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APOLLO 11:
ON THE MOON

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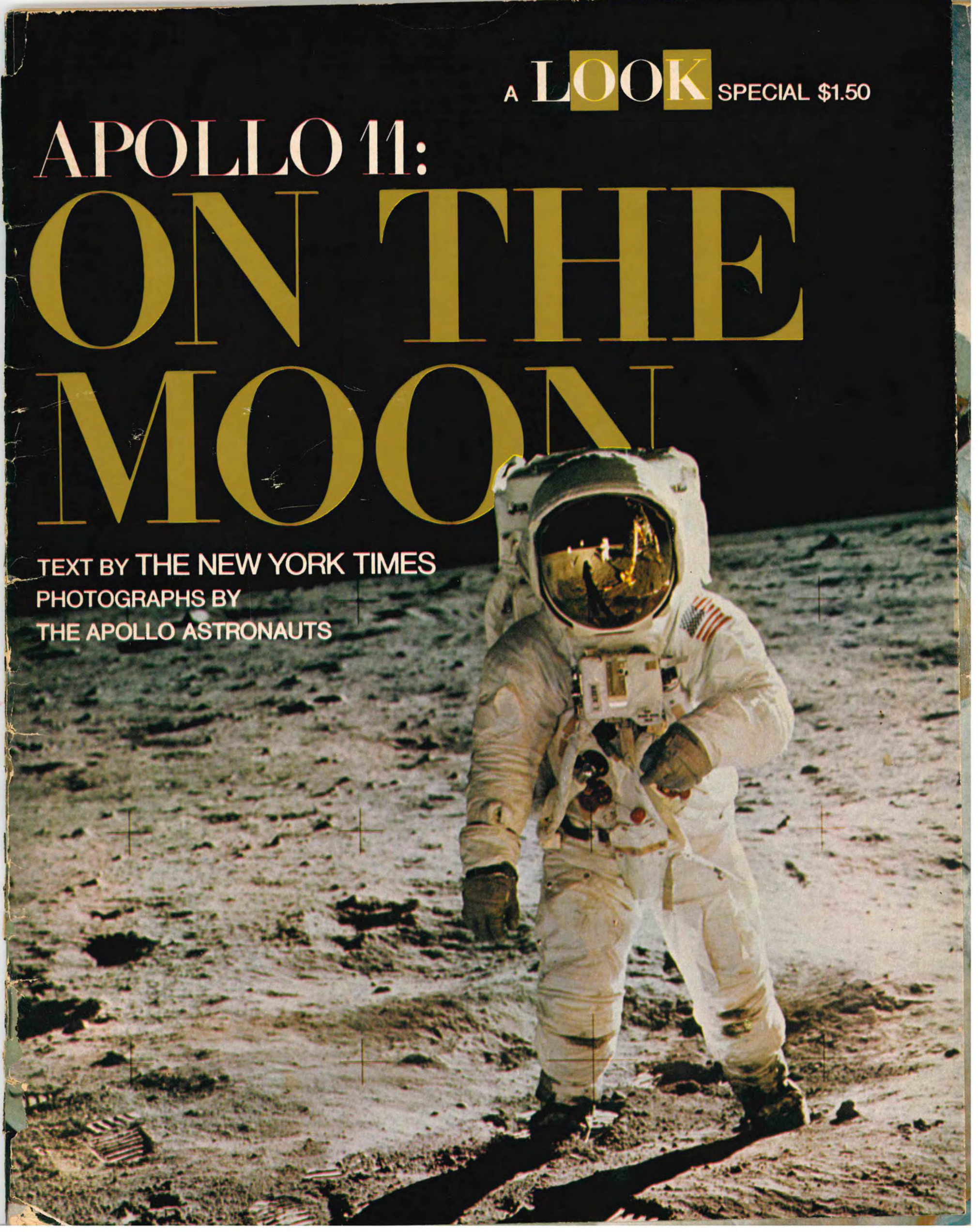

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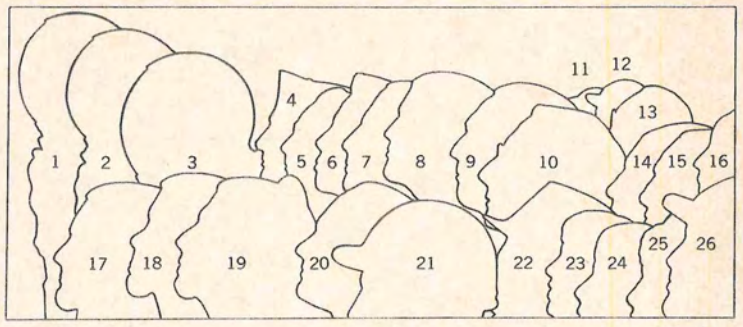

Behind Apollo 11—Background (left to right): Prime Crew **1, 2, 3** *Cdr. Neil A. Armstrong; LM Pilot Edwin E. Aldrin, Jr.; CM Pilot Michael Collins;* **4** *Joe W. Schmitt, Insertion Technician;* **5** *Dr. Charles A. Berry, Director of Medical Research and Operations;* **6** *Alan B. Shepard, Jr., Chief, Astronaut Office;* **7** *George M. Low, Manager, Apollo Spacecraft Program;* **8** *Dr. Wernher von Braun, Director, Marshall Space Flight Center;* **9** *Dr. Kurt H. Debus, Director, Kennedy Space Center;* **10** *Kenneth S. Kleinknecht, Manager, Apollo Command and Service Modules;* **13** *Dr. George E. Mueller, Associate Administrator, Manned Space Flight;* **14** *Dr. Robert R. Gilruth, Director, Manned Spacecraft Center;* **15** *Lt. Gen. Samuel Phillips, Apollo Program Director;* **16** *Gatha Cottee, Public Information Officer, Kennedy Space Center. Foreground (left to right): Backup Crew* **17, 18, 19** *Cdr. James A. Lovell, Jr.; LM Pilot Fred W. Haise, Jr.; CM Pilot William A. Anders;* **20** *Christopher C. Kraft, Jr., Director, Flight Operations, Manned Spacecraft Center;* **23** *Mrs. Neil A. Armstrong;* **24** *Mrs. Edwin E. Aldrin, Jr.;* **25** *Mrs. Michael Collins;* **11, 12, 21, 22, 26** *NASA staff.*

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20

APOLLO 11:

ON THE MOON

Text by
THE NEW YORK TIMES

Photographs by
The Astronauts

Commemorative painting by
Norman Rockwell

Produced by
LOOK Magazine

NEIL ARMSTRONG

COL. EDWIN E. ALDRIN JR.

LIEUT. COL. MICHAEL COLLINS

THE MEN

There were different causes for the eagerness they shared; yet life for all of them will simply never be the same again.

By WILLIAM K. STEVENS

NEIL ARMSTRONG walked into the room, a conservative plaid sports jacket draping his small-boned 5-foot-11-inch frame, his blond hair parted on the left and slicked down like a Sunday school boy's. He was about to talk with a stranger, and his odd sort of lopsided grin suggested he was trying hard to meet the stranger halfway.

That does not appear to come easily to the commander of America's first lunar landing mission, the man chosen to first set foot on the moon. He is surrounded by protective walls of shyness and modesty. There is an almost palpable air of reserve about him. During a chat in Houston—his part in a round-robin series of conversations with the men of Apollo 11—Mr. Armstrong comported himself formally, weighing his words carefully, often pausing inordinately long before delivering a sparse answer to a question.

On the basis of such an encounter, you would never know that he was a champion chug-a-lugger of beer in the night spots around Edwards Air Force Base on the Mojave Desert of California, where he once flew the X-15 to the fringes of space and earned a reputation as one of the world's best test pilots; or that he is a shrewd player of the stock market; or that among close friends, he is one of the most cherished of companions; or that he has lived for one thing—flying—ever since he was a precocious, introverted little boy who often would rather stretch out with a book on the living room floor than play with other children.

Lieut. Col. Michael Collins, pilot of the Apollo 11 command ship, was as open and breezy in the interview as Mr. Armstrong was reserved. He is slightly, almost delicately built, with merry brown eyes and dark brown hair that is receding gradually toward the crown. He was in shirtsleeves, with a pencil behind his ear, and he sat down, threw his leg over a chair and talked animatedly. "Stay casual" has always been his unspoken motto.

This manner seems to mask much, too. Hidden is the fact that Mike Collins' existence was drifting and unfocused until late in life, leading some of his colleagues to expect that he would never do anything special. But lurking beneath the casual exterior all along were a hard competitiveness and determination. These qualities, which make him the untouchable handball champion among astronauts, also made him an astronaut in the first place, once a late-blooming excitement about space flight gave his life an organizing focus.

Col. Edwin E. (Buzz) Aldrin Jr., who is to join Mr. Armstrong on the moon's surface, gives an immediate impression of suave urbanity. His disappearing blond hair, once thick and curly, is closely cropped, accentuating his protruding ears. But the graying sideburns he sometimes wears counter the Astronaut stereotype. During the conversation in Houston he wore a stylish, subdued aqua suit with a crisp handkerchief in the pocket, flashed two rings on the right hand and one on the left, crossed one knee over the other, and toyed with a pipe as he talked.

