



Chase in space nears its triumphant end as Gemini 6 homes in on a moonlike Gemini 7 for the world's first spacecraft rendezvous. Distance between them: 275 feet.

Flying at five miles a second, the two-man American spaceships perform a stately dance (left). Gemini 6 looks straight down at its twin, 90 feet away, and beyond to the cloud-dappled Pacific Ocean, 185 miles below.

Space Rendezvous

MILESTONE ON THE WAY
TO THE MOON

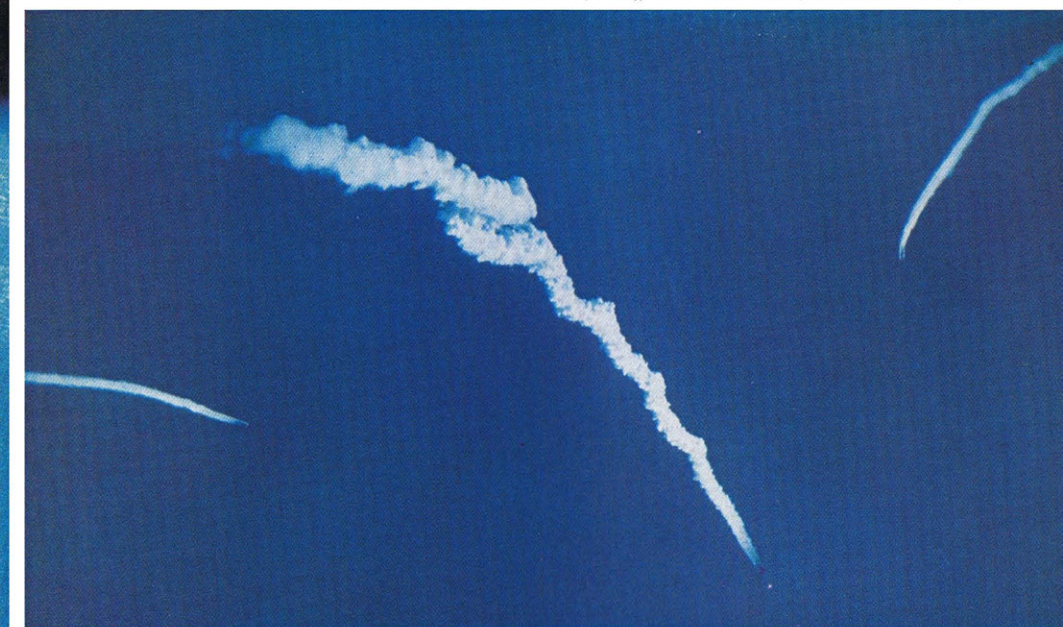
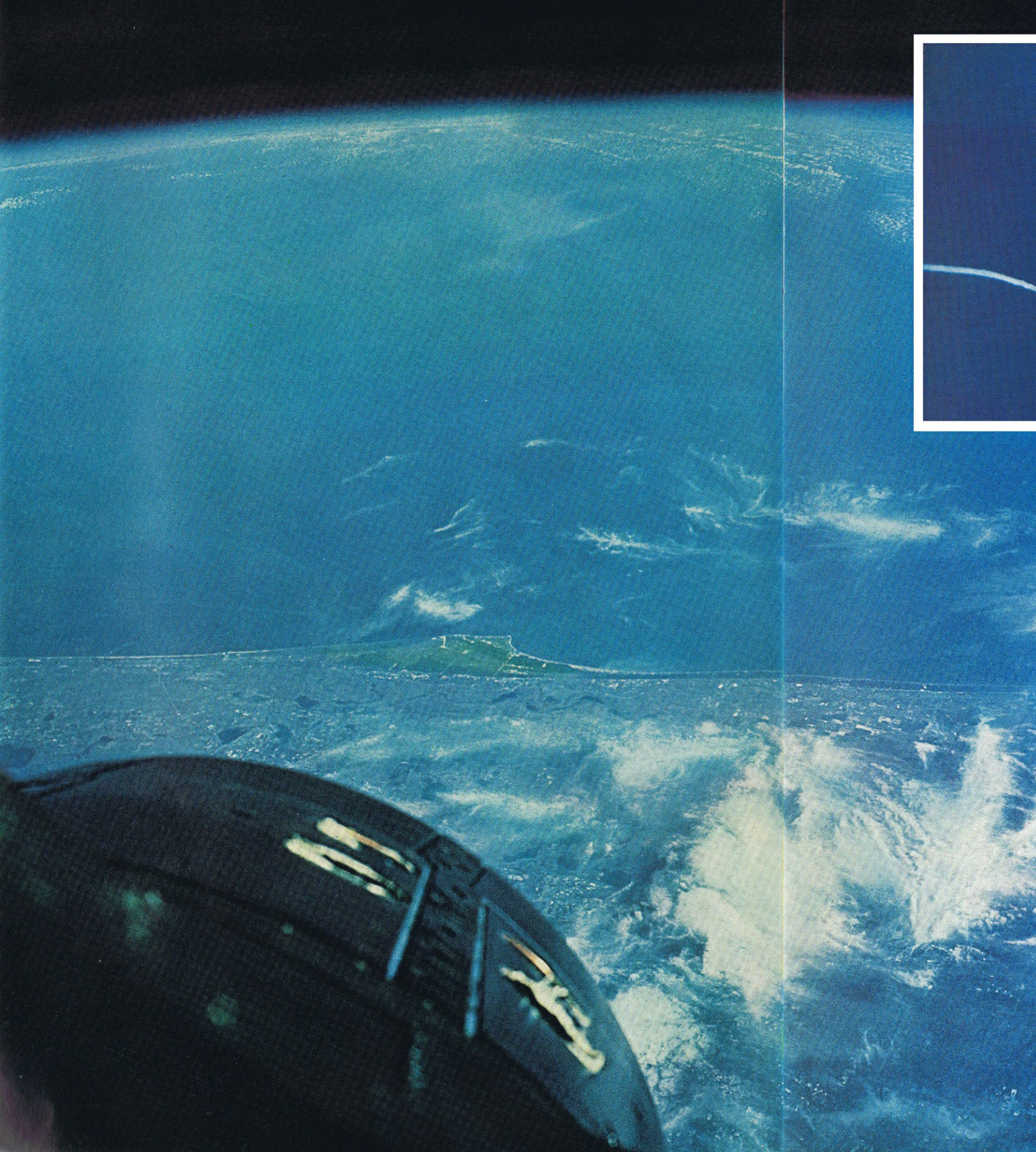
By KENNETH F. WEAVER
National Geographic Senior Staff

