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Materiel Test Procedure 10-2-107
General Equipment Test Activity

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U. S. ARMY TEST AND EVALUATION COMMAND
COMMODITY ENGINEERING TEST PROCEDURE

METASCOPES - INFRARED, IMAGE-FORMING

1. OBJECTIVE

This document provides test methods and testing techniques necessary to determine the technical performance and safety characteristics of image-forming infrared metascopes and associated peripheral equipment, as described in Qualitative Materiel Requirements (QMR's), Small Development Requirements (SDR's), Military and/or Technical Characteristics (MC's or TC's), and to determine the items suitability for service tests.

2. BACKGROUND

Combat units need a hand-held portable, all-weather surveillance device, suitable for the detection of near-infrared sources during the hours of darkness, or as a general purpose night infrared viewer. The device, or metascope, should be reliable, easy to maintain and repair, and safe to operate.

The metascopes may be used as a countermeasures device during night operations under combat conditions. Surveillance of enemy-held positions with the passive metascope receiver will reveal active infrared or near infrared search activities and provide a tactical advantage. Further, under favorable tactical conditions, the metascope may also be used with a companion infrared source to illuminate an area of interest for observation with the metascope receiver.

3. REQUIRED EQUIPMENT

a. Platform Scales.
b. Steel Measuring Tape.
c. Still Camera and Film.
d. Light Source (grey-body) and Power Supply Combination Capable of operation at Color Temperature of 2870 degrees K.
e. White Diffuse Screen.
f. Filter, 10% neutral.
g. Filter, 10% infrared.
h. High Gain Photo-Detector/Multiplier with Spectral Response Approximating the Sensitivity of the Photopic Eye.
i. Regulated High Voltage Power Supply, 700 to 1000 Volts D.C., ± 0.1% Regulation.
j. Low Frequency Oscilloscope with at least 1 sec. persistence or Recorder.
k. Sweep Generator.
l. Test Targets as follows:

1) Resolution - lines from 0.2 lines/mm. to 3 lines/mm.
2) Field of view - 2 vertical lines spaced in accordance with test item field of view specifications.

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3) Focus Range - Multi-lines suitably spaced to obtain positive focus with test item 1 yard or less from test target.

m. Collimator Lens System.
n. Pick-up Lens System or Low Power Telescope.
o. Single Vertical Slit approximately 1.5 ± 0.5 mm wide and 5 mm high.
p. Test Bench for mounting Optical and Electronic Components.
q. Telescope with provision for measuring angular displacement horizontal and vertical planes, magnification typically from 1 to 2, and cross hairs.
r. Tripod for mounting test item.
s. Meteorological Equipment to measure the following:

1) Temperature
2) Barometric Pressure
3) Relative Humidity

t. High Voltage D.C. Voltmeter.
u. Standard Photometer and N.B.S. Standard Lamp.
v. Relative Measurement Color Selective Photometer.
w. High-density Filter Photometer.
x. Infrared Filter Photometer.
y. Insulation Test Set.
z. Drop Test Facility.

4. REFERENCES

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R. MTP 10-2-500, Physical Characteristics.
S. MTP 10-2-501, Operator Training and Familiarization.
T. MTP 10-2-503, Transportability.
U. MTP 10-2-505, Human Factors Evaluation.
V. MTP 10-2-507, Maintenance Evaluation.

## 5. SCOPE

### 5.1 SUMMARY

This procedure describes the preparation for, and methods of, evaluating the performance characteristics of image-forming infrared metascopes, as follows:

a. Preparation for Test - A determination of the condition of the test upon its arrival, and the test item's physical characteristics.

b. Receiver Brightness Gain and Resolving Power Test - An evaluation to determine the ability of the test item image forming receiver to record fine detail in the object as limited by diffraction, optical system aberrations, image converter tube resolution capabilities, and the precision employed in preparing and centering the test item's optical components.

c. Receiver Linear Distortion Test - An evaluation to determine the degree of test item image deformation as caused by variations in the magnification of the optical system and image converter tube.

d. Receiver Field of View Test - An evaluation to determine the maximum angle at which the test item will admit object field rays as limited by the maximum specified allowable distortion.

e. Receiver Focus Range Test - An evaluation to determine the test item's ability to meet the specified minimum and maximum focus limits.

f. Infrared Light Source Characteristics and Light Source-Receiver Alignment Test - A study to determine the beam candle-power distribution and the alignment of the beam with the test item receiver optical axis.

g. Infrared Filter Characteristics Test - An evaluation to determine the optical efficiency of the test item infrared filter as indicated by the ratio of the filter's effective visual light transmission to the filter's capability for transmitting infrared energy at the specified wave lengths.

h. Maintenance - An evaluation to determine the adequacy of the manufacturer's technical and maintenance instructions provided with the test item and to determine the degree to which the test item is designed fo facilitate maintenance and repair.

i. Transportability - An evaluation to determine the capability of the test item to withstand the shock and vibration associated with normal handling and while being transported.

j. Safety - An evaluation to determine the safety characteristics of the test item.

k. Human Factors Evaluation - An evaluation to determine the adequacy of the design and layout of controls, and any operability and accessibility design deficiencies.

l. Value Analysis - A study to reveal any unnecessary test item features.

5.2 LIMITATIONS

The test methodology and techniques prescribed by this document pertain only to optical devices which utilize image converter tubes. Appendix A describes the unique construction features imposed by this restriction. Appendix B describes a range of available image converter tube performance parameters which have been addressed by this document and may be considered as the limiting factor of the tests summarized by 5.1 above.

6. PROCEDURES

6.1 PREPARATION FOR TEST

6.1.1 Initial Inspection

Upon receipt of the test item at the test site, the test item shall be subject to the applicable portions of MTP 10-2-500 and the following procedures:

a. Visually inspect the test item package(s) and record the following:

1) Evidence of packaging damage or deterioration.
2) Identification markings, including:

a) Name of contractor
b) Number and date of contract
c) Date of manufacture
d) Other markings pertaining to the test item

b. Weigh and measure the individual package(s) of the test item and its accessories and record the following:

1) For each shipping package:

a) Contents
b) Weight
c) Length, width, and height
d) Cubage

2) For the entire test item:

a) Weight
b) Cubage

c. Unpack the test item, visually inspect it and record the following, when applicable:

1) Evidence of defects:

a) Manufacturing
b) Material

c) Workmanship

2) Evidence of damage
3) Evidence of wear

NOTE: Make use of photographs, diagrams and narration to indicate the condition of the test item.

d. Presence of instruction plates, if applicable, including:

1) Identification, name and serial number
2) Caution instructions
3) Service instructions

e. Existence of shortages.

6.1.2 Physical Characteristics

Determine and record the following physical characteristics of the test item.

a. Type, size, and serial number of each test item being tested.
b. For individual test item components, if applicable:

1) Weight
2) Length
3) Overall diameter

c. For each complete test item (fully assembled):

1) Weight
2) Length
3) Overall diameter

6.1.3 Operator Training and Familiarization

Orient the test personnel in all phases of maintenance, operation, and safety of the test item according to MTP 10-2-501.

6.2 TEST CONDUCT

NOTE: During installation and operation, the operating techniques provided in the manufacturer's instruction manual or technical manual will be used. Any change or deviation from these instructions will be recorded in the test item log book.

6.2.1 Receiver Brightness Gain and Resolving Power Test

6.2.1.1 Preparation for Test

a. Obtain the following components,or equivalent, and arrange them

for the test as shown in Figure 1:

1) Electronics Lens Bench

NOTE: The electronic lens bench is an extension of the ordinary optical lens test bench. Additional provisions are made for the adjustable mounting of electro-optical devices, such as photo-detectors/photomultipliers, onto the lens holder track such that overall optical centering may be accomplished in the conventional manner.

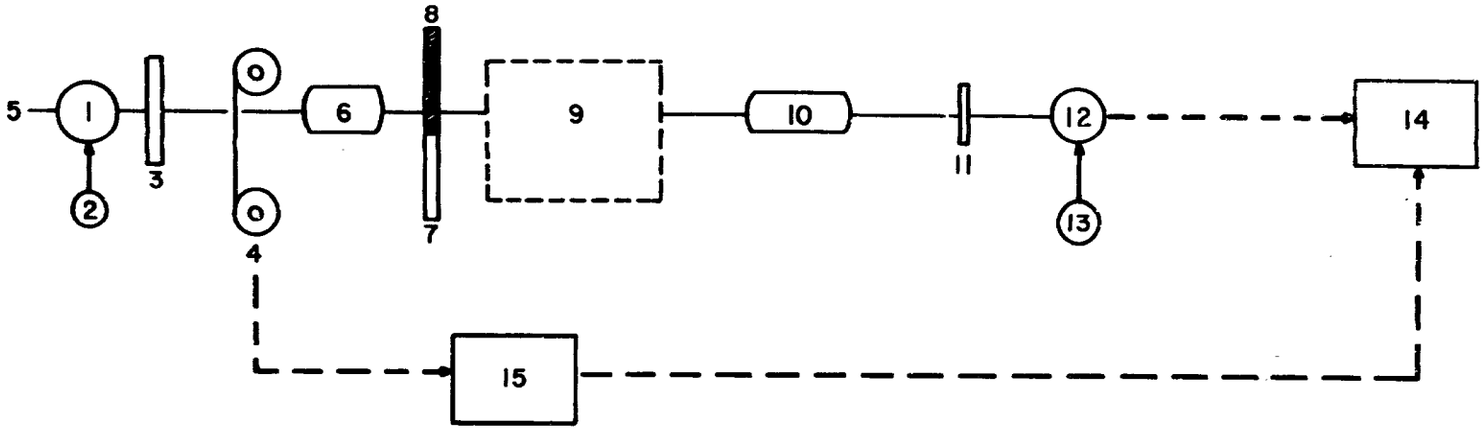
2) A light source (grey-body) and power source combination capable of operating at a color temperature of 2870 degrees K. (See Appendix C.).
3) White diffuse screen.
4) Filters, 10% Neutral and 10% infrared.
5) A high gain photo-detector/multiplier suitable for the detection and measurement of low light levels with a spectral response approximating the sensitivity of the photopic eye. (See Appendix D).
6) A regulated high voltage power supply for the photo-multiplier which is adjustable over the range of 700 volts D.C. to 1,000 volts D.C.

NOTE: For a desired photomultiplier overall gain variation of ± 1% power supply regulation must not vary by more than ± 0.12%.

7) Low frequency oscilloscope with a long persistence (100 millisec to 1 sec) screen phosphor or recorder.
8) A sweep generator as required to synchronize the oscilloscope horizontal sweep circuits in respect to test target frame linear motion and the vertical oscilloscope input from the photomultiplier.
9) A variable frequency high contrast test target.

NOTE: The test target should be suitable for sweeping across the electronics lens bench optical axis in the horizontal plane. The frequency range of the test target should extend from .2 lines per MM to 3 lines per MM. The suggested frequency range is based on an expected reduction of 25X by the test set up optical components which furnish the collimated test image for the test item receiver when it is inserted and centered along the electronic lens bench optical axis. The 25X reduction would then yield a range of lines varying from 5.0 per MM to 75 per MM or approximately 2.5 line pairs per MM to 37.5 line pairs per MM per target frame.

