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APPLIED RESEARCH ON SEC AMPLIFICATION CAMERA TUBE

TECHNICAL DOCUMENTARY REPORT NO. ASD-TDR-63-840
September 1963

AF Avionics Laboratory
Research and Technology Division
Air Force Systems Command
Wright-Patterson Air Force Base, Ohio

(Prepared under Contract No. AF33(657)-9190
by Westinghouse Electric Corporation, Pittsburgh;
G. W. Goetze, A. H. Boerio, H. Shabanowitz, authors)

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FOREWORD

This is the final report for the Westinghouse applied research program on an SEC amplification camera tube under Air Force Contract AF33(657)-9190. The work was done jointly by the Research Laboratories and the Electronic Tube Division during the period from December 1962 through June 1963. The work was done for the Aeronautical Systems Division under the cognizance of Mr. Melvin R. St. John, Air Force Project Scientist, Electronic Technology Laboratory*, Wright-Patterson Air Force Base.

This report was prepared by Dr. G. W. Goetze, and Mr. A. H. Boerio of the Westinghouse Research Laboratories and Mr. H. Shabanowitz of the Electronic Tube Division. Acknowledgement is made to Messrs. A. E. Anderson, J. A. Hall, J. L. McIntyre, and W. H. Kennedy for their technical and editorial contributions.

*Presently designated Electronic Technology Division of the AF Avionics Laboratory.

ABSTRACT

The report describes the design, construction, and evaluation of several experimental camera tubes employing the SEC target, stressing the compatibility of SEC targets with photocathodes of the S-20 type. It covers special problems connected with scanning the SEC target by a low-velocity direct beam and discusses, as a solution to the problem of target crossover under overload, the use of an additional screen in front of the reading side of the target. From the experimental data presented, it is concluded that camera tubes of the type described compare favorably in over-all performance with conventional camera tubes using return beam readout, while presenting several practical advantages due to the use of the SEC target.

PUBLICATION REVIEW

"This report presents the scientific findings of an Air Force sponsored program. It does not direct any specific application thereof. The report is approved for publication to achieve an exchange and stimulation of ideas."

William H Nelson
WILLIAM H. NELSON
Technical Manager (Sensor & Display)
Physical Electronics Branch
Electronic Technology Division

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1. INTRODUCTION

The performance of a camera tube, and especially its sensitivity, can be improved by multiplying the electronic charge emitted by the photocathode prior to storage and the subsequent scanning for readout. One possible method of achieving such a prebeam gain is the efficient and lagless conversion of high energy electrons into a larger number of low energy electrons. Based on this approach, a new type of storage target for use in camera tubes has recently been developed at the Westinghouse Research Laboratories.[1,2] The target operates on the principle of Secondary electron Emission and Conduction (SEC) in a low density layer of an insulator under excitation of KeV electrons.

The application of SEC targets to camera tubes with direct beam readout has been demonstrated to be feasible under Contracts AF33(657)-8017 and AF33(657)-8676. This work together with related projects[3,4] advanced our understanding of the physical phenomenon involved, achieved reproducibility and a high degree of reliability in target performance and preparation, and demonstrated the characteristics essential and desirable for advanced camera tubes. A number of areas yet to be studied were undertaken under the contract covered by this report. Examples are the possible interaction between the target and materials used for processing photocathodes of the S-20 type, and the safe operation under input signal overload.

Since the question of materials compatibility could be answered only by experiments performed in sealed off vacuum envelopes, it seemed logical to build a certain number of complete tubes, including a scanning gun, instead of conducting separate investigations. Although this approach involved a certain risk, it appeared justified by enabling a direct comparison of the performance of these experimental tubes with other camera tubes, thus eliminating the need for extrapolation.

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Section 2 of this report reviews and summarizes the function and operation of the SEC target as applicable to this contract. Section 3 presents the design, construction, and evaluation of the experimental tubes built. Included in the scope of this program was the consideration of such performance parameters as halation, which are normally not readily accessible through quantitative measurements, but which are important for the general assessment of the quality of the transmitted picture.

2. THE SEC TARGET

2.1 GENERAL DESCRIPTION

Although the SEC target has been described in detail elsewhere, a brief summary of its more important features is included here. The target consists of a supporting layer of 500 to 1000 Å of Al_2O_3, on which is evaporated a conductive layer of 500 Å of aluminum. The aluminum is covered by a low density deposit of KCl with a thickness of approximately 25 μ and a density of only 2% of the bulk density of KCl, corresponding to a mass per unit area of 100 μ gm/cm^2 (reference 5).

In operation, the target is polarized by applying a positive voltage to the Al-layer and stabilizing the KCl surface at ground potential (gun cathode potential). Electrons with an energy of approximately 10 KeV impinge onto the target from the Al_2O_3 side. This energy is high enough so that the electrons penetrate the aluminum oxide layer and the aluminum electrode and dissipate a large fraction of their initial energy within the low density layer of KCl, where they create conduction electrons and free secondary electrons. Charge transport due to conduction electrons is avoided because of the interparticle barriers and the comparatively low electric field across the layer. A fraction of the free secondary electrons is emitted from the KCl surface and collected by the wall screen, whereas part of the free electrons flows through the voids of the porous layer to the backplate.