IT WAS NIGHTTIME, just becoming light. We were face down, and coming out of the murky blackness below was this little pinpoint of light. The sun was just coming up and was not illuminating the ground yet, but on the adapter of Gemini 6 we could see sunlight glinting, and as it came closer and closer, just like it was on rails, it became a half-moon. At about half a mile we could see the thrusters firing, like water from a hose. And just in front of us it stopped. Fantastic!"

Astronaut James A. Lovell, Jr., thus recalls how he and Frank Borman, command pilot of Gemini 7, saw the historic rendezvous with spacecraft Gemini 6, piloted by Walter M. Schirra, Jr., and Thomas P. Stafford.

Fantastic it was, indeed. For on that December day last year, a day that will live in the annals of exploration of the universe, man cleared away one of the major obstacles on the hard road to the moon. He proved that he could find and reach his fellow man in the vastness of space.

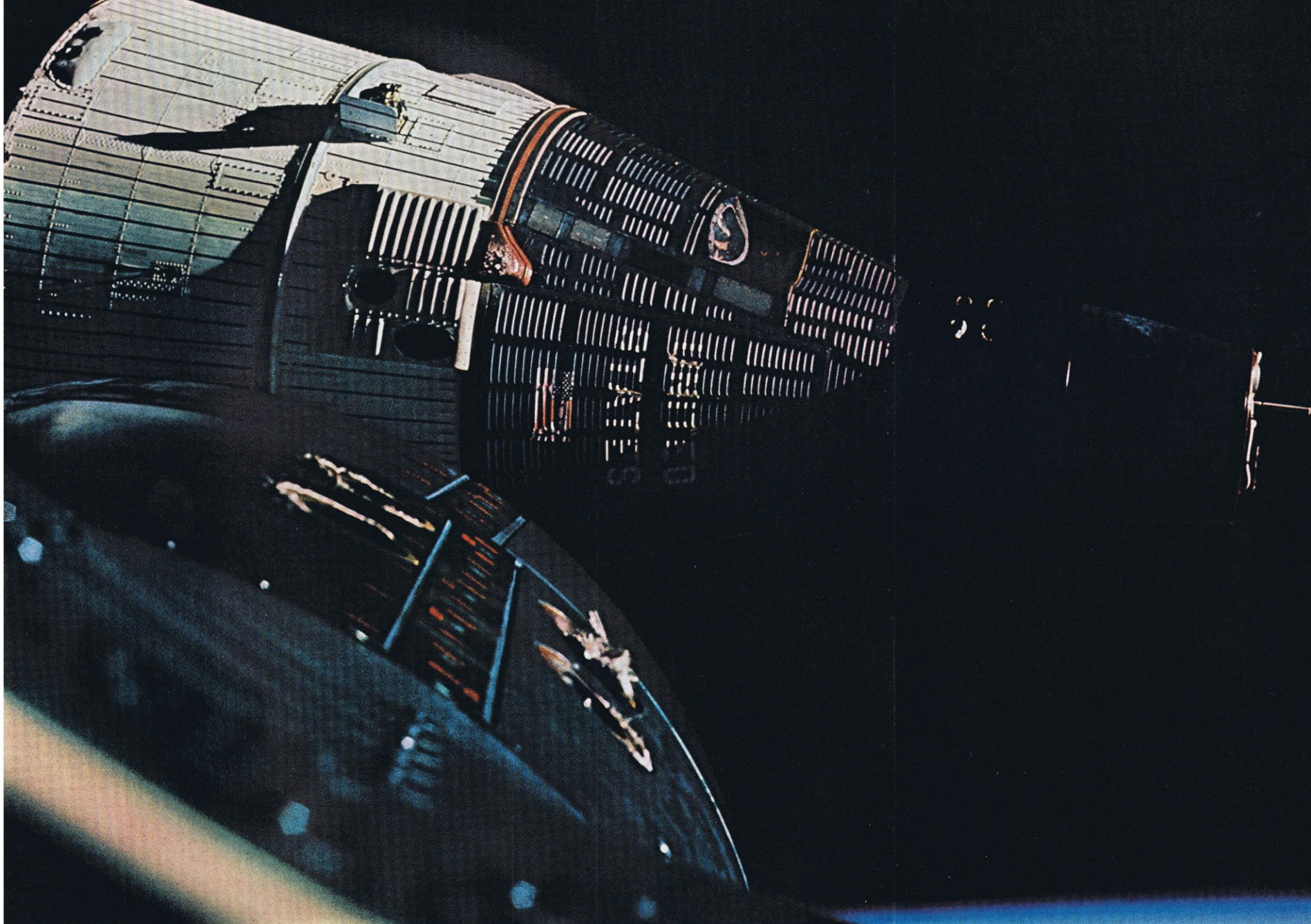
When these American astronauts brought their spaceships 539



Rocketing off in pursuit of Gemini 7, G-6 trails a snowy wake as it streaks into space. Winds aloft twist the plume like a pretzel. Camera-bearing Air Force chase planes sweeping up beside the Titan rocket stripe the sky with smaller contrails.

Huge Kennedy Space Center, from 135 miles up, shows as a small bulge on Florida's Atlantic coast as G-7 Astronauts Frank Borman and James A. Lovell, Jr., soar over the peninsula. At this moment, down on Pad 19, technicians labor feverishly to ready G-6 for launch. Command pilot Walter M. Schirra, Jr. (below, foreground), and pilot Thomas P. Stafford check controls in the cabin. After two thwarted attempts, they roared heavenward on December 15, 1965, to rendezvous with G-7.





