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# THE TV SYSTEM FOR THE APOLLO TELESCOPE MOUNT

## INTRODUCTION

The Apollo Telescope Mount (ATM) scheduled for launch in 1971 is to be a manned earth-orbiting experiment for studying solar phenomenon without the distortions and absorptions of the earth's atmosphere. This space station designed for a continuous 56-day mission consists of a telescope package (the ATM), a control cabin (a modified Lunar Module), and crews' quarters (a modified Saturn S-IVB stage liquid hydrogen fuel tank). See figure 1 for an artist's concept of this configuration. An alternate configuration where the control console is located in the S-IVB stage (dry workshop) without the use of a Lunar Module is also being considered. Direct viewing of the telescope images by the astronaut is impractical because of environmental and physical space considerations and because of astronaut fatigue. To enable the astronaut to operate with maximum efficiency and minimum fatigue and to allow more versatility, a closed circuit TV system has been designed for the ATM.

## EXPERIMENTS

Several solar experiments will be conducted aboard the ATM. It is not the intent of this paper, however, to describe these experiments but rather to describe the TV system used in support of these experiments. To enable a better understanding of the functioning of the TV System, a brief description will be given of those experiments which contain a television camera.

### ATM H-Alpha Telescope

The ATM H-Alpha telescope is required for pointing control of the ATM toward specific areas of the sun. This telescope contains a 0.7 Angstrom Fabrey-Perot interference filter at Hydrogen Alpha frequency (6563 Å) and has a 5:1 zoom capability (7 to 35 arc minutes). Because of the narrow spectral bandwidth

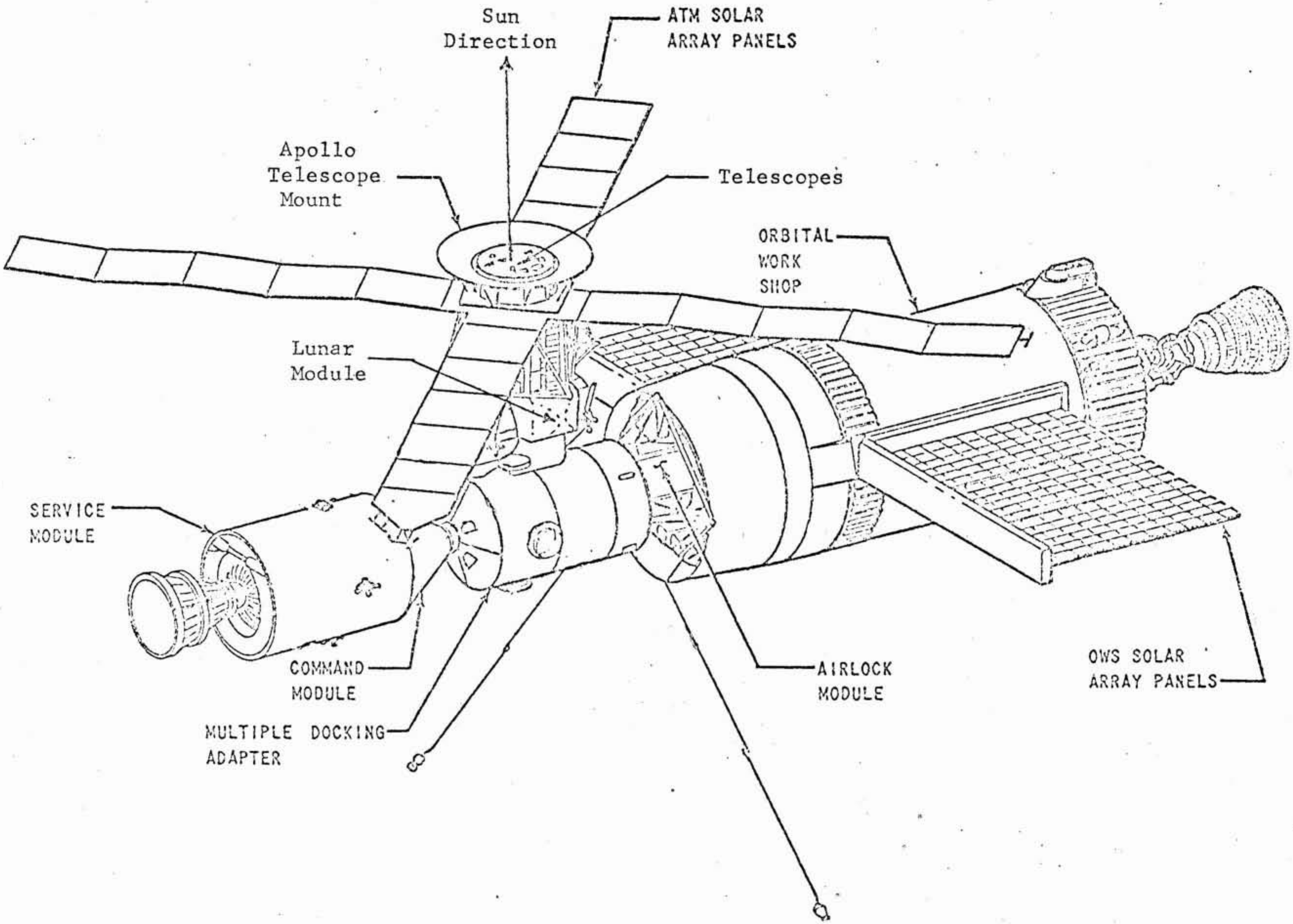


Figure 1: ATM General Configuration

approximately 0.5 footcandles of light are available for the television camera. No film camera is installed on this telescope.

HCO H-Alpha Telescope

The Harvard College Observatory (HCO) H-Alpha telescope is required for photographing the sun at H-Alpha frequency and contains the same type interference filter as the ATM H-Alpha telescope (6563 Å). The light level available to the television camera is less than that of the HCO H-Alpha Experiment (approximately 0.1 footcandle) because 10 percent of the light must be split off to the film camera and because the telescope zoom range is different (4.5 to 22 arc minutes).

NRL XUV Telescope

The Naval Research Laboratory (NRL) Extreme Ultra-Violet (XUV) telescope is required for studying the sun's image as seen through a 150 to 600 Å filter with a 42 arc minute field of view. A special conversion layer which converts the 150 to 600 Å spectral region of the sun to white light is deposited directly on the faceplate of the SEC TV camera by the Aerospace Division of Westinghouse in Baltimore, Md. Depending on the particular solar phenomenon being viewed, the light intensity available to the TV camera varies from $5 \times 10^{-5}$ to $1.5 \times 10^{-1}$ footcandles. No zoom is available in this telescope.

