

N70-19901
CR-102175

PTR 2096 - 463

INFINITY DISPLAY OPTICAL UNIT
("PANCAKE WINDOW")
PATENT 3,443,858

FINAL TECHNICAL REPORT
NOVEMBER 1969

Prepared by:

Farrand Optical Co., Inc.
New York, New York

For:

NASA Manned Spacecraft Center
Houston, Texas

Under Contract No. NAS 9-8140

CASE FILE
COPY

FOREWORD

This final technical report on Infinity Display Optical Unit (Pancake Window)* summarizes the work performed by Farrand Optical Company, Inc. in accordance with NASA Manned Spacecraft Center, Houston, Texas, Contract No. NAS 9-8140

The design, construction and principle of operation of the equipment are briefly reviewed. An appendix is included giving the final acceptance test procedures and results.

*Patent 3,443,858

TABLE OF CONTENTS

SECTION	PARAGRAPH	TITLE	PAGE
		Foreword	i
I		Introduction	1
	1.1	General	1
	1.2	Construction	1
	1.2.1	Optical Components	1
	1.2.2	Mechanical Design	3
	1.3	Principle of Operation	3
	1.4	Alignment	3
II		Discussion	5
III		Recommendations	6

APPENDIX A

A-1 Acceptance Test Data Serial No. 101

A-1 Acceptance Test Data Serial No. 102

ILLUSTRATIONS

FIGURE	TITLE	PAGE
I-1	Infinity Image Display System Schematic	2
I-2	Infinity Display Optical Assembly	4

I. INTRODUCTION

I.1 General

An infinity display optical unit (Pancake Window) as used in simulators for aerial or space training devices is capable of presenting to the eye of the observer scenes or objects which actually appear on a spherical surface at the object plane in such a manner as to make the projected scene or objects appear to be optically at infinity. A high degree of realism is achieved by the use of the Pancake Window as a mirror eyepiece whose focal plane may be at the observer's eye to provide a field of view of approximately 70° . Realism is further enhanced by the apparent broadening of the field as the eye is brought closer to the window and apparent narrowing of the field as the eye recedes from the window.

In the Pancake Windows which are discussed in this report, the spherical object surface may be as large as 19 inches diameter and the image as seen by the observer fills a 30 inch diameter window when the eye is at the optimal distance from the window, increasing or decreasing as the eye approaches the window or withdraws from it.

I.2 Construction

I.2.1 Optical Components (Figure 1-1)

There are three major optical elements, namely the First Polarizing Plate, Eyepiece Mirror and Birefringent Assembly. The latter comprises

