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NON-BLOOMING IMAGE ORTHICON

Report No. 2

Second Quarterly Progress Report
1 November 1963 through 31 January 1964

Contract No. DA-36-039-AMC-03249(E)
DA Task No. 1G6-22001-A-055-03

U. S. Army Electronics Research and
Development Laboratories
Fort Monmouth, New Jersey

435563

WESTINGHOUSE ELECTRIC CORPORATION
ELECTRONIC TUBE DIVISION
ELMIRA NEW YORK

NON-BLOOMING IMAGE ORTHICON

Report No. 2
Second Quarterly Progress Report
1 November 1963 through 31 January 1964

<u>Objective:</u> To study and reduce phenomena pertinent to the suppression of the black halos produced in the video picture from an image orthicon surrounding spots of light of much higher intensity than the general scene illumination viewed by the tube.

Contract No. DA-36-039-AMC-03249(E)
Technical Guidelines dated 24 January 1963
DA Task No. 1G6-22001-A-055-03

J. Mueller

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LIST OF ILLUSTRATIONS

PURPOSE

This study is directed toward a research investigation of phenomena pertinent to the suppression of the black halo produced in the video picture from an image orthicon surrounding spots of light of much higher intensity than the general scene illumination level viewed by the tube.

The objective specifications are given in the "Technical Guidelines" dated 24 January 1963 of the Special Tubes Branch, Electron Tubes Division, Electronic Components Department, USAELRDL, titled "Non-Blooming Image Orthicon."

ABSTRACT

Evaluation was performed to optimize field-mesh-to-target spacings. Minimum beam bending was observed on the close-spaced field-mesh tube. Limitation in spacings is set by interference pattern produced by the field-mesh and scanning beam, and by the electrostatic forces which develop between target and field-mesh, causing microphonics and target breakage.

PUBLICATIONS, LECTURES, REPORTS, AND CONFERENCES

Publications, lectures, reports, and conferences resulting from research and development under this contract are listed below:

Publications	- None
Lectures	- None
Reports	- First Quarterly Progress Report 1 August 1963 - 31 October 1963
Conferences	- The Contracting Officer's Technical Representative, Mr. Munsey E. Crost of the Pickup, Display, and Storage Devices Section, USAELRDL, Fort Monmouth, visited the Image Tube Engineering Department of the Westinghouse Electric Corporation on December 5, 1963. Contract progress was reviewed.

FACTUAL DATA

Introduction

Work performed during this period mainly concerned optimizing the field mesh in relation to the target and a study of its relation to beam-bending.

To date 10 tubes were built and evaluated under this contract. Seven tubes with variations in field-mesh-to-target spacings from 0.100" to 0.500" were evaluated in regard to beam-bending and moiré pattern. High electrostatic forces between target and field-mesh have produced strong microphonics and breakage of thin-film targets. This prevented an evaluation of tubes with spacings below 0.100".

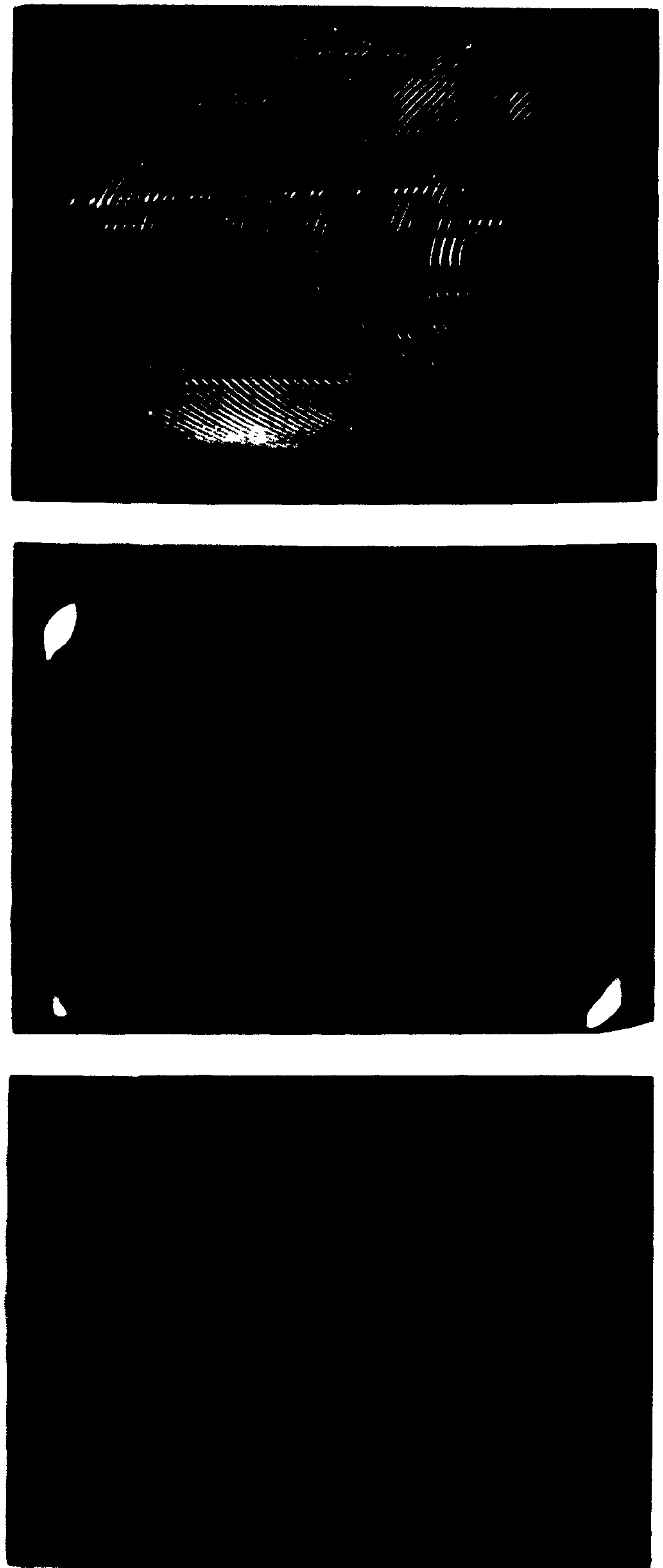
The tubes that were made had S-20 photocathodes and thin-film targets (Al_2O_3).

Moiré Pattern

A field-mesh employed in an image-orthicon produces a homogeneous, high decelerating, electrostatic field between it and the target. This homogeneous electrostatic field improves linearity and resolution as it reduces the beam-bending effect. The limited transmission of the field-mesh adds an unwanted pattern to the video signal produced by the scanning beam on the mesh. The scanning beam passing twice through this mesh will be modulated by its symmetrical structure and will produce three different moiré patterns:

a. A line moiré which develops by focusing the primary scanning beam at the mesh. This line moiré is relatively strong and covers the whole scanning field. Figure 1a is a typical moire pattern.

b. A line moiré which develops if the node of the returning beam is at the mesh. This pattern is less strong and covers sections of the scanning field. (Figure 1b). Line-moiré pattern is developed by the relation between field-mesh lines and the scanning line system.



