through 32, which also show diagrammatic representations of the motion of the high-intensity beams

Figure 27 illustrates the effect of the rotating V-reflector light when mounted on top of the fuselage and used in conjunction with the standard wing-tip and tail configuration Figure 28 shows the wing-tip installations of the sweep-beam light and the high-intensity flashing taillights Figure 29 shows a Glitterlite intensity distribution A system comprising Glitterlites is not shown Figure 30 illustrates the effect of the rotating parabolic-reflector light, the Pounder, when used in conjunction with the standard low-intensity position lights

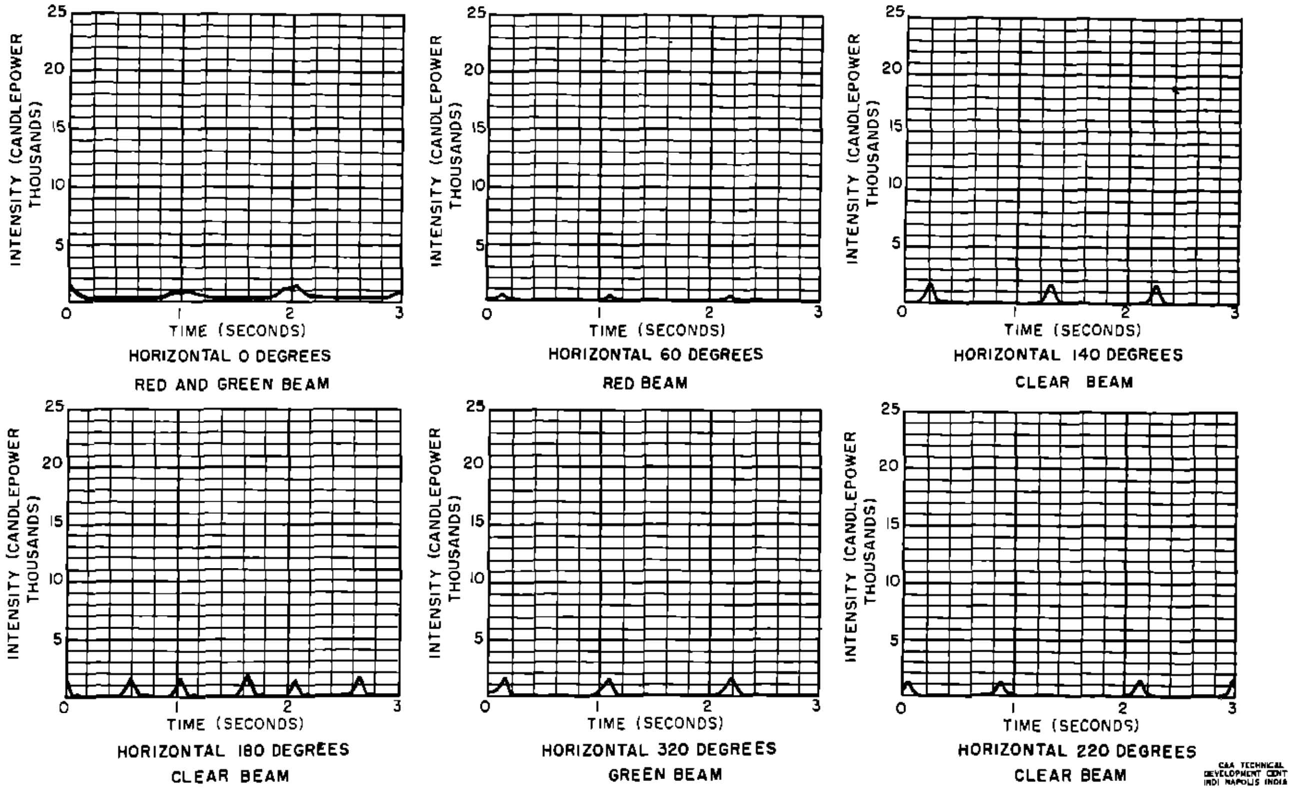

Fig 22 Time-Intensity Characteristics of Oscillating Four-Way-Reflector Light

Figure 31 shows the effect of the oscillating four-way-reflector light when used alone Figure 32 illustrates the four-lamp rotating cluster light A resume of the time-intensity characteristics of the various light installations, together with lamp and filter data, is presented in Table IV