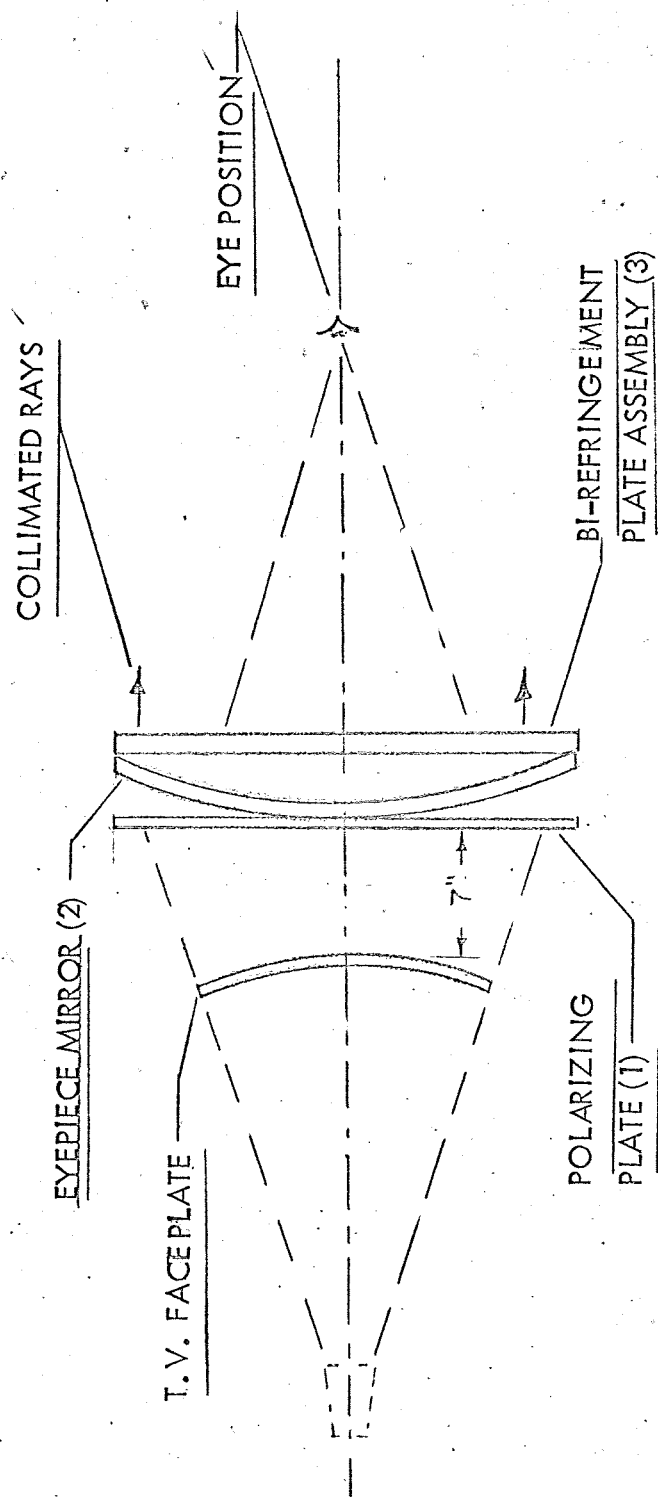


Figure 1-1 Infinity Image Display System - Schematic

two birefringent plates, a beamsplitter and a polarizer.

1.2.2 Mechanical Design

As shown in Figure 1-2, the Pancake Window elements are mounted in a metal frame which also includes provision for locating the spherical surface of the object at the correct distance from the first optical surface.

The optical system, consisting of a Birefringent Plate Assembly, a Spherical Beamsplitter Mirror (Eyepiece Mirror) and a Polarizing Plate, is mounted in the Housing. The Housing, in turn, is mounted, through an intermediate adapter, to the TV frame. This frame constitutes the interface with the actual TV system.

1.3 Principle of Operation

As shown in Figure 1-1, light from the object plane is polarized by passing through the first polarizing plate. This polarized light passes through the partially reflecting eyepiece mirror and the first element of the compound plate. The beamsplitter element of the compound plate reflects the image to the eyepiece mirror which collimates the light and produces the infinity effect.

1.4 Alignment

The proper alignment is obtained by placing the vertex of the outside radius of the TV face plate 7" from the surface of the Polarizing Plate.

- LEGEND
1. WINDOW ASSEMBLY
 2. WINDOW ADAPTER
 3. FRAME ADAPTER
 4. SPACER
 5. SCREW
 6. SIDE COVER
 7. ACCESS COVER
 8. SCREW
 9. SCREW
 10. EYEBOLT
 11. FRONT COVER
 12. PLASTIC FASTENERS