10) A collimator lens system, having a focal length (a collimator lens system speed of f/3.5 is typical) which will produce




| ITEM NO. | DESCRIPTION | ITEM NO. | DESCRIPTION |
|---|---|---|---|
| 1 | 2870°K LIGHT SOURCE | 9 | TEST ITEM (IMAGE FORMING RECEIVER - NOT INSTALLED DURING TEST SET-UP CALIBRATION) |
| 2 | LIGHT SOURCE POWER SUPPLY (DC) | | |
| 3 | WHITE DIFFUSE SCREEN | 10 | PICK-UP LENS SYSTEM |
| 4 | TEST TARGET(S) & TRANSPORT MECHANISM | 11 | SINGLE SLIT |
| 5 | ELECTRONIC LENS BENCH, OPTICAL AXIS | 12 | PHOTO MULTIPLIER TUBE |
| 6 | COLLIMATOR LENS SYSTEM | 13 | HIGH VOLTAGE POWER SUPPLY |
| 7 | 10% NEUTRAL FILTER (CALIBRATION) | 14 | RECORDER OR OSCILLOSCOPE |
| 8 | 10% INFRARED FILTER (TEST) | 15 | SWEEP GENERATOR |

FIGURE 1. SCHEMATIC LAYOUT OF A TYPICAL IMAGE FORMING RECEIVER RESOLVING POWER AND BRIGHTNESS GAIN TEST SET-UP.

the reduction ratio of the test target specified in the test plan.

NOTE: The test target is aligned and calibrated to scan at (M + 1) focal lengths in front of the collimator lens system. "M" is the desired reduction ratio of object to image size.

11) A pickup lens system or low power telescope suitable for focusing the test target image onto the plane of the single slit.
12) A single vertical slit which is approxumately 1.5MM ± .5MM wide and 5MM high and is otherwise capable of projecting the diffracted image onto the plane of the photomultiplier photocathode.

b. Carefully align each component in step a to the optical axis of the electric lens bench.

NOTE: The high voltages at which typical photomultipliers operate are very dangerous. Care should be taken in the design of apparatus to prevent the operator from coming in contact with these voltages. Precautions should include the enclosure of high potential terminals and the use of interlock switches to break the primary supply when access to the apparatus is required.

6.2.1.2 Test Conduct

a. After checking the alignment of the test setup with the optical axis of the electronic lens bench, calibrate the optical lens bench without the test item installed and record the values obtained for comparison with test data obtained with the test item installed.

NOTE: Preliminary operation including final alignment and calibration of the test setup is required as an integral part of the brightness gain and resolving power determinations. During this phase of test conduct, reference comparison values are obtained without the test item installed in the test apparatus. Adjustments performed to calibrate the optical lens bench and peripheral equipment should not be altered in any way following measurement and recording of the reference data. This requirement, however, does not preclude test officer directed pre-test operations of the test apparatus for the purpose of familiarizing test personnel with test conduct procedures and to verify satisfactory performance of the test setup.

b. Measure and record test area temperature.

NOTE: The test conduct area temperature would typically be maintained at 68 degrees F. or at the temperature specified as normal

for the test item. Test conduct should not be undertaken at area temperatures exceeding photomultiplier specified maximum operating parameters. Operation at or above these maximum values or under variable ambient conditions may result in excessive or unstable photomultiplier "dark current" in the absence of any other input energy contribution.

c. Insert the 10% neutral filter in the electronic lens bench optical path.

NOTE: The image forming receiver is not installed at this time.

d. Apply the light source voltage and adjust the current flow to obtain operation at a color temperature of 2870 degrees K. Measure and record the voltage and current values.

e. Adjust and focus applicable test setup components to achieve a precise test target image on the plane of the single slit aperture.

f. Record the high voltage value and the anode current value of the photomultiplier after performing the following:

1) Close the photomultiplier photocathode enclosure aperture.
2) Apply primary power to the photomultiplier regulated high voltage power supply and adjust the high voltage to produce the photomultiplier gain required in the test plan.
3) Verify proper operation of the photomultiplier by measuring the anode current and assuring that this current value is the specified "dark current" for the selected tube type for the measured test area temperatures.

g. Initiate horizontal sweeping of the test target across the electronic lens bench optical axis.

h. Open the photomultiplier photocathode enclosure aperture and observe the resulting wave form trace on the oscilloscope. Adjust, as required, the distance between the single slit and the photomultiplier photocathode to achieve a clearly defined trace and maximum deflection as observed on the oscilloscope.

i. Adjust the oscilloscope vertical gain for a wave form maximum deflection of 50% full scale deflection and measure and record the maximum and minimum values of wave form deflection.

NOTE: The values recorded in the step above represent the reference comparison data which will be used to calculate the reference light source percentage of modulation. Changes to test setup adjustments following this step will void the test.

j. Replace the 10% neutral filter with the 10% infrared filter.

k. Measure and record the high voltage supplied to the image forming receiver after performing the following:

1) Install the image forming receiver along the optical axis

of the electronic lens bench between the collimator and the infrared filter.

2) Adjust the high voltage power supply to the value specified in the test item operating manual.

l. Measure and record the maximum and minimum deflection of the resulting wave form on the oscilloscope.

m. Observe and record the maximum number of line pairs per MM which the test item can resolve.

n. Record the reduction ratio of the collimator lens system in the test setup.

6.2.2 Receiver Linear Distortion Test

6.2.2.1 Preparation for Test

a. Obtain the following components or equivalents and arrange them for the test as shown in Figure 2.:

1) Electronic lens bench
2) A light source (grey-body) and power source combination capable of operating at a color temperature of 2870 degrees K. (See Appendix C).
3) A linear distortion test target consisting of three vertical, equally spaced lines. (The equal-distance line should be centered on the test target and the lines to the right and left should be spaced to represent the angular displacement from the optical axis for which the test item linear distortion requirement is specified).

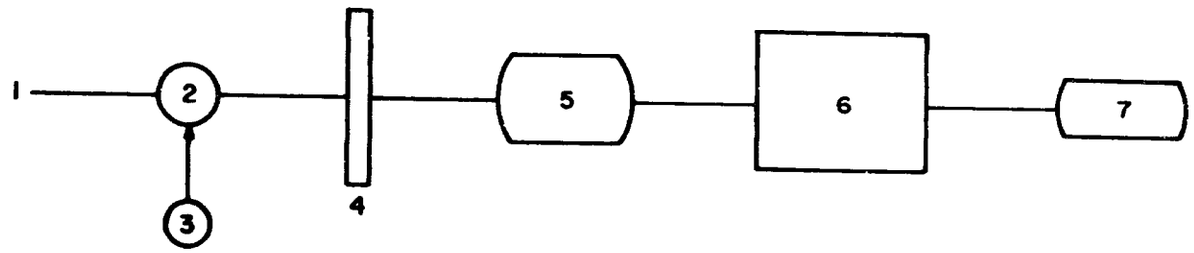
NOTE: Although line height and width are not critical, these dimensions should be considered in respect to the selected reduction ratio.

4) A collimated lens system, having a focal length which will produce the reduction ratio of the test target specified in the test plan.
5) A telescope with provisions for measuring angular displacement in the horizontal and vertical planes. (The telescope magnification may typically range from 1 to 2 power; cross hairs are required).

b. Carefully align each component in step a, as applicable, to the optical axis of the electronic lens bench.

6.2.2.2 Test Conduct

NOTE: Preliminary operation including final alignment and calibration of the test setup is an integral part of the linear distortion determination. This requirement, however, does not preclude test officer directed pre-test operation of the test apparatus




| ITEM NO. | DESCRIPTION |
|---|---|
| 1. | LENS HOLDER TEST BENCH* |
| 2. | 2870° LIGHT SOURCE* |
| 3. | LIGHT SOURCE POWER SUPPLY* |
| 4. | TEST TARGET |
| 5. | COLLIMATOR LENS SYSTEM* |
| 6. | TEST ITEM (IMAGE FORMING RECEIVER) |
| 7. | TELESCOPE |

* THESE ITEMS ARE IDENTICAL TO APPLICABLE FIGURE 1 COMPONENTS.

FIGURE 2. SCHEMATIC LAYOUT OF A TYPICAL IMAGE FORMING RECEIVER LINEAR DISTORTION TEST SET-UP

for the purpose of familiarizing test personnel with the test conduct procedure and to verify satisfactory performance of the test setup.

a. Measure and record test area temperature.

NOTE: The test area temperature and temperature stability requirement for this test is based on normal operating parameters specified for the test item.

b. Apply the light source voltage and adjust the current flow to obtain operation at a color temperature of 2870 degrees K. Record the voltage and amperage.

NOTE: Steps b through g are performed without the test item installed in the test setup.

c. Set the telescope horizontal and vertical adjustment controls to zero degrees and zero minutes.

d. While observing the test target image through the telescope, adjust the telescope focus to obtain a clear image of the test target center line.

e. With the telescope, measure and record the angular height of the test target center line.

f. Rotate the telescope around the entrance pupil and align the telescope vertical cross hair to the right test target line. Measure and record the angular height of the right test target line.

g. Rotate the telescope around the entrance pupil and align the telescope vertical cross hair to the left test target line. Measure and record the angular height of the left test target line.

h. Measure and record the high voltage supplied to the image-forming receiver after performing the following:

1) Install the test item along the optical axis of the lens bench as shown in Figure 2.
2) Adjust the high voltage power supply to the value specified in the test item operating manual.

i. Repeat steps d through g with the test item in operation.

6.2.3 Receiver Field-of-View Test

6.2.3.1 Preparation for Test

a. Mount the test item on a tripod or similar rigid structure at the distance specified in the test plan (approximately 15 feet) from a smooth vertical surface suitable for mounting a test target. (See Figure 3 for a schematic layout of a typical test setup).

b. Prepare a test target consisting of two vertical lines spaced to represent the angular subtense of arc at which the test item field-of-view requirement is specified and the distance selected for placement of the test item from the test target.

NOTE: The test target would typically be of high contrast, i.e., 50/1 to 100/1. Line width would typically be as narrow as possible, but within the resolving capabilities of the test item.

c. Attach the test target to the vertical surface.

NOTE: The test setup is aligned such that the optical axis of the test item is perpendicular to the plane of the test target at a point equal distant between the test target vertical lines.

d. Install a light to illuminate the test target with visible light.

6.2.3.2 Test Conduct

NOTE: Preliminary operation including final alignment and calibration of the test setup is an integral part of the field-of-view determination. This requirement, however, does not preclude test officer directed pre-test operation of the test apparatus for the purpose of familiarizing test personnel with the test conduct procedure and to verify satisfactory performance of the test setup.

a. Measure the distance between the test target and test item to confirm that the distance is equal to that specified in the test plan. Record the test item to test target distance.

b. Check the alignment of the test item to confirm that its optical axis is perpendicular to the test target at a point midway between the vertical lines.

c. Measure the distance between the test target lines to confirm that they are spaced as required in the test plan and record the distance.

d. Adjust the high voltage power supply for the test item to the value specified in the test item operating manual and measure and record the value.

e. Illuminate the test target with visible light.

