NATIONAL BUREAU OF STANDARDS REPORT

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STUDY OF OPTICAL SYSTEM
FOR
AIRPORT TRAFFIC SIGNAL PROJECTOR

by

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Department of Commerce

N.B.S. Test 21A-9/53

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

STUDY OF OPTICAL SYSTEM
for
AIRPORT TRAFFIC SIGNAL PROJECTOR

1. SCOPE

This report gives the results of a study of the candlepower distribution of an experimental airport traffic signal projector submitted by the Civil Aeronautics Administration. To afford a basis of comparison, the performance obtainable with plastic lenses has been measured and the results are included.

2. DEVICE TESTED

The projector tested was designed and built in one of the sections of the Airways Engineering Division of the C.A.A. It is described in Specification C.A.A. 500c. Its optical parts consist of a principal parabolic reflector, a spherical auxiliary reflector, a lamp, and red and green filters which may be placed in the optical path or withdrawn at the option of the operator. There is a cover glass to keep dirt away from the optical parts. The principal reflector is 5.5" in diameter and 5.25" in focal length. The most important differences between this unit and the signal projector of standard design is the smaller diameter of the reflector, which makes possible a smaller, lighter device, and some changes in the filter operating mechanism, which were made for operational reasons and are not included in the present tests. The unit is designed to be used with a lamp of type No. 1501. Four of these lamps were furnished with the unit. They are designed to be used at 5.9 volts with an average life of 200 hours.

The lenses used in the comparison test are 8" x 8" Kodak "Ektalite" field lenses having a focal length of 10.25". They were manufactured by the Eastman Kodak Co., Rochester 4, N. Y. These lenses are identified by the following numbers:

EK-36538-0, bought by N.B.S. several years ago (1 lens)
CW-123770-0, furnished through C.A.A. (1 lens)
EK-36538-1 & 2, furnished by Eastman Kodak Co. (2 lenses)
CW-123770-1 & 2, furnished by Eastman Kodak Co. (2 lenses)

The manufacturer has informed us that the lenses of type EK-36538 were press-molded whereas those of type CW-123770 were injection-molded.

3. TEST PROCEDURE

Three lamps of type No. 1501 were seasoned and standardized at 6.2 volts and at 7.5 volts for candlepower output. These are designated as lamps No. 1, 2 and 3 in this report.

Lamps No. 1, 2 and 3 were all used in making the candlepower distri-

bution measurements on the C.A.A. experimental unit. Lamp No. 2 only was used to make the candlepower distribution measurements on the six "Ktalite" lenses. No auxiliary reflector was used behind the lamp in this case.

All the measurements were made with the test lamp operating at 6.2 volts but the results shown in the figures are corrected to show the candlepower to be expected if the test lamp is operated at 7.5 volts as requested by the C.A.A. This is made possible by including in the calibration of the photometer a factor for each lamp representing the ratio of its total flux at 7.5 volts to its total flux at 6.2 volts.

The candlepower distribution measurements were made with an automatic, recording distribution photometer at a photometric distance of 30 meters (98.4 feet) and calibrated with standard lamp N.B.S. 120. The C.A.A. experimental traffic signal projector was mounted on a goniometer to allow horizontal and vertical rotation. It was measured without refocusing as the focusing appeared to be satisfactory. The six "Ktalite" lenses were successively mounted with the test lamp on a wooden base which was mounted on the goniometer. In each case the lamp was adjusted to the proper focal distance by finding the setting for the maximum candlepower. The calibrations were carried out in the same manner as those for the experimental unit.

4. RESULTS

The curves shown in figures 1 and 2 give the horizontal and vertical candlepower distributions of the experimental unit operated with lamp No. 1 in its original position as submitted by the C.A.A.

The curves shown in figures 3 to 8 give the corresponding candlepower distributions of the unit operated with lamps No. 1, 2 and 3 after the socket had been rotated 90° so as to aline the filament with the optical axis of the reflector.

The results shown in figures 9 to 11 give the horizontal candlepower distribution for each of the six plastic lenses with the lamp filament alined with the optical axis. For these curves the entire lens, which is square except for the corners that are rounded, was used.

To compare the efficiency of the three types of lenses their luminance in kilo candles per square inch has been computed and the following values were found:

Glass reflector* of C.A.A. unit	7.03 kilo cd/sq in.
Plastic lens type KM-36538	5.81 " "
Plastic lens type CM-123770	2.61 " "
Reflector*, Test 21A-1/51	4.59 " "

*Measured thru cover glass.

5. DISCUSSION

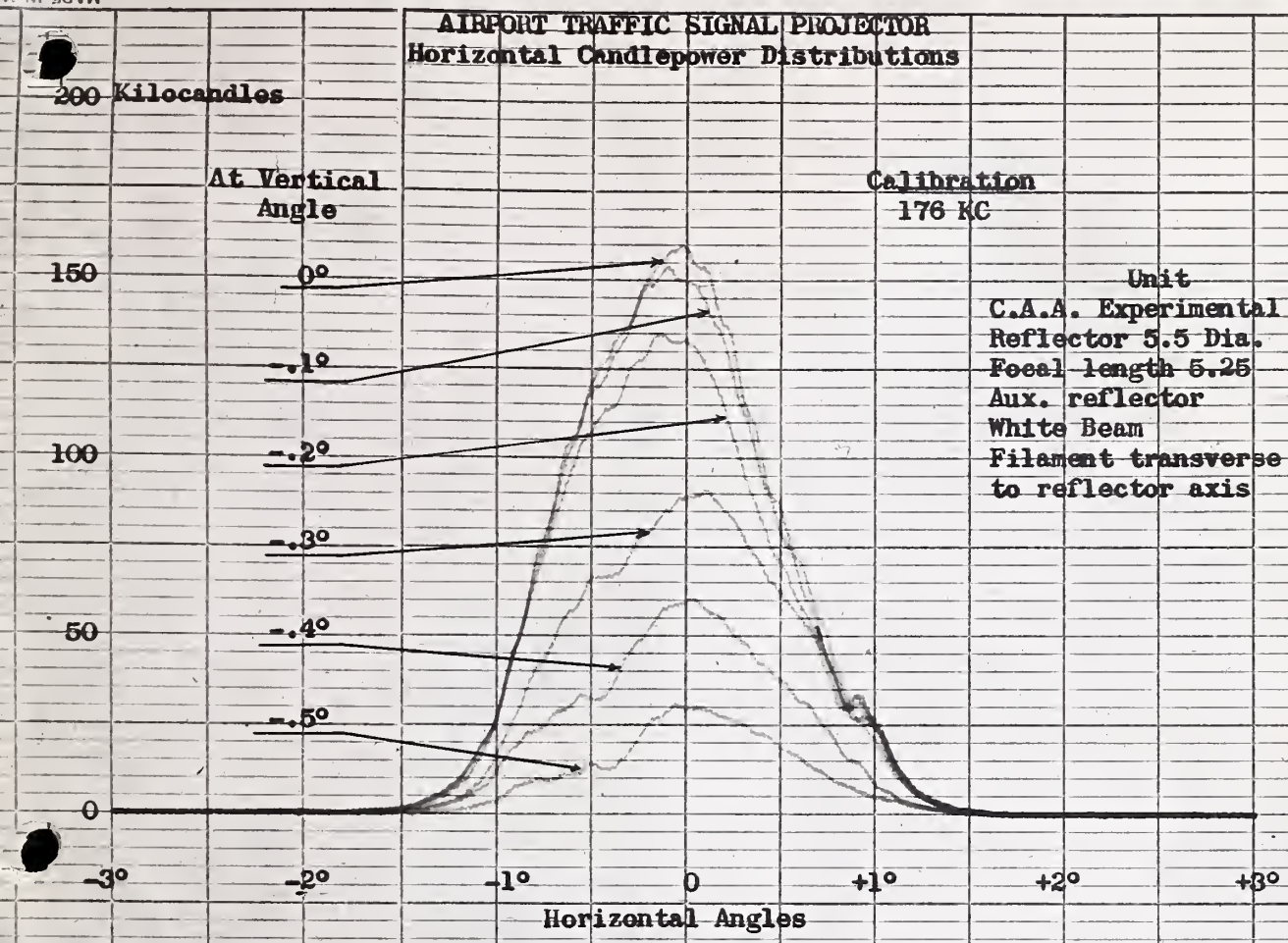
A comparison of the candlepower distributions of Figures 1 and 2 with those of Figures 3 and 4 shows that rotating the lamp to make the filament coaxial with the reflector in the experimental unit results in increasing the axial candlepower about 10% and reducing the horizontal spread by about 1/3. Both of these changes are presumably beneficial. The maximum candlepowers obtained with the three different lamps in the experimental unit vary about ±5% from their mean which is less than frequently occurs for different lamps of the same type.

