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SEC IMAGE INTENSIFIER VIDICON DEVELOPMENT (U)

Interim Report

Author:

B. E. Day

February 1967

Components Division
Night Vision Laboratory
U. S. Army Engineer Research and Development Laboratories
Fort Belvoir, Virginia

Contract Number DA 44-009-AMC-1495(T)

Pickup Tube Operation
Tube Department
General Electric Company
Syracuse, New York

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Author:

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7 July 1966 through 7 January 1967

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SUMMARY

(U) Test results of the vidicon readout of a thin film target are given. An intensifier image orthicon has been constructed. Layout drawings of an intensifier vidicon are presented.

FOREWORD

Authorization for this work under contract number DA 44-009-AMC-1495(T) was given to the Pickup Tube Operation by the Components Division, Night Vision Laboratory, USAERDL, Fort Belvoir, Virginia.

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INTRODUCTION AND SUMMARY

(U) Test results of the vidicon readout of a thin film target are given. An intensifier image orthicon has been constructed. Layout drawings of an intensifier vidicon are presented.

INVESTIGATION AND DISCUSSION

(U) With increased electron gains obtainable from multiplier channel plates (MCP's) the need for the Secondary Electron Conduction (SEC) target, has diminished. As a substitute for the higher gain SEC target, two thin film-type targets have been investigated.

(U) Thin films of approximately 500 Å thickness of both MgO and SiO have been processed upon 1000-line nickel mesh. Figure 1 shows a microphotograph of the MgO film and mesh assembly. In contrast to the SiO film, which sagged considerably within each mesh square, the MgO polycrystalline film is uniformly tensioned across the entire surface. One area, where the film is ripped due to a mesh square, the MgO polycrystalline film is uniformly tensioned across the entire surface. One area, where the film is ripped due to a mesh defect, is shown in the center of the photograph.

(U) Both targets, one inch in diameter, were mounted within a standard three-inch image orthicon for evaluation. Circuit changes within the camera were made so that the video signal could be taken from the target mesh (vidicon mode) or the return beam image orthicon mode. The tube containing the SiO thin film target produced no picture at all. It is possible, however, that cesium destroyed the target by lowering the resistivity to a point where the charge leaked rapidly to the target mesh. Very encouraging results, however, were obtained with the thin film MgO target. In the orthicon readout mode, a resolution of 200 RETMA lines was obtained at 1×10^{-5} foot candles of illumination on the photocathode. The tube resolution sensitivity of 333 TV lines per target inch at this light level is exceptionally good for a target-to-mesh spacing of zero (intimate contact). The S-10 photocathode luminous sensitivity is 25μa/lumen.

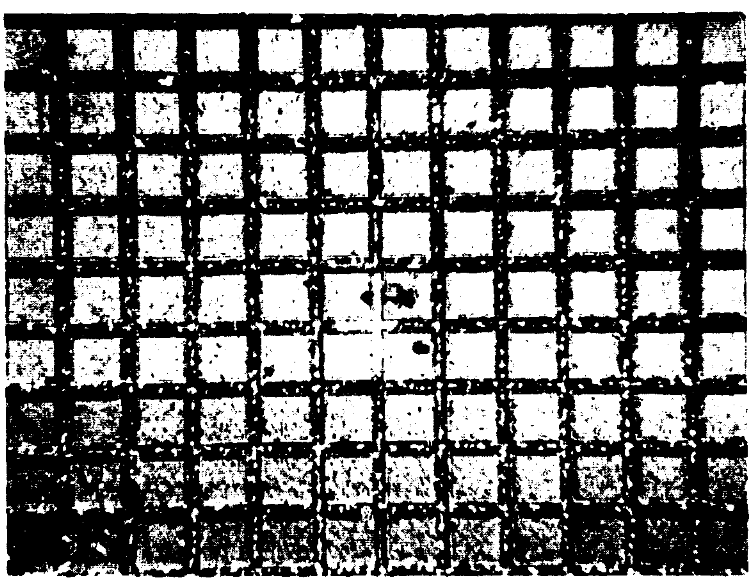


FIGURE 1 (U)

Magnesium Oxide Film on 1000-Line Nickel Mesh.
Magnification (150)

