

PRINCETON UNIVERSITY OBSERVATORY
Princeton, New Jersey

FINAL REPORT
NSr-31-001-127

"DEVELOPMENT AND EVALUATION OF TELEVISION TUBES
FOR SPACE ASTRONOMY"

for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington, D.C.
May 10, 1974

PURPOSE

Develop television type image sensors, sensitive in the visible and ultraviolet, capable of long exposures at high spatial resolution, and otherwise suitable for space astronomy applications.

PERSONNEL

Principal Investigator	-	Prof. Lyman Spitzer
Research Staff	-	Mr. John L. Lowrance Mr. Paul Zucchini Mr. John Opperman Mr. Patrick Murray

FISCAL STATUS

Value of Contract	464,958
Expenditures as of March 31, 1974	464,958
Balance	-0-

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I. BACKGROUND

In 1964 Princeton University began a study of the best type of television type image sensor for future space astronomy missions in the visible and ultraviolet spectrum. This study concluded that the SEC-vidicon offered the most overall potential. This was largely based on its ability to integrate the photoelectron image for long periods of time as required in many astronomical observations. This study was followed by a program to make ground based observations using an SEC-vidicon camera on the 36" telescope of the Princeton University Observatory in order to indicate whether the SEC vidicon camera had the operational characteristics required for spectrophotometry and imaging. These tests were encouraging and the program was continued to make improvements to the television tubes that would make them more suitable for astronomical observations.

These improvements included reducing the internal background of the tube, removing a mesh used to stabilize the KCl target and working out a mode of sequential operation that would still be safe. Considerable work was done to develop a reliable way to seal the ultraviolet transmitting windows to the tube and to achieve acceptable photocathode quantum efficiency on these MgF_2 windows. The tubes were redesigned to make them rugged enough to survive a rocket launch. There was also considerable work on the magnetic deflection and focus coils for the tubes. New preamplifier designs were developed to improve the dynamic range by reducing the readout noise. The target assembly was redesigned to reduce the microphonic signals and reduce the shunt capacitance to the rest of the tube since this also affected the readout noise.

Figure 1 gives an overview of the chronological improvement in resolution through the program.

As the tubes improved, it became clear that they were not only good for space applications but could be used to good advantage for some ground-based observations. The camera was used on the Mt. Wilson 60" and the Mt. Palomar 200". It has also been used on a 36" at Kitt Peak and the 106" at McDonald Observatory.

A substantial number of technical and scientific papers have resulted from the program as noted in the attached bibliography.

The WX-31718 (40 mm, UV sensitive) has been flown in an Aerobee sounding rocket and performed well, even after a parachute landing. The WX-31958 (7056 glass window version) has been used extensively by Princeton and others for ground-based observing and is currently being incorporated in a balloon-borne telescope that is a joint venture of the Netherlands and the NASA Johnson Spaceflight Center.

This program has been superseded by a program to develop a 70 mm version of the tube for the Large Space Telescope.

II. STATUS OF SEC-VIDICON DEVELOPMENT

Figure 2 shows in schematic form the SEC-vidicon. A photoelectron from the photocathode is accelerated by 8000 volts; strikes a target causing a charge transfer across the target of approximately 50 electrons. The optical image is integrated as an electrical charge pattern on the target. Following an exposure the electron gun is turned on and the electron beam is scanned across the target depositing electrons in those areas where electrons have been depleted by the exposure. The image section and the electron gun are focused by a magnetic field. Further details of the operation may be found in the references listed in the bibliography.

Figure 3 shows the WX-32192 and WX-31718 which has a magnesium fluoride window sealed to gold foil by frit glass. Table I lists the characteristics of these tubes, as well as a smaller version developed for possible use on the International Ultraviolet Explorer satellite. The photoelectric transfer function for the WX-31718 is shown in Figure 4.

Under NGR-31-001-236 and NAS5-20069 work is continuing to increase the resolution and extend the dynamic range of these sensors.