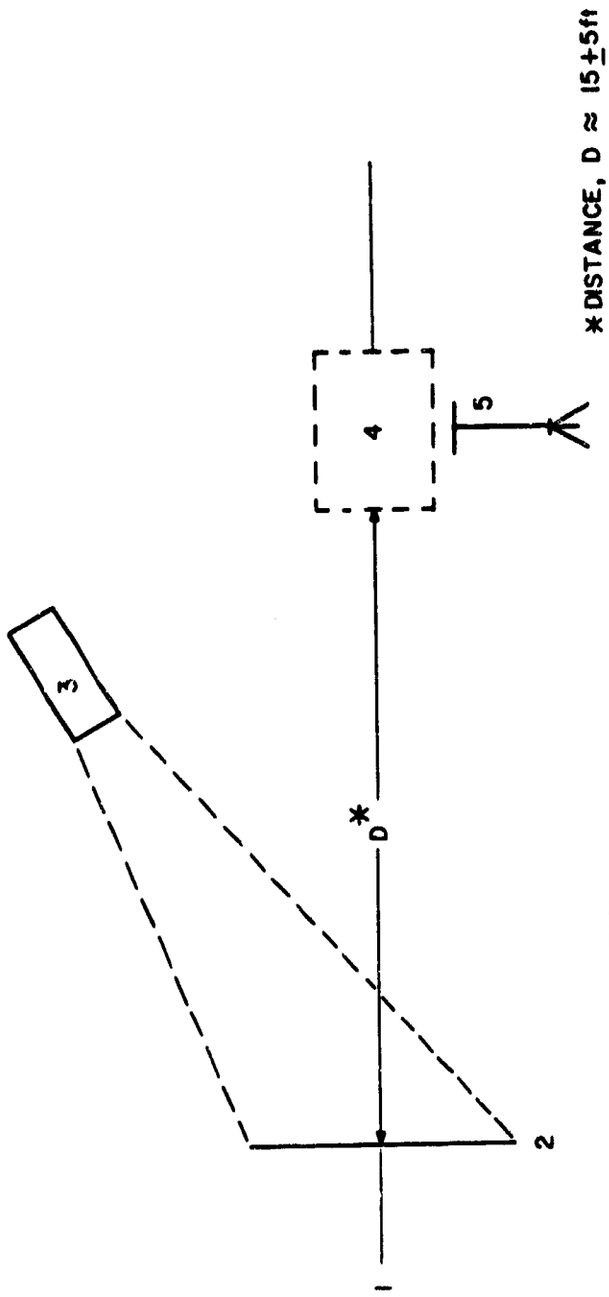
f. Measure and record test area temperature.

NOTE: The test area temperature and temperature stability requirement for this test is based on normal operating parameters specified for the test item.

g. Observe the test target through the test item. Record the number of vertical lines visible.

h. If two test lines are visible, decrease the distance between the point of original observation and the test target in small increments. Continue until one or both lines disappear from the field-of-view. Record the distance value.

i. When fewer than two lines are observed in step g, increase the distance between the point of the original observation and the test target in small increments. Continue until both lines are visible. Record the distance value.




| ITEM NO. | DESCRIPTION |
|---|---|
| 1 | OPTICAL AXIS |
| 2 | TEST TARGET VERTICAL SURFACE |
| 3 | ILLUMINATING SOURCE (VISIBLE SPECTRUM) |
| 4 | TEST ITEM (IMAGE FORMING RECEIVER) |
| 5 | TRIPOD |

FIGURE 3. SCHEMATIC LAYOUT OF A TYPICAL IMAGE FORMING RECEIVER FIELD OF VIEW TEST SET-UP

6.2.4 Receiver Focus Range Test

6.2.4.1 Preparation for Test

a. Mount the test item on a tripod or similar rigid structure. (See Figure 4 for a schematic layout of a typical test setup .

b. Prepare a test target consisting of multi-lines. Individual line width, height, and spacing to adjacent lines are chosen such that positive test item focus may be obtained at a distance greater than 100 yards.

c. Prepare a test target consisting of multi-lines similar to 6.2.4.1(b) except suitable for obtaining test item positive focus at a distance of 1 yard or less.

d. Mount the test targets so that they can be moved along the optical axis of the test item.

e. Position visible light sources so as to illuminate the test targets.

6.2.4.2 Test Conduct

NOTE: Preliminary operation including final alignment and calibration of the test setup is an integral part of the focus range determination. This requirement,however, does not preclude test officer directed pre-test operation of the test apparatus for the purpose of familiarizing test personnel with the test conduct procedure and to verify satisfactory performance of the test setup.

a. Adjust the high voltage power supply for the test item to the value specified in the test item operating manual and measure and record this value.

b. Measure and record test area temperature.

NOTE: The test area temperature and temperature requirement for this test is based on normal operating parameters specified for the test item.

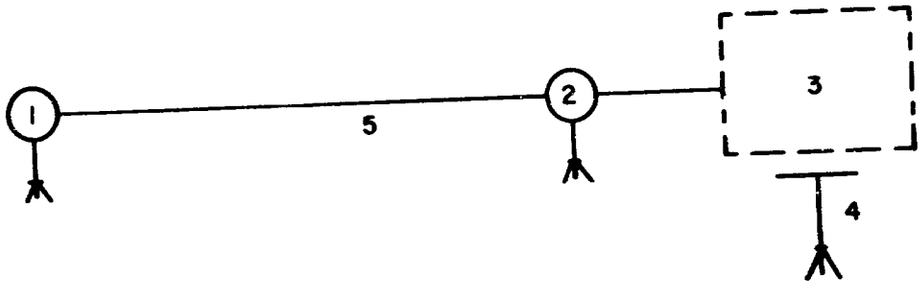
c. Set the test item focus adjustment to the mechanical stop indicating the minimum focus point.

d. Position the short range test target a few inches from the test item objective lens and illuminate it with visible light. Increase the distance between the test target and the test item until a sharp clearly defined image is obtained. Measure and record this distance.

NOTE: The focus adjustment obtained above is not changed until the final focus range test step.

e. Position the long range test target a minimum of 100 yards from the test item and illuminate it with visible light. Measure and record the distance between the test target and test item.

f. Slowly change the test item focus adjustment until a sharp, clearly defined image is obtained of the long range test target. Record the range of test item focus adjustment remaining.




| ITEM NO. | DESCRIPTION |
|---|---|
| 1 | TEST TARGET - LONG RANGE |
| 2 | TEST TARGET - SHORT RANGE |
| 3 | TEST ITEM (IMAGE FORMING RECEIVER) |
| 4 | TRIPOD |
| 5 | OPTICAL AXIS |

FIGURE 4. SCHEMATIC LAYOUT OF A TYPICAL IMAGE FORMING RECEIVER FOCUS RANGE TEST SET-UP

6.2.5 Infrared Light Source Characteristics and Light Source-Receiver and Alignment

6.2.5.1 Preparation for Test

a. Mount the test item on a tripod or similar rigid structure. (See Figure 5 for a schematic layout of the test item setup).

b. Select a new lamp of the type required by the test item at random and install it.

c. Obtain a standard photometer and calibrate against a National Bureau of Standards (NBS) standard lamp.

NOTE: The applicable NBS standard lamp operates at a color temperature of 2360 degrees K.

d. Obtain a relative measurement color selective photometer.

e. Connect an external, adjustable power source capable of furnishing the voltage and amperage specified for the test item lamp.

f. Locate the optical axis of the test item and extend this line to the vertical test surface. Indicate the point at which the test item optical axis is perpendicular to the vertical surface.

6.2.5.2 Test Conduct

NOTE: Preliminary operation including final alignment and calibration of the test setup is an integral part of the beam characteristics and light source-receiver alignment determinations. This requirement, however, does not preclude test officer directed pre-test operation of the test apparatus for the purpose of familiarizing test personnel with the test conduct procedure and to verify satisfactory performance of the test setup.

a. Position the test item at the distance specified in the test plan from the vertical test surface and record the distance.

b. Measure and record the test area temperature.

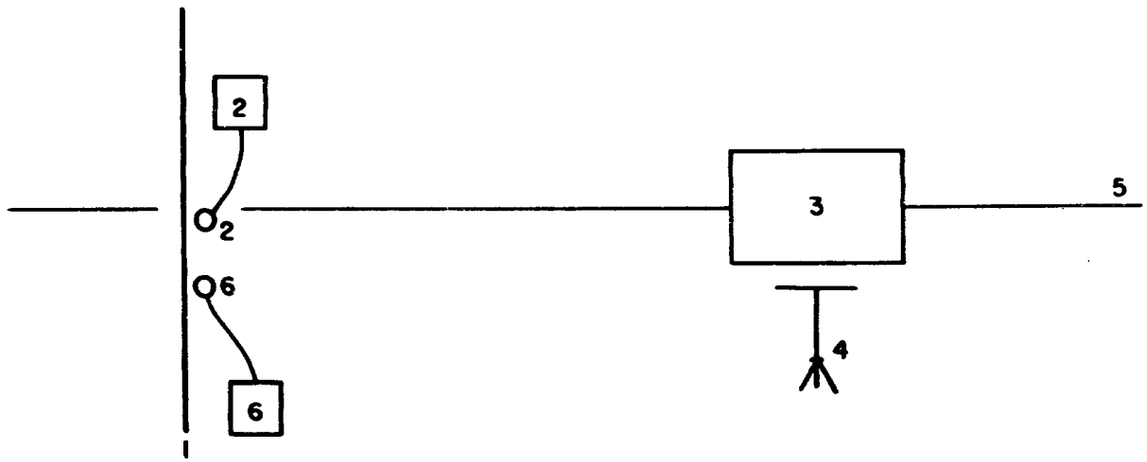
NOTE: The test area temperature and temperature stability requirement for this test is based on normal operating parameters specified for the test item.

c. Adjust the lamp power source voltage to the value specified in the operator's manual.

d. Apply the voltage to the lamp of the test item and measure and record the operating voltage and current.

NOTE: The infrared filter is not installed in the light source during this test.

e. With the standard photometer, locate the point on the vertical test surface of peak foot-candles. Mark this "maximum hotspot" on the vertical surface.




| ITEM NO. | DESCRIPTION |
|---|---|
| 1 | VERTICAL SURFACE |
| 2 | PHOTOMETER WITH PROBE (STANDARD) |
| 3 | TEST ITEM ( LIGHT SOURCE & RECEIVER) |
| 4 | TRIPOD |
| 5 | OPTICAL AXIS |
| 6 | PHOTOMETER WITH PROBE |

FIGURE 5 SCHEMATIC LAYOUT OF A TYPICAL INFRARED LIGHT SOURCE BEAM CHARACTERISTICS TEST

Measure and record the peak foot-candle at this point.

f. Measure and record the deviation, if any, of the "maximum hotspot" from the mark indicating the test item extended optical axis.

g. Determine the luminance distribution of the test item lamp by the following method:

1) Draw a circle on the vertical test surface using the "maximum hotspot" as the center and a radius equal to the calculated linear distance corresponding to the manufacturer's specified angular distribution of the test item lamp beam.
2) Draw a polar grid in the circle by drawing a vertical and a horizontal line through the center of the circle and three concentric circles with centers at the center of the circle and radii equal to $\frac{1}{4}$, $\frac{1}{2}$, and $\frac{3}{4}$ of the radius of the circle.
3) Place the spectral response S-4 (blue) probe of the relative measurement color selective photometer at the "maximum hotspot" on the vertical test surface and set the photometer linear percent scale to read 100%.
4) Measure the beam intensity in terms of percentage of peak candle power at each grid point drawn on the vertical test surface in step 2.
5) Record the following:

   a) Angular distribution of lamp beam
   b) Radius of circle drawn in step 1
   c) Photometer readings at each grid point

h. Insert the infrared filter in the light source.

i. Adjust the high voltage power supply for the test item image former receiver to the value specified in the operating manual and measure and record the voltage after the test item has been placed in operation.

j. Locate the apparent center of the image forming receiver field-of-view on the vertical test surface. Measure and record the distance between the receiver center of view point and the maximum foot-candle point.

6.2.6 <u>Infrared Filter Characteristics Test</u>

NOTE: The object of this test is to determine the optical efficiency of the test item. This is accomplished by determining: (a) how well the infrared filter transmits infrared light (energy) at the specified wave lengths (EHT) and (b) how well the infrared filter blocks the transmission of visible light (EVT) generated by the test item light source. The ratio, then $\frac{EHT}{EVT}$, will yield the optical efficiency factor for the test item filter.

6.2.6.1 Effective Visual Transmission Test

6.2.6.1.1 Preparation For Test - Perform the following:

a. Prepare a high density filter photometer for operation. The photometer may be obtained as a unit or constructed by assembling the following components as shown in Figure 6:

NOTE: Since the inherent design objective of the metascope near infrared filter is to block visual energy, a standard photometer will prove insensitive to the low levels of visible light transmitted by the filter.