The distinguishing features of the SEC target are that it uses free electrons for multiplication and charge storage and that conduction due to electrons in the conduction band can be avoided. It is therefore possible to obtain a high speed of response, limited ultimately only by the transit time of free electrons across the target thickness under the action of the applied polarizing voltage. This time is very short and negligible in comparison with the beam discharge lag. Thus the target can be read out completely within one frame. The target is relatively free of trapping sites so that carriers subsequently released from these sites are not sufficient in number to regenerate the image.

The electric field across the layer for optimum operation is of the order of 10^4 volts/cm, which accounts for the very low dark current. A resistivity of greater than 10^{18} ohms·cm is typically measured with the SEC target.

Maximum gain is reached whenever all the secondary electrons produced are either collected by the wall screen or by the backplate. Since the mean energy expenditure per free secondary electron formed can be assumed to be of the order of 30 eV, the maximum gain for 9 KeV primary energy is about 9000/30, or 300. This estimate does not take into account the average energy lost by the primary electron in penetrating the base layer of Al and Al_2O_3. Since the latter is typically 3 KeV, 12 KeV primary energy will be needed for gains of 300, as is also indicated by the measured values.

Since the image amplification takes place entirely within a thin membrane, amplification is achieved in an inherently high resolution process. Having a signal storage capacity of about 800 $\mu\mu F/cm^2$ and yet requiring no artificial cellular structure, the target is well suited for a high gain camera tube to be used for viewing low contrast scenes.

2.2 SPECIAL PROBLEMS CONNECTED WITH SCANNING THE SEC TARGET

One major complication occurs in scanning the SEC target. Depending on signal intensity, integration time, and backplate voltage, the free electrons liberated within the target may migrate to the conductive backing layer or may be emitted from the scanned surface and then collected instead by the wall screen which separates the unipotential deflection space from the decelerating region in front of the target. If this mesh is operated at a potential of 200 to 300 volts or higher, as is normally the case, the exit surface of the target may become sufficiently positive, due to an intense signal or a temporary interruption in the scanning beam, to exceed first crossover potential for the reading beam electrons. In this case, the beam will cause further secondary electron emission, which will in turn eventually charge the scanned surface to wall screen potential rather than back down to cathode potential.

Under these circumstances, signal reversal will take place and what is essentially the total wall screen voltage will appear across the target layer. If this voltage is low (50 to 100 volts), the operation of the tube will be interrupted until normal conditions are re-established; for example, by reducing the wall screen potential to a value below first crossover for the target, which is about 20 volts. If, on the other hand, the wall screen potential is much higher, as is desirable for optimum gun performance, the resulting higher field across the layer under signal overload may cause permanent damage to the target.

Since the probability of accidentally exposing a camera tube to too strong a signal is very high in any practical application, this problem was given prime consideration in the design of the experimental tubes. Among the several approaches possible, it was decided to choose the one which had the advantages of simplicity and direct applicability. A stabilizing mesh closely spaced in front of the scanned surface of the target and held at a potential of approximately 25 volts was used to limit the maximum voltage excursion of the target exit surface to this value[6]. This method made the operation of the tubes built under this contract completely safe against signal overload or accidental beam current interruptions.

2.3 TARGET COMPATIBILITY WITH PHOTOCATHODE MATERIALS AND TUBE PROCESSING

Prior to this contract, the performance of the SEC target had been tested and evaluated in demountable systems with ultraviolet-sensitive photocathodes of the heavy metal type. The demountable system could not be subjected to elevated temperatures, so that no knowledge existed on target behavior during or after vacuum bake. This information was obtained from a parallel program[3,4] involving the construction of sealed-off tubes with photocathodes sensitive in the ultraviolet portion of the spectrum. This related program established the fact that the SEC target could be exposed to normal tube processing techniques, including vacuum bake at moderate temperatures (150°C - 325°C) without adverse effects. No information, however, was yet available on the compatibility of the SEC target with materials released in the tube envelope during processing of photocathodes of the S-20 type.

Under the program covered by this report, a total of eight tubes were built, each containing an internally processed S-20 cathode together with an SEC target. The average photocathode efficiency of these tubes was 110 μamp/lumen, with a maximum efficiency of 175 μamp/lumen. Considering the fact that no previous experience existed in processing an S-20 cathode in this particular structure and that no allowance was made for incidental effects like poor vacuum, etc., these figures can be taken as evidence that the presence of an SEC target does not interfere with processing of standard S-20 cathodes within the same envelope.

It was also established from the electrical evaluation of the tubes, as described in Section 3, that the formation and presence of an S-20 photocathode in the same vacuum envelope does not adversely affect the function of the target. The over-all target performance as well as individual parameters, like gain, dark current, resolution, and storage capability, were found to be consistent with those measured in demountable systems or in sealed-off tubes with ultraviolet-sensitive cathodes of the Cs-I or Cs-Te type. The observed average target performance as well as the variation from tube to tube are consistent with this conclusion.

