RCA TV CAMERA ON APOLLO 8 ORBITS ARMCHAIR VIEWERS 'ROUND THE MOON

When men for the first time in history orbited the moon during December 1968, millions of TV viewers around the world journeyed vicariously with them through the eye of a 4½ pound TV camera on board the spacecraft. The portable camera provided a "fourth" seat in the Command Module enabling the home audience to monitor the three American astronauts at work inside their spaceship, during the ½ million mile round trip, and to enjoy a spaceman's view of the moon and the earth. This tiny camera, small enough to fit in the glove compartment of a car, is an exact duplicate of the RCA camera which sent back the live TV pictures during the Apollo 7 earth orbit in October. It was developed by RCA for the National Aeronautics and Space Administration to enable armchair explorers to view this historic space happening.

TV System

The Apollo TV system consists of the portable TV camera on board Apollo 8, and electronic signal processing equipment (scan converters) at Merritt Island, Florida; Goldstone, California; and Madrid, Spain. The TV camera and ground equipment were produced by the RCA Astro-Electronics Division, Princeton, N. J.

The camera was built under contract to North American Rockwell, Inc., prime contractor to NASA's Manned Spacecraft Center for the Apollo Command Module. The scan converters were built under contract to NASA's Goddard Space Flight Center, which manages the Flight Network.

TV Camera

The tiny RCA camera weighs less than five pounds, including lens. It uses a 160-degree wide-angle lens for on-board monitoring of the Astronauts, and a 100-mm lens for viewing scenes outside the spaceship. The TV signal from the camera was fed into the spacecraft's communication system for transmission to Goldstone or Madrid. There it was received, processed, and relayed to the NASA Manned Spacecraft Center for release to the world's major TV networks. The use of integrated circuits permitted building the small, lightweight camera that requires only six Watts of power to operate.

Spacecraft Transmission Link

The TV camera output is fed into a Premodulation Processor where it is frequency multiplexed with voice and telemetry data. The video then feeds into an S-Band antenna system for transmission to earth. For close-to-earth transmission an omni-band antenna is used, for transmission from deep space a high-gain antenna is used.

Operating Principles

Normally broadcast TV operates with a signal bandwidth of 4½ million cycles. However, because of space limitations, the Apollo system was designed to operate with a ½ million cycle bandwidth. This 9-to-1 reduction in bandwidth results in substantial saving of power—but makes it necessary to reduce TV frame and line rates. Apollo TV is 10 frames per second (compared to 30 for regular TV) and produces a picture with 320 scanning lines (525 for regular TV). The scan converter systems convert the signal from Apollo standards to broadcast scan standards in order to have suitable picture display on home receivers.

Apollo TV in the future will also transmit high-definition "still" photographs for scientific purposes. To accomplish this within the 500 kHz bandwidth requirement, the photographs will be transmitted at a rate of one frame per 1.6 seconds, allowing 1280 lines per frame. The RCA scan conversion system has been designed to compensate for these irregularities in transmission and convert the incoming signals from Apollo to broadcast format.

Elements of RCA Converter System

(1) TV Display. This consists of 5CK11 flying-spot tube and vertical line wobble to reduce line structure without affecting horizontal resolution. Because of Apollo TV's two scanning rates (10 frames per second, 320 lines per frame, and one frame per 1.6 seconds, 1280 lines per frame), deflection circuits were specially designed to maintain size, centering and linearity when switched between the two scanning rates: a hor-

FIG. 1 Millions enjoyed live telecasts from space, by means of this compact RCA camera, during the first manned flight of the Apollo Command Module.


UNITED
STATES

izontal rate change of 4-to-1 and a vertical rate change of 16-to-1. The 10-frame-per-second (non-interlaced) Apollo TV system uses either conventional pulse-type sync or tone-burst sync at 409.6 KC. The high-definition "still" photograph system uses the tone-burst for its sync.

(2) Vidicon Camera. This is a standard broadcast RCA TK-22 model, modified to accept an external vidicon gating pulse. It also incorporates gamma correction circuitry that is variable to enable operator to place "break points" in the transfer characteristic where desired. The TV camera uses a type 8480 vidicon tube, larger than normal.