(a)

(b)

(c)

Figure 1

Moiré Pattern

c. A third moiré pattern, produced by the relation of the scanning beam passing twice through the symmetrical field-mesh structure and its own electron-optical focusing-field. This moiré pattern is seen as a very coarse mesh in the video readout and is shown in Figure 1c.

Moiré patterns can be eliminated by choosing a proper field-mesh-to-target spacing at normal tube potentials. Figure 2 is a diagram showing the field-mesh-to-target spacing vs the applied field-mesh potential at 75 gauss. The field-mesh is connected to the focusing electrode (G_4) of the tube. The moiré pattern covers a large operational range for field-mesh tubes. This diagram was made with a relatively high scanning-beam current, which produces a stronger interference pattern than that in normal tube operation. The beginning and the end of an interference pattern which may not be visible in the readout at normal tube operation was recorded. The almost vertical area is the area of the mesh moiré as seen in Figure 1c.

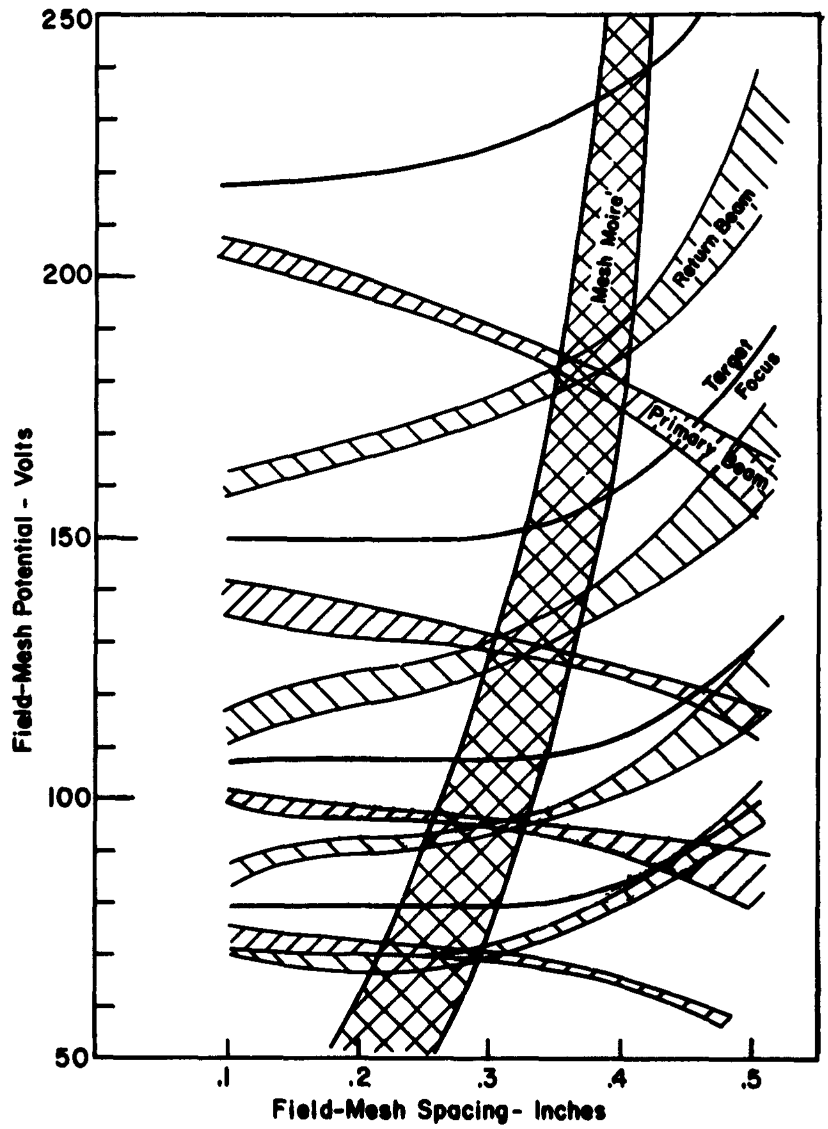
The horizontal lines are nodes at which the target is in focus, and the corresponding line-moiré areas for the primary and the return beams are s seen in Figure 1a and Figure 1b. The open area in this diagram shows the possible operating regions of the field-mesh image-orthicon without developing moiré pattern.

Figure 3 is a similar diagram with a focusing field of 80 gauss.

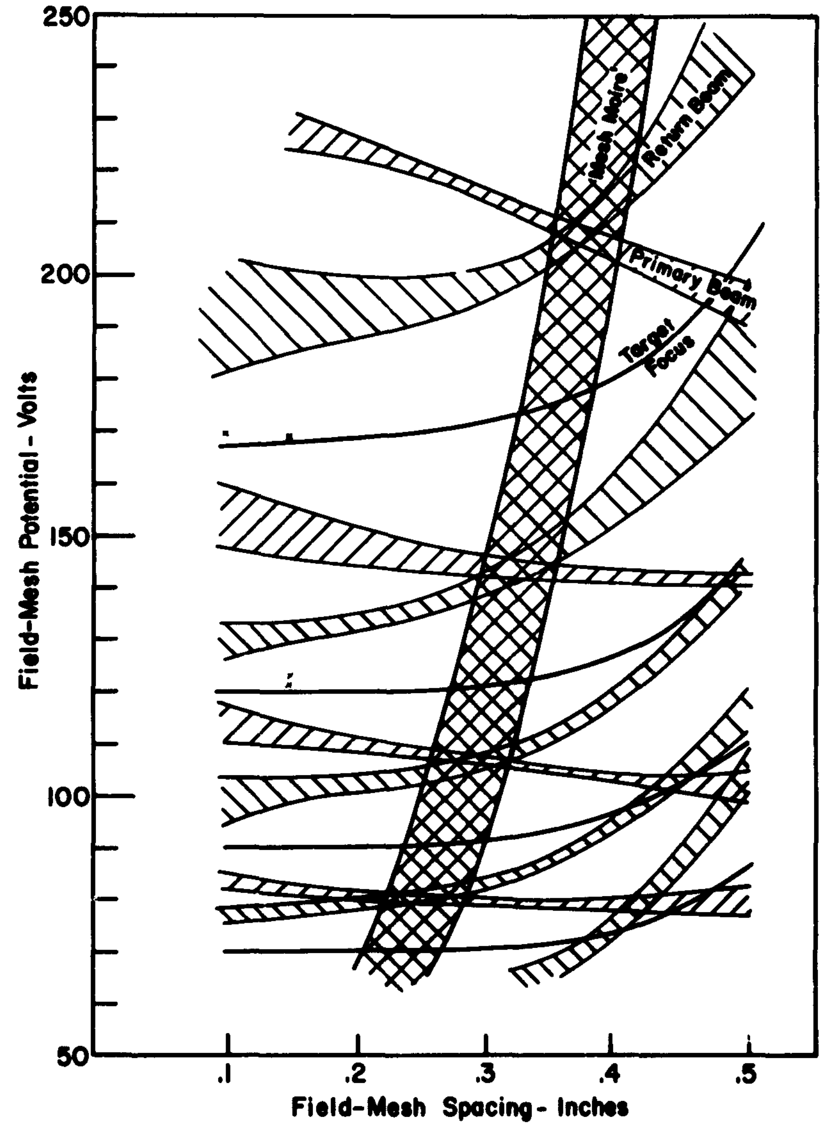
A field-mesh tube with a target spacing of 0.200" or less produces a new interference pattern in the video readout on the 6th and lower target nodes. This unwanted pattern is not produced by the scanning beam and the field-mesh alone. It is assumed that it is developed by some relation of the scanning lines used in the system, the field-mesh, and the target-mesh.