NASA EKTACHROMES BY THOMAS P. STAFFORD (ABOVE), JAMES A. LOVELL, JR. (LOWER RIGHT), AND FRANK BORMAN

almost within touching distance 185 miles above the Pacific on December 15, 1965, they pioneered a technique that must be mastered before men can make a round-trip flight to the moon. After exploring its surface, they can return only by making successful rendezvous with their mother ship (pages 552-3).

For that reason the remaining Gemini flights, all scheduled for 1966, are designed primarily to practice rendezvous maneuvers. Indeed, by the time you read this article, Astronauts Neil A. Armstrong and David R. Scott may already have gone into orbit aboard

Gemini 8, seeking to hook up with an Agena spacecraft—an unmanned rocket specially fitted with a docking collar.

What do men say to each other on such an unprecedented occasion as the first meeting in space? When 200 feet still separated G-6 and G-7, Schirra greeted his fellow astronauts with a laconic, "Having fun?"

The words, garbled perhaps, were not heard on the ground, nor was G-7's response: "Hello, there!"

And then, his eyes aching from the intense glare of the rising sun on the other spacecraft,

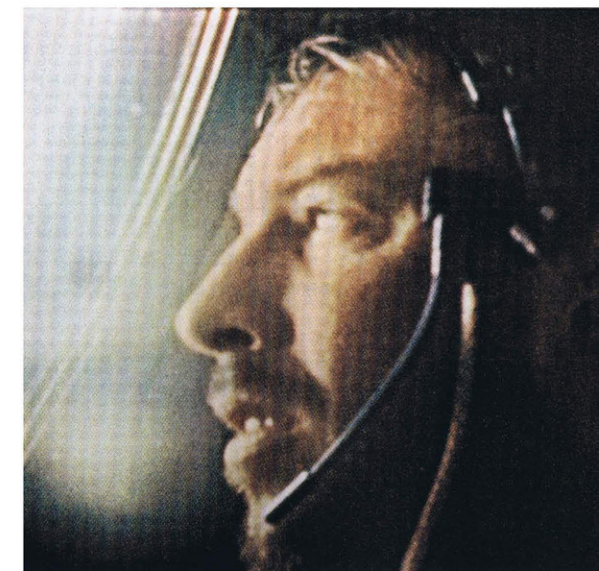
Schirra said, "Hey, Frank, I see your hatch is on fire!"

A little later, Schirra told ground controllers in Hawaii:

"There seems to be a lot of traffic up here!"

To which Borman shot back, "Call a policeman!"

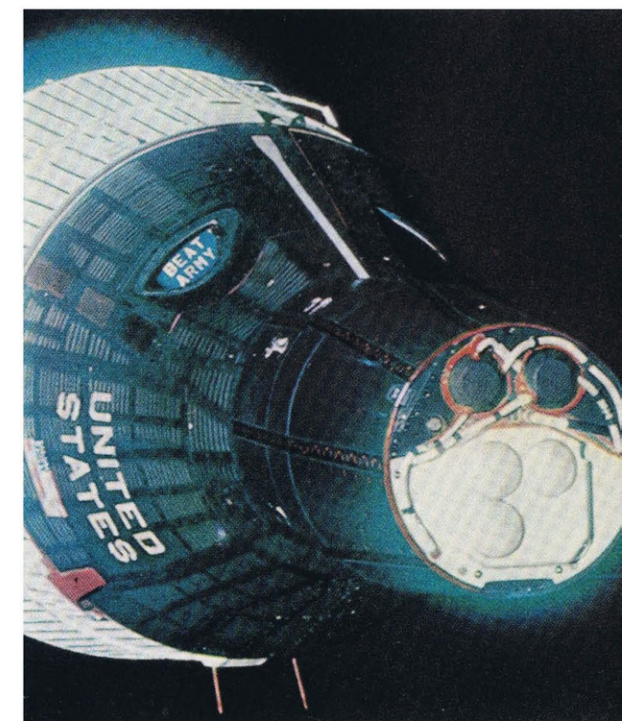
But the astronauts, for all their joshing, knew better than anyone else the meaning—and the difficulty—of their accomplishment. Their rendezvous came as the climax of an extraordinary chase through space—100,000 miles at speeds of more than 17,300 miles an



Splash of sunlight marks lines of strain in the bearded face of Navy Commander, now Captain, Lovell during G-7's 14-day, 220-orbit flight.

With the cool skill of a seasoned pilot, Navy Captain Schirra nudges within 14 feet of G-7. Later he closed the gap to a single foot. Smoke from jettisoned staging rockets thinly clouded the windows, but the crews could see each other.

Friendly taunt, carried to space by Schirra and his fellow Annapolis graduate, Air Force Major, now Lt. Col., Stafford, urges football victory over West Point, the alma mater of Air Force Lt. Col., now Colonel, Borman. White shield covers a radar unit used to track G-7.



hour before Gemini 6 closed in on its target (diagrams, pages 546-7). It took nearly six hours of complicated maneuvering, using radar, a global tracking network, and one of the world's largest assemblages of computers, as well as that more primitive instrument known to astronauts as the "Mark I Human Eyeball."

And yet, ironically, it all seemed so simple to the earth-bound audience when Schirra and Stafford eased their four-ton vehicle to

within a single foot of Gemini 7, to look through the windows and marvel at Jim Lovell's 11-day-old beard. Or when they slowly circled in a stately minuet, then settled down to fly nose to nose for hundreds of miles.

Schirra himself noted this irony while flying from Bermuda to Cape Kennedy the day after the Atlantic splashdown. Frowning as he read a sheaf of glowing press reports on the rendezvous, he remarked: "I'm real sorry

they made the rendezvous sound so easy. It may have looked easy, but it was only because we had practiced so much."