FLIGHT TESTS

The lighting units were installed on a DC-3 airplane Methods of mounting and locations of the units on the airplane were chosen to simplify the work of installation and to facilitate flight observation These are not necessarily the optimum locations from the standpoint of economy, maintenance, or effectiveness Figure 33 shows where the various units were

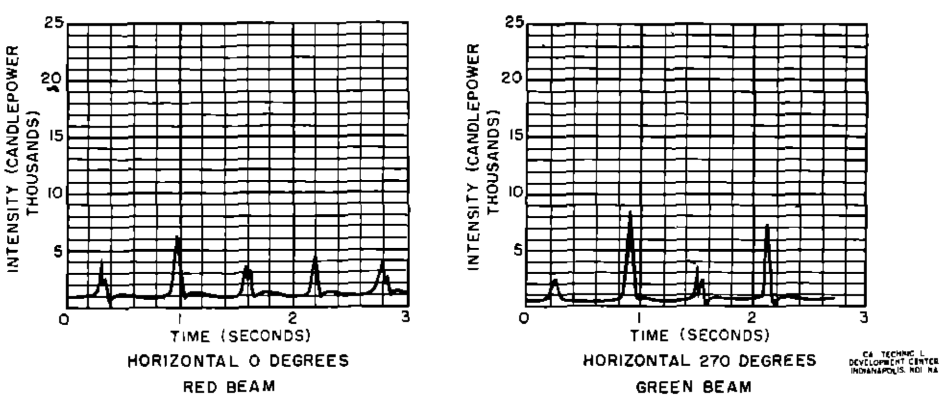

Fig 23 Time-Intensity Characteristics of Rotating Cluster Unit

TABLE IV

SUMMARY OF LIGHT-UNIT CHARACTERISTICS

Light Unit	Lamp No	Filter Color	Filter Trans-mission (per cent)	Maximum Intensity of Unit (candlepower)	Time (seconds) Cycle	Flash	Eclipse	Flashes (per minute)
Rotating V-reflector	4594	Red	30	4,500	0 52	0 04	0 48	58
				940	0 52	0 04	0 48	58
Sweep-beam	4591	Red direct	20-32	15,700	2 0	0 20	1 8	30*
		Reflected		5,000				
		Green direct	32-60	36,700	2 0	0 20	1 8	30
		Reflected		10,000				
High-intensity taillights	Experimental wide beam	Clear	92	8,850	1 48	0 68	0 80	40**
		Red	24-35	3,200	1 48	0 68	0 80	40
High-intensity taillights	4501	Clear	92	44,000	1 52	0 64	0 88	40**
		Red	24-35	15,500	1 52	0 64	0 88	40
Rotating prismatic-lens	5190	Clear	92	48,750	No definite eclipse			
		Red	15	7,850	Light seems to glitter			
		Green	16	8,360				
Rotating parabolic-reflector	988	Red	30	1,420	0 84	0 04	0 8	70
Oscillating four-way-reflector	4594	Clear	80-95	2,060	1 04	0 10	0 94	58
		Red	32	1,000	1 04	0 10	0 94	58
		Green	32	1,370	1 04	0 10	0 91	58
Rotating cluster	4591	Clear	92	39,000	0 60	0 08	0 52	100
		Red	15-28	6,400	0 60	0 08	0 52	
		Green	18-40	8,500	0 60	0 08	0 52	
Standard taillights	308	Clear	75	40	0 75	0 54	0 21	40**
		Red	16	14	0 75	0 54	0 21	40
Standard wing-tip	1524	Red	25	83	0 75	0 54	0 21	
		Green	10	64	0 75	0 54	0 21	40
Small rotating	A-7079-24	Red	30	455	0 67	0 16	0 51	90
Beacon-ray-type	4502	Red	31	1,990	2 86	0 08	2 78	22
	4505	Red	31	10,000	2.86	0 12	2 74	22

*Flash frequence is 60 except at end of sweep as indicated
**Alternate red and white flashes combine to produce 80 flashes per minute

