CQ

March 1969
75¢

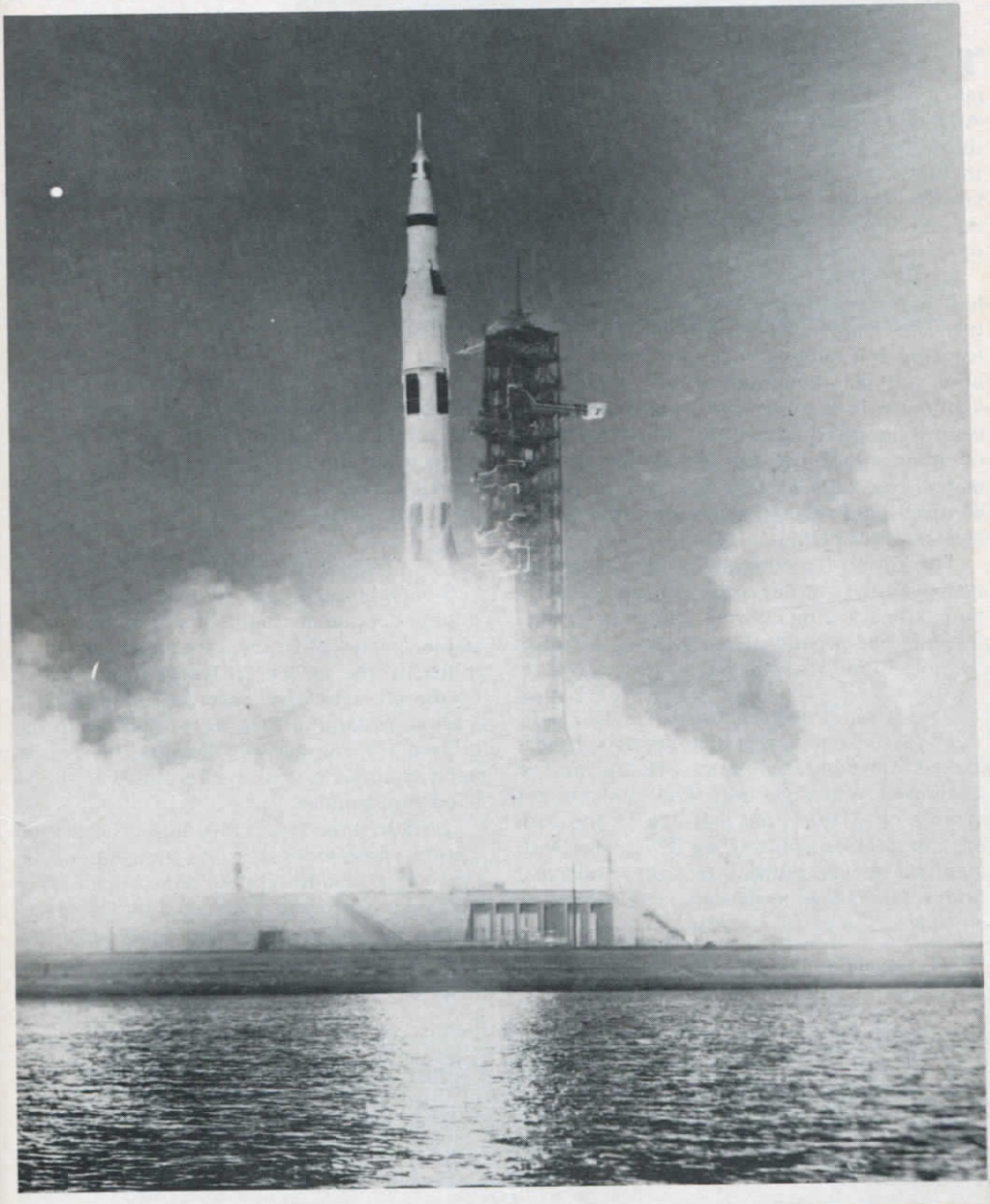
THE VOICE OF APOLLO-8

Page 17

The Radio Amateur's Journal

The Voice of Apollo-8

BY HOWARD W. KELLEY,* K4DSN



Apollo-8 leaves the pad December 21, 1968 at 7:51 A.M. At this moment communications are handled basically on v.h.f./a.m. with a 2100 mc backup and data link. It takes 7,500,000 lbs. of thrust to get the Saturn 5B and spacecraft off the launch hill.

