Multiplier Phototubes

Electron Multipliers

Photodiodes

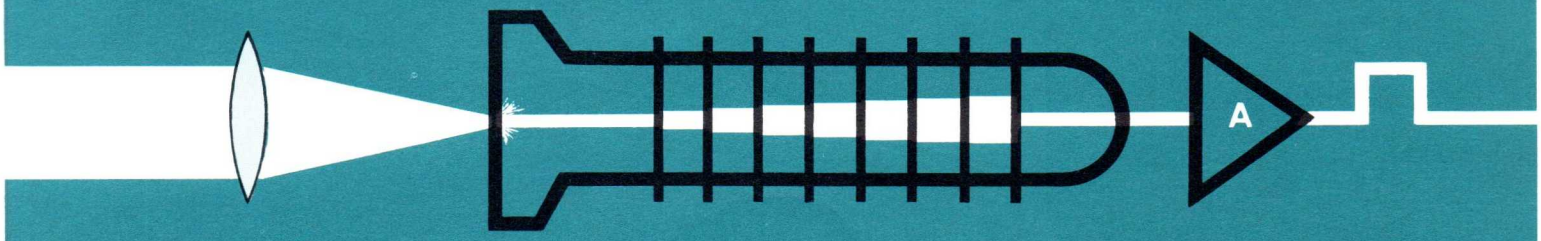
Image Converters

Image Dissectors

Integrated Sensor Packages

Associated Electronic Products

PHOTO-ELECTRO-OPTICAL PRODUCTS



PHOTOELECTRIC DIVISION
ELECTRO-MECHANICAL RESEARCH, INC.

All ASCOP Photoelectric Products
are manufactured by EMR

EMR

PHOTOTUBES FOR TOUGH APPLICATIONS

The Photoelectric Division of Electro-Mechanical Research, Inc. designs and manufactures a broad line of rugged, high performance photoelectric products. The EMR technical staff originally developed photosensitive devices for subsurface geophysical exploration. A family of high-temperature multiplier phototubes for scintillation counting was developed to meet the needs of geophysical studies into the earth's mantle. These tubes now are used successfully world-wide in the extreme environments of deep oil-well exploration. During use in these environments, the tubes have demonstrated a capability to withstand stresses more severe than could be imposed upon any other phototubes available.

As new programs of space exploration burgeoned these phototubes were found to be ideally suited to space environments. Their size, weight, and rugged construction easily met the exacting requirements of missile, satellite and space-probe missions. In addition, superior performance characteristics have gained and assured a very wide acceptance among scientific personnel working on the most advanced space-research programs.

ASCOP photoelectric devices are built in elaborate, modern, research and manufacturing facilities located at the Photoelectric Division of EMR in Princeton, New Jersey. Assembly of all tubes is performed in a dust-free, controlled-climate, "white room." Individual processing of tubes and proprietary high-vacuum processing techniques assure stable, high-sensitivity performance. Other unique manufacturing operations include identification and traceability of parts, rigorous in-process quality control, and engineer testing with precision electro-optical equipment.

ASCOP Multiplier Phototubes form a rigid vertebrate structure. They are the only tubes available with a built-in "backbone" for ruggedness. The unique, segmented glass-to-metal sealed dynode construction provides both radial and axial strengths capable of withstanding shocks greater than 100g and vibrations greater than 30g. The complete dynode resistor network is an integral part of these phototubes. Precision resistors are spot-welded to the outside envelopes along the dynode support flanges. Each tube is normally potted in a high di-electric strength compound which also provides shock resistance.

As can be seen in the chart on pages 4 and 5, standard ASCOP Multiplier Phototubes offer selective wavelength detection from the near infrared to far ultraviolet. EMR has pioneered the development of several stable low-noise photocathodes for the near and far ultraviolet, as well as high-temperature bi-alkali photocathodes for the visible light region. Experimental windowless tubes for detection of wavelengths as short as 100 Å have also been designed and built in EMR laboratories.