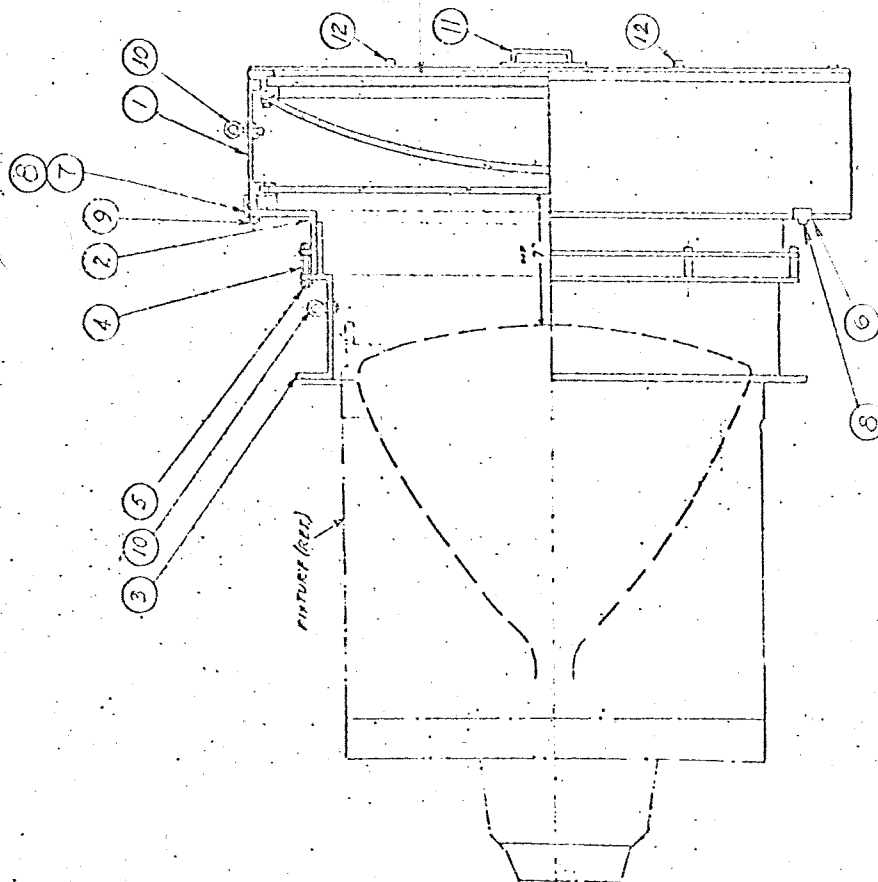


Figure 1-2 . Infinity Display Optical Assembly
("Pancake Window")

II. DISCUSSION

2.1 Component Considerations

2.2 In the first unit, #101, an HN-38 Linear Polarizer was used in the Birefringent Plate Assembly with an HN-32 as the Polarizing Plate Assembly. Also, two Quarter Wave Plates were used in the Birefringent Plate Assembly. In comparison, an HN-22 Linear Polarizer was used in the Birefringent Plate Assembly as well as in the Polarizing Plate of unit #102. An additional Quarter Wave plate was used in unit #102 acting as a trimmer for unwanted ghost images.

2.3 The optimum eye position on Unit #102 was found to be 26" from the Birefringent Plate, minimizing unwanted "ghost" and bleedthrough effects to practically zero when viewed on-axis. Bleed-through becomes more visible from an off-axis position. Transmission was .4%.

2.4 Test Results

All test results of Unit 101 and Unit 102 are recorded in Appendix A.

III. RECOMMENDATIONS

3.1 It is recommended that consideration be given in the future to updating the NASA windows, serial numbers 101 and 102, to take advantage of state-of-the-art advances in the reflection reducing film. These advances should provide films of less than 0.2% visual reflectance per surface.

3.2 Also, to be considered in updating the NASA windows serials 101 and 102 is the use of Quarter wave plates and polarizers which provide elliptical polarization whose degree of ellipticity is independent of the angle of incidence.

3.3 Materials are at hand and in development which should result in overall system performance to reach 1% transmission and to reduce the variation in bleed-through with eye position both longitudinally and laterally. The latter should increase the practical limits of the trainee's freedom of head motion. The acquisition of these materials and initiation of development were accomplished after delivery of the NASA windows, #101 and #102.