See page 110 for New Reader Service

The Voice of Apollo-8

BY HOWARD W. KELLEY,* K4DSN

THE world is still reveling over the remarkable success of the Apollo-8 moon mission. Among its many successes, the flight introduced new strength into communication theories and practical applications. To the Greeks, Apollo was a god of light and if Apollo-8 did little else it certainly shed a lot of it on modern science.

Telecommunications aboard the spaceship had to be something special to be able to provide voice, television, telemetry, and tracking and ranging back to earth. It had to also provide communication among the astronauts in the spacecraft and include the central timing equipment for synchronization of other equipment and correlation of telemetry gear. All of this and still be small, compact, and require minimum drain on the craft's power plant.

The key to the entire telecommunications system in the Apollo series is a new innovation in the tracking network known as Unified S-band. The S-band of frequencies occupies from 1550 mc to 5200 mc.

Unified S-Band

The actual equipment includes two phased-locked transponders and one f.m. transmitter all housed in a single unit. The transponders operate on 2106.4 mc and 2287.5 mc with the f.m. section emitting on 2272.5 mc with identical power outputs of 300 milliwatts. Both sections feed amplifiers increasing their outputs to 2.8 or 11.2 watts.

*6563 Sapphire Drive, Jacksonville, Florida 32208.

The fact that this system does use this particular stretch of frequencies and puts out what some hams might regard as flea power is not really so important as what the system can do in terms of the Apollo mission.

Unified S-band combines the functions of acquisition, telemetry, command, voice, television, and tracking on *one* radio link. This means much fewer antennas to cope with as well as transmitters and receivers, but preserving the capacity to process all the needed data.

This single frequency system makes things simpler on the ground, too. Practically all of the jobs of a tracking station can be performed on one high-gain antenna. For a tracking ship at sea more data can be compiled with less equipment.

Range Measuring System

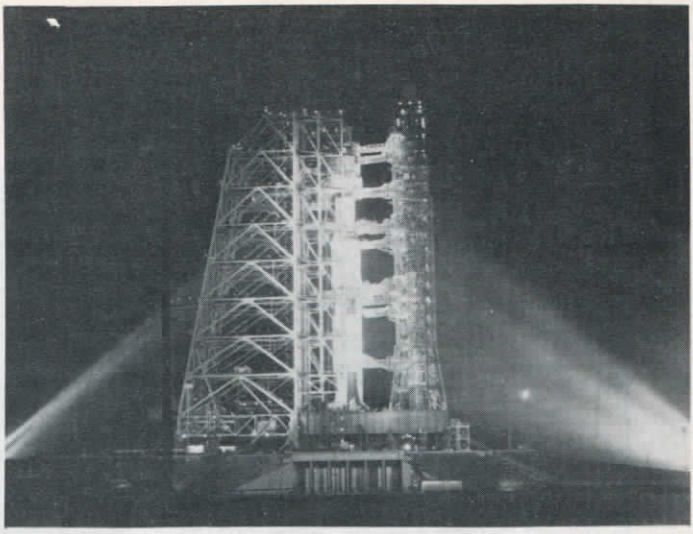
S-band tracking is by the two-way or double-doppler method. In this technique, a stable carrier of known frequency is transmitted to the spacecraft where it is received by the phased-locked receiver, multiplied by a know ratio, and then re-transmitted to the ground for comparison. Because of this, S-band equipment is also referred to as the S-band transponder.