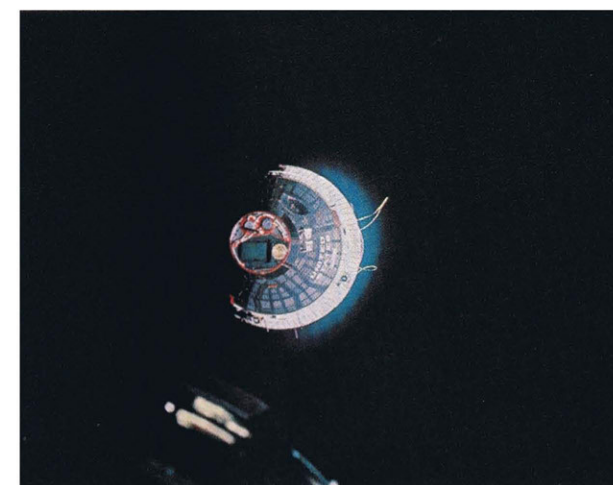
Tom Stafford agreed: "I figure we must have worked out at least 80 times in the simulators, an hour and a half each time."

Wally Schirra reacted also to suggestions that if two spacecraft come within three or four miles of each other—as the Russians' Vostok 3 and 4 did momentarily in 1962—then

a true rendezvous has been accomplished.

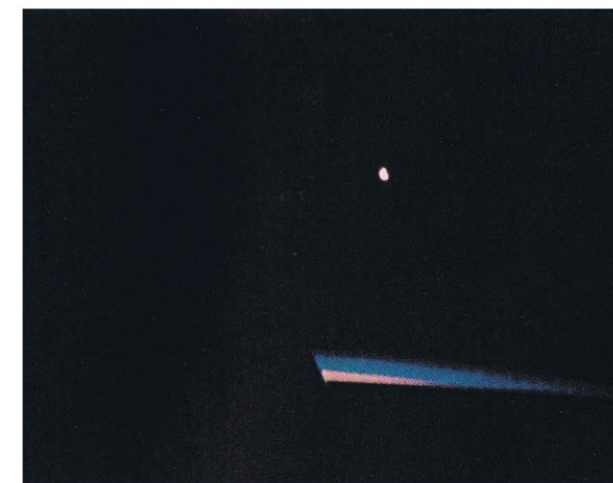
"That's when the job really starts," said Schirra. "I don't think rendezvous is over until you are completely stopped, with no relative motion between the two vehicles, at a range of approximately 120 feet. From there on it's station keeping. That's when you can play the game of driving a car, or driving an airplane; it's about that simple."

Other astronauts agree. "It's easier to fly in



Spaceships part company (above) when Schirra fires his thrusters and moves away from a radiant G-7; both craft orbited the earth at 17,300 miles an hour.

Lovell, watching G-6 recede, photographs it from a quarter mile away (below). Nose of G-7 partially hides a horizon aglow with bands of color at sunset.



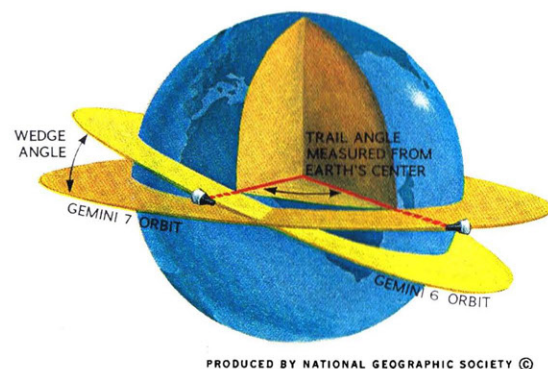
NASA EKTACHROMES BY THOMAS P. STAFFORD AND JAMES A. LOVELL, JR. (LOWER RIGHT)

"Brightest thing I've ever seen in my life," Schirra described the sunlight blazing on G-7's white skirt (left). Nose to nose, the vehicles glide through the void in a game of near-tag, and later of celestial ring-around-a-rosy.



How Gemini 6 caught its twin in a 6-hour, 100,000-mile chase

LIKE A RACE HORSE on the rail, with less ground to cover than an outside horse, G-6 circled the earth faster than higher-flying G-7. This helped G-6 catch up with G-7. But G-6 also had to climb into G-7's orbit (diagram above). The rules of motion in space helped G-6 rise: Each burn of its thrusters automatically raised its altitude. As G-6 moved farther from earth, Schirra needed less speed to offset the pull of gravity. Thus, G-6 went slower in the higher orbit. Schirra began the chase at 25,414 feet per second. Burns of his thrusters totaled 208.6 feet per second, but by raising his orbits, they slowed him finally to G-7's speed of 25,366 feet per second at rendezvous.



Whirling in different planes, G-6 and 7 could not have rendezvoused without delicate maneuvers. G-6 went into orbit 1,200 miles behind G-7 (trail angle). To catch up, Schirra kept his craft in a lower and faster orbit. While still 439 miles behind, he jockeyed into G-7's plane by turning at a right angle to his line of flight and firing aft thrusters for 40 seconds. This erased the fraction-of-a-degree difference in their orbital planes (wedge angle). The execution of such intricate tactics marks the rendezvous as a masterful feat of flying. The angles in the diagram are exaggerated for clarity.

space than to pilot an aircraft, once you've mastered the controls," says Frank Borman. And Neil Armstrong adds: "Docking is like putting a car in the garage."

Gemini 6 and 7 did not touch, leaving still unanswered the question of whether a spark of static electricity will jump between two docking spacecraft. As a safeguard, the Agena's collar wears metal "whiskers," like a lightning rod, to bleed off any charge.

When Gemini 6 went into orbit, it trailed more than 1,200 miles behind Gemini 7. Its orbit was lower and was tilted slightly to the orbital plane of the other craft.

To correct these differences, Wally Schirra fired his thrusters in a series of skillfully controlled "burns," timing them according to instructions from the ground and computations made by Tom Stafford with the spacecraft's own computer. Stafford, incidentally, was so busy with his navigation duties that he was able to look out of the window no more than 15 minutes during the first six hours of flight.