APPENDIX A

A-1 Acceptance Test Data Serial No. 101

A-2 Acceptance Test Data Serial No. 102

FOCI QA.16015-463

FACTORY ACCEPTANCE TEST PROCEDURES

INFINITY DISPLAY OPTICAL UNIT

November 6, 1968

Prepared By:

Farrand Optical Co., Inc.
New York, New York

For:

NASA Manned Spacecraft Center
Houston, Texas
Under Contract No. NAS 9-8140

Prepared by:

Approved by:

J. H. Brown
Quality Assurance Manager

Approved by:

F. R. Allen
Project Engineer

ACCEPTANCE TEST DATA

PANCAKE WINDOW

FOCI P/N 135340 Rev. C - S/N 101

Lot size 1 Sample size 1
 Accepted By J. H. H. H.
 Date Insp. 12-24-64 Var. Pmt.
 Normal Tightened Reduced
 Qty Rej. 0 Qty Rej. in lot 0

MAJOR TESTS (AQL=1)	Contract NAS-9-8140	Requirement	Results						Equipment
			H	CL	UP	DN	LT	RT	
Resolution	Par. 2.3	2000 TV lines	V	1-2	1-2	1-5	1-4	1-4	A.F. Resolution Chart
Collimation	Par. 2.4	.25 diopters max	H	20	20	20	20	20	Target #121322
MINOR TESTS (AQL=4)									
Transmission of Infinity Image	Par. 2.2.3	.5% minimum	.42%						Photometer
Ratio of Bleedthrough to Infinity Image	Par. 2.2.2	9% maximum	.016% max A 70 IMAGE						Photometer
Field of View	Par. 2.2.1	70° min. at 24"	70° 34'						Pocket Transit
Eye Relief	Par. 2.2.4	Nominal 24"	OK						Scale

Customer witness - accepted by W. E. Miller Date 10-29-69

FACTORY ACCEPTANCE TEST PLAN

1.0 GENERAL

The Farrand Optical Co., Inc. will demonstrate the operational compliance of the Infinity Display Optical Units by performing the tests specified herein.

1.1 All optical, mechanical, and electrical alignment and adjustment will have been completed during laboratory testing prior to start of the Demonstration Tests described below.

2.0 LIST OF TESTS

Para.	Page	Test	Requirements	Per Contract No. NAS 9-8140
2.1	2	General Inspection	Per Standard MIL-SPECS	Par. 2.5, 3.0
2.2	3	Eye Relief	19.0 Inches $\pm \frac{1}{2}$ inch	Par. 2.2.4
2.3	5	Bleed-Through	Less than 9.0%	" 2.2.2
2.4	7	Transmission	1% Minimum	" 2.2.3
2.5	9	Field of View	70 Degrees Minimum	" 2.2.1
2.6	11	Collimation	Less than 0.25 Diopters	" 2.4
2.7	13	Resolution	Equal to 1000 Line Pairs	" 2.3

DISTORTION

$\pm 0.5^\circ$

TEST 2.1

GENERAL INSPECTION

(Ref. Purchase Specification Para.2.5 and 3.0)

Equipment shall be inspected to determine compliance with the applicable drawings and specifications with respect to materials, workmanship, and marking.

Applicable Drawings:

135340

134870

134875

134879

REMARKS

(A) Workmanship

1) Damaged Parts

2) Missing Parts

3) General Finish

(B) Cleanliness

1) Mirror Surfaces

2) Lens Surfaces

3) Beamsplitter Surfaces

4) Chambers

Witnessed:

Customer - Rep

Date

V. Costello
FOCI - Q.A.

3/12/69
Date

DCASR

Date

TEST 2.2

EYE RELIEF

(Ref. Purchase Specification Para. 2.2.4)

GENERAL

This parameter is defined by measurement only and forms a part of Test 2.3, 2.4, 2.5, 2.6 and 2.7 of this document. Therefore, no separate test is required.

