

# Docking Transmitted Live in First Color TV From Space

By Warren C. Wetmore

**Houston**—Extensive use of the onboard Westinghouse Electric Corp. television camera by the Apollo 10 crewmen last week gave viewers on earth the first color TV images from space.

These images included the first space maneuver seen as it happened—the docking of the command module with the lunar module after translunar injection. This began at approximately 3 hr. after launch when the spacecraft were about 3,100 naut. mi. from earth and ended 22 min. later when Apollo 10 was 8,187 naut. mi. away.

By transmitting on an unscheduled as well as prearranged basis, the Apollo 10 crewmen logged more television time in the first four days—about 3 hr.—than was allocated in the flight plan for the entire eight-day mission.

Other sequences with the 12-lb. camera included:

- Views of the interior of the command module and the astronauts performing some of their mission tasks.

- View of the McDonnell Douglas S-4B third stage of the Saturn 5 booster after separation from the command module and lunar module, approximately 4 hr. into the mission. Distance from earth was about 12,700 naut. mi.

- Pictures of the earth, beginning 5 hr. 6 min. after launch and 21,000 naut. mi. away. Transmission lasted 13 min.

- Pictures of the surface of the moon, beginning at 80 hr. 40 min., when the

spacecraft were 60.1 naut. mi. from the lunar surface and 214,443 naut. mi. from earth.

The crew's enthusiasm for the TV system appeared greater than that of previous Apollo crews and is attributed largely to spacecraft commander Thomas P. Stafford.

"As far as we're concerned, he was the prime mover" on getting color television capability into the Apollo 10 command module, an Apollo TV engineer here said. "He influenced our management, and they influenced us." The ground-based color conversion equipment was put together in about four months.

Resolution of the pictures was much improved over the three previous manned Apollo flights and was very nearly as good as commercial television. This was because network

standards—525 lines per frame and 30 frames/sec.—were employed for the first time.

The sequential red-blue-green color filter wheel system used was originally developed by the Columbia Broadcasting System about 20 years ago, and the technique was modified by Westinghouse. Color quality of the video seen on monitors here at the National Aeronautics and Space Administration's Manned Spacecraft Center was good.

For the first time, there was a tiny black-and-white monitor on board the spacecraft so that the astronauts would be able to judge the focus and exposure of the TV camera and properly aim it. This monitor weighs less than 4 lb., and has a screen that measures 2 x 2.75 in.

One of the problems encountered during the flight was a basic shortage of color in space, except for the command module's interior and the earth as seen from the spacecraft. The lunar module was a bright, silvery-white except for the orange platform in front of the front hatch. The lunar module was so bright that the astronauts were asked to keep the camera moving slightly in order to prevent spots from

being burned into the image tube. The S-4B also was a bright white, and the moon was grayish brown.

But the earth showed a good contrast of whorls and banks of white clouds over brilliant blue-green oceans and predominantly red-brown land masses.

At the transmission just before lunar orbit injection on May 21, when the camera lens was at maximum magnification, Stafford noted that "at this distance [about 209,000 naut. mi.] the earth looks slightly smaller than a tennis ball . . . and a little bit larger than a golf ball."

Views of the interior of the spacecraft were sharp, and the flesh tones of the astronauts' faces and hands accurate except when they were in shadow.

The green lights on the instrument and control panels also were seen clearly and it was easy to identify panels and components of the spacecraft.

One of the difficulties of operating the camera inside the command module was the intense sunlight streaming in the windows, giving a high contrast with the shadows. Since the camera was set for lower light levels, occa-

sionally the sunlit white colors washed out, with consequent loss of definition of the object.

After the docking maneuver, a TV sequence from the command module clearly showed the lunar module rendezvous window, with reddish-orange frame and light green docking reticle.

The astronauts demonstrated the effects of weightlessness by free-floating maneuvers. A highlight of these demonstrations showed command module pilot John W. Young floating inverted. Then Stafford cupped Young's head in one hand and gently raised and lowered him.

#### **Water Problem**

Lunar module pilot Eugene A. Cernan was able to show the mission controllers on the ground the problems that the astronauts were having with the plastic centrifuge bag designed to separate gaseous hydrogen in the potable water from the fuel cell. Cernan spun the bag in front of the on-board camera to demonstrate how the gas collected into one large bubble, but did not rise to the bleed valve at the top, as it was supposed to do (see p. 21).

The TV camera uses the basic elec-

tronics of the 7.25-lb. Westinghouse unit flown on Apollo 9 (AW&ST Mar. 24, p. 56) but is heavier and larger because of the color wheel. Its overall length is 17 in., including the zoom lens with a variable focal length from 12.5 mm. to 75 mm. The aperture range is from f/2.2 to f/22 and focus range is 20 in. to infinity. The secondary electron conduction image tube permits the camera to be used at low light levels.

The color wheel has six color fields in it, sequential red-blue-green-red-blue-green. The wheel is turned at 10 rps., synchronous with the camera's frame rate, so that each complete frame is made through a single color. In this manner, the first frame of the sequence would have the red information in it, the second the blue, and the third the green and so on. They are transmitted separately and in series, rather than three colors in parallel as with the systems used on network television.

The images were received by the NASA earth stations—Madrid and Goldstone, Calif., have been used—and transmitted to Manned Spacecraft Center by communications satellite or land line. There, they underwent two proc-

esses: doppler effect compensation and conversion to color.

Because of the greater sensitivity of color TV to frequency distortion due to the spacecraft moving at high speed away from or toward the earth, it was necessary to design a compensator. This was accomplished by two video recorders with a variable-length tape loop between them. One of the units recorded in synchrony with the incoming video signal as the tape was fed into a loop between the two machines. Tension was maintained on the loop by means of a counterweighted roller arm.

#### **Image Pickoff**

The downstream end of the loop was fed to the other recorder, which was slaved to a synchronous pulse generator operating at network standards. This allowed the images to be picked off the tape at the correct speed for the TV networks. The difference in speeds of the two machines is small but was varied according to the speed of the spacecraft and whether it was approaching the earth or going away.

There was sufficient length in the loop to allow at least 1 hr. of continuous television without having to readjust the loop.

But the existence of this loop meant that there was an unavoidable 10-12 sec. delay between reception and output of the signal.

The heart of the color converter was a video disk recorder similar to those used by the networks to provide slow-motion instant replays for sporting events. The incoming red field was recorded on one track, the subsequent blue field on the next and the green on the third.

Then all three were played back together for serial-to-simultaneous red-green-blue conversion.

The simultaneous colors were fed to a conventional color multiplexer and its network-compatible output was passed through distribution amplifiers to the network. The color multiplexer also added the red, blue and green together to get a black-and-white output.

#### **Color Adjustment**

NASA engineers also had the capability of adding colors to obtain greater realism. This operation was done in the first minute or so of the first TV broadcast on launch day, and the color controls were then fixed.

The fact that a particular color is updated only once in three frames means that color distortion is possible if the motion recorded by the camera is too fast.

This was seen when Cernan was spinning the water bag—the individual red, green and blue separated in the image of the rapidly spinning bag.