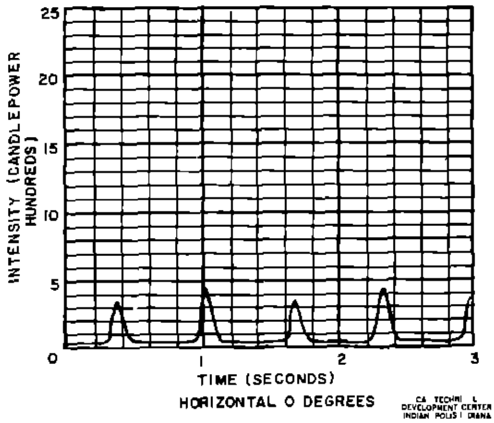

Fig 24 Time-Intensity Characteristics of Small Grimes Rotating Light

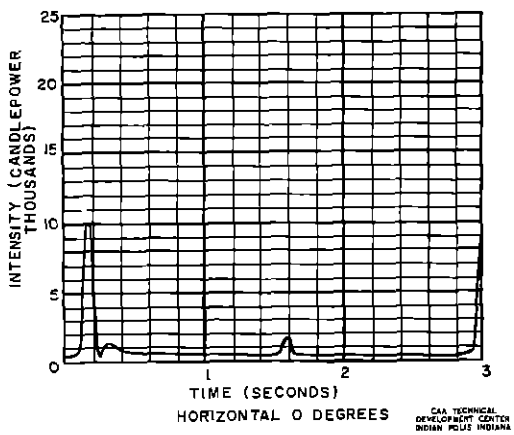

Fig 25 Time-Intensity Characteristics of TWA Constellation Beacon-Ray Light

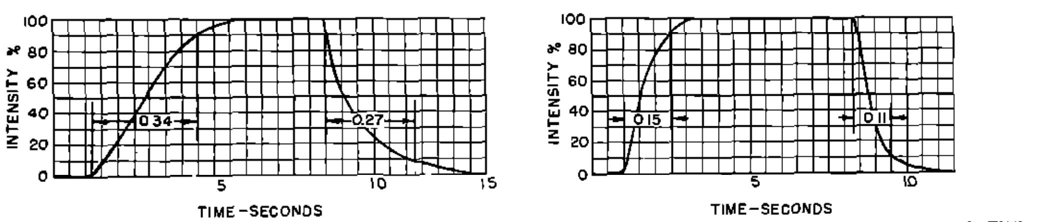

Fig 26 Incandescence and Nigrescence Times for Lamps Used in High-Intensity Taillights