This telescope also has the capability to view the sun directly in white light through the Image Dissector TV Camera. In the white light mode the camera field of view is 3 arc minutes while viewing a 2 x 60 arc second slit superimposed on the sun. No film camera is installed on this telescope.

HAO WLCE Telescope

The High Altitude Observatory (HAO) White Light Coronagraph Experiment (WLCE) is required for viewing of the sun's corona in white light. An occulting disc which blocks out the radiation from the solar disc is installed in the telescope, and the resulting energy from the corona is imaged on either a film or a TV camera.

The field of view of this telescope is 6 solar diameters (192 arc minutes).

COMPONENTS

The ATM TV System (see figure 2) consists of five (5) TV cameras, a sync generator, two (2) video switches, and two (2) closed circuit television monitors - the same general type components one would find in a typical commercial television studio, but the similarity between the ATM TV components and commercial components is in name and output waveforms only. All of the ATM TV System components are highly reliable, state of the art devices capable of withstanding the launch environment of the Saturn IB and then operating unattended in the torturing thermal vacuum environment of space.

TV Cameras - General

A total of five TV cameras is used on the ATM to relay solar data from the telescope to the astronaut: two standard vidicon cameras, two low light level SEC cameras, and one image dissector camera. All cameras operate at standard scan rates conforming to EIA Standard RS-170 except that a 1:1 aspect ratio is used instead of 3:4. The line frequency is 15,750 Hz and the field rate is 60 Hz with 2:1 interlace. Individual cameras have no internal sync generators and must be synchronized externally by the application of both horizontal and vertical drive pulses. Dual isolated noncomposite video outputs of 1.0 Vpp are provided on all cameras.

The vidicon and SEC cameras have several special features that increase their versatility. In a case such as viewing the sun's corona where the light level is very low, the image may be manually integrated for several frames or even several seconds to improve image quality by remotely commanding the camera to this mode. The readout time of this data is very short - a frame or two - but this technique has been found to be valuable when used by a trained observer looking for familiar data. The vidicon and SEC cameras can be wired for either automatic (AGC), manual,

# ATM TV SYSTEM

(1) TV CAMERA FOR ATM TELESCOPE
- (1) CAMERA HEAD
- (1A) CAMERA CONTROL UNIT

(2) TV CAMERA FOR HCO HYDROGEN ALPHA TELESCOPE
- (2) CAMERA HEAD
- (2A) CAMERA CONTROL UNIT

(3) TV CAMERA FOR NRL XUV SPECTROGRAPH, SO 82 EXP. B
- (3) CAMERA HEAD
- (3A) CAMERA CONTROL UNIT

(4) TV CAMERA FOR NRL SPECTROGRAPH, SO 82 EXP. B (NOT SHOWN)

(5) TV CAMERA FOR ~~HCO-SEIT~~ HAO WHITE LIGHT CORONOGRAPH EXPERIMENT
- (5) CAMERA HEAD
- (5A) CAMERA CONTROL UNIT

(6) SYNC GENERATOR

(7) VIDEO SWITCH NO. 1

(8) VIDEO SWITCH NO. 2

(9) TV MONITOR NO. 1

(10) TV MONITOR NO. 2

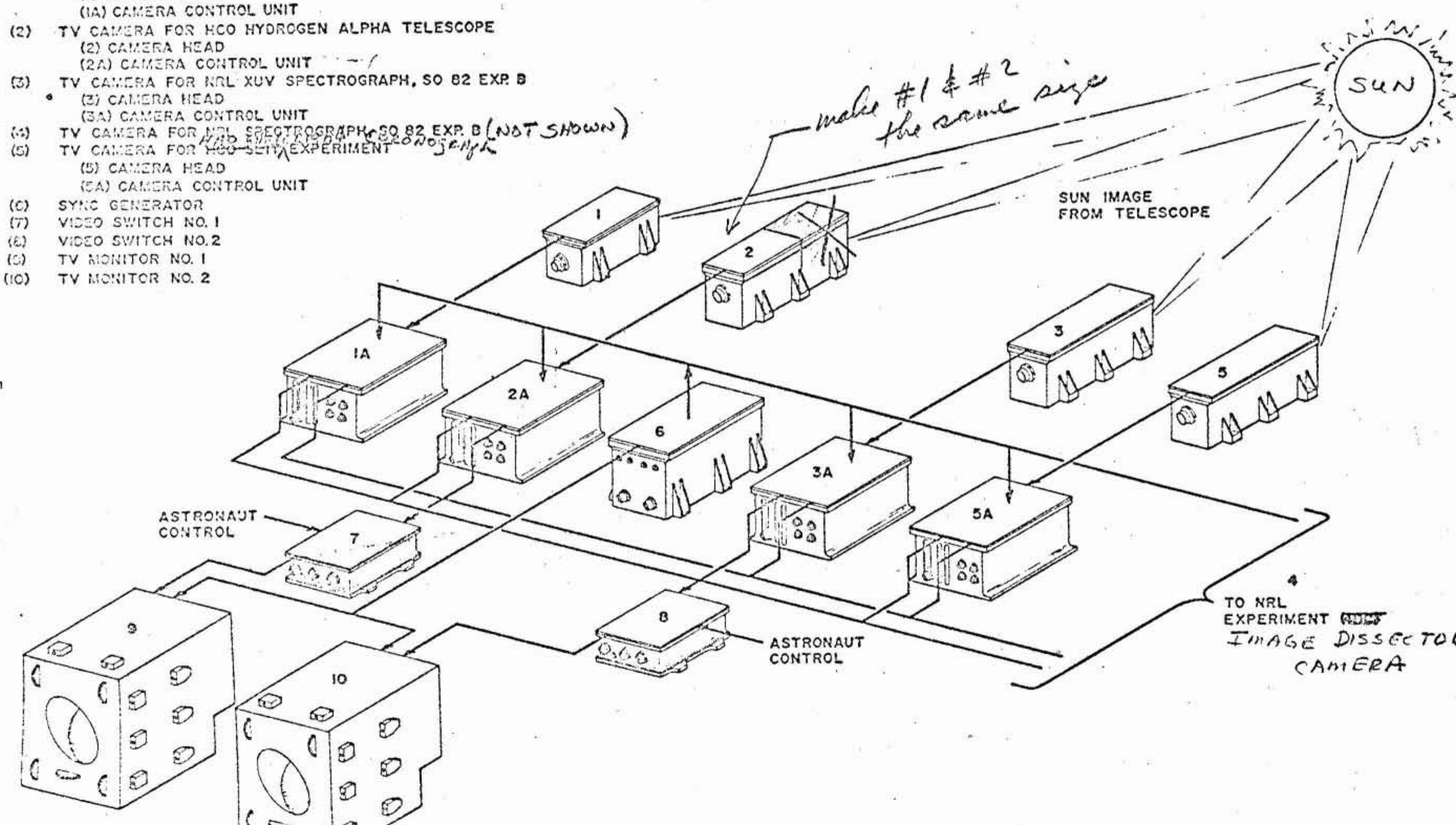


FIGURE 2:

or remote gain control enabling them to adapt to any light conditions.