TEST 2.3

BLEED-THROUGH

(Ref. Purchase Specification Para. 2.2.2)

PURPOSE:

The purpose of this test is to demonstrate that "Bleed Through" or brightness of the source image seen through the optics shall be no greater than 9.0 percent of the brightness of the projected image:

EQUIPMENT:

Pritchard Light Meter or equivalent
TV Test Fixture, P/N.121322

METHOD:

- a) Cover TV fixture with black paper except for a .5 inch circular opening in center of diffusing screen. Illuminate circular opening evenly with xenon arc lamp.
- b) Place TV Test Fixture in focal plane of window.
- c) Set up Pritchard Light Meter 10.0 feet in front of window sufficiently off axis, so that prime image and bleed-through image appear adjacent to one another.

TEST 2.3 (cont)

- d) Set Pritchard Light Meter at infinity focus and measure the illumination level of the natural image. Record reading, R_p .
- e) Measure illumination level of "Bleed-Through" image and record, R_b .

Calculate "Bleed-Through" illumination level as follows:

$$\frac{R_b}{R_p} \times 100\%$$

TEST 2.3 (cont)

BRIGHTNESS DATA SHEET

PRITCHARD READINGS		BLEED-THROUGH BRIGHTNESS
R_p	R_b	%
.088	.0044	5%

REMARKS:

Witnessed:

Customer - Rep

Date

FOCI - Q.A.

Date

DCASR

Date

TEST 2.4

TRANSMISSION

(Ref. Purchase Specification Para.2.2.3)

PURPOSE:

The object of this test is to measure that the minimum light transmission through the optical system is one percent of the input illumination.

EQUIPMENT:

- 1) Pritchard Light Meter or equivalent
- 2) TV Test Fixture, P/N.121322

METHOD:

- a) Cover TV Test Fixture with black paper except for .5" diameter circular opening in center of diffusing screen.
- b) Place TV Test Fixture in focal plane of window.
- c) Set up Pritchard Light Meter 19 inches in front of window on axis (eyepoint).
- d) Set Pritchard at infinity focus, measure the illumination level of the circular image and record reading R_p .

TEST 2.4 (cont)

- e) Remove window, leaving TV screen and move Pritchard Light Meter 10 ft. from screen.
- f) Record illumination level R_s and calculate transmission:

$$= \frac{R_p}{R_s} \times 100\%$$

TEST 2.4 (cont)

TRANSMISSION DATA SHEET

PRITCHARD READING R R		WINDOW TRANSMISSION %	SPEC.
1088	11.8	.75 %	

REMARKS: _____

Witnessed:

W. E. Miller 3-12-69 V. Costello 3/12/69
Customer - Rep Date FOCI - Q.A. Date

DCASR Date

TEST 2.5

FIELD OF VIEW

(Ref. Purchase Specification Para. 2.2.1)

PURPOSE:

To demonstrate that the circular field of view
is 70 degrees minimum.

EQUIPMENT:

T-12 pocket transit or equivalent
TV Test Fixture, P/N.121322

METHOD:

- a) Illuminate the entire TV Test Fixture
screen and place in focal plane of window.
- b) Place T-12 pocket transit axis of rotation
at exit pupil, i.e. $19\pm\frac{1}{2}$ inches from nearest
optical element on axis.
- c) Measure field of view by rotating T-12 transit
to edge of the field as required by table and
record readings.

TEST 2.5 (cont)

FIELD OF VIEW DATA SHEET

DIRECTION	TRANSIT READS	TOTAL
HORIZ.	LEFT SIDE = $243^{\circ} 00'$	
	RIGHT SIDE = $172^{\circ} 30'$	$70^{\circ} 30'$
VERT.	TOP SIDE = $3^{\circ} 32'$	
	BOTTOM SIDE = $73^{\circ} 57'$	$70^{\circ} 25'$

REMARKS:

Witnessed:

W. E. Miller 3-12-69 V. Costello 3/12/69
 Customer - Rep Date FOCI - Q.A. Date

DCASR

Date

TEST 2.6

COLLIMATION

(Ref. Purchase Specification Para. 2.4)

PURPOSE:

The purpose of this test is to show that variation in collimation across the field of view does not exceed 0.25 diopters.

