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HELIPORT BEACON DESIGN, CONSTRUCTION, AND TESTING

FRED WALTER
SCIENTIFICO
Scientific Components Company
Newport Beach, California 92660

DEPARTMENT OF TRANSPORTATION · UNITED STATES OF AMERICA

DECEMBER 1971

FINAL REPORT

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16. Abstract

A heliport beacon production prototype was designed, constructed, and tested for optical performance and resistance to environmental conditions. The revolving beam beacon employs two 250 W, 130 V tungsten-halogen lamps, one each for the aviation green and aviation yellow projectors, and one 500 W, 120 V tungsten-halogen lamp for the white split beam projector. Lamp life is in excess of 5,000 hours at 115 V except with the 500 W lamp of the white beam projector, for which no 5,000 lamp has yet been found. The life of this lamp is approximately 3500 hours. The entire beacon system is sealed against the environment. The complete device weighs less than 50 pounds and can be mounted on standard light poles. It is about 16" in diameter and 24" tall. Low weight and cost are accompanied by low power consumption and minimal maintenance requirements, reducing the costs for installation and operation to a fraction of the amounts heretofore associated with devices of this kind.

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Abstract

A heliport beacon production prototype was designed, constructed, and tested for optical performance and resistance to environmental conditions. The revolving beam beacon employs two 250 W, 130 V tungsten-halogen lamps, one each for the aviation green and aviation yellow projectors, and one 500 W, 120 V tungsten-halogen lamp for the white split beam projector. Lamp life is in excess of 5,000 hours at 115 V except with the 500 W lamp of the white beam projector, for which no 5,000 lamp has yet been found. The life of this lamp is approximately 3500 hours. The entire beacon system is sealed against the environment. The complete device weighs less than 50 pounds and can be mounted on standard light poles. It is about 16" in diameter and 24" tall. Low weight and cost are accompanied by low power consumption and minimal maintenance requirements, reducing the costs for installation and operation to a fraction of the amounts heretofore associated with devices of this kind.

Performance Specifications

According to the contract schedule, the heliport beacon must meet the following performance requirements:

A) Optical Performance

Effective Intensities at all angles of azimuth and throughout a vertical beam spread from 0° to 10° with the axis at 5°

Aviation white, non-split mode:	20,000 candela
Aviation green :	3,000 candela
Aviation yellow :	7,000 candela

Flash Duration, maximum: 100 milliseconds

Flashing Sequence: green-white/white-yellow

Repetition Rate: 12 times per minute (36 total for 3 colors)

Elevation Adjustability: From 5 to 7.5°

Automatic start and stop: "on" at 35 ftcd, "off" at 58 ftcd ambient light level.

B) Environmental Test Conditions

Aerodynamic Stress: Determine analytically, stress resulting from ½" thick ice accumulation and 100 knot wind.

Altitude: From sea level to 10,000 feet above sea level

Temperature: -55 to +55° C

Humidity: Up to 95%

Rain: Including 40 mph wind, as per Mil-Std-810 B.

C) Service Life and Maintenance

Lamp Life : 5,000 hours

Power Consumption : 2.5 KW maximum

Selection of Design Concepts

In order to meet the requirements listed in the previous section, a beacon has to be an optimized package with respect to minimum weight, low operational and maintenance costs, and low purchase price. A trade-off analysis shows that these three key parameters are controlled by the choice of the optical elements. They are, in order of importance:

1. Type and filament size of stock lamps
2. Choice of color filters
3. Choice of beam optics

An evaluation of available lamps indicates that long life tungsten-halogen lamps are clearly superior to arc lamps. While some arc lamps are optically superior to tungsten-halogen incandescent lamps because of their greater source luminance, they last only about 2,000 hours. Arc lamps having life spans in excess of 5,000 hours are of relatively low radiance and require much larger optical elements in order to provide the required beam power. Furthermore, all arc lamps require bulky and costly starting and power conditioning equipment. This expense, combined with the high cost of replacement lamps, puts the cost of arc lamp operation at 10 to 50 times that of incandescent lamps.

In recent years several long life tungsten-halogen lamps have been introduced by General Electric, Westinghouse, and Sylvania. Both low and line voltage lamps, single and double ended, are available in the 250 to 750 Watt range.

Measurements with refractive and reflective optical systems showed that 250 W, single ended, coiled-coil halogen cycle lamps provide adequate life and performance for the aviation green and yellow projectors, while minimizing heat load and power consumption. A 500 W lamp of the same design is currently employed in the white split beam projector. We intend to replace it with another of the 250 W variety, as soon as larger optical elements can be procured. When beacon construction started, only 80 mm diameter lenses of suitable focal length could be purchased.

Aspheric lenses with 95 to 100 mm diameter and approximately 2.75" focal length are expected to produce adequate white beam power with the 250 W lamp. The design of the split beam projector is such that lens and lamp changes can be readily incorporated into existing beacon assemblies.

The choice of aviation color filters was facilitated by th fact that the optical systems utilize flat filter plates. Both dichroic interference and colored glass absorption filters are available from several manufacturers, in suitable size and quality. Thus, price and delivery became the governing parameters in the choice of filters. We determined that well-designed green interference filters transmitted at least twice as much light as their best colored glass counterparts, making them clearly the superior choice (Figure 1). By contrast, aviation yellow absorption filters proved to be optically nearly as efficient as interference filters, but were more readily available and less expensive than interference filters. The heliport beacon is therefore equipped with an aviation green interference filter and an aviation yellow colored glass filter, (Figure 2).

With components and dimensions of the optical systems determined, materials and methods for packaging and construction were selected. The upper temperature limit of 55° C ambient dictated the use of high temperature plastics such as nylon, Kel-F, and Teflon for plastic parts, and silicon rubber for joints and adhesives. Structural metal parts were made from stainless steel and aluminum sheet, to save weight and cost. A synchronous gear motor and a single stage gear belt drive form the drive system for the turntable. A long life brushblock and slipring assembly transmits a.c. power to the rotating optical systems, supported by a large double row ball bearing mounted in the baseplate of the beacon assembly. The three-projector package is mounted on a hinged plate, the vertical position of which can be adjusted through normally closed access holes in the baseplate. A silicone rubber vibration damper is installed near the hinge, preventing rapid vibrations near the natural frequency of the assembly. A pyrex cylinder topped by an anodized and painted aluminum heat exchanger forms the outer shell (Figure 3).

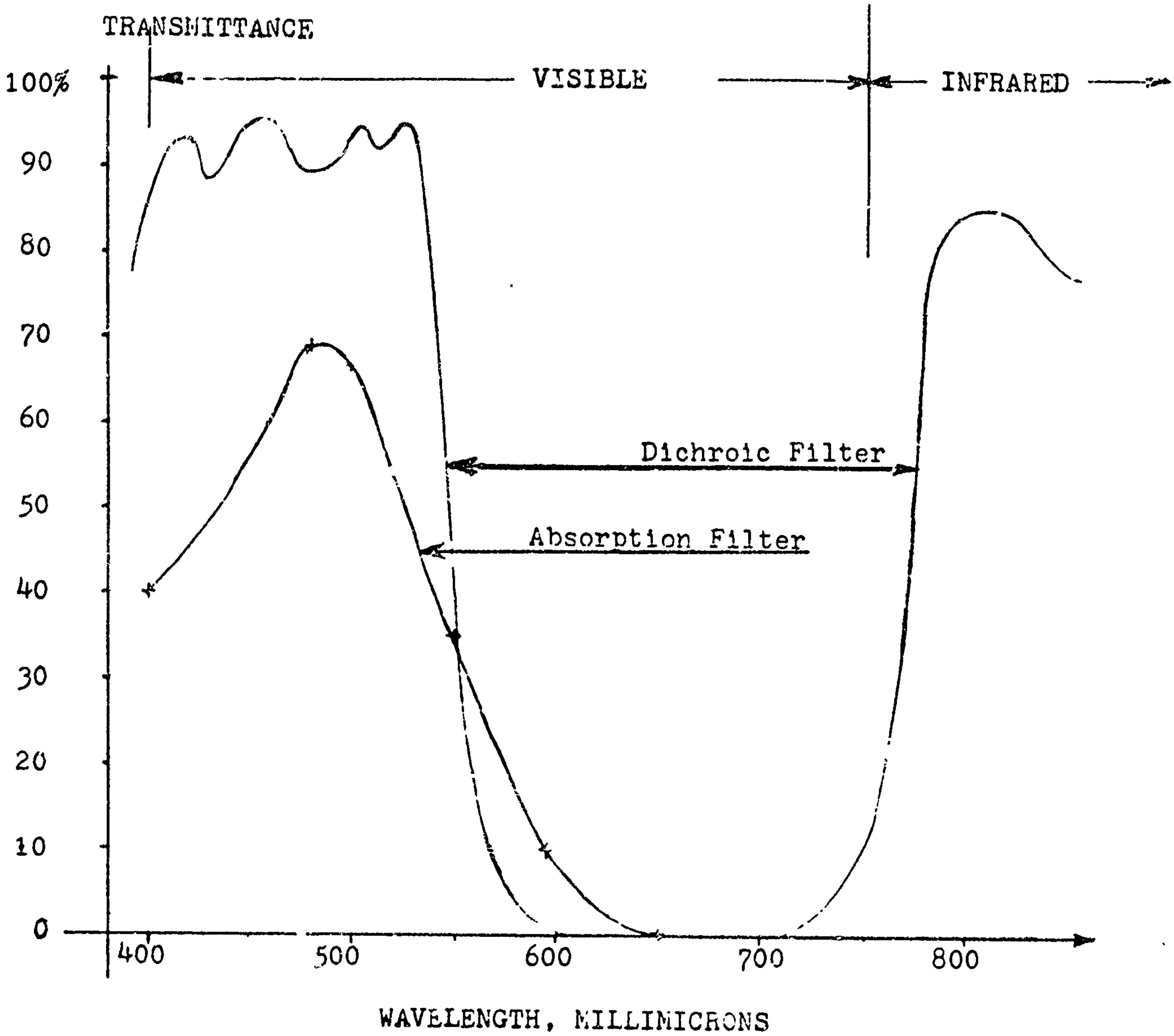


Figure 1. TRANSMITTANCE CHARACTERISTICS OF AVIATION GREEN FILTERS

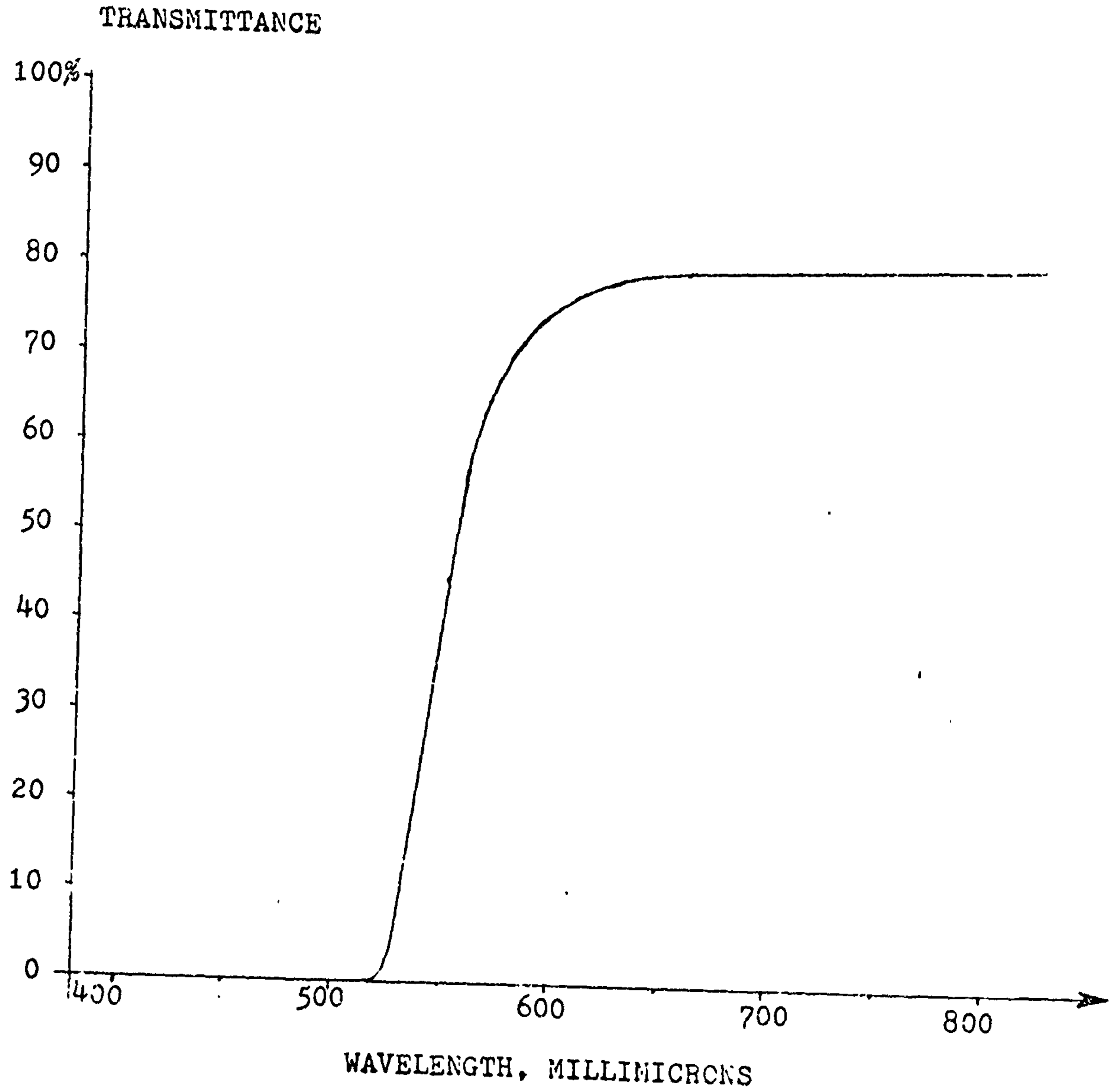


Figure 2. TRANSMITTANCE CHARACTERISTICS OF AVIATION YELLOW COLORED GLASS FILTER

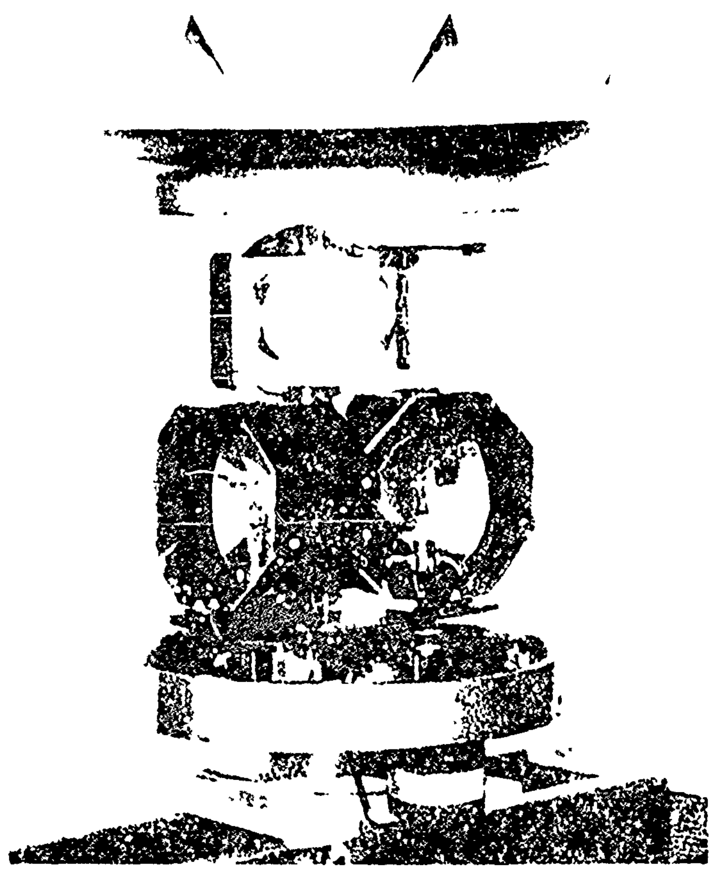


Fig. 3

MODEL 2000-69 HELIPORT BEACON ASSEMBLY

Selection of the light beam projection systems was based upon an evaluation of beam patterns produced by several first surface collectors, as well as aspheric condenser lenses. It was found that systems having high collection efficiencies, such as deep, short focal length paraboloids, or short focal length, very small f-number lenses, did not produce the required aspect ratio of the revolving beams. In order to obtain flash durations below 100 milliseconds, the horizontal beam width cannot exceed 9°, while the vertical beam height has to be at least 12° in order to meet the specified performance. Thus, less efficient but more practical systems were eventually chosen. They produce rectangular beam cross-sections with aspect ratio of about 2:1. The colored beam projectors consist of 2" F.L., 6" diameter Alzak paraboloids and 250 W tungsten-halogen lamps. The split white beam system employs two aspheric lenses of 80 mm diameter and 2.6" F.L. in addition to an adjustable flat mirror which deflects one of the two beams so as to generate the desired "off" period (Figure 4). The split beam projector is equipped with a 500 W quartz-iodine lamp. A 6" diameter reimaging hemisphere is used to improve the overall efficiency of the optical system.