Behind this urbane demeanor is an intelligence that very nearly enables him, some of his colleagues say, to compute orbital maneuvers in his head. The suave manner covers a fierce ambition and an enthusiasm so intense that Colonel Aldrin has been known at times to irritate associates and friends with his assertiveness and compulsion to talk business. And the stylish clothes hide a well conditioned body whose individual muscles are under disciplined control, an asset that has made Colonel Aldrin probably the most accomplished of the six Americans to walk in space.

Astronauts Armstrong, Aldrin and Collins, who set out to accomplish the first manned landing on another celestial body, are among the supertechnicians of their day. They are not scientists seeking fundamental truth—although astronauts on future flights will be—but supremely self-confident pilots, who like action; and highly disciplined engineers whose natural habitat is the sometimes bewildering technology of the electronic age.

From one point of view, they are the most flexible and versatile components in what is perhaps the most complex technological system ever devised. But they are also in many ways ordinary men who, despite an extraordinary psychological stability, display very human foibles of personality.

All three astronauts were born in 1930, as the nation skidded toward the bottom of the Great Depression—Colonel Aldrin on Jan. 20, Mr. Armstrong on Aug. 5, and Colonel Collins on Oct. 31. But all three were sheltered from the ravages of that depression. None has ever come close to privation.

All three are expressions of the dominant values of the broad American middle class, but each represents a different current in that mainstream of society.

In the late eighteen-sixties, families of stolid German farmers and merchants fleeing the draft under Bismarck's blood-and-iron foreign policy emigrated to northwestern Ohio, and in succeeding years mixed their blood with that of the descendants of Revolutionary War veterans who settled the country in the eighteen-twenties, when the Shawnee Indians were still vigorous. This produced a culture whose dominant verities still include hard work, honesty, church on Sunday and the Republican party.

Neil Alden Armstrong was born of that heritage and into that culture, in the living room of his grandparents' farmhouse six miles southwest of Wapakoneta (population about 7,000), a place whose open manners, broad, tree-lined streets, and abundance of old-fashioned, two-story clapboard houses make it almost a model of small-town mid-America.

Neil was the first of three children of Stephen Armstrong, a sometimes bluff but usually gentle and smiling state employe who spent Neil's formative years as an auditor of county records around the state, a job in which he helped send some cheating Cleveland officials to prison; and Viola Engel Armstrong, a slim, gracious woman who has always been drawn to music and books, and whose attitudes influenced her son.

Young Neil began working part-time at age 7, cutting grass in a cemetery in Upper Sandusky, Ohio, for 10 cents an hour and progressing as a teen-ager to stock boy in a Wapakoneta drugstore. This kind of thing was simply expected in "Wapak," as the local residents call the town.

"I told all my children I hoped they would pick out something worthwhile, that would do some good for other people, to set their goals high, do the best they could, and they'd have a happy life," says Neil's mother.

Because of the elder Armstrong's roving job, the family moved from one northern Ohio town to another six times during Neil's first six years. But the essential quality of family life remained constant. Mrs. Armstrong put her finger on one of its essential ingredients: "I was an only child, and I was so thrilled at having the children that I thought I would never be as near to heaven. Just being around them was enough for me." Young Neil flourished in an atmosphere of such attention and care.

The hours Mrs. Armstrong spent leafing through magazines with her son, reading books to him, and constantly talking with him produced a very bright little boy who talked early, read 90 books during the first grade and skipped the second grade because he could read on a fifth-grade level. Later, at Wapakoneta's Blume High School, he flourished in science and mathematics, studying calculus outside of school and teaching science and math courses temporarily during the illness of Grover Crites, the teacher who encouraged and guided him in his advanced studies.

Always small, younger than most of those in his classes and looking even younger, Neil developed into a shy, unassertive, not particularly athletic boy. His younger brother, Dean, recalls that although Neil moved in a small circle of close friends who went to the normal teen-age parties of the day, he seldom had dates in high school; that he went away to Purdue University in Indiana at age 17 an immature, withdrawn youth and that he grew into a man and developed an underlying self-confidence only when he left Purdue after two years to become a Navy combat pilot.

Neil, at age 20 the youngest man in his squadron, flew 78 combat missions off the carrier Essex during the Korean War, including one in which a cable stretched across a North Korean valley—the one made famous in James Michener's "The Bridges at Toko-Ri"—clipped off the wing of his jet. He won the respect and admiration of his older squadron mates by nursing the plane back over friendly territory, then bailing out safely.

Neil's obsession with flight began on a casual family excursion to the Cleveland municipal airport when he was two years old. Four years later, a frightened, white-faced Stephen Armstrong took a delighted six-year-old Neil for his first plane ride in a Ford Tri-Motor. A year later the boy built his first 10-cent model plane, the first of hundreds of models to grace, and sometimes clutter, his bedroom over the next several years. He worked as a teen-age grease monkey at Wapakoneta's small airport; he paid $9 an hour for flying lessons, and won his pilot's license before he was licensed to drive a car. He built a wind tunnel in the basement of the Armstrongs' white, two-story clapboard house. He collected vintage issues of the magazine "Air Trails," and was as upset about their loss as about anything else when, years later, after he became an astronaut, his house burned down in Houston.

"With Neil," says Paul Haney, the former Voice of Apollo, "flying comes on like a religion. When he talks about the Wright brothers, his voice is almost hushed. He took along a part of the Wright Flyer on his Gemini mission, like it was a part of the True Cross."

Aside from aeronautics, the young Neil filled up his time with Boy Scout activities, reading, playing baritone horn in the school band and for a jazz combo he organized, learning the piano, and making his first forays into space science.

Several such forays were made in the backyard observatory of Jacob Zint, Wapakoneta's amateur astronomer. With his telescope, Mr. Zint could bring the moon within 1,000 miles. "Most of the kids would look for two or three minutes and that would be enough," Mr. Zint recalls. "But Neil would look and look and look."

A bigger, stronger, more experienced, but still reserved and youthful-looking Neil Armstrong returned to college after Navy service, then left Purdue in 1955 with an aeronautical engineering degree and joined the National Aeronautics and Space Administration (then the National Advisory Committee on Aeronautics). His father says he had declined to remain a Navy flier partly because of the semi-compulsory wining and dining required to get ahead in the naval officer corps.

The already-skilled aviator spent the next seven years at Edwards Air Force Base, becoming one of the most accomplished test pilots in the world. Characteristically, perhaps, he and his wife, Janet, chose not to live in the nearby town of Lancaster, Calif.,

where most of the test pilots lived, but to acquire and restore a former forest ranger's cabin in the isolated foothills of the San Gabriel mountains. Those years were marred by the death of one of the Armstrongs' three children, Karen, of a brain tumor.

If anyone was a natural to become an astronaut, Neil Armstrong was it. He was assigned as a pilot on the now-defunct Dyna-Soar project, in which he was to have flown a craft part spacecraft and part airplane. Apparently anticipating the end of Dyna-Soar, which finally came in 1963, he applied for the astronaut corps. In 1962 he became the first civilian to be admitted to the corps.

EDWIN EUGENE ALDRIN JR. was born of mixed Swedish, Dutch, Scottish and English ancestry in the affluent New York City suburb of Montclair, N.J. He lived in that serene enclave for the first 17 years of his life, a relatively sheltered youth in a relatively sophisticated environment.

He grew up as the highly prized only son of a very proud man in a household dominated by six females.

Col. Edwin Eugene Aldrin Sr., United States Army, retired, now a 73-year-old resident of Brielle, N. J., has himself accomplished much in aviation, and has brushed the fringes of fame. He learned physics at Clark University under Dr. Robert Goddard, the father of modern American rocketry; he taught himself to fly airplanes; he served at intervals as military aide to Gen. Billy Mitchell, whom young Buzz Aldrin met as a boy of five; he started what is now the Air Force Institute of Technology at Dayton, Ohio, and he set a cross-country flying record of 15 hours and 45 minutes in 1929, the year before his son was born.

Colonel Aldrin's work kept him away from home a lot. For two years, when Buzz was a budding adolescent, he was gone altogether, having returned to active duty in World War II. Edwin Jr. was surrounded most of the time by women. There were two older sisters, who let him get away with nothing. There was his mother, who was at once affectionate (the Aldrins, mother and children, always kissed goodby), letting her children always know where she was so they would feel secure, and insistent that her children do their best. There was his grandmother, whose last name, coincidentally, was Moon. And there was a woman Negro cook and a Negro nursemaid.

Mrs. Fay Potter of Cincinnati, Ohio, 20 months older than the astronaut and the younger of his two sisters, is responsible for her brother's nickname. As an infant she could not pronounce "brother." "Buzzer," as it came out, stuck, and was shortened to "Buzz" when the boy was about 10.

Mrs. Potter remembers Buzz as "a typical rascal boy, a pest." She described him as "forever moving, the kind of kid that would drive a mother crazy, I would think."

"He was very active, but easy to manage," recalls Mrs. Alice Howard of Montclair, who was Buzz's nursemaid for most of his first nine years of life. Despite the boy's easy manageability, she said, he had a tendency suddenly to run off, disappear and cause great anxiety. And he would not take naps but, in Mrs. Howard's words, "would get out of bed and sneak down the stairs, and I'd have to push him back up again."