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CHRONOLOGY OF SEC-VIDICON RESOLUTION IMPROVEMENT AT PRINCETON UNIVERSITY OBSERVATORY

Year	No. of picture elements at 50% MTF
1968	1.6×10^4
1969	4×10^5
1971	1×10^6
1972	4×10^6

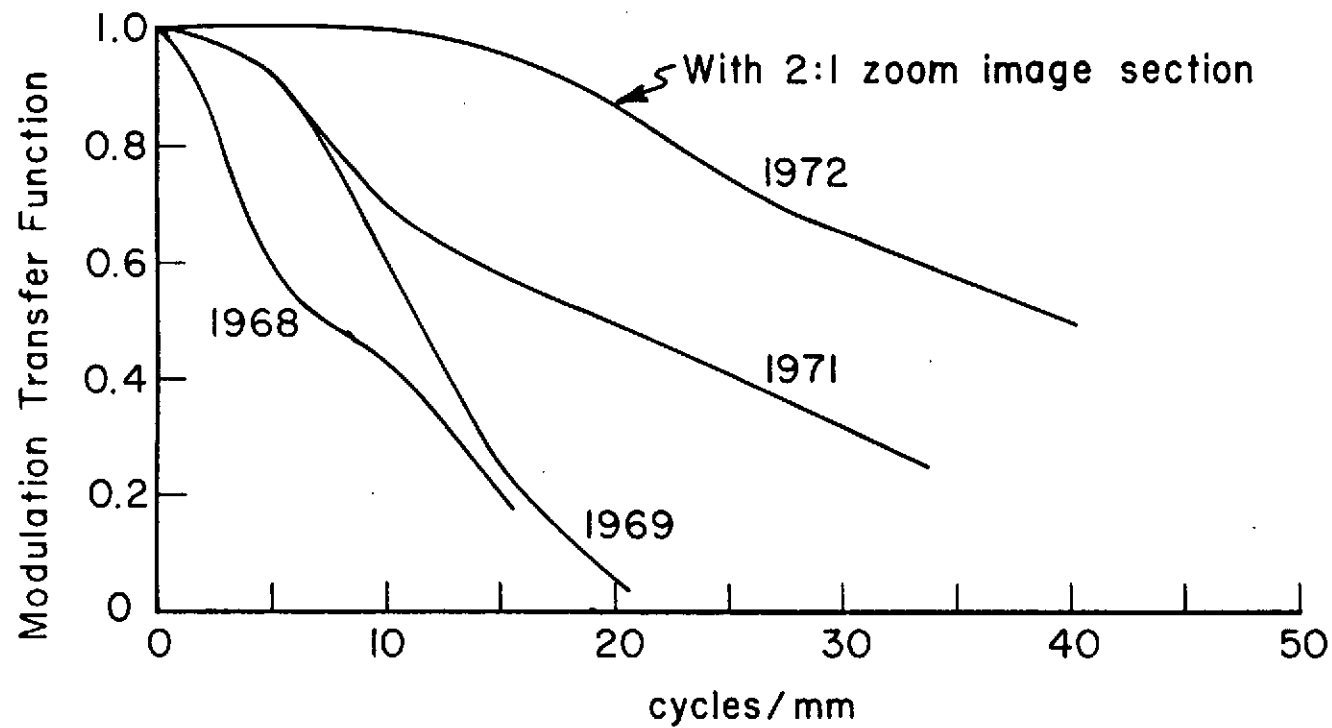


Figure 1