1) A light source (grey-body) and power supply combination capable of operation at a color temperature of 2870 degrees K.
2) A lens system suitable for focusing the light source rays onto the plane of the filter under test.
3) A Lummer-Brodhun cube.

NOTE: The Lummer-Brodhun cube consists essentially of two right angle prisms, the outer portion of the hypotenuse of one being ground away before they are cemented together. When illuminated from two sources, as shown in Figure 6, the net effect to the observer, who has the capability of viewing both light sources through the cube, will be two light spots of unequal brightness. However, when the current to the standard lamp is varied such that the intensity of the standard lamp is made to equal the unknown source intensity may be calculated from the standard lamp calibration curves of candle power vs. current and a linear proportion involving the square law of the distances. Under the most favorable conditions, an experienced observer can attain an accuracy of .2% in the mean of a large number of tries.

4) A standard lamp and adjustable power supply capable of being operated at 6-candlepower.

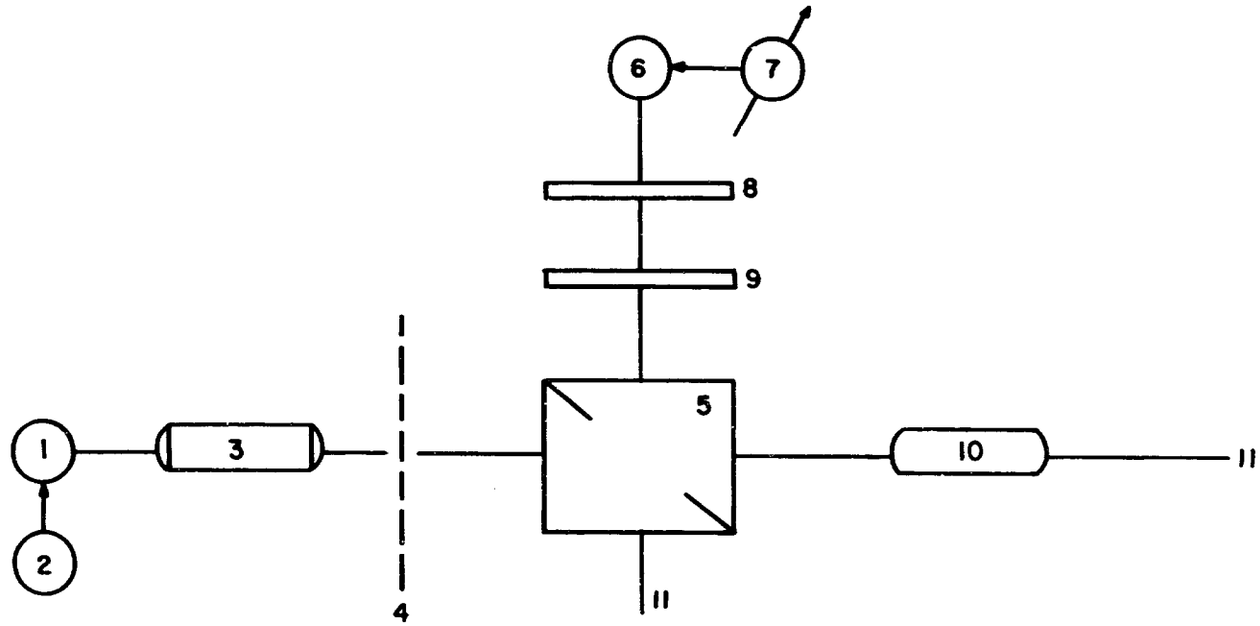
NOTE: The standard lamp is NBS calibrated and includes a calibration curve of candlepower vs. current.

5) A diffuse screen of opal glass.
6) Color match filters for the standard lamp optical path.

NOTE: Since the transmission of visible light by the test item infrared filter may be color selective, it is necessary to not only match brightness, but also apparent color, as observed.

b. Calibrate the photometer using the procedure provided, if a preassembled unit is used, or by comparison against a record standard lamp for an assembled lamp, in order to correct for the losses in the primary standard lamp optical path caused by the opal glass and match filters.

6.2.6.1.2 Test Conduct - Perform the following:




| ITEM NO. | DESCRIPTION |
|---|---|
| 1. | LIGHT SOURCE |
| 2. | LIGHT SOURCE POWER SUPPLY |
| 3. | LENS SYSTEM |
| 4. | TEST ITEM (INFRARED FILTER) |
| 5. | LUMMER-BRODHUN CUBE |

| ITEM NO. | DESCRIPTION |
|---|---|
| 6. | STANDARD LAMP ADJUSTABLE |
| 7. | STANDARD LAMP POWER SUPPLY |
| 8. | OPAL GLASS |
| 9. | COLOR MATCH FILTER (S) |
| 10. | PICK-UP LENS SYSTEM |
| 11. | OPTICAL AXIS |

FIGURE 6. SCHEMATIC LAYOUT OF A TYPICAL INFRARED FILTER VISIBLE LIGHT TRANSMISSION DETERMINATION (EVT) TEST SET-UP

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a. Insert the test item infrared filter in the test setup between the focus lens system and the Lummer-Brodhun cube.

b. Apply power to the light source. Adjust the voltage and current to produce a color temperature of 2870 degrees K and measure and record the operating voltage and current.

c. Apply power to the standard lamp and adjust to some nominal value.

d. Observe the resulting field through the pick-up lens system.

e. Obtain a color match with the available match filters and record the filter selected.

f. Obtain a brightness match by adjusting the current flow to the standard lamp. Measure and record the standard lamp voltage and current values.

6.2.6.2 Effective Holo-Transmission Test

6.2.6.2.1 Preparation for Test - Prepare an infrared filter photometer for operation. The photometer may be obtained as a unit or constructed by assembling the following components as shown in Figure 7:

a. A light source identical to the infrared filter EVT test setup.

b. A lens system suitable for focusing the light source rays onto the plane of the image converter tube.

c. An image converter tube with an RETMA S-1 sensitivity. (See Appendix B).

d. A pick-up lens system suitable for focusing the output of the image converter tube onto the photomultiplier photocathode.

e. A photomultiplier tube with an RETMA S-4 sensitivity.

NOTE: Refer to section 6.2.1.1 for additional photomultiplier considerations.

f. An electronic signal processor capable of rendering the photomultiplier output signal suitable for display on an output meter.

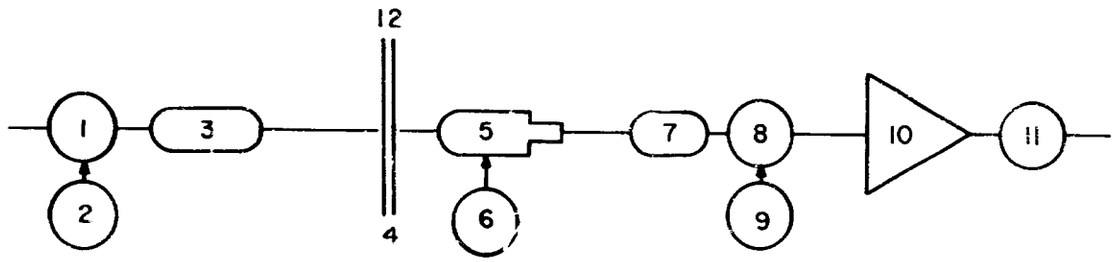
6.2.6.2.2 Test Conduct - Perform the following:

NOTE: Preliminary operation including final alignment and calibration of the test setup is an integral part of the EHT determination. This requirement, however, does not preclude test officer directed pre-test operation of the test apparatus for the purpose of familiarizing test personnel with the test conduct procedure and to verify satisfactory operation of the test setup.

a. Apply power to the light source and adjust the voltage and current to obtain operation at a color temperature of 2870 degrees K. Measure and record the voltage and amperage.

NOTE: The test item infrared filter is not installed in the test setup at this time.

b. Apply high voltage to the image converter tube. Measure and




| ITEM NO. | DESCRIPTION | ITEM NO. | DESCRIPTION |
|---|---|---|---|
| 1 | LIGHT SOURCE | 7 | PICK-UP LENS SYSTEM |
| 2 | LIGHT SOURCE | 8 | PHOTOMUTIPLIER |
| 3 | LENS SYSTEM | 9 | HIGH VOLTAGE POWER SUPPLY |
| 4 | APERTURE | 10 | SIGNAL PROCESSING |
| 5 | IMAGE CONVERTER TUBE (SI) | 11 | OUT PUT METER |
| 6 | HIGH VOLTAGE POWER SUPPLY | 12 | TEST ITEM ( INFRARED FILTER) |

FIGURE 7. SCHEMATIC LAYOUT OF A TYPICAL INFRARED FILTER INFRARED SPECTRUM TRANSMISSION DETERMINATION (EHT) TEST SET-UP.

record the high voltage value.

c. Apply high voltage to the photomultiplier tube, adjust it to produce the degree of gain specified in the test plan, and measure and record the high voltage and anode current values.

d. Adjust the electronic signal processor gain to obtain a 100% reading on the test setup output meter.

NOTE: Adjustments to the test setup following this step will void this test.

e. Measure and record the test area temperature.

NOTE: The test area temperature would typically be maintained at 68 degrees F. or at the temperature specified as normal for the test item. Test conduct should not be undertaken at area temperatures exceeding photomultiplier specified maximum operating parameters. Operation at or above these maximum values or under variable ambient conditions may result in excessive or unstable photomultiplier "dark current" in the absence of any other input energy contribution.

f. Insert the infrared filter at the photomultiplier aperture and, using the output meter, measure and record the amount of infrared light transmitted through the filter.

6.2.7 Maintenance

During the conduct of paragraphs 6.2.1 through 6.2.7, determine the maintenance criteria of the test item as described in MTP 10-2-507 and the following:

a. Maintain a record of scheduled maintenance conducted in accordance with the manufacturer's instructions furnished with the metascope assembly.

b. Determine and record the following, as required:

1) The adequacy of the interchangeability of parts for replacement operations.
2) The adequacy and accuracy of the technical and maintenance instructions provided by the manufacturer.
3) Equipment deficiencies, causes, and suggested or corrective action taken.

NOTE: All equipment failures shall be reported in accordance with USATECOM Regulation 705-4.

6.2.8 Transportability

6.2.8.1 Shock Test

a. Inspect the test item and record indications of the following:

1) Defects in metascope assembly chassis.
2) Presence of scratches, cracks, or other damage to the following:

   a) Image forming receiver optics
   b) Light source lamp, lens and filter

b. Pack the metascope for shipment as direct in the test plan.

NOTE: Remove self-contained batteries, if applicable, from the test item. Wrap the batteries in acid-proof material and pack as instructed with the test item.

c. Subject the packaged test item to the shock test of MIL-STD-810B Method 516, Procedure II.

d. At the completion of the test, unpackage the test item and perform the following:

1) Repeat the inspection of step a.
2) Inspect the light source lamp with the aid of a magnifier to determine if the lamp filament was damaged and record all indications of damage.

6.2.8.2 Vibration Test

a. Perform the inspection and packaging operations of 6.2.8.1.a and b.

b. Subject the packaged test item to the vibration test procedures of Equipment Category g (Shipment by Common Carrier) of Method 514 of MIL-STD-810B.

c. Repeat step 6.2.8.1.d.

6.2.9 <u>Safety</u>

NOTE: The principal hazard associated with the metascope assembly is the presence of the image converter tube high voltage. Depending on the type of tube employed, this voltage will range from 12,000 volts to 20,000 volts.

a. Determine the electrical hazards inherent in the test item by performing the following:

1) Disassemble the metascope image forming receiver.
2) Using an insulation test set, measure and record the dielectric breakdown of the various connectors which route the high voltage to the image converter tube and the insulating materials which protect the operator.
3) Measure and record the test area temperature, humidity, and barometric pressure during the test.