EQUIPMENT:

- 1) Diopter-scope or equivalent
- 2) TV Test Fixture, P/N.121322

METHOD:

- a) Place TV Test Fixture in focal plane of window.
- b) With the aid of a Diopter-scope, placed at the eyepoint, scan the field of view, focusing on each light horizontally and vertically and record.

Variation of collimation shall not exceed 0.25 diopters.

TEST 2.6 (cond)

COLLIMATION DATA SHEET

SPOT ON TARGET	DIOPTER-SCOPE READING	VARIATION
Center	- .01	
1 Left	0	
2 "	0	
3 "	0	
4 "	- .06	
5 "	- .09	
6 "	+ .05	
7 "	+ .07	
8 "	+ .1	
9 "	+ .11	
10 "		

SPOT ON TARGET	DIOPTER-SCOPE READING	VARIATION
Center	- .01	
1 Right	- .01	
2 "	- .02	
3 "	0	
4 "	+ .01	
5 "	+ .01	
6 "	0	
7 "	0	
8 "	0	
9 "	- .04	
10 "		

Center	- .01	
1 Up	- .02	
2 "	- .01	
3 "	0	
4 "	0	
5 "	0	
6 "	0	
7 "	- .03	

Center	- .01	
1 Down	- .06	
2 "	0	
3 "	+ .03	
4 "	- .02	
5 "	- .05	
6 "	0	
7 "		

TEST 2.6 (cont)

Witnessed:

W. E. Miller 3-12-69
Customer - Rep Date

V. Costello 3/12/69
FOCI - Q.A. Date

DCASR Date

TEST 2.7

RESOLUTION

(Ref. Purchase Specification Para.2.3)

PURPOSE:

This test will show that the resolution of the system is equivalent to 2000 TV lines (1000 line pairs) across the field of view, vertically and horizontally.

EQUIPMENT:

Air Force Resolution Chart or equivalent.

METHOD:

- a) Place Air Force Resolution Chart at the focal plane of the TV input.
- b) With the unaided eye, from the eye relief position, observe the Resolution Chart and record the smallest resolvable pattern.
- c) Repeat procedure at various places horizontally and vertically and record as per data sheet on page 15.

RESOLUTION DATA SHEET

Witnessed:

DCASR	Date

SUMMARY

This test procedure includes the Inspection and Tests performed on:

1) Unit: Infinity Display Optical Unit

Part No: 135340

S/N: 102

2) Date: 6-12-69

In compliance with specification: Contract No. NAS 9-8140

REMARKS: IN - HOUSE TEST - PREVIOUS TO
SHIPPING TO MSC.

FACTORY ACCEPTANCE TEST PLAN

1.0 GENERAL

The Farrand Optical Co., Inc. will demonstrate the operational compliance of the Infinity Display Optical Units by performing the tests specified herein.

1.1 All optical, mechanical, and electrical alignment and adjustment will have been completed during laboratory testing prior to start of the Demonstration Tests described below.

2.0 LIST OF TESTS

Para.	Page	Test	Requirements	Per Contract No.NAS 9-8140
2.1	2	General Inspection	Per Standard MIL-SPECS	Par. 2.5, 3.0
2.2	3	Eye Relief	19.0 Inches $\pm \frac{1}{2}$ inch	Par. 2.2.4
2.3	5	Bleed-Through	Less than 9.0%	" 2.2.2
2.4	7	Transmission	1% Minimum	" 2.2.3
2.5	9	Field of View	70 Degrees Minimum	" 2.2.1
2.6	11	Collimation	Less than 0.25 Diopters	" 2.4
2.7	13	Resolution	Equal to 1000 Line Pairs	" 2.3

TEST 2.1

GENERAL INSPECTION

(Ref. Purchase Specification Para.2.5 and 3.0)

Equipment shall be inspected to determine compliance with the applicable drawings and specifications with respect to materials, workmanship, and marking.