Each ASCOP Multiplier Phototube comes from a distinguished family and each carries its own complete test data sheets listing the following parameters:

absolute cathode sensitivity
spectral response characteristics
current amplification as a function of voltage
anode dark current measurements

Individual processing and calibration is supervised by qualified engineers; continuous and stringent inspection techniques screen out possible rejects during every stage of manufacture. The performance of an ASCOP phototube is guaranteed.

PHOTOTUBE ORDERING INFORMATION

The ASCOP phototube model number is the key to its various parameters. A typical model number is shown along the right-hand edge of this page with an explanation to its left of the parameters specified by each part of the number.

PRODUCT FAMILY AND TUBE DIAMETER KEY*

54 ( ) end window, semitransparent photocathode

66 ( ) side window, semitransparent photocathode

64 ( ) side window, photocathode on reflective substrate

(0) Type 0.82″ diameter electron multiplier structure with resistors and potting, packaged in a 1⅛″ maximum OD housing.

(1) Type 1″ diameter electron multiplier structure with resistors and potting, packaged in a 1¼″ maximum OD housing. Useful cathode diameter is 1″, depending upon specific tube model.

(2) Type 1″ diameter electron multiplier structure with larger photocathode areas, up to 1.5″ useful cathode diameter. Maximum package diameter, with resistors and potting, 1¾″ for visible and near UV tubes and 2″ for far UV tubes.

(3) Type 1-9/16″ diameter electron multiplier structure, packaged with resistors and potting, in a 2″ diameter housing. Useful cathode diameter is 1.70″.

(4) Type 1-9/16″ diameter electron multiplier structure with resistors and potting in a maximum 3″ diameter housing. Useful cathode diameter is 2.6″.

*Applies to multiplier phototubes only; other ASCOP tube products such as imaging tubes have a unique number.

PHOTOCATHODE KEY

A Cesium antimonide

C Silver-oxygen-cesium (available in custom configurations)

D Bi-alkali, high temperature

E Tri-alkali

F Cesium telluride "solar blind"

G Cesium iodide

J Potassium bromide

N High quantum efficiency bi-alkali

R Multi-alkali

W No cathode (electron multiplier)

WINDOW MATERIAL KEY

01 7056 glass

03 9741 glass (Used primarily in side-window tubes)

05 Selected UV grade sapphire[1]

08 Selected UV grade cleaved lithium fluoride

09 Selected UV grade cleaved magnesium fluoride

[1] On 541 size tubes 05M designation refers to a 1″ diameter UV grade sapphire window.

NUMBER OF DYNODE STAGES

Dynode stages are normally 14 or 18, depending upon the tube type; 00 Code designates photodiodes.

Dynode material: silver-magnesium or beryllium-copper is available.

There is an additional numerical code following the dynode number key to designate the resistance value of the interstage resistors; five digits indicate this value in kilohms, e.g., 03900 for 3.9 megohms. Resistance values from 500K to 40 megohms are available, e.g., 541-A-01-14-03900 specifies 3.9 megohm interstage resistors.