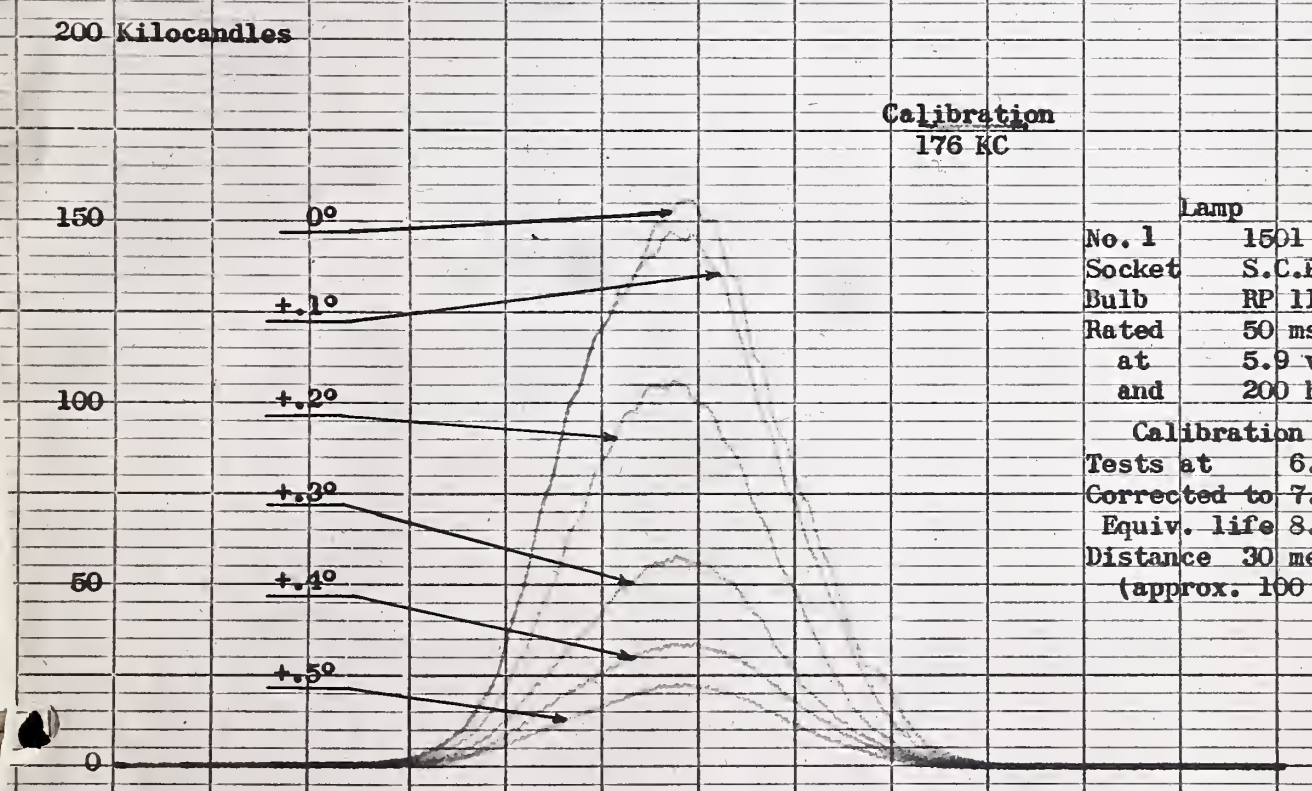
The distributions obtained with the plastic lenses fall into two groups. In three cases, curve A of Figure 9 and curves 1 and 2 of Figure 10, the distributions have maxima about twice the values obtained with the experimental unit, Figures 1 to 8. The other three cases, Figure 9, curve B, and Figure 11, curves 3 and 4, range in maximum candlepower from approximately equal down to 2/3 of the peak candlepower for the experimental unit. The plastic lenses all look much alike but their type numbers correspond to the grouping above and reflect the fact that the lenses have been produced by different processes. Evidently the type EH-36538 press-molded lenses are more than twice as efficient as the injection-molded lenses.

The type EH-36538 lenses give excellent beams and would make possible a highly desirable reduction in the weight and size of the projector as compared with the present standard model but unfortunately the manufacturer no longer produces this type as a standard item. In the quantities that would be required for traffic control projectors the cost of the lenses would apparently be more than would be warranted for the purpose. Unless this problem can be solved it is useless to attempt further development work based upon the type EH-36538 lens.

The performance of the C.A.A. experimental unit can be improved by rotating the lamp so as to place the filament coaxial with the reflector axis. The candlepower so obtained is lower than that of the last standard type unit accepted but higher than that of most of the standard type units measured during the last few years. For peak candlepower in relation to its size, it is the most efficient traffic signal projector that has been tested at this Bureau. It is recommended that the optical design of this projector be used as a new standard for future purchases of traffic signal projectors.