<u>Field-Mesh</u>

The field-mesh as commonly used in image-orthicons is connected to the G_4 or focusing electrode. To maintain the best focusing conditions for the scanning beam a very restricted field is permitted to develop between



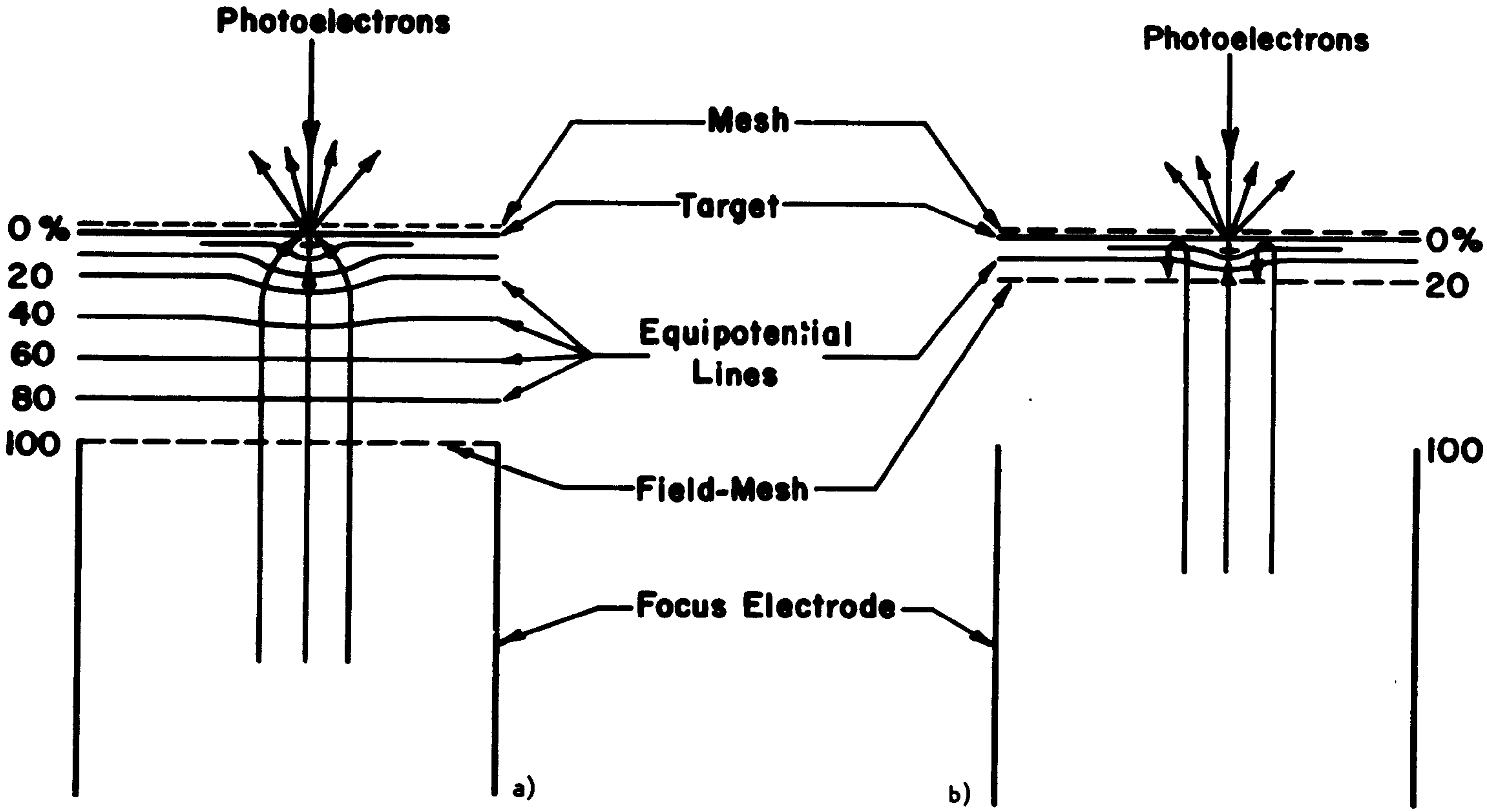
Moiré Pattern in Image Orthicons (75 Gauss)



Moiré Pattern in Image Orthicons (80 Gauss) target and field-mesh. Critical spacings have to be observed in manufacturing of such tubes to avoid possible interference patterns which may develop at the required operating mode. A very narrow spacing will focus the field mesh on the target and the resulting high electrostatic forces between field-mesh and target can develop microphonics which may break the thin film target.

Figure 4a shows schematically the electrostatic field distribution between target and field-mesh. A positive charge established on the target by photoelectrons will locally destroy the homogeneous field next to the target. Scanning electrons are deflected toward the positive charge. By disconnecting the field-mesh from the focusing electrode the field-mesh can be placed closer to the target, and proper potential can be applied to maintain the desired electrostatic field-strength on the target surface. This condition is shown schematically in Figure 4b, which demonstrates an additional reduction in the beam-bending effect.