541-A-01-14

TABULATION OF

Model Number	Type of Phototube	Photocathode Material	Window Material	(2) Spectral Range-Å°	Packaged Diameter - Inches	Overall Length - Inches	Active Cathode Diameter - mm	S_K (3) Microamperes/ Lumen
541A-01-14	End-On MP (1)	Sb-Cs	7056 Glass	2700-6500	1.250	4¼	25	65
541A-05M-14	End-On MP	Sb-Cs	Sapphire	1450-6500	1.250	4¼	25	60
541D-01-14	End-On MP	Bi-Alkali	7056 Glass	2700-6000	1.250	4¼	25	15
541D-05M-14	End-On MP	Bi-Alkali	Sapphire	1450-6000	1.250	4¼	25	15
541E-01-14	End-On MP	Tri-Alkali	7056 Glass	2700-8500	1.375	4¼	25	185
541E-05M-14	End-On MP	Tri-Alkali	Sapphire	1450-8500	1.375	4¼	25	185
541F-05M-14	End-On MP	Cs-Te	Sapphire	1450-3500	1.250	4¼	25	NA
541F-08-18	End-On MP	Cs-Te	LiF	1050-3500	1.250	5⅜	10	NA
541G-05M-14	End-On MP	CsI	Sapphire	1450-2300	1.250	4¼	25	NA
541G-08-18	End-On MP	CsI	LiF	1050-2300	1.250	5⅜	10	NA
541J-08-18	End-On MP	KBr	LiF	1050-1800	1.250	5⅜	10	NA
541N-01-14	End-On MP	Bi-Alkali	7056 Glass	2700-6000	1.250	4¼	25	72
541N-05M-14	End-On MP	Bi-Alkali	Sapphire	1050-6500	1.250	4¼	25	72
541R-01-14	End-On MP	Multi-Alkali	7056 Glass	2500-8550	1.375	4¼	25	225
541R-05M-14	End-On MP	Multi-Alkali	Sapphire	1050-8550	1.375	4¼	25	225
541W-00-19	Electron Multiplier	NA	Note 9	NA	1.250	4¼	NA	NA
542A-01-14	End-On MP	Sb-Cs	7056 Glass	2700-6500	1.750	5	38	65
542A-05-14	End-On MP	Sb-Cs	Sapphire	1450-6500	1.750	5	38	60
542D-01-14	End-On MP	Bi-Alkali	7056 Glass	2700-6000	1.750	5	38	15
542D-05-14	End-On MP	Bi-Alkali	Sapphire	1450-6000	1.750	5	38	15
542F-08-18	End-On MP	Cs-Te	LiF	1050-3500	2.00	5½	28	NA
542G-08-18	End-On MP	CsI	LiF	1050-2300	2.00	5½	28	NA
543A-01-14	End-On MP	Sb-Cs	7056 Glass	2700-6500	2.00	7 3/16	43	60
543A-05-14	End-On MP	Sb-Cs	Sapphire	1450-6500	2.00	7 3/16	43	60
543C-01-14	End-On MP	Ag-O-Cs	7056 Glass	6000-10,000	2.00	7 3/16	10	30
543D-01-14	End-On MP	Bi-Alkali	7056 Glass	2700-6000	2.00	7 3/16	43	15
543D-05-14	End-On MP	Bi-Alkali	Sapphire	1450-6000	2.00	7 3/16	43	15
543E-01-14	End-On MP	Tri-Alkali	7056 Glass	2700-8500	2.00	7 3/16	43	150
543F-05-14	End-On MP	Cs-Te	Sapphire	1450-3500	2.00	7 3/16	43	NA
543N-01-14	End-On MP	Bi-Alkali	7056 Glass	2500-6500	2.00	7 3/16	42	55
544A-01-14	End-On MP	Sb-Cs	7056 Glass	2700-6500	2.945	8	66	60
544A-05-14	End-On MP	Sb-Cs	Sapphire	1450-6500	2.945	8	66	60
571E-01-14 (11)	Quadrant End-On MP	Tri-Alkali	7056 Glass	3200-8000	1.375	4¼	10	125
573E-01-14	Quadrant End-On MP	Tri-Alkali	7056 Glass	3200-8000	NA	NA	42	150
578G-08-00	U. V. Image Converter	CsI	LiF	1050-2500	2.250	3 3/16	25	NA
579G-08-MPA	Photon Scintillator	CsI	LiF	1050-2500	2.00	8½	14	NA
582X-05	U. V. Calibration Lamp	NA	Sapphire	1450-1600	.625	2¾ (12)	NA	NA
641A-03-18	Side-Window MP	Sb-Cs	9741 Glass	2000-6800	1.250	5	10	100
641E-01-18	Side-Window MP	Tri-Alkali	7056 Glass	3200-8000	1.375	5	10	170
641F-03-18	Side-Window MP	Cs-Te	9741 Glass	2000-3500	1.250	5⅜	10	NA
641G-08-18	Side-Window MP	CsI	LiF	1050-2200	1.250	5⅜	10	NA
641J-08-18	Side-Window MP	KBr	LiF	1050-1800	1.250	5⅜	10	NA
641K-08-18	Side-Window MP	RbI	LiF	1050-2000	1.250	5⅜	10	NA
641L-08-18	Side-Window MP	Cs-Br	LiF	1050-1900	1.250	5⅜	10	NA
641P-03-18	Side-Window MP	Ro-Te	9741 Glass	1850-3300	1.250	5	10	NA