Applicable Drawings:

135340

134870

134875

134879

REMARKS

(A) Workmanship

1) Damaged Parts

OK

2) Missing Parts

2 PCs135342 SIDE COVER

3) General Finish

OK

(B) Cleanliness

1) Mirror Surfaces

OK

2) Lens Surfaces

OK

3) Beamsplitter Surfaces

OK

4) Chambers

OK

Witnessed:

Customer - Rep

Date

FOCI - Q.A.

Date

DCASR

Date

TEST 2.2

EYE RELIEF

(Ref. Purchase Specification Para. 2.2.4)

GENERAL

This parameter is defined by measurement only and forms a part of Test 2.3, 2.4, 2.5, 2.6 and 2.7 of this document. Therefore, no separate test is required.

TEST 2.3

BLEED-THROUGH

(Ref. Purchase Specification Para. 2.2.2)

PURPOSE:

The purpose of this test is to demonstrate that "Bleed Through" or brightness of the source image seen through the optics shall be no greater than 9.0 percent of the brightness of the projected image.

EQUIPMENT:

Pritchard Light Meter or equivalent.

TV Test Fixture, P/N.121322

METHOD:

- a) Cover TV fixture with black paper except for a .5 inch circular opening in center of diffusing screen. Illuminate circular opening evenly with zenon arc lamp.
- b) Place TV Test Fixture in focal plane of window.
- c) Set up Pritchard Light Meter 10.0 feet in front of window sufficiently off axis, so that prime image and bleed-through image appear adjacent to one another.

TEST 2.3 (cont)

- d) Set Pritchard Light Meter at infinity focus and measure the illumination level of the natural image. Record reading, R_p .
- e) Measure illumination level of "Bleed-Through" image and record, R_b .

Calculate "Bleed-Through" illumination level as follows:

$$\frac{R_b}{R_p} \times 100\%$$

TEST 2.3 (cont)

BRIGHTNESS DATA SHEET

PRITCHARD READINGS		BLEED-THROUGH BRIGHTNESS
R _p	R _b	%
100%	1.2%	1.2%

REMARKS: _____

Witnessed:

Customer - Rep _____ Date _____

John H. Hurd 6-11-69
 FOC1 - Q.A. _____ Date _____

DCASR _____ Date _____

TEST 2.4

TRANSMISSION

(Ref. Purchase Specification Para.2.2.3)

PURPOSE:

The object of this test is to measure that the minimum light transmission through the optical system is one percent of the input illumination.

EQUIPMENT:

- 1) Pritchard Light Meter or equivalent
- 2) TV Test Fixture, P/N.121322

METHOD:

- a) Cover TV Test Fixture with black paper except for .5" diameter circular opening in center of diffusing screen.
- b) Place TV Test Fixture in focal plane of window.
- c) Set up Pritchard Light Meter 19 inches in front of window on axis (eyepoint).
- d) Set Pritchard at infinity focus, measure the illumination level of the circular image and record reading R_p .

TEST 2.4 (cont)

- e) Remove window, leaving TV screen and move Pritchard Light Meter 10 ft. from screen.
- f) Record illumination level R_s and calculate transmission:

$$= \frac{R_p}{R_s} \times 100\%$$

TEST 2.4 (cont)

TRANSMISSION DATA SHEET

PRITCHARD READING R R		WINDOW TRANSMISSION %	SPEC.
100%	.4%	.4%	

REMARKS: _____

Witnessed:

Customer - Rep

Date

John Harold
FOCI - Q.A.

6-12-69
Date

DCASR

Date

TEST 2.5

FIELD OF VIEW

(Ref. Purchase Specification Para. 2.2.1)

PURPOSE:

To demonstrate that the circular field of view
is 70 degrees minimum.

EQUIPMENT:

T-12 pocket transit or equivalent
TV Test Fixture, P/N.121322

METHOD:

- a) Illuminate the entire TV Test Fixture
screen and place in focal plane of window.
- b) Place T-12 pocket transit axis of rotation
at exit pupil, i.e. $19\pm\frac{1}{2}$ inches from nearest
optical element on axis.
- c) Measure field of view by rotating T-12 transit
to edge of the field as required by table and
record readings.