Buzz Aldrin was athletic from the start. As a young boy he set up hurdles in the backyard of the three-story, seven-bedroom home next to a park at 25 Princeton Place in Montclair. He walked on stilts, set up a chinning bar, and did calisthenics. Today, Mrs. Potter says, he does "the most fantastic exercises" on the beach. When the popular Royal Canadian Air Force exercise book was published, an adult Buzz Aldrin turned to the last page, reserved for champion athletes, and zipped through the whole series.

The boy had his share of traumas. There was the time he came home and found that the adult white mice he kept had eaten their young, and burst into tears; and the time a big wave knocked him down on the beach, causing him to fear water for a long time afterward. But mostly he was a happy, healthy, blond boy who was able and willing to respond to his mother's expectations.

"Mother was very demanding of excellence, in a nice way," Mrs. Potter says. "She provoked us to do our best, but she never attacked our self-respect. She never hurt me, that I recall."

When Buzz was pushed ahead into first grade a year early because he was bored with the second year of kindergarten, then required in Montclair, he "strained every nerve to prove he could make good," recalls Miss Rita Hogan of Montclair, now a retired teacher, who inherited Buzz in the second grade. "In school," said Miss Hogan, "he was all business."

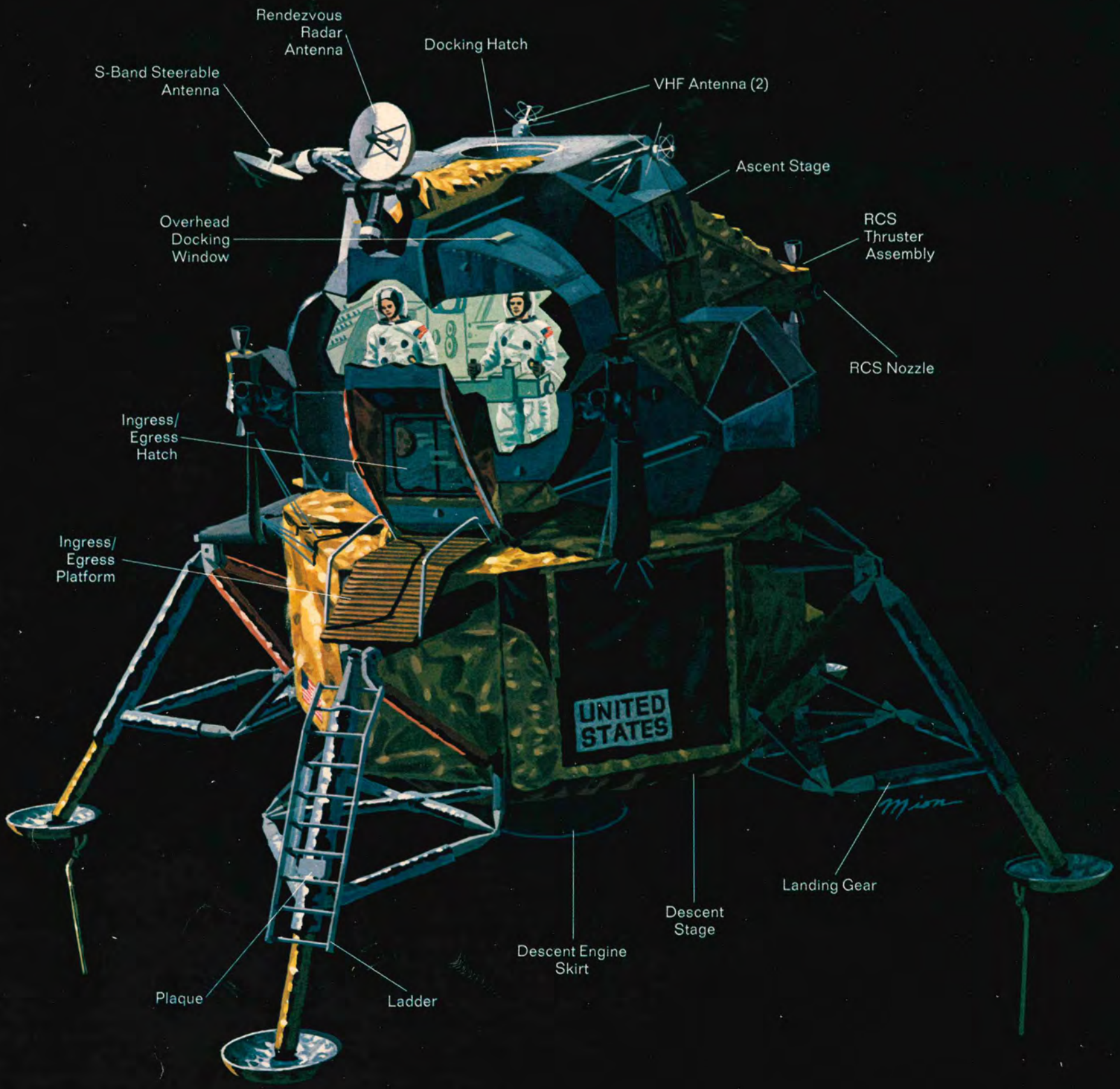
The astronaut himself believes the seven summers he spent at a boys' camp in Maine had much to do with shaping his personality. "It was the competition, the athletics, being with people," he said. "Schooling didn't really provide that." The camp "turned him into a real boy-kid," Mrs. Potter says.

The Buzz Aldrin of high school days took a full part in the social activities of the time, but there was much unusual about him. These aspects are recalled by his former football coach, his former mathematics teacher, and a former classmate.

The coach, Clarence Anderson, once asked the 140-pound Buzz to switch from halfback to fill the vacant center spot on what turned out to be a state championship team. "He accepted it as a matter of fact, like 'I'm a team man and here we go,'" Mr. Anderson says. "He was clean, crisp and quick, and he never made a bad pass from center. He had backbone, heart and guts."

Allen Dumont of Montclair, Buzz's former classmate, who now hunts executive talent for a major management consulting firm, recalls: "He was the most physically and mentally disciplined guy I've known, then and now. He spent his time on serious things. There was not much clowning around."

And William Filas, the math teacher at Montclair High, from which Buzz graduated in the top 10 per cent of his class, recalls, "He seemed to enjoy success where you can see success, as in solving math problems. There was no attempt to outshine other stu-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Docking Hatch
S-Band Steerable Antenna
VHF Antenna (2)
Ascent Stage
Overhead Docking Window
RCS Thruster Assembly
RCS Nozzle
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UNITED STATES
Landing Gear
Descent Stage
Descent Engine Skirt
Plaque
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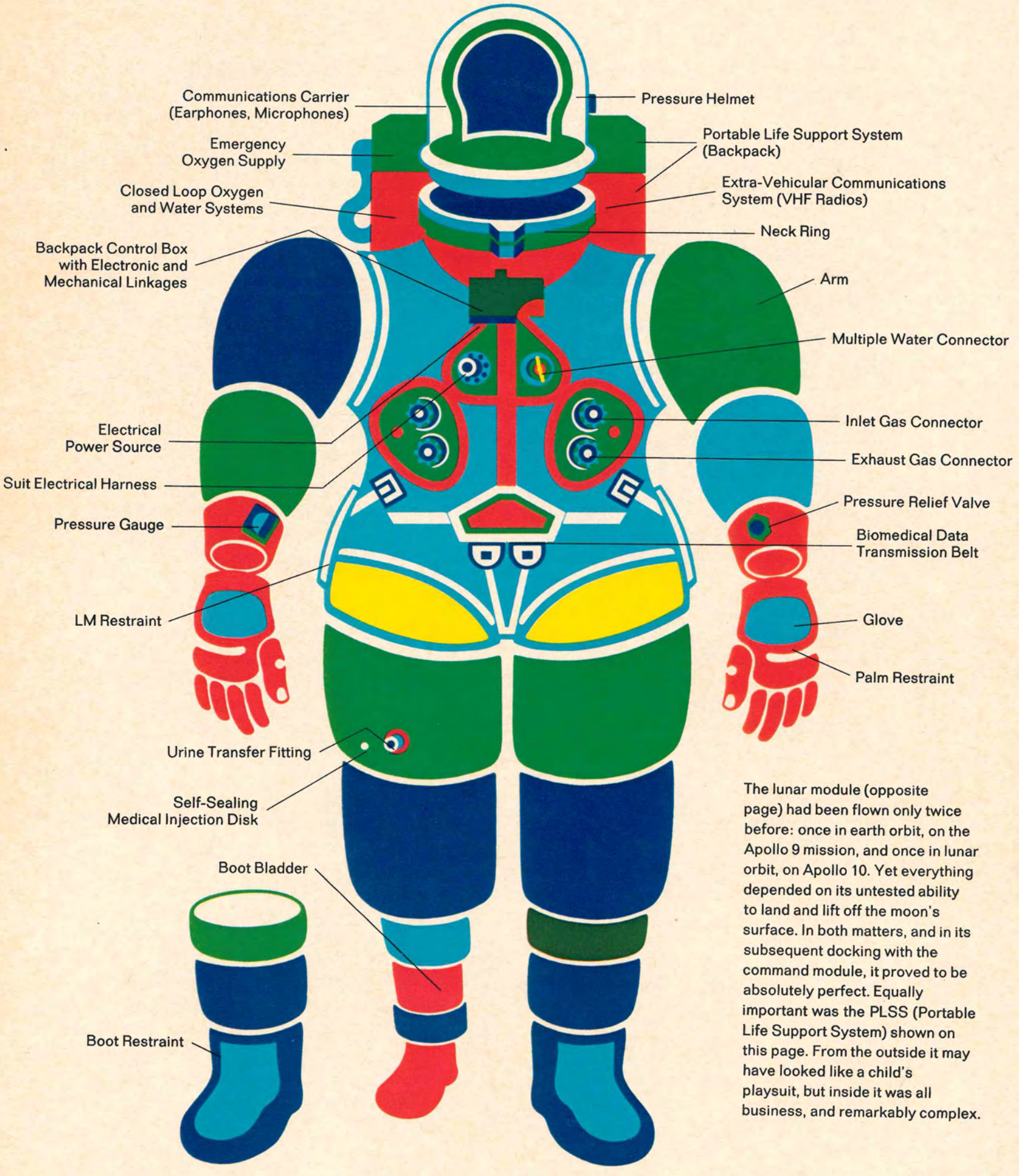