## Vidicon and SEC Cameras

The vidicon and SEC camera systems are identical except for the type sensor used and except for any peripheral electronics and hardware peculiar to the SEC vidicon. Both cameras use the same electronic circuitry except for the different test select components and cross connects that are used to adapt the circuitry for the standard vidicon or for the SEC. The deflection assemblies for the two cameras are different because of the differences between the two types of vidicons. Since the SEC vidicon requires approximately -8 KV to operate the image section, a high voltage power supply is required in this camera that is not required in the standard vidicon. Because the SEC vidicon is physically larger than a standard vidicon and because a high voltage power supply is required, the housing for the SEC camera is larger than the housing for the vidicon camera. The approach of commonality for these two designs was selected to conserve cost, simplify manufacture, and to provide greater versatility during repair operations.

## Vidicon Camera Block Diagram

The block diagram for the standard vidicon and SEC vidicon cameras is shown in figure 3.

The RCA 4503 ruggedized separate mesh vidicon was selected for use in the standard vidicon camera because of its excellent performance characteristics and ability to withstand a severe vibration environment. Flight tubes are selected for best sensitivity and uniformity with minimum blemishes and minimum dark current. Because high resolution is not required for the ATM mission, the tube is operated in the low resolution mode. High quality pictures are available down to 0.1 footcandle and good usable pictures are possible down to illumination of $3 \times 10^{-2}$ footcandles.

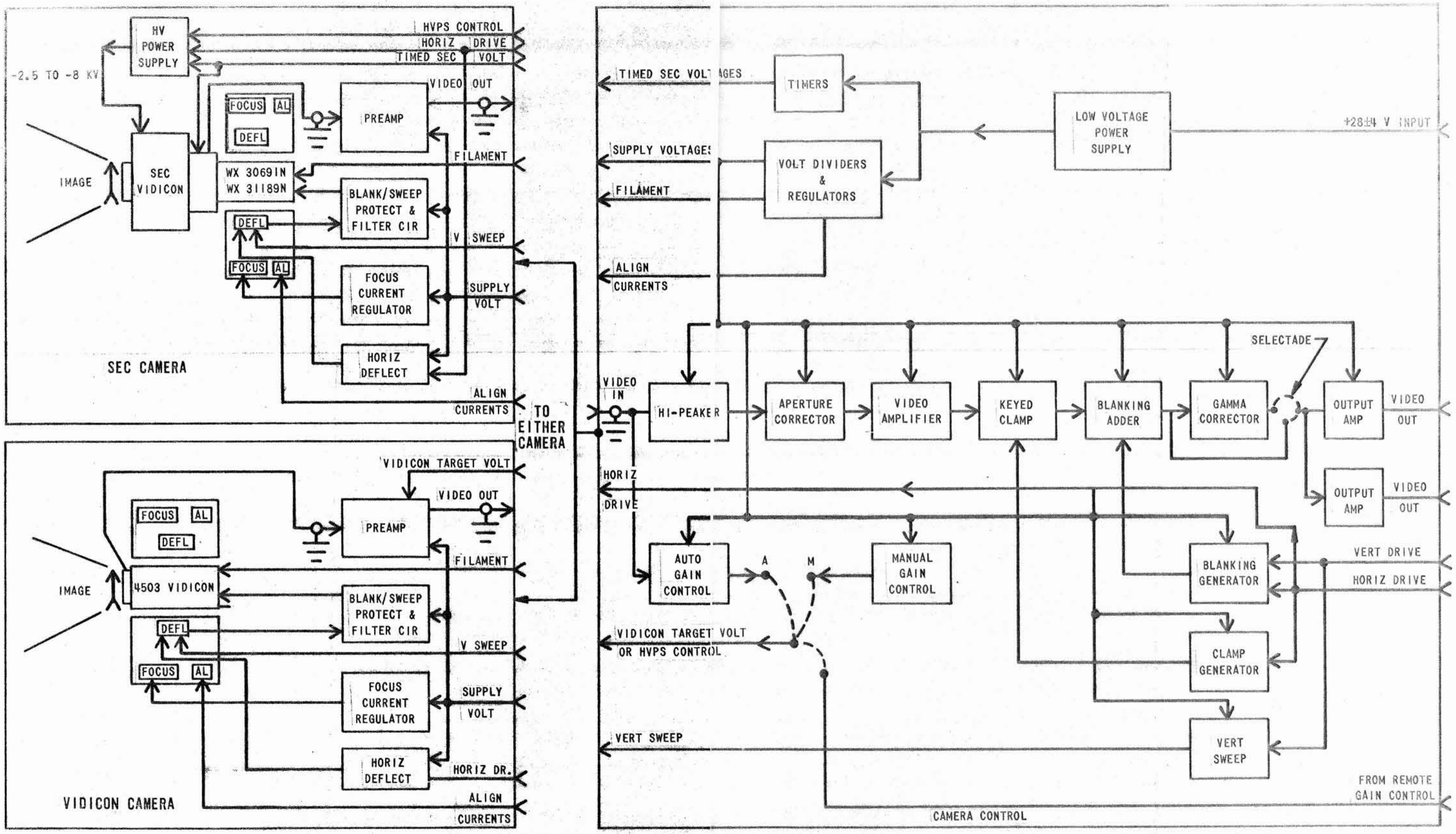


Figure 3. Camera & camera control block diagrams.

Focus, alignment, and deflection coils are potted into a single assembly to prevent movement of the coils relative to one another during launch vibration and to simplify assembly and checkout. After initial electrical setup and mechanical alignment, the 4503 vidicon is potted into the deflection and focus assembly to fix it into position.

The preamplifier circuitry employs a high gain field effect transistor to gain a very low equivalent noise current allowing the camera to operate at very low signal currents and, therefore, lower light levels. Particular attention is paid to grounding and shielding to keep noise pickup to a minimum. It is desirable to keep the length of the lead connecting the vidicon target to the preamplifier input as short as possible and shielded. It was found that the use of RG-187A/U miniature coax provided the best compromise between physical size and shunt capacitance. Shunt capacitance at the preamplifier input is of great inportance because of its effect on bandwidth, i.e., the higher the shunt capacitance, the lower the bandwidth of the preamplifier because of its shunting effect on the target load resistor. It then follows that the high peaker circuitry in the camera control unit must start operation at a lower frequency to keep the overall bandwidth flat, and, therefore, there is a corresponding increase in output noise level.