TEST 2.5 (cont)

FIELD OF VIEW DATA SHEET

DIRECTION	TRANSIT READS	TOTAL
HORIZ.	LEFT SIDE = $172^{\circ} 24'$	
	RIGHT SIDE = $243^{\circ} 52'$	$71^{\circ} 28'$
VERT.	TOP SIDE = $331^{\circ} 22'$	
	BOTTOM SIDE = $260^{\circ} 12'$	$71^{\circ} 10'$

REMARKS:

Witnessed:

Customer - Rep

Date

FOCI - Q.A.

Date

DCASR

Date

TEST 2.6

COLLIMATION

(Ref. Purchase Specification Para. 2.4)

PURPOSE:

The purpose of this test is to show that variation in collimation across the field of view does not exceed 0.25 diopters.

EQUIPMENT:

- 1) Diopter-scope or equivalent
- 2) TV Test Fixture, P/N.121322

METHOD:

- a) Place TV Test Fixture in focal plane of window.
- b) With the aid of a Diopter-scope, placed at the eyepoint, scan the field of view, focusing on each light horizontally and vertically and record.

Variation of collimation shall not exceed 0.25 diopters.

TEST 2.6 (cond)

COLLIMATION DATA SHEET

SPOT ON TARGET	DIOPTER-SCOPE READING	VARIATION
Center	+ .17	
1 Left	+ .19	
2 "	+ .19	
3 "	+ .17	
4 "	+ .12	
5 "	+ .10	
6 "	+ .10	
7 "	+ .09	
8 "	+ .09	
9 "		
10 "		

SPOT ON TARGET	DIOPTER-SCOPE READING	VARIATION
Center	+ .17	
1 Right	+ .20	
2 "	+ .20	
3 "	+ .20	
4 "	+ .18	
5 "	+ .18	
6 "	+ .10	
7 "	+ .10	
8 "	+ .05	
9 "		
10 "		

Center	+ .17	
1 Up	+ .22	
2 "	+ .22	
3 "	+ .18	
4 "	+ .10	
5 "	+ .05	
6 "	0	
7 "		

Center	+ .17	
1 Down	+ .17	
2 "	+ .17	
3 "	+ .17	
4 "	+ .15	
5 "	+ .15	
6 "	+ .10	
7 "		

TEST 2.6 (cont)

Witnessed:

Customer - Rep

Date

John Arnold *6-12-69*

FOCI - Q.A. Date

DCASR

Date

TEST 2.7

RESOLUTION

(Ref. Purchase Specification Para.2.3)

PURPOSE:

This test will show that the resolution of the system is equivalent to 2000 TV lines (1000 line pairs) across the field of view, vertically and horizontally.

EQUIPMENT:

Air Force Resolution Chart or equivalent.

METHOD:

- a) Place Air Force Resolution Chart at the focal plane of the TV input.
- b) With the unaided eye, from the eye relief position, observe the Resolution Chart and record the smallest resolvable pattern.
- c) Repeat procedure at various places horizontally and vertically and record as per data sheet on page 15.

TEST 2.7 (cont)

RESOLUTION DATA SHEET

LOCATION	AIR FORCE	HORIZONTAL RESOLUTION	AIR FORCE	VERTICAL RESOLUTION
CENTER	1-5	3080 LINES	1-5	3080 LINES
15 Right	1-5	3080 "	1-5	3080 "
30 Right	1-5	3080 "	1-5	3080 "
15 Left	1-5	3080 "	1-5	3080 "
30 Left	1-4	2720 "	1-4	2720 "
10 Up	1-5	3080 LINES	1-5	3080 LINES
20 Up	1-4	2720 "	1-4	2720 "
10 Down	1-5	3080 "	1-5	3080 "
20 Down	1-4	2720 "	1-4	2720 "

Witnessed:

Customer - Rep

Date

F. J. Q.A.

Date

DCASR

Date