AIRPORT TRAFFIC SIGNAL PROJECTOR
Horizontal Candlepower Distributions

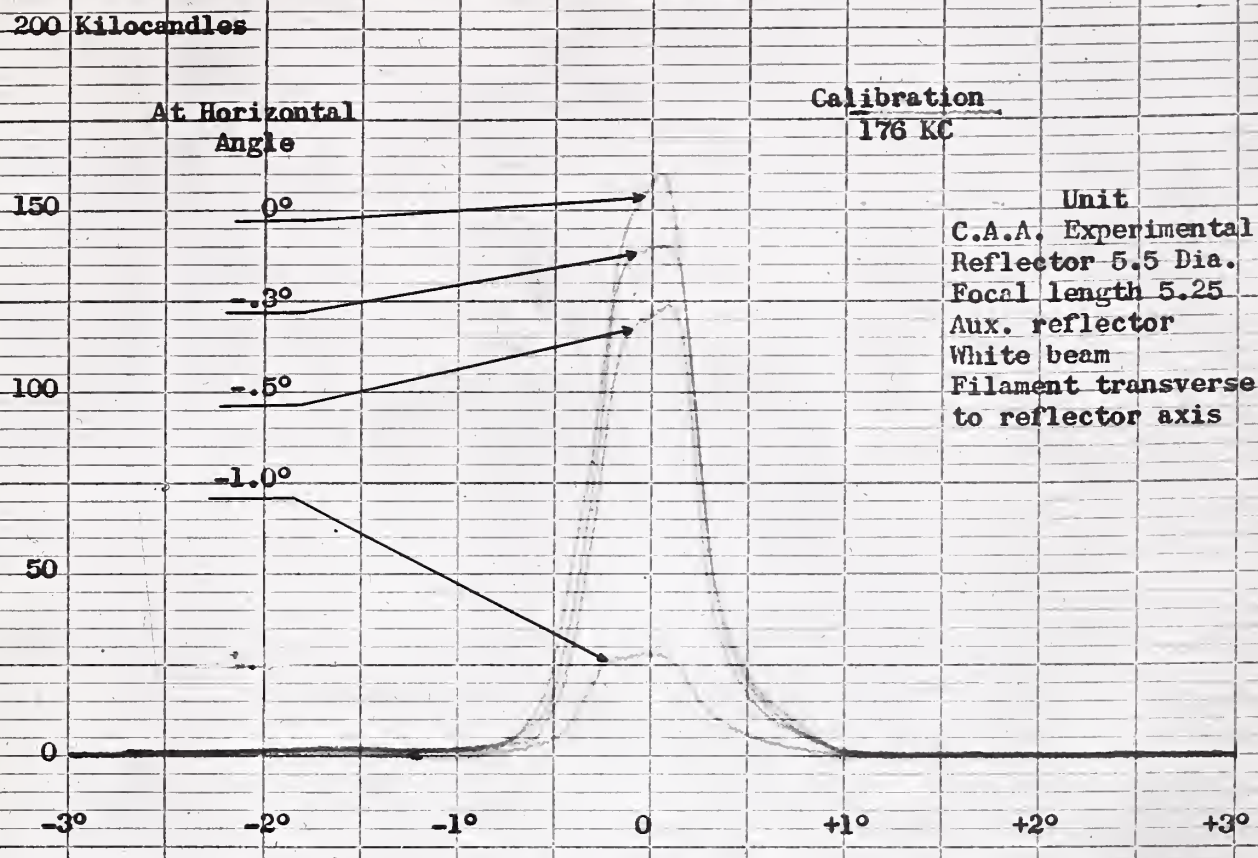




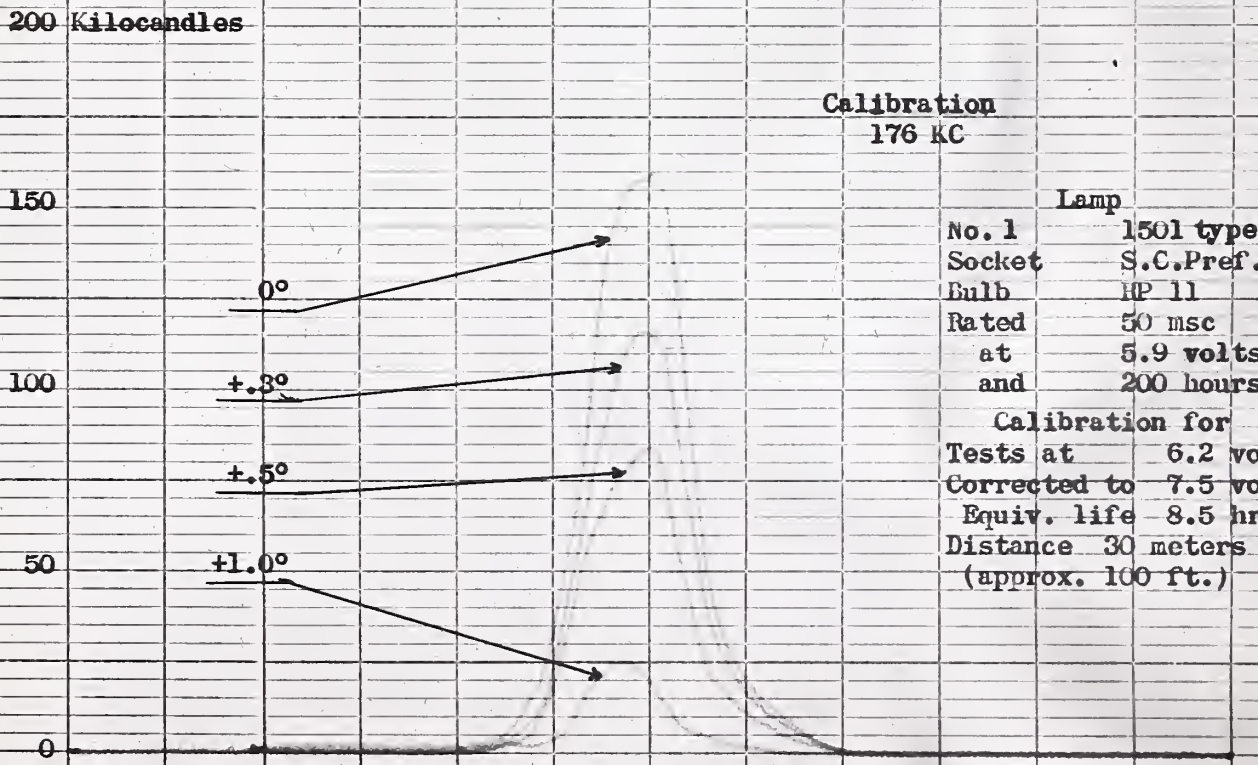
NBS Test No. 21A-9/53

Figure 1

AIRPORT TRAFFIC SIGNAL PROJECTOR
Vertical Candlepower Distributions



Unit
C.A.A. Experimental
Reflector 5.5 Dia.
Focal length 5.25
Aux. reflector
White beam
Filament transverse
to reflector axis



Lamp

No. 1	1501 type
Socket	S.C.Pref.
Bulb	MP 11
Rated	50 msc
at	5.9 volts
and	200 hours

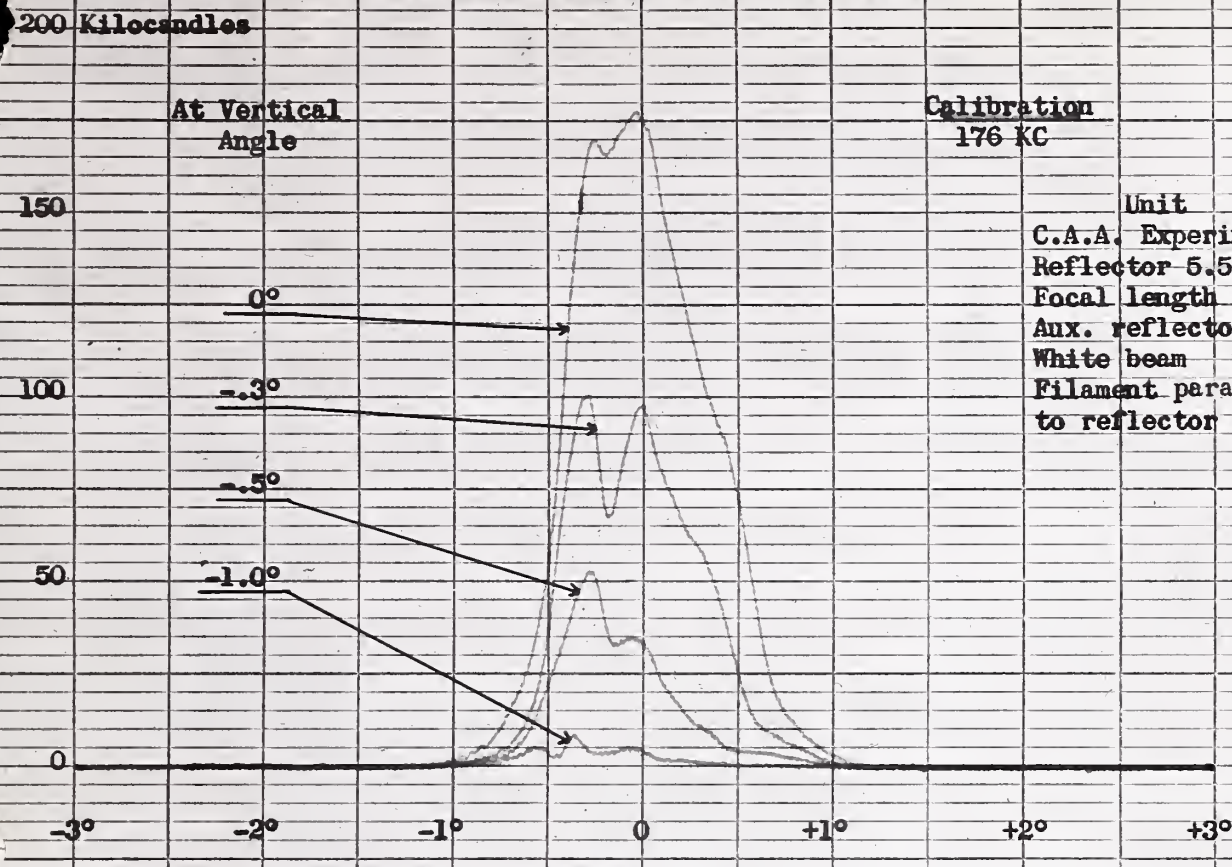
Calibration for

Tests at	6.2 volts
Corrected to	7.5 volts
Equiv. life	8.5 hrs.
Distance	30 meters (approx. 100 ft.)

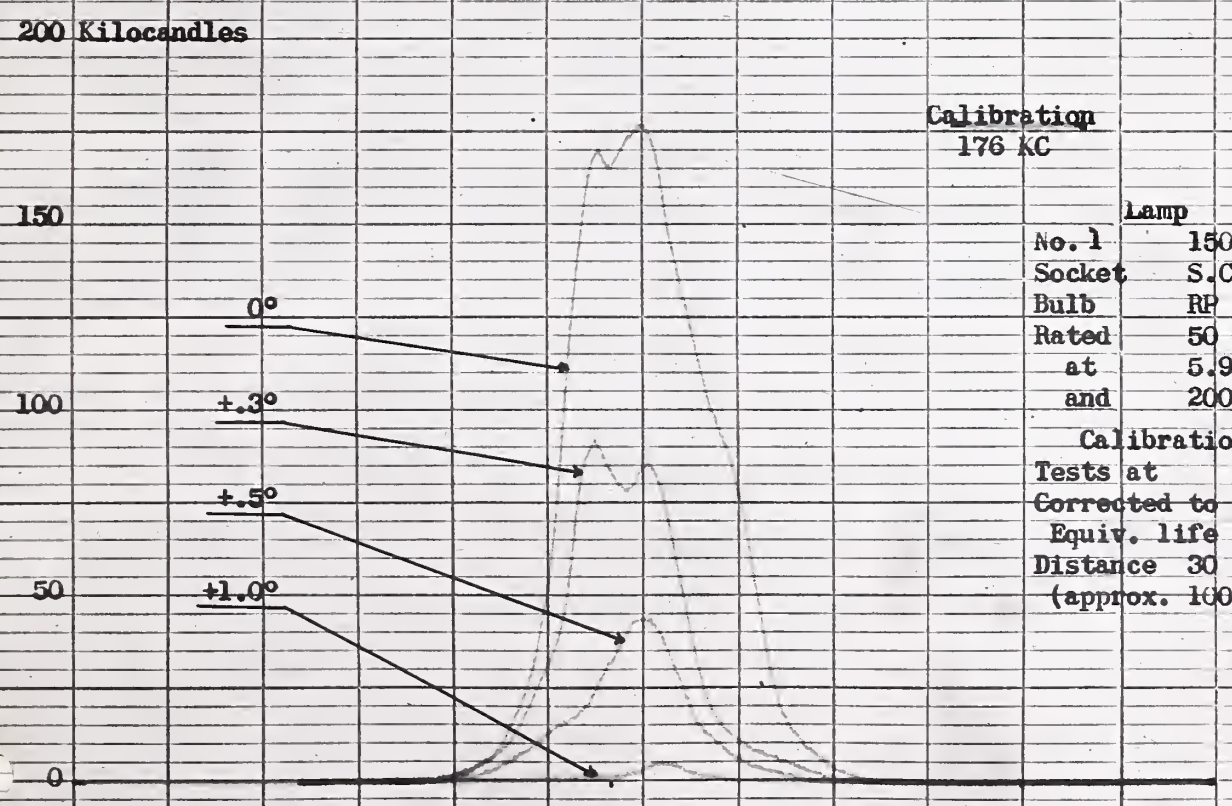
NBS Test No. 21A-9/53

Figure 2

AIRPORT TRAFFIC SIGNAL PROJECTOR
Horizontal Candlepower Distributions



Unit
C.A.A. Experimental
Reflector 5.5 Dia.
Focal length 5.25
Aux. reflector
White beam
Filament parallel
to reflector axis