WESTINGHOUSE WX 31718 SEC VIDICON

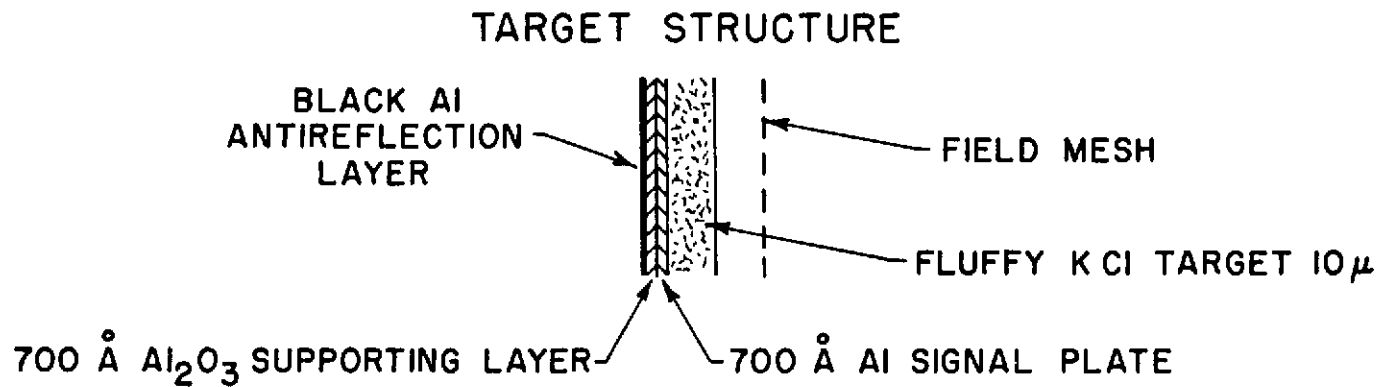
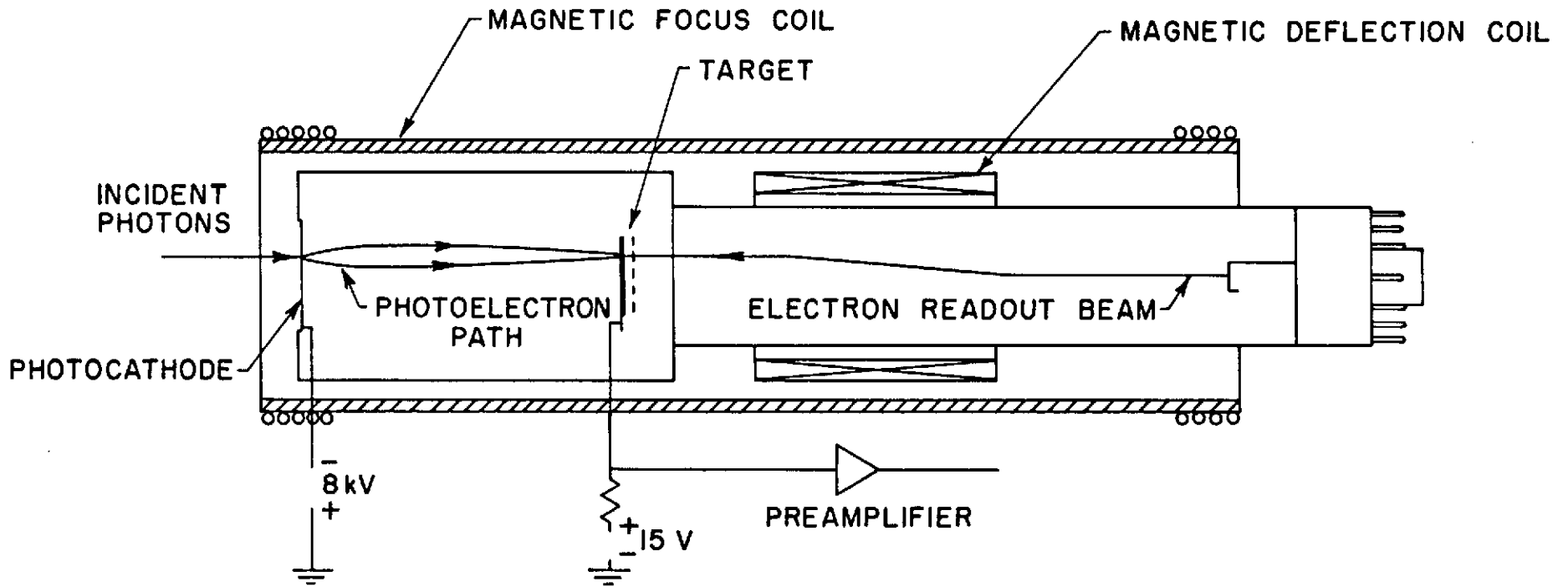
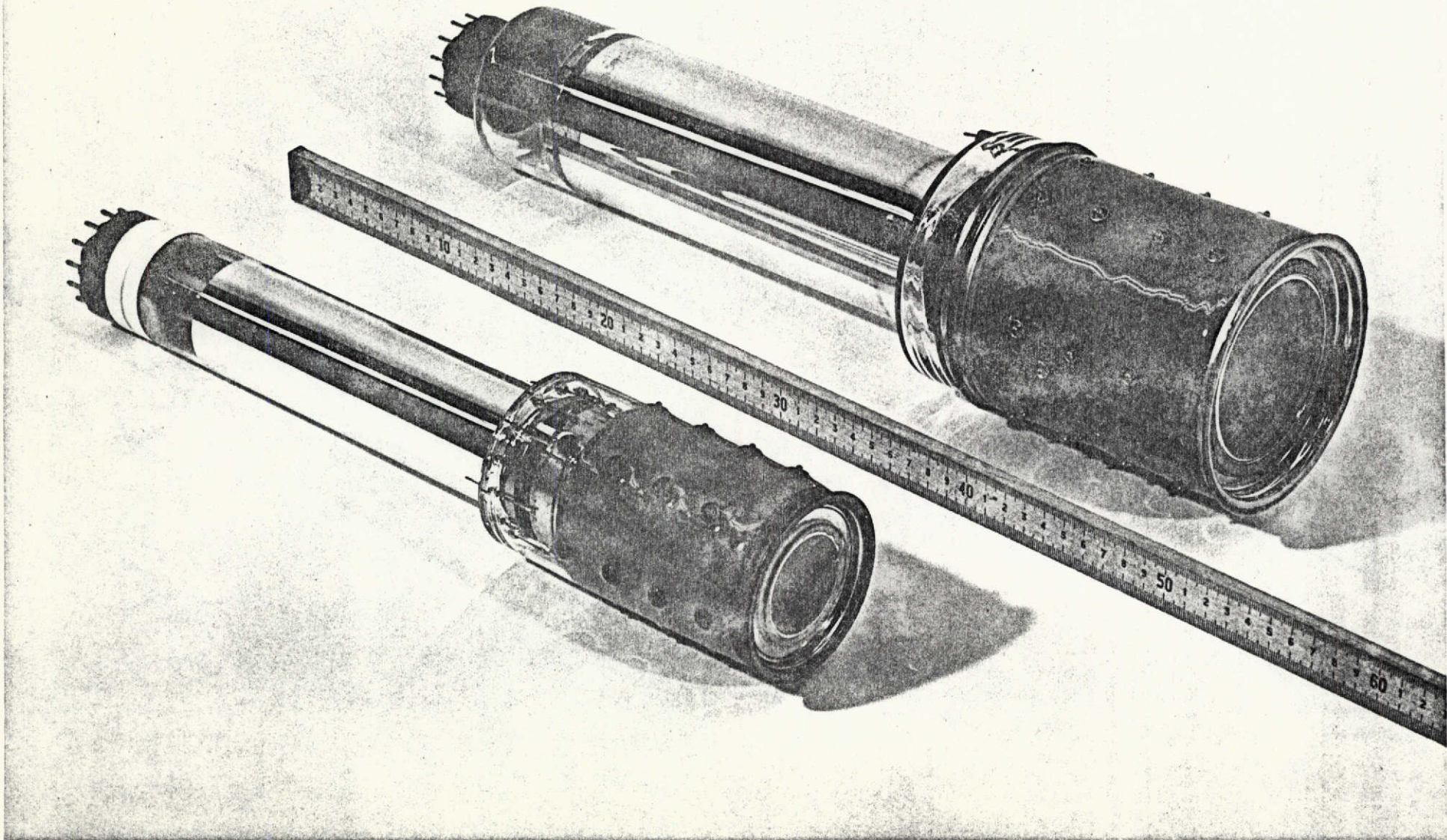