A second characteristic was considered in modifying existing field-mesh image-orthicons. Primary electrons will impinge on the field-mesh with approximately 160 eV. The secondary-emission yield of the copper mesh is normally near unity but may be higher because of an alkali deposit resulting from the photocathode processing. By using a 70% light-transmitting field-mesh structure, 30% or more of the primary electrons produce noise electrons, and again 30% or more of the returning electrons will produce secondary electrons (as seen in Figure 5a). A suppressor-grid eliminates the largest portion of those secondary electrons from reaching the multiplier section. More than half of the total primary beam is intercepted by the field-mesh and does not contribute to the signal current. A low-potential field-mesh placed close to the target will collect primary scanning electrons without



Field Mesh Connected To Focus Electrode

Close Spaced and Low Potential Field Mesh

Figure 4

Electrostatic Field Distribution
(Target - Field-Mesh)

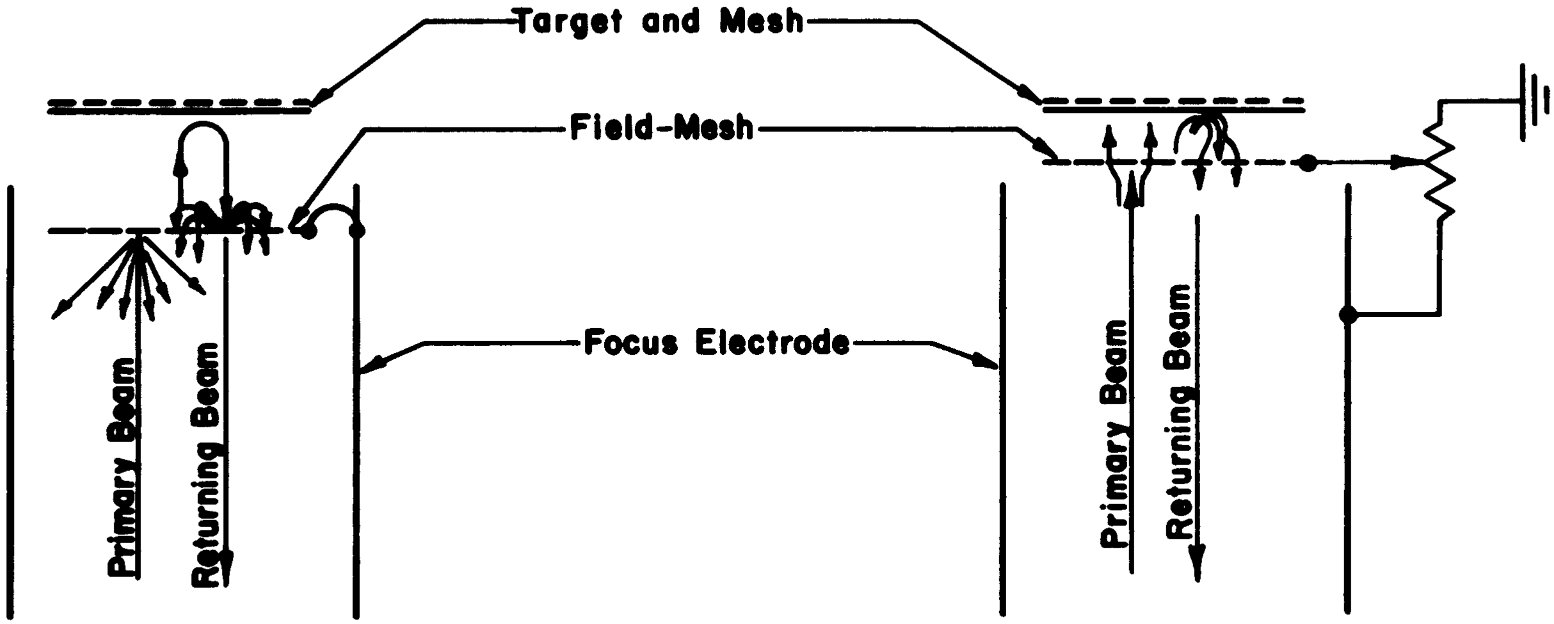


Figure 5 (a)

High-Potential Field-Mesh
(Schematic)

Figure 5 (b)

Low-Potential Field-Mesh
(Schematic)

producing so many secondary electrons and will focus a part of the returning modulated electrons through the mesh, resulting in a higher total signal current. This is schematically demonstrated in Figure 5b. By comparing Figure 5a and Figure 5b, the preferred operating mode will be seen in Figure 5b.

Disconnecting the field-mesh from the G_4-electrode (focus electrode) and applying a separate potential to the mesh permits a selection of the electrostatic field strength in front of the target; avoiding microphonics, target breakage, and interference pattern. Figure 6 shows the relative current vs field-mesh potential for an image orthicon with a 0.100" field-mesh-to-target spacing. Operating the field-mesh at approximately 40% of the focusing potential of the tube increases the signal current by 50%. Signal-to-noise measurements were not taken on this tube, but observation indicated that the noise increased proportionally with the signal. It should be mentioned that the lower field-mesh potential allowed a reduction in beam current. A slight performance improvement is expected in separate-field-mesh tubes.

Blooming

The blooming effect for variable field-mesh-to-target spacings is shown in Figure 7 and Figure 8. The closer-spaced field-mesh is generally better than a wider-spaced field-mesh. It is illustrated that the scanning beam is deflected less in a stronger electrostatic decelerating field. A high target-resistance is another requirement to limit the blooming effect produced by charge leakage. This is shown on a 0.300"-spaced-field-mesh tube which had a low target-resistance. Its blooming was the largest seen on any field-mesh tube. The target condition will explain the unequal blooming-effect relation between tubes with the 0.205" and the 0.400"-spaced field-meshes.

The reference tube was a standard WL 22722 image-orthicon employing a S-20 photocathode and a thin-film target without a field-mesh. The