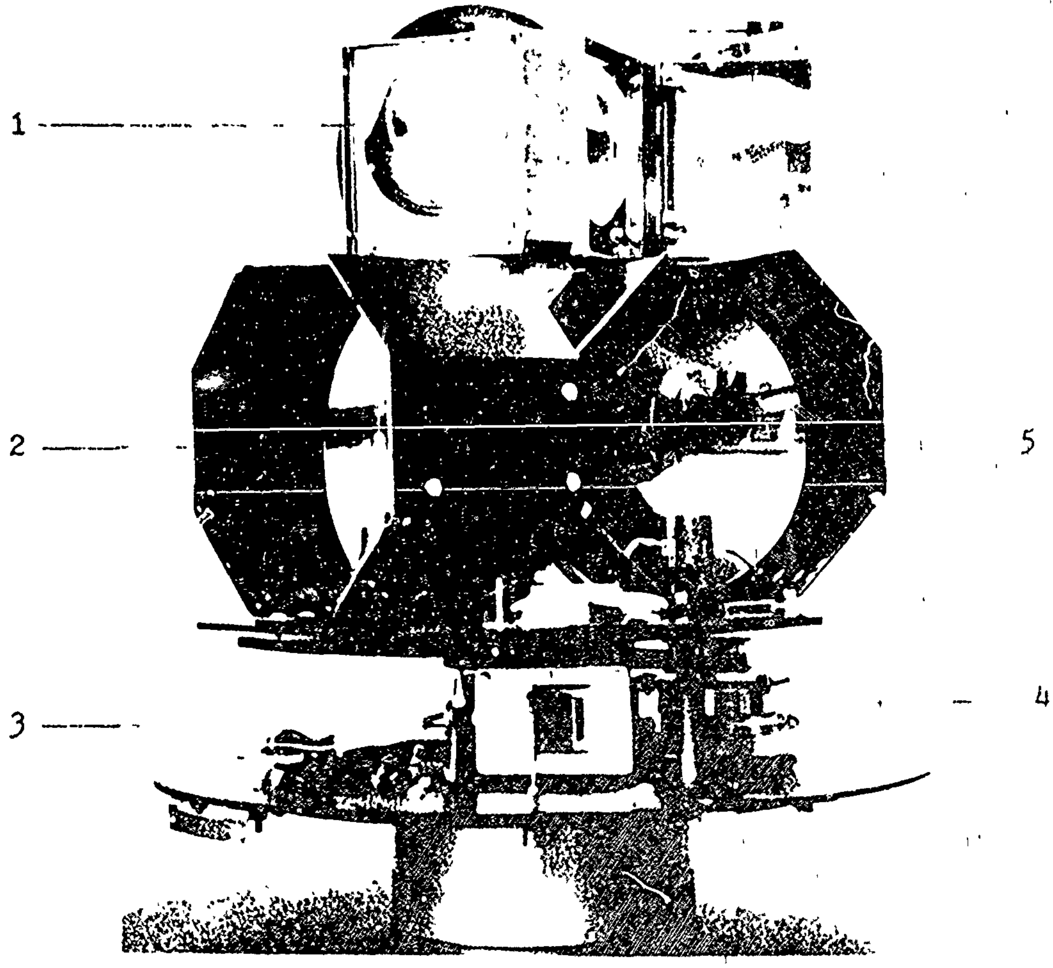


Fig. 4. MODEL 2000-69 HELIPORT BEACON OPTICAL ASSEMBLY

1 - Split Beam Projector System
2 - Aviation Green Projector
3 - Photoswitch
4 - Drive Motor
5 - Aviation Yellow Projector

Construction Details

All optical elements and moving parts of this beacon are protected against precipitation and dust by a sealed shell, which consists of an anodized aluminum baseplate, a pyrex cylinder with stainless steel transition rings on either end, and an anodized aluminum heat exchanger which serves as top cover. The baseplate is bolted to an anodized aluminum pole adapter which fits a variety of pipe diameters (Fig 5).

Access to the screw adjustment of the tilting table is obtained through plugged access ports in the baseplate. When opened, an Allen screwdriver can be inserted through one of these access ports in order to adjust the tilting table. The two bubble levels are adjusted by turning stainless steel Allen head screws which protrude through the baseplate. The threads of these screws are sealed by means of nylon insert lock nuts pressed into the baseplate.

All electrical components are housed inside of the sealed beacon shell. The field of view of the photoswitch is partially shielded, preventing light produced by sources on the ground from turning it off unintentially. The automatic turn-on light level can be adjusted by changing the tilt angle of a small door, which can be rotated from the outside by means of a sealed threaded rod (Figure 6). All fuses are located inside the beacon; the motor fuse is mounted on the baseplate, the lamp fuses are attached to the tilting table. Access to these parts can only be obtained after lifting the pyrex cylinder/heat exchanger assembly off the baseplate.

Surface finishes, where applicable, are anodized according to military specifications on all aluminum parts. Fasteners are either made from stainless steel, or plated. High temperature aircraft wire, meeting applicable military specifications, is used for all internal connections. Insulating sleeves are made from silicone-coated fiberglass. Performance degradation due to dust and dirt accumulation on optical surfaces cannot occur as long as the outer shell remains intact.

BASEPLATE AND POLE ADAPTER ASSEMBLY.

MODEL 2000-69 HELIPORT BEACON

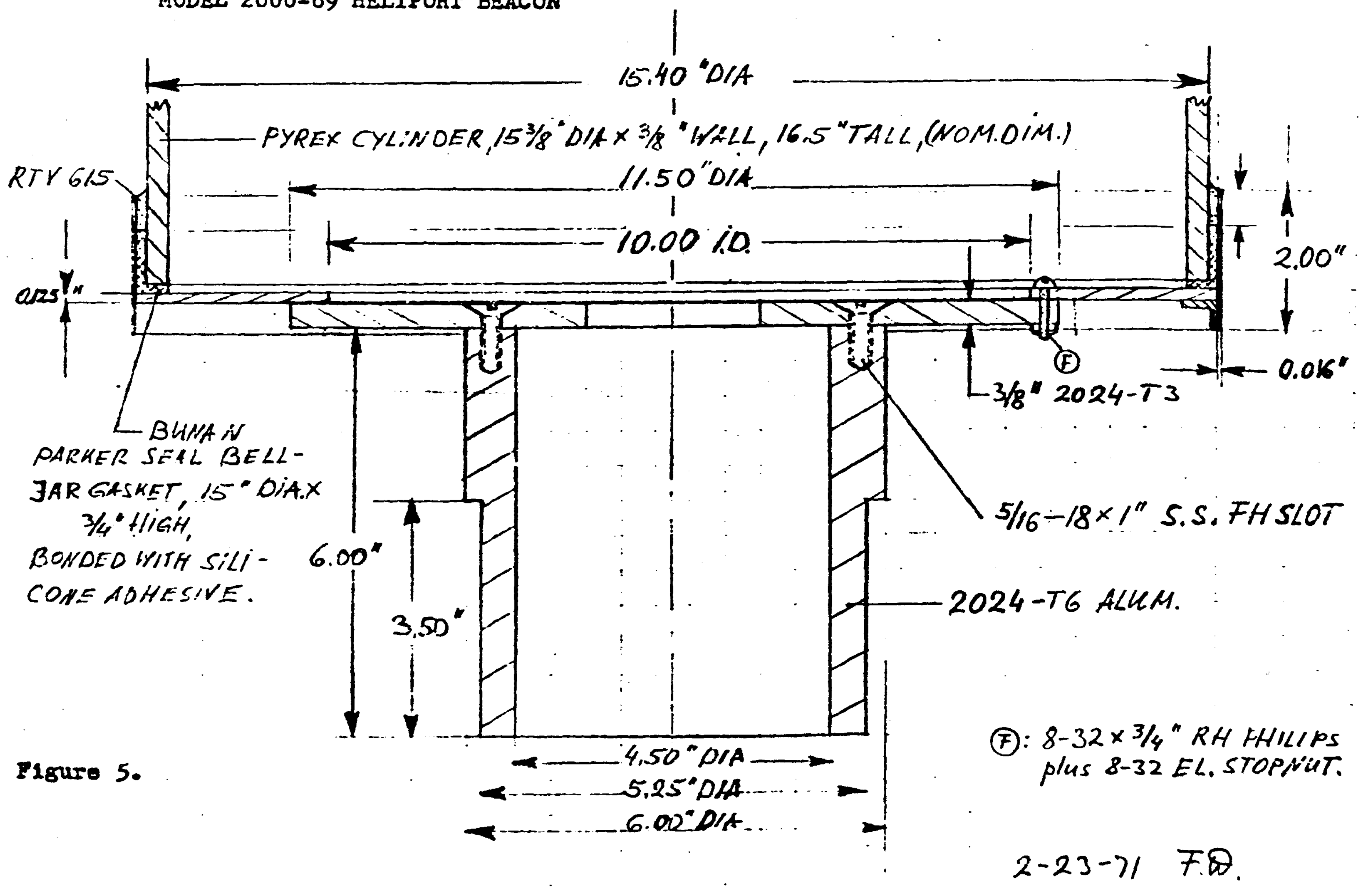


Figure 5.

Figure 6. PHOTOSWITCH AND

ADJUSTABLE LIGHT CONTROL VANE

The optical environment of a heliport beacon will depend upon the individual installation. Thus, a fixed setting of the photoswitch may result in significant variations of turn-off and turn-on light levels. The vane adjustment covers a range of actuation from approximately 5 to 100 footcandles, well in excess of the contractual requirement of "on" at 35 ftcd, "off" at 58 ftcd.

Economics of Operation

The maximum power consumption permissible under the terms of this contract is 2,500 W. The Model 2000-69 Heliport Beacon consumes slightly less than 1,000 W. This reduction represents a substantial saving in wiring cost, and in operating costs per year. At an annual average operating time of 4,000 hours, and a price of 2¢ per KWH, for example, power costs are $80.00. This cost is $120.00 less than the typical annual cost for a beacon operating at the specified maximum rating of 2,500 W.

Lamp replacement expense is minimal. A set of three lamps costs about $30.00. If replaced once a year during routine annual inspection, cost of lamps and labor should be below $50.00 - a fraction of the annual relamping costs incurred with previous beacon designs.

Cleaning of the exterior surface of the pyrex cylinder can be accomplished by hosing it down with tap water, provided the solid content of the water supply is not excessive. Hydrophobic coating for laboratory glassware, available from many lab glass distributors, can be applied to the outer surface of the pyrex cylinder to prevent spotting, and to accelerate drying.

Lamp Life

The contract schedule calls for a minimum lamp life of 5,000 hours, without further qualifying the term "life". No such additional qualification would be possible without severely restricting the choice of lamp types that might be employed in a heliport beacon. However, once a particular kind of lamp has been selected, lamp life has to be specified not only in terms of hours of operation, but in terms of optical performance throughout this life-span as well.

Most lamp life specifications include a substantial drop, of from 35 to 50% of the initial light output, before a lamp's useful life is terminated. Thus, under the prevailing specifications of lamp life, a filament lamp can fail for two reasons: because of filament breakage, or because of an excessive decrease in light output. With tungsten-halogen lamps, however, the latter failure mode does not apply. These lamps retain 85 to 90% of their initial light output until their life is terminated by filament breakage or other mechanical failure. The light output of the Model 2000-69 Heliport Beacon will therefore show no noticeable decrease during the rated lamp life.

This beacon employs one Sylvania EHD, 500 W quartz-iodine lamp, and two Sylvania 250 Q/CL tungsten-halogen lamps in which the manufacturer has replaced iodine with another halogen. These 250 Q/CL lamps have a rated life of 2,000 hours at 130 V. At the specified 115 V, their life expectancy is substantially in excess of 5000 hours.

The EHD lamp has a rated life of 2,000 hours at 120 V, or 3,500 hours at 115 V, according to industry standards (Figure 7). Experience with industrial lamp developments indicates that this lamp will some day soon be replaced by an otherwise identical tungsten-halogen version having 5,000 hours life at 115 V. Until this happens, we recommend replacing the EHD lamp during each annual inspection of the heliport beacon. This approach is far more economical than lamp change "on demand", i.e. after failure of a lamp; it also assures continuous, uninterrupted service of this important safety device.

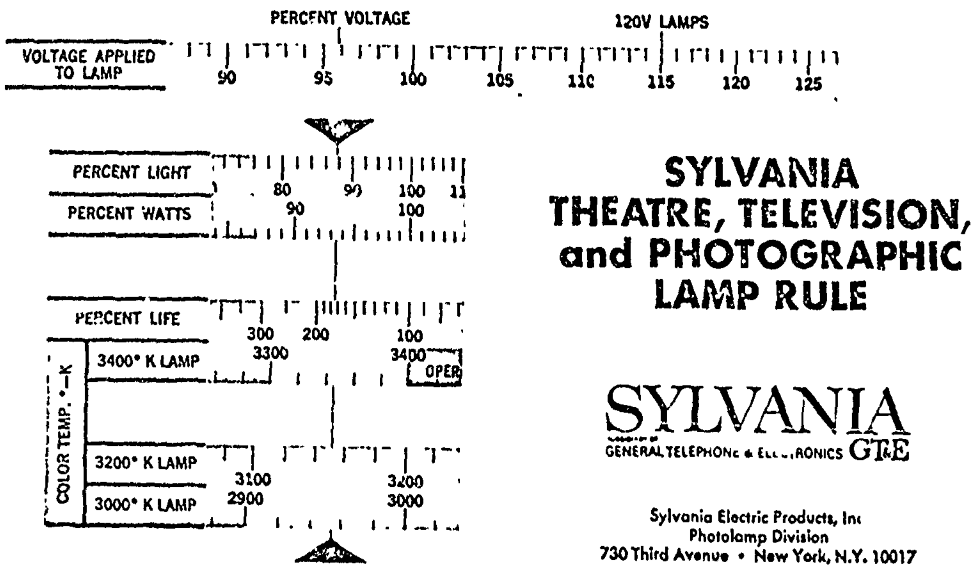


Figure 7. Life of 120 V Tungsten-Halogen Lamp at 115 V

Test Results

Photometric and Colorimetric Performance

Compliance with the specified optical requirements is established according to Scientifico's FAA approved "Heliport Beacon Performance Test Procedure." The results obtained with respect to filter colors and effective intensities of the green, split white in the non-split mode, and yellow flash are summarized in the following sections.

A) Filter Colors

Spectrophotometer curves for the green and yellow filters in conjunction with illuminant A are shown in Figure 1 and Figure 2 respectively. Illuminant A at 2854° K corresponds closely to the color temperature of the beacon lamps, which operate between 2800° K and 2900° K at 115 V.

The chromaticity coordinates for the green filter are $x = 0.23606$ and $y = 0.44313$. For the yellow filter they are $x = 0.592$ and $y = 0.407$. Both fall well within the regions specified for these aviation colors by MIL-C-25050A (Figure 8).

Both filters are of an extremely stable construction. They are not subject to deteriorating environmental effects, since they are not exposed to wind and rain.

B) Effective Intensities

Horizontal beam patterns were measured for each beam at the following angular displacements: -5°, -2.5°, 0°, +2.5°, +5°. Additional measurements were made at other vertical displacements if deemed necessary. In order to determine how well these 5 points represented the entire vertical beam pattern, each projector was tilted 90° from its normal mounting position, and the vertical beam distribution recorded (Figure 9, Figure 10).