To determine spacecraft range, the ground station phase-modulates the transmitted carrier with a pseudo-random noise binary ranging code. This code is detected by the spacecraft's S-band receiver and used to phase-modulate the carrier transmitted to the ground. The ground station receives the

Table I—Frequency Chart of Apollo Moon Missions

Freq. (mc)	*Mode*	*Information*
2287.500 (sec)	PM	Voice, tracking/ranging, data
2272.500	FM	TV, data
2106.400 (pri)	PM	Voice, tracking/ranging, data
296.800	AM	Voice, data
259.700	AM	Voice, data, Apollo-to-moon
243.000	AM	Recovery beacon

See page 110 for New Reader Service



The night before launch and the Apollo-8 stands majestically on Pad 39 at the Merritt Island Moonport on Florida's east coast. The 363-foot "bird" weighs 6,200,000 lb. with a full load of propellant.

signal and measures the amount of delayed time between transmission of the code and reception of the same code, thus obtaining an accurate measurement of range. Once established, this range can be continually updated by the double-doppler measurements.

Data and Voice Link

The ground stations also can transmit data commands and voice to the spacecraft by means of two subcarriers: 70 kc for up-data and 30 kc for up-voice.

The S-Band transponder is a double-super-

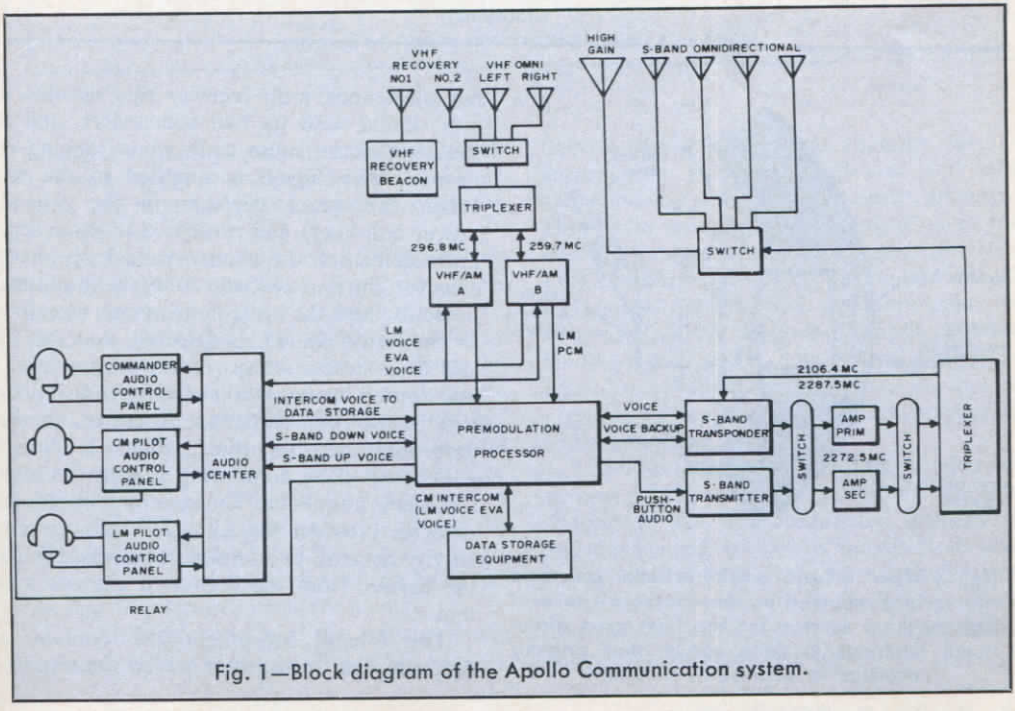


Fig. 1—Block diagram of the Apollo Communication system.