NOTE: (1) Multiplier Phototube.
(2) Spectral range cutoffs, short wavelength by 10% energy transmission and long wavelength by point at which QE becomes 1.0%.
(3) Typical cathode luminous sensitivity in microamperes/lumen.
(4) Typical peak cathode radiant sensitivity in amperes/watt.
(5) Wavelength in angstroms (Å°).
(6) Anode luminous sensitivity in amperes/lumen.

CHARACTERISTICS

σ_K [4] Amperes/Watt	Peak Quantum Efficiency -%	λ [5] Wavelength - Å	S [6] Amperes/Lumen	Nominal Cathode To Anode Voltage	i_D [7] Amperes	E_N [8] Lumens	ε_N [9] Watts	Model Number
.055	15	4100	65	2100	2×10^{-9}	3.9×10^{-13}	4.6×10^{-16}	541A-01-14
.051	14.5	4100	60	2100	2×10^{-9}	4.2×10^{-13}	4.9×10^{-16}	541A-05M-14
.020	6	4100	15	2600	3×10^{-11}	2×10^{-13}	1.5×10^{-16}	541D-01-14
.019	7.4	3125	15	2600	3×10^{-11}	2×10^{-13}	1.5×10^{-16}	541D-05M-14
.084	25	4200	185	2400	7.5×10^{-10}	8.2×10^{-14}	1.8×10^{-16}	541E-01-14
.084	25	4200	185	2400	7.5×10^{-10}	8.2×10^{-14}	1.8×10^{-16}	541E-05M-14
.014	7	2537	NA	2330	4×10^{-11}	NA	2.6×10^{-16}	541F-05M-14
.014	7	2537	NA	2400	2×10^{-11}	NA	1.8×10^{-16}	541F-08-18
.007	6	1470	NA	3500	6×10^{-12}	NA	2.2×10^{-16}	541G-05M-14
.007	7	1216	NA	2900	3×10^{-12}	NA	1.4×10^{-16}	541G-08-18
.009	9.2	1216	NA	2850	2.1×10^{-12}	NA	8.9×10^{-17}	541J-08-18
.071	21.5	4100	72	2950	2.5×10^{-11}	3.9×10^{-14}	4.0×10^{-17}	541N-01-14
.071	22	2537	72	2950	2.5×10^{-11}	3.9×10^{-14}	4.0×10^{-17}	541N-05M-14
.078	24	4100	225	2160	5.6×10^{-10}	3.8×10^{-14}	1.1×10^{-16}	541R-01-14
.078	24	4100	225	2160	5.6×10^{-10}	3.8×10^{-14}	1.1×10^{-16}	541R-05M-14
NA	NA	NA	NA	3300	2×10^{-12}	NA	NA	541W-00-19
.055	15	4100	65	2100	3×10^{-9}	4.7×10^{-13}	5.6×10^{-16}	542A-01-14
.051	14.5	4100	60	2100	3×10^{-9}	5.1×10^{-13}	6.0×10^{-16}	542A-05-14
.020	6	4100	15	2600	4.5×10^{-11}	2.6×10^{-13}	1.9×10^{-16}	542D-01-14
.019	7.4	3125	15	2600	6×10^{-11}	2.8×10^{-13}	2.1×10^{-16}	542D-05-14
.014	7	2537	NA	2400	4×10^{-11}	NA	2.5×10^{-16}	542F-08-18
.007	7	1216	NA	2900	6×10^{-12}	NA	1.8×10^{-16}	542G-08-18
.048	14	4100	60	2000	4×10^{-9}	6×10^{-13}	7×10^{-16}	543A-01-14
.048	14	4100	60	2000	4×10^{-9}	6×10^{-13}	7×10^{-16}	543A-05-14
.0032	0.5	8000	30	2500	4×10^{-6}	3.8×10^{-11}	3.5×10^{-13}	543C-01-14
.020	6	4100	15	2400	5.5×10^{-11}	3×10^{-13}	2×10^{-16}	543D-01-14
.019	7.4	3125	15	2400	8×10^{-11}	2.9×10^{-13}	2.3×10^{-16}	543D-05-14
.074	22	4200	150	2550	8×10^{-10}	1.1×10^{-13}	2.2×10^{-16}	543E-01-14
.013	6.5	2537	NA	2400	7×10^{-11}	NA	3.6×10^{-16}	543F-05-14
.060	18	4100	55	2600	2.1×10^{-11}	4.6×10^{-14}	4.2×10^{-17}	543N-01-14
.048	14	4100	60	2000	7.5×10^{-9}	8.2×10^{-13}	9.6×10^{-16}	544A-01-14
.048	14	4100	60	2000	7.5×10^{-9}	9.2×10^{-13}	9.6×10^{-16}	544A-05-14
.068	20	4200	125	2400	2.0×10^{-10}	NA	NA	571E-01-14
.074	22	4200	150	2550	8.0×10^{-10}	7.5×10^{-14}	1.5×10^{-16}	573E-01-14
.008	8	1216	NA	16	NA	NA	NA	578G-08-00
.008	8	1216	NA	20	NA	NA	NA	579G-08-MPA
NA	NA	NA	NA	400	NA	NA	NA	582X-05
.076	23	4100	100	1950	3.8×10^{-9}	3.7×10^{-13}	4.6×10^{-16}	641A-03-18
.088	26	4200	170	2200	4×10^{-11}	1×10^{-14}	2.2×10^{-17}	641E-01-18
.037	18	2537	NA	2300	2×10^{-11}	NA	1×10^{-16}	641F-03-18
.020	20	1216	NA	2900	3×10^{-12}	NA	4×10^{-17}	641G-08-18
.020	20	1216	NA	2900	3×10^{-12}	NA	4×10^{-17}	641J-08-18
.020	20	1216	NA	2900	3×10^{-12}	NA	4×10^{-17}	641K-08-18
.020	20	1216	NA	2900	3×10^{-12}	NA	4×10^{-17}	641L-08-18
.030	15	2537	NA	3000	1×10^{-11}	NA	1.5×10^{-16}	641P-03-18