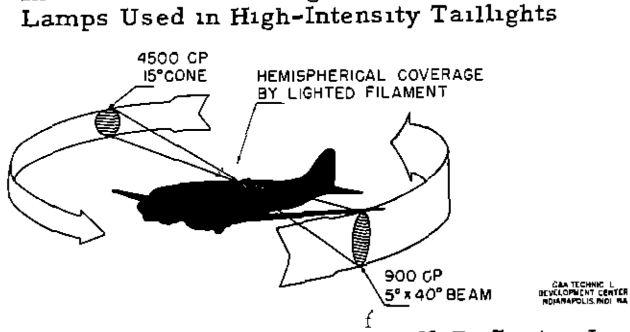

Fig 27 Beam Coverage, Grimes Rotating V-Reflector Light

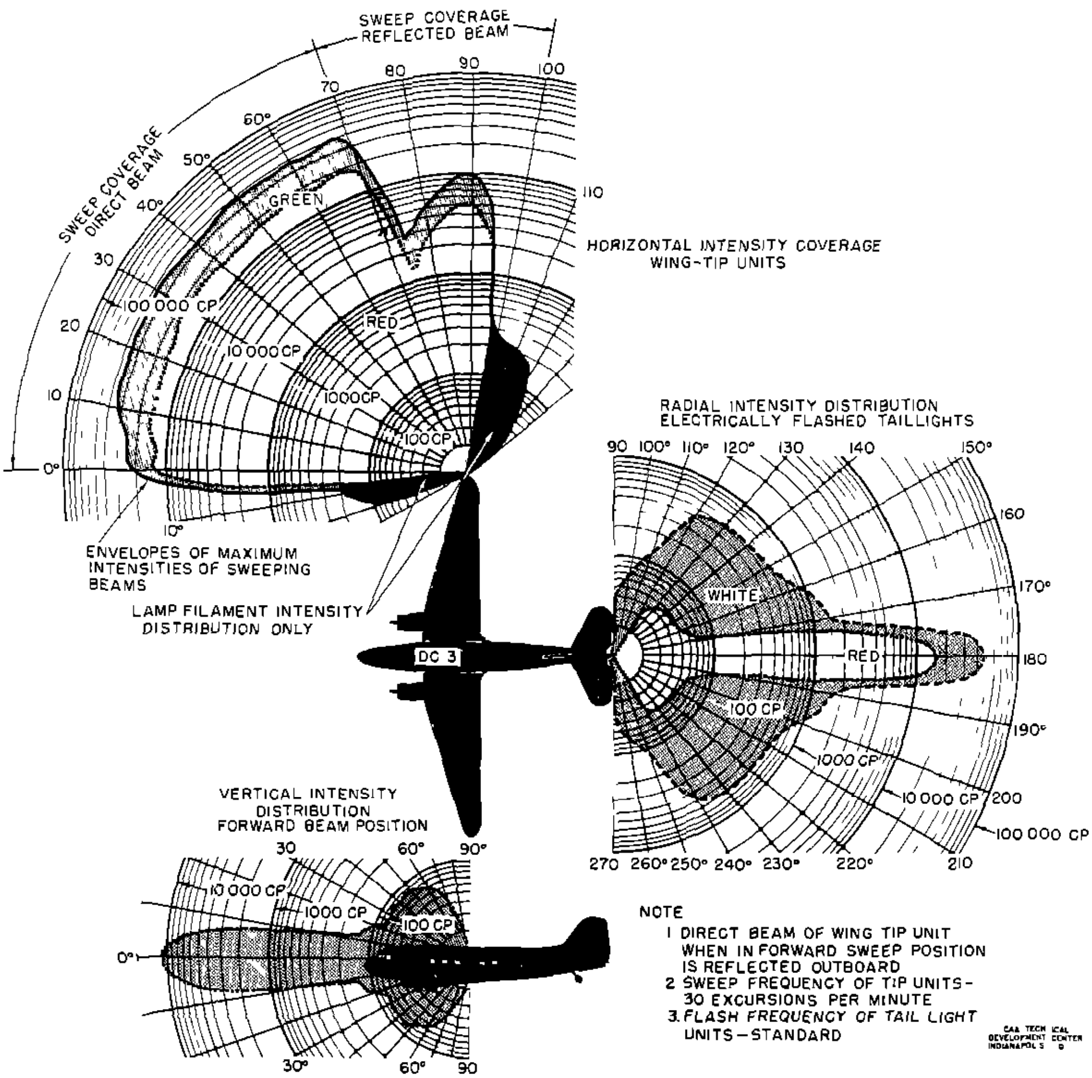

Fig 28 Coverage and Intensities, High-Intensity Position-Light Arrangement

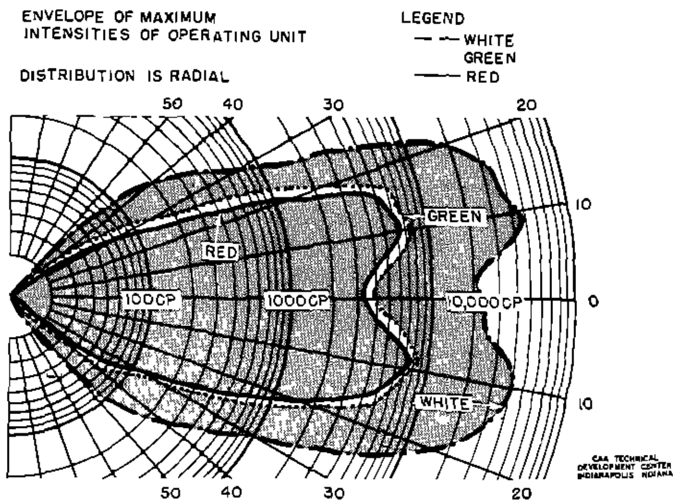

Fig 29 Coverage and Intensities, Rotating Prismatic-Lens Light

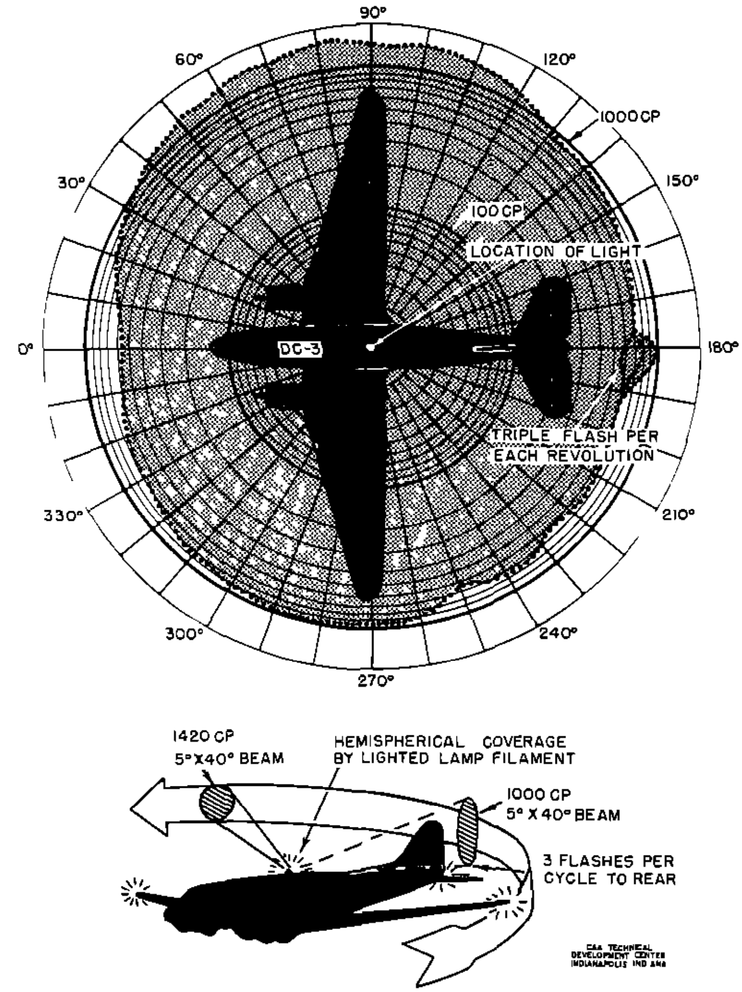

Fig 30 Hemispherical and Horizontal Beam Coverage, Rotating Parabolic-Reflector Light

located on the airplane A second DC-3 airplane carried a group of observers during the flight tests Flights were conducted on clear nights and at altitudes above any haze that might have existed at the time Various angles of approach were flown so that all of the light units were observed from all significant angles Omnirange and DME instrumentation in both airplanes made it possible to determine the distance between airplanes when the lights were sighted

The airplanes were flown away from each other until they were separated by a distance greater than the maximum visible range of the light to be observed They then were flown on converging courses at predetermined angles of approach

The pilot, co-pilot, and two other observers in the observation airplane knew the direction from which the lighted airplane would approach, and all were alert to sight it When it became just visible and was sighted, the pilot of the lighted airplane was advised by radio and both airplane positions were determined Through this procedure the separation distance between the airplanes at the initial sighting was determined for each light unit and for each approach angle The threshold-visibility distances for each light unit, as measured during the flight tests, together with other pertinent data, are listed in Table V.