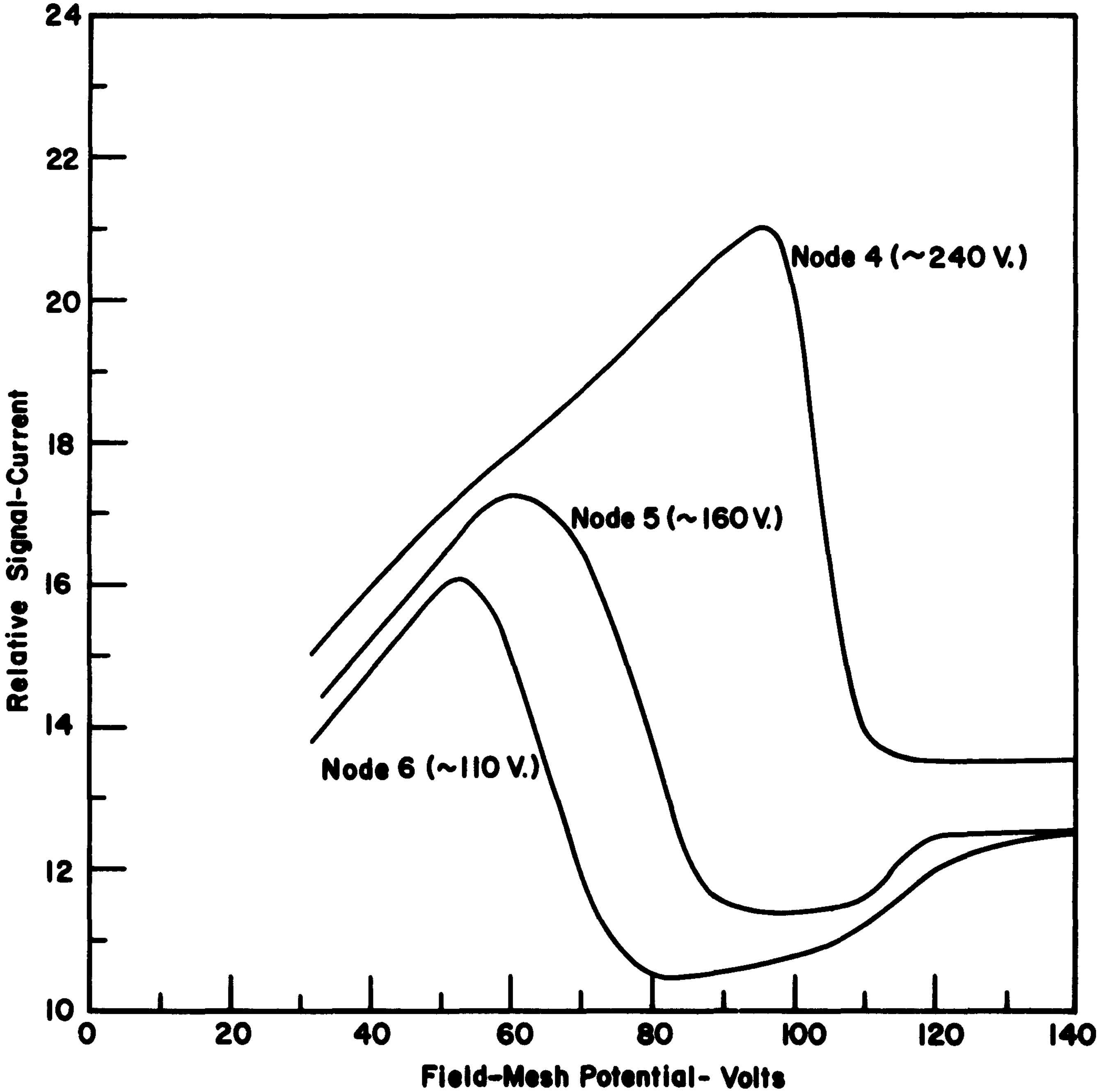


Figure 6

Signal-Current vs Field-Mesh Potential

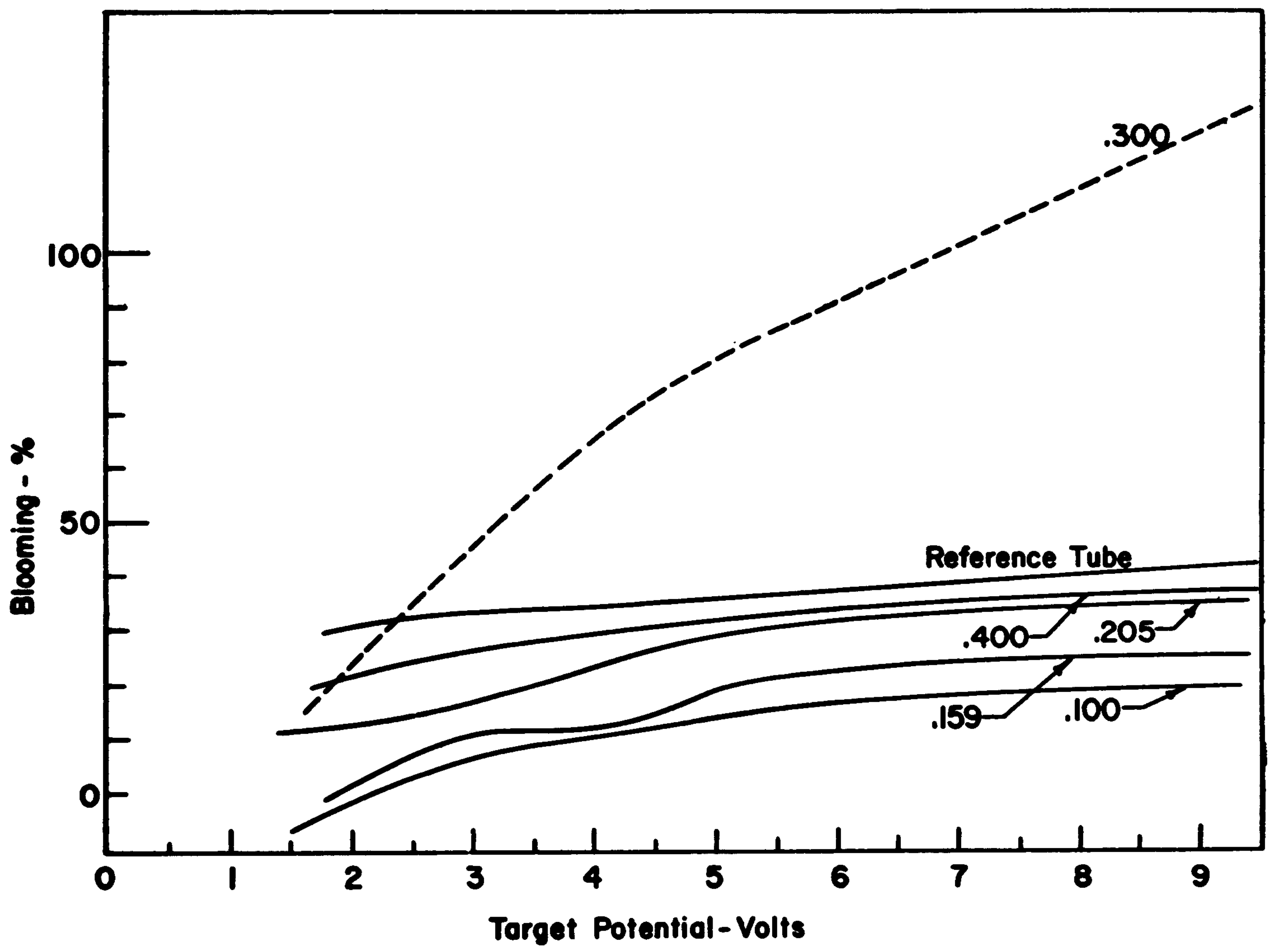


Fig. 7

Blooming vs. Target Potential (Normal Tube Operation)