(7) Typical anode dark current in amperes.

(8) Typical luminous equivalent noise input in lumens.

(9) Typical radiant equivalent noise input in watts.

(10) Electron multipliers have a crack off head which contains a filament & shield for use in calibration.

(11) Formerly had Model Number 568A-01-14.

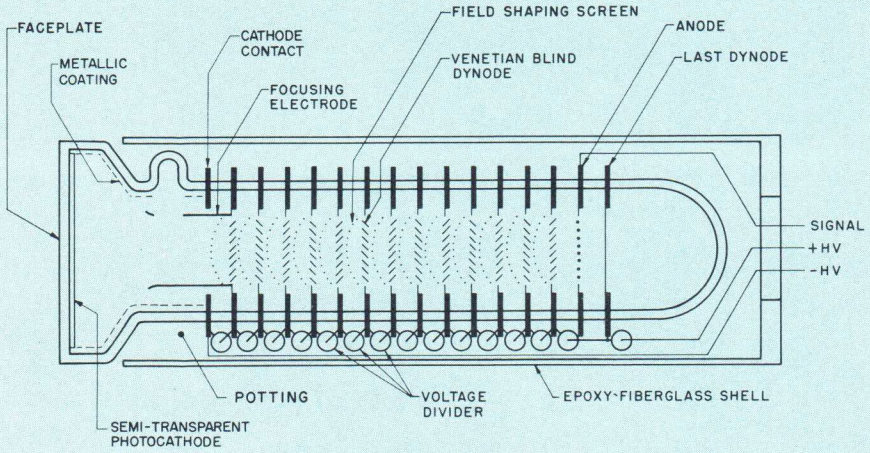
(12) Unpackaged dimensions only.

