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A Gated Microchannel Plate Image Intensifier Packaged in a Reflex Camera Back

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We describe a fast (exposures down to ~10 ns) electrically triggered camera back/shutter designed for use with the Hasselblad 500C still camera. This camera back contains a microchannel plate image intensifier which can be gated and provides a gain of approximately ×1000. It reads out on to Polaroid film through a fiber optic face plate. The gated camera back is interchangeable with the regular Polaroid back (or any other) for the Hasselblad 500C and maintains the "through the lens" focusing.

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CONTENTS

A GATED MICROCHANNEL PLATE IMAGE INTENSIFIER PACKAGED IN A REFLEX CAMERA BACK

I. INTRODUCTION

One of the missions of our Experimental Plasma Physics group is to study the interaction of charged particle beams with reduced density channels in atmospheric pressure air. Reduced density channels are produced by lasers or electrical discharges, which emit orders of magnitude more light than is emitted by a channel-electron beam interaction. In order to photograph the interaction it is necessary that the camera shutter be closed during the channel producing discharge and open a few microseconds later for the passage of the electron beam pulse. It was for this reason that this gated image intensifier package was designed.

The proximity focussed microchannel plate intensifier tube (ITT F-4111) used in this package is a continuous operation amplifier of a type used in night vision devices. The first reported use of a channel plate tube as a fast shutter was by Albert J. Lieber in 1972,[1] who achieved a shuttering time of four nanoseconds. N.P.S. King, et al.,[2] reported shuttering times of one nanosecond for the F-4111. The device described in this present paper uses an electrical configuration very close to the one described by these later authors.

The contribution of the present work is one of convenience and versatility. The image intensifier package is mounted, interchangeably, on the back of a reflex camera with its photocathode located at the camera's focal plane and a pack of Polaroid film pressed against its fiber-optic output plate (Figure 1). A scene to be photographed through the image intensifier is focussed through the reflex optics of the camera. No continuous operation

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'focus' mode is necessary for the image intensifier. Further, by replacing the image intensifier package with a regular polaroid film back, the scene can be photographed directly for alignment or reference purposes. Lastly, this image intensifier system has the advantage of a complete camera system: a variety of commercially available accessories and a large variety of lenses each with its own mechanical shutter and iris.

II. DESCRIPTION OF CAMERA

a) Mechanical Detail

The image intensifier package consists of three parts: a metal adapter plate that mates with a Hasselblad 500/C, an aluminum housing that contains the intensifier tube, and a standard plastic Polaroid film pack holder. The adapter plate and the film pack holder make up a standard 500/C Polaroid back. In its operating position, the image tube photocathode is located at the image plane of the camera lens, the output fiber-optic plate is pushing gently against the Polaroid film, and the film pull-tabs are covered by a lever. Pulling the lever to expose the pull-tabs also moves the intensifier tube away from the film, allowing the film to be pulled without wiping on the fiber-optic plate. The only alterations of standard parts necessary for assembly of the package are removal of a glass plate from the metal adapter plate and trimming about one millimeter of the silicone potting compound from the photocathode end of the intensifier tube.

Figure 2 is an assembly drawing of the image intensifier housing. Figure 2a is a view of the side that faces the Hasselblad camera. The coverplate for this side is the metal adapter plate for a Hasselblad supplied Polaroid film camera back. All of the mechanical mating mechanisms are thus between Hasselblad parts. In the operating position, the photocathode of the intensifier tube, including a .185 inch thick silica window, is at the focal plane of the lens.

Figure 2b is a view of the other side of the housing. This side faces a pack of Polaroid film and, in the operating position, the fiberoptic faceplate of the intensifier tube touches the film. The mechanical complexity of the device is due to the necessity of removing the fiberoptic faceplate from the Polaroid film when the film is being pulled. The intensifier and holder are moved away from the film by raising the thumb lever from its normal vertical position to a horizontal position. This motion not only moves the intensifier but it also uncovers the film tabs so that they may be pulled. The thumb lever is linked to the cam as shown in Figure 2b, and lifting the thumb lever moves the cam to the right. It is not evident from the assembly drawings, but the cam can only move left and right, and the intensifier holder can only move into and out of the plane of the drawing. Two pairs of diagonal slots are milled into the cam, and as it moves right and left, the cam following rods must slide in and out. The range of motion of the intensifier is about 0.030 inches.