(3) Magnetic Disc Recorder. The disc is about 14 inches in diameter and rotates at 3600 revolutions per minute, servo-controlled for long term stability.

(4) Pulse and Timing Units. The RCA system uses a standard sync generator but specially designed sync lock unit and gating generator. Each of these three

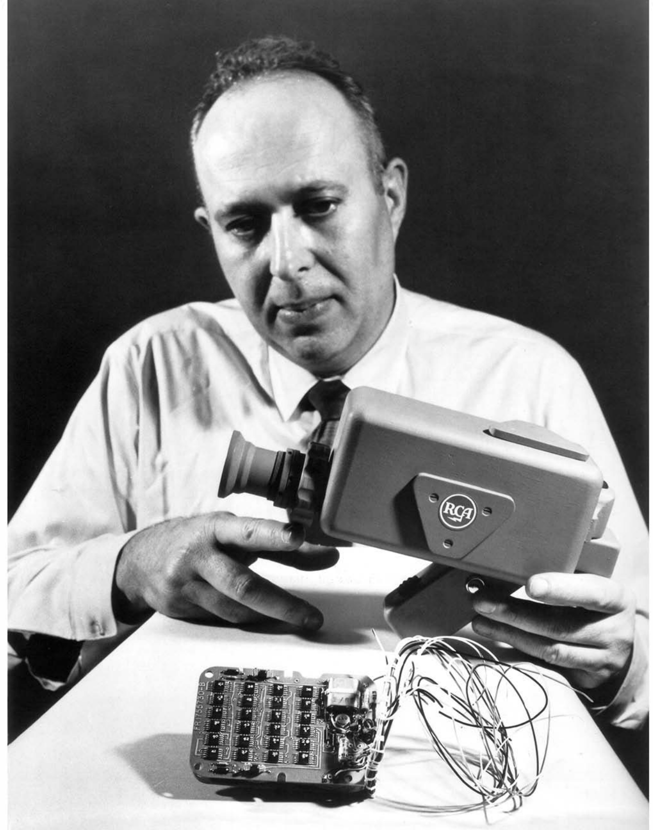

FIG. 3 The use of integrated circuits made it possible to produce a 4½ pound miniaturized TV camera. Hundreds of IC's are contained in the black squares on this circuit board from the Apollo camera.

FIG. 2 Dick Dunphy, who headed the RCA space camera team, operates the miniature TV camera in same manner as astronauts did inside their spacecraft.

elements is a solid-state device, employing primarily digital logic to obtain desired timing pulses.

How Scan Converter Works

A TV signal received from Apollo is applied to the TV display, focused on the RCA broadcast vidicon camera, and stored on the photoconductor target of the vidicon tube. During each sixth broadcast field, which corresponds to each single Apollo frame, the camera reads out one field of video signal at broadcast rates. During the next five broadcast fields, the camera's scanning beam is gated "off". The result is an interrupted video of one field "on", five fields "off".

The interrupted video signal—one field on, five off—then is fed to a magnetic disc recorder. The first field is recorded on the magnetic disc and read out five additional times to fill in the "off" fields. In effect, the recorder repeats the field five times to convert from interrupted to continuous broadcast video.

The magnetic disc recorder is similar in concept to "instant replay" devices used in sports telecasts. As soon as one broadcast field has been recorded, it passes a read-out head as a converted signal ready for commercial broadcast. The field is read out five times and a new field is then recorded.

Critical in the scan conversion process is the storage timing. The first storage comes when the incoming Apollo signal is taken from the display and stored on the photoconductor target of the vidicon camera tube to convert one field of Apollo scan rates to one field at broadcast scan rates. The second storage is on the magnetic disc recorder, which repeats each of the "on" broadcast fields five times to produce continuous broadcast video.

Scan converter performance, from pickup by an Apollo-rated camera, through the scan conversion process, to display on a broadcast quality monitor, produces a signal-to-noise ratio better than 35 dB, good gray scale fidelity, and a resolution response down less than 6 dB at 4 MC.