Lamp

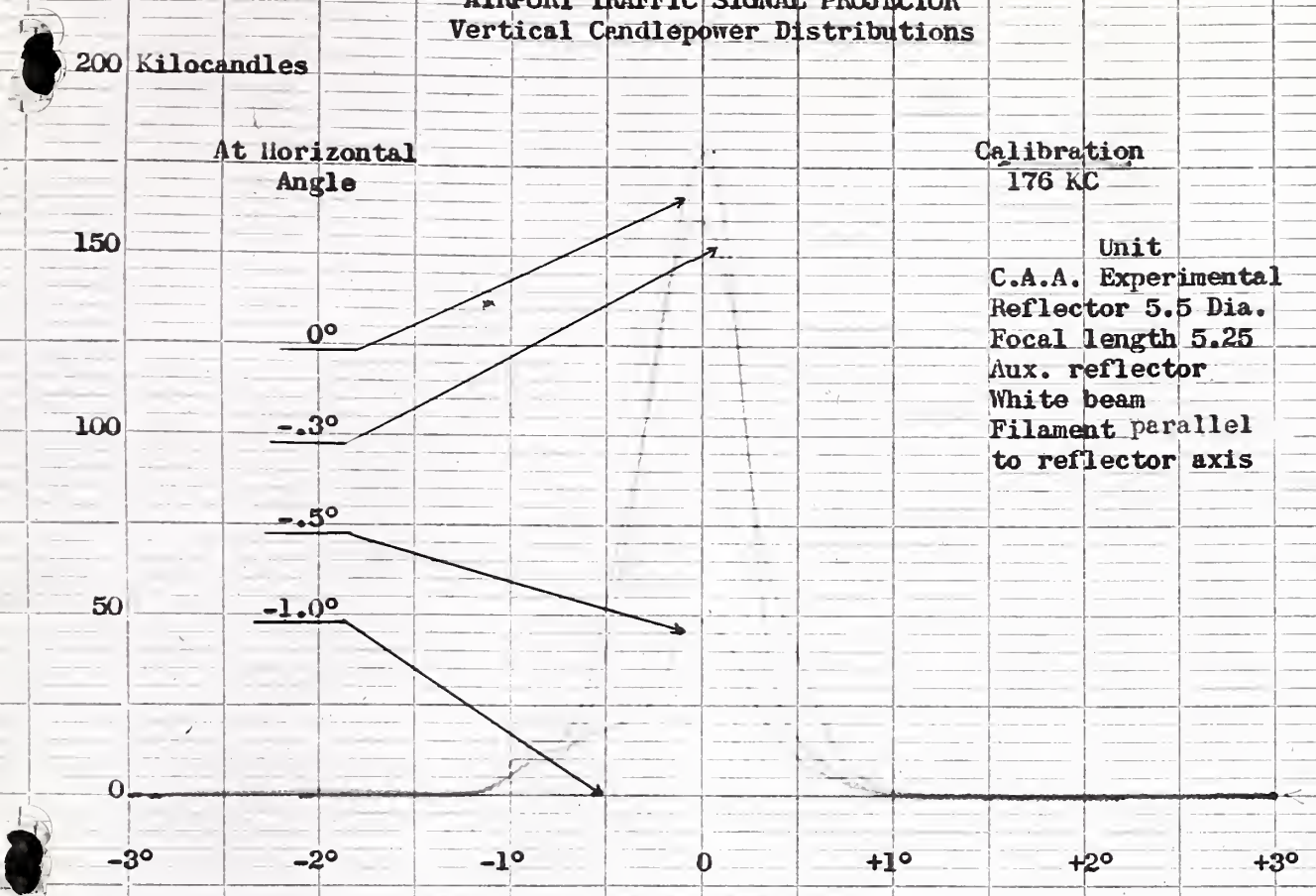
No. 1	150l type
Socket	S.C.Pref.
Bulb	RP 11
Rated	50 msc
at	5.9 volts
and	200 hours

Calibration for
Tests at 6.2 volts
Corrected to 7.5 volts
Equiv. life 8.5 hrs.
Distance 30 meters
(approx. 100 ft.)

NBS Test No. 21A-9/53

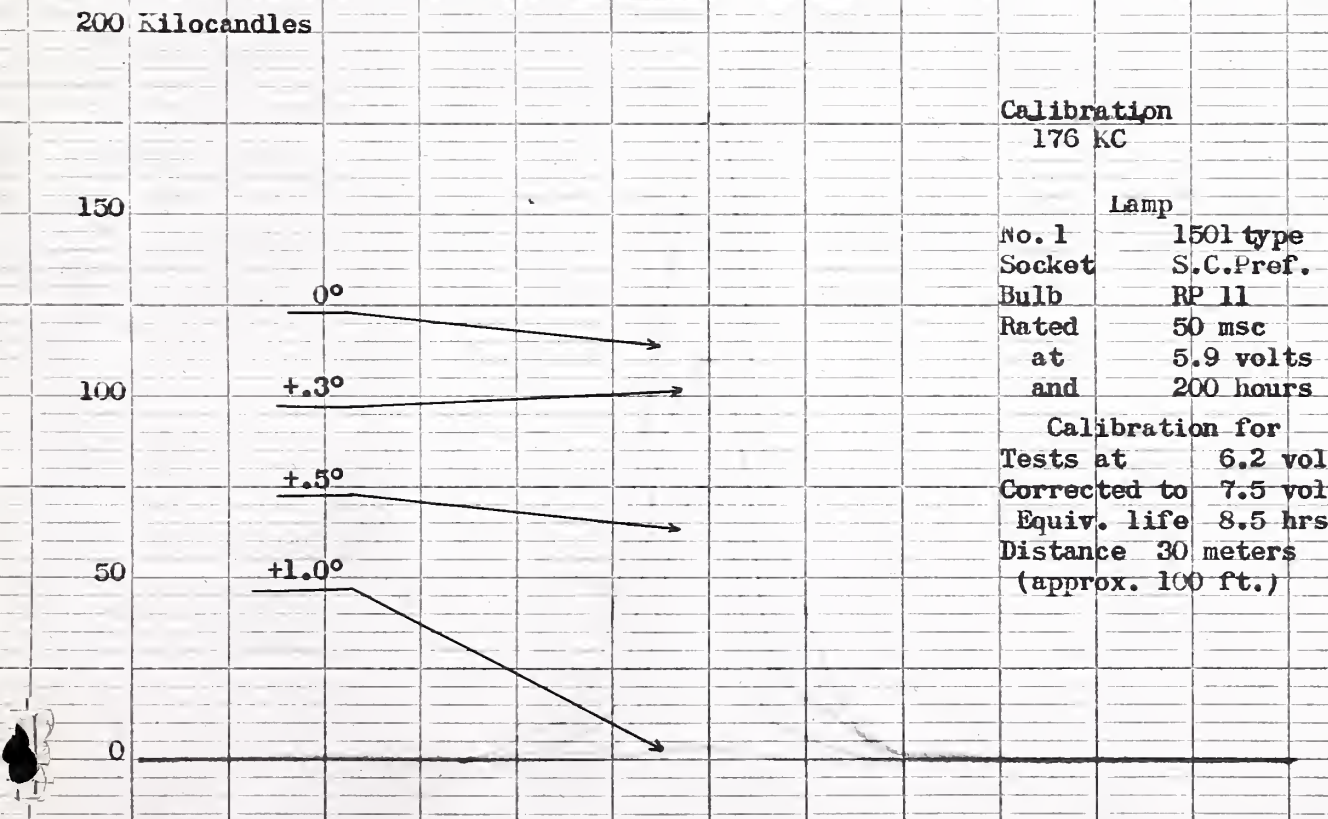
Figure 3

AIRPORT TRAFFIC SIGNAL PROJECTOR
Vertical Candlepower Distributions



Calibration
176 KC

Unit
C.A.A. Experimental
Reflector 5.5 Dia.
Focal length 5.25
Aux. reflector
White beam
Filament parallel
to reflector axis



Calibration
176 KC

Lamp

No. 1	150l type
Socket	S.C.Pref.
Bulb	RP 11
Rated	50 msc
at	5.9 volts
and	200 hours