EMR

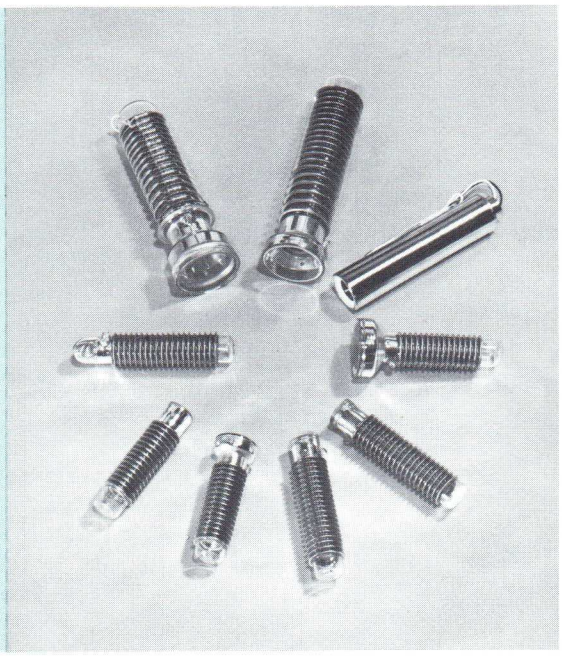
PHOTO-ELECTRO-OPTICAL PRODUCTS WITH A WIDE RANGE OF APPLICATION

In the broad field of photoelectric sensors, the EMR Photoelectric Division applies basic physics to develop new photoelectric devices and substantially improve existing ones. Backed by specially designed facilities and proprietary manufacturing techniques, unmatched elsewhere, EMR research has created a new class of photoelectric sensors which combine precisely controlled parameters with outstanding mechanical qualities. Each photoelectric sensor produced by EMR may be regarded as a precision optical instrument which itself may be used as a stable calibration standard over very extended time periods.

Coordination of EMR's design capabilities in the fields of electronics, photoelectrics, optics and mechanical packaging, has resulted in the development of a proprietary line of "photo-electro-optical" products. Typically these products combine customized optics, a unique photoelectric sensor and its associated electronics in a single ruggedized package. Examples of such subsystems which EMR supplies are integrated star tracker assemblies; scintillation detector assemblies; gamma ray spectrometers; radiometers and photometers with unusual dynamic range; and a new type of ultra selective Lyman-α detector.



ASCOP MULTIPLIER PHOTOTUBE
showing segmented, glass-to-metal sealed dynode construction



MULTIPLIER PHOTOTUBE ADAPTATIONS

For Special Purposes

To solve specialized photodetection problems, several specialized versions of the ASCOP Multiplier Phototubes are available. In addition to the standard "end window" configuration, "side window" tubes with either semitransparent photocathodes or with a photocathode internally deposited on a reflective substrate are available. The latter type has a higher quantum efficiency since incident radiation passes through the semitransparent photoemissive cathode twice. For outer space or hard vacuum applications, a side-window reflective substrate tube with a special removable face plate is available. This tube provides detection of wavelengths in the far ultraviolet region beyond 1050 Å . A unique mechanism which can be remotely programmed breaks the window cleanly and removes it from the path of the incoming light. Special windowless photodiodes having metal cathodes are available for detection at wavelengths down to 100 Å . For detecting high energy particles such as protons, and electrons, EMR supplies electron multiplier tubes such as the Model 541W. This tube is normally supplied with a "break-away" glass head which can be removed just prior to placing the multiplier in operation. A filament within a Faraday shield is included within the break-away head for use in gain calibration.

For calibrating ultraviolet sensitive multiplier phototubes of all types EMR supplies a variety of monochromatic ultraviolet light sources. Light sources are available with strong monochromatic lines throughout much of the ultraviolet spectrum.