The lunar module (opposite page) had been flown only twice before: once in earth orbit, on the Apollo 9 mission, and once in lunar orbit, on Apollo 10. Yet everything depended on its untested ability to land and lift off the moon's surface. In both matters, and in its subsequent docking with the command module, it proved to be absolutely perfect. Equally important was the PLSS (Portable Life Support System) shown on this page. From the outside it may have looked like a child's playsuit, but inside it was all business, and remarkably complex.

ILLUSTRATION LEFT
BY PIERRE MION

ILLUSTRATION ABOVE
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dents on a commonplace problem, but when it came to deep analysis and thought, he had this drive to excel. He was a natural in mathematics, and he gave the appearance of being absolutely sure of himself at all times."

These qualities enabled him to graduate third in the class of 1951 at the United States Military Academy. Having grown up in an aviation household and gone to West Point at a time when the Air Force was viewed as the coming service, Buzz decided to become a pilot.

Eventually he wound up flying an F-86 Sabrejet in the Korean War, in which he shot down two MIG-15's.

Jack Waite, an official of the North American Rockwell Corporation in Houston, who has known Colonel Aldrin for years, summed up the Aldrin of the Air Force this way: "Gung ho, eager, always trying to get the most out of the plane, always trying to get the highest gunnery score."

Buzz Aldrin won a doctor of science degree in astronautics at the Massachusetts Institute of Technology in 1963, and soon thereafter, as an expert in orbital rendezvous, was assigned as an Air Force representative at the Manned Spacecraft Center. It was only a short step to astronaut status in 1964.

MICHAEL COLLINS was born in a lush apartment house off the sculpture-studded Borghese Gardens in Rome, one of Europe's most beautiful parks, of an ancestry extending back to County Cork, Ireland, on his father's side and into pre-Revolutionary America on his mother's.

The youthful Michael was as insouciant as Buzz Aldrin was intense and disciplined, and as drifting and undirected as Neil Armstrong was single-minded.

Such a personality might at first glance seem unlikely, in that few people have ever come from so military a background. Mike Collins is the son of an Army general (the late James L. Collins, who was military attaché in Rome when Michael was born), the nephew of another (J. Lawton Collins, a former Army Chief of Staff) and the brother of yet another (James L. Collins Jr., presently commander of 5th Corps artillery in Darmstadt, Germany).

But the Collins household was lively, cultivated, free of military stiffness. Michael's father was a short, athletic man who spoke his mind when he felt like it, played polo, was able to do handstands at age 65, and was Gen. John J. Pershing's aide in the Philippines, in the Mexican campaign against Pancho Villa, with the American Expeditionary Force during World War I, and at the Coronation of King George VI. From his father Michael got the athletic bent that made him a quick, aggressive captain of the wrestling team at St. Albans School for Boys in Washington.

From his mother, a slight, soft-spoken lady who now lives in Washington, he got an affinity for books and music. "Mother studied a lot," says one of Michael's two sisters, Mrs. H. C. Weart of Merritt Island, Fla., near Cape Kennedy. "She learned to speak Italian in Rome, and she saw that we spoke the language, too. She used to take us to museums and churches and places like that."

By the time Michael entered St. Albans School at age 12, he had lived in Rome, in Oklahoma, on Governor's Island in New York Harbor, just outside Baltimore on Chesapeake Bay, in Texas and in Puerto Rico. In San Juan, where his father was commander of the Army's Puerto Rico Department, the family lived in a great, sprawling, sixteenth century mansion called Casa Blanca, and Michael attended a private school.

"I think a life like that is good for a kid," Colonel Collins says of the constant moving about. "You learn some things twice in school, and others not at all, and you have to leave a lot of friends. But on the other hand, it's a damned interesting life for a kid. On balance I think it's an advantage."

The family's gypsy life caused it to grow closer in support of each other, Mrs. Weart believes. Her mother adds: "We did a great many things together. We were quite a close family, we really were, and I thoroughly enjoyed my children."

Because he was by far the youngest of the family — his brother, for example, is 13 years older — young Michael was its pet. He was also subject to a subtle, love-laced discipline, which, in the astronaut's words, caused him to "go to great lengths to avoid doing anything to displease my parents. To gain their approval was important to me."

But the parents were not pushers, as is evidenced by Mrs. Collins' attitude toward the children's careers: "We just told them they were to do what they wanted. Neither one of us thought we should live our children's lives."

In such an atmosphere, young Mike did what was expected of him, did not attract particular attention from those looking for achievement, and enjoyed the swimming, fishing and playing that make up a normal boy's life.

Carrying his low-voltage demeanor to St. Albans, a fashionable preparatory school in leafy, secluded surroundings next to the Washington National Cathedral, Mike Collins quickly became one of the most popular boys there, one of the least dedicated, and one of the most mischievous.

"I've got to say I just didn't like school," he explains now. "I think St. Albans let me in sort of to be nice."

Boarding students at St. Albans live an almost Spartan existence in small cubicles that resemble monks' cells. But within this atmosphere, Mike Collins was known among the masters as a perpetrator of mischief. To this day, they say, they are unable to pinpoint exactly what he did, but they were always sure he was in on much of what went on behind the scenes. "He had an immobile face," says Ferdinand Ruge, one of the masters. "You always wondered what he was concocting."

Mike served as a prefect—one of the top student leaders—during his senior year, and the St. Albans yearbook for 1948 noted that he was one of the four most popular boys in the school. It noted also that a little knowledge might have seeped into him

"despite the lures of Morpheus [the Greek god of sleep]." His sleepiness may have been the result of having to get up to be a Cathedral altar boy at the 6:30 A.M. service.

His grades at St. Albans were not spectacular, although he made the equivalent of B-pluses in mathematics, his best subject. John Davis, now assistant headmaster and a former teacher of Mike's, noted "an intellectual precision" and "a desire to see the limits of a problem and then go to the heart of it."

Michael Collins graduated from West Point in 1952 with a less than brilliant academic record. The yearbook noted that his battle cry was "stay casual" and that "he took the cash and let the credit go and seldom heeded the distant rumble." Freely translated, that means "live today and don't worry about tomorrow."

What led Mike Collins into the Air Force is not exactly clear. But once in, the astronaut says, he was interested in flying the newest kinds of planes. So he became a test pilot. "To avoid being static, that's why you do something like that," he explains.

"Even after he came here [to Edwards Air Force Base] to test pilot school, I thought he was just going to be another guy who was going to drift through life," says Bill Dana, a NASA test pilot who knew young Collins well at West Point and was his roommate in flight training. "I think the space briefings here really turned him on, and he bloomed."

Once his ambition was fired, Mike Collins applied his underlying intelligence and determination. "And voilà, here I am," he says. "I don't know where I go from here."

THE astronautical accomplishments of the Apollo 11 crewmen speak for themselves. The Gemini 8 flight of Neil Armstrong in March, 1966, was testimony to the dangers of space-faring. Maneuvering thrusters ran wild, causing the spacecraft to tumble out of control, and Mr. Armstrong's superb piloting skill saved his life and that of his crewmate, David Scott. Four months later, Mike Collins in Gemini 10 walked twice in space and took part in a rendezvous with two separate space vehicles. In November of the same year, on Gemini 12, Buzz Aldrin established a five-and-one-half-hour record for time spent walking in space.

On the job, according to those who worked most closely with the crewmen during their training of the moon landing, Neil Armstrong displays pride in his skill at the manual art of flying, in his ability as a man to master the machine. Buzz Aldrin, they say, is more of a computer man who takes pleasure in making the machine work for him. Mike Collins is said to be fascinated by the wide variety of tasks required of the command module pilot, who must run an entire spaceship by himself. It is a fortunate balance.

All three are said to be basically quiet and relaxed, not officious or overbearing, although Colonel Aldrin is more apt to tell people what he thinks and is more stubborn in his convictions. His constant display of knowledge, his unending stream of suggestions for better ways to do things let him in for much good-natured ribbing—as in his nickname, "Dr. Rendezvous."