Schirra, who had more opportunity to observe outside the spacecraft, said later of the cloud-banked earth: "If we four had come from another planet, I'm sure we would have said, 'That's not inhabitable. Let's leave!'"

In the wave of excitement over the successful rendezvous, it is easy to lose sight of the importance of the equally successful 14-day flight of Gemini 7. Dr. George E. Mueller, the National Aeronautics and Space Administration's Associate Administrator for Manned Space Flight, says:

"It's true that we could not go to the moon until we learned to rendezvous. The first astronauts who set foot on the moon will have to rendezvous with the mother ship orbiting 92 miles above them, or they will have no possible way to return to earth.

"But neither could we go to the moon until we learned whether man could function successfully in space for days at a time, and then

adjust easily to gravity on earth after a long period of weightlessness."

The experience of the Gemini 7 pilots with weightlessness is reassuring. They did react to retrofire, the reverse blast of rockets that slows a spacecraft and starts its fiery plunge to earth. But they said they had no real problems after returning to the ground.

"After being desensitized to G's [weightless] for 14 days," reported Borman, "we felt we were going backward when the retrorockets fired—I think John Glenn said back to Hawaii—I felt we were going back to Japan. But when we got back on the carrier, if we had any deterioration at all, it was that our legs were heavy because they hadn't been

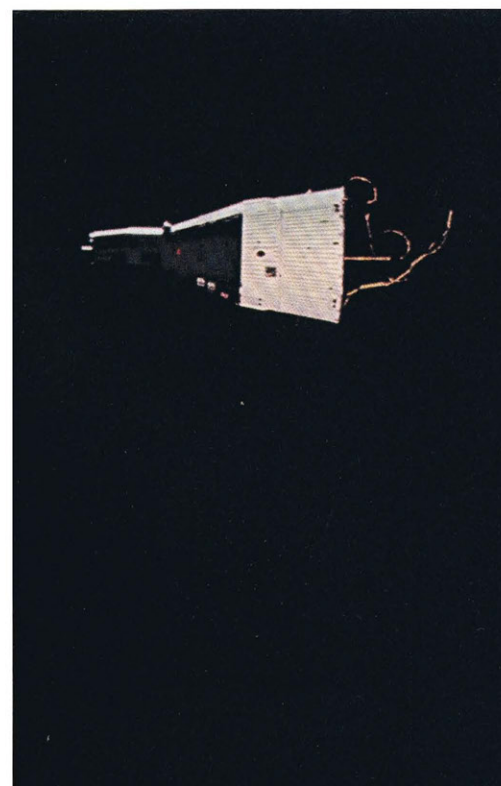
used. We were able to run a mile the day we got back to the Cape. In my opinion, with proper crew-comfort provisions, people will have no difficulty going a month, two months, or as long as they want to in space."

Both men stressed the necessity of comfort, noting that they functioned much better when they took off their bulky pressure suits.

"One of our biggest problems," says Jim Lovell, "was the same thing that everybody faces here on earth—eating, sleeping, and housekeeping. We were worried that we'd sort of get pushed out of the spacecraft with all the debris that would accumulate. So we spent many hours prior to the flight finding little spots and crevices in the spacecraft

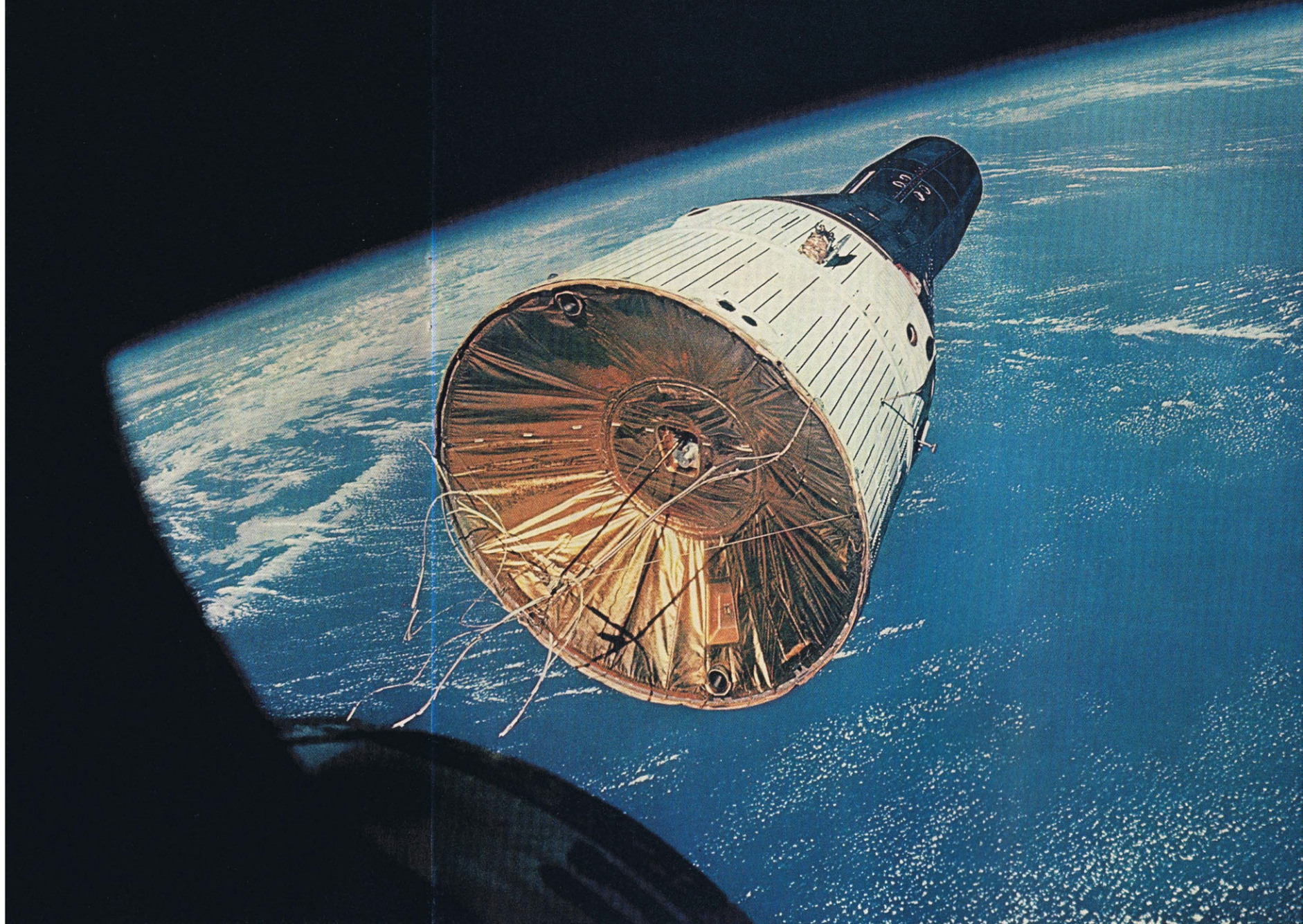
Tail feathers of tape, part of the insulating material used to minimize blast damage at separation, float behind G-7. They flapped on 7's roof during its third orbit, mystifying Lovell and Borman until G-6 reported sighting the cords.