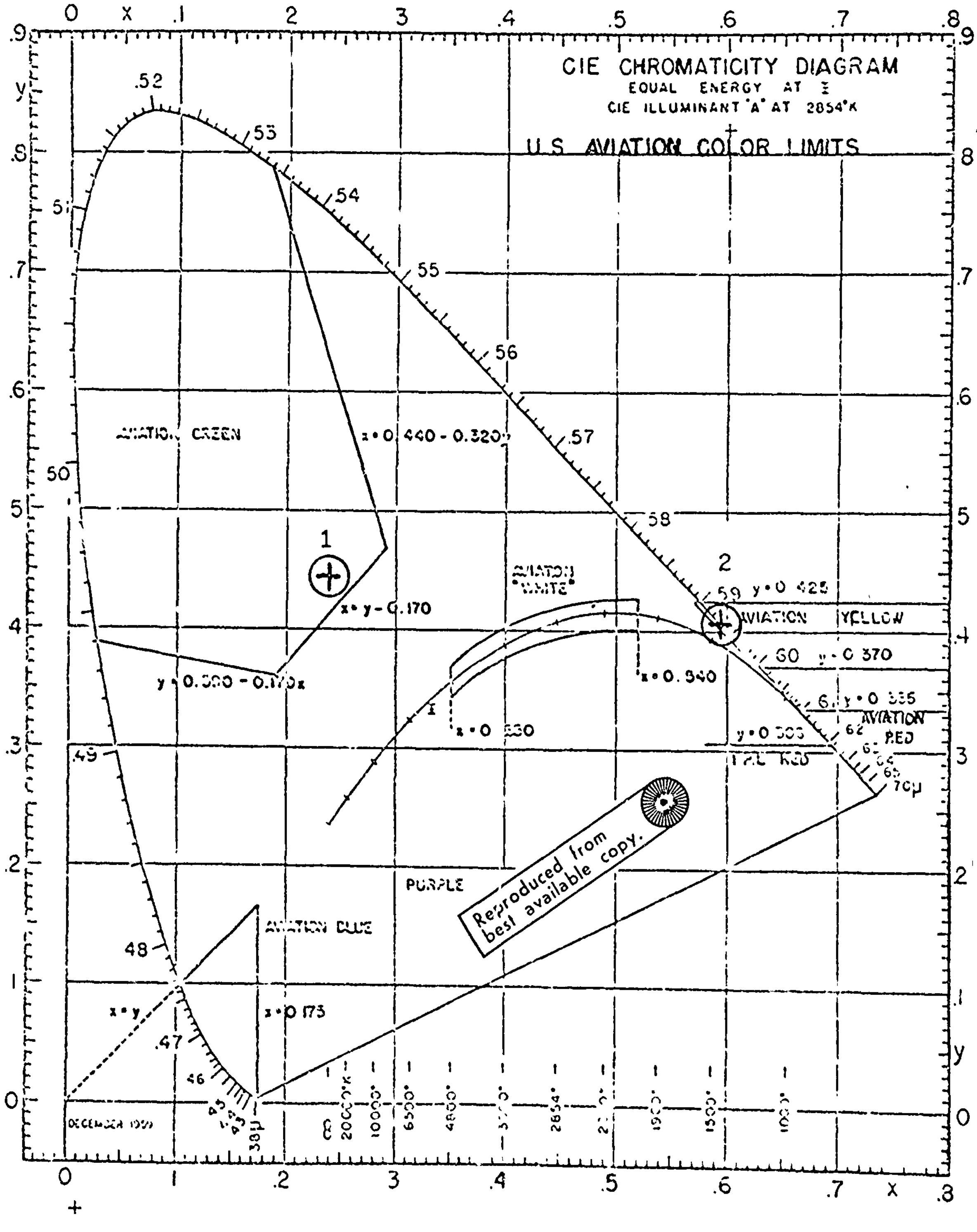


Figure 8. Locations of Optical Industries' Aviation Green (1) and Schott Optical Glass' Aviation Yellow (2) Filters in CIE Chromaticity Diagram

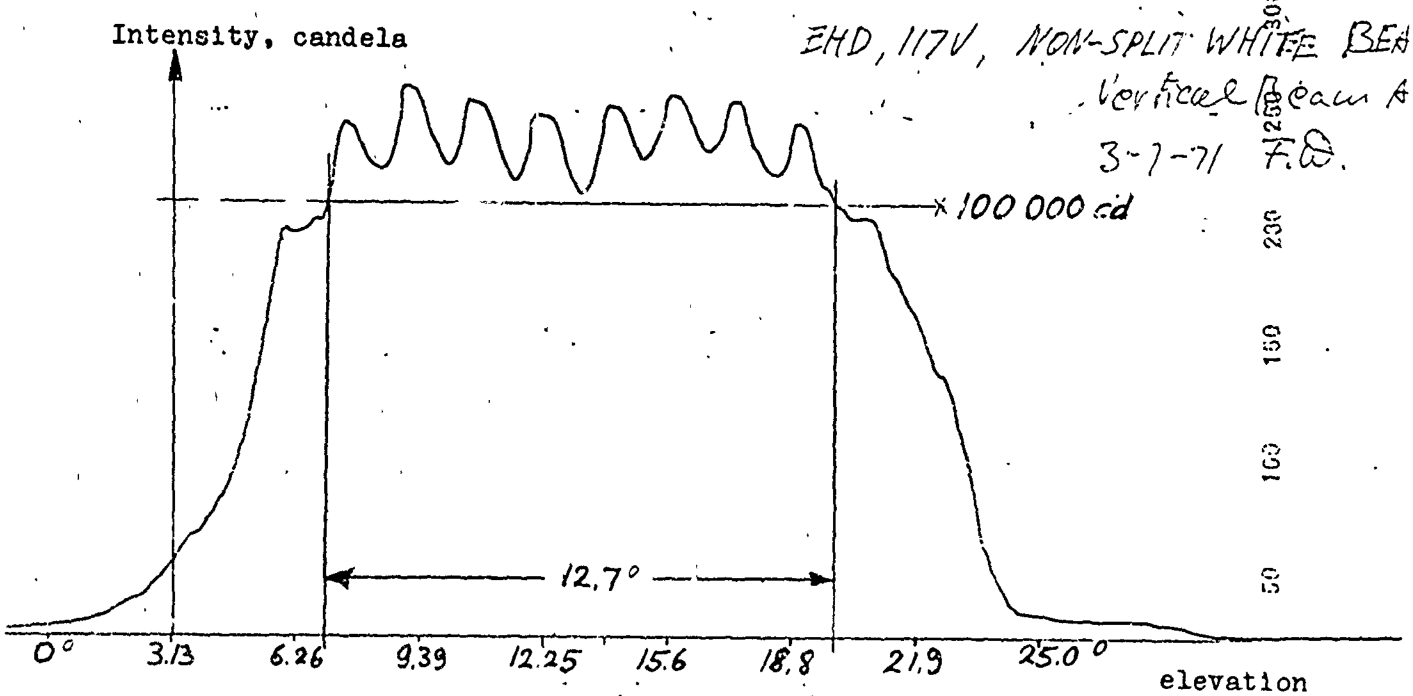


Figure 9

Vertical cross section of split white beam in the non-split mode. The intensity modulation is due to the structure of the lamp filament, which is recorded by the high resolution detector. The periodic intensity valleys do not appear during a horizontal sweep of this beam; they are filled in by contributions from parts of the filament coil not seen by the detector during this vertical scan.

Lightsource: Sylvania EHD lamp at 117 V AC.

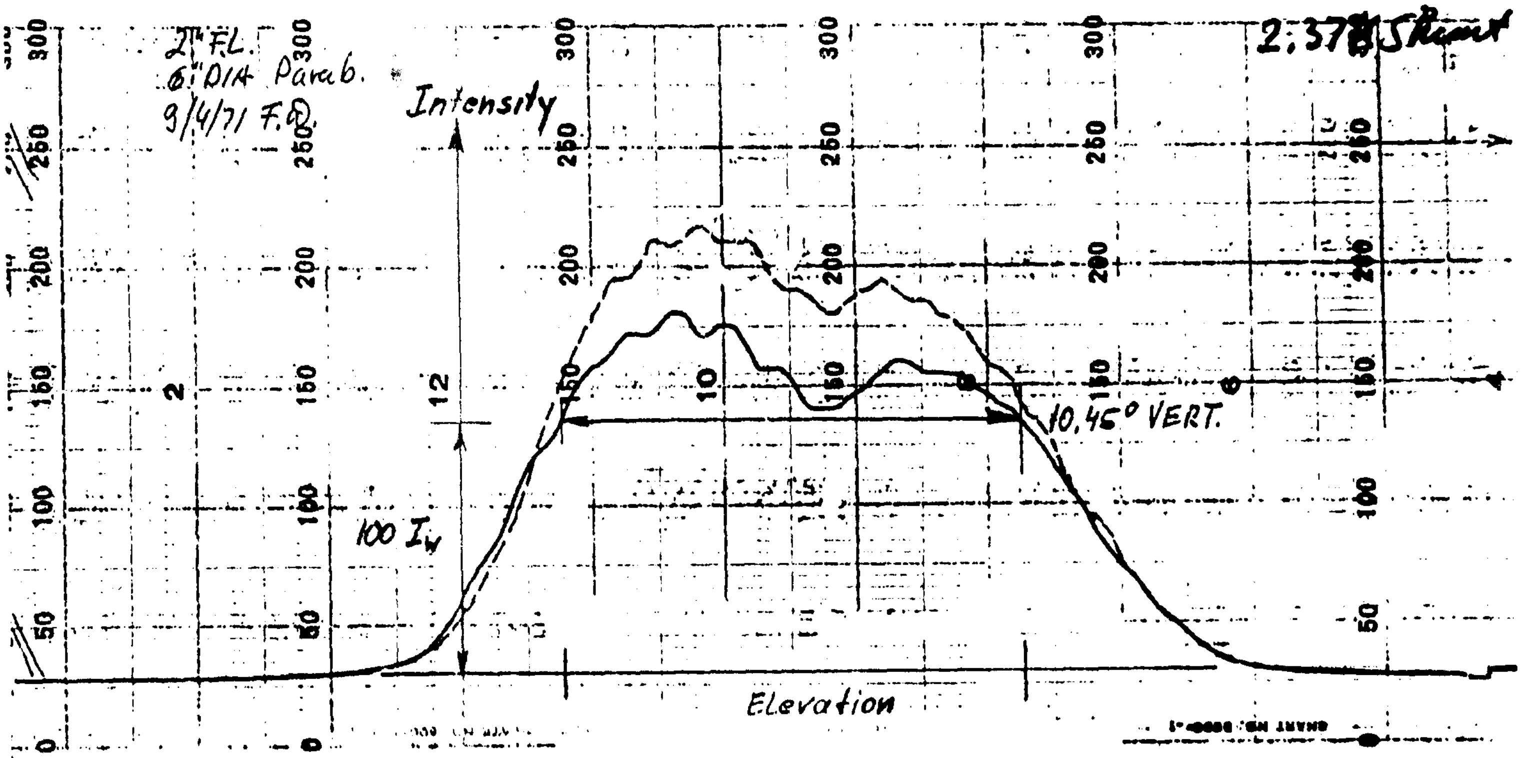


Figure 10

Vertical Beam Profile of Aviation Green and Yellow Projectors.

The dashed line shows the improved performance obtained through use of Sylvania 250 Q/CL lamps compared to Westinghouse lamps (solid line) of the same designation. 100 I_W represents the intensity level used in the effective intensity calculations at the $+5^{\circ}$ and -5° points.

During all measurements, the a.c. input voltage to the lamp was monitored with a Model PY-4 Westinghouse a.c. voltmeter, which was calibrated before and after these measurements (Figure 11). The observed voltage values were recorded, together with other pertinent information, on a photometry data record form which was signed and dated by the Q.C. inspector witnessing the photometric measurements. (See pages 31, 39, and 42)

The Weston photocell used in the beam photometer was calibrated before and after these measurements. Consistency of the calibrations made almost eleven months apart is obvious from Figure 12.

Effects of line voltage fluctuations during the course of each horizontal beam profile measurement varied from small to negligible. While the aviation yellow projector was measured, a periodic line voltage fluctuation of about 1.8 volt introduced a light output variation of less than 3.5% (Figure 13). In all other cases, line voltage remained more stable. Figure 14 shows the typical light output as function of line voltage during these photometric measurements.

Most measurements were made slightly above the specified 115 V, e.g. at 116 or 118 V (Table A). Appropriate corrections have been made on the basis of one volt change in line voltage causing a 2% change in luminance, resulting in an identical change in beam intensity. This assumption is valid only throughout a range of line voltages from 115 to 120 V; thus it is adequate for the measurements made during this program.

The computations of the effective intensities listed in Table A are recorded on pages 30 through 43. The energy content of each time vs intensity curve, $\int_{t_1}^{t_2} I\,dt$, was determined by superimposing an integration grid over the intensity versus time curve (Figure 1_), and counting the number of rectangles contained in the area under each curve between t_1 and t_2, the limits of the flash duration. The energy content of each rectangle is the product of intensity, measured individually for each projector, and the time interval of

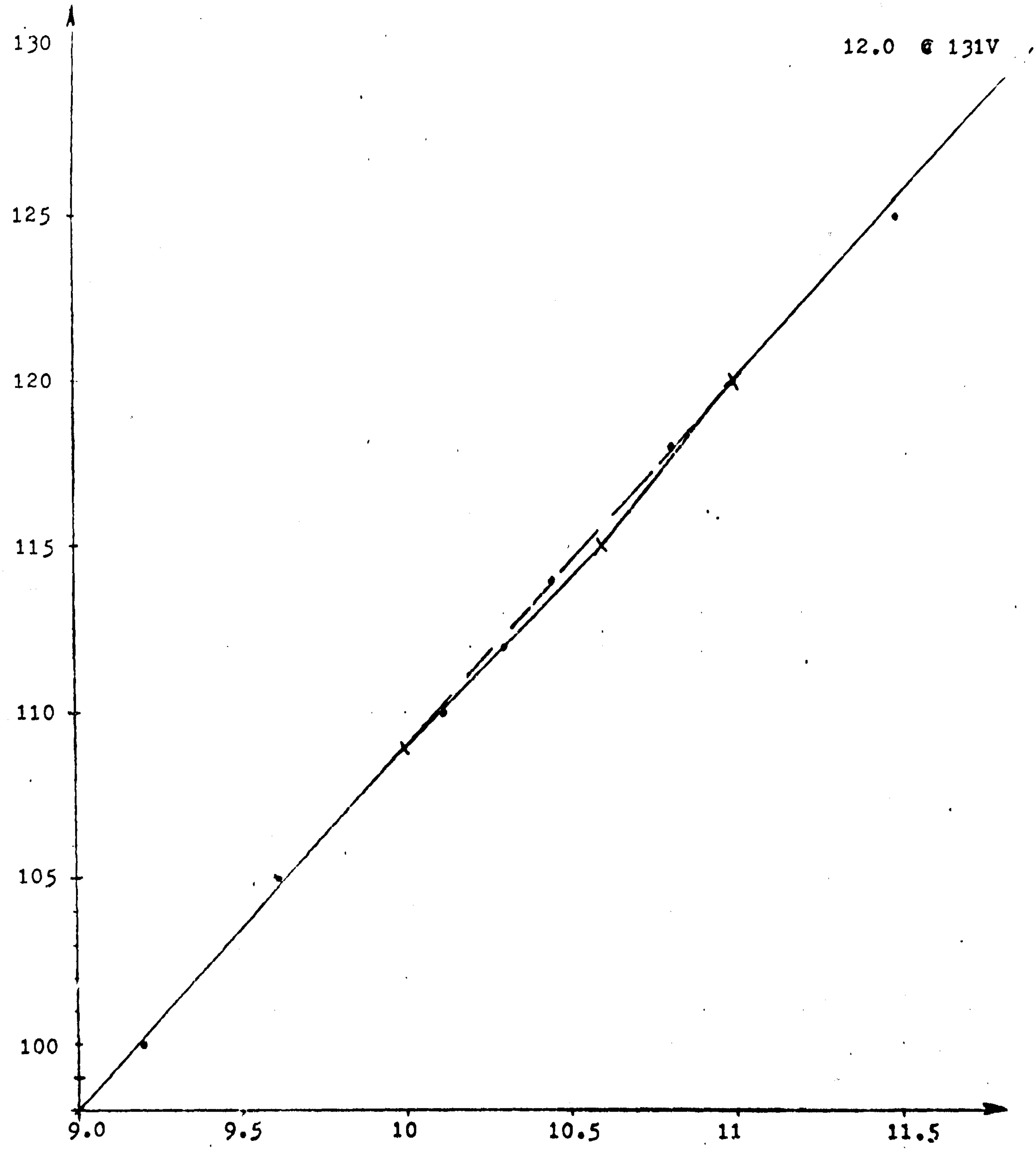


Fig. 11 : Calibration Points of Westinghouse Type PY-4 Voltmeter with 1500 Ohm, 1% series resistor

• : 11-3-70; X : 6-4-71.