641A Side-window multiplier phototube

Breakaway mechanism removes side-window for hard vacuum operation

541W Electron multiplier for high-energy particle detection

IMAGE TUBES

For Conversion of Ultraviolet To Visible Light

Advances made by EMR research in materials and device fabrication have permitted the design of image tubes with extended capabilities in the conversion of ultraviolet and far UV light frequencies to visible light. In the image converter, a high-efficiency photocathode converts a UV optical image into a focused cloud of electrons which is linearly accelerated and impinges on an anode phosphor providing a visible light output with overall photon gain. Both electrostatic and magnetic focusing models are available. Fiber optic plates at the output can be provided for high resolution optical coupling to other imaging devices or recorders. By combining various window materials and photocathodes, images in a precisely determined wavelength range may be made visible and recorded photometrically with some precision. Applications include military surveillance and navigation instruments, and astronomical and astrophysical sensors.

Image converter provides photon gain in ultraviolet to visible light conversion

STAR TRACKING SENSORS

For Sensitive Low-Cost Guidance Systems

Special manufacturing techniques enable EMR to make multicathode multiplier phototubes in which a number of independent photocathodes share a common electron multiplier structure within the same envelope. A particular series of these tubes, Models 571 through 574, called quadrant multiplier phototubes (QMP), are useful as star trackers in low-cost direction sensing units for use in pointing or guidance systems. The four QMP photocathodes comprise 90° quadrants in a single image plane. Normalized gain for all photocathodes is assured by the use of a single electron multiplier section. Sequential electronic sampling of the four photocathodes and appropriately comparing output signals provides a null determination when a star image is focused exactly on the juncture of the four photocathodes. When appropriate optics are used, a precision of less than 3 arc-seconds in a 1° field is possible. Star tracking sensors may be obtained as an integral unit which includes ASCOP QMP optics, switching electronics, power supply, output amplifier and logic, all self-contained in a single packaged assembly.

571E Quadrant multiplier phototube for star tracking

IMAGE DISSECTORS

For High Resolution Image Systems

The image dissector is an image scanning device consisting of a photocathode, an electron focusing system, a deflection system, and an electron multiplier structure preceded by a defining aperture.

The photocathode converts an optical image into an electron image which is focused onto the aperture plate. Electrons passing through the aperture are multiplied through a high gain dynode structure. An anode signal which is an analog of the original optical image is obtained by scanning the electron image across the aperture.

The ASCOP Model 574 image dissector utilizes electrostatic focusing and electrostatic deflection. This device features a flat input image plane, a high rejection ratio between non-illuminated and illuminated areas of the photocathode, and a near-ideal single electron pulse height distribution for pulse counting applications.

The ASCOP Model 575 image dissector employing magnetic focusing and magnetic deflection, is a high resolution device capable of operating with high reliability at extremely wide ranges of high cathode current densities for long periods of time.

All ASCOP image dissectors incorporate EMR's unique mechanical design features which result in highly reliable and extremely rugged devices which are unexcelled for space applications. EMR's proprietary manufacturing techniques insure exceptionally low noise, excellent linearity, and good stability. ASCOP image dissectors are available with either ultraviolet, X-ray, or visible response.

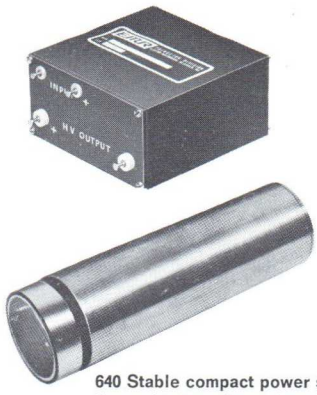
Integrated systems featuring ASCOP image dissectors and the associated electronics are available from EMR.