NASA EKTACHROMES BY THOMAS P. STAFFORD





Eye test occupies Borman in this motion-picture sequence taken by cabinmate Lovell. He holds a biteboard that, clamped between his teeth, maintains the proper distance from his face to a binocular device used for testing ability to see detail. Borman has shed his space suit and wears only underwear, as did Lovell during much of the flight.



NASA EKTACHROMES BY THOMAS P. STAFFORD (ABOVE) AND JAMES A. LOVELL, JR.



"You guys are really a shaggy-looking group with all those wires hanging out," G-6 radios to G-7 as both pass over the Pacific, 600 miles west of Chile. G-7 to G-6: "You have some too." Gold curtain guards the instrument package from solar radiation.

"Constellation Urion," Astronaut Schirra jokingly labeled this photograph at the postflight press conference. Droplets of urine, vented from G-7 at twilight and instantly frozen in space, follow as miniature satellites. They eventually sublime and vanish, like dry ice.

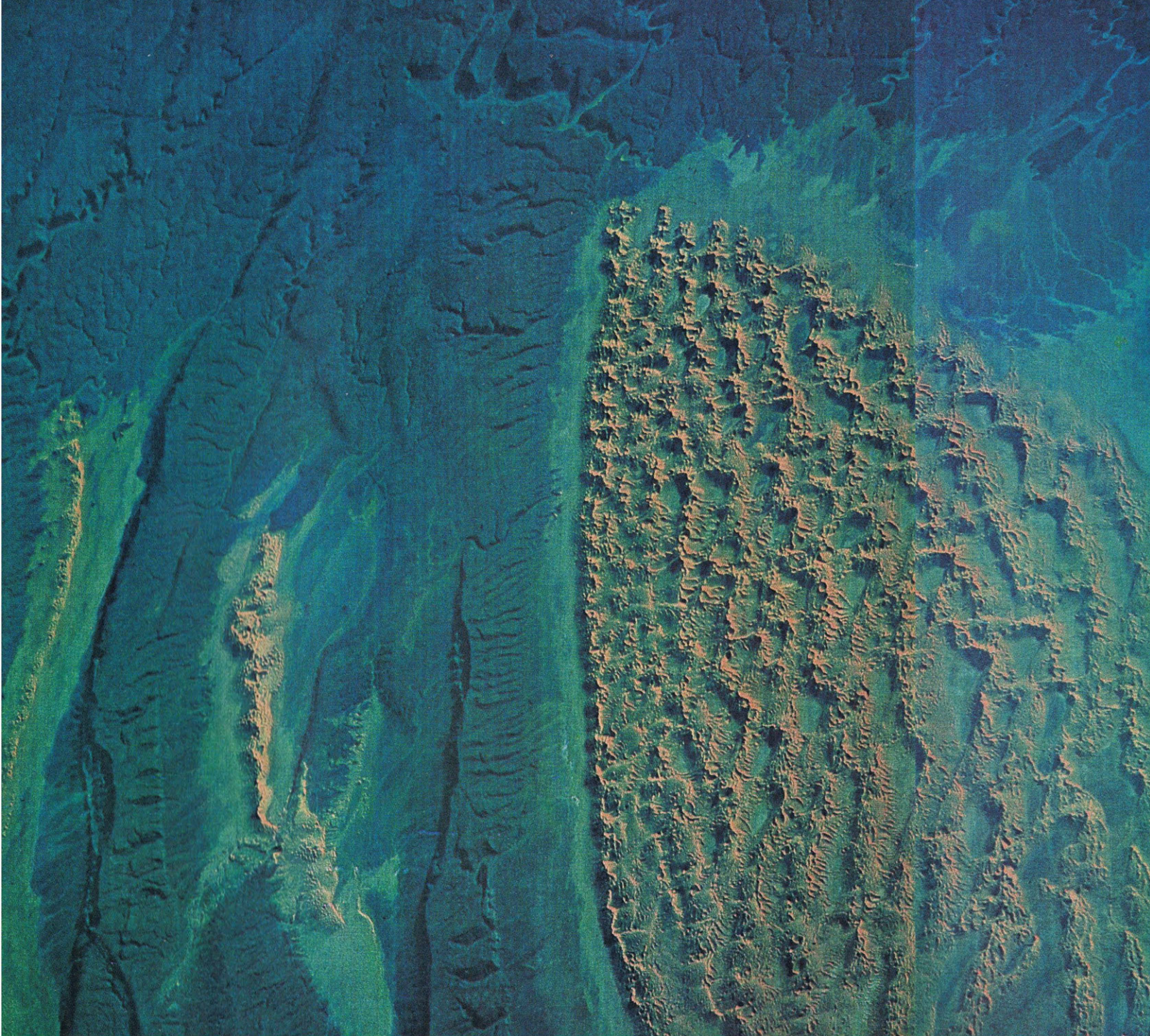
where we could pack things. We would eat three meals a day, and Frank would very nicely pack the containers in a small bag, and at the end of the day he would throw it behind the seat. We managed to get nine days' debris behind those seats."