b) Electrical Detail

Figure 3 is an electrical schematic diagram for the ITT F-4111 proximity focused channel plate intensifier tube. The device requires three voltages plus ground. In the circuit of this system, the input side of the of the microchannel plate is chosen as ground. A positive dc voltage is applied to the photocathode to keep the tube off unless it is pulsed. The output side of the microchannel plate is biased to about 700 volts, providing a nominal gain of 10,000. The P-20 phosphor, aluminized anode is biased 5000 volts above the microchannel plate output side. To turn the tube on, the cathode is pulsed with a negative voltage large enough to overcome the positive bias and accelerate photo-electrons into the microchannel plate. The bias voltages are supplied by a battery operated power supply manufactured by K-M Electronics, a company that specializes in image intensifying tube power supplies. The power supply is equipped with safety features to prevent the tube from being damaged by too intense a light input and too high a microchannel plate bias voltage.

The negative gate pulse to the photocathode is a 50 ohm signal between 80 and 120 volts. There are two coaxial connectors leading to the photocathode. One is used as the input connector and the other is to be terminated. It is useful to use as a termination a line back to an oscilloscope input. In this way, for fast pulse operation, the pulse degradation can be monitored.

Appendix I contains manufacturers' data sheets on the intensifying tube and the battery operated power supply.

III. EXAMPLE OF RESULTS

The net optical gain of the system is about 1000. This number is determined by comparing film exposure generated directly on the film by an open shutter photograph of an electrical discharge of known duration through a set of neutral density filters, with the film exposure of the same scene through the intensifier pulsed for several nanoseconds. The same camera and lens are used in both exposures. A regular polaroid film pack back is used for the first exposure, and the intensifier back for the second. The neutral density filters are adjusted to obtain equal exposures and the gain is computed by equating the products of light gain times exposure time for the two equal exposures. This gain is about a factor of ten lower than the quoted light gain, which is a cw gain.

Figure 4 is a 100 ns exposure of an interferogram of a reduced density channel generated by a pulsed CO_2 laser beam in one atmosphere of nitrogen that has been seeded with SF_6. The interferometer is back lighted by a 0.5 mw cw HeNe laser. The off-on contrast ratio of the intensifier is such that the laser may impinge on the ungated cathode for as long as thirty seconds before the film is fogged. The two burn spots in the photograph are the result of trying to increase the pulse current capability of the channel plate electron multiplier and the phosphor anode in an effort to bring the pulse gain up to the value of the quoted cw gain.

IV. CONCLUSIONS

This report describes a single frame, fast (of the order of ten nanoseconds exposure time) exposure camera system with a light amplification factor of 1000. The system uses a commercially available proximity focused micro-channel plate intensifier tube and the Hasselblad 500/C still camera system. The cost of the single frame system, including a modest lens, camera body, two Polaroid backs, intensifier tube, battery operated power supply, and machine work is about $13,000.

V. ACKNOWLEDGMENT

The authors are grateful to George Yates of Los Alamos National Laboratory for discussions and information on the design of fast pulse generators.