NOTE: The parameters above should be as close as possible to the normal operating conditions specified for the test item.

b. Through the test period, test personnel will observe and record any condition that might present a safety hazard, the cause of the hazard, and steps taken to alleviate the hazard.

c. Record special precautions required for operating and maintaining the test item.

NOTE: Test personnel should never point the metascope toward the sun or any other intense visible light source.

6.2.10 Human Factors Evaluation

Subject the test item to the applicable sections of MTP 10-2-505, Human Factors Evaluation, and the following:

a. Throughout the test, observe and record any difficulties such as excessive pressure or awkwardness in the operation of controls.

b. Throughout the test, observe and record difficulties in accessibility or operation of the test item.

c. Record any inadequacies in the design of the viewing device effecting ease of vision, comfort, etc.

d. Measure and record the noise level of equipment, if applicable.

e. Observe and record the anthropometric effects of protective clothing on operations.

6.2.11 Value Analysis

Conduct a value analysis of the test item to determine whether the device has any nonfunctional, cost, or unnecessary features in accordance with USATECOM Regulation 700-1, and perform the following:

a. Observe the metascope being operated and maintained. Record any evidence that the test item incorporates features which could be eliminated without compromising performance, reliability, durability, or safety.

b. Informally question metascope operators and maintenance personnel in regard to their opinion of test item features which could be eliminated without decreasing the functional value of the test item. Record these findings.

c. Test team members shall observe the test item in use and will comment separately in the daily log in regard to the elimination of unnecessary features.

6.3 TEST DATA

6.3.1 Preparation for Test

6.3.1.1 Initial Inspection

Record the following:

a. Evidence of package damage or deterioration
b. Identification markings:

1) Name of contractor
2) Number and date of contract
3) Date of manufacture
4) Other pertinent markings

c. For each shipping package:

1) Contents
2) Weight, in pounds
3) Overall dimensions, in feet and inches, of:

a) Length
b) Width
c) Height

4) Cubage, in $ft^3$

d. For the entire test item:

1) Weight, in pounds
2) Cubage, in $ft^3$

e. Defects in:

1) Manufacturing
2) Material
3) Workmanship

f. Evidence of damage
g. Evidence of wear
h. Presence of:

1) Identification plate
2) Caution instruction plate
3) Service instruction plate

i. Shortages (parts and instructions)

6.3.1.2 Physical Characteristics

Record the following for each metascope under test:

a. Type, size and serial number
b. For individual test item components, if applicable:

1) Component nomenclature
2) Component weight, in pounds
3) Component length, in feet
4) Component diameter, in inches

c. For complete test item (fully assembled):

1) Weight, in pounds
2) Length, in feet
3) Overall diameter, in inches

6.3.2 Test Conduct

6.3.2.1 Receiver Brightness Gain and Resolving Power Test

Record the following:

a. Calibration factors for optical lens bench.
b. Test area temperature, in degrees F.
c. For the 2870 degrees K light source supply:

1) Voltage
2) Amperage

d. For the photomultiplier:

1) Voltage
2) Anode current, in amperes

e. Calibration measurements of oscilloscope wave deflection:

1) Maximum deflection, in cm
2) Minimum deflection, in cm

f. Image converter tube high voltage.
g. Oscilloscope deflection with image-forming receiver in operation:

1) Maximum deflection, in cm
2) Minimum deflection, in cm

h. Test target resolution, in line pairs per MM.
i. Reduction ratio of collimator lens system.

6.3.2.2 Receiver Linear Distortion Test

Record the following:

a. Test area temperature, in degrees F
b. For the 2870 degrees K light source supply:

1) Voltage
2) Amperage

c. Angular height, in degrees (without test item) of:

1) Center line
2) Right line
3) Left line

d. Image converter operating high voltage
e. Angular height, in degrees (with test item in test setup) of:

1) Center line
2) Right line
3) Left line

6.3.2.3 Receiver Field-of-View Test

Record the following:

a. Test area temperature, in degrees F
b. Image converter tube high voltage
c. Test target lines:

1) Line separation, in inches
2) Line width, in inches
3) Line height, in inches

d. Perpendicular distance, in inches, between the test target and the test item:

1) Distance at time of initial setup
2) Distance at which one or both lines disappear from view
3) Distance at which both lines appear

6.3.2.4 Receiver Focus Range Test

Record the following:

a. Test area temperature, in degrees F
b. Image converter tube high voltage
c. Distance between test item and short range target, in inches
d. Distance between test item and long range test target, in feet
e. Range of test item focus adjustment remaining

6.3.2.5 Infrared Light Source Characteristics and Light Source-Receiver and Alignment

Record the following:

a. Test area temperature, in degrees F.
b. Distance between test item and test surface, in inches.
c. For the infrared source:

1) Voltage
2) Amperage

d. Distance between "hot spot" and point at which optical axis intersects the test surface, in inches.
e. Light intensity at "hot spot" in lumens.

f. Relative light intensity at the four equally spaced points on the 0°, 90°, 180°, and 270° radii in percent of the maximum "hot spot".

g. Image converter tube high voltage.

h. Distance between center point of the test item field-of-view and the "hot spot".

6.3.2.6 Infrared Filter Characteristics Test

6.3.2.6.1 Effective Visual Transmission Test -

Record the following:

a. For the 2870 degrees K light source:

1) Operating voltage
2) Operating amperage

b. Color match filter number

c. For the standard lamp:

1) Voltage
2) Amperage

6.3.2.6.2 Effective Holo-Transmission Test -

Record the following:

a. For the 2870 degrees K light source:

1) Operating voltage
2) Operating amperage

b. Image converter tube high voltage.

c. Test area temperature, in degrees F.

d. For the photomultiplier:

1) Anode voltage
2) Anode amperage

e. Infrared filter transmission, in percent of intensity transmitted without filter.

6.3.2.7 Maintenance

Record the following:

a. Data as described in MTP 10-2-507.

b. Record of scheduled maintenance.

c. Component interchangeability.

d. Adequacy and accuracy of the manufacturer's technical and maintenance instructions.

e. Equipment deficiencies.

6.3.2.8 Transportability

Record the following:

a. Prior to testing:

1) Defects in metascope assembly chassis, if any.
2) Presence of scratches, cracks, or other damage to the following, if any:

a) Image forming receiver optics
b) Light source lamp, lens, and filter

b. At the completion of the test:

1) Defects in metascope assemble chassis
2) Presence of scratches, cracks, or other damage to the following:

a) Image forming receiver optics
b) Light source lamp, lens, and filter

3) Damage to lamp filament

6.3.2.9 Safety

Record the following:

a. For the dielectric breakdown measurements:

1) Temperature, in degrees F.
2) Barometric pressure, in inches of Hg.
3) Humidity, in percent.
4) Dielectric breakdown values of test item electrical protective materials.

b. Conditions that might present a safety hazard, cause of the hazard, and steps taken to alleviate the hazard.

c. Special precautions required for operating and maintaining the test item.

6.3.2.10 Human Factors Evaluation

Record the following:

a. Difficulties, such as excessive pressure or awkwardness in operation of controls.

b. Difficulties in accessibility to or operation of the test item.

c. Inadequacies in the design of the viewing device effecting ease of vision, comfort, etc.

d. Noise level of equipment, if applicable.
e. Anthropometric effects of protective clothing on operations.

6.3.2.11 Value Analysis

Record the following:

a. Features which could be eliminated without compromising performance, reliability, durability, or safety.
b. User opinion of features which could be eliminated without decreasing functional value.

## 6.4 DATA REDUCTION AND PRESENTATION

### 6.4.1 Receiver Brightness Gain and Resolving Power Test

a. Determine the percentage of modulation, $M_{REF}$, of the test setup (without the test item), as follows:

$$M_{REF} = \frac{D_{REF\ MAX} - D_{REF\ MIN}}{D_{REF\ MAX}} \times 100$$

where: $D_{REF\ MAX}$ = Maximum oscilloscope

$D_{REF\ MIN}$ = Minimum oscilloscope deflection

b. Determine the percentage of modulation, M, of the test item, as follows:

$$M = \frac{D_{MAX} - D_{MIN}}{D_{MAX}} \times 100$$

where: $D_{MAX}$ = Maximum oscilloscope deflection

$D_{MIN}$ = Minimum oscilloscope deflection

c. Determine the resolution factor ratio, as follows:

$$\text{Resolution factor} = \frac{M}{M_{REF}}$$

d. Prepare a graph of the resolution factor ratio vs. test target lines per MM.
e. Determine the receiver brightness gain as follows:

$$\%\ \text{Brightness gain} = \frac{D_{REF\ MAX}}{D_{MAX}} \times 100$$

f. Display the results, as appropriate.



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6.4.2 Receiver Linear Distortion Test

a. Determine the test setup (without the test item) linear distribution, as follows:

$$\% \text{ Linear Distortion}_R = \frac{h_{CAL_O} - h_{CAL_R}}{h_{CAL_O}} \times 100$$

$$\% \text{ Linear Distortion}_L = \frac{h_{CAL_O} - h_{CAL_L}}{h_{CAL_O}} \times 100$$

where: $h_{CAL_O}$ = angular height of the center line

$h_{CAL_R}$ = angular height of the right line

$h_{CAL_L}$ = angular height of the left line

b. Determine the test item linear distortion, as follows:

$$\% \text{ Linear Distortion}_R = \frac{h_O - h_R}{h_O} \times 100$$

$$\% \text{ Linear Distortion}_L = \frac{h_O - h_L}{h_O} \times 100$$

where: $h_O$ = angular height of the center line

$h_R$ = angular height of the right line

$h_L$ = angular height of the left line

c. Display the results, as appropriate.

6.4.3 Receiver Field-of-View

a. Calculate the actual field-of-view of the test item.
b. Display the results of so as to compare the actual field-of-view with the required field-of-view.

6.4.4 Receiver Focus Range

Display the results directly, as appropriate.

6.4.5 Infrared Light Source Characteristics and Light Source-Receiver Alignment

a. Display directly, as appropriate, the deviation of the light source "hot spot" from the light source optical axis.

b. Plot the candlepower distribution of the light source in polar form.

c. Calculate the angular deviation of the receiver apparent field-of-view center from the "hot spot" maximum point. Display, as appropriate.

6.4.6 Infrared Filter Test

a. From the standard lamp curve of candlepower vs. current, determine the EVT of the infrared filter.

b. Display directly the EHT output meter reading.

c. Determine the ratio of EVT to EHT and plot the results, as appropriate.

6.4.7 Results of Other Test

Other data obtained will be summarized using charts, narrative reports and graphs, as appropriate.