(U) Figures 2, 3 and 4 are photographs of the tube output with the video signal taken directly from the target mesh (vidicon mode). Since the feasibility of target operation was the prime objective, no particular precautions were taken with the target used in this test. Defects, such as the white smudge appearing diagonally across the target, were caused by handling. Two major contributors to the reduction of signal output are the large target distributed capacity and the necessity of operating the tube at low target voltage as a result of the lack of reading beam current. A reduction of the signal output, especially the high frequency response, is attributed to the large target distributed capacitance to other tube electrodes. This capacitance was measured to be 140 $\mu\mu$f with the tube positioned within the focus coil deflection yoke assembly. The largest contributors to this capacity are the signal output lead and the image orthicon target cup assembly. Insufficient beam current transmitted through the 1-1/2 mil defining aperture of the image orthicon gun, necessitated the use of a low target mesh voltage of not more than 7 volts. Illumination on the tube faceplate (photograph, Figure 2), was 0.25 foot candles. The resolution attained at this light level is 600 RETMA television lines.

(U) The primary advantage of this tube over a standard vidicon or image orthicon is its ability to maintain resolution on a moving scene with no lag whatsoever. One disadvantage is that the 1000-line target mesh is visible. This can be corrected, however, by substituting a finer mesh or spacing the target away from the mesh with a suitable dielectric. The photograph shown in Figure 3 emphasizes the good halation properties of the target. The photograph of Figure 4 was taken with a light level of 3.3 x 10^{-3} foot candles on the faceplate. Actually 665 TV lines per target inch were observed at this light level which is close to a standard 5820 image orthicon performance.

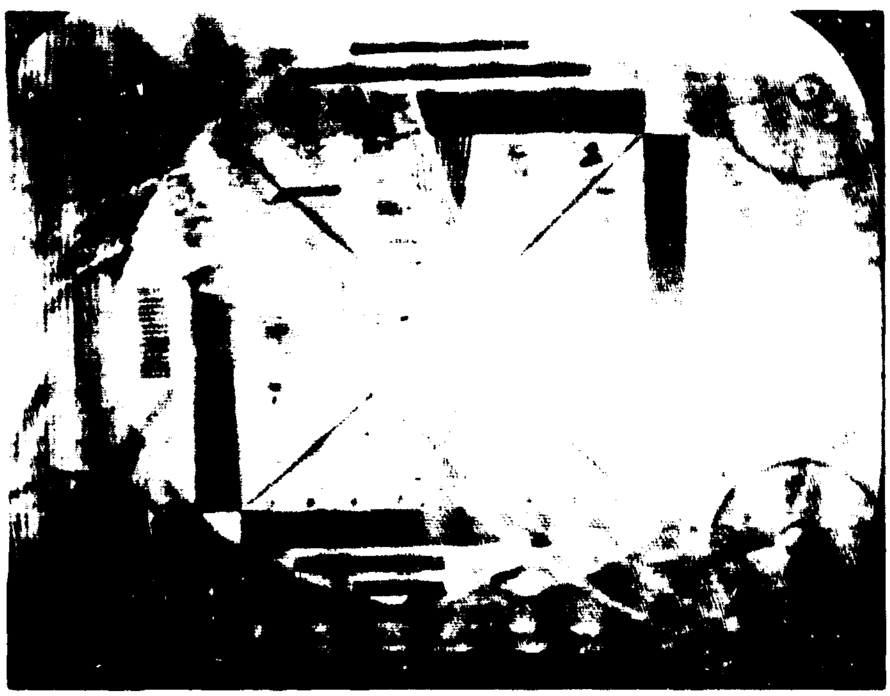


FIGURE 2 (U)