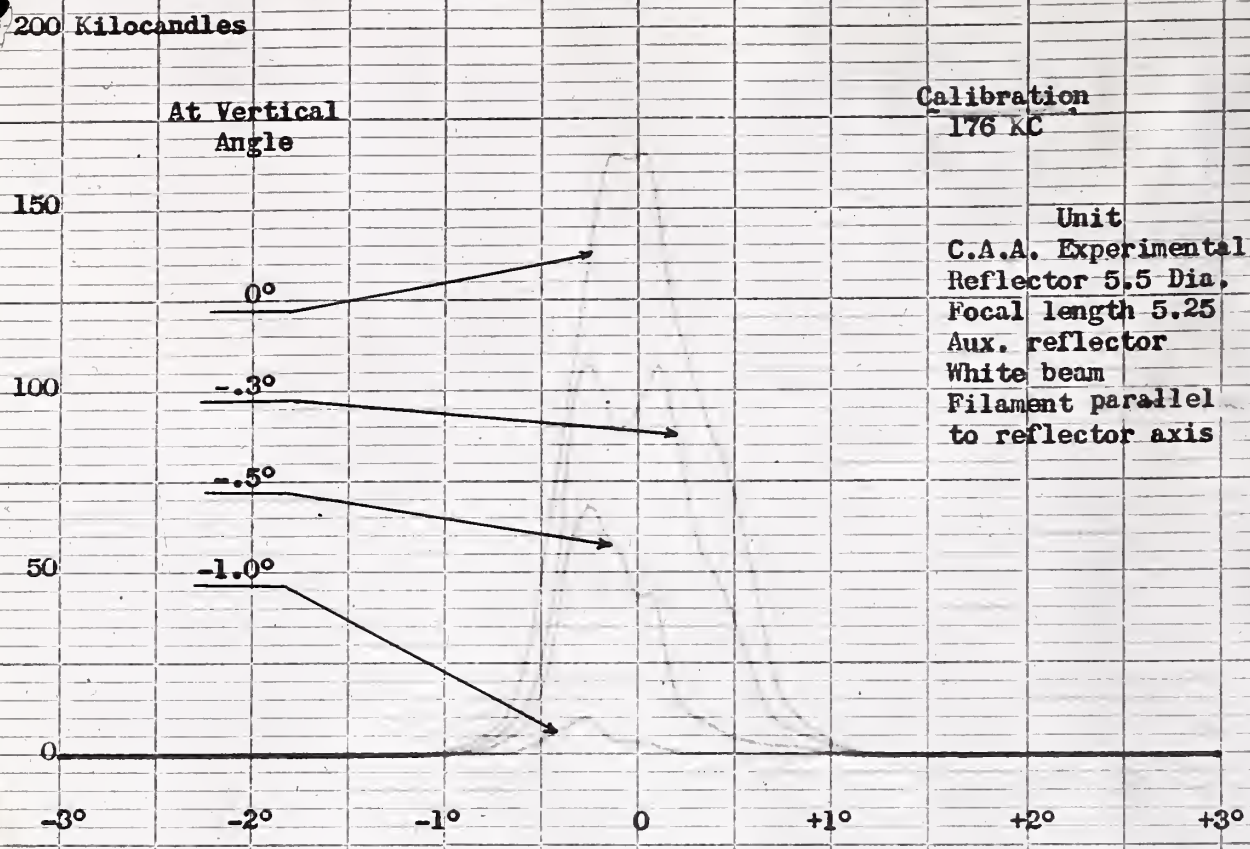
Calibration for

Tests at	6.2 volts
Corrected to	7.5 volts
Equiv. life	8.5 hrs.
Distance	30 meters (approx. 100 ft.)

NBS Test. No. 21A-9/53

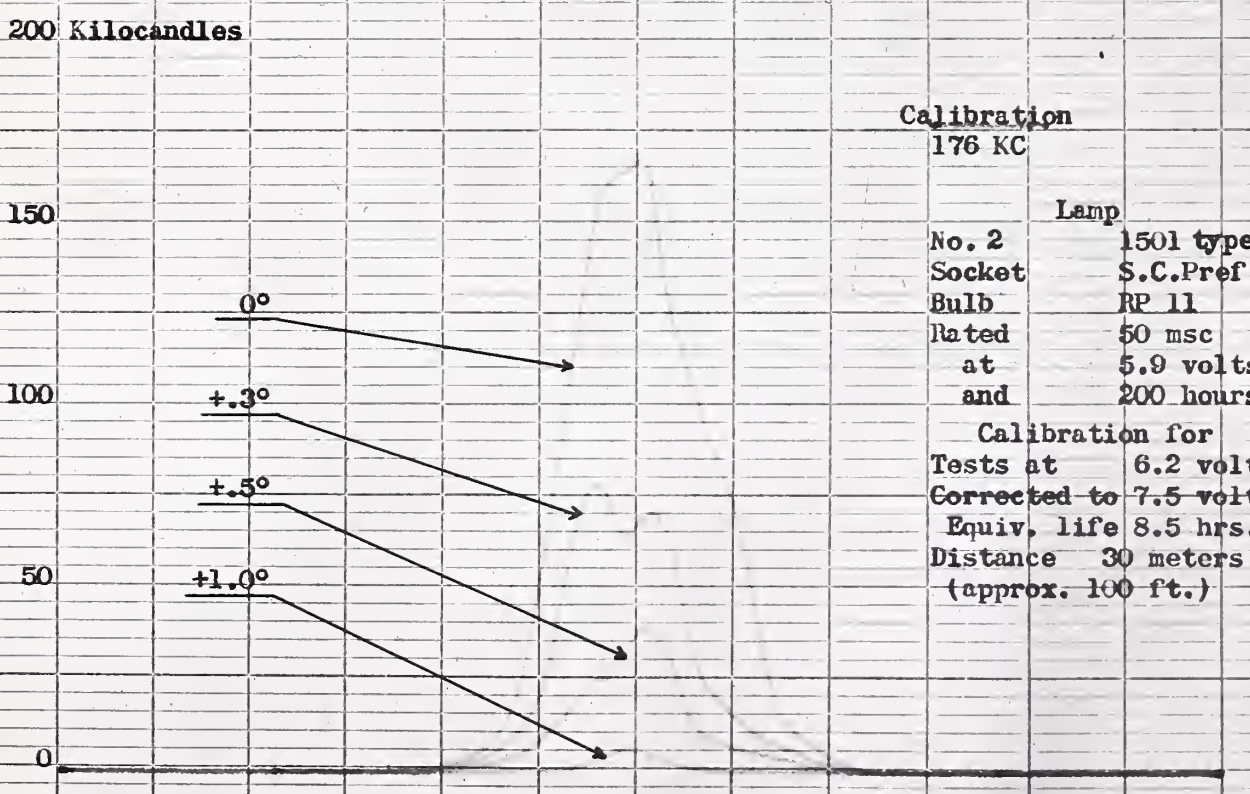
Figure 4

AIRPORT TRAFFIC SIGNAL PROJECTOR
Horizontal Candlepower Distributions



Calibration
176 KC

Unit
C.A.A. Experimental
Reflector 5.5 Dia.
Focal length 5.25
Aux. reflector
White beam
Filament parallel
to reflector axis



Calibration
176 KC

Lamp

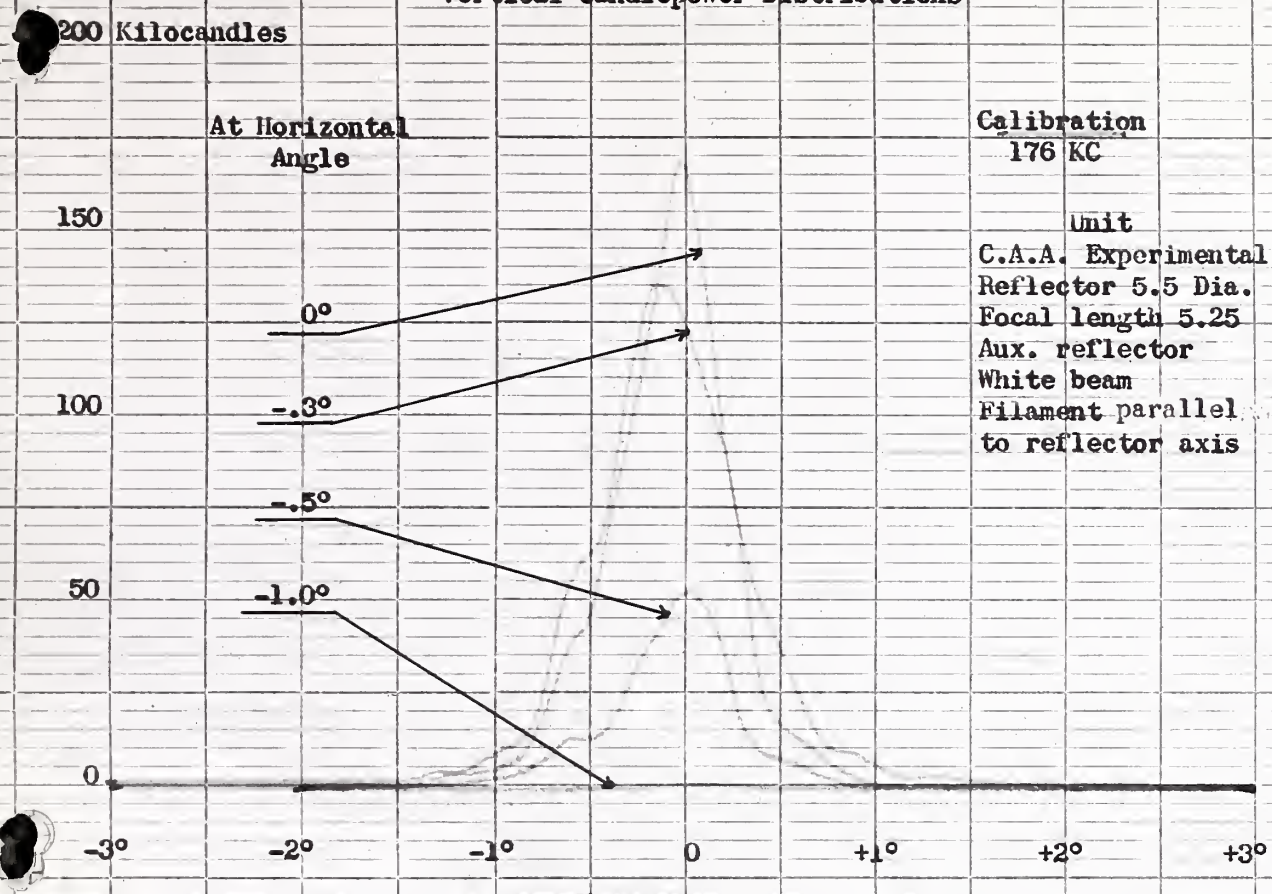
No. 2	1501 type
Socket	S.C.Pref.
Bulb	RP 11
Rated	50 msc
at	5.9 volts
and	200 hours

Calibration for
Tests at 6.2 volts
Corrected to 7.5 volts
Equiv. life 8.5 hrs.
Distance 30 meters
(approx. 100 ft.)