Mike Collins is described as being "very understanding, perhaps too understanding;" a nice fellow who doesn't want to make people feel bad. Neil Armstrong is said to be almost infinitely patient. No one can recall ever having seen him lose his poise.

Off the job, the men who flew to the moon are what one associate called "home and hearth" men. In training at Cape Kennedy, they do not carouse as some astronauts have been known to do. In their comfortable suburbs near the Manned Spacecraft Center outside Houston, they are basically homebodies.

Neil Armstrong likes to listen to a wide variety of music, enjoys fishing and sailplaning, and seeks utter privacy with his wife and two sons. Unlike his crewmates, he has an unlisted telephone number. When he and his wife attend parties, Neil often stands bashfully back and declines to mix, at first, but then he invariably warms up and becomes the last to leave. He smokes cigars, but rarely. He drinks, but is never visibly affected. He keeps his own counsel so effectively that even his parents do not know what his philosophical and religious beliefs are.

Buzz Aldrin, according to his sister, Mrs. Potter, is so thoroughly wrapped up in his work that he sometimes finds it difficult to give full attention—psychologically—to family matters. He and his wife, Joan, are said to attend parties rather more frequently than the other Apollo 11 astronauts. On some such occasions, according to Jack Waite, when Colonel Aldrin really relaxes, "he has some drinks and it oils his mouth real good." Mostly, he talks business. Colonel Aldrin is a Boy Scout merit badge counselor and an elder and trustee of the Webster, Tex., Presbyterian Church. His hobbies are running, scuba diving and high-bar exercises.

Mike Collins is perhaps the most stay-at-home of the three. He is said to be quick to admire people, impossible to dislike, so considerate that he will not say anything unpleasant to anyone. He drinks martinis, sometimes several of them, but with no apparent effects. He has a passion for fishing and for books, and although he gains much pleasure from tending roses, he declines to fertilize his lawn so that he will not have to cut it. Sometimes he can be seen hopping around trying to catch the family's white rabbit as it munches clover. He and his wife, Pat, and their three children form what a neighbor says is "a very close family circle."

There are indications that the men of Apollo 11 are beginning to be concerned about the consequences of the fame that surely awaits them. Mrs. Potter says her brother, Colonel Aldrin, is starting to worry about loss of privacy and freedom. Colonel Collins' mother says her son is slightly irritated that, because of him, his family should be subjected to public scrutiny and prying. "He doesn't think an old lady like me should have to put up with that," said the 73-year-old Mrs. Collins.

The astronauts' concern about such things is one of the latest facts of existence for all three, and one thing is certain: Now that they have succeeded in the epic mission on which they embarked, all that is in their personal past is merely prologue, and life for them will never be the same again.

THE MISSION

PROLOGUE
The American space effort grew slowly, past the doubters, a technological enterprise that sprawled across the land.

By JOHN NOBLE WILFORD

THE Space Age was in its fourth year when the long countdown for the voyage to the moon began in the spring of 1961. President Kennedy's decision that year to put a man on the lunar surface by the end of the decade set in motion the greatest mobilization of men and resources ever undertaken for a peaceful project of science and exploration.

This vast, diffuse and far-flung effort was to be directed and welded into a smoothly functioning enterprise by the fledgling National Aeronautics and Space Administration, which, like President Kennedy's decision, was born of reaction to a Soviet triumph in space.

In October, 1957, the Soviet Union had sent into orbit the first artificial earth satellite, Sputnik 1, shocking an American public that had grown used to the idea that technological superiority rested with the United States, and touching off a somewhat panicky effort to catch up to the Russians.

In that climate, Lyndon B. Johnson, then the Democratic leader of the Senate, spearheaded a drive in the Congress that culminated, within 10 months of Sputnik 1's launching, in the creation of NASA out of the old National Advisory Committee for Aeronautics. Thus was born a powerful new civilian agency to oversee America's venture into space.

Not until May of 1961, however, did the American space effort gather momentum. The United States had just suffered two swift blows to its standing among nations—the abortive Bay of Pigs invasion of Cuba and the orbital flight of Yuri Gagarin, the Soviet cosmonaut who became the first man to go into space. President Kennedy and his advisors saw in the moon a way to regain lost prestige and to inspire the nation to greater accomplishments.

Once President Kennedy announced his decision to land men on the moon "in this decade," it fell to James E. Webb, a former director of the Bureau of the Budget and NASA's administrator from 1961 until last October, to persuade Congress to finance the flight to the moon. The effort was to cost $24-billion, not including $392-million for Project Mercury and $1.3-billion for Project Gemini, the precursors of Project Apollo, the moon venture itself.

Mr. Webb succeeded. The space agency's annual budget grew from $966.7-million in fiscal year 1961 to $5.25-billion in fiscal year 1965, the peak year of the development effort for Apollo.

The momentum of the lunar landing project stimulated a rich variety of unmanned space activities as well—nearly $10-billion worth in a 10-year period. Only 21 of more than 250 major rocket launchings carried out by NASA have involved astronauts. The unmanned launchings, about three-quarters of which succeeded, have carried weather or communications satellites or scientific experiments, or have borne robot craft to probe the moon and planets.

As Project Apollo began to grow under NASA's direction, abandoned war factories sprang to life as rocket assembly plants. A Massachusetts hosiery mill was turned into a laboratory for guidance instruments. Piney woods in Mississippi were cleared for rocket test firings. A desolate stretch of sand in Florida was transformed into a billion-dollar moonport. A network of tracking stations was strung around the world on ships and islands at remote sites in Africa and Australia. A pasture outside Houston was bulldozed for the flight control center, a complex of training simulators and test chambers, computers and control consoles.

The NASA investments invigorated Southern localities that became home to various production and operational centers for Project Apollo. Activity at the Cape Kennedy launching pads caused the population of Florida's Brevard County, historically a sultry agricultural area, to soar from 24,000 to 224,000 between 1950 and 1965. The manned space program accounted for the last five years of that growth.

Huntsville, Ala., once a declining textile town, became the home of the Marshall Space Flight Center, which developed the rockets for Project Apollo. Its population grew by 90 per cent between 1960 and 1965, its employment by 95 per cent.

Houston, which became the home of the Manned Spacecraft Center, felt less impact than the other areas because the Texas petrochemical industry had already induced a boom. (Conversely, Houston stands to suffer least from the budget cutbacks the space program is now facing.)

Building the rockets and spacecraft for the moon voyage required the concerted efforts of thousands of industrial contractors,

scores of university laboratories and hundreds of thousands of people. They were drawn from disparate backgrounds.

There was the "Langley crowd," engineers who had learned their trade at Langley, Va., in the old national advisory committee. Under Dr. Robert R. Gilruth, they took leading parts in designing the vehicles, plotting the mission and training the astronauts.

There were "the Germans," the most prized booty of World War II. They were the men who, under Dr. Wernher von Braun, developed the first workable ballistic rocket, Hitler's V-2, at Peenemünde on the Baltic Sea. After Germany's defeat, the United States Army brought Dr. von Braun and 118 aides, their rocket blueprints and some captured V-2's to this country. From this talent came the design for the moon rocket, the Saturn 5.

There were also the bright and eager engineers at the Jet Propulsion Laboratory in Pasadena, Calif. Directed by Dr. William H. Pickering, they developed many of the guidance and communications techniques required for lunar travel.

In addition, all the unmanned scouting probes to the moon —the Rangers, Surveyors and Lunar Orbiters—were controlled from JPL. The pictures and data these probes sent back to earth reassured the men of Apollo that the moon, though barren, harbored no insurmountable hazards to a manned landing.

And finally there were the men to fly in this strange new realm. The three Apollo 11 crewmen—Neil A. Armstrong, a civilian, and Col. Edwin E. Aldrin Jr. and Lieut. Col. Michael Collins of the Air Force—were chosen from a corps of 50 active astronauts, many of whom had gone before in pathfinding flights to prove the spaceworthiness of the machines and to scout the landing site on the moon.

But most of the people involved were those who worked for the aerospace companies that had won contracts from NASA to build the Apollo "hardware."

The North American Rockwell Corporation built the Apollo spacecraft, the second stage of the three-stage Saturn 5 and the engines for all three stages. The Grumman Aircraft Engineering Corporation built the lunar module, the craft in which men actually were to land on the moon. And the Boeing Company, the McDonnell Douglas Corporation and the International Business Machines Corporation produced the other main components of the Saturn 5.

Apollo 11 was not, therefore, a lonely journey by romantics in search of an unknown shore. It was carefully conceived and elaborately planned. Nevertheless, there were accidents.

The three astronauts who were to make the first test flight of the Apollo command ship died in the flames that broke out in their cockpit on Jan. 27, 1967. It happened suddenly and where an accident was least expected—on the launching pad at Cape Kennedy, during an unfueled countdown rehearsal.

The deaths of the three men—Virgil I. Grissom, Edward H. White and Roger B. Chaffee—plunged the Apollo program and NASA into their gloomiest period, a time of self-doubt and near-paralysis. Investigators uncovered "many deficiencies in design and engineering, manufacture and quality control" in the project.