Video Signal (Vidicon Mode) From MgO-Mesh Target

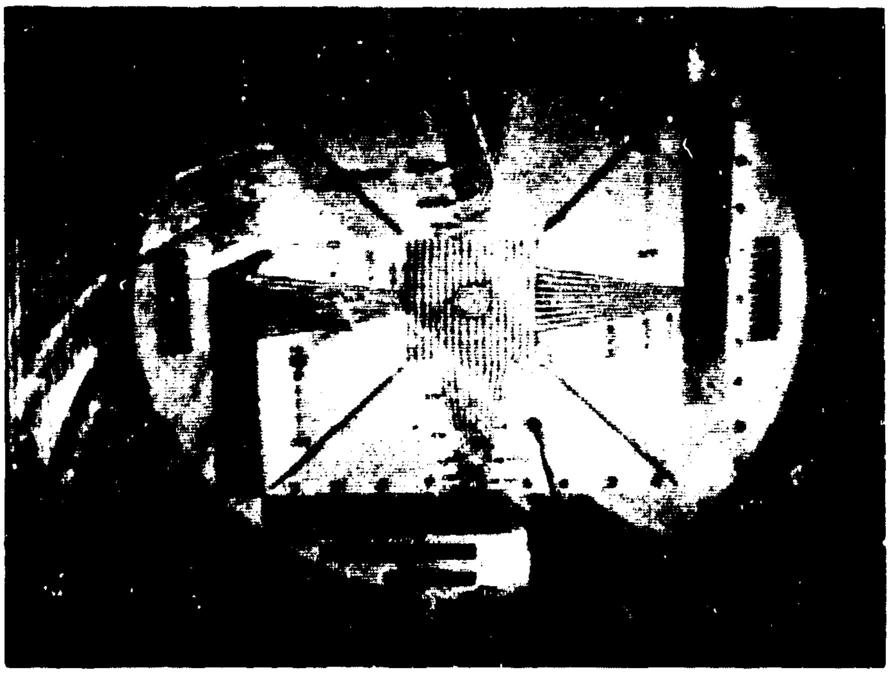


FIGURE 3 (U)

Halation Properties of MgO-Mesh Target

FIGURE 4 (U)

Low Light Video Signal Properties of
MgO-Mesh Target

(Illumination on Faceplate - 3.3×10^{-3} Foot Candles)

(U) Comparing the sensitivity of the tube with that of a vidicon containing an antimony trisulfide photoconductor, one finds the quantum efficiency of the antimony trisulfide photoconductor is approximately 5 percent whereas an S-10 photocathode having a luminous sensitivity of 25μa/lumen has a quantum efficiency of 3 percent. Assuming this to be approximately equal, the higher sensitivity experienced with the mesh MgO target must be derived from the secondary emission ratio (δ) of the MgO film. From past experience, it is known that δ drops considerably when an MgO film is placed in intimate contact with a copper mesh. The results of the above tube show that the δ of the MgO film on nickel mesh must be greater than 10. Signal current measurements from the target mesh are being taken but are not available at this writing.

Image Orthicon Intensifier

(U) The two-inch diameter image orthicon intensifier layout is shown in Figure 5. The design of a magnetic focused stage between the photocathode and the MCP and a proximity focused stage between the MCP and the target were chosen for the following reasons:

1. A photograph can be made in the normal manner. (No external processing necessary.)
2. Much lower accelerating voltage in the (e-m) focused stage for a comparable resolution.
3. The proximity focused stage between the MCP and the target was chosen since it has been shown, from measurements made on 18mm microstatic tubes, that the radial energy distribution of electrons leaving the MCP are lower than those emitted from an S-20 type photosurface.