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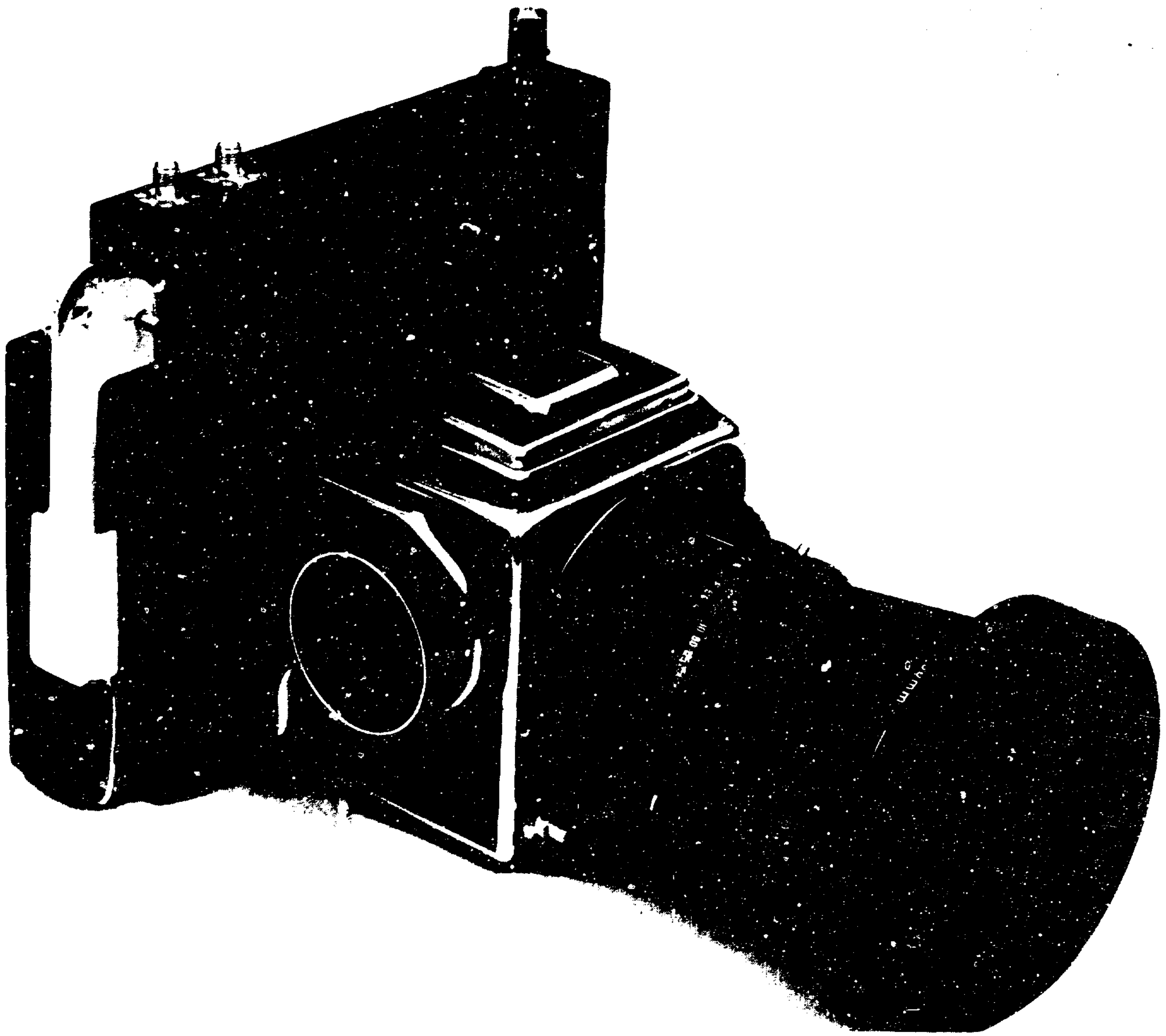

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Fig. 1a — Photograph of the single fast frame intensifier system.