Vidicon blanking is accomplished by sampling a portion of the horizontal and vertical deflection current, amplifying these signals, and applying them to the vidicon cathode. This circuitry, also, serves to protect the vidicon target in case of sweep failure by "cutting off" the tube.

To conserve power, a resonant type horizontal deflection circuit is used. A silicon NPN 2N3902 transistor is used in conjunction with a series linearity coil to achieve a horizontal linearity of typically 1.5 percent.

The focus coil current is maintained at correct levels by use of a feedback amplifier scheme using a 709 integrated circuit amplifier.

Because of the very low preamplifier equivalent noise current, it was found early in the development stages of the camera system that extreme care would be necessary to preserve the good noise characteristics of the preamplifier. The switching transients coming from the d.c. to d.c. converter in the low voltage power supply had to be very carefully filtered from all lines driving the vidicon tube or running in its vicinity.

SEC Camera Block Diagram

Since the SEC vidicon employs a standard vidicon electron gun assembly, the circuitry associated with this part of the tube is either identical or very similar to the standard vidicon circuitry as mentioned before, and, therefore, the description given above for the preamplifier, horizontal deflection, focus current regulator, filter, and blanking and sweep protect circuitry applies also to the SEC camera.

The SEC vidicon is different from a standard vidicon because its target construction is different and because it employs an electrostatically focused image section to achieve sensitivity. The manufacturer of the tube advises against using the target voltage as a means of tube gain control and, therefore, a fixed target voltage is applied. The suppressor mesh associated with the target also must be supplied with a fixed voltage.

The image section supply voltage for the SEC vidicon is obtained from a miniature high voltage power supply (see figure 3). This unit provides an output voltage variable from zero to -8 KV that is controlled by a low voltage input variable from 0 to 8 volts. The gain of the SEC vidicon is controlled by this voltage, i.e., maximum sensitivity is at -7.5 KV and minimum sensitivity is at -2.5 KV. This power supply is synchronized to the horizontal line rate so that output ripple may be kept out of the television picture by hiding it in the horizontal blanking interval. Ripple must not exceed 0.025 percent (.00025) at the line frequency to be tolerable because of radiation from the image section to the target of the tube.

SEC Vidicon

The SEC vidicon is a relatively new low light level imaging device that is approximately 30 times more sensitive than a standard vidicon. The tube provides its full resolution capability (550 TV lines with 3:4 aspect ratio) down to an illumination of $3 \times 10^{-3}$ footcandles and provides 200 TV lines at $5 \times 10^{-5}$ footcandles.

The SEC vidicon achieves its greater sensitivity by the use of a special KCL target and a diode image section. The electron image formed by a S-20 photocathode is accelerated toward and focused on the KCL target by the image section with considerable energy (-8 KeV). Secondary electron conduction (SEC) occurs causing the target to charge to a higher voltage providing an equivalent light gain and, therefore, an increase in sensitivity.

The SEC scanning mechanism is identical to a separate mesh vidicon except for the addition of one additional grid - the suppressor grid (G5). This grid, located between G4 and the target, is required to keep the target from charging to too high a potential where the target "crosses over" and video inversion occurs. This one element is the cause of the major problems of the SEC vidicon. Its presence limits the resolution of the SEC to 550 TV lines maximum and presents a continuous danger of possible damage during tube installation or camera repair. The G5 and target are physically located so close to one another and are so thin that a static charge applied between the two elements will pull them together causing the KCL to pull off the target onto the G5 or causing complete destruction of the target. Special safety precautions will prevent this, but the danger is always there. This close spacing of the G5 and target also accounts for the upper vibration limit of 15 g's on the tube.

The useful lifetime of the tube is at present not a well defined parameter, and preliminary life data causes some concern. With maximum tube loading - a fixed black and white coarse bar chart across the tube - usable lifetime is approximately 500 hours. It is felt that this test is not valid since such a static high contrast scene is very seldom encountered in actual use. One normally encounters a lower contrast dynamic scene that is much easier on the tube than the coarse bar chart. This fact should enable the tube to be used for at least 4000 to 5000 hours.

Overall, the SEC vidicon is a good reliable device and is quite useful where sensitivity is of prime concern and high resolution and fidelity is not required.

Camera Control Unit Block Diagram

The camera control unit for the SEC and vidicon cameras has three primary functions: generation of the necessary voltages required throughout the camera system, generation of the vertical sweep waveform, and processing of the video received from the camera head. The camera control unit block diagram is shown in figure 3.

Low Voltage Power Supply

The low voltage power supply is required to operate within specification limits over the input voltage range of 24 to 32 volts d.c., but the unit will actually operate from 16 to 45 volts d.c. with only slight degradation of output characteristics. For maximum efficiency the unit uses a variable pulse width type switching circuit for d.c. to d.c. conversion. Regulated output voltages of 450, -100, +40, and +20 volts and unregulated outputs of +20, +14, and -14 volts are provided. In addition, a filament current source of 135 to 300 ma is also provided.

Because the SEC vidicon voltages must be turned on in a certain sequence, timers are required in the low voltage power supply. When primary power is applied to the camera control unit, all voltages are immediately generated, but two voltages, the +40 V and +20 V regulated busses, are routed through time-delayed switches. After a 60-second delay the +40 V buss is applied, and after an additional 5 seconds, the +20 volt buss is applied. This sequence is required to protect the target of the SEC vidicon. The 60 seconds is allowed for the cathode to come up to temperature, thus establishing the beam before the target and suppressor mesh voltages are applied - these voltages are generated from the +40 volt buss. Five seconds thereafter, the +20 volts is applied to the high voltage power supply which powers the SEC image section. A delay is needed here to allow the target to be "scanned off" prior to being exposed to an image from the image section.

An input LC filter is provided at the +28 volt input to the supply to enable the unit to meet all the requirements of MIL-I-6181D and transient specifications.

The low voltage power supply is synchronized to the horizontal line rate to improve picture noise levels. A large transient is generated when the switching transistor turns on and this transient is coupled into the video. By synchronizing the supply, this transient was held in the horizontal blanking interval where it is not visible on the monitor screen.

Vertical Sweep

The vertical sweep circuitry utilizes a 709 operational amplifier and a feedback scheme to achieve a linearity of better than one percent. Since the circuitry is designed to drive a constant current waveform into the deflection coils, resistance changes of the vertical deflection coils with temperature have no significant effect on picture vertical linearity.

Video Processor

The video signal from the camera head must be processed before it can be displayed on the TV monitor because the low and high frequency portions of the video waveform are very low in amplitude and must be restored and amplified. Also, blanking must be added.