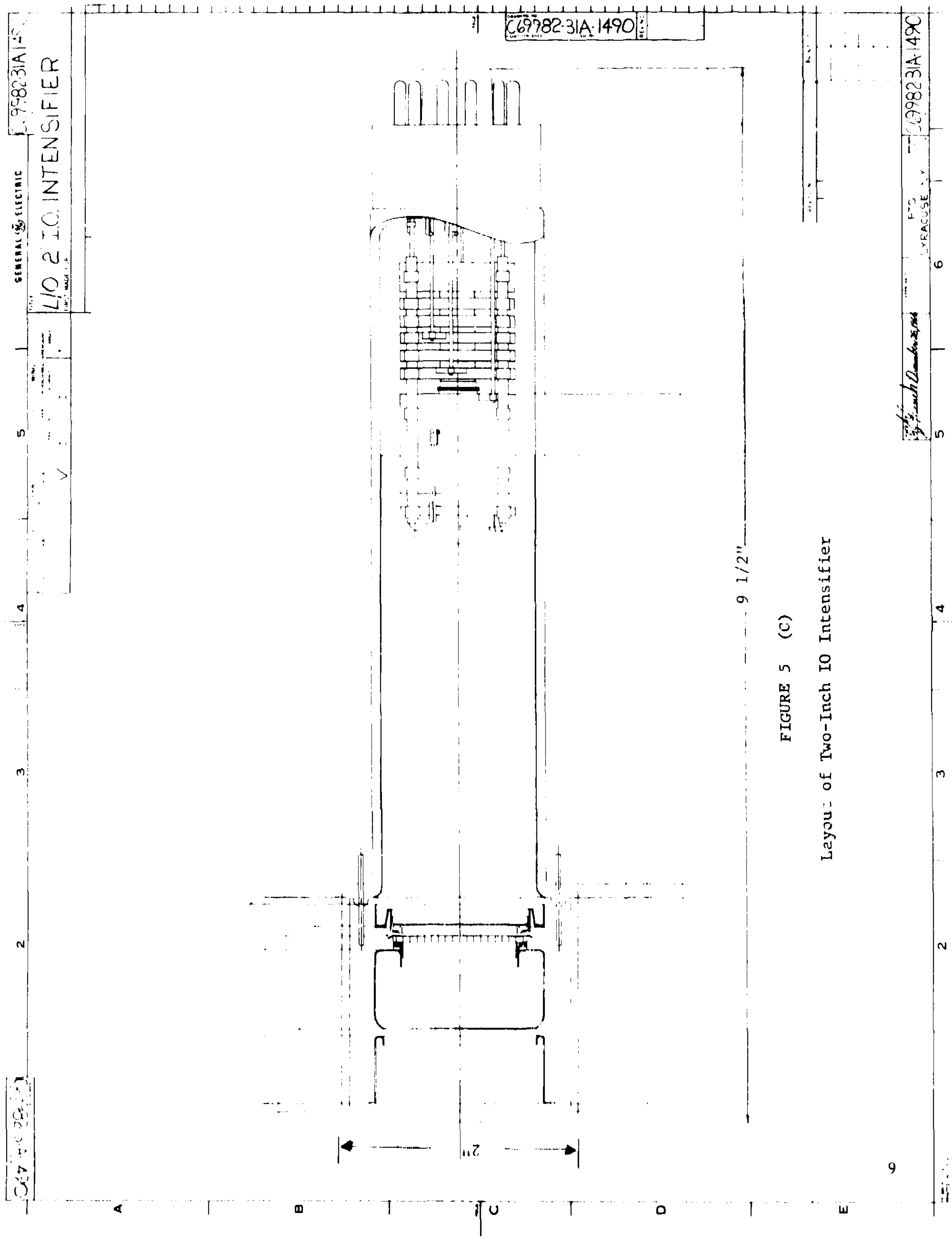


FIGURE 5 (C)

Layout of Two-Inch IO Intensifier

(U) An image orthicon intensifier with MCP has been built, while the parts are being fabricated for a 1-1/2 inch magnetically focused and deflected vidicon. The image section for the intensifer vidicon will be almost identical to that of the intensifier image orthicon (see layout Figure 6). Resolution calculations for the image section of the intensifier are somewhat lower, however, than that of the intensifier vidicon. The proximity focus relationships between two planes of uniform gradient are given by:

$$\varphi = 4d\sqrt{\frac{V_o}{V_a}} = \frac{1}{2R}$$

$$V_o = V_a/64R^2d^2$$

where φ is the spot size in mm

d is the spacing between the two planes

R is the resolution in lp/mm

V_a is the accelerating voltage between the planes

and V_o is the average energy of the radial component of electrons leaving the cathode.

(U) Resolution measurements taken on several 18mm microstatic tubes (Contract No. DA 44-009-AMC-1060(T)) have yielded the following results. At the phosphor screen which was spaced 2mm from an MCP, 20 lp/mm has been obtained. A microphotograph of this MCP with channel-to-channel spacing of 16.5 microns is shown later in this report. The accelerating phosphor voltage was 3000 volts. Applying the proximity focus relationships and solving for V_o yields a radial energy component of only 0.03 volts. Secondary emission from an MCP, however, generally has a broad spectral distribution both in space and energy. The calculated radial energy component of 0.03 volts, however,