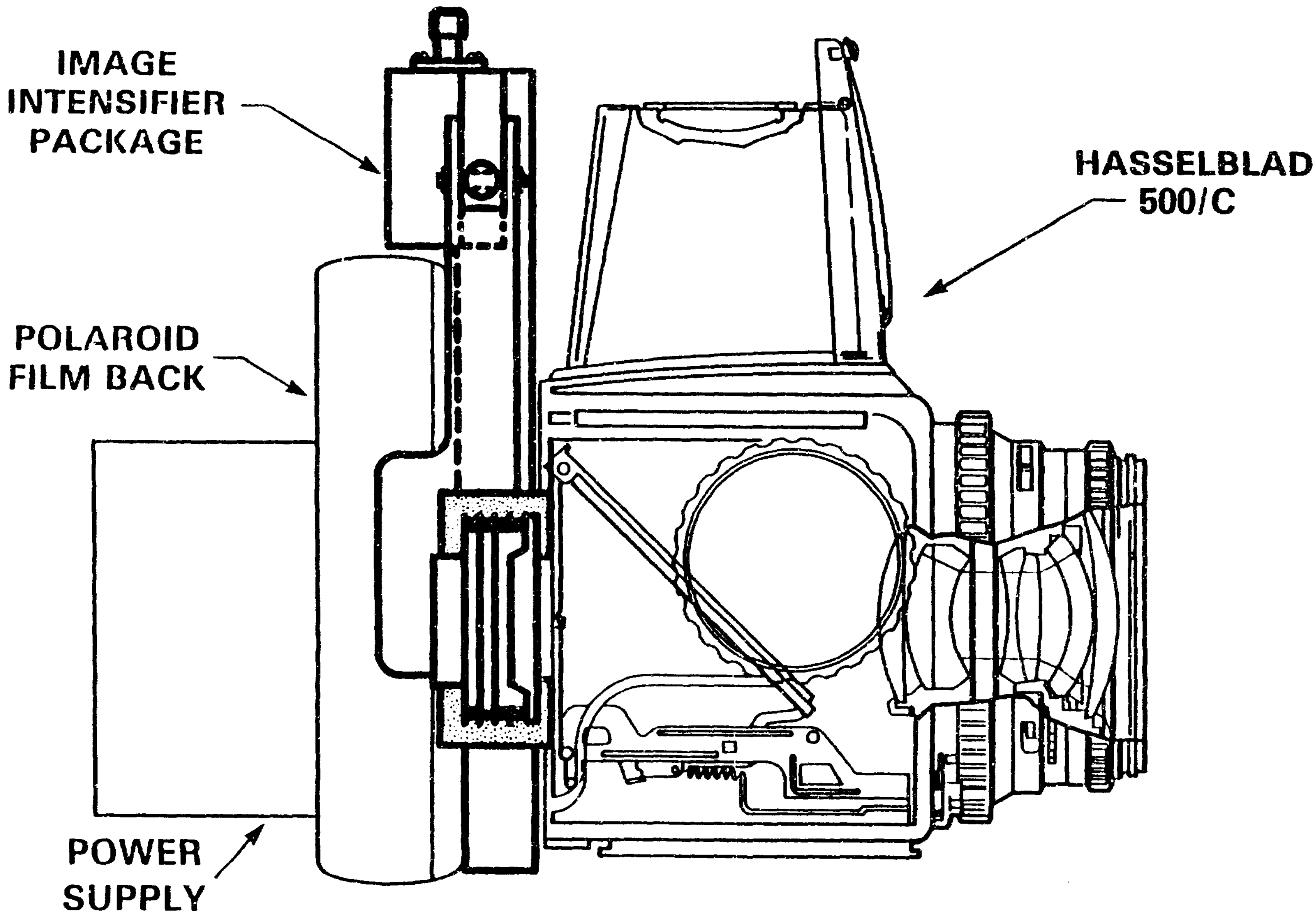


Fig. 1b — Scaled drawing of the single fast frame intensifier system.