NBS Test No. 21A-9/53

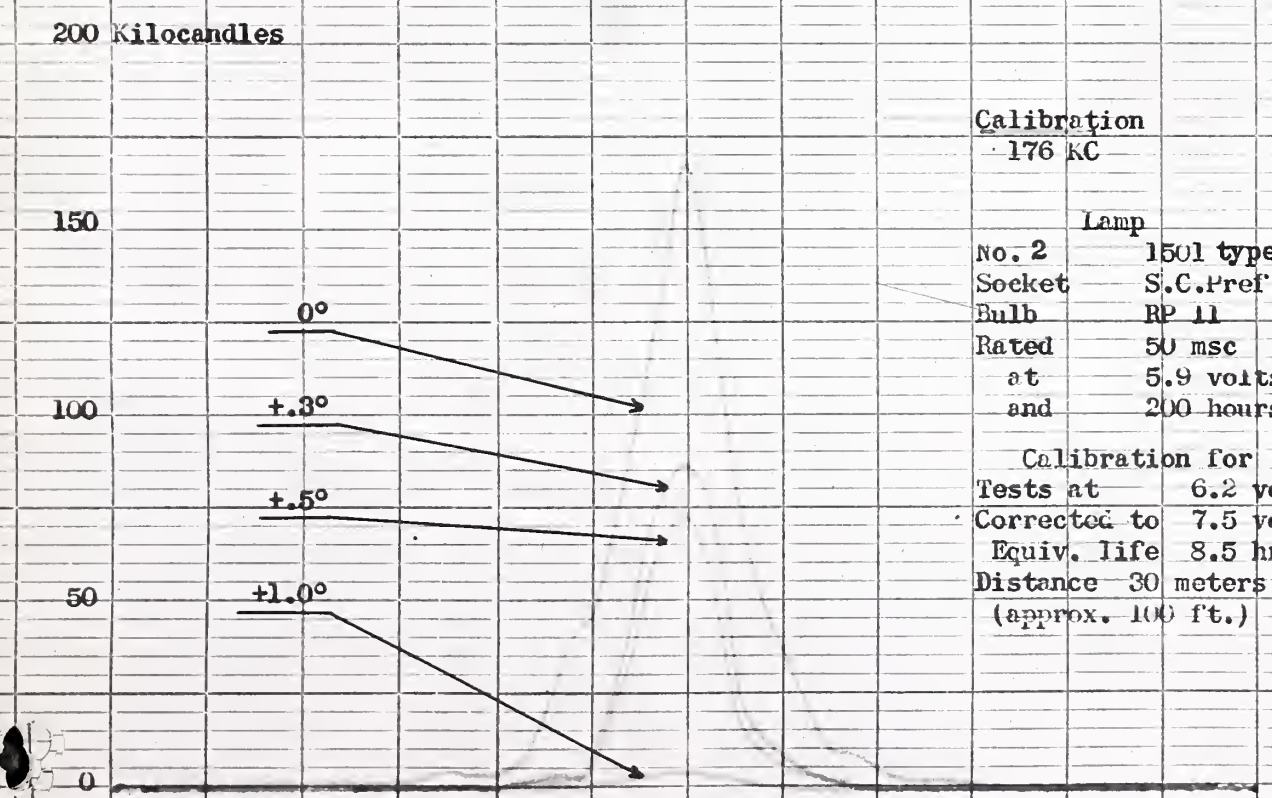
Figure 5

AIRPORT TRAFFIC SIGNAL PROJECTOR
Vertical Candlepower Distributions



Calibration
176 KC

Unit
C.A.A. Experimental
Reflector 5.5 Dia.
Focal length 5.25
Aux. reflector
White beam
Filament parallel
to reflector axis



Calibration
176 KC

Lamp

No. 2	1501 type
Socket	S.C.Pref.
Bulb	RP 11
Rated	50 msc
at	5.9 volts
and	200 hours

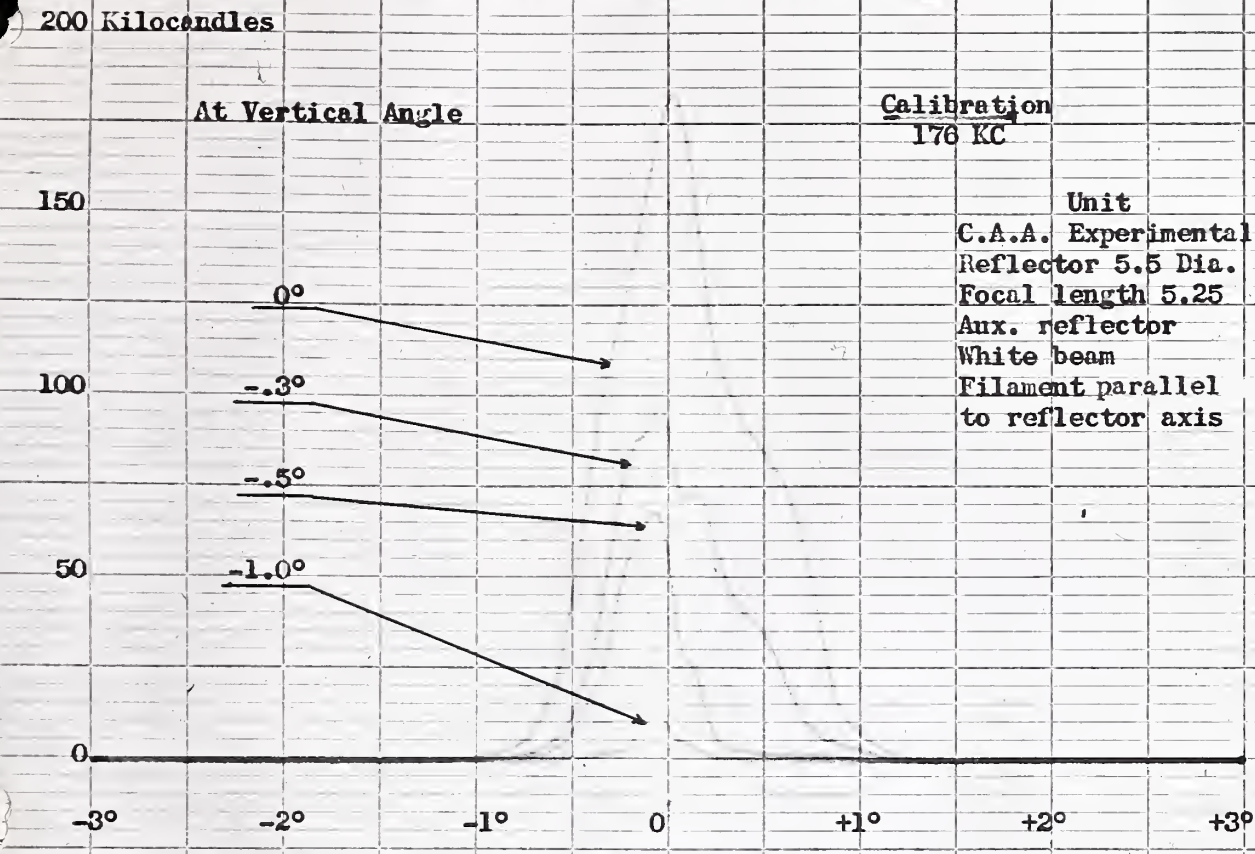
Calibration for

Tests at	6.2 volts
Corrected to	7.5 volts
Equiv. life	8.5 hrs.
Distance	30 meters (approx. 100 ft.)