Hi-Peaker

To restore the high frequency response lost because of the vidicon and preamplifier shunt capacitance a high peaker circuit is required. This circuit employs a common emitter stage with an emitter feedback resistor shunted by a small capacitor. This results in a response that is constant up to a frequency where the impedance of the shunt capacitor becomes significant and causes the gain of the amplifier stage to increase with increasing frequency at a rate of 6 db per octave. This action flattens the high frequency response of the system to 10 MHz.

Aperture Corrector

A narrow band peaking circuit is provided in the vicinity of 9 MHz to compensate for the finite size of the vidicon scanning beam. This circuit is not needed for the SEC camera because of the SEC's inherent lower resolution, but significant improvement is achieved in the performance of the standard vidicon system by use of this circuit.

Amplifier

A standard feedback pair amplifier is used to achieve the desired overall video level and to provide a low output impedance to drive the keyed clamp circuitry.

Keyed Clamp

A back porch four diode keyed clamp is required to restore the low frequency response of the system that was lost in the previous amplifier stages and to re-establish the d.c. reference (black level) of the system. This device is a must in the system because it enables the use of a.c. coupled amplifier stages with relatively small coupling capacitors instead of a d.c. coupled video chain that would be very difficult to achieve.

Blanking Adder

Composite blanking is added following the clamp to clean up the uneven vidicon tube blanking waveform which is unusable as system blanking because of the presence of a large horizontal flyback pulse.

### Gamma Corrector

The "gamma" or slope of the transfer characteristics of the SEC and 4503 vidicons are considerably different, and this difference must be corrected to achieve a true picture reproduction. Because the transfer characteristic of the standard vidicon and the monitor cathode ray tube complement one another, no gamma correction is necessary for the standard vidicon camera. The SEC transfer characteristic must be shaped so that it is the same as that of the vidicon. This is accomplished simply with a diode matrix following the blanking adder. Additional voltage gain must be provided in the feedback pair amplifier to drive this circuit.

### Output Amplifier

Two Darlington output amplifiers are incorporated to provide a 75 ohm output impedance.

### Blanking and Clamp Generators

Standard pulse circuitry is utilized to combine incoming horizontal and vertical drive pulses into a composite blanking waveform and a line rate clamping waveform. These signals are applied to the blanking adder and keyed clamp circuits previously described. The clamp pulse is generated from the trailing edge of horizontal drive and has a duration of approximately three microseconds.

### Automatic Gain Control

The unprocessed video from the camera head is amplified and rectified to generate a zero to 80 volts d.c. control voltage that is inversely proportional to the camera incident illumination. This voltage is used directly as the target voltage in the vidicon camera and is used as the high voltage power supply control voltage in the SEC camera after passing through a 10 to 1 resistive divider. A low pass filter network is installed in the SEC control line to eliminate oscillations.

Manual and Remote Gain Controls

A variable resistive divider is provided for use as a manual gain control during initial checkout or for a system in which a fixed sensitivity is required. Connections are also provided for external remote gain control.

Miscellaneous Provisions

Telemetry readouts of temperature, +450 supply buss, AGC voltage, filament current, vidicon cathode voltage, and input current are available at the camera control unit.

An interlock for the SEC high voltage power supply voltage is available at the camera control unit to provide a quick disable capability for the SEC vidicon without turning off the system.

The SEC suppressor grid (G5) voltage (isolated) is routed to the camera control unit so that this voltage may be temporarily grounded externally to aid beam alignment.

A provision for testing the vidicons for gas by lowering G4 potential to slightly below G3 is also externally available at the camera control unit.

Detailed performance parameters for the SEC and vidicon camera systems are shown in tables 1 and 2, respectively.

Image Dissector Camera

A camera using an image dissector tube was designed and manufactured by Ball Brothers Research Corporation in Boulder, Colorado. This camera runs at standard scan rates being controlled by the system master sync generator which supplies horizontal and vertical drive signals to the unit. Two 1.0 Vpp composite video outputs are provided from the system to drive the two video switches. A horizontal only scan mode is available for this camera to enable video analysis of sun information and pointing information when required. This camera is used in the Naval Research Laboratory Experiment B.

The image dissector tube was selected for use because of its excellent

## ATM VIDICON TELEVISION
## CAMERA PERFORMANCE CHARACTERISTICS

Table 1

Resolution: Horizontal - Center 900 TV lines at 5%
Corner 500 TV lines
Vertical - 330 TV lines

Shades of Gray: 10 minimum

Sweep Linearity: ±2%

Geometric Distortion: ±3%

Image Format: 0.44 inches square

Sensitivity: 0.050 $\frac{\text{microamps}}{\text{microwatt}}$ at 6563 Å with 0.02 microamps dark current
Full resolution and gray scales - 4.0 microwatts
400 TV lines - 0.4 microwatts

Sensitivity: 2870° K Tungsten Source
Full resolution and gray scales - 0.1 footcandles
400 TV lines - 0.01 footcandles

Dynamic Range: 3000:1

Signal to Noise (highlight): 35 - 40 db

Lag: 30% max. in the third field readout for highlight signal current

Aspect Ratio: 1:1

Scan Parameters: 525 scan lines (15,750 Hz); 30 frames per second, 2:1 interlace
All pulse formats in accordance with EIA Standard RS-170

Electrical Power: 22 watts total at 28 ± 4 volts
6 watts dissipated in camera head

Size: Camera - 8.75 x 4.60 x 5.00 inches
Control Unit - 9.50 x 7.75 x 4.87 inches

Weight: Camera - 7.75 lbs.
Control Unit - 11.5 lbs.

Temperature Range: Camera - -26° to +45°C
Control Unit - -40° to +74°C

Vibration: 15 g's rms; 20 - 2000 Hz shaped

Altitude: 0 - 600,000 ft.

## ATM LOW LIGHT LEVEL TELEVISION CAMERA PERFORMANCE CHARACTERISTICS

Table 2

Resolution (highlight): Horizontal - Center 600 TV lines at 5%
Corner 400 TV lines
Vertical - 330 TV lines

Shades of Gray: 8 (minimum)

Sweep Linearity: ±2%

Geometric Distortion: ±5% max.

Image Format: 0.7" x 0.7" square

Sensitivity: 1.0 $\frac{\text{microamps}}{\text{microwatt}}$ at 6563 Å
Full resolution and gray scales - 0.1 microwatt
200 TV lines - 0.002 microwatt
Operating Range: .002 to 8 microwatts

Sensitivity: 2870° K Tungsten Source
Full resolution and gray scales - $5 \times 10^{-3}$ footcandles
200 TV lines - $5 \times 10^{-5}$ footcandles
Operating Range: $5 \times 10^{-5}$ to $2 \times 10^{-1}$ footcandles

Signal to Noise (highlight): 34 db

Lag: Less than 10% in the third field readout for highlight signal current

Spectral Sensitivity: S-20 photocathode

Aspect Ratio: 1:1

Scan Parameters: 525 scan lines (15,750 Hz) at 30 frames/sec. with 2:1 interlace
All pulse formats in accordance with EIA Standard RS-170

Electrical Power: 22 watts total at 28 ± 4 Vdc
6 watts dissipated in camera head

Size: Camera - 12.40 x 4.60 x 5.00 inches
Control Unit - 9.50 x 7.75 x 4.8 inches

Weight: Camera - 11.5 lbs.
Control Unit - 11.5 lbs.