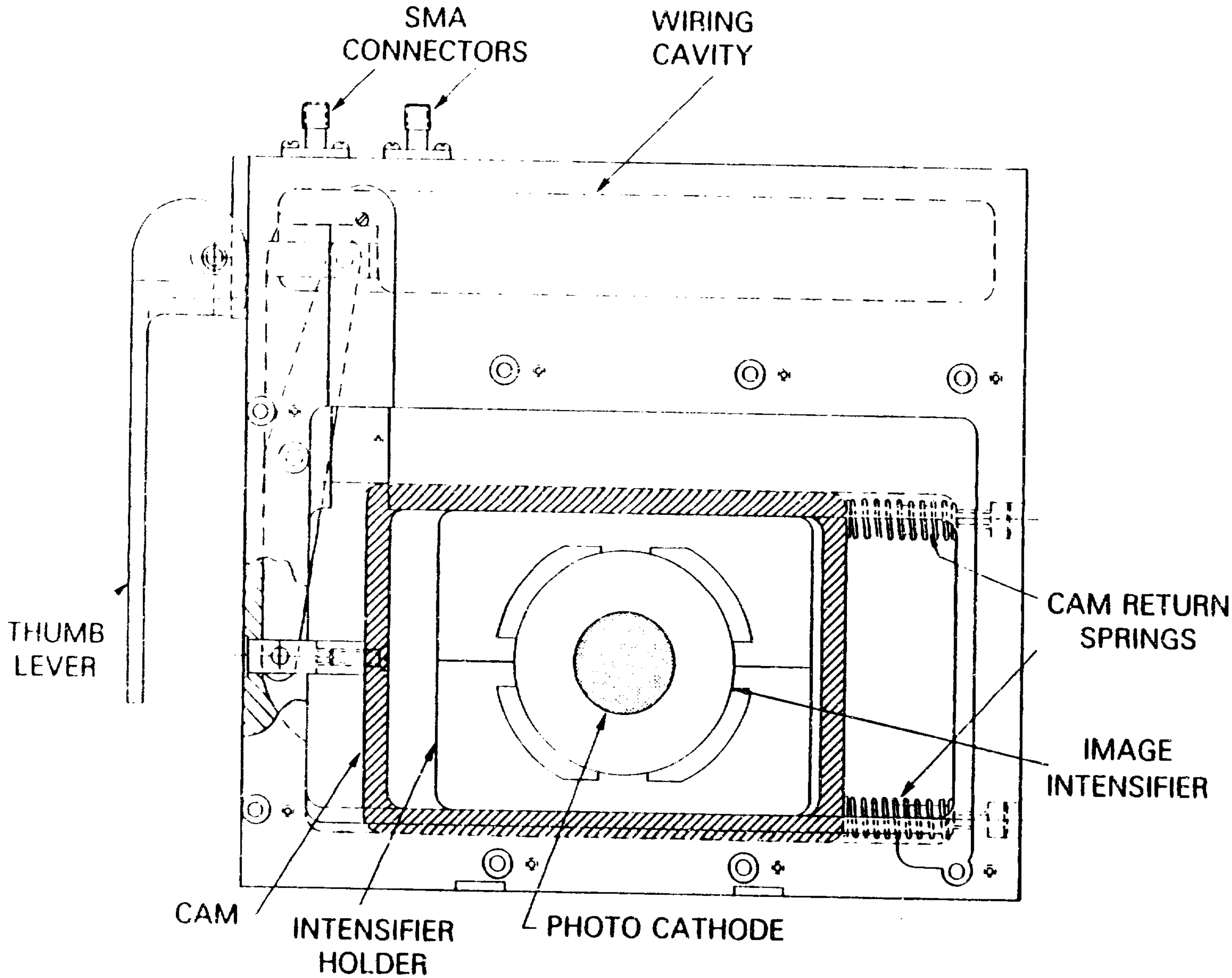


Fig. 2a — Assembly drawing of the intensifier tube housing and transport mechanism viewed from the camera lens side