574 Electrostatic Image Dissector

PHOTOTUBE POWER SUPPLIES

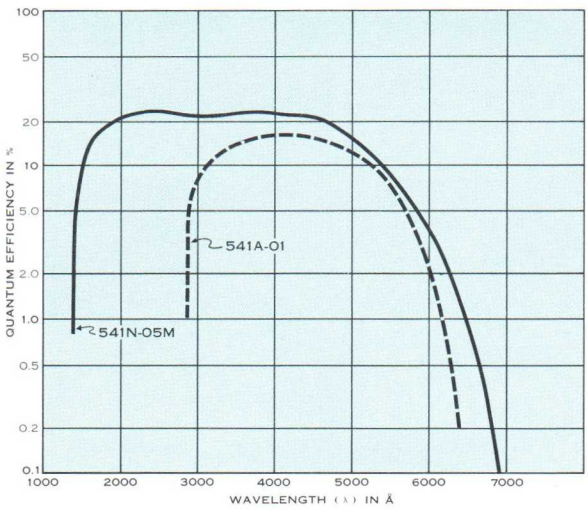
For ASCOP Photoelectric Sensors

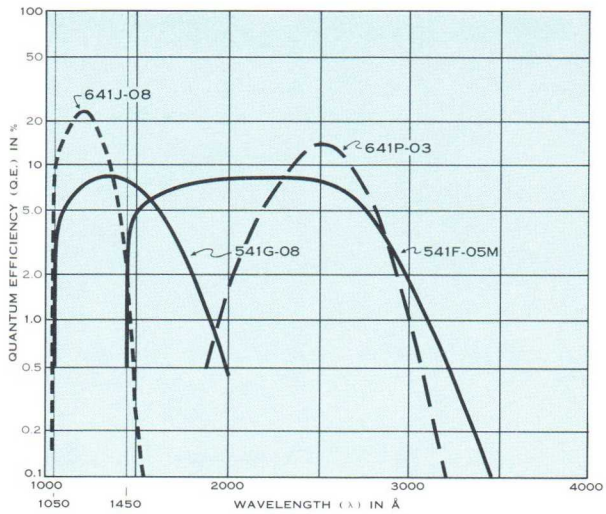
The precision of a photoelectric sensor to a great extent is determined by the stability of the applied cathode-to-anode voltage. EMR produces high-voltage power supplies for use with photoelectric sensors. The stability and low output ripple of these supplies assure that the full capabilities of the sensor may be realized. Typically, these power supplies are available as a separate compact unit for mounting near the photoelectric device or as a wrap-around package which becomes an integral part of the sensor thus eliminating high-voltage conductors between components. When the power supply is supplied as an integral part of the tube, the sensor package usually exhibits greater overall stability through matched characteristics and temperature compensation. In general, ripple is less than 0.01% peak-to-peak, while regulation for line voltage variations and temperature variations is within 1%. Power supplies are available for 28 volt input and provide output voltages ranging from 875 to 3500 volts. Certain EMR power supply designs permit feedback for automatic gain control.

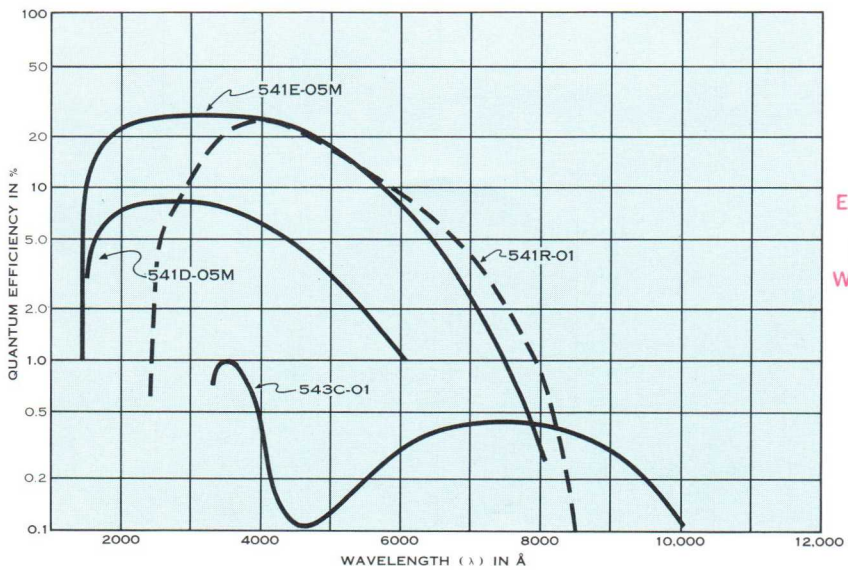


640 Stable compact power supply for multiplier phototubes (top); power supply can be potted as an integral part of the tube (bottom)

TYPICAL SPECTRAL RESPONSES FOR ASCOP PHOTOTUBES







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