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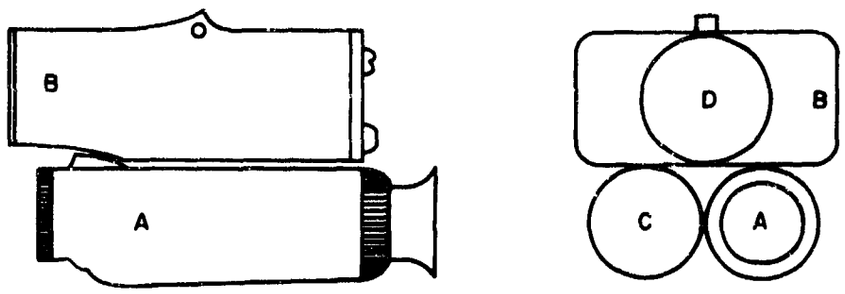
# APPENDIX A

## TYPICAL NEAR INFRARED IMAGE FORMING METASCOPE DESIGN AND CONSTRUCTION

### A. Near Infrared Image Forming Metascope

A typical infrared metascope, shown in Figure A-1, consists of the following assemblies:




A. IMAGE FORMING RECEIVER

B. LIGHT SOURCE, AND POWER SUPPLY

C. HIGH VOLTAGE POWER SUPPLY AND LOW VOLTAGE POWER SUPPLY

D. INFRARED FILTER

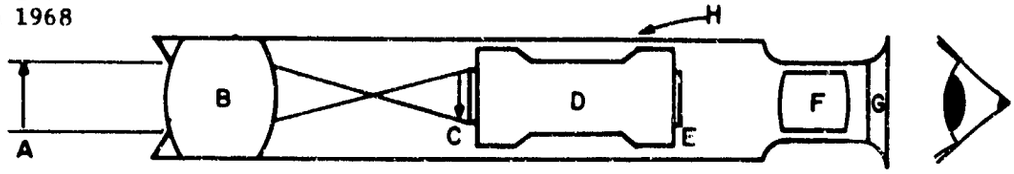
FIGURE A-1

### B. Image Forming Receiver

A typical image forming receiver consists of an optical system designed to focus a scene either emitting near infrared radiation or reflecting near infrared radiation on the semitransparent image tube photocathode. As a result, electrons released from the photocathode are electrostatically focused on the fluorescent screen at the other end of the image converter tube by electron-optical methods to form a reduced image which can be viewed with an optical magnifier. The inverted image produced by the optical system on the photocathode is reinverted by the image converter tube to give an observed image that is erect. The foregoing description of the near infrared metascope image forming receiver is illustrated in Figure A-2.

### C. Light Source and Power Supply

A typical infrared light source consists of basically a flashlight with an infrared filter placed over the replaceable prefocused lamp and reflector. The assembly would typically contain the required battery power source for the lamp




A. OBJECT - EITHER EMITTING NEAR INFRARED ENERGY OR REFLECTING NEAR INFRARED ENERGY.

B. IMAGE FORMING RECEIVER OBJECTIVE LENS SYSTEM.

C. INVERTED IMAGE OF OBJECT FOCUSED ON IMAGE TUBE PHOTOCATHODE SURFACE.

D. IMAGE CONVERTER TUBE.

E. FLOURESCENT SCREEN.

F. MAGNIFIER LENS SYSTEM.

G. EYE-RELIEF.

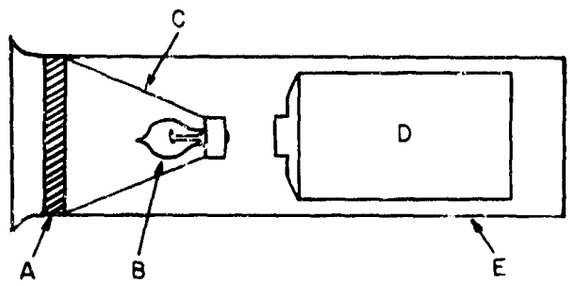
H. IMAGE FORMING RECEIVER BODY.

FIGURE A-2

or a flexible cable for connection to an external lamp power source. The foregoing description of the infrared light source is illustrated in Figure A-3.

D. Image Forming Receiver High Voltage Power Supply

The image forming receiver high voltage power supply is required to furnish the image converter tube accelerating and electro-focusing voltages. High voltage values depend on the type of image converter tube employed and may typically range from 10KV to 20KV.




A. INFRARED FILTER

B. PREFOCUSED LAMP

C. MIRROR REFLECTOR

D. BATTERY (S)

E. LIGHT SOURCE BODY

FIGURE A-3

# APPENDIX B

## TYPICAL NEAR INFRARED IMAGE CONVERTER TUBE CHARACTERISTICS

### A. General

Available near infrared image converter tubes have a semitransparent photoemissive cathode at the input end of an evacuated glass envelope. Electrons emitted in a pattern corresponding to the image falling on the surface are accelerated and focused onto an output surface of electroluminescent phosphor at a high potential to produce a bright picture. Near infrared image converter tubes use a silver-oxygen-cesium photocathode and are used to convert an image formed in near infrared radiation to a visible image. If a fast optical system is used to image the object scene on the photosurface, the output phosphor image can be made brighter than the scene. For 2870 degree K tungsten illumination of monocolor selective objects, the screen brightness/scene brightness ratio is given by:

CONVERSION INDEX

$4 f^2 M^2$ where,

f = f/ ratio of the optical system

M = magnification $\left(\frac{\text{output image}}{\text{input image}}\right)$

### B. Detailed Near Infrared Converter Tube Characteristics

1. Spectral Response

Input photocathode Surface Response: The relative response of a photosensitive surface to energy of various wavelengths is known as its spectral sensitivity. Image converter tubes are available with input photocathode wavelength sensitivities in two regions of the photoelectric spectrum (See Figure B-1):

a) Tubes with a range of maximum response from 7000 Angstroms to 9000 Angstroms. (S1)
b) Tubes with a range of maximum response from 4000 Angstroms to 5000 Angstroms. (S21)

The spectral responses of photosensitive devices are ordinarily indicated by "S" designations and reflect RETMA Standards. Only image converter tubes with the S-1 response are suitable for near infrared metascope application; the S-21 occurs in the visible light region. The following image converter tubes are typical of those available with photocathode surfaces exhibiting the S-1 (near infrared) response:

a) 6032
b) 6032-A
c) 6914

d) 6914-A
e) 6929

Consult Figure B-2, "S-1, Relative Sensitivity vs Wavelength", for an illustration of the spectral response characteristics of the listed image converter tubes.

2. Output - Electroluminescent Screen Surface Emission: All known image converter tubes employ the identical output fine-grain screen phosphor. This phosphor type is identified by the RETMA designation: P-20. When excited, the P-20 phosphor fluoresces to produce a yellow-green luminescense characterized by good visual qualities and a high luminous efficiency. The spectral-energy emission characteristics of phosphor P-20 are shown in Figure B-3. The presistence exhibited by phosphor P-20 is termed "medium-short" and may be used in applications requiring relatively short persistence and good visual efficiency. A description of the phosphor persistence modifier terms commonly used is shown by Figure B-4, "Persistence Terms vs Time Decay to 10%."

The foregoing image converter tube characteristics have been common to a near infrared image converter tubes, however, other pertinent characteristics such as resolution, conversions factors, magnification, distortion, and tube anode voltage current requirements will vary depending on the selected tube type. To illustrate the performance range which may be expected from typically available near infrared image converter tubes applicable to metascope engineering tests, two types have been selected for disclosure of other performance data. The selected image converter tubes are:

a) 6032 and,
b) 6929

NOTE: It should be noted that the characteristics required for engineering tests on the near infrared metascope types will depend almost entirely on the capabilities of the applicable image converter tube. This stems from the fact that the optical components used in these devices will exhibit superior performance in the order of several magnitudes above the expected performance of image converter tubes, especially in the areas of resolution and distortion.

Characteristics of these representative tubes which do not vary as a function of radial distance from the photocathode center or other parameters are presented in Table B-1. Performance characteristics of these representative tubes which are suitable for graphical comparison are presented by Figures B-5 through B-7, and are briefly described as follows:

Figure B-5: A comparison of image tube resolution in line pairs/MM vs the radial distance on photocathode from center.
Figure B-6: A comparison of image tube magnification vs the radial distance on photocathode from center.
Figure B-7: A comparison of image tube distortion vs the radial distance on photocathode from center.

| NEAR INFRARED IMAGE CONVERTER TUBE TYPE | PHOTO-CATHODE SEMITRANS-PARENT MINI-MUM USEFUL DIAMETER | FLUORESCENT SCREEN MINI-MUM USEFUL DIAMETER | MINIMUM CONVER-SION INDEX | MINIMUM RESOLUTION (AT PHOTO-CATHODE CENTER | PARAXIAL MAGNIFICA-TION FACTOR | SPECTRAL RESPONSE | ANODE VOL-TAGE (DC) | FLUORES-CENT PHOSPHOR RESPONSE | AVERAGE PHOTO-CATHODE CURRENT |
|---|---|---|---|---|---|---|---|---|---|
| 6032 | 1.00" | 0.625" | 10 | 18 line-pairs per mm | 0.50 | S-1 | 20,000 volts | P-20 | .40 micro-amps |
| 6929 | 0.75" | 0.570" | 10 | 25 line-pairs per mm | 0.75 | S-1 | 12,000 volts | P-20 | 0.35 micro-amps |