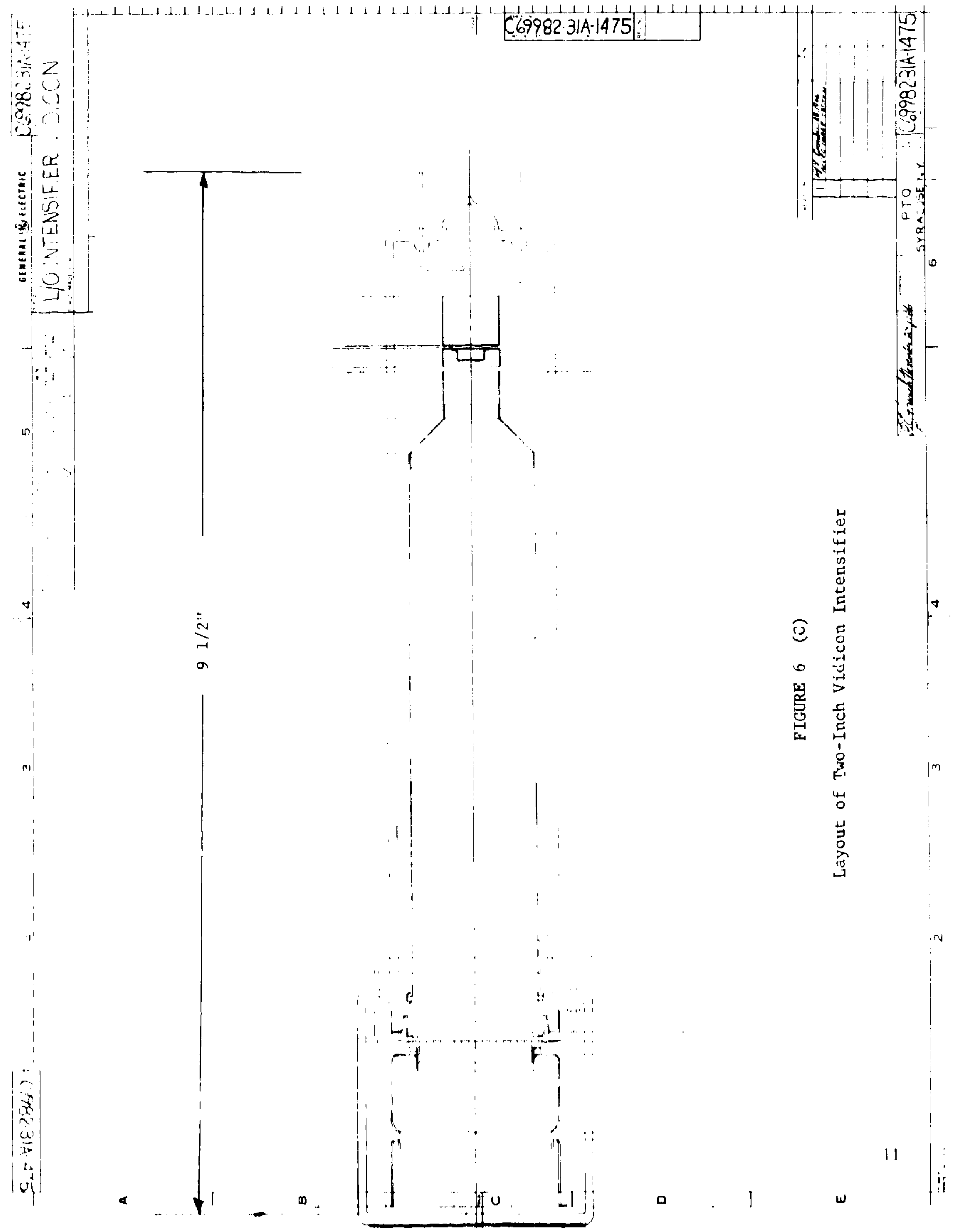


FIGURE 6 (C)

Layout of Two-Inch Vidicon Intensifier

may have been lowered as a result of the microlens which can be formed when the electric gradient (E_p) in the proximity focus space is greater than the gradient (E_{MCP}) in the MCP. When $E_p/E_{MCP} > 1$, the field extends into the channels of the MCP, converging the output electron rays, thus reducing the spot size. When the output electrons from the MCP are proximity focused to a thin film target, the ratio E_p/E_{MCP} will be less than one and in order to reduce the effective V_o, it may be necessary to extend the MCP contacts within the channel, thus spoiling the gain near the exit of the channels.

(U) Applying the most optimistic V_o value of 0.03 volts to the proximity focused stage between the MCP and the thin film target yields a resolution of 21.5 lp/mm at a voltage of 500 volts with a spacing (d) of 3/4mm.

(U) The overall resolution of the image section (R_t) is expressed by:

$$R_t = 1\Big/\sqrt{\left(\frac{1}{R_i}\right)^2 + \left(\frac{1}{R_c}\right)^2}$$

where R_i is the optics resolution entering the MCP and R_c is the proximity stage resolution. The input resolution of a two-inch electromagnetically focused image section is at least 1000 RETMA TV lines which corresponds to 33 lp/mm. Solving for R_t yields 18 lp/mm or 540 RETMA TV lines. As multiplier channel plates with reduced channel-to-channel dimensions become available, the spacing (d) can be reduced to 0.5mm which will, under the same conditions above, yield a proximity focus resolution of 32.5 lp/mm and an overall image resolution (R_t) of 23.4 lp/mm. This corresponds to 702 RETMA TV lines in a vertical dimension of 0.6 inch.