The spacecraft returned surprisingly clean. "Other Gemini crews," says Lovell, "have reported that they became increasingly tired due to the fact that one person would be on watch and the other sleeping, and communication between the ground and the spacecraft would wake the sleeping person. So we decided to sleep simultaneously.

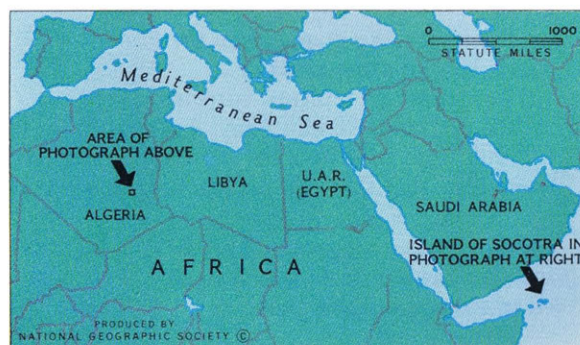
"We worked on a Houston day. Our watches were set on Houston time. We had a regular work day, had three meals a day, and then at night we went to bed. We put up light filters in the windows and didn't look out, and to us it was nighttime.

"We had absolutely no sensation of movement. Our world was inside the spacecraft. We even had some books along. Frank had one which was quite apropos: It was called *Roughing It*, by Mark Twain!"

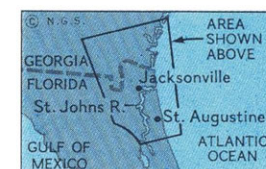
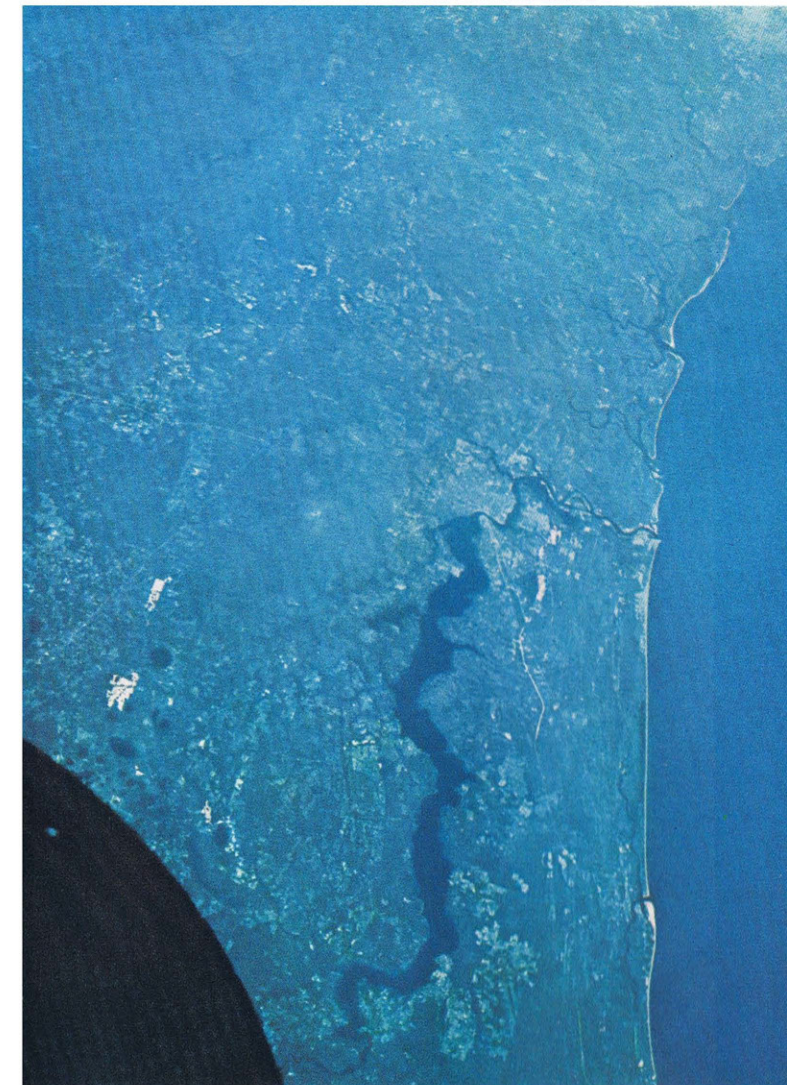
These December flights climaxed a year in which five Gemini teams orbited the earth for a total of 650 hours, covering more than



"We spent many hours just observing the beautiful tones and colors," Lovell said of North Africa. With hand-held Hasselblad camera, Borman captured the thousand-foot-high Tifernine sand dunes in Algeria from 150 miles up. His 250mm lens looked south as the setting sun burnished the tops of the dunes against a desert darkened by dusk. Filtering effect of the atmosphere tints the earth blue. As Heinz Haber wrote in the *GEOGRAPHIC* ten years ago—even before the first satellite—ours is "the most beautiful planet of the solar system. It is Earth, the blue planet, the home of man."