TABLE V

FLIGHT-TEST DATA

Light Unit	Installation Type, Location	Lamp Used Filter Color	Total Watts at 27 4 Volts	Beam Coverage (degrees horizontal)	(degrees vertical)	Maximum Distance Observed (statute miles)
Rotating V-reflector	Dome, fuselage	4594 Red	94	360 360	40 10	43
Sweep-beam	Streamlined housings, wing tips	4591 Red, green	98	110	14	75
High-intensity taillights	Dome, taillight units	Experimental Red, clear	88	22 cone		*
High-intensity taillights	Dome, taillight units	4501 Red, clear	150	12 cone		110
Rotating prismatic-lens	Flush, nose and sides of fuselage	5190	252	56 cone		
		Clear				75
		Red				32
		Green				32
Rotating parabolic-reflector	Dome, fuselage	988 Red	58	360	20	30
Oscillating four-way-reflector	Dome, fuselage	4594	101			
		Clear		220**	38	40
		Red		110	32	17
		Green		110	32	16
Rotating cluster	Dome, fuselage	4591	407	360	15	
		Clear				65
		Red				50
		Green				57
Standard taillight	Dome, taillight units	308 Clear Red	16			13
Standard wing-tip	Streamlined, wing tips	1524 Red Green	18			11

*Distances not obtained in flight
**Two clear beams, each covering 110°

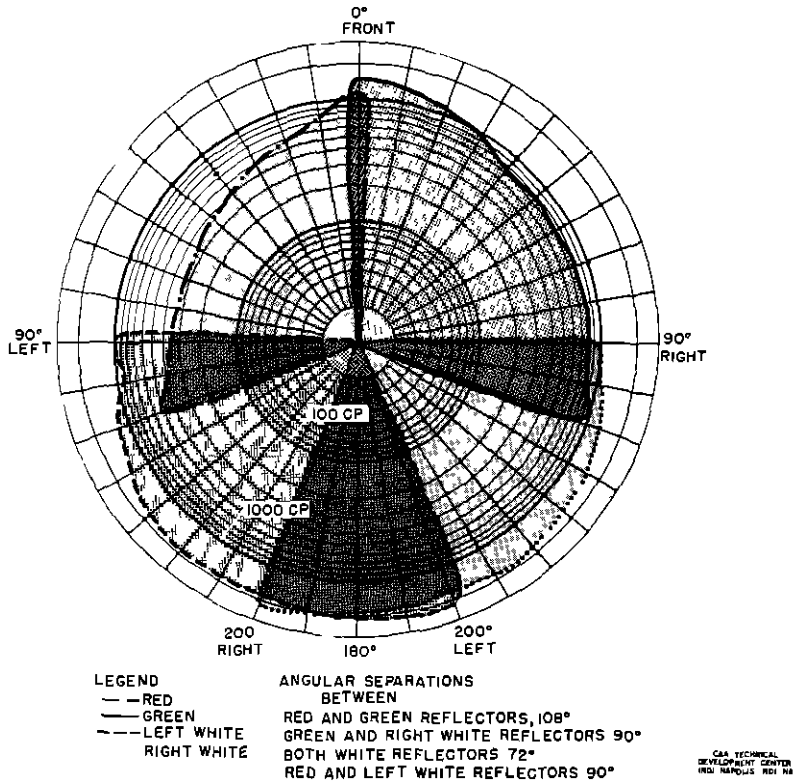

Fig 31 Horizontal Beam Coverage, Oscillating Four-Way-Reflector Light

CONCLUSIONS

Laboratory tests and flight observations of a number of recently developed high-intensity external lighting units for aircraft were conducted The test data provide a means for comparing the characteristics of the lighting units, and they facilitate an evaluation of the lighting units and systems tested.

