Attachment to ORD # 5491-66 (10)

~~CONFIDENTIAL~~

DALMO VICTOR COMPANY
BELMONT, CALIFORNIA • LY 1-1414

November 28, 1966

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Attention: Dr. William B.

Gentlemen:

In accordance with Contract 7129/100, 296-66WR, three copies of the Final Report and the Final Operating Manual are enclosed. These items complete the delivery of all items on this contract including its change orders and amendments. Being sent under separate cover is a complete set of drawings along with a set of reproduceables.

One copy of the Final Report and Final Operating Manual have been forwarded to the attention of the Contracting Officer in Los Altos, California. In addition, two copies of the Final Operators manual only, and one set of drawings have been sent to Mr. Dave Lane of LTV Electrosystems.

Yours very truly,

DALMO VICTOR COMPANY
Division of Textron Inc.

J. H. Smith

J. H. Smith, Product Manager
Electro-Optic Systems

RBM:JHS:cw
Encls.

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SECRET

FINAL REPORT

LOW LIGHT LEVEL TELEVISION SYSTEM

November 28, 1966

Dalmo Victor Company
Belmont, Calif.

Prepared by: [signature]
R. B. McIntosh
Project Engineer

SECRET

Approved by: [signature]
Paul Mengers, Manager
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FINAL REPORT

LOW LIGHT LEVEL TELEVISION SYSTEM

A low light level television system, containing the following components was completed on November 1, 1966:

A. 1 - LLLTV camera head containing an image intensifier-SEC Vidicon.
B. 1 - Wide angle camera lens containing an automatic iris and iris control sensor.
C. 1 - Camera electronics box containing LLLTV processing and iris control circuitry.
D. 2 - Television display monitors.
E. 1 - Two axis rate stabilized platform.
F. 1 - Servo electronics box.
G. 1 - Control console.
H. 2 - Platform hand controls.
I. 1 - Set of interconnecting cables.

The system underwent final checkout and test at Dalmo Victor during the week ending November 6, 1966. On November 6, 1966, this system was transported to LTV's facility at Greenville, Texas where a week was spent on aircraft installation and flight testing.

The purpose of this report is to describe the test results obtained at Dalmo Victor and at Greenville.

A. FINAL SYSTEM CHECKOUT AND TEST

1. Purpose

The purpose of this test was to establish that each unit of the system, as well as the system as a whole, was operating properly in accordance with previously established performance criteria.

2. Optoliner Resolution Test

The first method by which camera resolution was measured utilized a Spectra Model TVO-2000 C optoliner. This instrument contains a standard RETMA chart reticle which is illuminated by a calibrated 2870°K light source. The reticle is imaged on the fiber optics faceplate of the camera's image intensifier. The illuminance of the image can be attenuated from 1.0 to 1×10^{-8} ft-c at the intensifier photocathode by means of calibrated neutral density filter inserts. The optoliner illuminance can be calibrated for both intensity and color by an attachable calibration unit which was compared to a standard NBS lamp.

Resolution tests employing an optoliner provide the most convenient and consistent method for evaluating the cameras both quantitatively and qualitatively. However, there is the disadvantage that the effect of the camera lens cannot be included.

3. RETMA Chart Resolution Tests

To measure the resolution of a complete camera, including its lens, a standard RETMA television chart is employed. The chart is positioned to a distance from the camera where it just completely fills the camera field. For a one inch diameter photocathode, the lines per inch markings on the wedges of the RETMA chart directly correspond to camera resolution in lines per picture height. The chart is then illuminated uniformly by a calibrated 2870°K source which has the ability to be either attenuated continuously by an iris, or in decade steps by neutral density filters. The brightness of the chart is determined by a photometer. The Photo Research, Inc. Spot Photometer having a field of view of approximately 1° x 1° is used to determine the brightness of the high light or white portions of the chart.

It can be shown that the illumination on the photocathode of the image intensifier is equal to

$$E = \frac{B T_o}{4 F^2}$$

where

E = photocathode illuminance in foot candles

B = chart brightness in lumens per steradians per $ft.^2$

T_o = lens transmission

F = lens f-number

4. Additional Tests

The television monitors are aligned with standard television test equipment. As the monitors are incorporated in the overall camera resolution tests their performance is included in the resolution measurements.

The platform was checked to determine that it was operating properly. A vibration and transient shock test was conducted to establish that it was properly rate stabilized. The platform was controlled individually by the two hand controls. Slew rates were adjusted for desired response and damping.

The automatic iris was tested to determine that it provided proper attenuation for light levels ranging from 1×10^{-7} ft-c to conditions of total sunlight. The system was operated outside the laboratory in sunlight for the high level check.

A pressure holding test was made on the lens and camera head and the accuracy of the cross reticle, the elevation and azimuth indicators on the control console were checked.