INVESTIGATION AND DISCUSSION (Continued)

(U) Since the intensifier image orthicon (see photograph Figure 7) must be constructed with a target which is spaced parallel to and at a distance (a) from the target mesh, one will expect to find a reduction of the image section resolution due to beam spreading between the target mesh and the target. This is illustrated in Figure 8.

(U) An approximation of the value of focal length (f) of the mesh lens can be made by means of the Davisson and Calbich expression:

$$f = \frac{4V_m}{E'-E}$$

where $E' = \frac{V_t - V_m}{a}$ and $E = \frac{V_m - V_o}{b}$

The focal length is found to be negative and equal to four times the distance (b) or the spacing between the target and mesh and the MCP. Solving ›r the ratio of the spot enlargement at the target over the spot siz‹ at the target mesh yields:

$$\frac{\varphi'}{\varphi} = \frac{.75}{.5} = 1.5$$

Therefore, since the spot size is increased by the factor 1.5, the resolution will be reduced by this same amount for the spacings given above.

(C) An S-10 photosurface was made in the intensifier image orthicon as all the image pin connections were used, with the addition of two MCP contacts. A Bendix MCP with a usable area of one inch was used in this tube. The processing of the MCP was accomplished prior to fabrication into the image section. The electron gain, with 1600 volts across the MCP was only 125. The effective luminous sensitivity of the tube, however will be the product of the MCP gain and the

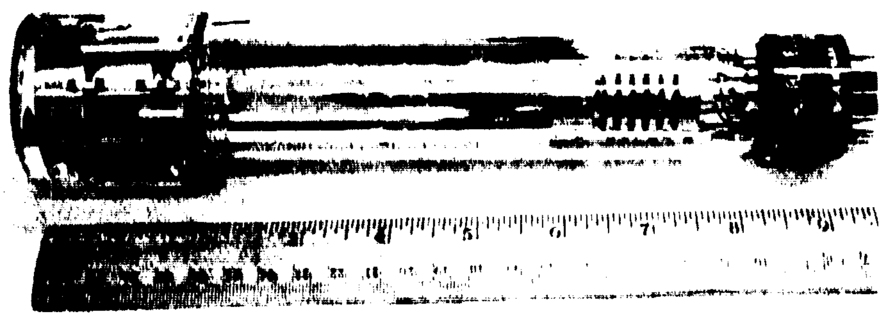


FIGURE 7 (C)