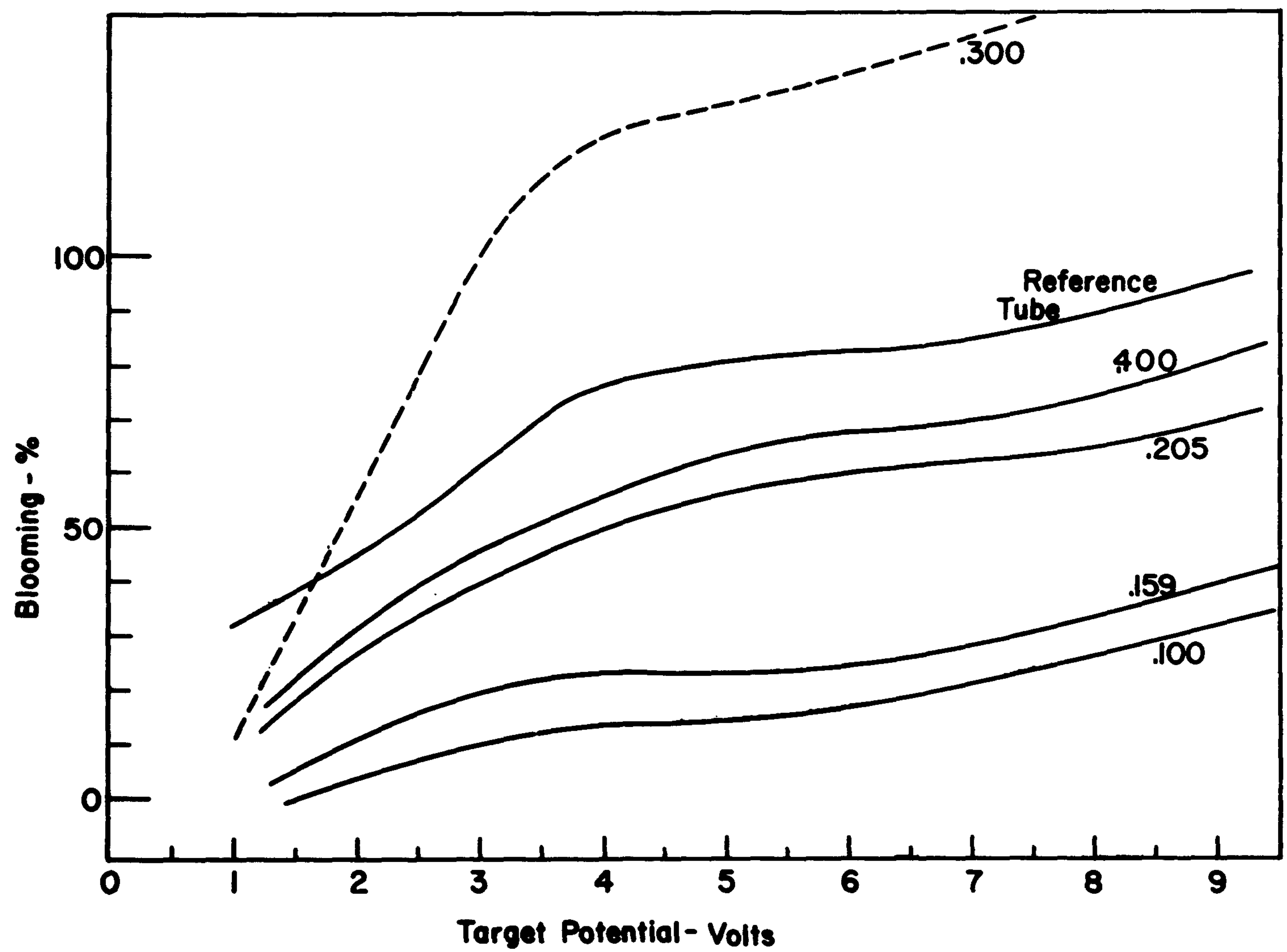


Fig. 8

Blooming vs. Target Potential (Low Beam Current) diagrams in Figure 7 and Figure 8 were plotted under the following conditions:

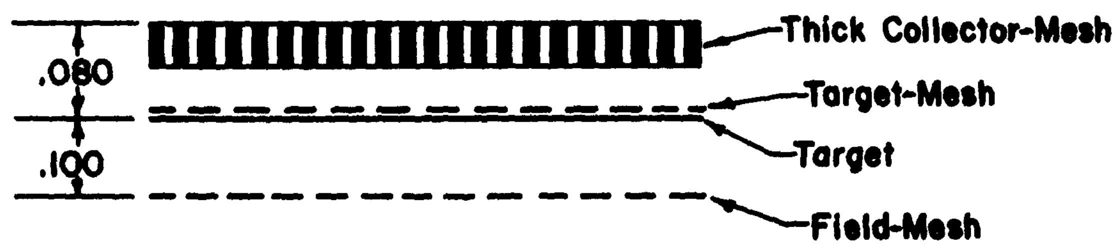
a. The photocathode was illuminated to a level which produced a signal-current of 0.2 V/cm on an oscilloscope at a target potential of 2.0 V above target-cutoff.

b. By changing the target potential the beam-current was adjusted to maintain a 0.1 V/cm scope reading in Figure 8 and 0.2 V/cm scope reading in Figure 7, respectively. In Figure 7 the beam-current is sufficient to discharge a bright spot produced by photoelectron bombardment on the target. This assumption corresponds to a normal operation of the image-orthicon.

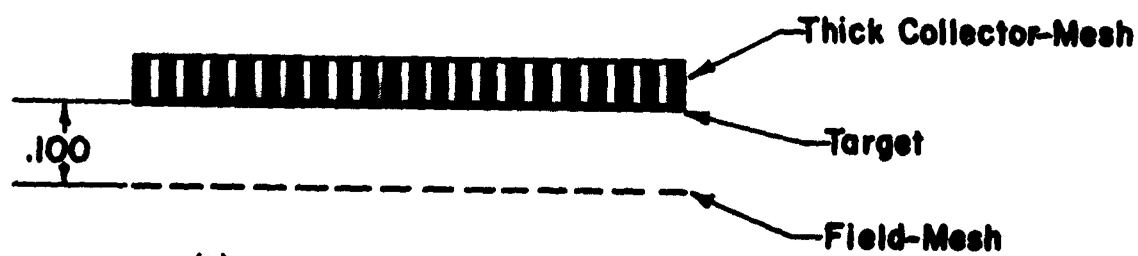
In Figure 8 the condition established corresponds to a bright spot on a low-level illuminated scene when the beam-current is insufficient to discharge a "bright" spot on the target. By comparing Figure 7 with Figure 8, it is seen that insufficient beam-current increases the blooming substantially. If the illuminated scene has no "bright" spots, the blooming effect is hardly noticeable. The blooming effect is reduced on field-mesh tubes and gradually increases with the illumination and increased field-mesh spacing. The larger blooming effect at higher target-potentials is produced by a higher charge established on the target. The scanning beam is not sufficient to discharge the spot, and leakage will result toward the lower-charged surrounding target area.