3. EXPERIMENTAL TUBES

3.1 DESIGN AND CONSTRUCTION OF EXPERIMENTAL TUBES

In order to economize the total program, it had been decided to build complete tubes for evaluation in terms of over-all performance. To further concentrate the available time and effort on the principal problems involved, i.e., the question of photocathode-target interaction and stability of operation under signal overload, it was additionally decided to construct the tubes with, or around, existing pieces of hardware available from other programs.

Obviously this approach was not intended to yield tubes which were optimized in every respect. For example, no attempt was made to minimize the geometrical dimensions or even to obtain ultimate resolution. However, certain minimum values established for the individual components had to be ascertained by separate experiments in order to guarantee success for the experimental tube program.

The performance of the image section, which is a slightly modified WX4970 front end, was evaluated by building and testing sealed-off models in which a P-11 type phosphor was used in place of the target. When the image diode was operated in a 80 to 120 gauss focus field, a resolution of at least 28 lp/mm was observed with very little fall-off at the edges. This resolution was judged to be adequate. Additional information was obtained on the processing techniques for S-20 type photocathodes in this structure during the construction of the image section dummies.

For scanning the 1 inch diameter target, a simple electron gun was designed to operate with moderate deflection angles. It consists basically of a modified vidicon triode section mounted in a shortened image orthicon stem. The aluminum coated inside wall of the stem serves as part of the G_3 electrode. The operation of this gun was tested by building two complete vidicons with a 1 inch diameter photoconductive surface in place of the SEC target. The first of these models could not be operated due to insufficient emission of the thermionic cathode, but the second operated satisfactorily, after initial difficulties caused by an intermittent contact between the wall screen and the G_3 electrode. The difficulties were overcome by a direct connection to the mounting pins of the wall screen which were accessible externally. The resolution observed with this tube was 1000 TV lines per target diameter.

At this point, the over-all performance of the 1 inch vidicon together with the information obtained from the image diode tubes was considered sufficient to proceed with the construction of the first complete SEC vidicon. A cross-sectional view of the SEC vidicon, together with the important geometrical dimensions, is shown in Figure 1. Figure 2 is a photograph of a sealed-off tube.

A special feature of the tube is that the wall mesh (G_4) is electrically disconnected from the G_3 electrode in order to enable operation of these electrodes at different potentials thereby eliminating the need for an auxiliary mesh to prevent target crossover. This arrangement gave adequate performance of the scanning section, i.e., resolution and beam landing characteristics, although the potential applied to the G_4 electrode had to be kept below +50 volts.

Seven tubes of the described type were built. An eighth tube included an additional mesh (G_5) located between target and G_4 electrode for stabilization of the target. Unfortunately, the performance of this tube could not be evaluated properly because of internal leakage in the target-G_5-G_4 assembly. Out of the first seven tubes, six tubes were operable and have been evaluated. Table 1 lists the sealed-off tubes constructed, including date of tip-off, photocathode response, and other pertinent remarks.

3.2 TUBE EVALUATION

In order to operate the tubes in the absence of a standard system to accommodate them, a camera head was constructed. It was decided to build the equipment in such a manner that it could be supplied to ASD together with the one tube required for evaluation, thereby facilitating additional testing there without need for improvisation.

Figure 3 shows a photograph of the SEC camera complete with cover and lens, and Figure 4 shows the same unit with cover removed. The preamplifier is mounted on one side of the focus coil, with the voltage