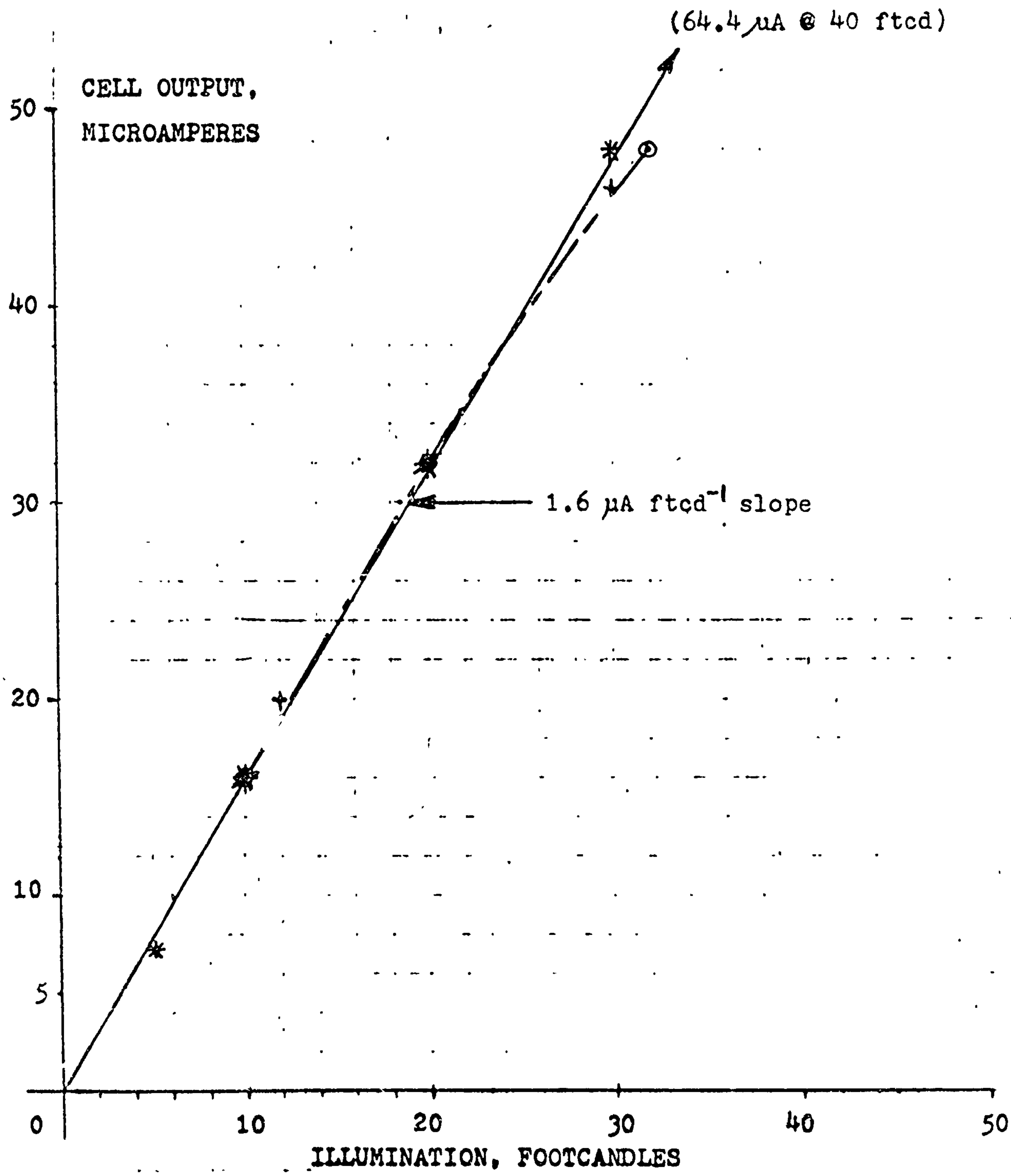


Figure 12

SENSITIVITY OF WESTON MODEL 856

TYPE RRV PHOTOMETER CELL No. 990201

+ Measured 7-15-70; ✱ Measured 6-4-71.

o Catalog Data for Typical Cell

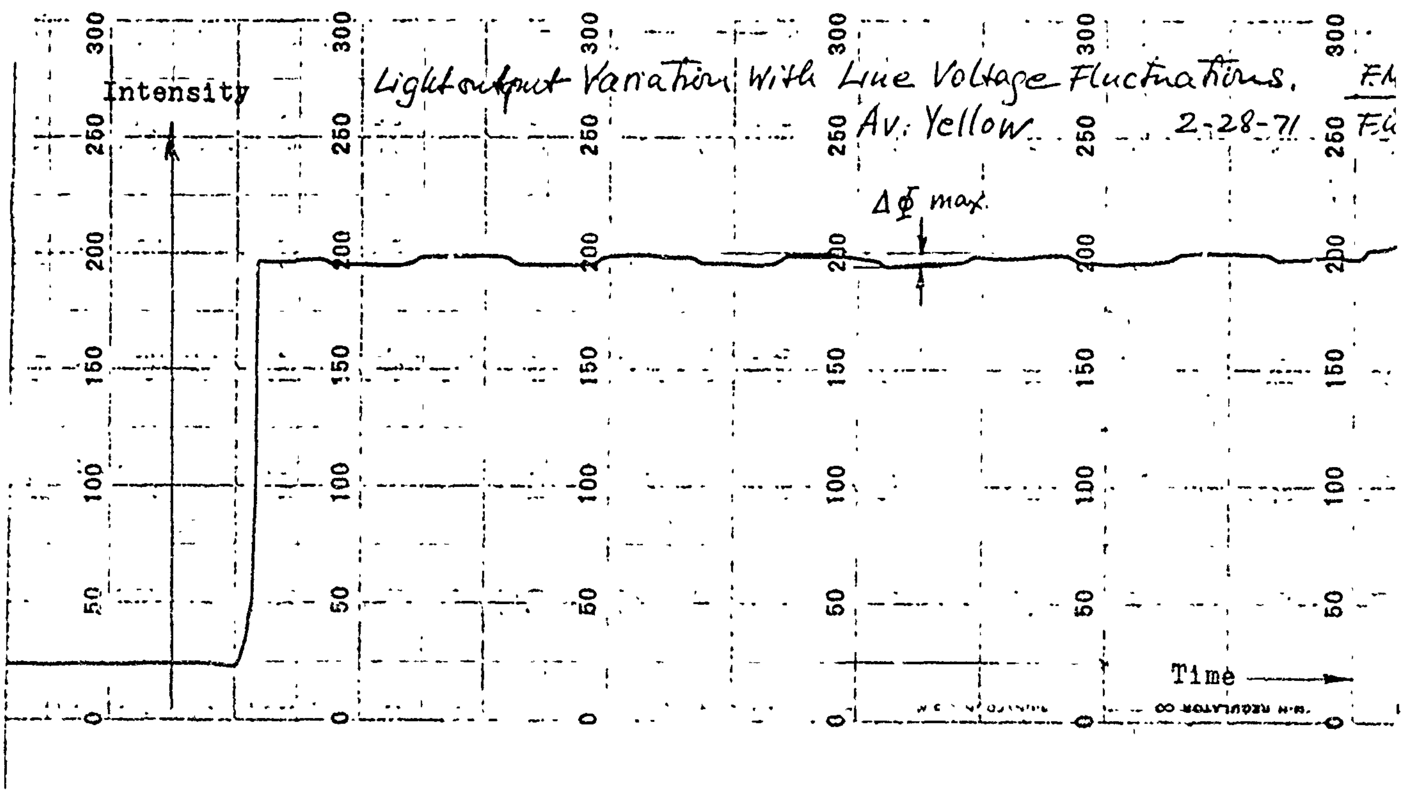


Figure 13
Effect of Periodic Line Voltage Fluctuations on Lightoutput.

The maximum intensity change $\Delta \Phi$ max is 3%.

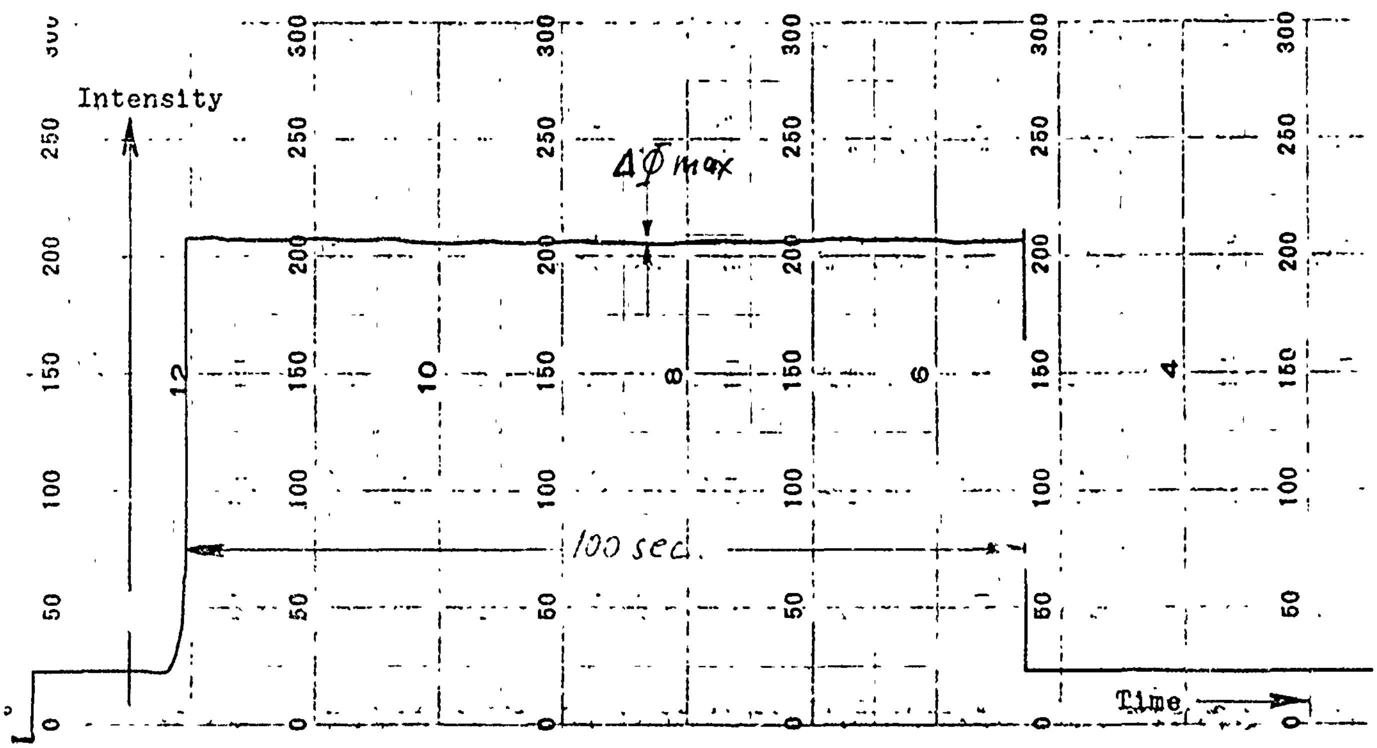


Figure 14

Effects of Line Voltage on Lightoutput

Maximum intensity change $\Delta\Phi$ max is 2.5%. Here and in the case of periodic fluctuations, shown in Fig. 13, the statistical average during the typical 50 sec duration of an intensity versus time trace measurement is less than 2.5%.

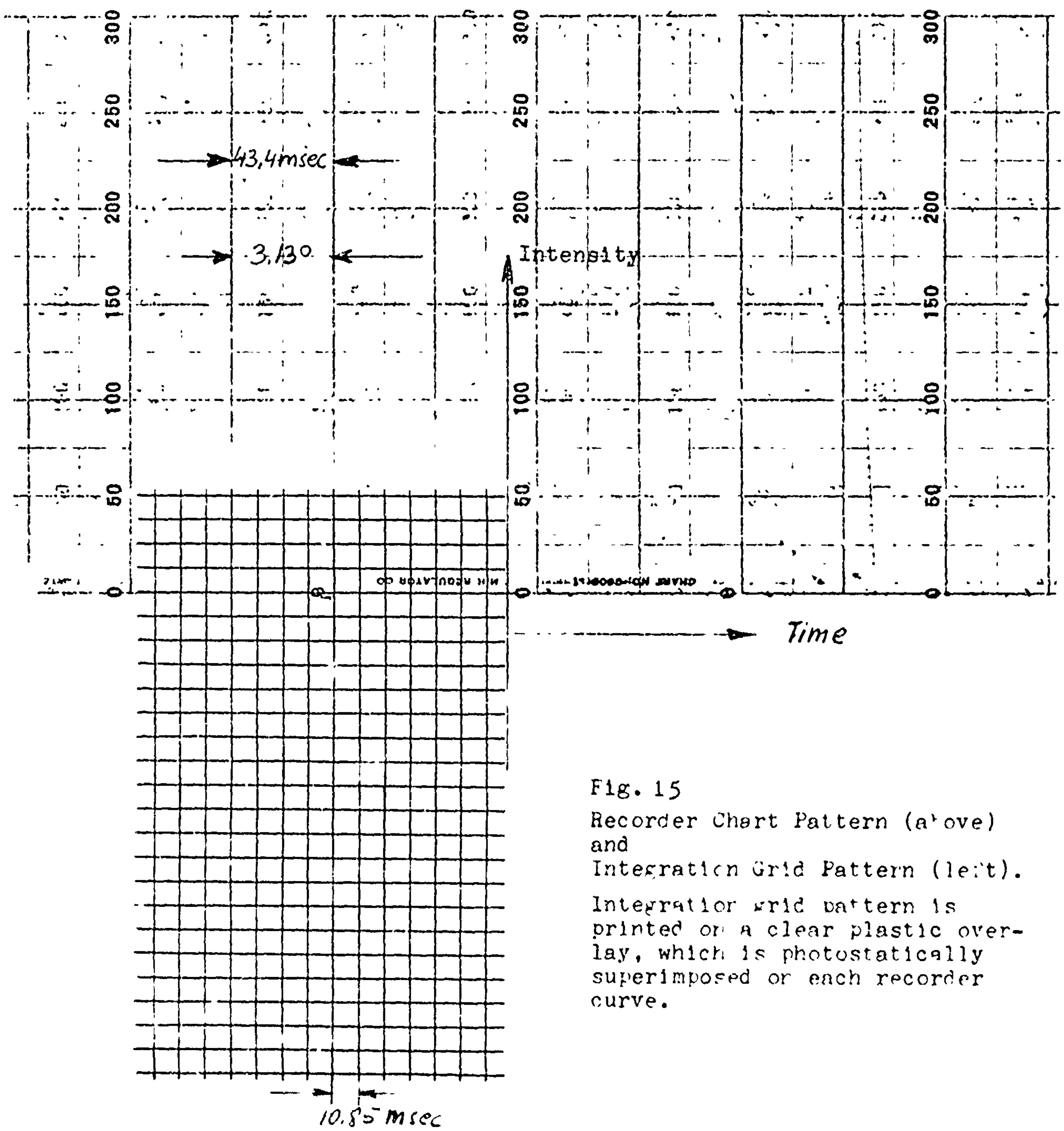


Fig. 15

Recorder Chart Pattern (above)
and
Integration Grid Pattern (left).

Integration grid pattern is printed on a clear plastic overlay, which is photostatically superimposed on each recorder curve.

10.85 milliseconds, computed from the angular velocity of the revolving beam beacon at the specified 12 rpm, the goniometer's angular velocity of 4.8 sec deg^{-1}, and the recorder chart speed of 15 seconds per horizontal chart division:

15: 4.8 = 3.13 degrees per horizontal chart division.

At 12 rpm the heliport beacon's angular velocity is

72^{o} sec^{-1} :

12 rpm = 5 sec per 360° = 72° per second.

At 72^{o} sec^{-1}, the beacon's beams traverse one degree

in 13.9 milliseconds:

$$\frac{1}{72} = 0.0139$$

One horizontal recorder chart division, being equal

to 3.13°, therefore corresponds to 43.4 milliseconds:

3.13 x 13.9 = 43.4

The integration grid divides each horizontal chart division into four equal parts of 10.85 msec:
43.4 : 4 = 10.85

Figure 15 shows examples of these units.

The flash duration $T = t_2 - t_1$, is measured for each computation of the effective intensity by counting the number of horizontal divisions between t_1 and t_2, and multiplying this number by 10.85. For the final division, T is converted to seconds by multiplication with 10^3.

$$Idt\,[cd\,sec] : (0.2 + T)\,[sec] = E_{eff}(cd).$$

This computation is repeated for different values of T in order to obtain the maximum effective intensity value.

Experience gained during the computation shown on the following pages often results in the first computation of E_{eff} being so close to the maximum that subsequent computations produce no significant improvement.

The accuracy of this method is estimated to be close to 5%. Individual sources of error are:

1) Photometric error, overall, approx.	2.5%
2) Graphic integration, approx.	1.5%
3) Computation error,	1.0%

The computation error results primarily from the inability to compute a beneficial third value of the effective intensity, in addition to the two shown with each intensity versus time curve. Frequently, the first try is already within 1% of the retrial maximum, as is shown by the fact that the second value is within 1% or 2% of the first. Whenever a third computation was made, it usually showed that the maximum lies between the results of the first and second computation.

In order to further improve the accuracy, much greater precision in measuring small differences in flash duration and flash energy is required. At least twice the chart width used for the measurements reported here would be required. Such an increase in recorder resolution would about double the cost of this effort. In view of the small gain in accuracy, it is doubtful that this approach is desirable.

It appears from most of the calculations presented herein that the maximum effective intensity values shown in Table A are only about 2% lower than the best possible values which could be expected with a much more accurate procedure. A proportional reduction in flash duration can be expected in most of these cases.

Both the yellow and green projectors used for the effective intensity measurements presented here were equipped with Westinghouse 250 Q/CL, 120 V, 2000 hour lamps. With one of these lamps, the intensity of the aviation yellow beam falls below the required minimum near the upper edge of the beam. When the lamps were replaced with Sylvania Q/CL, 130 V, 2000 hour lamps, the beam pattern was significantly improved. This improvement is due to the greater uniformity and concentricity of the filament geometry of the Sylvania lamps. The increase in intensity, shown in Fig. 10, page 19, is more than sufficient to eliminate the excessive intensity drop which occurred with the Westinghouse lamp.

AVIATION GREEN; Minimum Required: 3000 cd.

Displacement from Beam Axis:	-5.0°	-2.5°	0.0°	$+2.5^{\circ}$	$+5.0^{\circ}$	
At 119 V	3520	4580	5140	(118V) 5260	4100	cd
At 115 V	3000	4200	4700	4850	3770	cd
Flash duration	86.8	89.5	91.0	92.4	94.0	msec

AVIATION YELLOW; Minimum Required: 7000 cd.

Displacement from Beam Axis:	-6.0°	-5.0°	-2.5°	0.0°	$+2.5^{\circ}$	$+4.0^{\circ}$	
At 119 V	8120	7950	9180	9660	7210	6850*	cd
At 115 V	7500	7300	8400	8900	6650*	6300*	cd
Flash duration	87.0	85.6	82.5	76.0	84.0	83.5	msec

*Below 7000 cd. However, see Fig. 10, page 19, for data meeting requirement.