NBS Test No. 21A-9/53

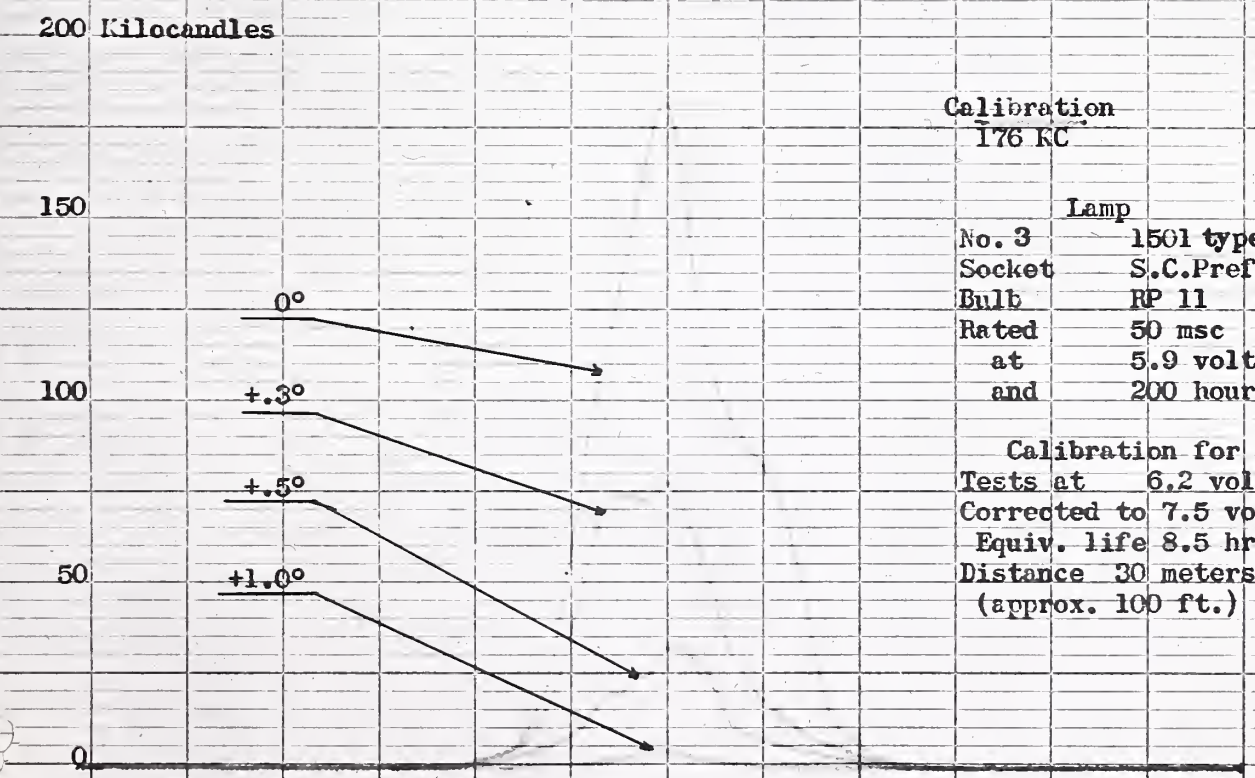
Figure 6

AIRPORT TRAFFIC SIGNAL PROJECTOR
Horizontal Candlepower Distributions



Calibration
176 KC

Unit
C.A.A. Experimental
Reflector 5.5 Dia.
Focal length 5.25
Aux. reflector
White beam
Filament parallel
to reflector axis



Calibration
176 KC

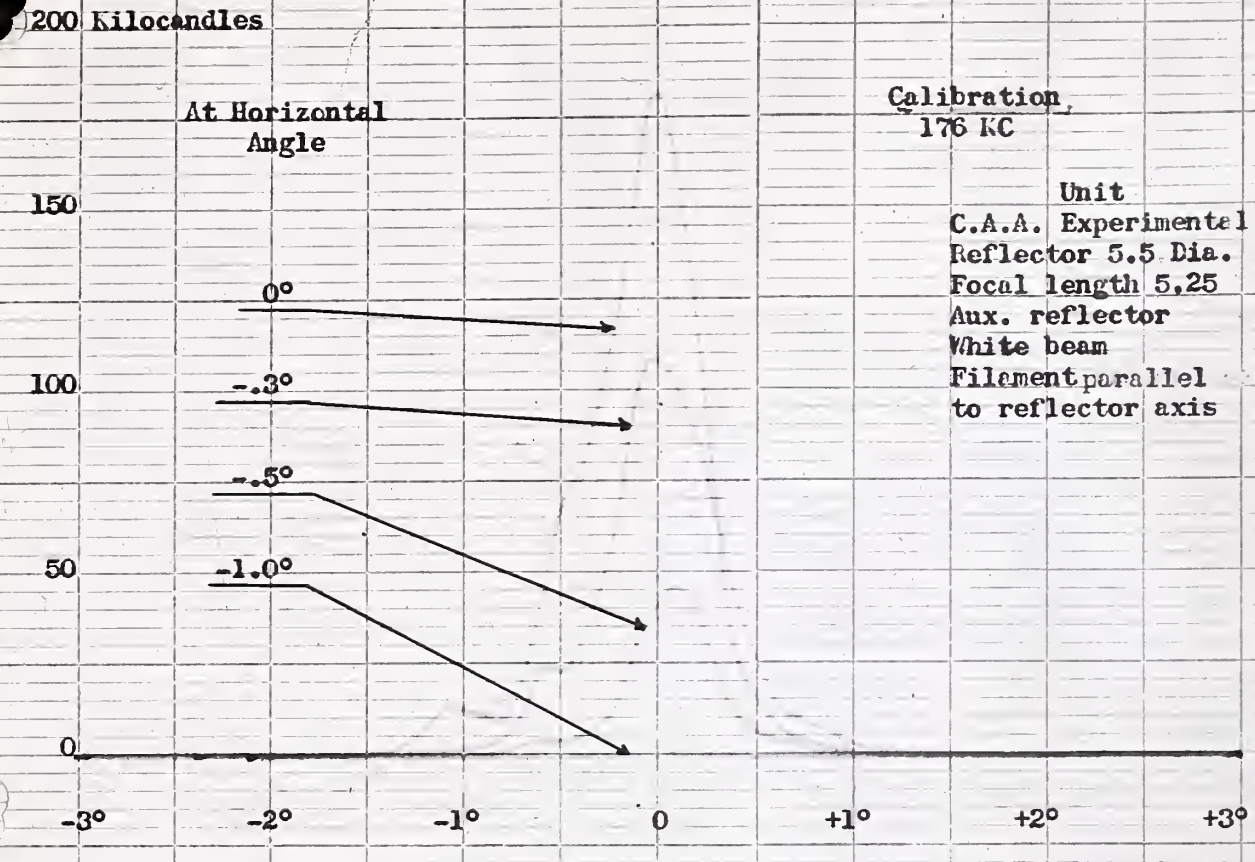
Lamp
No. 3 1501 type
Socket S.C.Pref.
Bulb RP 11
Rated 50 msc
at 5.9 volts
and 200 hours

Calibration for
Tests at 6.2 volts
Corrected to 7.5 volts
Equiv. life 8.5 hrs.
Distance 30 meters
(approx. 100 ft.)

NBS Test No. 21A-9/53

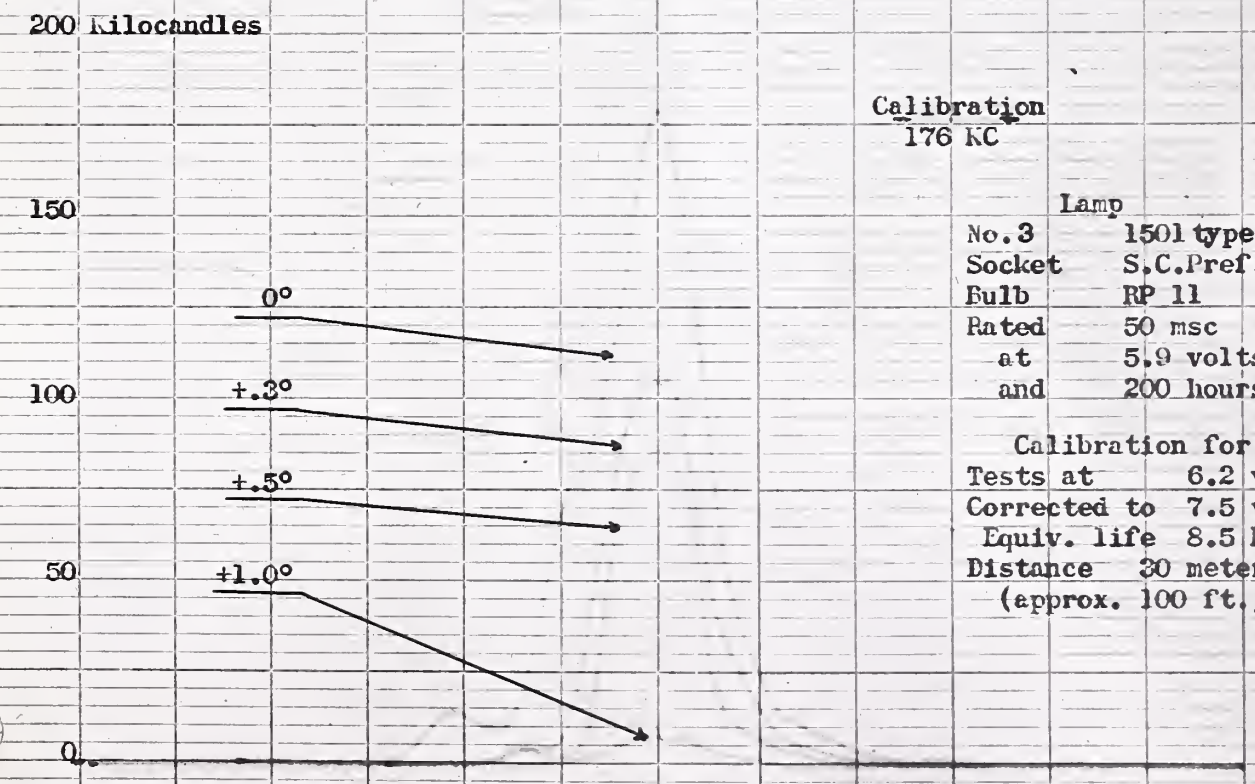
Figure 7

AIRPORT TRAFFIC SIGNAL PROJECTOR
Vertical Candlepower Distributions



Calibration
176 KC

Unit
C.A.A. Experimental
Reflector 5.5 Dia.
Focal length 5.25
Aux. reflector
White beam
Filament parallel
to reflector axis



Calibration
176 KC

Lamp

No. 3	1501 type
Socket	S.C.Pref.
Bulb	RP 11
Rated	50 msc
at	5.9 volts
and	200 hours

Calibration for

Tests at	6.2 volts
Corrected to	7.5 volts
Equiv. life	8.5 hrs.
Distance	30 meters
	(approx. 100 ft.)