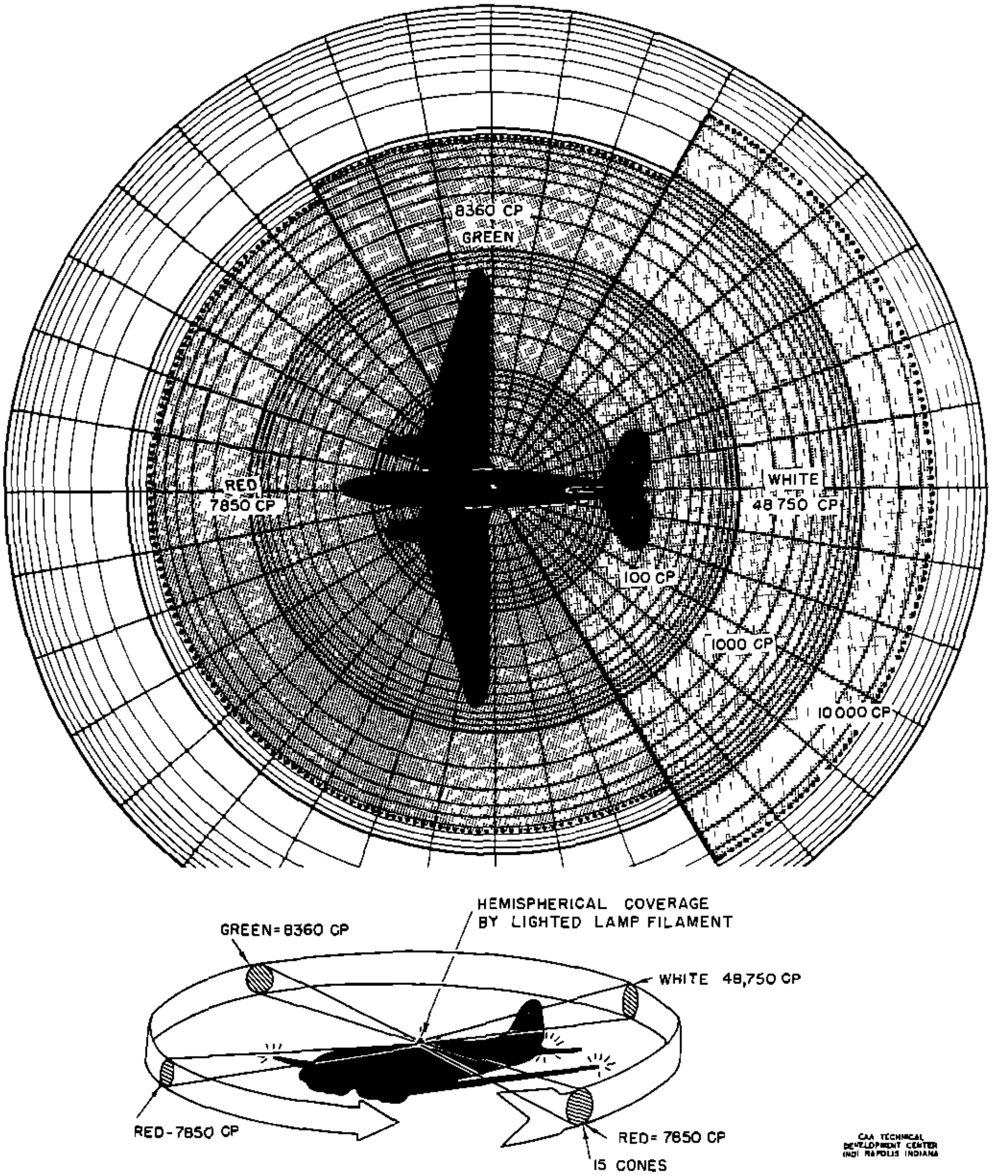

Fig 32 Hemispherical and Horizontal Beam Coverage, Rotating Cluster Light

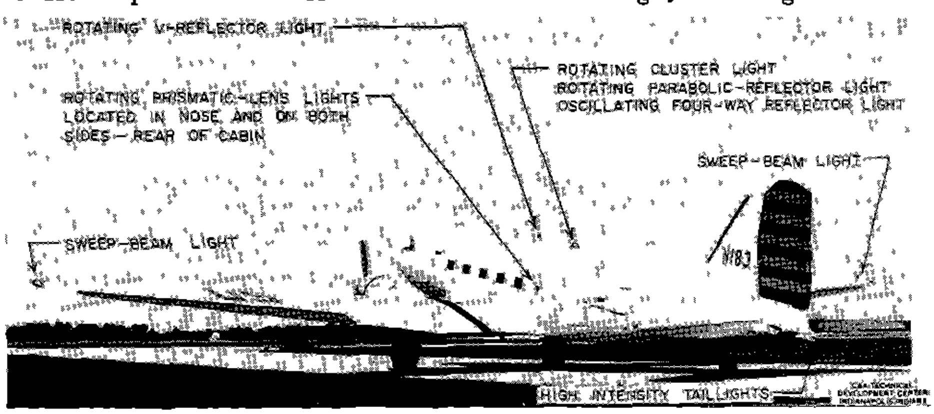

Fig 33 Mounting Locations of Units on the Airplane