AVIATION WHITE, NON-SPLIT; Minimum Required: 20,000 cd.

Displacement from Beam Axis:	-5.0°	-2.5°	0.0°	$+2.5^{\circ}$	$+5.0^{\circ}$	
At 116 V	21000	24000	21650	23800	22200	cd
At 115 V	20600	22500	21200	23300	21800	cd
Flash duration	94.5	102	103	103	102	msec

TABLE A: EFFECTIVE INTENSITIES OF HELIPORT BEACON FLASHES

Note: When in service, beam axes are 5° above horizon. Additional elevation up to 8.0° is optional.

Run #2. Aviation Yellow Projector

Intensity Calibration

1) At +4° Vertical Displacement from Beam Axis.

Detector Current at Intensity Peak: 12.75 μA

Corresponding Illumination Level: 8.0 ftcd

Distance: 65.3 ft. $D^2 = 4264$

Peak Intensity: 8 x 4264 = 34000 cd

Number of Vertical Divisions at Peak: 12.7

Intensity per Vertical Division: 2680 cd
34000 : 12.7 = 2680

Energy per Unit Area: 2680 cd x 10.85 x 10^{-3} sec
= 29 cdsec

2) At +5° Vertical Displacement from Beam Axis.

Detector Current at Intensity Peak: 10.6 μA

Corresponding Illumination Level: 6.63 ftcd

Distance: 65.3 ft; $D^2 = 4264$

Peak Intensity: 6.63 x 4264 = 28300 cd

Number of Vertical Divisions at Peak: 10.7

Intensity per Vertical Division: 2640 cd
28300 : 10.7 = 2640

Energy per Unit Area: 2640 x 10.85 x 10^{-3} sec
= 28.7 cdsec

PHOTOMETRY DATA RECORD

ITEM HELIPORT BEACON AVIATION YELLOW BEAM DATE 2-28-71

Detector: WESTON MODEL 856 # 9902001 TYPE RRV

Last Detector Calibration: July 15, 1970

Distance: 65'4"

Goniometer Sweep Rate: 4.8 sec/degree

Recorder Chart Speed: 15 sec per division

Input Shunt: 4100 Ω, .1%

Detector Current at Intensity Peak: 10.6 μA @ +5° (6.5 ft cd) (FCA); 12.75 μA @ +4° (8.0 ft cd)

Ambient Light Reading: 0.0 μA @ +5°; 0.0 μA @ +4°

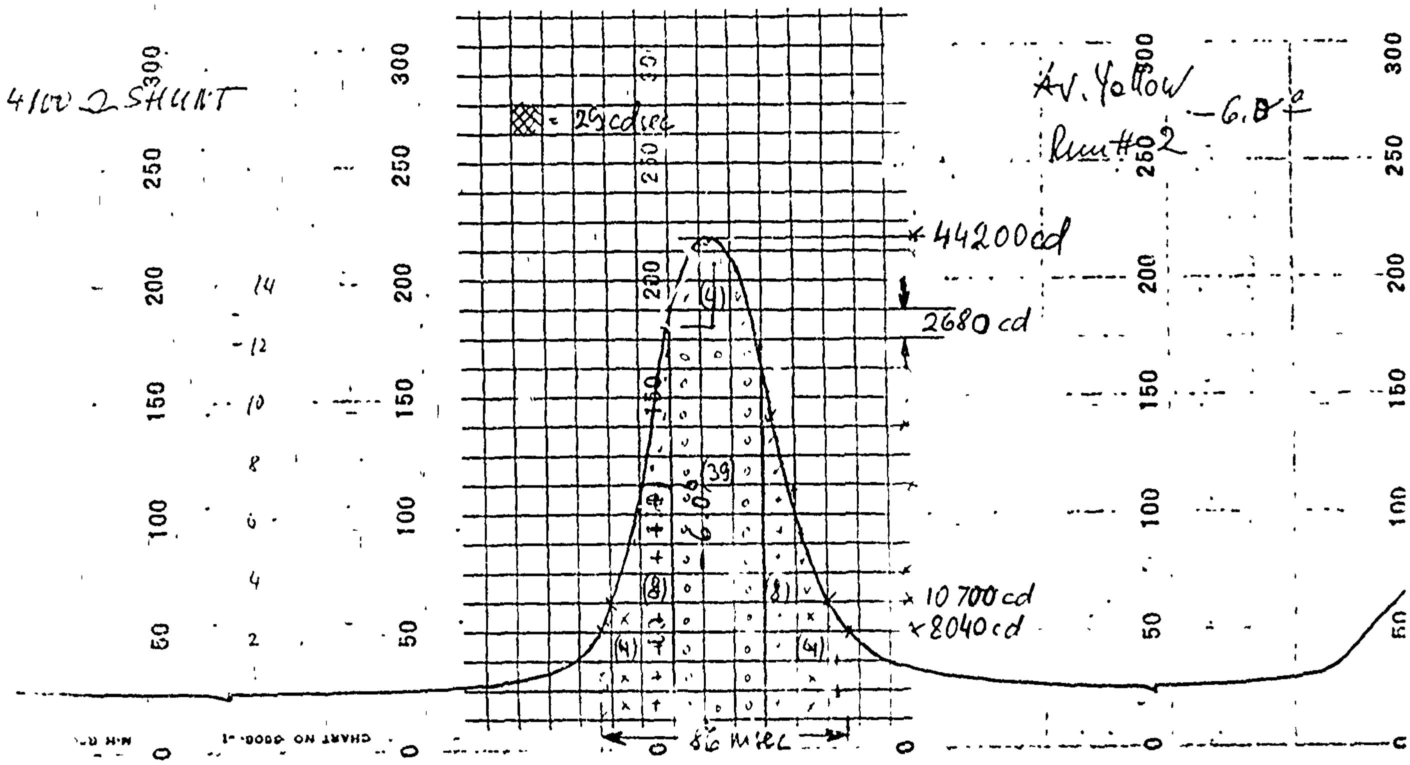
Test Object

Lamp	: (W) 250 Q/CL, 250 W 120V
Lamp Operating Voltage	: 10.8 to 10.93 == 118 to 120V
Optical Elements	2" F.L. 6" DIA. ALZAK PARABOLOID
Filter	: Schott OG 550, 3.5 mm thick
Vertical Displacement ~~Deviation~~ from Beam Axis	: -5°, -7.5°, -2.5°, 0°, +2.5°, +5°, +7.0°, -6.0, +4°.

Notes:

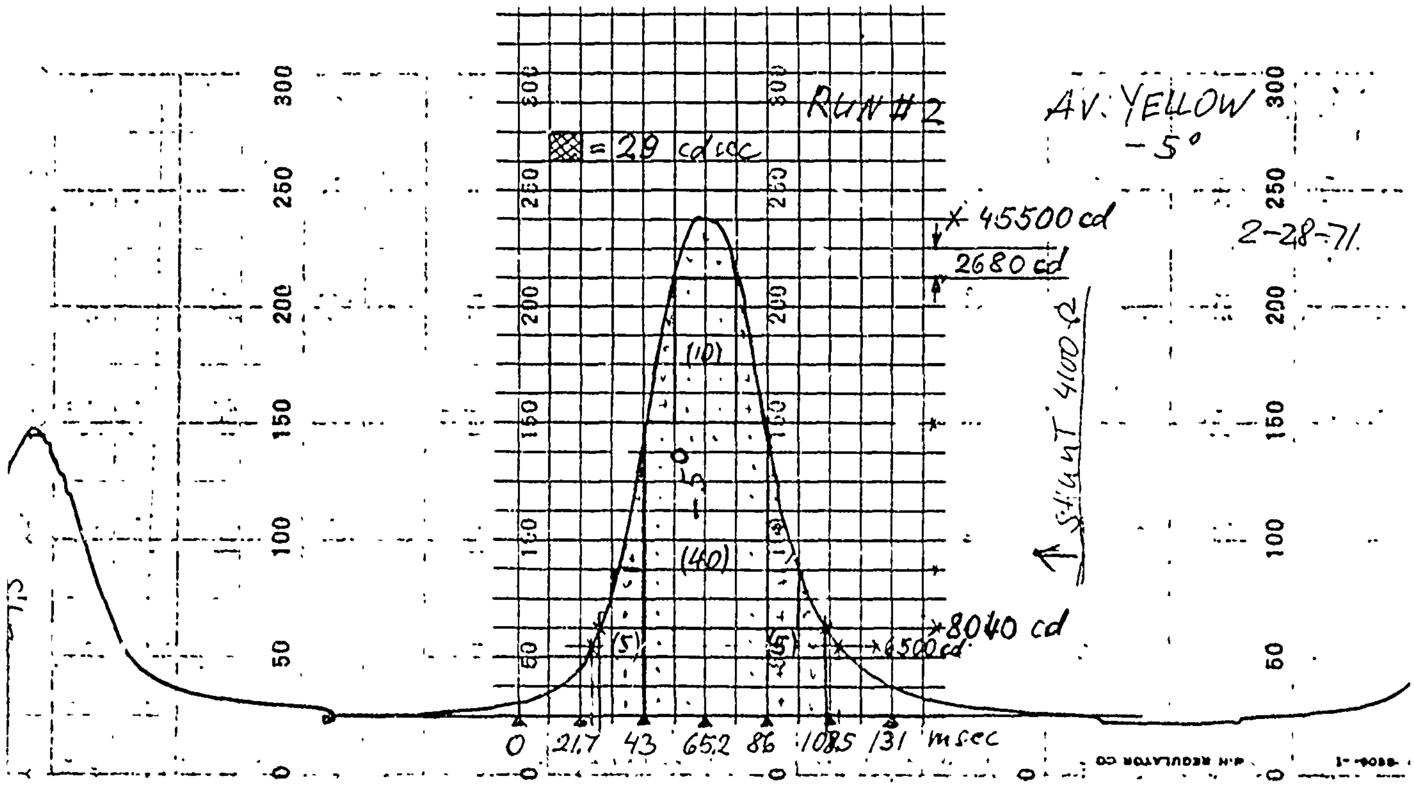
Certified by Fred [illegible] Miller
QC Inspector

Sheet 1 of 1



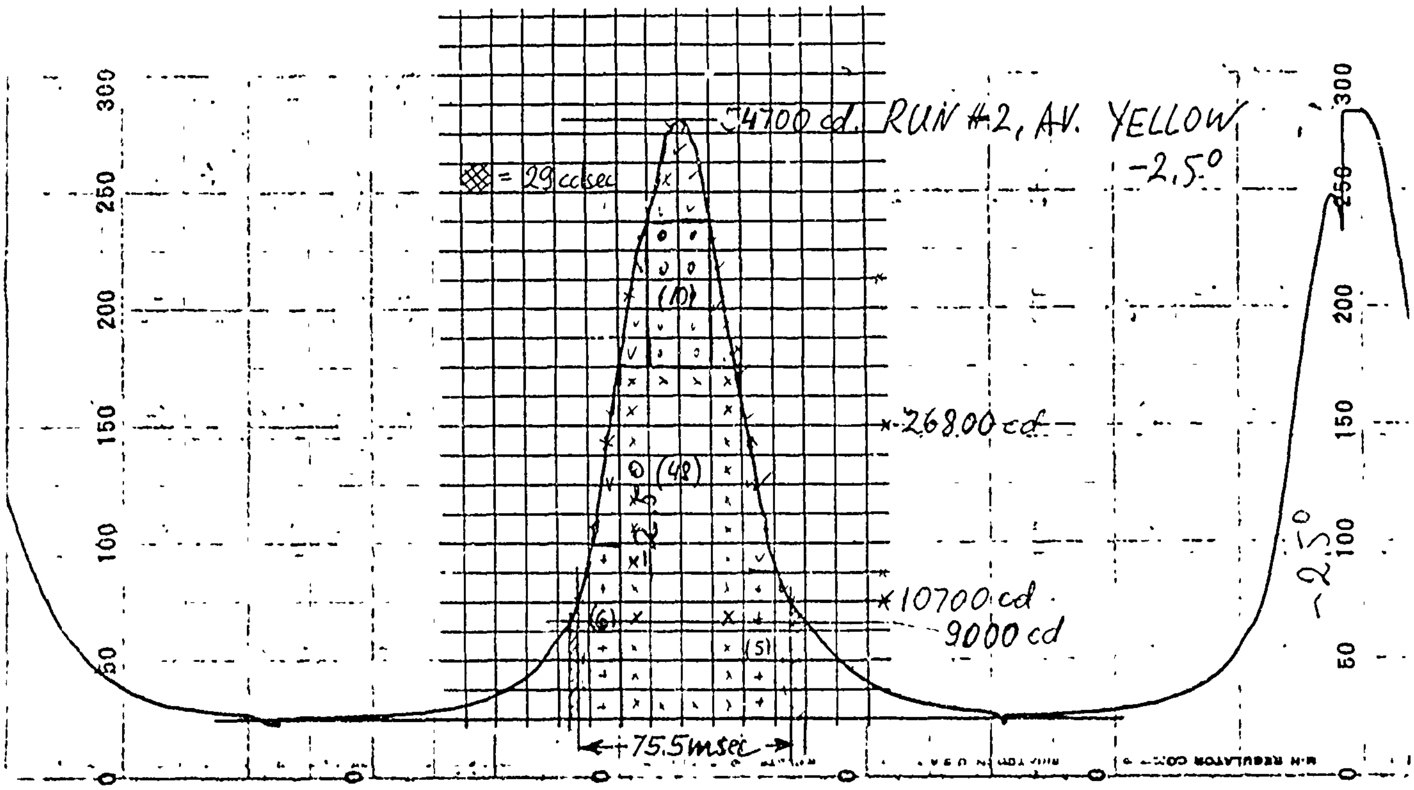
I₁ : $t_2 - t_1$ = 76.6 msec = 0.0766 sec
A_1 = 39 +8 +8 +4 +4 +4 +10 = 77 ea
77 x 29 = 2230 cdsec
I_1 = 2230 :(0.2 + 0.0766) = 8060 cd Effective Intensity

I_2: $t_2 - t_1$ = 87 msec = 0.087 sec
A_2 = 77 + 3.3 = 80.3 ea
80.3 x 29 = 2330 cdsec
I_2 = 2330 :(0.2 + 0.087)
= 8120 cd Effective Intensity



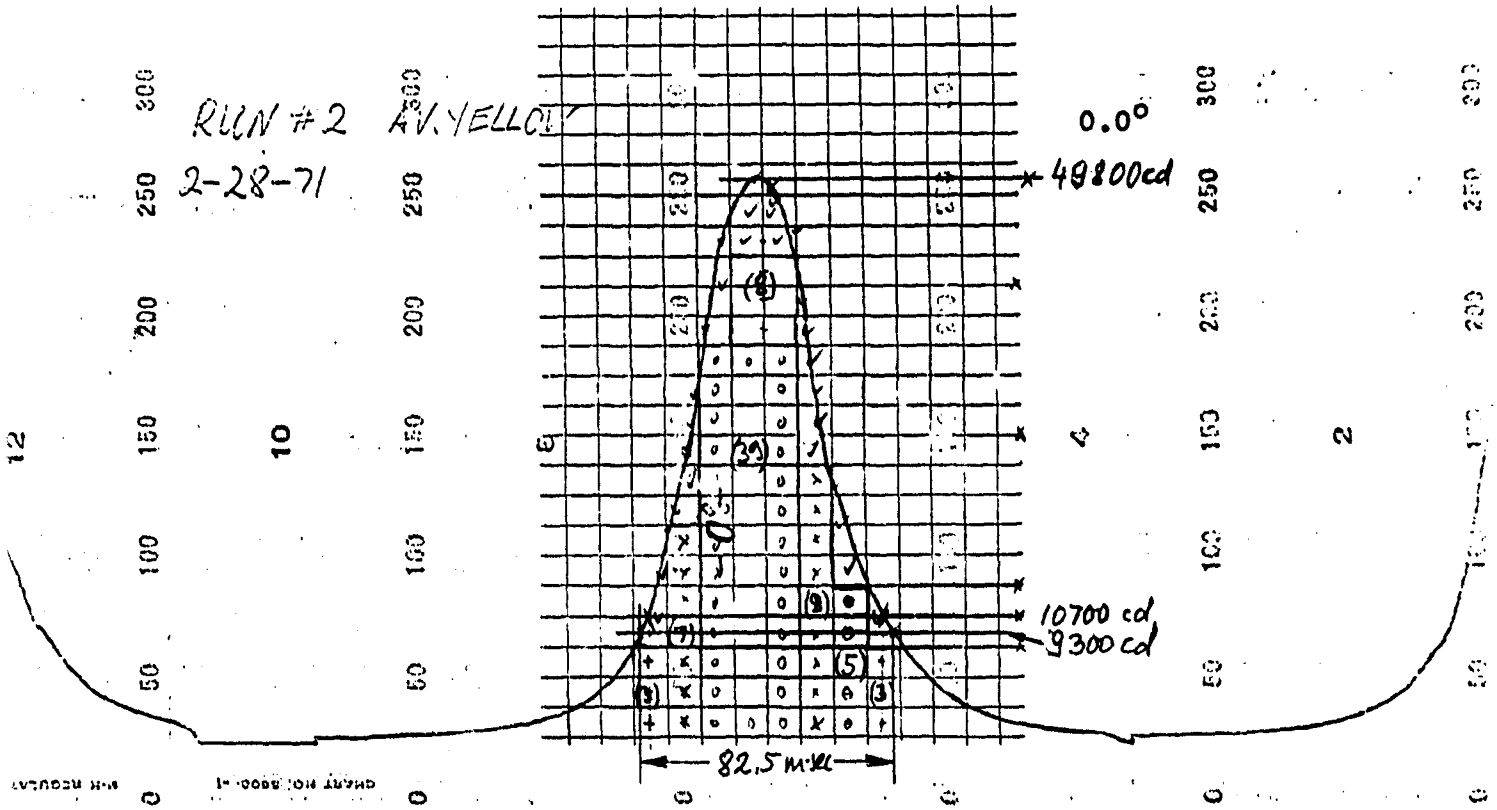
I_1: $t_2 - t_1$ = 79.5 msec = 0. sec
A_1 = 40 +10 +5 +5 +16 76.5 ea
76.5 x 29 = 2220 cdsec
I_1 = 2220 :(0.2 + 0.0795)
= 7950 cd Effective Intensity