As engineers began picking up the pieces, rebuilding the spacecraft and subjecting it to more rigorous tests, a growing number of Americans questioned the value of the project. They began to look upon Apollo as a magnificent irrelevance.

Apollo's critics usually raised these basic objections:

It cost too much. This became an issue debated in many an American home as taxes rose, as the war in Vietnam imposed new strains on the Federal budget and as the nation's long-neglected social ills became more evident.

The money and talent could be more usefully directed to down-to-earth problems. Riots on the campuses and in the city slums, lingering poverty amid plenty, and rising crime left people disturbed by different things toward the end of the decade than they were when the Apollo decision was reached.

It was a "childish stunt" to make a race out of going to the moon and insist on such an artificial deadline as the end of the decade. The moon, some pointed out, had been there a long time and showed no signs of disappearing any time soon.

To those who argued that man should first set his own earthly house in order before going to the moon, Dr. Margaret Mead, the anthropologist, replied that they were "shrinking from the future." She declared: "A society that no longer moves forward does not merely stagnate, it begins to die."

Some scientists, while sharing the enthusiasm for moon exploration, felt that it was being gone about in the wrong way. They argued that it would have been cheaper and less risky to send unmanned vehicles to gather the rocks and to probe the lunar surface.

John H. Glenn Jr., the first American to orbit the earth, gave the following defense of man's usefulness on a moon flight: "Instruments that we design can only measure what we know is there. Man has the unique ability, of course, to perceive and relate to unknowns, and to make judgments on these things as to how he can use them or of what value they are."

Opposition from the scientific community had largely died down by the time the voyage began. Geologists and physicists, chemists and biologists were eager to learn of the moon's secrets. They wanted to know what the moon is made of and how it came to be, whether it ever had any form of life or has any now.

They also wanted to know from the moon some of the secrets of the earth. For preserved on the surface of the airless moon, whose very changelessness makes it a museum piece of what worlds may have been like billions of years ago, may be clues to the formation of the earth and the other planets orbiting the sun.

Whatever its impact on man, earth and science, the voyage marked a bold extension of man's dominion over his environment. As Mr. Webb, former NASA administrator, said: "We are not limited to the water anymore. We are not limited to the air. We are not limited by the gravity of the earth. We can overcome those limitations and move out any place we really want to go."

TUESDAY, JULY 15
Nearly a million people crowded the beaches and towns, peering toward what one onlooker called "one big white candle."

Cape Kennedy, Fla.

IT WAS the day before lift-off. The giant rocket, the spaceship and the Apollo 11 astronauts were poised to embark on one of mankind's greatest voyages of exploration, the first flight to land men on the moon.

"Apollo 11 is proceeding well toward the planned launching tomorrow at 9:32 A.M., Eastern daylight time," George H. Hage, the mission director, reported as technicians began the final and most critical hours of preparation.

Astronauts Armstrong, Aldrin and Collins were said to be in excellent health, in good spirits and confident of success.

The moon vehicle, standing by the ocean on a sandy spit of land and bathed in floodlights like a towering monument, was the center of attention for nearly a million people crowding the towns and beaches surrounding the space center.

"It looks like one big white candle," said 21-year-old Jimmy Blount, a senior at the University of Georgia, who sat on a swarming, tent-filled inlet in Titusville, 11 miles west of the launching pad. "I'm going to tell my grandchildren about it—I was there when men went to the moon."

The crowd, largest ever to witness a launching, surged along beaches, parks, roads and highways. Diplomats, scientists, vacationing families, surfers, students, hippies, salesmen trudged along the eight-mile-long beach far into the night. The thousands of out-of-state tourists and VIP's mingled with local engineers and technicians in Cocoa Beach, Cape Canaveral, Titusville and the other coastal towns that rose with the space program.

Everywhere there were buttons and bumper stickers that read: "I was at the Apollo 11."

Air traffic in Brevard County quadrupled during the day, with the 10 airfields in the area handling more than 1,200 single-engine planes and 200 private jets.

Among the thousands were former President Lyndon Johnson, Vice President Spiro Agnew, congressmen, movie stars and industrialists. And camping out near the launching area were demonstrators from the "Poor People's Campaign," who came to make the point that no matter how far man flies into space he still has problems at home on earth.

"We do not oppose the moon shot," said Hosea Williams, a project director for the Southern Christian Leadership Conference, which organized the campaign. "We feel the effort is laudable. Our purpose for being here is to protest America's inability to choose human priorities. We are spending billions of dollars to explore outer space, but if America spent that same amount of money feeding the poor and hungry, then poverty and hunger would be gone from the face of America today."

The astronauts were to retire early after spending most of the day resting in their quarters and reviewing the flight plan. And they would rise early, at 4:15 A.M., for a medical examination, breakfast and the trip to launching pad 39-A and the spacecraft in which they would spend the following eight days.

While the astronauts slept, technicians pumped fuel into the Saturn 5 rocket and conducted the final computerized inspections of the 363-foot-tall vehicle. Space agency officials said the countdown was one of the smoothest ever.

The weather was expected to be favorable for the launching. But a high covering of clouds threatened to prevent the spectators from seeing much more than the first two minutes of the flight, the thunderous initial thrust of the Saturn's five booster engines.

If Apollo 11 blasted off on schedule, the astronauts would go into a 115-mile-high earth orbit and then, two and a half hours later, refire the Saturn's third-stage rocket to aim for the moon.

Mr. Armstrong and Colonel Aldrin were scheduled to land the lunar module on the moon's Sea of Tranquility on Sunday afternoon, July 20, while Colonel Collins piloted the command ship 70 miles above in lunar orbit. Later, the two moon explorers would open their hatch and step out on the lunar surface.

As the Apollo 11 countdown ticked inexorably toward the moment of blast-off, an unmanned Soviet spacecraft already was speeding toward the moon. The mission of the craft, called Luna 15, was a mystery to American space officials; but there was speculation that the Luna vehicle would land on the moon, scoop up some dirt and return it to earth before Apollo 11 could get there.

And as always, despite the general feeling of confidence that Apollo 11 would be launched safely, there was the submerged fear of failure. If the moon mission did fail, it would set back the American program; but it was all but certain the United States would try again. The next opportunity would be in September, which was the soonest another moonship could be made ready for launching.

There was the much grimmer possibility, too, of outright disaster. Danger lay at many points on the Apollo 11 flight-path, and one of the most hazardous events was the start of the flight, the launching itself.

"Any time you have a space vehicle with many million parts, there are a lot of elements that have to work right," said Mr. Hage. "Nevertheless, project officials have done everything man can do

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This narrative of the Apollo 11 mission is based primarily on the daily dispatches of John Noble Wilford from Cape Kennedy, Fla., and Houston, Tex., and of James T. Wooten from the carrier U.S.S. Hornet in the Pacific.

to minimize the chance of failure."

If the rocket failed on lift-off, it would force the astronauts to fire the needlelike launching escape rocket on top of their spacecraft to pull them free of the Saturn and drop them safely off into the ocean. The starkest possibility was that the rocket would suddenly explode before the astronauts could escape. But there had been five launchings of the Saturn 5, and all were safe and successful.

The mission could not succeed if the Saturn's third stage failed to restart in earth orbit, although the astronauts would not necessarily be endangered. The same would be true once Apollo 11 got to the moon, where the astronauts would have to fire the spacecraft's main rocket engine—reliable in all past tests—to slow them down to swing into lunar orbit. If the rocket should fail then, the spacecraft would still be able to whip around the moon and, gaining momentum from lunar gravity, return to earth on a "free-return trajectory."

"On any flight, those things that are new are the most dangerous," Mr. Armstrong said days before the launching. "In our case, it will be the descent to the surface, the landing, the lunar surface work and the lift-off from the moon."

In December, the men of Apollo 8 had orbited the moon for the first time. In May, the Apollo 10 astronauts had gone into lunar orbit and practiced flying the landing craft down to within 50,000 feet of the moon—but no closer.

This time, on July 20, Mr. Armstrong and Colonel Aldrin were to crawl into the lunar module, detach it from the command ship and descend to a lunar touchdown at 4:19 P.M. The spindly-legged craft was supposed to land on a plain near the crater Moltke, which is on the right side of the moon as seen from earth.

But if there were any indications of trouble, the astronauts could abort the landing at any time until they were within a few feet of the surface. To do this, they would quickly fire the ascent engine to return to the moon-orbiting command ship.

Until they got below 50,000 feet, it would be possible for Colonel Collins to swoop down in the command ship to rescue the lunar module should it become disabled.

Once on the moon, where they were to remain for 22 hours, Mr. Armstrong and Colonel Aldrin were supposed to go outside the landing craft for 2 hours and 40 minutes. They would deploy scientific instruments, collect 60 pounds of soil samples, plant an American flag and deposit a disk bearing messages of good will from heads of state of 73 nations. In addition, they would leave attached to the lunar module's descent stage a plaque that read:

HERE MEN FROM THE PLANET EARTH
FIRST SET FOOT UPON THE MOON
JULY 1969 A.D.
WE CAME IN PEACE FOR ALL MANKIND

WEDNESDAY, JULY 16

"That Saturn gave us a magnificent ride. We have no complaints with any of the three stages . . . . It was beautiful."