Redistribution

Two tubes were fabricated using a metalized thick glass-mesh collector. In one double-mesh tube the upper collector-mesh was replaced by the thick glass mesh. Figure 9a shows schematically the cross-section of the target assembly as used in this tube. The thick collector-mesh was metalized with copper, and a piece was broken from the disc. The 0.001" holes in this 74% transmittant, 0.070"-thick mesh, spaced 0.080" from the target, reduced the electron transmission completely around the periphery



(a) Double Mesh

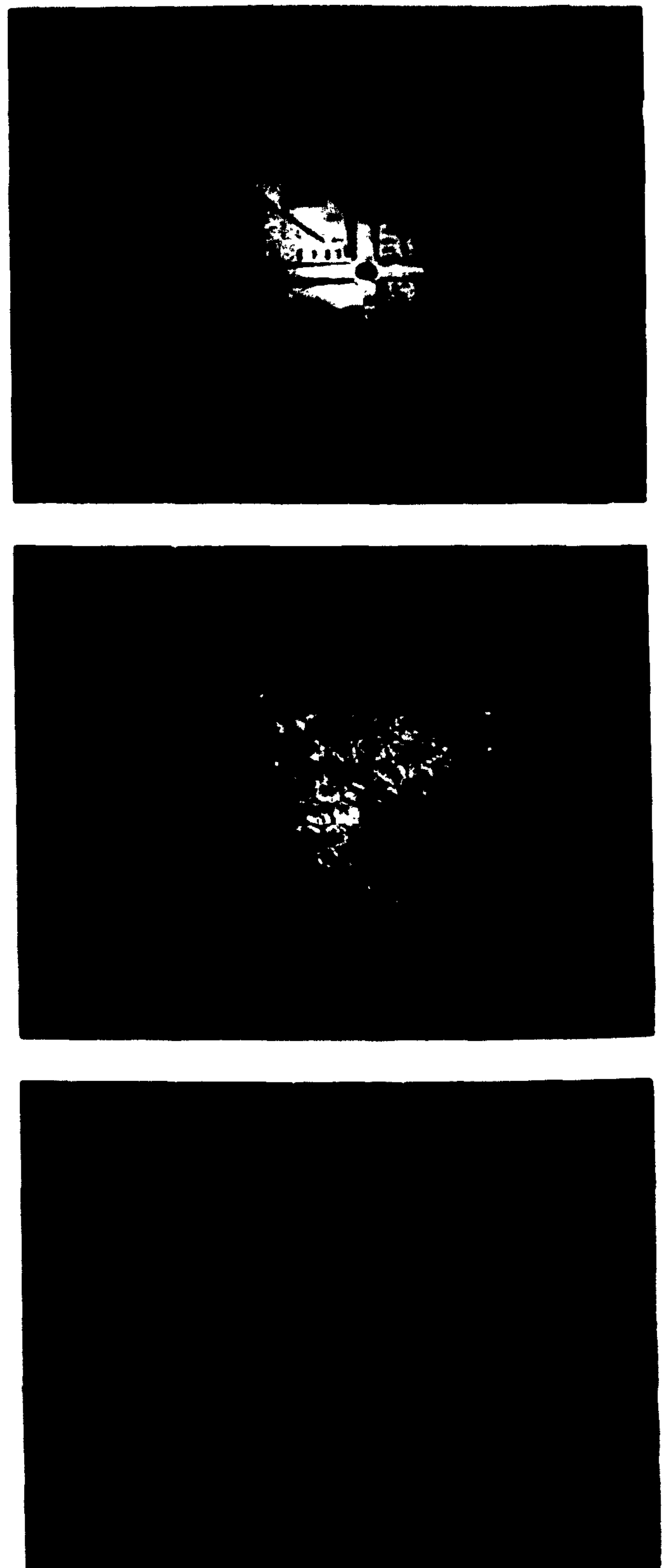


(b) Target On Thick Mesh

Figure 9

Cross Section Through Target Assembly (Schematic) of the target, and only a small quantity of electrons were able to penetrate the center of the thick mesh (See Figure 10a). The reduction in photoelectron penetration through the mesh can be compared over the target diameter with the lower part of the picture, where a part of the thick collector mesh is missing. Changing the photoelectron focusing node permitted also some electron penetration through the thick mesh around the periphery, as sown in Figure 10b. This tube has a very small redistribution area for high-velocity secondary electrons, and the black halo can be eliminated at proper target and collector potentials. Figure 10c was made with an illumination ratio of 20,000 to 1 and shows a relatively small redistribution area. An apparent fiber bundle structure is seen in these pictures. It is expected that a close target-to-thick-collector-mesh spacing will increase the ratio of the photoelectrons which may reach the target to photoelectrons which bombard the upper side of the thick mesh. Increasing this ratio and evaporation of a low-secondary-electron-yield material on top of the metalized thick collector-mesh should reduce this structure effect.

The second tube was fabricated at the other design extreme. Considering the use of a weak and flexible thin-film target in combination with a close spacing, the target was mounted in direct contact with the thick collector-mesh. The schematic cross-section is seen in Figure 9b. The evaluation of this tube showed that the metalized film peeled from the glass base and closed the holes more or less completely. After opening this tube, the photographs in Figure 11 were made. Figure 11a shows the thick glass mesh structure with reflecting light under a microscope. Figure 11b is the same area with transmitted light. This photograph shows that the main portion has no light transmission at all. Only very few holes permit full light penetration. Figure 11c is taken from another section of the mesh with transmitted light. The microscope magnification was 65 times.



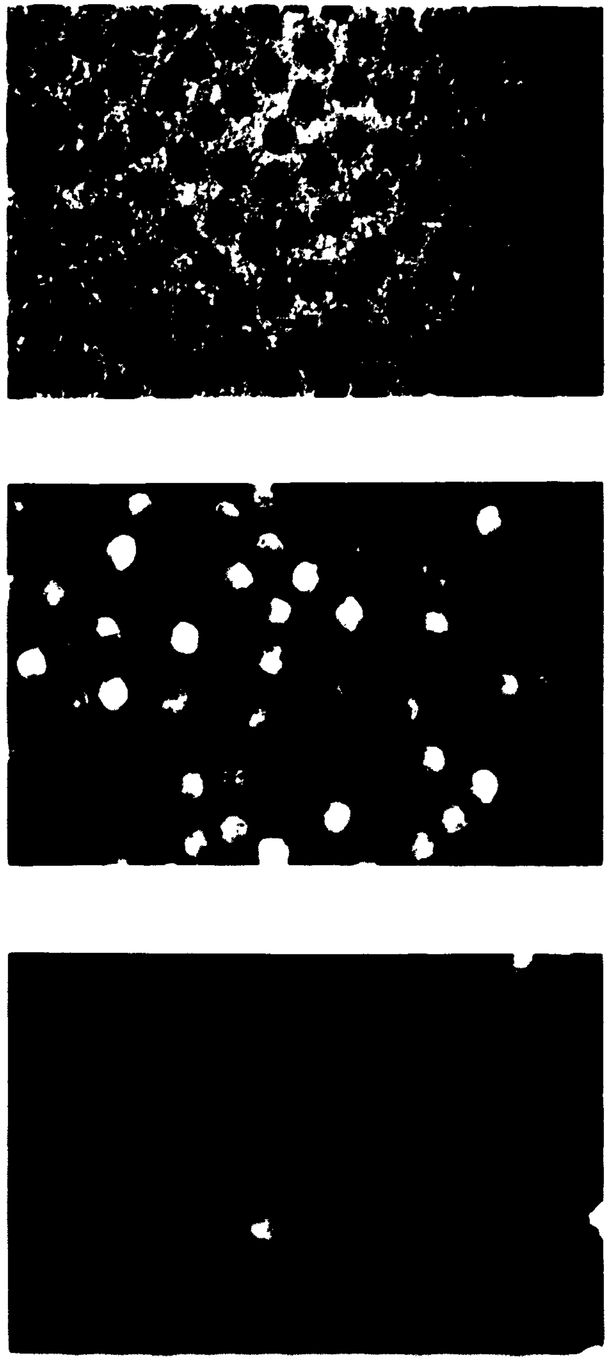
(a)