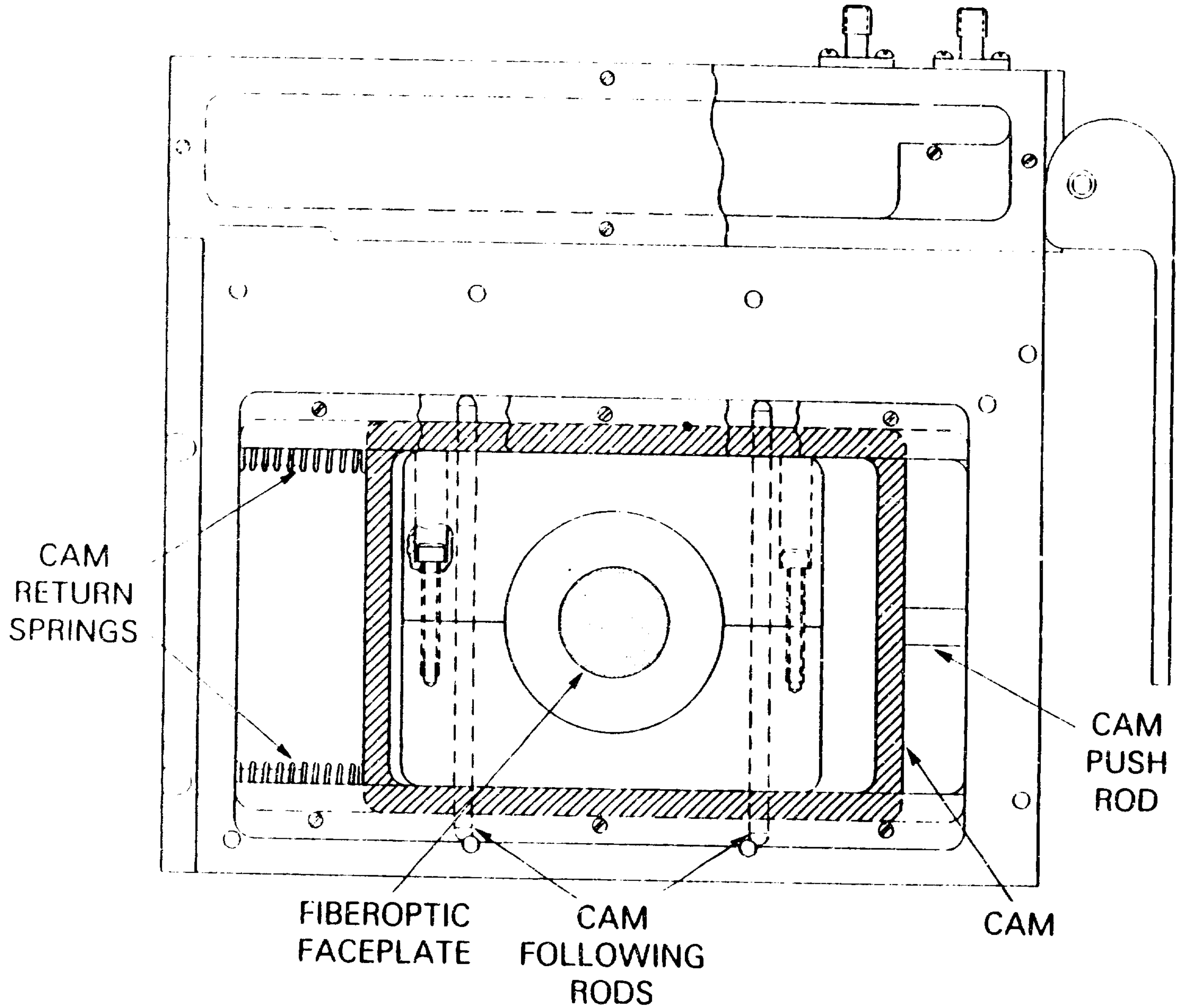


Fig. 2b — Assembly drawing of the intensifier tube housing and transport mechanism viewed from the film side