Photograph of Two-Inch IO Intensifier

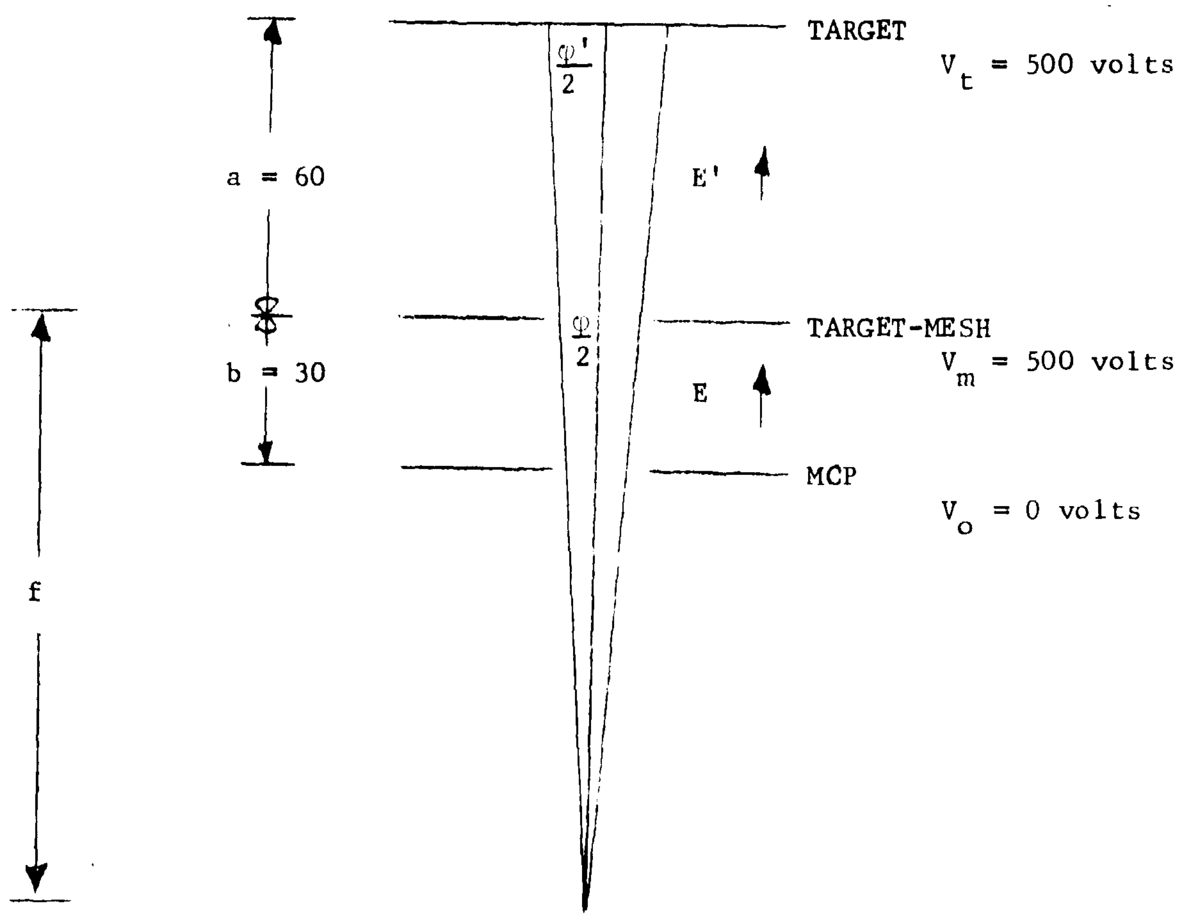


FIGURE 8 (U)

Beam Spread Between Target and Target-Mesh

INVESTIGATION AND DISCUSSION (Continued)

photocathode sensitivity which is 1,500 μa/lumen. An advantage of the orthicon image section over the vidicon image section is the absence of electrostatic forces on the target. The target mesh which is held near ground potential protects the target from these forces.

(U) The test equipment necessary to test the intensifier image orthicon is nearly complete. A two-inch image orthicon yoke and coil assembly will be used. A special alignment coil has just been received.

(U) To attain good resolution from a proximity focused MCP to target will in all probability depend upon a rather controlled process of spoiling the gain near the output of the MCP. This, of course, is accomplished at the expense of overall MCP electron gain. As a possible solution for overcoming the rather low resolution of the proximity focus stage in either the intensifier vidicon or intensifier image orthicon, the following is proposed. An enlargement in length of the image section would allow two electromagnetically focused stages. The MCP would be located in the center with the e-m stages on either side. Voltage gradients then would be minimized and resolution greatly increased.