Temperature Range: Camera - -26° to +45°C
Control Unit - -40° to +74°C

Vibration: 15 g's rms; 20 - 2000 shaped

Altitude: Atmospheric or space environment. SEC faceplate will not withstand critical pressure without arcing.

linearity over a wide dynamic range and because of its reliability. The tube has the additional advantages of high resolution, no lag, and fast turn on (no filament). The tube requires very high incident illumination, but this is no problem when viewing the sun directly.

Sync Generator

The sync generator for the ATM TV System provides master timing pulses to all of the ATM TV cameras and monitors. Since a failure of the sync generator would cause a complete failure of the ATM TV system, it was decided to make the sync generator totally redundant so that each sync generator package consists of two complete independent sync generators including power supplies. The 75 ohm outputs of each generator are wired in parallel and the output circuitry is designed in such a manner that when a unit is in the off condition, its output impedance is very high. A 68 ohm series resistor is inserted in each output lead ahead of the point where the redundant outputs are paralleled so that a shorted output transistor in one generator would not disable the other generator. This worst case failure would cause the output of the remaining generator to drop to half voltage -1.75 volts, but this would not cause a system failure because the cameras and monitors are designed to operate at this reduced level. See figure 4 for the sync generator block diagram and table 3 for detailed performance parameters.

Power Supply and Input Filter

The power supply for the sync generator is variable pulse width type device with two regulated outputs. A +5 volt output is provided to power the counter and pulse former circuitry, and a -12 volt output is provided to supply the pulse output circuitry. Because of the large number of output circuits (20), the -12 volt buss must be capable of delivering a surge current of 1.5 amps without sagging. The input filter circuitry isolates the power supply from the input power line to the requirements of MIL-I-6181D and protects the unit from power line transients.

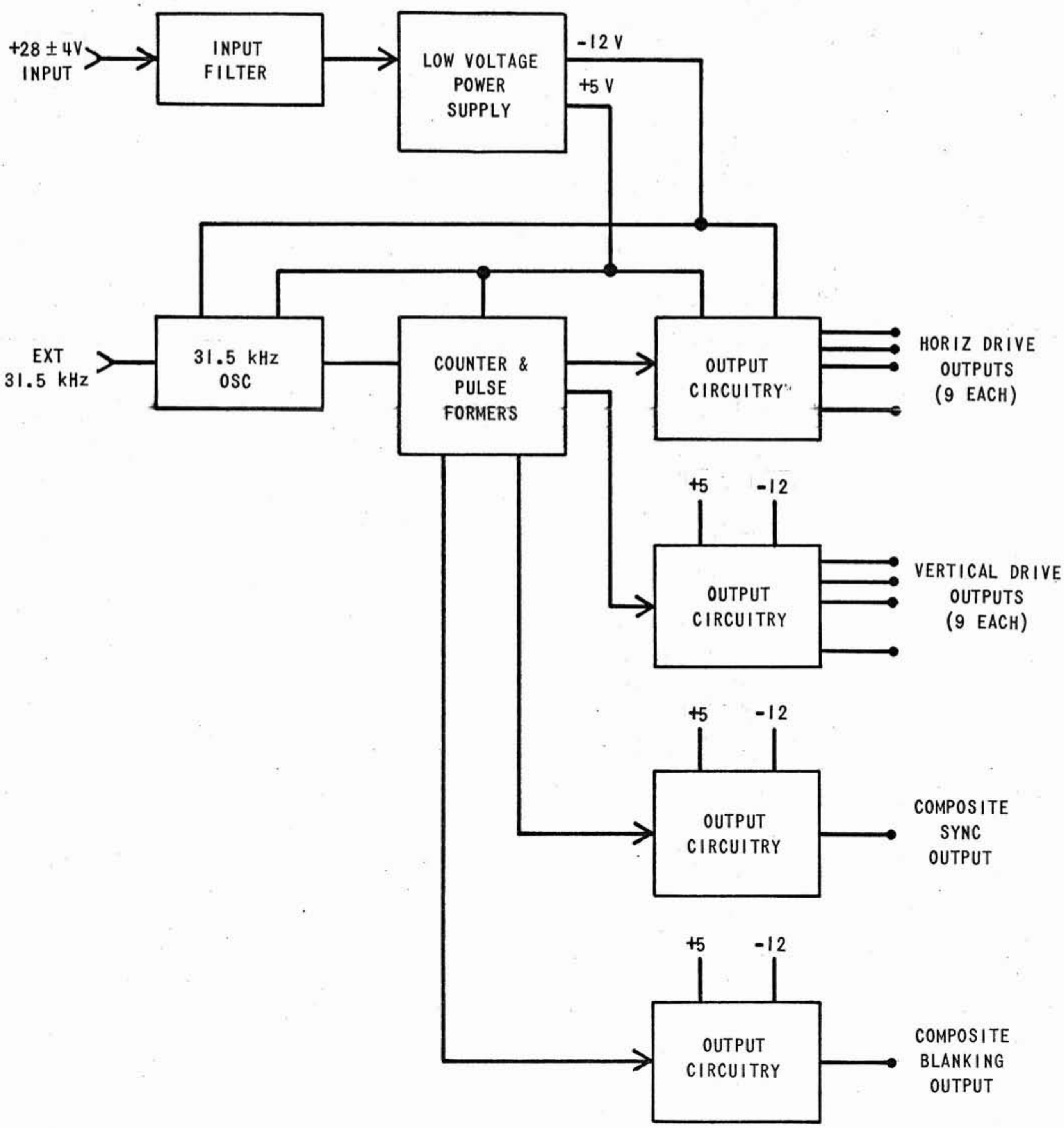


Figure 4. Sync generator block diagram (1/2 unit).

ATM SYNC GENERATOR
PERFORMANCE CHARACTERISTICS

Table 3

Function: To synchronize the ATM TV system by providing horizontal and vertical drive pulses to each TV camera and monitor.

Outputs: Horizontal Drive (9)

Width: 0.1 H ± 0.005 H*

Amplitude: -4.0 ± 0.5 volts

Vertical Drive (9)

Width: 0.04 ± 0.006 V**

Amplitude: -4.0 ± 0.5 volts

Oscillator Frequency: 31.5 kHz ± 1.0%

Redundancy: 100% (including power supply)

Electrical Power: 9 watts at 28 ± 4 volts

Scan Parameters: All outputs conform to EIA Standard RS-170

Size: 10.44 x 9.50 x 5.00 inches

Weight: 14.4 lbs.