Table 3-I. TYPICAL IMAGE CONVERTER TUBE CHARACTERISTICS

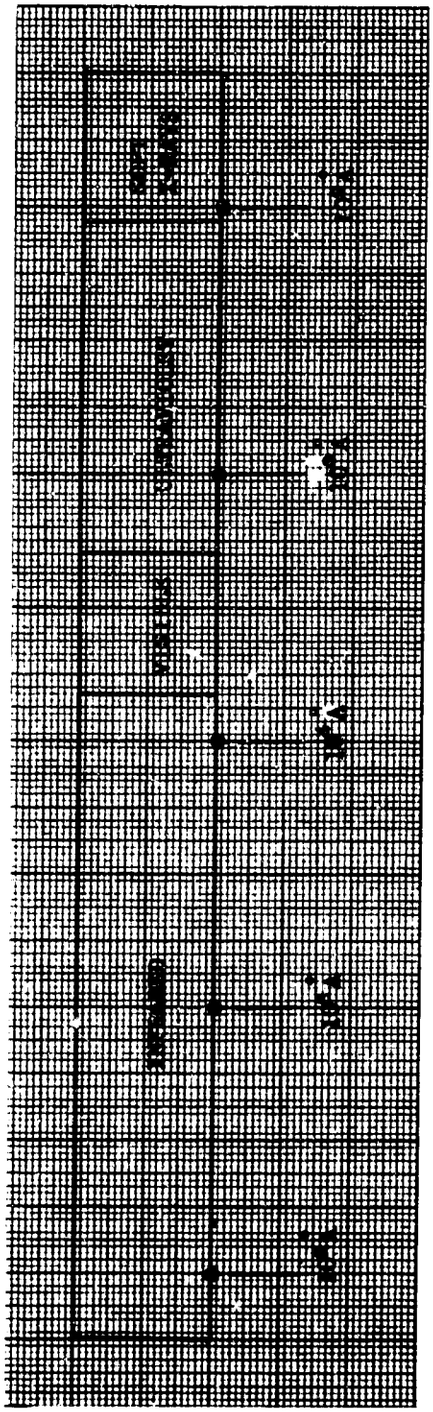



FIGURE B-1. PHOTOELECTRIC SPECTRUM

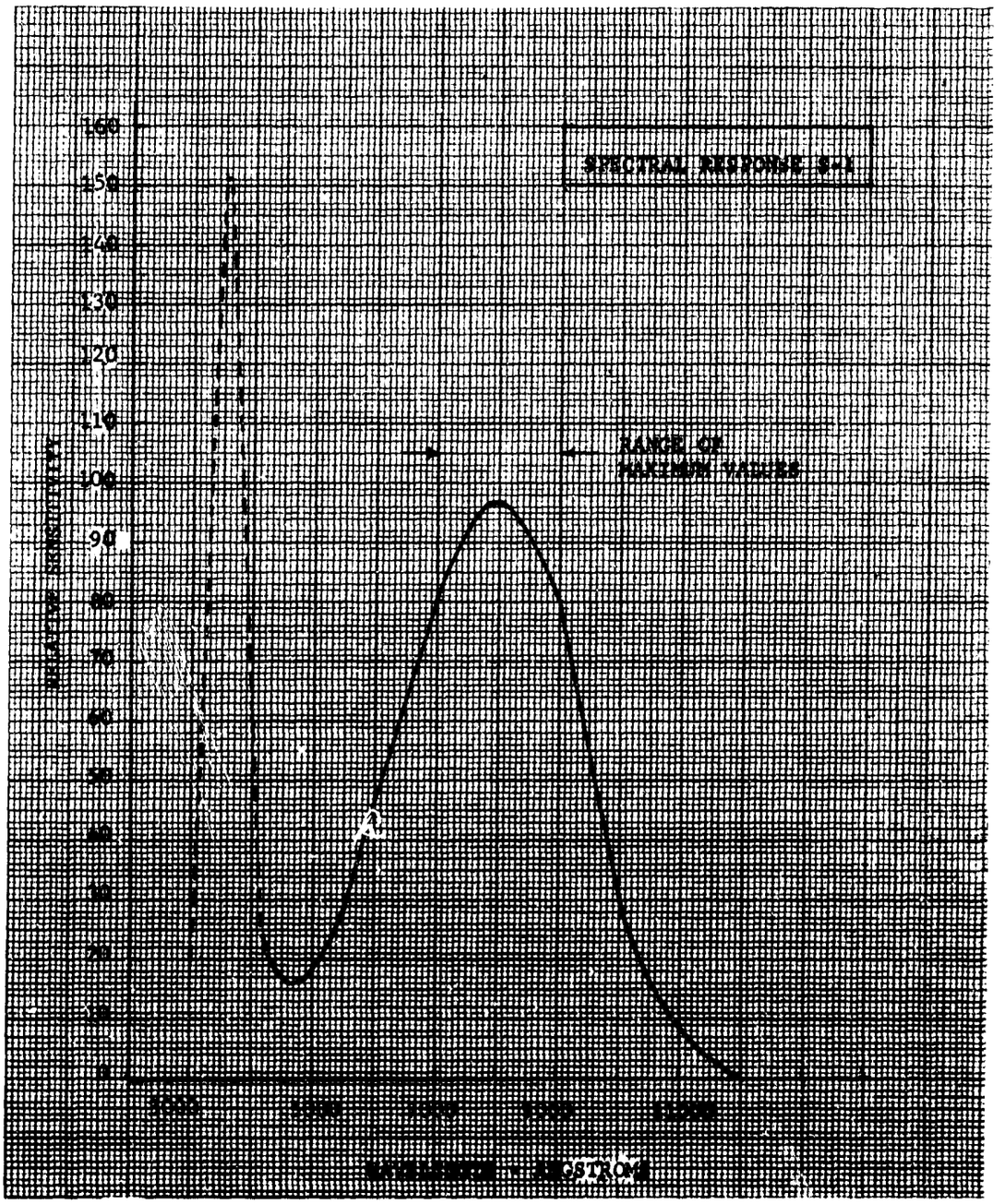



Figure B-2. S-1, RELATIVE SENSITIVITY $V_d$ WAVELENGTH

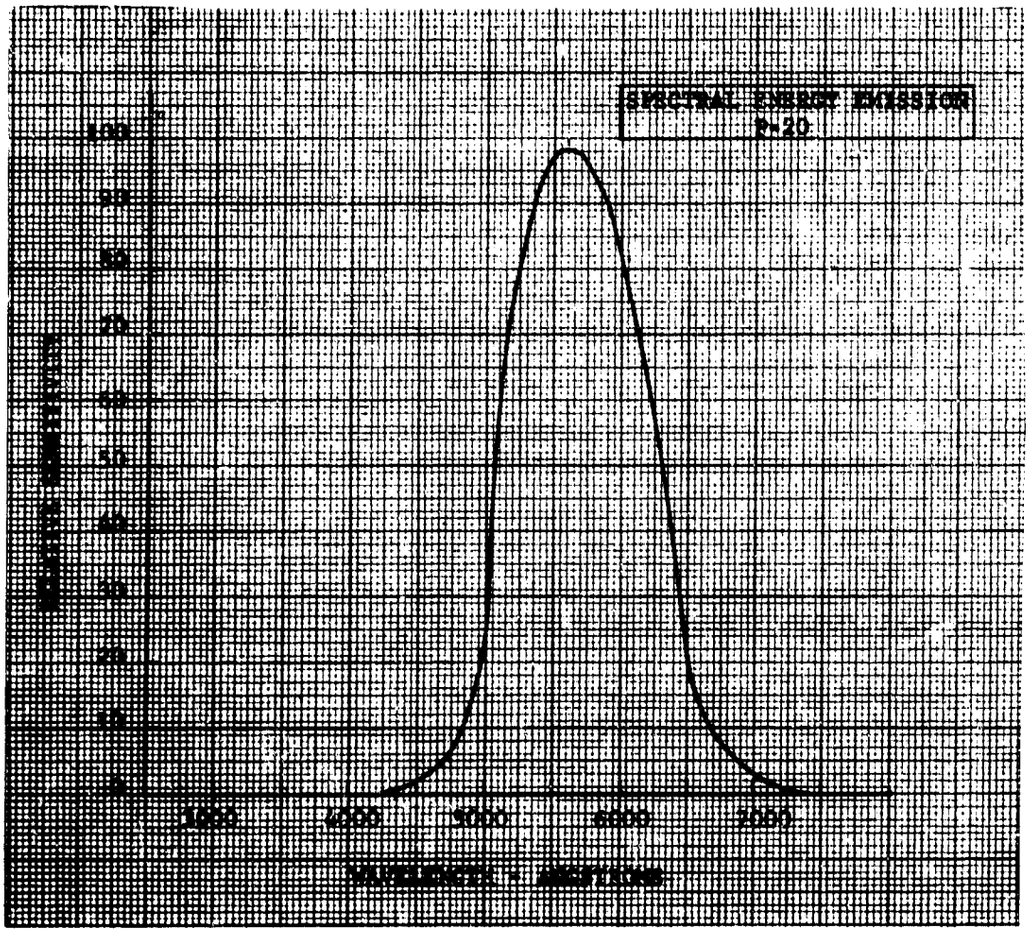



Figure B-3. P-20 SPECTRAL ENERGY EMISSION

| Description of Persistence | Time to decay 10% of initial brightness |
|---|---|
| VERY LONG | 1 second and over |
| LONG | 100 millisec to 1 sec |
| MEDIUM | 1 millisec to 100 millisec |
| MEDIUM SHORT | 10 microsec to 1 millisec |
| SHORT | 1 microsec to 10 microsec |
| VERY SHORT | Less than 1 microsec |

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Figure B-4. DEFINITION OF PERSISTENCE TERMS

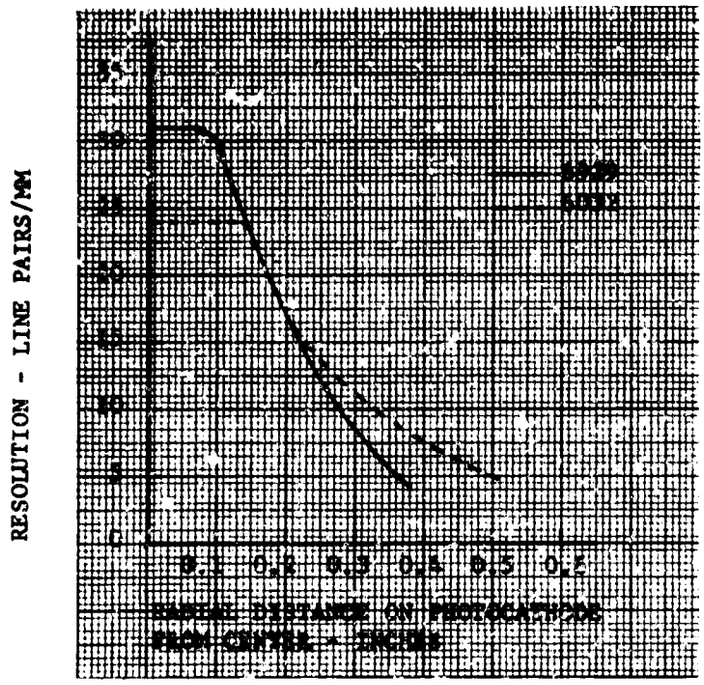


Figure B-5. TYPICAL IMAGE CONVERTER TUBE RESOLUTION CHARACTERISTICS

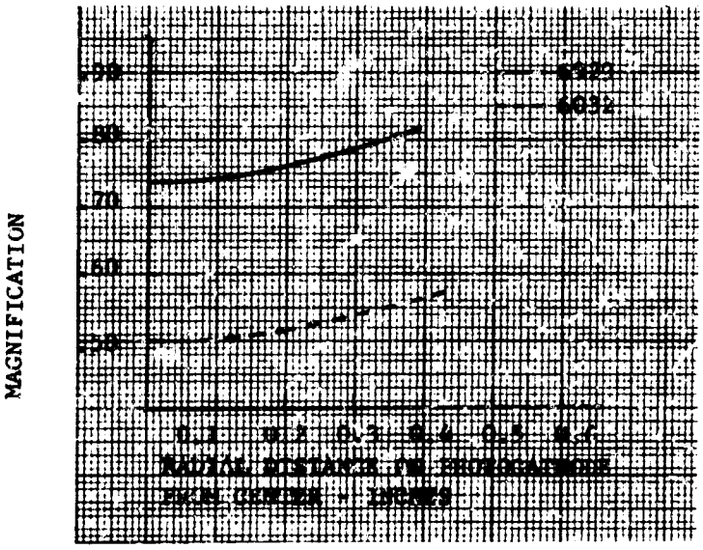


Figure B-6. TYPICAL IMAGE CONVERTER TUBE MAGNIFICATION CHARACTERISTICS

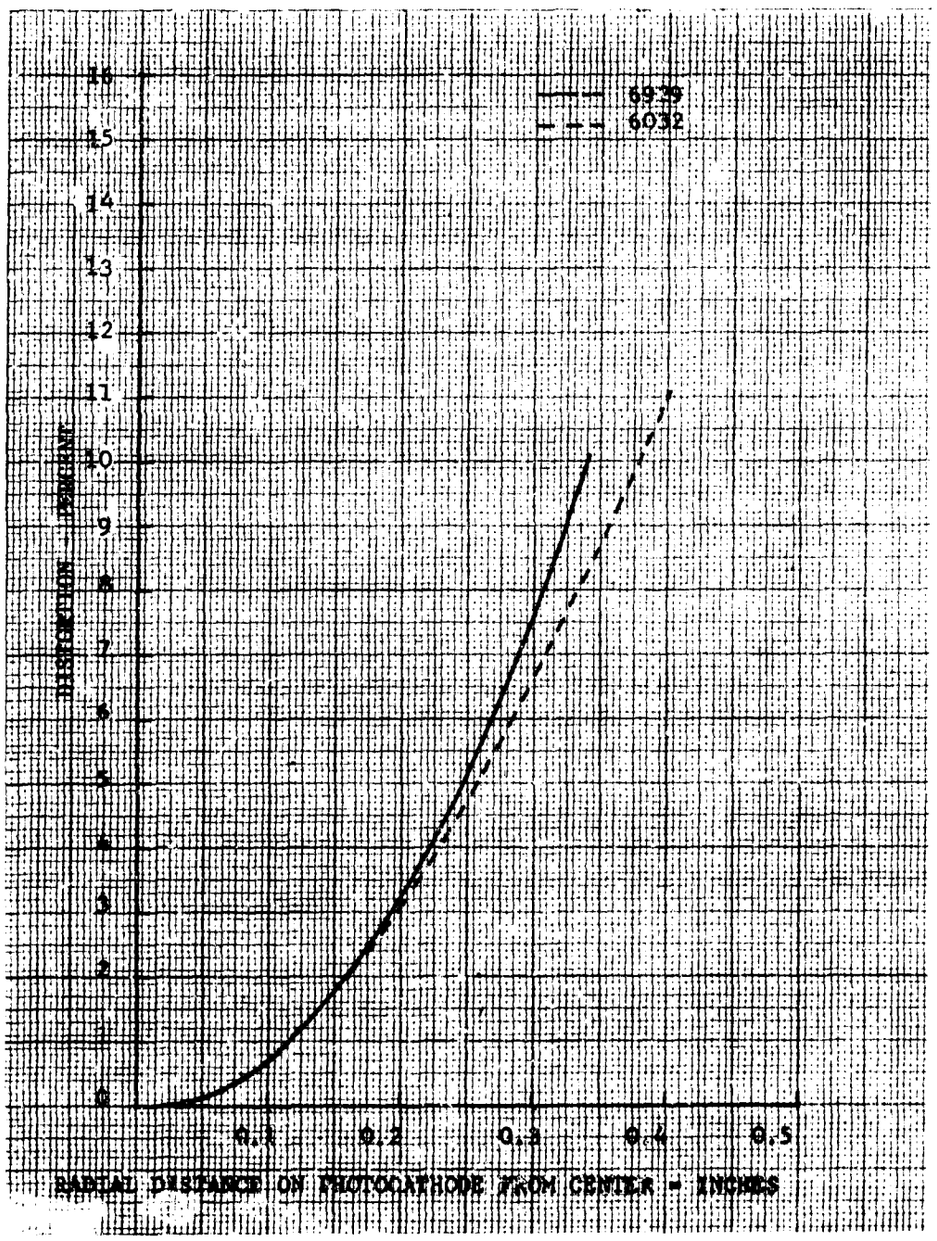


Figure B-7. TYPICAL IMAGE CONVERTER TUBE DISTORTION CHARACTERISTICS

# APPENDIX C

## NEAR-INFRARED MEASUREMENT STANDARD

The spectral sensitivity characteristics of near-infrared image converter tubes and other photoelectric devices designed for the infrared spectrum are usually stated in reference to the particular energy spectrum generated by a black body source operating at a color temperature of 2870 degrees K. Figure C-1 is provided to illustrate the energy spectrums generated by a black body operating at various temperatures.