Multiplier Channel Plates

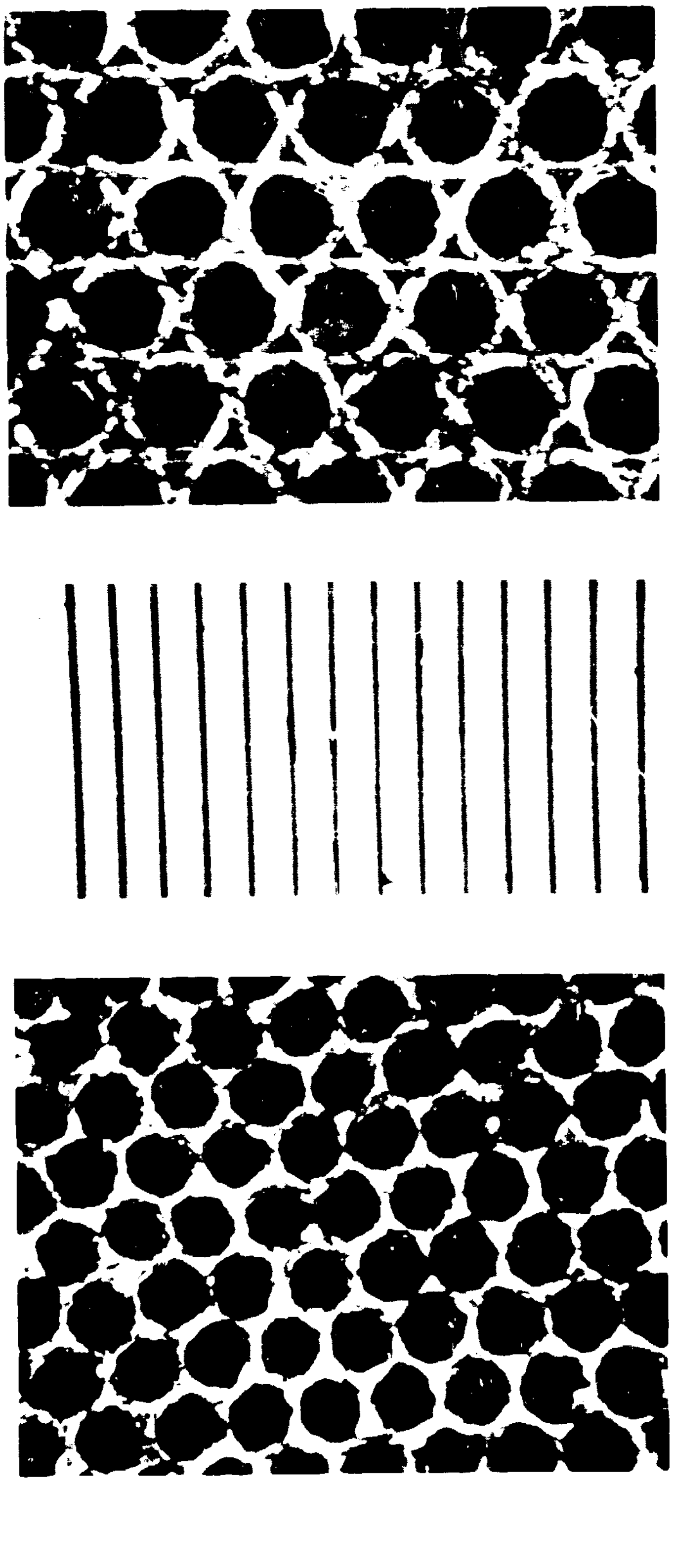
(C) The lack of availability of good multiplier channel plates is of great concern. Lately, electron gain has been a problem in the Bendix MCP's. Gain curves taken by the suppliers are made prior to MCP bakeout. The gain in this case can come largely from ion currents. The only one-inch diameter plates that are in house on this contract have extremely low gain as evidenced by the figures previously stated. Bendix has been notified of these problems.

INVESTIGATION AND DISCUSSION (Continued)

(C) A microphotograph of the Bendix plate used in the intensifier image orthicon is shown in Figure 9-a. This is the smallest channel-to-channel spacing available in the one-inch diameter MCP's. Pertinent information is given in Table 1. For contrast, a higher resolution plate is also shown (Rauland, Figure 9-b).

TABLE 1 (C)

MCP Mfr.	Channel Size	Channel-to-Channel Size	Observed Resolution	Theoretical Max. Resolution	% of Max. Resolution
	Microns	Microns	lp/mm	lp/mm	
Bendix	18.7	25.7	17.9	20	89.5
Rauland	12.7	16.5	23.0	30.8	74.7



a.
Bendix MCP

Scale Strip
(10 microns line-
to-line)

b.
Rauland MCP

FIGURE 9 (C)

Microphotographs of Channel Plates

CONCLUSIONS AND RECOMMENDATIONS

(U) Direct readout (vidicon mode) of a thin film target looks very promising. The thin film target formed on a target mesh is inherently rugged. The target electrical characteristics of no halation or lag along with its low light sensitivity make it very attractive.

(U) An alternate approach towards increasing the resolution of an intensifier incorporating an MCP is given. This approach eliminates the proximity focus stage and replaces it with an electromagnetically focused stage at the expense of increasing the tube length by two inches.

PROGRAM FOR NEXT INTERVAL

(U) Test equipment will be completed for tests of both the intensifier vidicon and intensifier orthicon. The final design will depend upon the results obtained from these tests.

(C) Multiplier channel plates with hole center-to-center dimensions of one mil or less have been ordered from Rauland Corporation. In the past, electron gain from Rauland plates have been good. A solution will be sought to the problems encountered with the five Bendix MCP's now on hand. A request for quotation on MCP's having a usable area of one inch and reduced hole to hole dimensions has been sent to Mosaic Fabrications, Inc.

(U) While awaiting the arrival of good MCP's, a vidicon similar to the layout of Figure 6 will be made. In this manner, the electron optics of the combination of the two-inch image section coupled to the 1-1/2 inch magnetically focused and deflected readout gun will be tested. Refinements of the techniques used in fabricationg the thin film MgO target on nickel mesh will be made.

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13 ABSTRACT

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Intensifier vidicon						
Multiplier Channel Plate						
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