NBS Test No. 21A-9/53

Figure 8

Horizontal Candlepower Distribution
Kodak Ektalite Field Lenses

Lenses
Ektalite
Types
A--HE-36538-0
B--CW-123770-0
Material Plastic
Size 8" x 8"
Focal length 10.25"
Filaments coaxial
with lenses

Lamp
No. 2 1501 type
Socket S.C.Pref.
Bulb MP 11
Rated 50 mse
at 5.9 volts
and 200 hours

Calibration for
Tests at 6.2 volts
Corrected to 7.5 volts
Equiv. life 8.5 hrs.
Distance 30 meters
(approx. 100 ft.)

NBS Test No. 21A-9/53

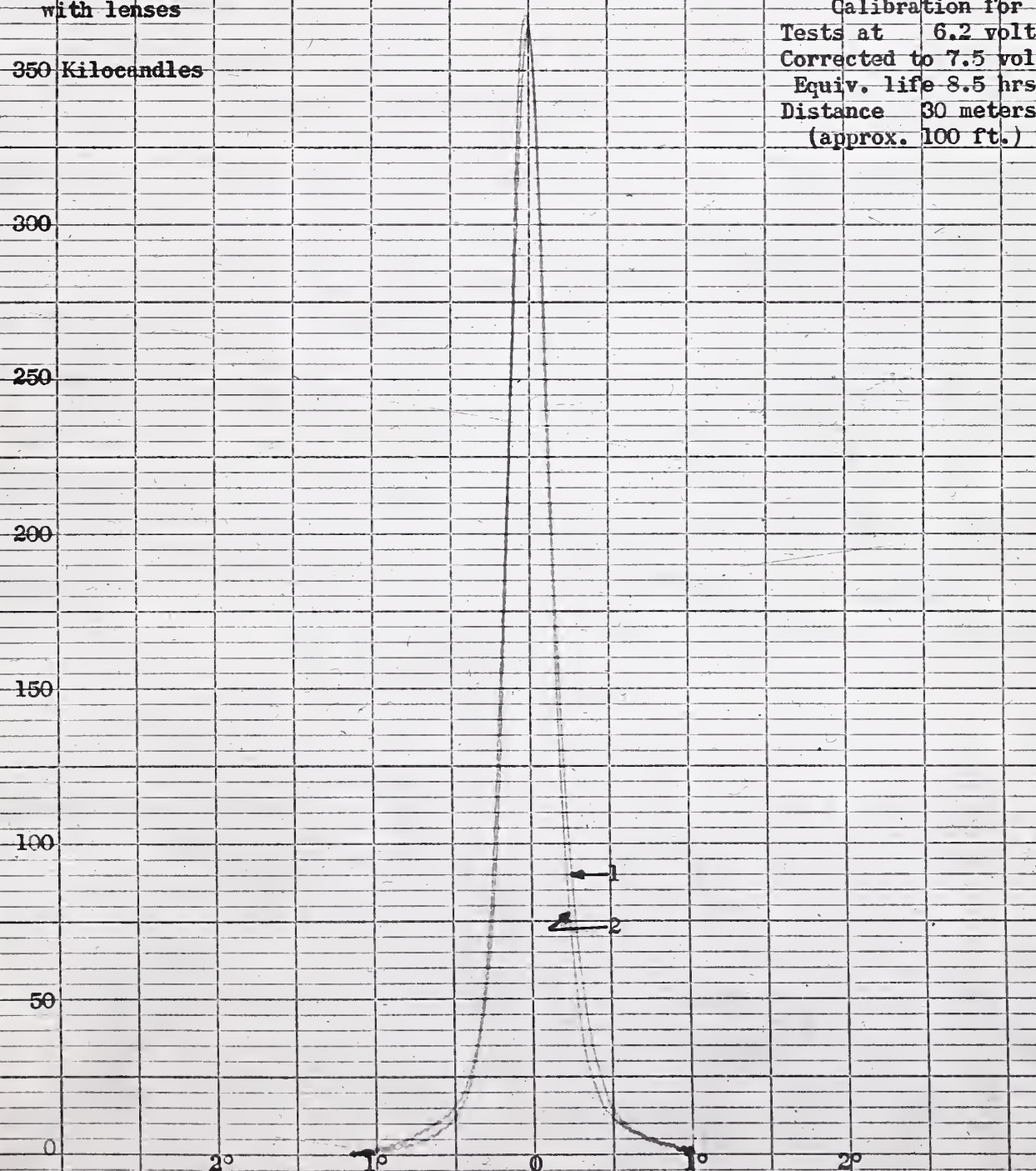
Figure 9

Horizontal Candlepower Distribution
Kodak Ektalite Field Lenses

Lenses
Ektalite
Types
1--HE-36538-1
2--HE-36538-2
Material Plastic
Size 8" x 8"
Focal length 10.25"
Filaments coaxial
with lenses

Lamp
No. 2 150I type
Socket S.C.Pref.
Bulb RP 11
Rated 50 msc
at 5.9 volts
and 200 hours

Calibration for
Tests at 6.2 volts
Corrected to 7.5 volts
Equiv. life 8.5 hrs.
Distance 30 meters
(approx. 100 ft.)



NBS Test No. 21A-9/53

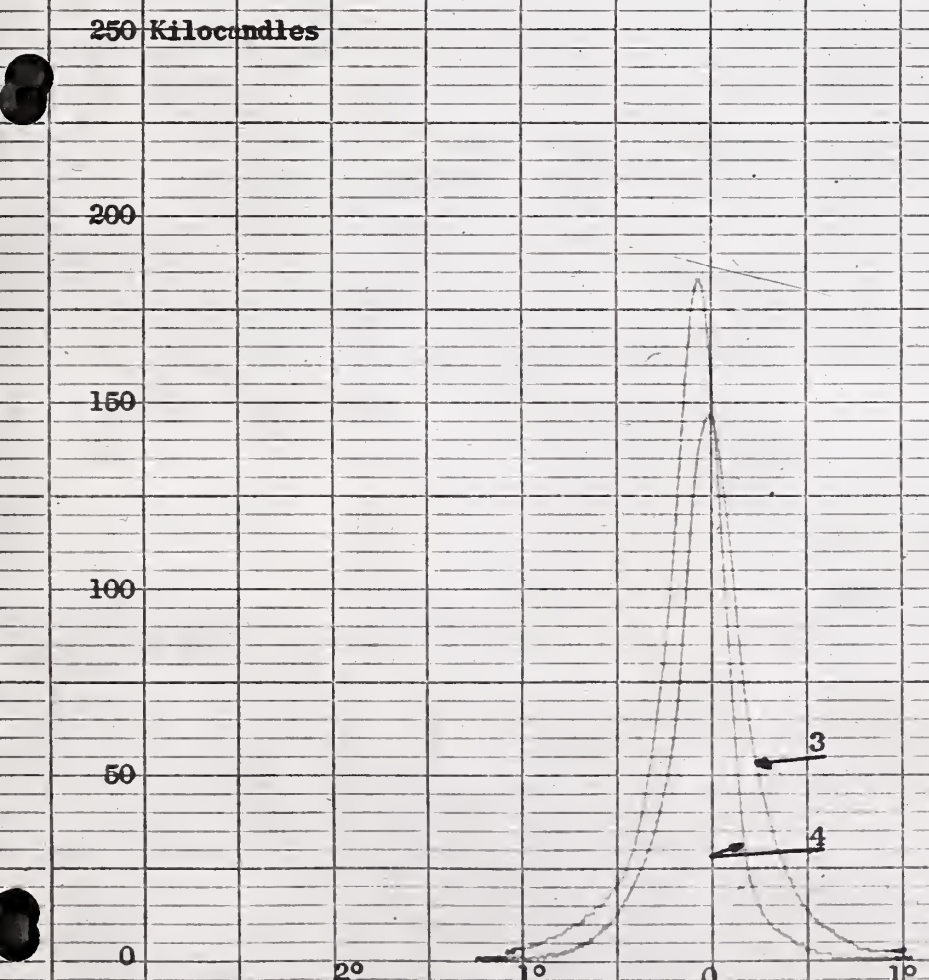
Figure 10

Horizontal Candlepower Distribution
Kodak Ektalite Field Lenses

Lenses
Ektalite
Types
3 cm 123770-1
4 cm 123770-2
Material Plastic
Size 8" x 8"
Focal length 10.25"
Filaments coaxial
with lenses

Lamp
No. 2 150l type
Socket S.C.Pref.
Bulb RP 11
Rated- 50 msc
at 5.9 volts
and 200 hours

Calibration for
Tests at 6.2 volts
Corrected to 7.5 volts
Equiv. life 8.5 hrs.
Distance 30 meters
(approx. 100 ft.)



NBS Test No. 21A-9/53

Figure 11