SEC VIDICON

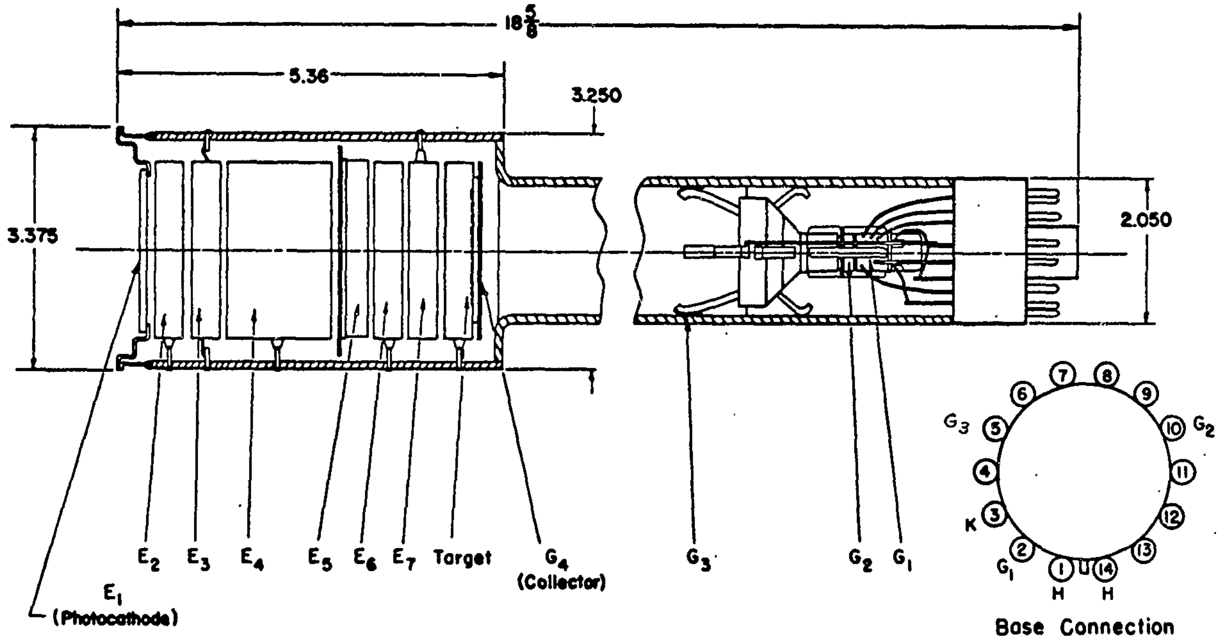


Figure 1 -- Cross section of SEC vidicon

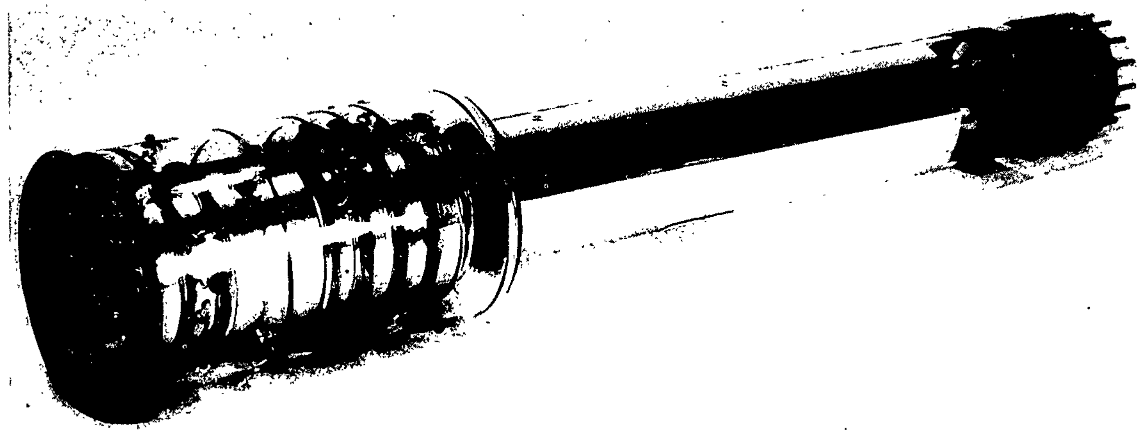


Figure 2 SEC Vidicon

TABLE 1

SEALED-OFF TUBES: CHARACTERISTICS AND DISPOSITION

Item	Completed	Disposition	Remarks	
1. Image Section No. 1	11-16-62	On hand	Photocathode: Sb-Cs 55 ua/l Phosphor: P-11	Resolution: 28 line pairs/mm at center (min.) with little fall off at edges
2. Image Section No. 2	11-23-62	On hand	Photocathode: Sb-Na-K-Cs 20 ua/l Phosphor: P-11	
3. Vidicon Gun No. 1	11-21-62	On hand	Low emission	
4. Vidicon Gun No. 2	11-21-62	On hand	Resolution: 1000 TV lines per target inch	Intermittent connection to wall-screen
5. SEC Vidicon No. 1	12-13-62	Tube opened	Photocathode: Sb-Na-K-Cs 70-80 ua/l wrinkled target, Gassy heater	Resolution: 750 TV lines
6. SEC Vidicon No. 2	1-23-63	Delivered to ASD	Photocathode: Sb-Na-K-Cs 115-125 ua/l Target: "Tension wrinkled" Low thermionic emission Gassy heater	
7. SEC Vidicon No. 3	1-29-63	Delivered to ASD	Photocathode: Sb-Na-K-Cs 175 ua/l (Avg) Target: Smooth, tight Adequate thermionic emission	Good tube. Light from heater interfering with low light level measurements
8. SEC Vidicon No. 4	2-21-63	On hand	Photocathode: Sb-Na-K-Cs 80 ua/l (Avg) Target: Smooth, tight Fair thermionic emission	
9. SEC Vidicon No. 5	3/7/63	Delivered to ASD	Photocathode: Sb-Na-K-Cs 42 ua/l (Avg) Target: Smooth, tight Good thermionic emission G-3 to T-M spacing larger than normal.	
10. SEC Vidicon No. 6	4/1/63	On hand	Photocathoue: Sb-Na-K-Cs 92 ua/l (Avg) Target: Smooth, tight Low thermionic emission	
11. SEC Vidicon No. 7	5/14/63	On hand	Photocathode: Sb-Na-K-Cs 135 ua/l (Avg) Target: Smooth, tight Fair Thermionic emission	
12. SEC Vidicon No. 8	6/3/63	On hand	Photocathode: Sb-Na-K-Cs 140 ua/l (Avg) Target: Smooth, tight, some blemishes Leakage in TM-assembly. Fair thermionic emission, double mesh tube	

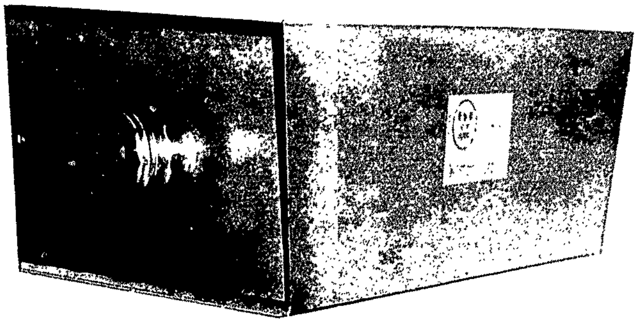


Figure 3 -- SEC camera head.