I_2: $t_2 - t_1$ = 85.6 msec = 0.0856 sec
A_2 = 76.5 + 1.5 = 78 ea
78 x 29 = 2260
I_2 = 2260 :(0.2 + 0.0856) = 7940 cd Effective Intensity



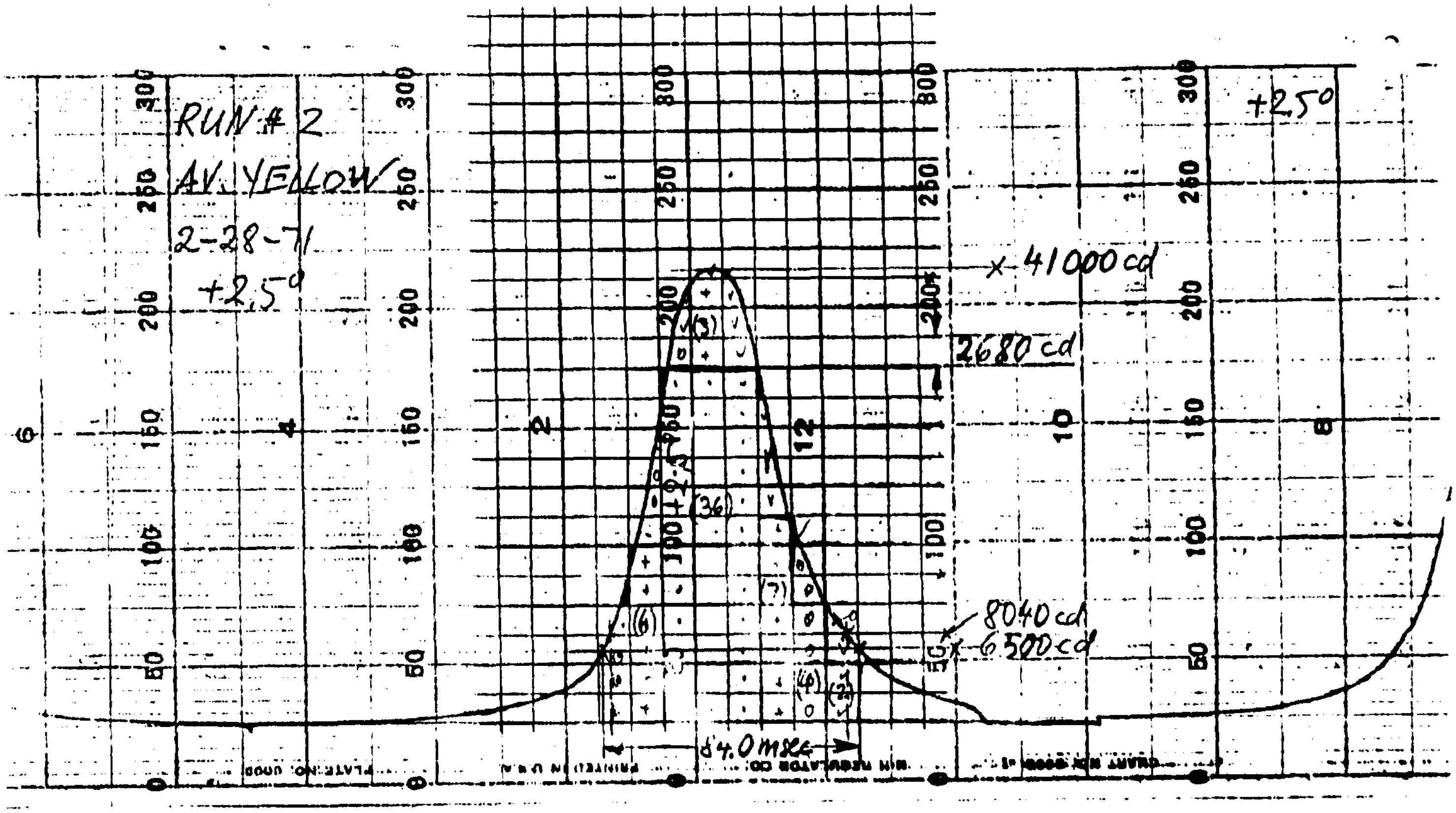
I_1 : $t_2 - t_1$ = 75.5 msec = 0.0755 sec
A_1 = 48 + 10 + 6 + 5 + 18 = 87 ea
87 x 29 = 2520
I = 2520 :(0.2 + 0.0755) = <u>9180 cd</u> Effective Intensity

I_2: $t_2 - t_1$ = 82.5 msec = 0.0825 sec
A_2 = 87 + 2.5 = 89.5 ea
89.5 x 29 = 2595
I_2 = 2595 :(0.2 + 0.0825)
= 9180 cd Effective Intensity



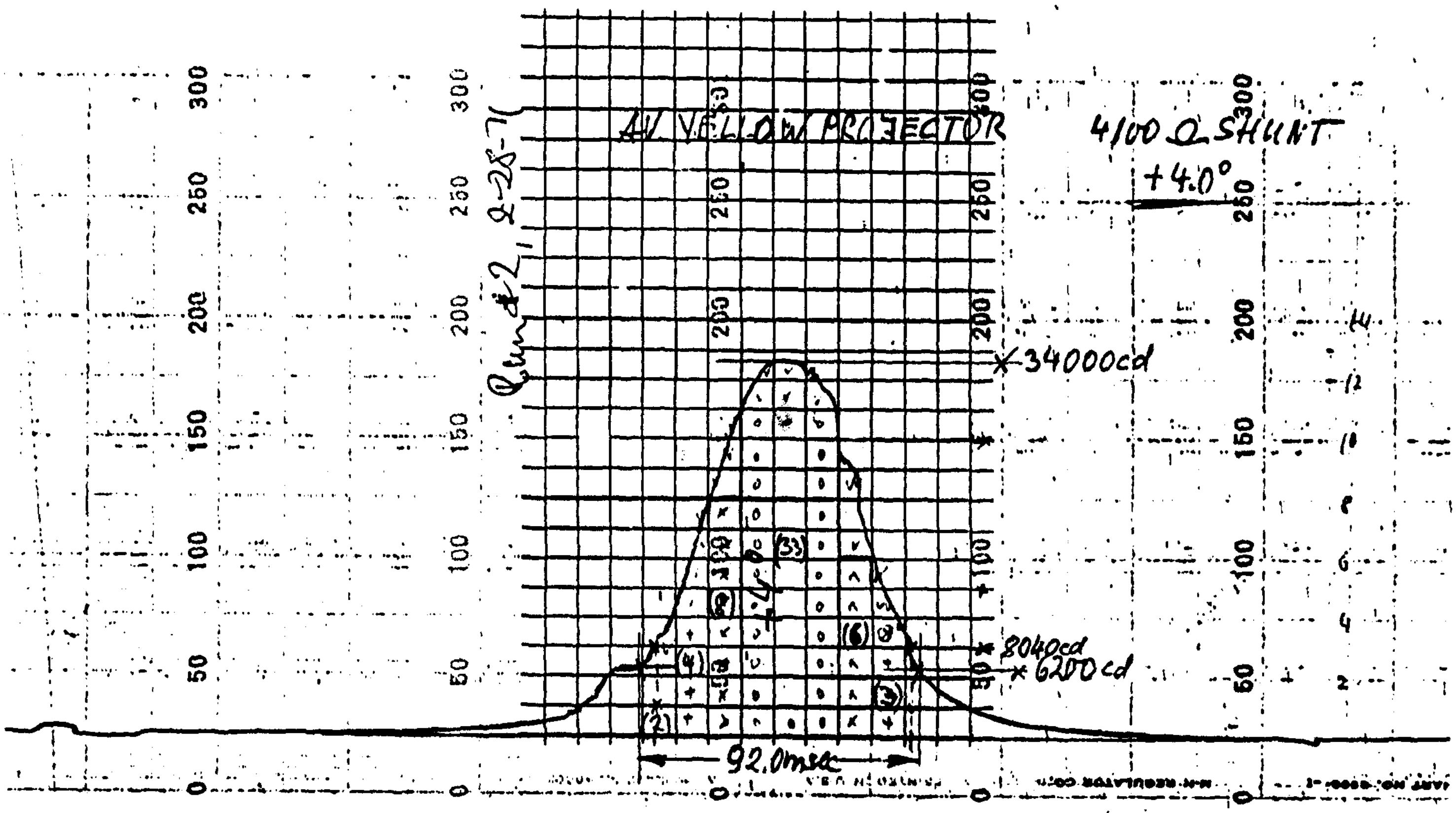
I_1 : $t_2 - t_1 = 76$ msec = 0.076 sec
$A_1 = 39 + 9 + 8 + 7 + 5 + 3 + 3 + 17 = 91$ ea
$91 \times 29 = 2640$ cdsec
$I_1 = 2640 : (0.2 + 0.076)$
$= 9660$ cd **Effective Intensity**

I_2 : $t_2 - t_1 = 82.5$ msec
$A_2 = 91 + 2 = 93$ ea
$93 \times 29 = 2700$ cdsec
$I_2 = 2700 : (0.2 + 0.0825) =$ 9470 cd Effective Intensity



I_1 : $t_2 - t_1$ = 78.7 msec = 0.0787 sec
A_1 = 36 + 7 + 6 + 4 + 3 + 13 = 69 ea
69 x 29 = 2000 cd sec
I_1 = 2000 : (0.2 + 0.0787) = <u>7160 cd</u> Effective Intensity

I_2 : $t_2 - t_1$ = 84 msec = 0.084 sec
A_2 = 69 + 1.7 = 70.7 ea
70.7 x 29 = 2050 cd sec
I_2 = 2050 : (0.2 + 0.084)
= <u>7210 cd Effective Intensity</u>



I_1: $t_2 - t_1$ = 83.5 msec = 0.0835 sec
A_1 = 33 + 8 + 6 + 4 + 3 + 13 = 67 ea
67 x 29 = 1940 cdsec
I_1 = 1940 ÷ (0.2 + 0.0835)
= 6850 cd Effective Intensity

I_2: $t_2 - t_1$ = 92 msec = 0.092 sec
A_2 = 67 + 1.5 = 68.5
68.5 x 29 = 1990 cdsec
I_2 = 1990 ÷ (0.2 + 0.092) = 6810 cd Effective Intensity

Run #1. Aviation Green Projector

Intensity Calibration

1) At Beam Axis (0° Vertical Displacement).

Detector Current at Intensity Peak: 9.8 μA

Corresponding Illumination Level: 6.12 ftcd.

Distance: 65.3 ft; $D^2 = 4264$

Peak Intensity: 6.12 x 4264 = 26180 cd

Number of Vertical Divisions at Peak: 19.2

Intensity per Vertical Division: 1360 cd
26180 : 19.2 = 1360

Energy per Unit Area: 1360 cd x 10.85 x 10^{-3} sec

= 14.75 cdsec

2) At $+5^\circ$ Vertical Displacement from Beam Axis.

Detector Current at Intensity Peak: 7.4 μA

Corresponding Illumination Level: 4.62 ftcd

Distance: 65.3 ft; $D^2 = 4264$

Peak Intensity: 4.62 x 4264 = 19800 cd

Number of Vertical Divisions at Peak: 14.5

Intensity per Vertical Division: 1362 cd
19800 : 14.5 = 1362

Energy per Unit Area: 1362 x 10.85 x 10^{-3}

= 14.80 cd sec

PHOTOMETRY DATA RECORD

ITEM HELIPORT BEACON AVIATION GREEN BEAM DATE 2-27-71

Detector: WESTON MODEL 856 # 9902001 TYPE RRV

Last Detector Calibration: July 15, 1970

Distance: 65' 4"

Goniometer Sweep Rate: 50° in 4 min = 4.8 sec per degree

Recorder Chart Speed: 15 sec per division

Input Shunt: 9100 Ω 1%

Detector Current at Intensity Peak: 9.8 μA @ 0°, 7.4 μA @ +5°
↳ 6.0 ft cd ↳ 4.6 ft cd

Ambient Light Reading: 0.0 μA.

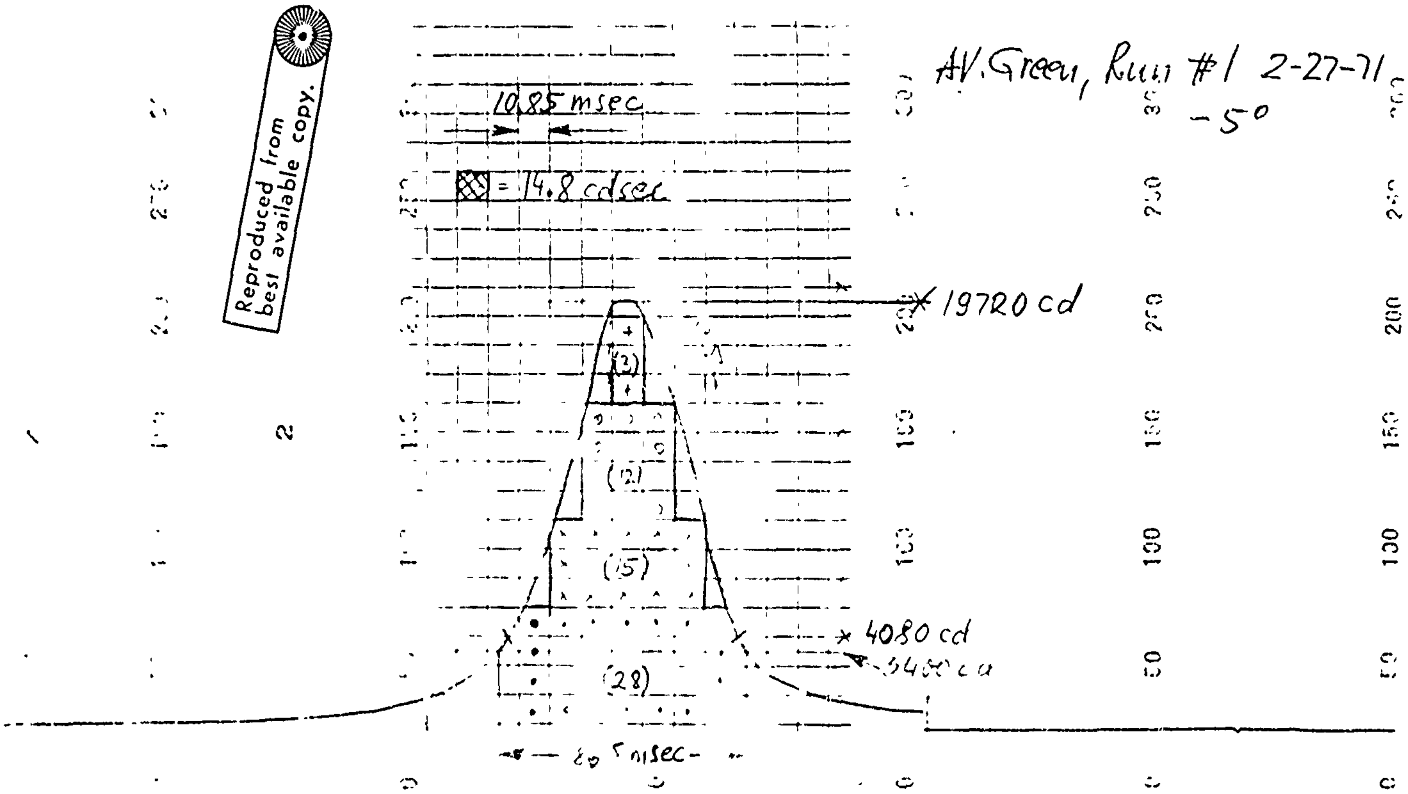
Test Object

Lamp (W) 250 Q/CL	: (250W @ 120V)
Lamp Operating Voltage	: 10.9 = 119 V
Optical Elements	: 2" F.L. 6" DIA ALZAK REFLECTOR
Filter	: Opt. Ind. Av. Green DICHROIC
Vertical Displacements ~~Deviation~~ from Beam Axis	: -5°; 0°; +5°, +2.5°; -2.5°.