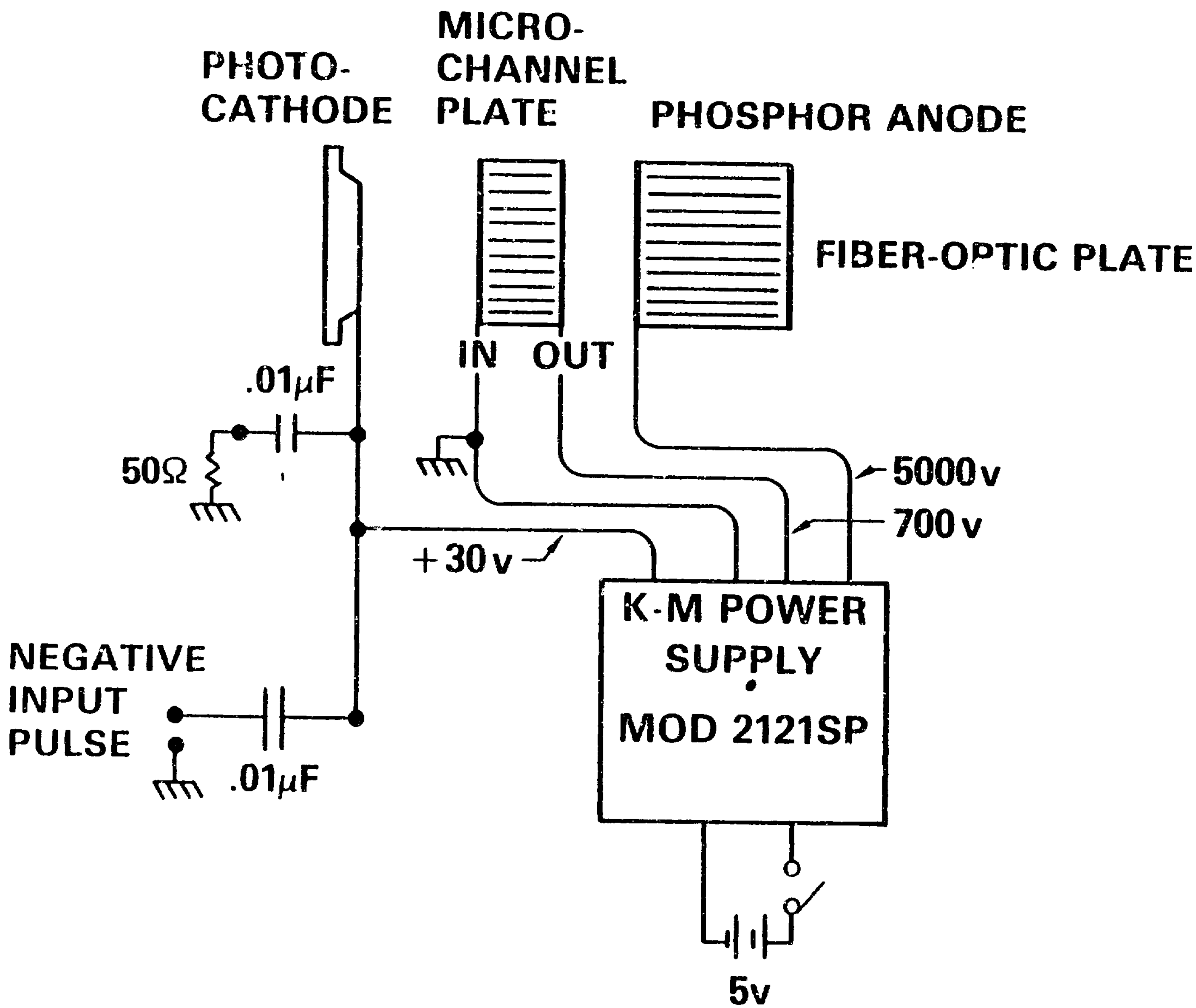


Fig. 3 — Electrical schematic diagram of the intensifier tube circuit.

Fig. 4 — Photograph of an interferogram taken at a 100 nanosecond exposure with the single fast frame intensifier system.

NOTE 1 Other photocathodes available on special order, include the S-1, to provide detection and conversion of 1.06 μ signals, and CsTe, CsI cathodes for special UV applications.

NOTE 2 Fiber optics, quartz, MgF_2, or other materials available on special order.

NOTE 3 Other phosphors available on special order.

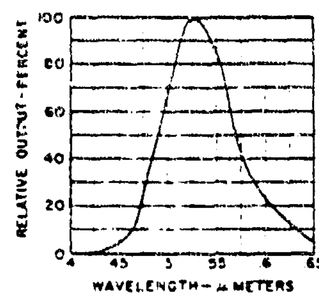
NOTE 4 Power Supplies can be an integral part of the tube assembly. Gateable and DC power supplies are available as separate units.

NOTE 5 Defined as the ratio of the total luminous flux from the phosphor screen to the total luminous flux incident on the photocathode from a standard 2,854° K tungsten lamp, and measured with a photometer as ft-1/ft-c with an input level of 1×10^{-5} ft-c incident on the photocathode. The ITT proximity focused channel intensifier tube provides a variable tube gain by varying the microchannel plate voltage.

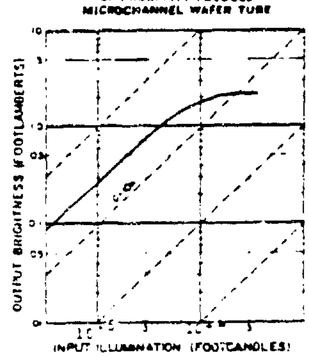
NOTE 6 There is no degradation of resolution from center-to-edge of screen. Resolution is measured with 5×10^{-4} footcandles on the photocathode to determine limiting, or 5 per cent MTF levels with a 100 per cent contrast target.

NOTE 7 For continuous operation; this value may be several orders of magnitude higher for pulsed operation.

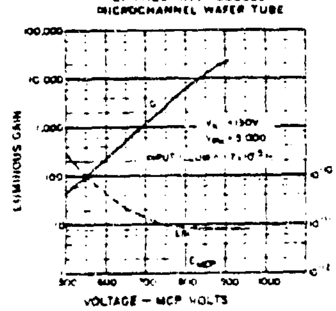
SPECTRAL OUTPUT
P-20 PHOSPHOR



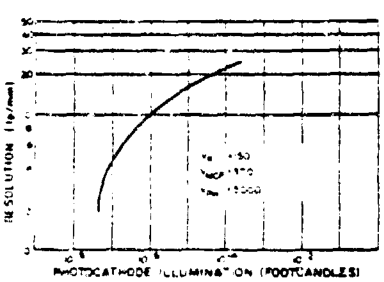
TYPICAL SATURATION CURVE OF PROXIMITY FOCUSED MICROCHANNEL WAFER TUBE



TYPICAL GAIN CHARACTERISTICS OF PROXIMITY FOCUSED MICROCHANNEL WAFER TUBE



TYPICAL RESOLUTION OF PROXIMITY FOCUSED MICROCHANNEL WAFER TUBE



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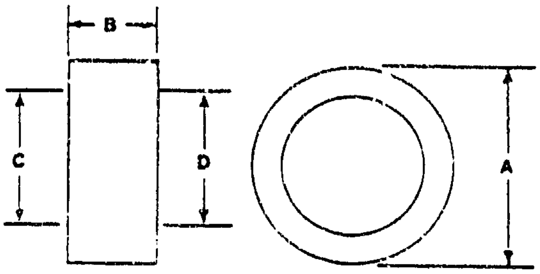
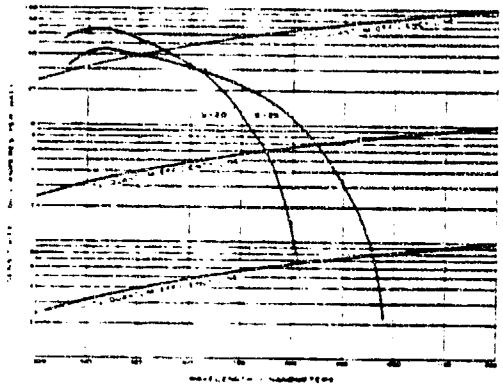