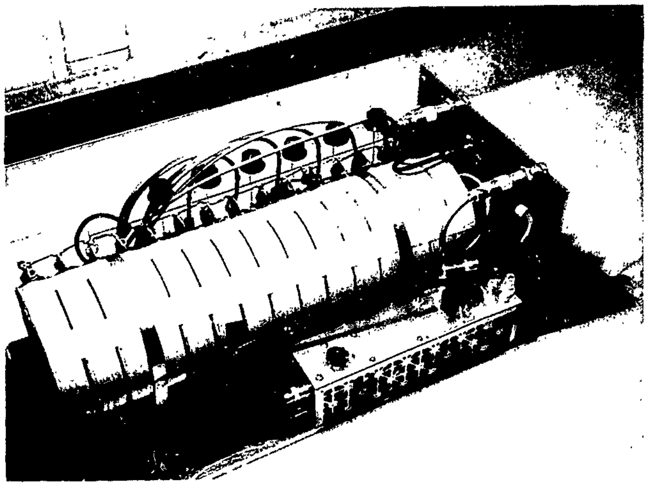


Figure 4 -- Internal view of SEC camera head.

divider for the image section visible to the rear of the magnet. All electrical connections are made through the back. The focus coil consists of 15 individual segments connected in series. Each of these segments is connected in parallel with a resistor to give the advantage of fine adjustement for uniformity of the focus field and to serve at the same time as a damping element to reduce oscillations caused by the deflection fields; this arrangement worked satisfactorily. A set of standard image orthicon deflection coils was used. Except for the high voltage power supply for the image section (-10 KV), the rest of the equipment needed to operate the SEC camera is quite standard, although a special system providing a wider than normal range of all operating values was used for the evaluation of the tubes at Westinghouse. Table 2 gives the range and typical ratings for the SEC vidicon.

All six tubes which were operable gave a good quality picture with no detectable lag, even at threshold light levels. Typical resolution was between 650 and 750 TV lines per target diameter. Figure 5 is a photograph of a resolution pattern (USAF 1951 test chart) as transmitted by one of the tubes and photographed from the monitor. By careful adjustment of all operating parameters which affect the resolution and by underscanning the target, a resolution of better than 1000 TV lines per target diameter was observed. From these measurements and other considerations[1], it was concluded that the resolution in present tubes is limited by tube and equipment parameters rather than by the target itself.

Figure 6 is a photograph of the monitor taken under above conditions and showing group 4-3 resolved, corresponding to 1000 TV lines/inch.

The resolution figures quoted were obtained for a PC-illumination of the order of 10^{-4} ft-candles and with reduced field mesh potential (25 to 40 volts) at which the tubes were completely stable; that is, no runaway occurred even when the tube was subjected to full room light.

The sensitivity was measured by determining threshold resolution as a function of photocathode illumination, at the conventional scan rate of 30 frames/sec. The noise equivalent current of the video amplifier was 2×10^{-8} amps at an over-all system bandwidth of 11 Mc/sec. The sensitivity was found to vary from tube to tube depending on PC-efficiency, target gain, and tube background. The maximum variation in sensitivity between the tube with the poorest performance (No. 6) and the best tube

TABLE 2

SEC VIDICON OPERATING VOLTAGES

Gun Section	Range (volts)	Typical (volts)
G_1	0 to -90	0
G_2	+200 to +300	+250
G_3	+200 to +300	+250
G_4	0 to +50	+30
Target	0 to +30	
Heater	6.3 volts 0.6 amps	

Image Section		
Electrode No. 1 (Photocathode)	-6 to -12 KV	
Electrode No. 2	85 to 93	In % of Electrode No. 1 voltage
Electrode No. 3	71 to 79	
Electrode No. 4	45 to 59	
Electrode No. 5	29 to 36	
Electrode No. 6	20 to 26	
Electrode No. 7	10 to 14	