Temperature Range: -40° to +74°C

Vibration: 15 g's rms; 20 - 2000 Hz shaped

Altitude: 0 to 600,000 feet

*H = 63.5 usec
**V = 16.67 msec

Master Oscillator

The master oscillator for the sync generator is basically an LC type oscillator with a 31.5 kHz 5 Vpp pulse output that drives the counter circuitry. The unit meets the requirements of EIA Standard RS-170 over the temperature range of -20°C to +74°C. If desired, the oscillator may be synchronized to an external 31.5 kHz source.

Counter & Pulse Former Circuitry

The counter circuitry converts the 31.5 kHz master oscillator signal into the basic horizontal and vertical rates, 15, 750 Hz and 60 Hz, respectively, resulting in 2:1 interlace waveforms.

The pulse former circuitry in conjunction with the counter circuitry generates the EIA Standard RS-170 horizontal drive, vertical drive, composite sync and composite blanking waveforms. At this point these waveforms are +5 Vpp high impedance signals.

Output Circuitry

The output circuitry accepts these signals, level shifts them to -4 Vpp, and converts them to 75 ohm impedance outputs. Nine pairs of horizontal drive and vertical drive outputs are available to synchronize the five cameras and two monitors. The two additional pairs of outputs are spares. One sync and one blanking waveform are provided for use on an RF downlink if added at a later date.

Video Switch

The video switches provide the astronaut with the capability to remotely select any one of the five TV cameras for viewing on either of the two TV monitors. These switches are solid state devices with a bandwidth from d.c. to 10 MHz flat within 0.5 db. A d.c. response was chosen over a keyed clamp system because the system scan rate was not firm at the time the video switch was designed. Serious thought was being given to slow scan rates at that time, and, therefore, a d.c.

response was chosen to give complete versatility. Crosstalk is -45 db at 10 MHz. See figure 5 for the video switch block diagram and table 4 for detailed performance parameters.

Power Supply and Input Filter

The power supply for the video switch is a variable pulse width device with two regulated outputs - +12 Vdc and -6 Vdc. The input filter circuitry isolates the power supply from the input power line to the requirements of MIL-I-6181D and protects the unit from power line transients.

Switch Circuitry

The switch circuitry has the capability to connect any one of six 0 to 1.8 Vpp video inputs to its output while keeping the other inputs isolated and terminated in 75 ohms. Switching is accomplished by simply applying an internally generated +5 Vdc to the control transistor of the channel to be energized. This action causes the series switch element to be closed and the shunt 75 ohm termination to be removed. No amplification is needed in the video switch because the 75 ohm termination seen by the active channel camera is the TV monitor and not the video switch itself.

TV Monitor

The TV monitor was designed and manufactured by CONRAC Corp. of Covina, California. The unit is capable of displaying the full resolution capability of the standard vidicon camera on a seven inch Thomas cathode ray tube (CRT). The raster is six inches square with the corners being lost over the edge of the seven inch CRT. This is of no consequence since the only scene being viewed is the circular sun.

The unit is synchronized by the horizontal and vertical drive pulses from the sync generator.

Front panel control of brightness and contrast is provided. Vertical and

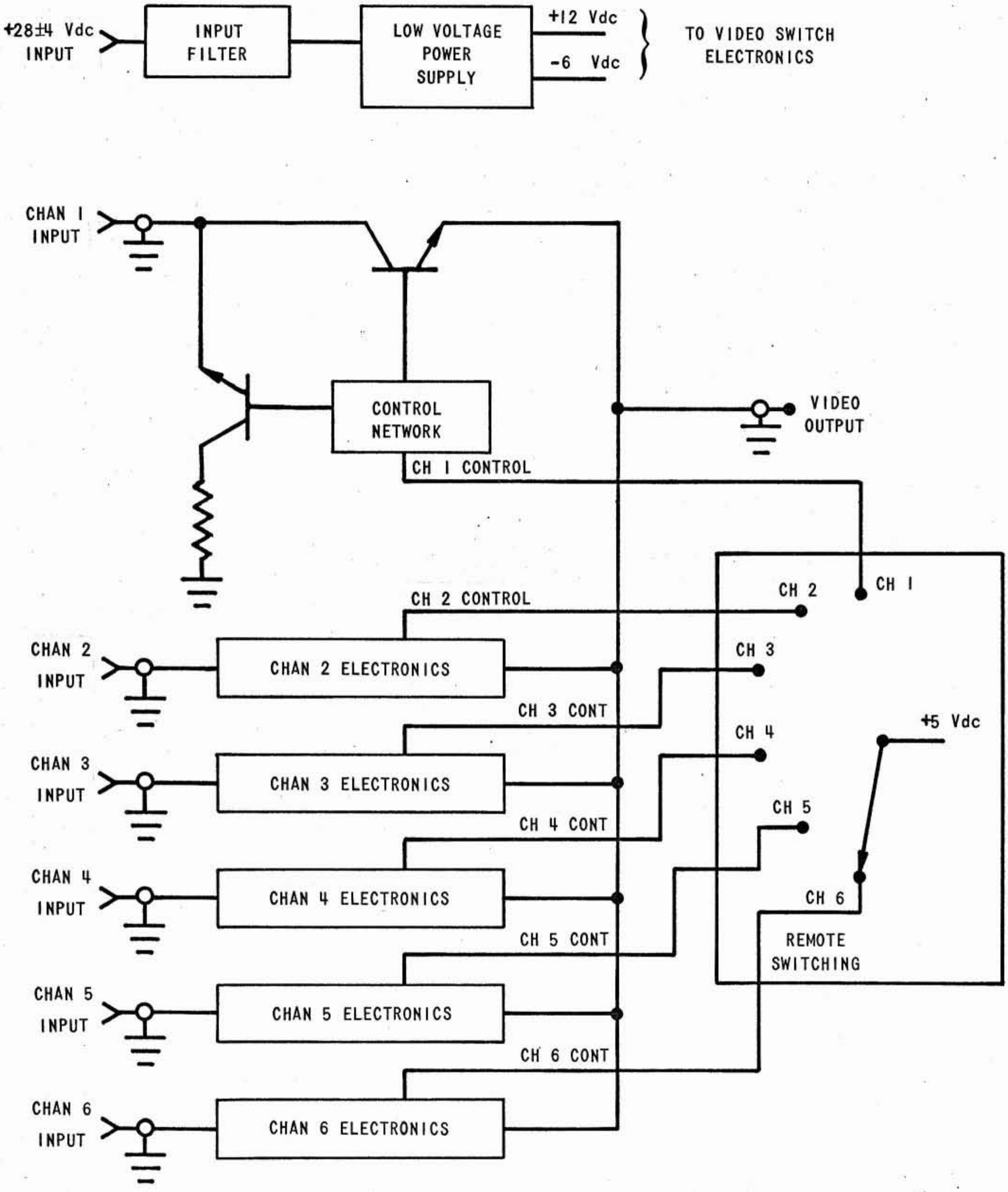


Figure 5. Video switch block diagram.