Notes: Photometer - Sensitivity 1.6 μA ftcd⁻¹

Certified by [signature]
Q.C. Inspector

Sheet 1 of 1



I_1 : $t_2 - t_1$ = [illegible]0 ms - 0. [illegible] sec
A_1 = 2[illegible] + 15 + [illegible] + [illegible] 67.[illegible]
67.[illegible] x 14.[illegible] [illegible] = [illegible] cdsec
I_1 = 980: (0.2 + 0.080) = 3500 cd eff. int.

I_2: $t_2 - t_1$ = 86.8 msec = 0.0868 sec
A_2 = 67.5 + 2 = 69.5 ea
69.5 x 14.5 cdsec = 1007 cdsec
I_2 = 1007 :(0.2 + 0.0868) = 352[illegible] cd Effective Intensity.

Similar intensity versus time traces were obtained at -2.5°, 0°, +2.5°, and +5° of elevation. The effective intensities measured at these points are listed in Table A on page 29.

Run #3. Aviation White, Non-Split

Intensity Calibration

1) At -5° Vertical Declination from Beam Axis

Detector Current at Intensity Peak: 42 μA

Corresponding Illumination Level: 26.3 ftcd

Distance: 65.3 ft; $D^2 = 4264$

Peak Intensity: 26.3 x 4264 = 112000 cd

Number of Vertical Divisions at Peak: 17.2

Intensity per Vertical Division: 6500 cd
11200 : 17.2 = 6500

Energy per Unit Area: 6500 cd x 10.85×10^{-3} sec
= 70.6 cdsec

2) At $+6^\circ$ Vertical Declination from Beam Axis

Detector Current at Intensity Peak: 37.5 μA

Corresponding Illumination Level: 23.4 ftcd

Distance: 65.3 ft; $D^2 = 4264$

Peak Intensity: 100000 cd

Number of Vertical Divisions at Peak: 14.5

Intensity per Vertical Division: 6900 cd
100000 : 14.5 = 6900

Energy per Unit Area: 6900 cd x 10.85×10^{-3} sec
= 74.8 cdsec

Note: The discrepancy between 70.6 and 74.8 cdsec per unit area is due to occasional "sticking" of the microampere meter movement during calibration. Recent experience has shown that slight tapping of the instrument will eliminate this source of error. The results of computations based on 70.6 cdsec at 116 V are therefore about 6% too low.

PHOTOMETRY DATA RECORD

Run #3

ITEM Heliport Beacon Split White Beam, Non-Split DATE 3-3-71

Detector: WESTON MODEL 856 #990201 TYPE RRV

Last Detector Calibration: July 15, 1970

Distance: 65'4"

Goniometer Sweep Rate: 50° in 4 min = 4.8 sec per degree

Recorder Chart Speed: 15 sec per division

Input Shunt: ~~1.84 1%~~ changed to 1.635 K, 1% F.W. 3-3-71

Detector Current at Intensity Peak: 42 μA @ -5° = 26 [illegible]; 37.5 μA @ +6° = 23 6 [illegible]

Ambient Light Reading: — 0.0 —

Test Object

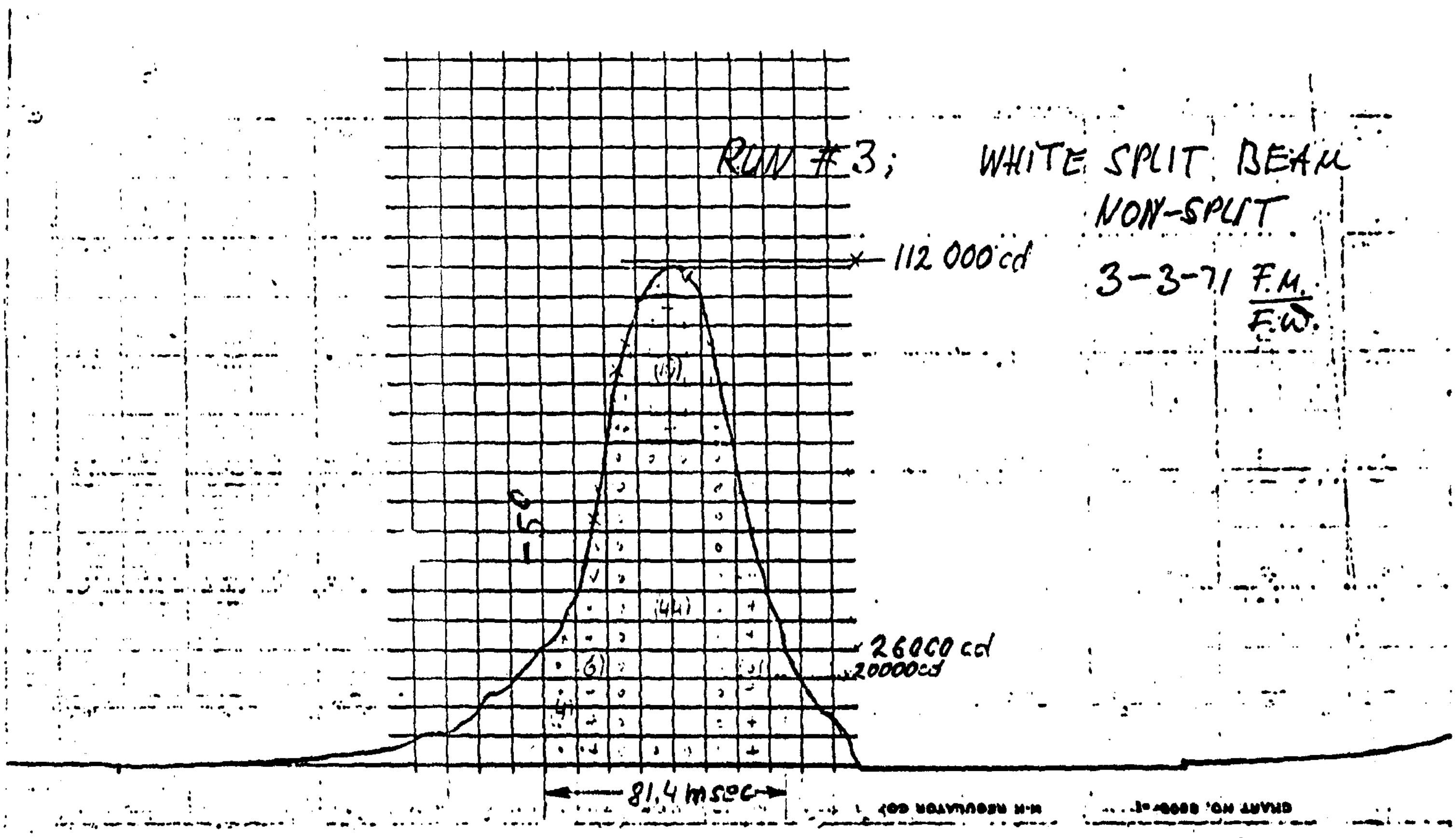
Lamp	:	Sylvania EHD 500W, 120V
Lamp Operating Voltage	:	10.8 to 10.9 = 118 to 119V; 10.6 = 116V
Optical Elements	:	2 ea 80 mm DIA, 2.4" F.L, Asph. Cond. Lenses, 1 ea flat ALZAK Mir
Filter	:	-NONE-
~~Deviation~~ Displacement from Beam Axis	:	see next line.

-5°, -2.5°, 0.0°, +2.5°, +5°, +6°.

Notes:

Certified by [signature]
QC Inspector

Sheet 1 of 1



I_1: $t_2 - t_1 = 81.4$ msec $= 0.0814$ sec
$A_1 = 44 + 10 + 6 + 6 + 4 + 12.7 = 82.7$ ea
$82.7 \times 70.6 = 5850$ cdsec
$I_1 = 5850 : (0.2 + 0.0814) =$ 20800 cd Effective Intensity

I_2: $t_2 - t_1 = 94.5$ msec $= 0.0945$ sec
$A_2 = 82.7 + 4.5 = 87.2$ ea
$87.2 \times 70.6 = 6170$ cdsec
$I_2 = 6170 : (0.2 + 0.0945)$
$=$ 21000 cd Effective Intensity

Similar intensity versus time traces were obtained at -2.5°, 0°, +2.5°, and +5° of elevation. The effective intensities measured at these points are listed in Table A on page 29.

ENVIRONMENTAL TEST PROGRAM
ON
HELIPORT BEACON
PART NUMBER 2000-69, UNIT NUMBER 1

WYLE LABORATORIES
NORCO, CALIFORNIA 91760

JULY 1971

SUMMARY

One Heliport Beacon, Part Number 2000-69, Unit Number 1, manufactured by Scientific Components Co., 350 Vista Baya, Newport Beach, California, was submitted to the following environmental tests, which were conducted according to Mil Standard 810B:

- Altitude, to 10,000 feet
- Rain and 40 mph wind
- Humidity
- High Temperature
- Low Temperature

All testing was conducted in accordance with the referenced specifications, with the exception that during the humidity test temperature deviations occurred on two occasions, as documented in Notice of Deviation No. 1, included in our test report. The total time the temperature exceeded the specification requirements was 65 minutes. At the direction of Scientific Components Co., the testing was continued.

The test specimen completed the environmental test program with no visible evidence of damage, or deterioration. The specimen performed satisfactorily at the required environmental conditions, but did not operate at full speed below -40F temperature.

At the conclusion of the environmental test program, the specimen was returned to Scientific Components Company.

A copy of the complete test report is available on request.

Correction of Deficiencies

The following defects and deficiencies were discovered in conjunction with the environmental test series, and were corrected as herein described.

1) Cracked Slipring

The bronze slipring assembly was replaced with 15 Ampere coinsilver sliprings meeting applicable military specifications. Total lamp current is less than 9 A at 115 V. Bronze slipring was originally chosen for use with 30 V, 30 A lamp system.

2) Corrosion on plated steel fasteners.

Severely corroded fasteners were replaced with stainless steel or anodized aluminum parts. Other beacon parts made from these materials showed no sign of corrosion.

3) Slow rotation below -40° F.

This failure was traced to excessive shrinkage of the bronze sleeve bearings in the Hurst GA synchronous motor. Installation of ball bearings by the motor manufacturer provided adequate performance at -55° C.

4) Gear belt exchange

Rubber and polyurethane gear belts were tested at low temperatures, showing that rubber belts became relatively stiff below -40°, while polyurethane belts retained adequate flexibility at -55° C. The rubber gear belt was therefore replaced with a polyurethane belt. Both kinds of belts contain a woven fiberglass cord.

DALE AIR-ENGINEERING

REPORT NO. SCC-2000

ISSUE DATE 7-8-71

REVISION DATE 8-12-71

AIRLOAD ANALYSIS

AND

STRUC TURAL STATIC TEST

PROGRAM

SC IENTIFICO COMPONENTS CO.

HELIPORT BFACON

MODEL 2000-69

REVISIONS

DATE	BY	PAGES AFFECTED	REMARKS
8-12	H. D	P. 6	Added Test Results

INTRODUCTION

The SCC Model 200-69 Heliport Beacon assembly is required to be structurally capable of resisting a 100 mph wind velocity when covered with approximately one-half inch of ice growth. This will be substantiated by means of a static test where the aerodynamic loading under these conditions has been computed to be 84 lbs.

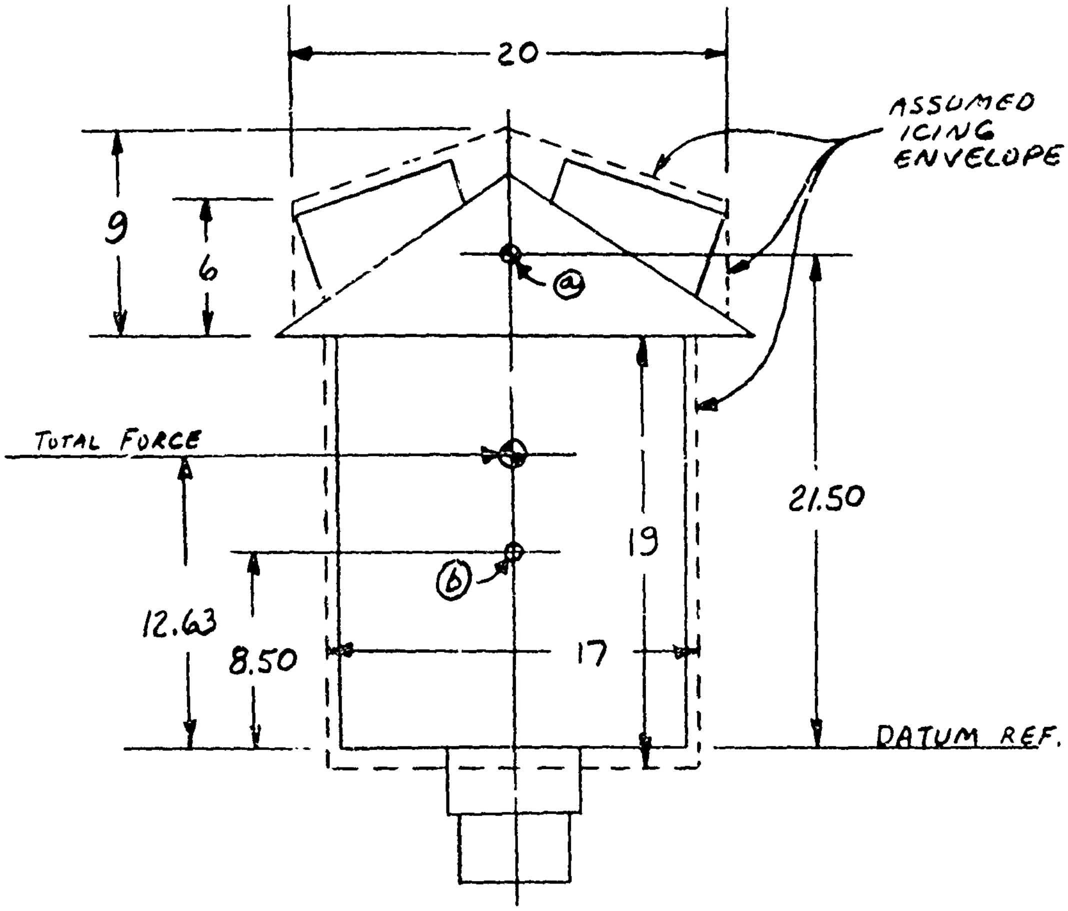
An arbitrary safety factor of two (2) has been chosen for the maximum loading level, and is considered to be more than adequate. The simulated airloads are distributed to the structure by use of a lever-tree system.

The test program has been set-up and witnessed by H. E. Dale, FAA DER LA-129 as noted under test results.

The beacon assembly appears to be satisfactory from a structural standpoint.

1. A 100MPH VELOCITY IS EQUAL TO A DYNAMIC PRESSURE VALUE OF $q = 25.58$ PSF.

2. AIRLOAD DISTRIBUTION



AREA ⓐ $\frac{6 \times 20}{144} = \frac{120}{144} = 0.833\ FT^2$

$\frac{3 \times 10}{144} = \frac{30}{144} = 0.208\ FT^2$

TOTAL = $1.041\ FT^2$

AREA ⓑ

$\frac{9 \times 17}{144} = \frac{323}{144} = 2.243\ FT^2$

(CONT)