See page 110 for New Reader Service

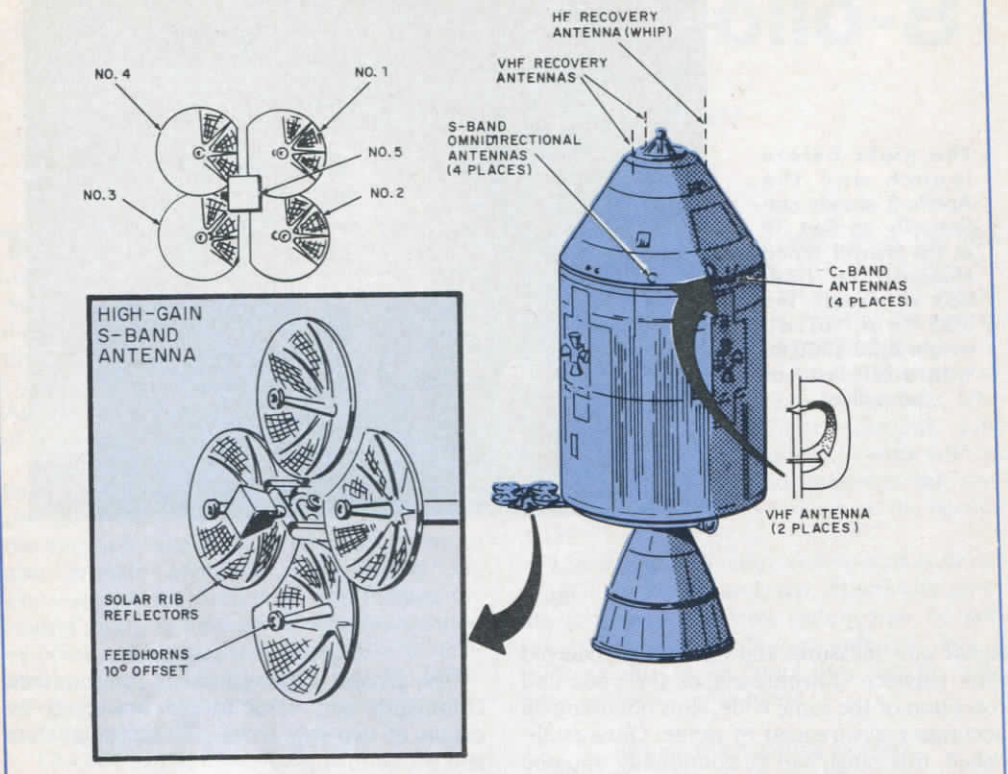


Fig. 2—The S-band high-gain antenna system aboard the Apollo spacecraft. Different antenna combinations provide five different gains and beamwidths as required for various communications situations.