Cape Kennedy, Fla.

RIDING a tail of flame from the mammoth Saturn 5 rocket, Mr. Armstrong, Colonel Aldrin and Colonel Collins rose from the launching pad and streaked across the black sea of space toward the moon, 240,000 miles from earth.

The thunderous blast-off at 9:32 A.M., Eastern daylight time, sent a tremor through the ground and staccato shock waves beating at an estimated total of one million people who stood under the hot Florida sun to see the start of the most daring voyage thus far in the age of spacefaring.

"I'm shaky, I'm tearful," whispered Mrs. John Yow of Jacksonville, who arrived at 4 A.M. to watch the launching from a crowded jetty 18 miles south of launching pad 39-A. "It's the beginning of a new era in the life of man."

On Cocoa Beach, five miles away, Mrs. Lee Formica, a Connecticut schoolteacher, stood on the sand and watched the rocket sweep out of sight, leaving a white, fluffy vapor trail.

"Everyone is so quiet," she said, with the shimmering ocean brushing over the beach several feet away. "Some of them just whisper, 'God bless them, God bless them.' "

Millions around the world watched over television relayed by satellites, a phenomenon noted by President Richard M. Nixon in a proclamation.

"In past ages," the proclamation said, "exploration was a lonely enterprise. But today, the miracles of space travel are matched by miracles of space communication; even across the vast lunar distance, television brings the moment of discovery into our homes and makes all of us participants."

The proclamation proposed that the next Monday—the day Mr. Armstrong and Colonel Aldrin were to set foot on the lunar crust, conduct their experiments, and lift off for the return to earth—be a National Day of Participation, a holiday in which Americans would mark "the moment of transcendent drama."

Even before Apollo 11 set out for the moon, Vice President Agnew urged that the United States set a new goal of landing men on Mars by the end of the century.

He said he had been urging on President Nixon his feeling that such a "simple, ambitious, optimistic goal" should be set because "whether we say it or not, someone's going to do it."

And former President Johnson, making a rare public ap-

pearance since leaving office, said just before the launching that the cooperative effort that sent Apollo 11 toward the moon should be used to fight poverty, hunger and disease and to bring peace.

"If our industrial people, these great managers of industry, the laboring people of the country, the government, the scientists, all with the help of the Congress, can get together and do a job like this, there's just nothing we can't do," Mr. Johnson said.

Then all eyes turned toward the mission itself. All the critical first steps of the epic Apollo 11 flight were taken without a flaw. The spaceship's course was so accurate that a planned corrective maneuver was canceled because it was unnecessary.

Apollo 11 could still fail in its moon landing attempt. But NASA officials and flight controllers seemed confident of success on the basis of the early performance of the spacecraft and the crew. "It all went very close to nominal," said Clifford E. Charlesworth, the flight director.

In slightly less than 12 minutes following the lift-off, as the Saturn's three stages fired one after another, Apollo 11 shot into earth orbit, where it remained two and a half hours to give the astronauts time to make sure they had a moonworthy vehicle.

At 12:16 P.M., another firing of the Saturn's third-stage engine, still attached to the spacecraft, boosted Apollo 11 out of its 118-mile-high orbit and onto its lunar trajectory at an initial speed of 24,200 miles an hour. "You're on your way now," Mission Control at the Manned Spacecraft Center in Houston radioed the astronauts.

Within the next two hours, as they left the earth farther behind, the astronauts separated their command ship from the Saturn's third stage by the automatic firing of explosive bolts.

Then, with Colonel Collins at the controls, the command ship pivoted 180 degrees and eased back to lock its nose into a connecting device on the lunar landing craft, which was still housed at the top of the third stage.

Colonel Collins reported that he had used more fuel than had been expected in firing the command ship's maneuvering rockets during the link-up. Flight controllers said it was no cause for worry.

The astronauts told flight controllers that the fragile, bug-shaped landing vehicle appeared to have survived in good condition the heat and vibrations of launching.

After nearly an hour, the linked command ship and lunar module pulled free of the rocket stage. A radioed command from the ground fired the rocket stage into a long solar orbit to get it out of Apollo 11's path.

By this time, Apollo 11 was already more than 50,000 miles from the earth. The astronauts could now settle down to a coasting three-day journey to the moon, gradually losing speed as the earth's gravity continued to exert a slight restraining tug on their combined command ship-lunar module. The men spent some time practicing star sightings for navigation purposes.

During their many intricate maneuvers, they rarely spoke to flight controllers, except to relate data in a businesslike manner. Only after most of his day's work was done did Mr. Armstrong, the commander, tell flight controllers, "That Saturn gave us a magnificent ride. We have no complaints with any of the three stages on that ride. It was beautiful."

Mr. Armstrong also took time to look out the window by his left-hand couch to give a quick travelogue.

"Out of my window right now," the commander said, "I can observe the entire continent of North America, Alaska, over the Pole, down to the Yucatan peninsula, Cuba, the northern part of South America, and then I run out of window."

In an unscheduled broadcast, the crewmen transmitted the first color television pictures of their flight at about 8 P.M. They showed the receding blue-green earth. A second color telecast was to be transmitted the next day. The astronauts planned at least one television broadcast a day on the flights to and from the lunar vicinity. There were also to be telecasts of Mr. Armstrong taking the first step on the moon and of his and Colonel Aldrin's subsequent activities during their scheduled 2 hours and 40 minutes outside the lunar module.

The crew went to sleep at about 9 P.M., two hours earlier than scheduled. The extra time became available because the midcourse correction was skipped.

Mr. Armstrong, Colonel Aldrin and Colonel Collins spent the final hours before the launching in much the same way their predecessors on Apollos 7, 8, 9 and 10 had. These were the earlier manned flights of the series that proved the equipment and techniques for the lunar mission.

Immediately after waking, at 4:15 A.M., the Apollo 11 astronauts underwent a brief physical examination, sat down to a steak-and-eggs breakfast and then donned their white spacesuits with the American flag emblazoned on the sleeves.

They rode in a special air-conditioned van to the launching pad, eight miles away from their quarters. As a workman saluted, they entered an elevator at the pad's base and rose to the 320-foot level where an access platform from the steel tower reached out to the spacecraft cabin perched high atop the Saturn 5.

The rocket had been fueled during the night, its cavernous tanks filled with 6,484,000 pounds of propellants.

Super-cold liquid oxygen was pumped into the third, second and first stages. Then the even colder liquid hydrogen was loaded into the second and third stages. High-grade kerosene, which was used as the first stage's propellant, had been loaded weeks before.

When the astronauts reached the spacecraft, technicians 100 feet below were working feverishly to tighten a series of bolts in a leaking valve. This was in the system that replenished the liquid hydrogen as it slowly evaporated in the heat of the Florida sun.

The problem was eventually overcome by bypassing the valve, causing no interruption in the countdown.

At 6:54 A.M., Mr. Armstrong stepped over the sill and into the spacecraft's cabin, followed by Colonel Collins and then Colonel Aldrin. They connected their spacesuits to the oxygen system,

hooked up communications and checked out the switch settings on the cockpit's many control panels.

After a cheery farewell from Guenter Wendt, the pad leader for the North American Rockwell Corporation, which built the spacecraft, the hatch was shut and sealed. Mr. Wendt was in charge of last-minute preparations of the cabin, a job he had had on nearly every American manned mission since the first one—Alan B. Shepard's flight in May, 1961.

Until the moment of ignition, most of the action was in Firing Room 1, a huge rectangular chamber three miles from the launching pad. This was the command post where 400 men seated at monotonous gray rows of consoles and racks of gauges conducted the countdown.

Firing Room 1 is one of three fully equipped launching rooms from which NASA carries out the largely automated process of sending Saturn 5 vehicles soaring into space.

"It's in the last 22 minutes that the countdown gets really dynamic," said Rocco A. Petrone, the launching director. "That's when the high-pressure hydrogen starts flowing into the tank bottles and from then on the guys are watching the temperature gauges and everything like hawks. Those last 22 minutes are when we really earn our pay."

From Firing Room 1, Paul Donnelly, the test conductor, informed the astronauts that the countdown, which had run smoothly since it started last Thursday night, was about 15 minutes ahead of schedule.

"That's fine," Mr. Armstrong replied. "Just as long as we don't launch 15 minutes early." A few minutes later, just before launching, Mr. Donnelly told the astronauts: "Good luck and Godspeed from the launch crew."

Mr. Armstrong replied, "Thank you very much. We know it will be a good flight."

When every system in the 363-foot-tall rocket and spacecraft appeared ready, Charles Lehtinen, an engineer with the Boeing Company, which built the rocket's booster stage, pressed a button in the firing room to start the "automatic sequencer"—the computerized system that runs the last three minutes and seven seconds of the countdown.

Like all the previous Saturn 5 launchings, the lift-off came within milliseconds of the appointed time.

Orange flames and dark smoke spewed out of the five nozzles below the rocket's five engines for 8.9 seconds before the vehicle began to move.

Steel restraining arms held the rocket in place for those last few seconds while a computer system made certain all the engines ignited properly and were building up to the full 7.7-million pounds of thrust.