(b)

(c)

Figure 10

Video Pictures From Experimental Tubes



(a)

(b)

(c)

Figure 11

Microscope Photographs Of Thick Collector-Mesh

The thick collector-mesh in this tube had two metallic coatings. The first metalization was a copper film, the same as on the first tube, and on top of this copper film a gold layer was added. It is surmised that during the long, high-temperature bake of the tube on the exhaust station, the peeling developed.

CONCLUSIONS

Field-mesh tubes with target-to-field-mesh spacings from 0.100" to 0.500" were graphically evaluated for beam-bending and interference pattern. Close-spaced-field-mesh tubes may have a field-mesh pattern on the target node or may develop microphonics and cause target breakage because of strong electrostatic forces, thus limiting the closeness of spacing. Separate electrical connection on the field-mesh permits tube operation with very close spacings and has additional advantages in tube performance; e.g., reduced secondary electron emission, less beam-bending, obtained higher signal-current, possible improvement in signal-to-noise ratio. Highly resistive targets are required to reduce the blooming effect caused by charge leakage in the lateral direction.

A double-collector-mesh tube, in which the upper mesh is replaced by a thick mesh, is an effective measure to reduce the black and white halos. For the purpose of reducing expenses, the metalizing process of the thick glass mesh was pursued in our plant and Mosaic Fabrications, Inc. are performing this process now.

PROGRAM FOR NEXT INTERVAL

The following work is planned for the next interval:

a. The manufacture and evaluation of closer-spaced-field-mesh tubes with an independently variable potential.

b. The manufacture of double-collector-mesh tubes with electrical evaluation for redistribution at various illumination ratios and optimizing the collector spacings.

c. The manufacture of one tube of the design with the best established performance during the entire contract to date and its evaluation for redistribution, beam-blooming, sensitivity, and aperture response.

d. Several thick-collector-mesh image-orthicons will be constructed and evaluated, and their performance will be compared with the best performance obtained from double-collector-mesh tubes.

IDENTIFICATION OF PERSONNEL

During the period of this report, 2275 engineering man-hours were devoted to the design and development of the Non-Blooming Image-Orthicon.

Listed below are the personnel who contributed to the program. Biographies of key personnel involved, not listed in the first quarterly report, are listed on the following pages.

	Hours
Engineers	
L. Healy	300
J. Mueller	470
J. McIntyre	46
R. Shaffer	40
Others	107
	963
Technicians	
J. Morrison	285
Others	1027
	1312
Total	2275

Approved by:

R. A. Shaffer
Supervisory Engineer
Image Tube Engineering

Submitted by:

J. Mueller
Project Engineer
Image Tube Engineering

Lawrence G. Healy

Education

Canisius College, Pre-Engineering 1951-1953.
University of Detroit, Mechanical Engineering 1953-1954.
Canisius College, B.S. Physics 1954-1956.

Professional Experience

1954 - Chevrolet Division, General Motors, Tool Design. (University of Detroit Cooperative Plan)

1956 - Westinghouse Electric Corporation graduate student course with assignments in Small Motor Division, Lima, Ohio, Electronic Tube Division, Elmira, New York, Motor & Control Division, Buffalo, New York, Air Armaments Division, Baltimore, Maryland

1958 - date - Electronic Tube Division, Westinghouse Electric Corporation, Elmira, New York. Camera Tube Development Engineering, specializing in fixturing, electronic and mechanical design of tubes and components.

Military Service

1956 - 1958 - 1st Lt. U. S. Army Corps of Engineers
Currently Active Reserves

1961 - 1962 - Recalled to active duty due to Berlin crises

Accomplishments

Several disclosures awards
Most Meritorious Award of 1960
One patent application filed
Built and ruggedized various camera tubes

Affiliations

Member of American Institute of Physics

James L. McIntyre

Education

Milwaukee School of Engineering, A.A.S. in Electronics, 1951.

Professional Experience

1951 - 1952 - Bell Aircraft Corporation, Niagara Falls. Worked as trouble shooter and technical writer, Guided Missiles Section.

1952 - 1957 - Westinghouse Electric Corporation, Elmira, New York. Process Engineer, Cathode Ray Tube Department

1957 - 1958 - New Products Division, Corning Glass Works, Corning, New York. Process Engineer, Assembly and Testing of Ultrasonic Delay Lines.

1958 - date - Electronic Tube Division, Westinghouse Electric Corporation, Elmira, New York. Process Engineer, Image Orthicons.

Military Service

1945 - 1946 - U. S. Army. Supply Sergeant in Prisoner of War Camps.

Accomplishments

One patent on oxide coated cathodes. Two patents filed on Image Orthicon. Meritorious disclosure award, 1961. Developed high sensitivity S-10 and S-20 photocathodes.

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This contract is supervised by the Special Tubes Branch, Electron Tubes Division, Electronic Components Department, USAELRDL, Fort Monmouth, N. J. 07703. For Further Technical Information contact:

Mr. Munsey E. Crost Project Advisor

Pickup, Display, and Storage Devices Section, Tel 201 5961102

Unclassified

1. Electron Tubes
2. Image Tubes

Redistribution-Blooming
Field Mesh-Collector

I. Mueller, J.
II. U. S. Army Electronics Research and Development Lab., Fort Monmouth, N.J.
III. DA-36-039-AMC-03249(E)

AD______________________________Accession No.__________

Camera Tube Dept., Westinghouse Electric Corp.
Elmira, N. Y.

NON-BLOOMING IMAGE ORTHICON - J. Mueller

Second Quarterly Progress Report, 1 November 1963 to 31 January 1964, 24 pp - 12 ill. Contract DA-36-039-AMC-03249(E) Task No. 1G6-22001-A-005-03
Unclassified Report

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Unclassified

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2. Image Tubes

Redistribution-Blooming
Field Mesh-Collector

I. Mueller, J.
II. U. S. Army Electronics Research and Development Lab., Fort Monmouth, N.J.
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