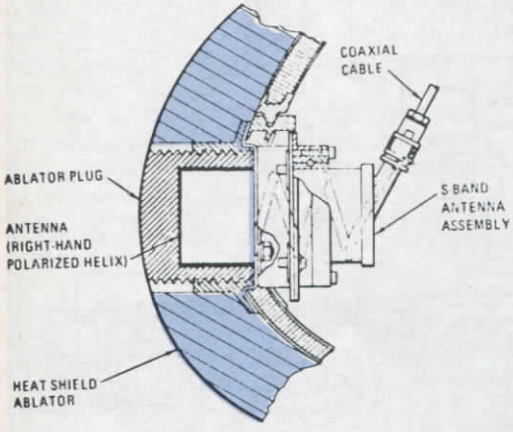
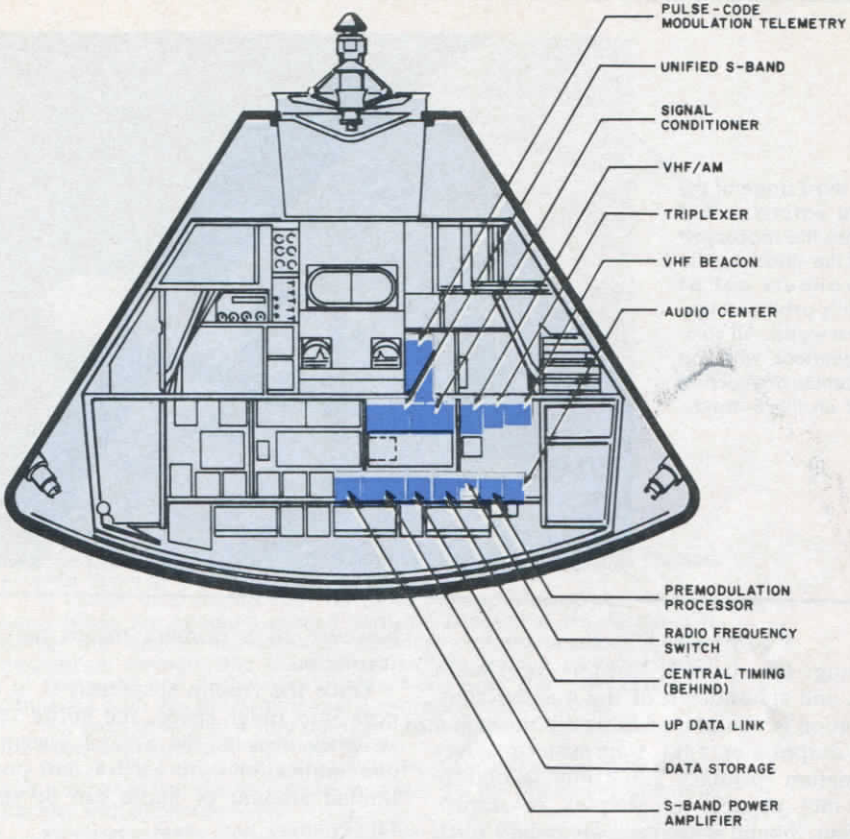


Fig. 3—Four S-band omnidirectional antennas are surface mounted on the spacecraft to provide back-up service for the high gain directional antennas in deep space, and primary coverage in near-earth situations.

het phase-lock loop receiver that accepts a p.m. signal with its two subcarriers, and a pseudo-random noise code when ranging is desired. This signal is supplied to the receiver through a triplexer in the S-band power amplifiers and presented to three separate detectors: the narrow-band loop phase detector, the narrow-band coherent amplitude detector, and the wide-band phase detector. In the latter, the i.f. is detected, and the 70 and 30 kc subcarriers are extracted, amplified, and routed to the data and voice discriminators in the premodulation processor. In the loop-phase detector, the i.f. signal is filtered and detected by comparing it with the loop reference frequency. The coherent amplitude detector provides the a.g.c. for receiver sensitivity control. In addition, it detects a.m. on the carrier from the high-gain antenna system.

The S-band equipment also contains a separate f.m. transmitter which permits sci-

See page 110 for New Reader Service



Location of Apollo telecommunication equipment.

entific, TV, or playback data to be sent simultaneously to the ground while voice, real-time data, and ranging are being sent through the transponder.

All received and transmitted S-band signals pass through the triplexer. Received signals from the antenna are fed through the triplexer to the receiver, but transmitter outputs are sent first to a pair of amplifiers. Here the signals may either be bypassed directly to the triplexer and out to the antennas, or amplified first if extra signal strength is called for, and then fed to the triplexer. Both low and high power (2.8 and 11.2 watts) are available. The high-power final is automatically chosen for the f.m. transmitter.