5. Final Test Results

a. Optoliner Resolution Tests

1. The high light limiting resolution measured at 1×10^{-3} ft-c at the photocathode was 515 lines/picture height.

2. The low light resolution at 1×10^{-7} ft-c at the photocathode was 275 lines/picture height.

b. RETMA Chart Resolution Tests

1. The high light limiting resolution at 1×10^{-3} ft-c was 425 lines/picture height at maximum aperture. The high light limiting resolution at 1×10^{-2} ft-c was 500 lines/picture height minimum aperture.
2. The low light limiting resolution at 1×10^{-7} ft-c was 225 lines/picture height.

c. Additional Tests

1. The camera presentation did not show any effects when the platform base was subjected to simulated aircraft vibration and shock.
2. The platform hand controls slewed the camera head at approximately a 0.5 radian per sec. rate. Control overshoot was negligible.
3. The automatic iris was found to keep the input light level below a point where both the automatic target and manual target control could safely discharge high light portions of the SEC Vidicon target. At low light levels, the iris opened completely.
4. The camera lens pressure was measured at 6.5 psi after a 24 hour hold period. The lens was initially purged with 8 psi of dry nitrogen. The camera head maintained a pressure of 7 psi after a 24 hour hold period. The camera was initially purged with 8 psi of dry nitrogen.
5. The azimuth and elevation meters on the operator's console indicated the position of camera head with respect to the platform base within 0.5° of arc.
6. The cross reticle indicated the position of the platform base (aircraft axes) on the monitor displays within 0.5° of arc.

B. FLIGHT TEST NO. 1

The first of a series of two flight tests was conducted at Greenville the evening of November 9, 1966. The flight commenced prior to sunset and extended into deep twilight. The sky was 100% overcast with a thick low altitude cloud layer. The system was turned on shortly after takeoff and remained on through landing. The camera operated satisfactorily for the duration of the flight. The low light level performance could not be completely evaluated as the flight was terminated before conditions of total darkness. The flight terminated early because the caging on the platform could not be released. This failure was traced to an improper 28V dc fuse value in the servo electronics box.

Some graininess was observed on a portion of the SEC Vidicon target. This effect resulted from the fact that the SEC Vidicon beam current was set at its maximum value during the flight. The appearance of target graininess at high beam setting is characteristic of SEC tubes. It is primarily a cosmetic effect as it does not measurably degrade camera resolution.

C. FLIGHT TEST NO. 2

The second flight test was conducted the evening of November 10, 1966. The flight started approximately half an hour prior to sunset and lasted through total darkness. The sky was clear and moonless. The flight was made at 1000 feet over a sparsely populated triangular course. A slight ground haze was observed occasionally after sundown. The camera and platform operated perfectly for the duration of the flight. The platform was caged and uncaged a number of times to demonstrate the elimination of the problem encountered during the previous flight test. The camera presented a picture of standard quality during the period up to sunset. After sunset and until total darkness, the camera demonstrated a distinct advantage over the eye. Foliage appeared white and rivers and other bodys of water appeared distinctly black against the rather low contrast countryside. The average contrast of the land surrounding Greenville is low. The land is dry and the majority of vegetation (grass fields with occasional scrub and trees) is a grey-brown. The soil itself is black velvet clay. Newly cultivated fields are jet black and present no noticeable reflection.

During the period of extreme darkness, very little could be seen on the television display; occasionally a river or body of water could just be distinguished. Some roads were observable. When a car was present on a road, the road was visible for a considerably long distance beyond that illuminated by its headlights.

Over all ranges of light level, building and vehicle lights did not effect the overall picture quality. During starlight illumination, when the camera was panned down and observing maximum V/H ratios, a slight short-term streaking resulted from a bright light in the camera field.

Target graininess was not noticeable at light levels above extreme darkness. During extreme darkness, its effect was negligible on camera resolution.

D. DISCUSSION OF FLIGHT TEST RESULTS

The results of final tests at Dalmo Victor and flight tests at Greenville demonstrated that the system met all specifications and objectives of the contract. The following personnel operated and evaluated the low light level television system during the two flight tests; Robert McIntosh, James Smith and Keith Henke of Dalmo Victor, and Flight Director Chuck Michealson of LTV Electrosystems.

Chuck Michealson approved LTV's signoff on a DD250 form, acting for the customer on the basis of the successful flight performance of the system.

Two observations were made during flight testing which warrant consideration in specifying future systems. The wide angle lens produces a large ground presentation on the screen which gives no magnification aid to the eye. A considerably smaller field of view would appear satisfactory for the identification of navigational aids. In addition, the presence of some low power magnification in the system would make the television more useful during daylight and twilight hours. Specific target identification could be achieved with greater ease and the system operated at higher altitudes because of increased angular resolution.

It was noted that while the S1 intensifier has the advantage of having a response extending into the near infrared, its overall low light level performance is almost a factor of 10 less than cameras employing S-20 image intensifiers. Had an S-20 tube been employed, it is felt that very useful camera results would have been obtained with the clear starlight illumination. Several small fires were easily detectable, however, previous flight test experience has indicated that this is also the case with S-20 photocathodes. The only advantage of the S1 is its ability to detect targets which are heated just below the point of incandescence. Positive identification of such objects would require a higher angular resolution available in narrower field lenses.

E. STORAGE AND OPERATING TEMPERATURE PRECAUTION

Westinghouse Electric Corporation, the manufacturer of the SEC Vidicon, have recently warned users of SEC Vidicons that this tube should not be stored or operated at temperatures exceeding 135°F. Tubes subjected to higher temperatures have, in some cases, experienced a reduction in sensitivity. It is recommended that every precaution be made to keep the camera storage and operation temperatures below 135°F.