TYPICAL ABSOLUTE SPECTRAL RESPONSE CHARACTERISTICS



Dimensional Data		18mm F-4111	25mm F-4112	40mm F-4113	Units
A	Maximum diameter (with potting)	45	53	71	mm
B	Length (nominal)	21	21	24	mm
C	Useable Photocathode Aperture	18	25	40	mm
D	Useable Screen Aperture	18	25	40	mm
	Potted Weight	60	105	215	grams

ELECTRO-OPTICAL PRODUCTS DIVISION ITT
3700 E. Pontiac St., Fort Wayne, Ind. 46803

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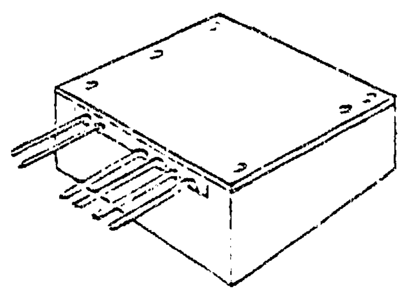
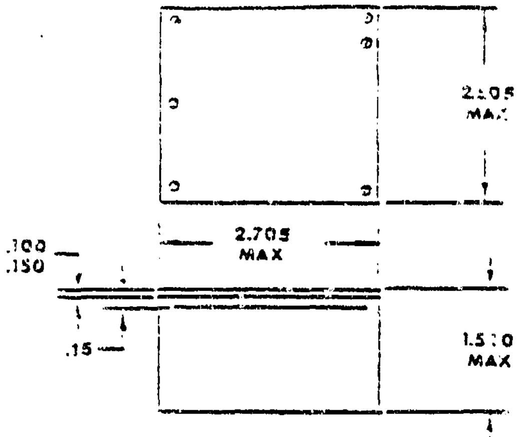
COMPACT IMAGE INTENSIFIER TUBE GATEABLE POWER SUPPLY



MODEL 2121SP



Dimensions are in Inches

FEATURES

- Compact Size
- Voltage Control or Pot Control MCP (Specify when ordering)
- Adjustable ABC Shutdown
- Grounded MCP-In

SPECIFICATIONS

PARAMETER	NAME	UNITS	MIN	NOM	MAX	REMARKS
Input Voltage Red	B+	+VDC	4.5	5.0	5.5	--
Input Current	Iin	mAdc	-	125	200	--
Cathode Off Blue	$+V_1$	+VDC	25	30	35	Ref to MCP-In
MCP-In white-(Gnd)		VDC	-	0	-	At B- Potential
MCP-Out Green	V_2	+VDC	700	-	800	Ref to MCP-In
Anode Yellow	V_3	+VDC	4500	5000	5500	Ref to MCP-Out
Cathode Load	CL_1	pf	-	-	100	18 mm Tube K
MCP-Out Load	RL_2	MΩ	50	-	-	--
Anode Load	RL_3	GΩ	-	-	-	Limited by ABC
Anode Sense	ABC	nA	-	40	-	

Temperature: Laboratory Environment (Room)

NOTES:

1. ABC shutdown adjustable with internal potentiometer.
2. On voltage control MCP models, the MCP output voltage is adjusted via a 0 to +10 Vdc applied to Vc line, where +10 Vdc is maximum MCP voltage. In addition, the maximum MCP voltage at + 10 Vdc can be set via an internal MCP max limit pot.
3. On pot control MCP models, the MCP output voltage is adjusted via an internal potentiometer, where clockwise rotation increases the MCP voltage. In addition, the maximum MCP voltage attainable with the MCP adjust pot can be set via an internal MCP max limit pot.

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VI. REFERENCES

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2. N.P.S. King, G.J. Yates, S.A. Jaramillo, J.W. Ogle, J.L. Detch, Jr., Los Alamos National Laboratory Report LA-UR-81-1126.

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