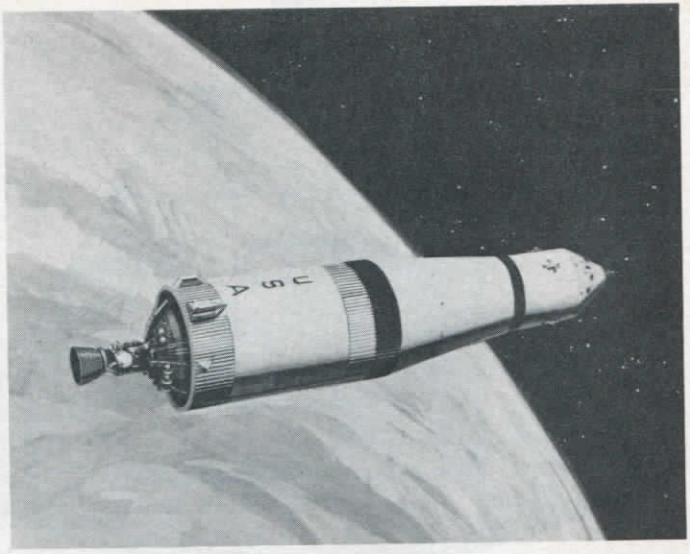
Figure 1 shows the audio, r.f. and antenna section in relation to other systems.

The source of much of this space-to-earth communication is the astronauts themselves. Each wears a headset that contains two independently operated earphones and two microphones with self-contained preamps. There is a separate audio control panel for each man that enables him to select any possible combination of transmitting and receiving sources. Push-to-talk is accomplished by a button on the electrical umbilical cable feeding the spacesuit. This button doubles as a key for c.w. in an emergency. At the flick of a switch each man can go from manual to VOX operation.

The audio signals go direct to the premodulation processor where nearly all forms of spacecraft data are assimilated, integrated, and distributed. It accepts signals from telemetry, data storage, TV, central timing, and audio center equipment. It modulates, mixes, and switches these signals to the appropriate transmitter or tape recorder.

See page 110 for New Reader Service

The third stage of the huge Saturn rocket pushes the spacecraft and the three Apollo astronauts out of earth's orbit and into a new world. All communications with the spacemen are carried out on the S-band.



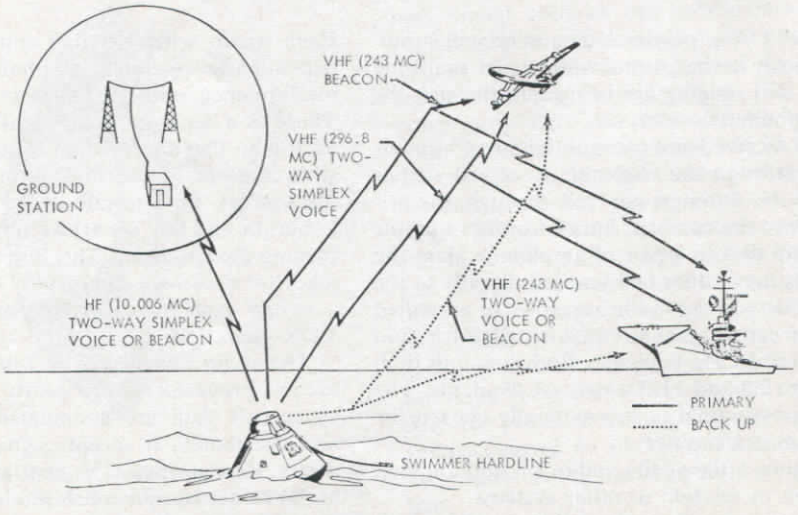
Equipment Function

During the launch, ascent, near-earth phases and splashdown of the mission communication is maintained basically through a 5 watt output a.m. v.h.f. transmitter-receiver combination (primary 296.8 mc, secondary 259.7 mc) capable of simplex or duplex operation. S-band is used as a secondary voice source during these phases of the mision, however, as a primary means for data information.

Once the Apollo spacecraft is in orbit or goes into outer space, the entire operation switches over to the S-band system. When communication with earth is not possible, a limited amount of audio can be stored on tape.

During recovery the a.m. v.h.f. gear and

[*Continued on page 95*]



Methods of communication after splashdown.

See page 110 for New Reader Service