3. AREA a FORCE

$$F_a = 1.041 \times 25.58 = 26.63 \text{ lbs.}$$

AREA b FORCE

$$F_b = 2.243 \times 25.58 = 57.37 \text{ lbs.}$$

NET TOTAL LIMIT FORCE

$$F_{tot} = 26.63 + 57.37 = 84.00 \text{ lbs.}$$

DESIGN TEST FORCE

Factor of Safety = 2.0

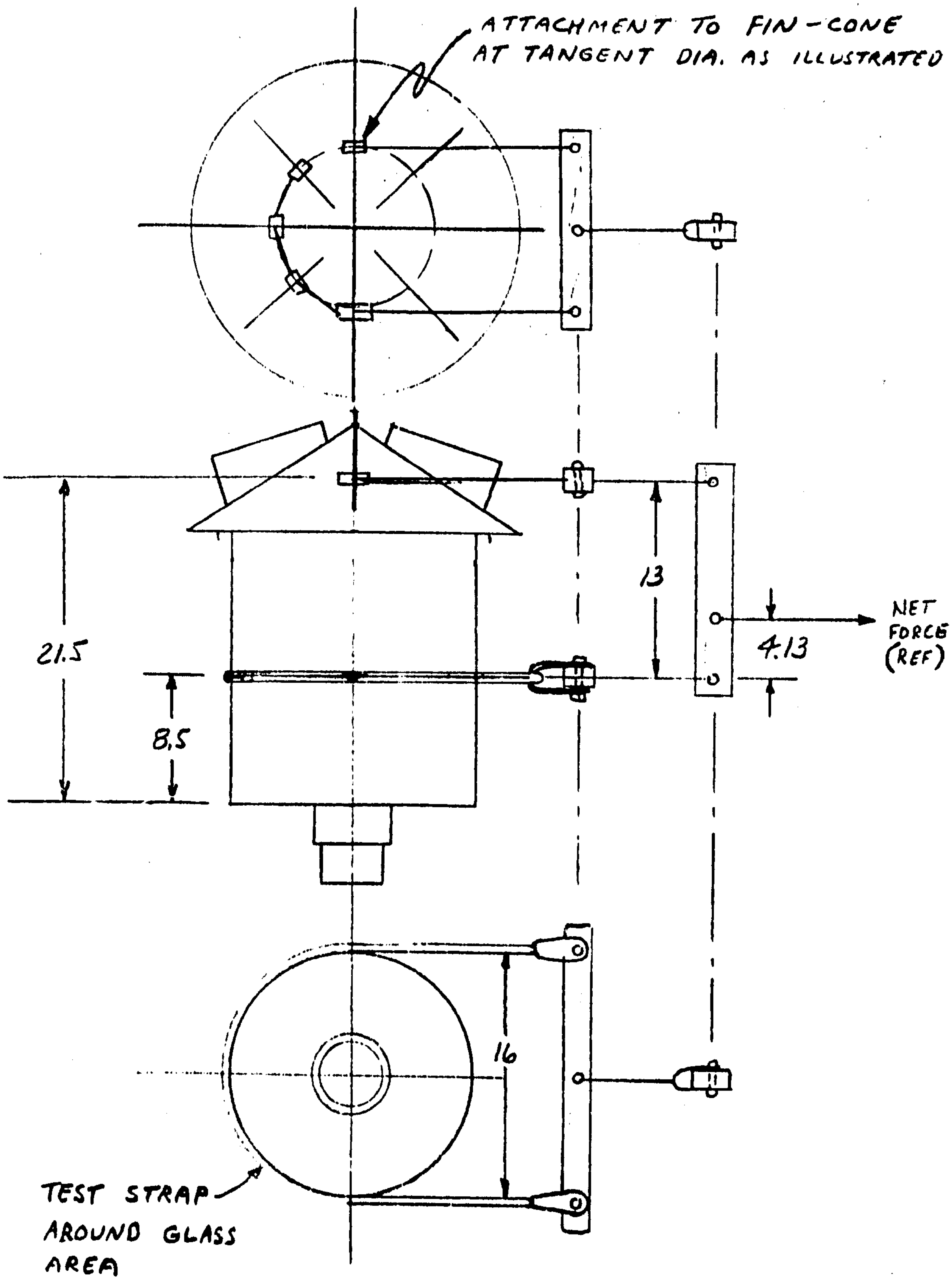
$$F_{test} \quad 84.00 \times 2.0 = 168 \text{ lbs.}$$

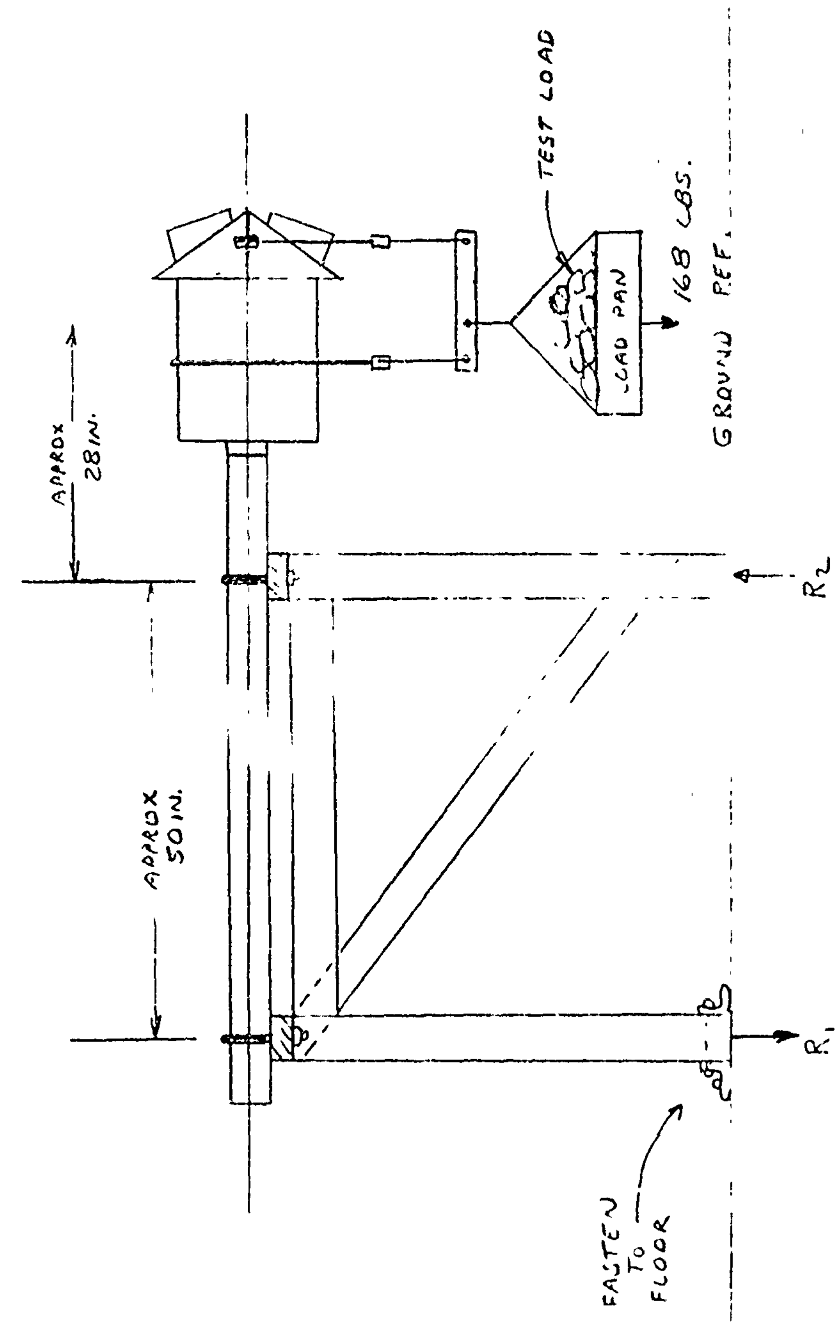
4.

FORCE	DIST.-DATUM	MOMENT
26.63	21.5	571.47
57.37	8.5	489.43
84.00	12.63	1060.90

↑ Location of Total Force

5. TEST SET-UP
LEVERAGE SYSTEM




TEST LOAD
168 LBS.
LOAD PAN
GROUND REF.
APPROX 28 IN.
APPROX 50 IN.
R2
R1
FASTEN TO FLOOR

6. TEST RESULTS

On 8-12-1971 the static test was performed and witnessed by FAA D. E. R. H. E. Dale LA-129.

The beacon assembly was loaded to the maximum value of 168 lbs. in the following increments:

1.	Limit	=	85 lbs	101%
2.	1.5	=	132 lbs	154%
3.	2.0	=	168 lbs	200 %
4.	2.05	=	172 lbs	205%

(actual test weight including tare weight)

NOTE:

The actual test weight of 172 lbs. is equal to a q value of 52.40 PSF which equates to a wind velocity of approximately 143 MPH.

THE TEST APPEARED SATISFACTORY WITH NO FAILURE OR PERMANENT SET.

H. E. Dale

H. E. Dale FAA D. E. R.
L. A 129

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
STATEMENT OF COMPLIANCE WITH THE FEDERAL AVIATION REGULATIONS

DATE: 8-13-71

AIRCRAFT OR AIRCRAFT COMPONENT IDENTIFICATION

MAKE	MODEL NO.	TYPE (Airplane, Radio, Helicopter, etc.)	NAME OF APPLICANT
SCIENTIFICO HELIPORT BEACON	2000-69	HELIPORT BEACON	SCIENTIFICO SCIENTIFIC COMPONENTS CO.

LIST OF DATA

IDENTIFICATION	TITLE
REPORT SCC-2000 DTD. 8-12-71	AIRLOAD ANALYSIS AND STRUCTURAL STATIC TEST PROGRAM HELIPORT BEACON MODEL 2000-69

PURPOSE OF DATA

TO SUBSTANTIATE BEACON ASSEMBLY STRUCTURAL INTEGRITY

APPLICABLE REQUIREMENTS (List specific sections)

GOVT. CONTRACT TO SCIENTIFICO COMPONENTS CO.
FROM FAA - ATLANTIC CITY
SPECIFICATION OUTLINED REQUIREMENTS

CERTIFICATION - Under authority vested by direction of the Administrator and in accordance with conditions and limitations of appointment under Part 183 of the Federal Aviation Regulations, data listed above and on attached sheets numbered NONE have been examined in accordance with established procedures and found to comply with applicable requirements of the Federal Aviation Regulations.

I (We) therefore
☒ Recommend approval of these data
☐ Approve these data

SIGNATURE(S) OF DESIGNATED ENGINEERING REPRESENTATIVE(S)	DESIGNATION NUMBER(S)	CLASSIFICATION(S)
H. E. Dale	LA-129	STRUCTURES D.E.R.

FAA Form 8110-3 (1-70) SUPERSEDES PREVIOUS EDITION

OPERATING INSTRUCTIONS

MODEL 200-69 HELIPORT BEACON
115 V, 1000 W, 60 Hz

Description of Design and Construction

This revolving beam beacon consists of two colored projectors, aviation green and aviation yellow, and a split white beam projector. The colored beams' axis are aligned 70° apart in the horizontal plane. Centered between these two beams is the split white beam projector which is mounted above the two colored projectors. The three projector cluster is mounted on a tilting table, which is hinged to a turntable. A 30 rpm synchronous motor drives the turntable at a fixed speed of 12 rpm through a gear belt reduction gear. The optical assembly is covered by a pyrex cylinder which is topped by an integral heat exchanger. Both ends of the pyrex cylinder are bonded to stainless steel rings by means of silicone adhesives. Eight #8 slotted flathead screws with nylon inserts hold the lower ring to the baseplate. The screws have to be removed and the pyrex cylinder assembly carefully lifted, in order to gain access to the beacon interior.

Lamps and Fuses

Each lamp and the motor are fused. Fuse locations are:

* on the baseplate, 0.1 Ampere, Motor fuse;
* on the tilting table, 2 each 3 Ampere, slow blow, for colored beam projectors, and one 6 Ampere, slow blow, for the white split beam projector.

Lamps in the colored beam projectors have mini-can screw bases, and can be reached after removing side panels which are attached by two #6 philips-head screws. The split white beam projector lamp has a two-pin base. It can be pulled out of its socket after removing the stainless steel wire clamp which attaches to the top of the reimaging hemisphere.

CAUTION: Do not touch lamp bulbs with fingers. Wear cotton gloves, or keep lamps wrapped in plastic film or soft paper while handling them. Finger prints will burn into the surface of the quartz envelopes and cause optical deterioration and premature failure. Clean quartz envelopes with rubbing alcohol or distilled water if touched accidently.

Adjustments

The tilting table can be adjusted through access holes in the baseplate. A suitable Allen wrench is provided with the beacon. The adjustment screws for the bubble levels protrude through the baseplate. All adjustment screws are permanently secured by elastic stop nut inserts.

Split beam separation is adjusted by changing the position of the hinged flat mirror by means of the knurled nut located atop the mirror. Access to this adjustment nut requires removal of the beacon housing.

Photoswitch

The light level at which the automatic photoswitch turns the beacon on and off depends upon the setting of the light control vane located in front of the photocell. Closing this "door" causes the switch to turn on at higher ambient light levels; opening it results in switch action at lower ambient light levels. The light level at which the switch is actuated thereby can be adjusted within the range from approximately 5 to 100 ft candles.
NOTE: This photoswitch is equipped with a built-in delay of several seconds so it will not respond to brief light flashes or similar transient changes in light level.

Cleaning

The outer surfaces of the beacon can be cleaned with water or detergent solutions. In areas where the water supply has a high solid content, rinsing with distilled water or rubbing alcohol is recommended. Interior surfaces can be wiped clean with a soft cloth or napkin, or brush.

Parts List

All Heliport Beacon Parts are identified in its parts list.

Maintenance Requirements

A good indication of the performance of all parts of the drive and slipring system is obtained by counting the number of revolutions per minute. If there is substantial deviation from 12 rpm, individual components of the drive train should be inspected. These components are:

Gear motor
Phase shift capacitor
Gear belt

Idler roller
Idler arm pivot bearing
Idler spring
Slip rings
Brush blocks
Main bearing

Operation at 12 rpm indicates that all these parts function properly.

Proper operation of the optical systems can be established visually. If all parts are in place, clean, and free from cracks, chips, or dirt, the specified light output will be maintained. The beacon's optical system is covered by a sealed shell assembly which keeps out dust, rain and fumes. Therefore, only the outside surface of the pyrex cylinder needs to be kept clean to assure full light output. This surface can be wiped with a moist sponge, or washed with water or a window cleaner. In areas having relatively soft water, spraying with a garden hose will remove most dirt accumulations.

Lamp Replacement should be done on an annual basis, even if not all of the rated lamp life has been used up. This routine replacement assures uninterrupted service and minimal labor costs. If lamps are changed only after burnout, the beacon will be inoperative from the moment of burnout until replacement is completed. In this event, the cost of the necessary special replacement effort exceeds the relatively small amount of money saved through lamp life extension beyond the recommended one year limit.
The beacon will continue to rotate regardless of lamp failure(s). However, the recommended replacement schedule provides good assurance against such partial failures.

Figure 16.

Vertical Adjustment of Tilt Table

Allen wrench can enter through any of five threaded access holes in the baseplate to reach adjustment screw. Access holes are normally closed by means of ¼-28 screws and internal seal washers.

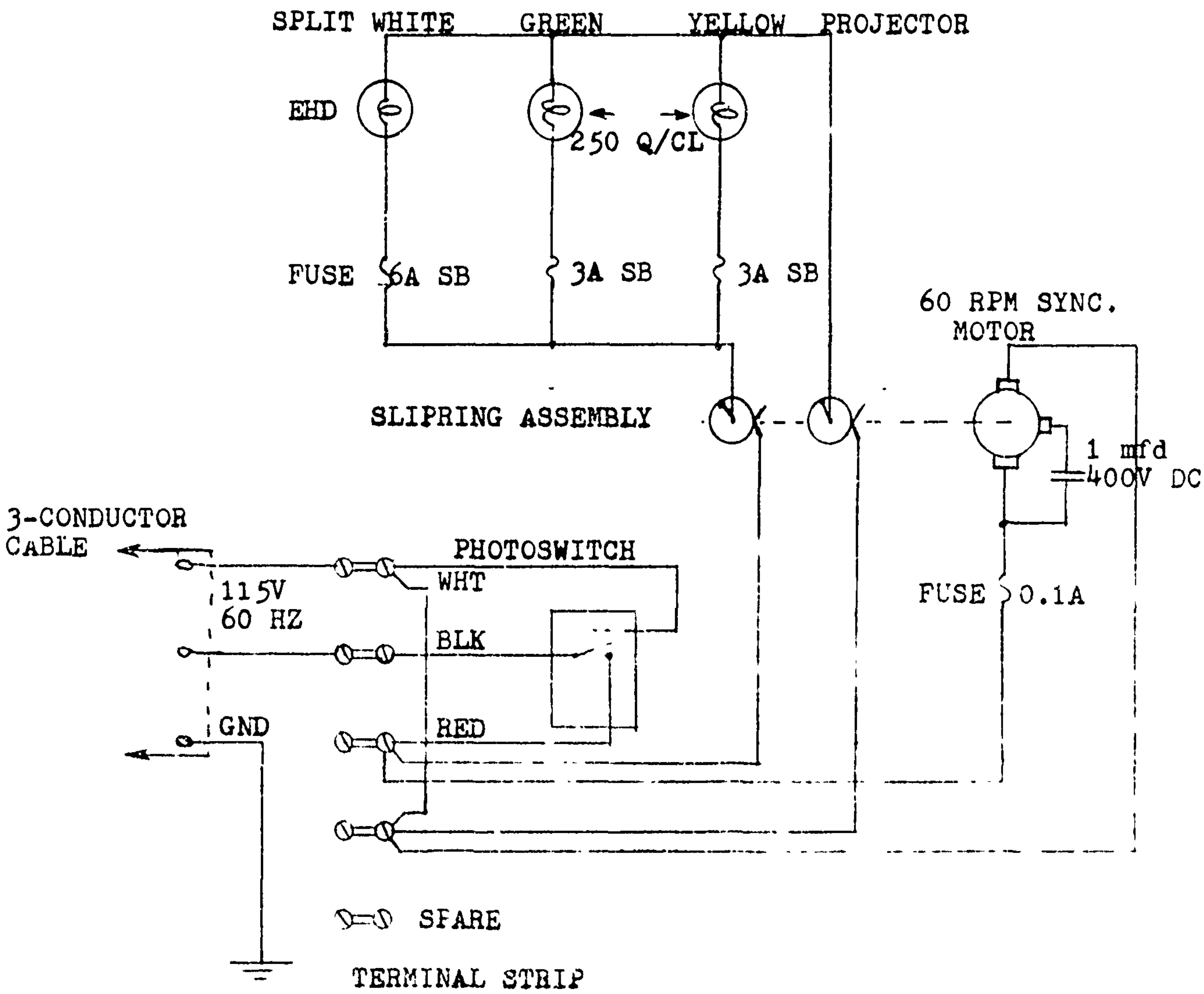


FIGURE 17

WIRING SCHEMATIC, HELIPORT BEACON