Focus Field

70 - 100 Gauss

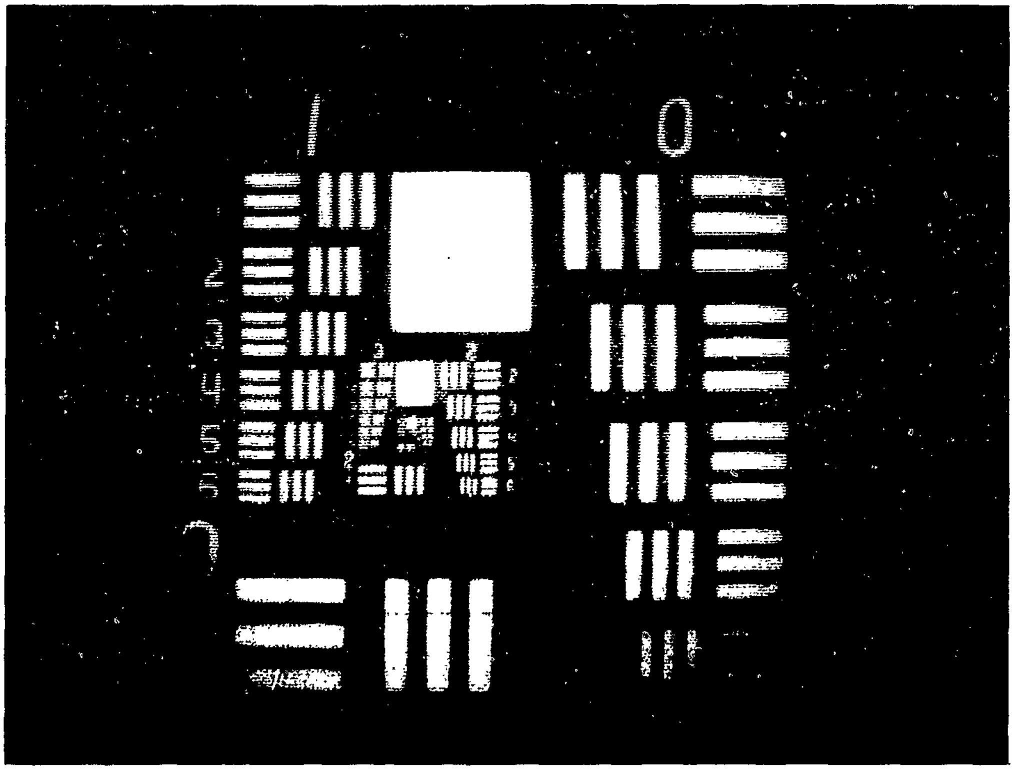


Figure 5 Resolution Pattern As Transmitted By Electromagnetically Focused SEC Vidicon

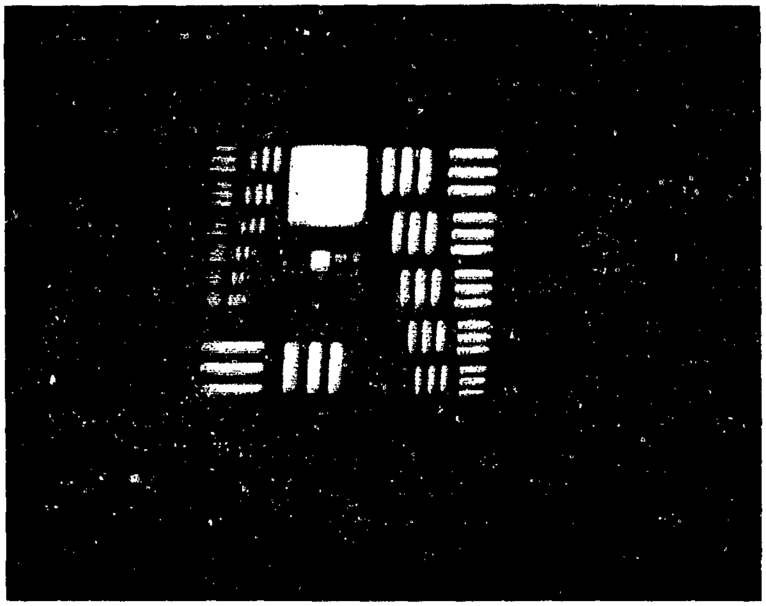


Figure 6 -- Test pattern with underscan (portion of preceding)

(No. 3) was, however, less than one order of magnitude in illumination required for any line number resolved. This good degree of reproducibility was obtained even though some of the targets were prepared at Research and some at the Tube Division by different personnel.

Figure 7 gives the limiting resolution in TV-lines/inch as a function of photocathode illumination for Tube No. 3 for a 100% contrast and a 10% contrast input. Representing what is considered a typical performance for the experimental SEC vidicons, these curves should not be interpreted as optimum values. While the curves in Figure 7 give an indication of the sensitivity of the SEC vidicon, they convey only part of the performance characteristic; because these tubes employ direct beam readout, the picture appears quiet at all beam current settings being inherently free from beam shot noise. As a result, the beam may be set at a value sufficient to discharge the highlights in any scene which the tube could reasonably be required to image. No re-adjustments are required when the tube is used for viewing with little light.

Comparable testing with an image orthicon shows that a dynamic range of 12, or at most 18, can be accommodated with a single beam current setting, and that to accommodate these ranges, the beam current must be larger than is optimum. Therefore, although figures as low as 2×10^{-7} ft-candles are quoted for an image orthicon to give threshold pictures, this performance is only obtained if the beam current is set so low that the IO would not operate if any highlights in the scene exceed about 5×10^{-6} ft-candles. In contrast, the threshold figure for the SEC vidicon (5×10^{-6} ft-candles) in its present form was obtained with a beam current set to handle a dynamic range of up to 150. This may point to great usefulness of the SEC device for remote operation, since beam current adjustment seems extremely difficult to provide in this case.