A number of black body sources are in common use and include:

| Black Body | Operating Temperature |
|---|---|
| Nernst Glower | 1500 deg K - 2000 deg K |
| Globar | 2200 deg K |
| Welsbach Mantle | 2400 deg K |
| Carbon Arc, low-intensity | 3900 deg K |
| Carbon Arc, high-intensity | 5000 deg K - 9000 deg K |
| Tungsten Ribbon-filament lamp | 2800 deg K |

Of these standard sources, the tungsten ribbon-filament lamp is generally used for the near-infrared source applications. It should be noted, however, that for a color operating temperature of 2800 degrees K, approximately 50 amperes is required. The life-time of the tungsten lamp at this elevated temperature is relatively short and external cooling is required.

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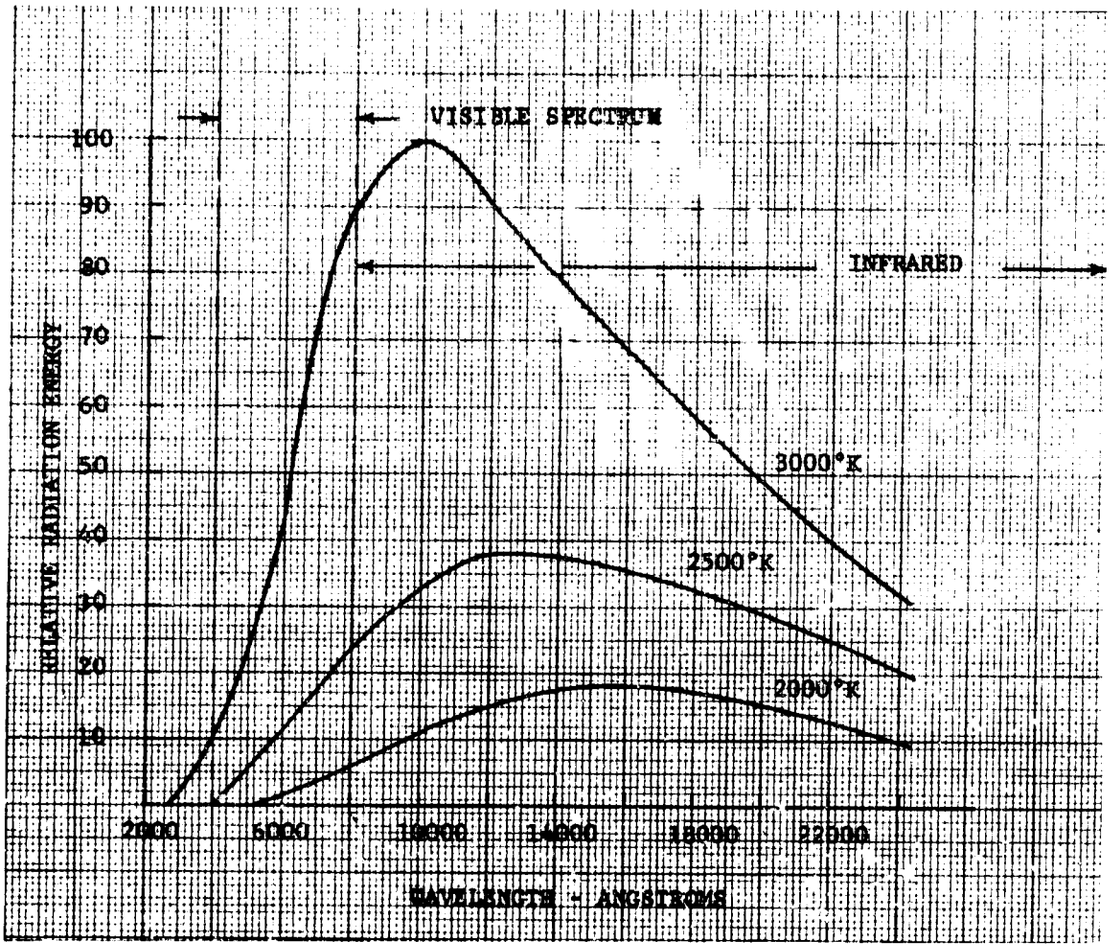


Figure C-1. SPECTRAL DISTRIBUTION CURVES OF BLACK BODY RADIATION AT VARIOUS TEMPERATURES

# APPENDIX D

## SIMULATION OF HUMAN EYE CHARACTERISTICS

A. Basic Visual Capacities:

Just as photographic film is sensitive only to certain wavelengths of light, the human eye is also restricted to sensitivity. The eye's sensitivity is governed by two basic receptor systems present in the human retina:

1) Scoptpic System - This system is the most sensitive and is effective only in the dark-adapted eye. Also, the wavelength of maximum response is shifted toward the blue region as compared to the daylight adapted eye.
2) Photopic System - The photopic sensitivity curve, dominant under daylight illumination conditions, has been adopted as the standard visibility or luminosity function specifying human sensitivity to light as a function of wavelength.

B. Sensitivity Curves:

1) Eye Systems Sensitivity Curves - Figure D-1 is provided to illustrate the relative visual sensitivity of the receptor systems as a function of wavelength. These curves show the relative energy required to produce a threshold response.
2) Photomultiplier Cathode Sensitivity - Figure D-2 is provided to illustrate the relative response characteristics of a typical photomultiplier tube with the REMTA S-4 spectral response sensitivity. This response curve was obtained with radiant flux from a tungsten source at 2870 degrees K and closely approximates the photopic system wavelength sensitivity response required for certain metascope tests.

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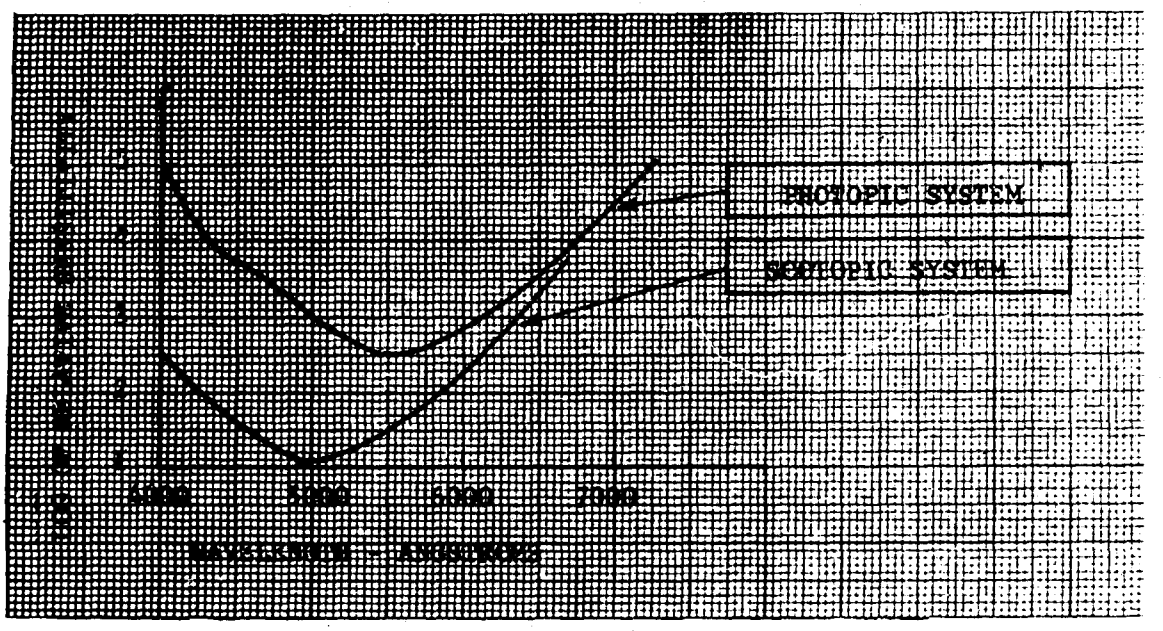


Figure D-1. RELATIVE VISUAL SENSITIVITY

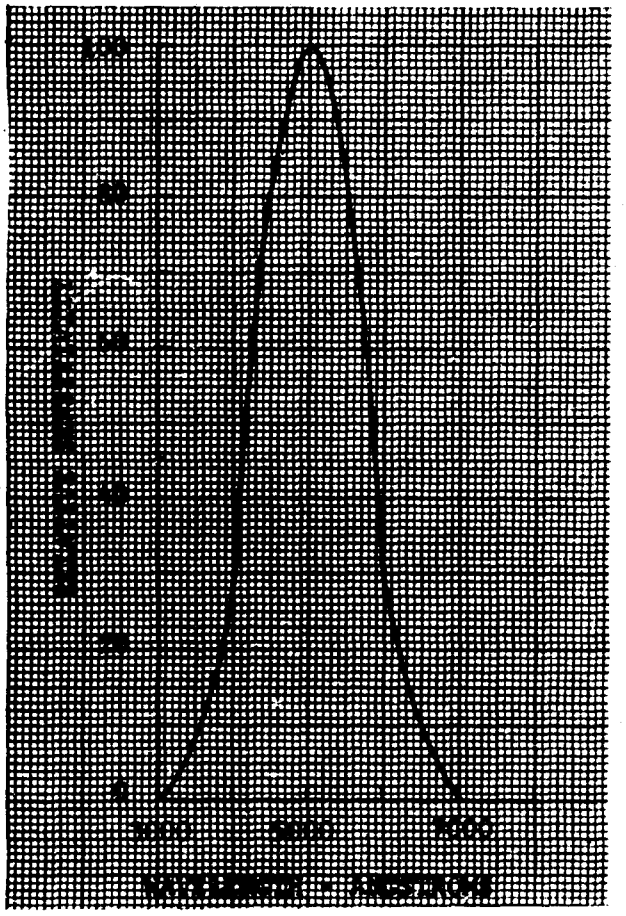


Figure D-2. RESPONSE CHARACTERISTICS OF TYPICAL S-4 PHOTOMULTIPLIER TUBE WHEN IRRADIATED WITH RADIANT FLUX FROM A TUNGSTEN SOURCE AT 2870° K.