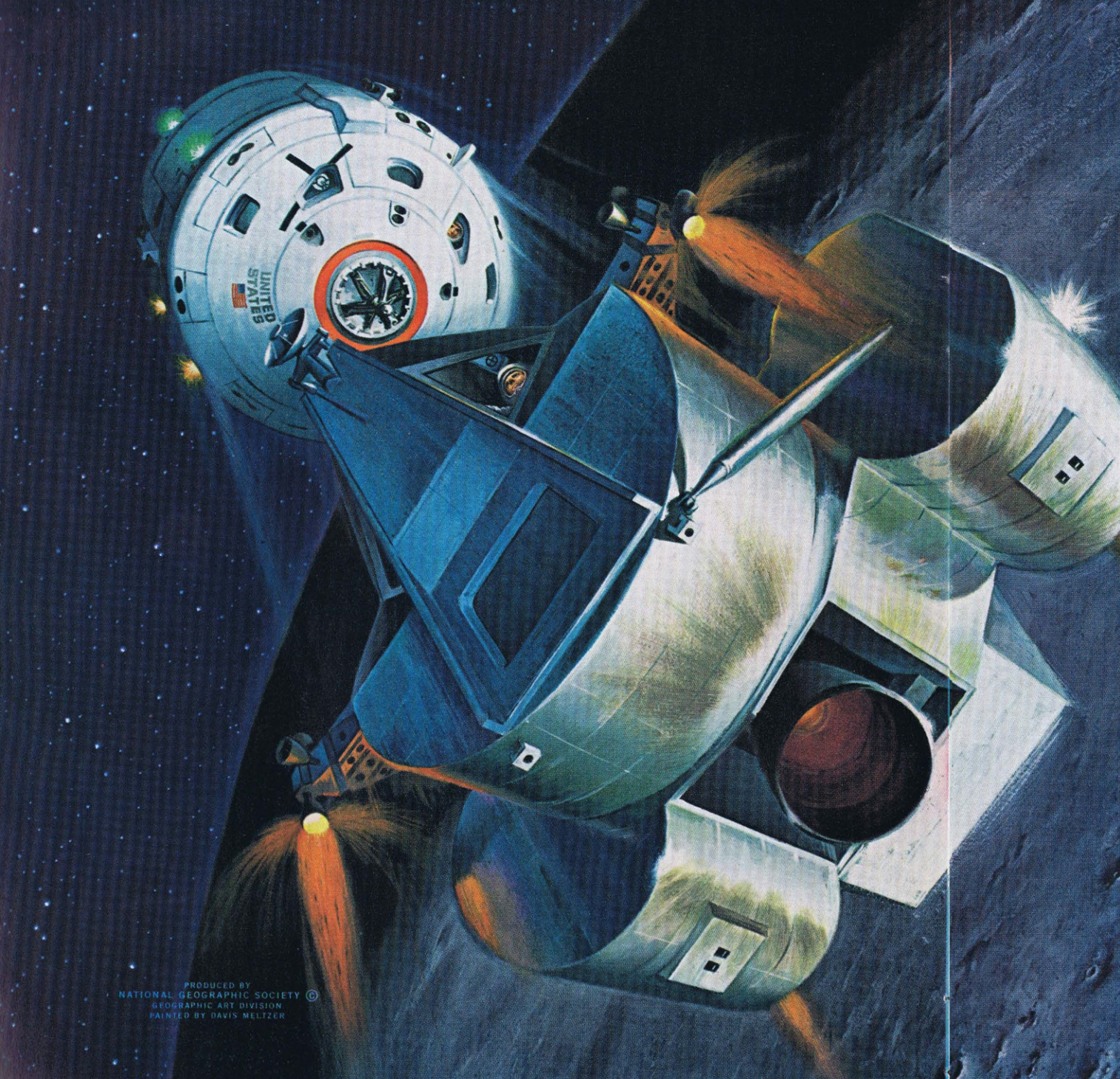
NASA EKTACHROMES BY FRANK BORMAN (LEFT AND LOWER) AND JAMES A. LOVELL, JR.



St. Johns River forms a broad path in the low-lying region of northern Florida before narrowing at Jacksonville. Southward, the inlet at St. Augustine appears as a tiny notch in the coast. Gemini pictures are the clearest yet made from space.

Island of Socotra, source of myrrh, frankincense, and dragon's blood—resin of the dragon tree—covers 1,400 square miles, about the size of Rhode Island. This view from G-7, 185 miles high, looks southwest. Islands at top center, The Brothers, lie between Socotra and the African coast. For this and most of their earth photographs, Borman and Lovell used an 80mm lens and a basic exposure of 1/250 at f11.





NASA EKTACHROME BY JAMES A. LOVELL, JR.

Beckoning destination of America's space program, the pearl-like moon rides high over the Pacific. NASA's Apollo astronauts hope to reach it by 1970.

Homeward bound from the moon, a LEM (lunar excursion module) fires its guidance rockets to dock with its orbiting mother ship. The Apollo pilot uses an overhead cross-hair sight to line up with the craft that will return the crew to earth. Artist Meltzer's look at the future incorporates the knowledge and advice of NASA experts, astronomers, and the Apollo contractors, Grumman Aircraft and North American Aviation. Dated June 24, 1969, 12 noon, Greenwich mean time, the painting shows the stars in their true positions for that date.

11,000,000 miles—nearly fifty times the distance from here to the moon.

What lies ahead now on the road to the moon? Dr. Mueller forecasts a wind-up of the Gemini program this year, with five two-man flights of from one to three days' length.

"On each flight," he says, "the astronauts will practice rendezvous and actual link-up with an Agena or a similar target. Then they may use the fuel supply of the Agena to propel

both vehicles into new orbits and maneuvers. On each flight an astronaut may leave the Gemini vehicle to 'walk around the earth.'* And once the Gemini and Agena have docked as a unit, they may seek out and rendezvous with a second Agena to be left in orbit from a previous Gemini flight."

As Gemini comes to an end, the real moon

*"America's 6,000-Mile Walk in Space," in the September, 1965, GEOGRAPHIC, described this feat.

program, Apollo, gets under way. With the success of G-6 and 7, it is now conceivable that the first manned Apollo vehicle, boosted by the huge Saturn 1B rocket, will carry three astronauts into orbit before the end of 1966. To NASA officials, the goal of Americans on the moon by 1970 now seems within grasp.*

Far beyond Apollo, scientists visualize

*See "Footprints on the Moon," by Hugh L. Dryden, NATIONAL GEOGRAPHIC, March, 1964.

space crews rendezvousing above the earth to assemble orbiting laboratories, or eventually to put together space ports from which travelers will set out for Mars and even more distant points. And they regard as certain the day when these techniques will permit rescue of astronauts stranded in space and examination of potentially hostile satellites.

Rendezvous—our newest space achievement—makes all this possible. **THE END**