Table 4

## ATM VIDEO SWITCH
## PERFORMANCE CHARACTERISTICS

Function: To provide camera selection for the television monitor.

Input Channels: 6 maximum

Output Channels: 1

Gain: 0.90 ± 0.05

Bandwidth: DC to 10 MC ± 0.5 db

Impedance: Input - 75 ± 5 ohms

Output - 75 ± 5 ohms

Input Level: 0.5 to 1.8 volts peak-to-peak

Switch Control: Remote (7 conductor cable and 6 position wafer switch)

Electrical Power: 2 watts at 28 ± 4 volts

Crosstalk: -45 db

Size: 7.75 x 6.62 x 2.83 inches

Weight: 5.0 lbs.

Temperature Range: -40° to +74°C

Vibration: 15 g's rms; 20 to 2000 Hz shaped

Altitude: 0 to 600,000 ft.

horizontal hold controls are not required.

Electronic vertical and horizontal crosshairs are available to mark positions of events of special interest on the sun. Controls for these crosshairs are on the monitor front panel along with a crosshair intensity control.

Because the monitor must operate in a man rated oxygen environment, special precautions were taken with the materials used. Materials or parts that would support combustion or inject toxic substances into the manned environment were not used. The faceplate of the CRT contains a bonded implosion panel to prevent accidental breakage of the tube faceplate. All controls are of sufficient diameter to be operated by an astronaut in a space suit. See table 5 for detailed performance parameters.

DETERMINATION OF SCAN RATES

At the inception of the program considerable effort was devoted to optimization of scan rates, video bandwidth and related parameters. The original concept included a video downlink to allow experts on the ground to analyze the solar data in real time and optimize experiment utilization. Since the expected bandwidth of the downlink was small, considerable effort was expended in an attempt to reduce the bandwidth requirement for the real time television data.

The most promising approach appeared to be the use of a non-standard interlace. A standard television system operates at 30 frames per second where each frame consists of two fields which occur sequentially with the scan lines interlaced. This provides an effective field rate of 60 per second which is sufficient to keep the display free from flicker under most conditions. A higher field rate should allow a reduced frame rate without objectionable flicker. It would also reduce the design requirement for the system significantly by reducing video bandwidth.

Unfortunately, the choice of frame rate, field rate, interlace, etc., involves a highly complex interrelationship between the physiological properties of the

# ATM TELEVISION MONITOR
## PERFORMANCE CHARACTERISTICS

Display Size: 6-inch diameter usable area (7 inch CRT)

Faceplate: Laminated safety glass

Controls: Brightness
- Contrast
- Electronic Crosshair (1 scan line wide)
  - Vertical Adjust
  - Horizontal Adjust
  - Intensity

Resolving Capability: 800 TV lines

Brightness: 35 foot-lamberts

Shades of Gray: 10 minimum

Geometric Distortion: ±1%

Raster: Square and overscanned so that edges of raster are tangent to CRT edge

Phosphor: P4

Spot Size: .006 inches maximum at tube center

Video bandwidth: 3 db down at 10 MC

Size: 13.25 x 9.88 x 13.38 inches (h x w x d)

Weight: 32 lbs.

Temperature Range: +10° to 30°C

Vibration: 15 g's rms; 20 to 2000 Hz shaped

Altitude: Atmospheric or space environment human eye, the characteristics of the phosphors in the display kinescope, ambient illumination, and many other items. To determine if the system could, in fact, be operated at a non-standard rate, a series of laboratory experiments were conducted. A variable scan sync generator was developed and used in conjunction with a representative group of kinescopes providing a range from very fast phospher decay to very slow. Laboratory scenes were televised and approximately six (6) viewers were employed to achieve a representative sample. The results were disappointing in that it was discovered that any interlace greater than 2:1 provided unacceptable interline flicker with any combination of ambient lighting and fast phospher. The only phospher which gave acceptable results was the P19 which was far too slow in decay time to allow viewing a rapidly changing phenomenon such as the sun in H-Alpha. With these results it was decided to use a system employing standard scan in accordance with EIA Standard RS 170 along with a standard P4 phosphor. A secondary advantage of this decision is provided by the fact that in case a TV downlink is incorporated at a later date any television desired for network transmission is directly compatible and does not require bulky complex conversion equipment as has been used on several of the Apollo flights.

## CHOICE OF LOW LIGHT LEVEL IMAGING DEVICES

The ultra low energy content of the white light coronagraph and the extreme ultraviolet spectrograph experiments require the use of a low light level device as a sensor. Three types were considered as follows:

1. Image Orthicon
2. Vidicon with Image Intensifiers
3. SEC Vidicon.

The image orthicon was eliminated at the outset primarily because of its large physical size and associated design problems, but the choice between SEC vidicon and intensifier vidicon was much more difficult. The intensifier vidicon possesses many desired advantages, but these are outweighed by its disadvantages; and, therefore, the SEC vidicon was chosen for use on the ATM. The factors regarded as pertinent are shown in table 6.

CONCLUSION

The ATM TV System will provide the astronaut with an invaluable tool for gathering solar data. The versatility and high quality of the TV system will enable him to spend more time on solar study than on the mechanics of gathering data. If a TV downlink is provided at a later date, the TV system will enable the solar astronomer to actively participate in the solar observations and guide the astronaut to data that he might have missed otherwise.

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# ADVANTAGES AND DISADVANTAGES OF SEC AND INTENSIFIER VIDICONS

## ADVANTAGES

### SEC-Vidicon

1. Good uniformity
2. Low lag
3. Good resolution
4. Can be integrated over long periods
5. Requires only -8 KV of high voltage
6. Readily available

### Intensifier Vidicon

1. Rugged environmental package
2. Good resolution
3. Allows use of standard vidicon
4. Minimizes design changes from standard vidicon camera
5. Low cost

## DISADVANTAGES

### SEC-Vidicon

1. Ruggedness of tube limited by G5/target
2. Tube easily damaged during installation
3. High cost
4. Blemishes
5. Lower Signal-to-Noise ratio than IV
6. Lower life time than IV

### Intensifier Vidicon

1. Poor uniformity
2. High lag
3. Can only be integrated for short time periods
4. Optical coupling problems
5. Requires -15 KV of high voltage