Another interesting characteristic of the SEC vidicon which is not directly evident from standard performance data is the absence of pronounced halation around areas of very high illumination. In some conventional camera tubes, this phenomenon interferes severely with the ability of detecting weak signals in the presence of strong signals, because of the masking effect caused by returned secondary electrons and reflected primary electrons during target saturation. From the mode of operation of the SEC target and the electric field configuration near the

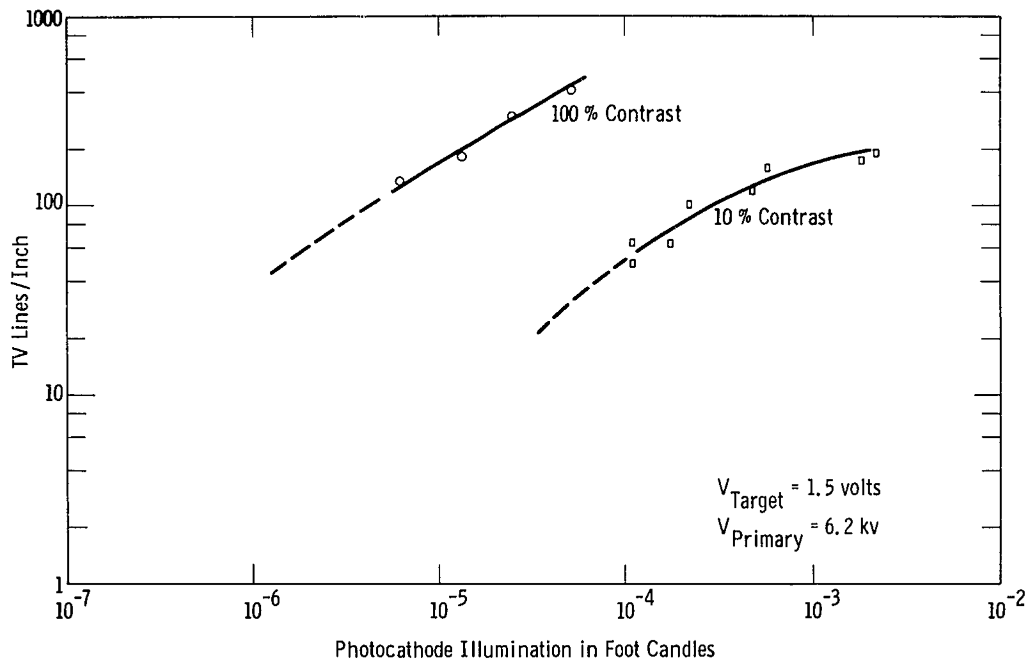
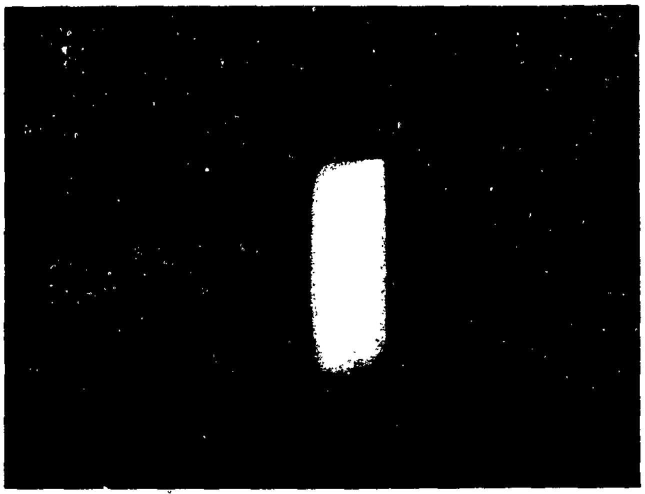


Figure 7 Limiting Resolution vs Photocathode Illumination, SEC Vidicon

scanned surface of the target, it is evident that the "black halo", the most objectionable form of halation, should indeed be greatly reduced. The only halation effect observable is caused by returned primary electrons; because of the comparatively high excursion tolerable for the exit surface potential, halation due to returned secondary electrons is not observed. In order to convey a qualitative impression of the SEC performance in this respect, Figure 8 shows two photographs of the image of a white bar taken from the monitor for a change in photocathode illumination by a factor of 10^2 with the tube operating under identical conditions. For comparison, reference is made to a similar picture taken with the image orthicon and published in the book "Television" by V. K. Zworykin and G. A. Morton on page 372, 2nd edition.

During similar experiments, and in order to test tube operation for signal overload, several of the tubes have been exposed repeatedly to very strong signals of the order of 10^5 times higher than normal. As was pointed out earlier, the tubes operated in a completely stable manner under these conditions and continued to transmit low light level scenes after the excess illumination was removed. It was noticed, however, that the area of the target which had been exposed to these strong signals showed a temporary decrease in gain by a small, but detectable amount. These areas of overexposure returned to normal operation after a period of several seconds, depending on the amount of previous overload. The reason for this behavior has not been established firmly. It could be verified, however, that the effect is reversible and does not affect the performance of tubes during later operation.