Figure 2

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Figure 3
SEC-VIDICONS

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SEC VIDICON PHOTOELECTRIC TRANSFER FUNCTION

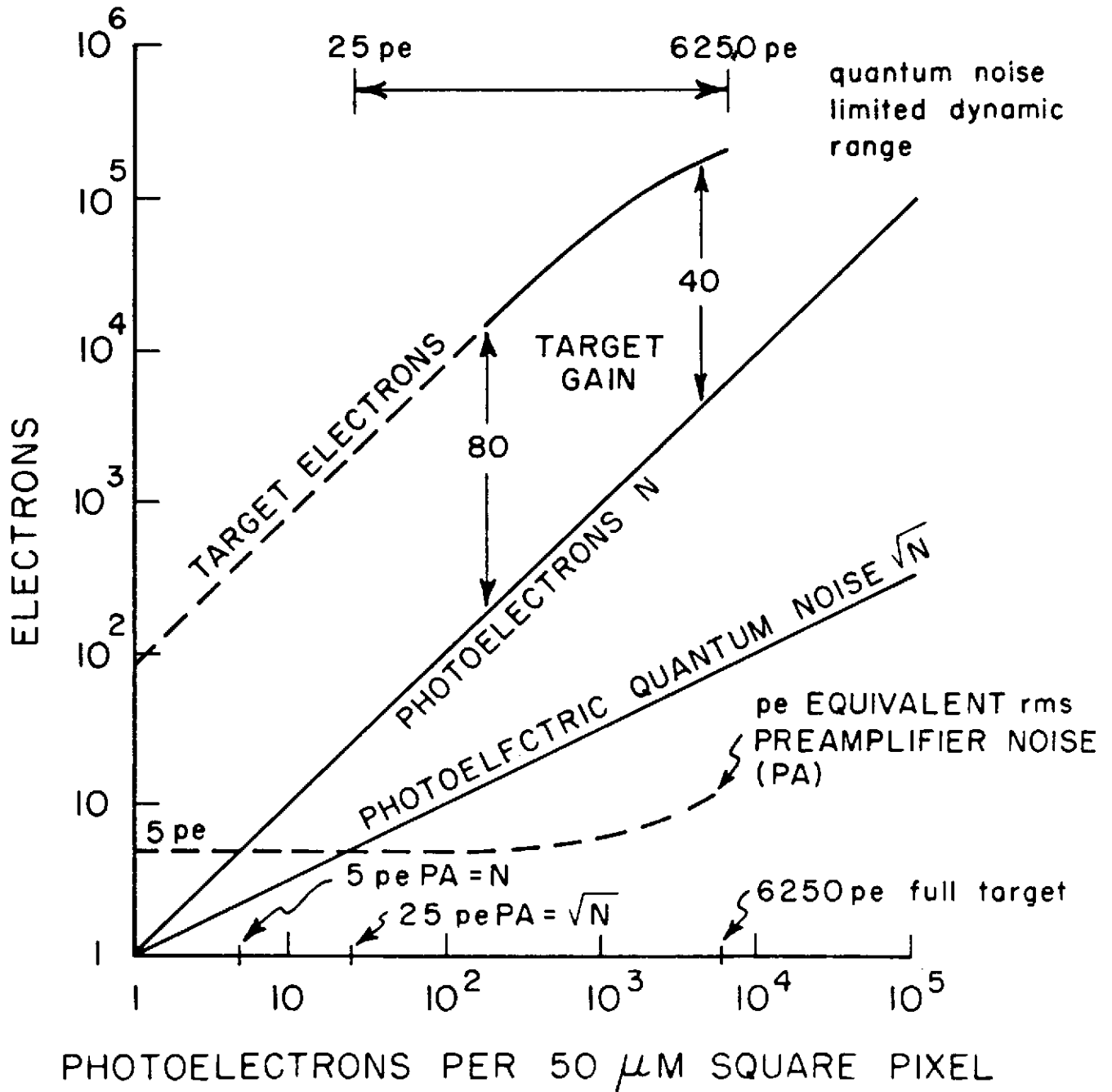


Figure 4

Table 1

	WX-32192	WX-31718	WX-
	Large SEC-vidicon	Medium SEC-vidicon	Small SEC-vidicon
Photocathode Diameter	76 mm 110 mm	38 mm	25 mm
Target Size	56 x 51 mm	25 x 25 mm	15 x 15 mm
Overall Length	487 mm	432 mm	240 mm
Maximum Diameter	128 mm	80 mm	58 mm
Window	MgF ₂ Glass	MgF ₂ Glass	MgF ₂ Glass
Focus Field	80 gauss	80 gauss	80 gauss
Resolution (50% modulation)	20 cycles/mm	20 cycles/mm	20 cycles/mm(?)
No. Picture Elements	4 x 10 ⁶	10 ⁶	3.6 x 10 ⁵
Photocathodes	NaK Sb S-20 ER	NaK Sb S-20 ER	NaK Sb CsTe S-20 ER

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