RCA Countdown Computers

One computer, located within a mobile launcher, checked out the Saturn V by commanding the rocket to exercise valves, engines, relays, and similar components then measuring the performance. A second RCA computer, located in the Launch Control Center, controlled the sequence of checkout and launch countdown programs performed by the first computer.

The two computers are joined by a digital data link that enables them to "talk" to each other. Should the mobile computer detect a problem, it is designed to inform its "twin" which will then initiate a search to pinpoint the trouble and to specify what corrective action must be taken.

The computers monitor 3000 parameters of the Saturn V. During the countdown, the information was displayed before the NASA mission directors—who could break in and direct the action manually at any time.

The computers used in the launch of Saturn V are part of 30 such systems developed by RCA for NASA.

First Homeside Space TV

As millions of armchair viewers watched the Astronauts at work in the spacecraft and saw the fascinating shots of moon and earth, they helped usher in a new era of space exploration. Until now most television camera systems for spacecraft had been designed to obtain scientific data. The Apollo system had the additional privilege of initiating live and taped coverage for the world TV audience.

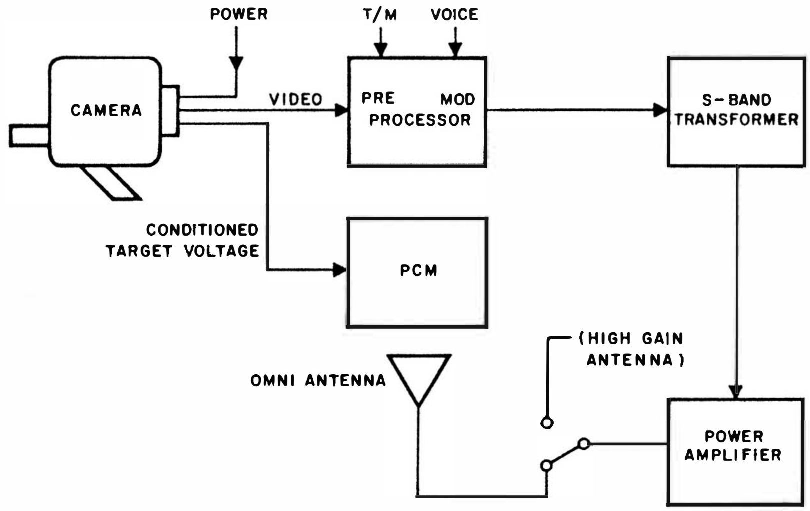

FIG. 4 Block diagram of the on-board Apollo television transmission system.

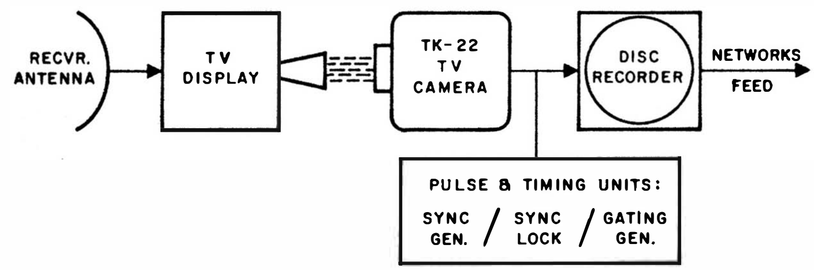

FIG. 5 Block diagram of Scan Converter system at ground stations in Florida, California and Spain.

Operating Parameters of Apollo TV Camera

Bandwidth	500 kHz
Frame rate/lines per frame	10 frames per second/320 lines per frame
Output S/N	36 dB typically
Camera Weight	4.18 lbs. + lens (0.7 lb.)
Power Consumed	5.3 Watts, 6.7 Watts max.
Imaging Tube	1" vidicon, RCA 8134
Sensitivity	0.1 ft.-candle highlight illumination minimum to 30 ft.-candles, maximum
Lenses	(a) Wide Angle—160° 5.4mm f 2.0 (b) 100mm, f 4.0 (T=9)
Controls	(a) On-off switch located near hand hold (b) Automatic light control switch
Resolution	250 TV lines limiting
Output Voltage	2 Volts
Aspect Ratio	4:3 horizontal to vertical
Gray Scale	7 minimum
Input Voltage	28 Volts nominal