(a) Image of white bar at threshold illumination



(b) Same image and same tube settings at 10^2 times threshold illumination

Figure 8 -- Halation effect of SEC vidicon

4. CONCLUSION

The construction of several experimental SEC vidicons showing satisfactory operating characteristics has demonstrated the practicability of this type of device for remote viewing at moderate scene illuminations (10^{-4} to 10^{-6} ft-candles) under continuous scanning. In particular, it was shown that the processing of multialkali photocathodes within the same vacuum envelope does not adversely affect the performance of the SEC target, thus making it possible to combine the very high sensitivity of the S-20 photocathode in the visible part of the spectrum with the unique advantages of the SEC target. The previously existing problem of target crossover was successfully solved for tubes with standard TV resolution.

In conclusion, SEC target tubes of the type developed under this contract are comparable in over-all performance with the standard image orthicon and, in addition, provide the potential of overcoming some of the inherent limitations of the image orthicon and the intensifier orthicon.

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1	Commanding General Frankford Arsenal Attn: Dr. M. L. Chwalow Philadelphia 37, Pa.
	OTHER U.S. GOVERNMENT AGENCIES
20	DDC Cameron Stn. Alexandria, Va.
4	Advisory Group on Electron Devices 346 Broadway, 8th Floor New York, N.Y. 10013

Cys	OTHER U.S. GOVERNMENT AGENCIES (cont'd)
1	NASA Manned Space Craft Center IESD, Rich Bldg. Attn: Max Engert 6040 Telephone Rd. Houston, Texas
1	NASA Goddard Space Flight Center Attn: Mr. J. Moody Bldg 3, Rm L8 Greenbelt, Md.

NON-GOVERNMENT INDIVIDUALS AND ORGANIZATIONS

1	The Rand Corp. Attn: Librarian 1700 Main St. Santa Monica, Calif.
2	Radio Corp. of America Electron Tube Div. Attn: Mr. Don Garvin Lancaster, Pa.
1	Radio Corp. of America Astro Electronics Div. Attn: Dr. Sidney Gray Princeton, N. J.
1	General Electric Co. Pickup Tube Operation, Power Tube Dept. Attn: Dr. H. Hannum Bldg. 6, Electronics Park Syracuse, N. Y.
1	Hollamore Electronics Div. Attn: R. VanWechel 714 North Brookhurst St. Anaheim, Calif.
1	CBS Laboratories 227 High Ridge Rd. Stamford, Conn.
1	Nortronics Attn: Mr. R. H. Lane 222 North Prairie Ave. Hawthorne, Calif.

Cys	NON-GOVERNMENT INDIVIDUALS AND ORGANIZATIONS (cont'd)
1	Bendix Radio Div. of Bendix Aviation Corp. Attn: Mr. P. Erlich Joppa Road Towson, Md.
1	AB DuMont Labs. Div. Fairchild Camera Instrument Corp. Attn: Mr. K. Hoagland 760 Bloomfield Ave. Clifton, N. J.
1	Vare Industries Attn: Mr. H. Beste 128 W. First St. Roselle, N. J.
1	Westinghouse Electric Corp. Electronic Tube Div. Attn: J. A. Hall P. O. Box 284 Elmira, N. Y.
1	Westinghouse Electric Corp. Air Arm Div. Attn: Mr. Robert Lee Baltimore, Md.
1	Aeronutronic Div. Ford Motor Co. Attn: Library Ford Rd. Newport Beach, Calif.
2	Defense Research Member Canadian Joint Staff 2450 Massachusetts Ave., N.W. Washington 8, D. C.
3	Scientific Information Officer British Defense Staff Defense Research Staff British Embassy 3100 Massachusetts Ave. Wash. 8, D. C.
1	Kitt Peak Observatory Attn: Dr. Wm. C. Livingston 950 N. Cherry Ave. Tucson, Ariz.

Cys	NON-GOVERNMENT INDIVIDUALS AND ORGANIZATIONS (cont'd)
1	University of Minnesota Institute of Technology Dept. of Electrical Engr. Attn: W. G. Shepherd Minneapolis, Minn.
20	Office of Technical Services 1200 South Eads Street Arlington, Va.

Air Force Avionics Laboratory, Research and Development Div., AFSC, Wright-Patterson AFB, Ohio
Rpt. No. ASD-TDR-63-840. APPLIED RESEARCH ON SEC AMPLIFICATION CAMERA TUBE. Final report, Sept 63, 22p. incl. illus., tables, 6 refs Unclassified Report

The report describes the design, construction, and evaluation of several experimental camera tubes employing the SEC target, stressing the compatibility of SEC targets with photocathodes of the S-20 type. It covers special problems connected with scanning the SEC target by a low-velocity direct beam and discusses, as a solution to

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the problem of target crossover under overload, the use of an additional screen in front of the reading side of the target. From the experimental data presented, it is concluded that camera tubes of the type described compare favorably in over-all performance with conventional camera tubes using return beam readout, while presenting several practical advantages due to the use of the SEC target.

UNCLASSIFIED

1. Camera tubes
2. Television cameras
3. Secondary emission
4. Electrophotography
I. Contract AF33(657)-9190
II. Westinghouse Electric Corp., Pittsburgh, Pa.
III. G. W. Goetze, et al.
IV. Secondary Rpt. No. 63-912-255-R8
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