Then, ever so slowly, the 3,817-ton vehicle struggled to overcome the earth's gravity, finally cleared the launching tower and arced out over the Atlantic Ocean. It poked a hole in a thin cloud and could still be seen, three minutes later, when the five smaller engines of the second stage ignited far off in the blue sky.

The first word from Mr. Armstrong, as he began the moon voyage, was characteristically terse. To let Mission Control know that a planned maneuver had begun, the Apollo 11 commander radioed, "We've got a roll program."

THURSDAY, JULY 17

As the three sped outward, Russia's Luna 15 went into orbit around the moon. Still no word of what its mission was.

Houston, Tex.

THE moonbound Apollo 11, its systems sound and its aim true, coasted far past the halfway point of its 240,000-mile outward journey amid rising expectations of success for man's first lunar landing attempt.

The three astronauts fired the moonship's main rocket to sharpen its aim and to test the engine that had to work perfectly to get them into and out of lunar orbit.

When the astronauts had ventured 148,000 miles from earth, at 7:35 P.M., Eastern daylight time, Mr. Armstrong, Colonel Aldrin and Colonel Collins transmitted their first regularly scheduled color telecast. From their reports, the astronauts seemed to be comfortable and relaxed.

The view outside the spacecraft window was of a greenish-blue earth streaked with clouds. It was a half-earth, not unlike a half-moon but more colorful.

"We do not have the depth of color we enjoyed at 50,000 miles out," Mr. Armstrong said, describing the sights far below —the blue of the Pacific Ocean, greens along the northwest coast of the United States, a storm southwest of Alaska and the brownish-gray land mass up and down the Americas.

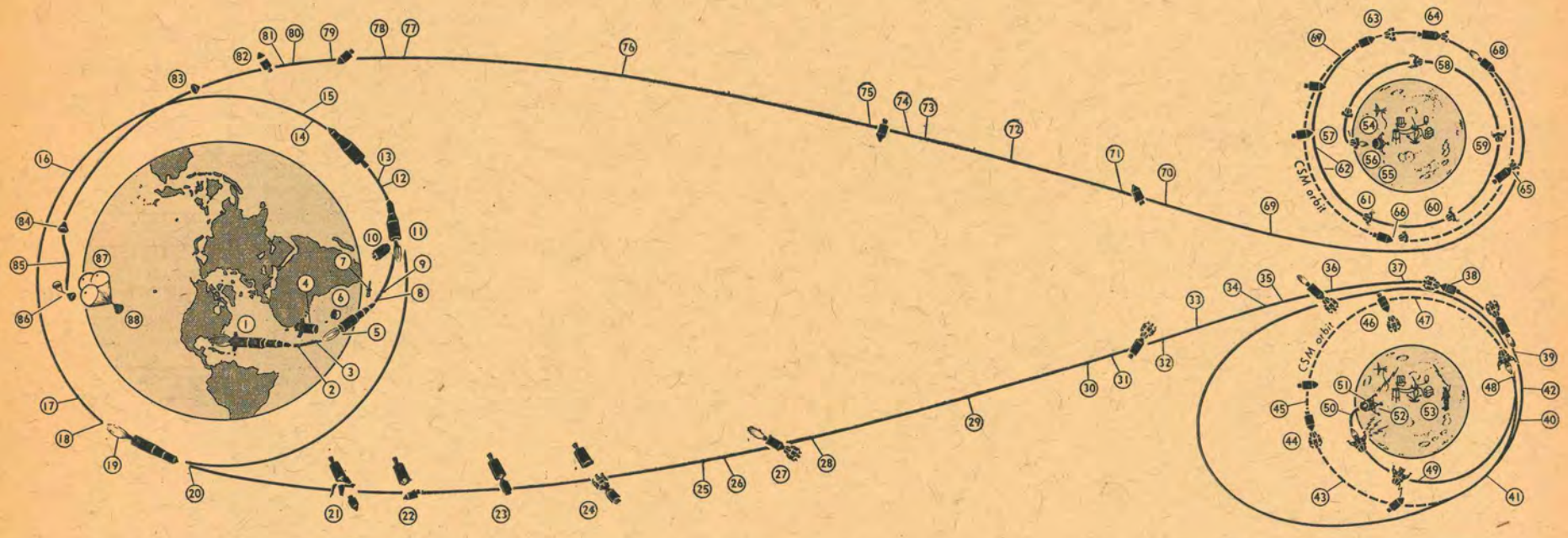
Colonel Aldrin rotated the camera several times to give the effect of the earth rolling and bouncing in the blackness of space. "You don't get to do that every day," he said.

During the 35-minute telecast, the crew showed closeup views of the sextant and telescope used for navigation, a star chart and the display panel for the guidance and navigation computer.

The panel's flashing numbers gave the mission's "ground elapsed time" of 34 hours, 16 minutes and 2 seconds—the time, at that moment, from lift-off Wednesday at Cape Kennedy.

Meanwhile, the Soviet Union broke its silence on Luna 15 and said the unmanned spaceship had become "the moon's latest artificial satellite." The wording of the report by Tass, the Soviet press agency, was similar to that of April, 1968, announcing that Luna 14 had gone into moon orbit.

A scarcity of official information about Luna 15 led many



There were 88 steps to the moon and back

1. First stage of Saturn 5 ignites; lift-off.
2. First stage powered flight.
3. First stage cutoff.
4. First stage separates, drops away; second stage ullage.*
5. Second stage ignites.
6. Connection between first and second stages is jettisoned.
7. Launch escape tower is jettisoned.
8. Second stage powered flight.
9. Second stage cutoff.
10. Second stage separates, drops away; third stage ullage.
11. Third stage ignites.
12. Third stage powered flight.
13. Third stage cutoff.
14. Earth parking orbit.
15. Begin systems status checks.
16. Adjust guidance system of command and service module (CSM).
17. Orient for translunar injection.
18. Third stage ullage.
19. Third stage re-ignites.
20. Translunar injection.
21. CSM separates from rest of vehicle.
22. CSM turns around 180 degrees.
23. CSM docks with lunar module (LM), which is still attached to third stage.
24. CSM and LM separate from third stage.
25. Adjust CSM inertial guidance system.
26. Orient spacecraft for midcourse correction.
27. Ignite service propulsion engine.
28. First midcourse correction.
29. Systems status checks; eat and sleep period; transmit data to earth.
30. Adjust CSM inertial guidance system.
31. Orient spacecraft for midcourse correction.
32. Midcourse correction, if required.
33. Systems status checks; eat and sleep period; transmit data to earth.
34. Adjust CSM inertial guidance system.
35. Orient spacecraft for midcourse correction.
36. Final midcourse correction, if necessary.
37. Adjust CSM inertial guidance system.
38. Orient spacecraft attitude for lunar orbit insertion.
39. Lunar orbit insertion.
40. Begin lunar orbit.
41. Adjust CSM inertial guidance system.
42. Circularize lunar orbit.
43. Systems status checks.
44. Pilots transfer to LM.
45. Activate and check out LM systems.
46. CSM and LM separate.
47. Orient LM for descent orbit insertion.
48. Descent orbit insertion.
49. Adjust LM inertial guidance system.
50. LM descent.
51. Landing on moon.
52. Check out LM systems.
53. Explore surface, set up experiments.
54. LM prelaunch checkout.
55. LM's rendezvous radar begins tracking CSM.
56. Lift-off from moon.
57. LM ascent.
58. LM heads into orbit nearly matching that of CSM.
59. LM changes plane of its orbit.
60. LM and CSM fly in tandem.
61. Final rendezvous maneuver begins.
62. Midcourse correction.
63. Rendezvous.
64. CSM and LM dock.
65. Transfer crew and equipment from LM to CSM.
66. CSM and LM separate; LM is jettisoned.
67. Determine transearth injection thrusting requirements.
68. Transearth injection.
69. Systems status checks; eat and sleep period; transmit data to earth.
70. Orient CSM attitude for midcourse correction.
71. First midcourse correction.
72. Systems status checks; eat and sleep period; transmit data to earth.
73. Adjust CSM inertial guidance system.
74. Orient CSM attitude for midcourse correction.
75. Midcourse correction, if required.
76. Systems status checks; eat and sleep period; transmit data to earth.
77. Adjust CSM inertial guidance system.
78. Orient CSM attitude for midcourse correction.
79. Final midcourse correction, if necessary.
80. Adjust CSM inertial guidance system.
81. Orient CSM for separation of command module (CM) and service module (SM).
82. CM and SM separate.
83. Orient CM for re-entry.
84. Re-enter earth's atmosphere.
85. Communications blackout period.
86. Jettison forward heat shield and deploy drogue chute.
87. Deploy main chutes.
88. Splashdown.

*Ullage: A slight acceleration of a rocket vehicle, using special thrusters, to force fuel into engine pump intake lines so main engine can ignite.

observers in Moscow to continue to speculate that the orbiting was only a prelude to an effort to try to land Luna 15 on the moon and then return it to earth with rock specimens ahead of the Apollo 11 astronauts.

In Washington, President Nixon announced that the astronauts would place on the moon five medals honoring the Soviet and American astronauts who have died in the conquest of space.

The medals, Mr. Nixon said, would recognize "the dedication and sacrifice of brave men of different nations" and "underscore an example we hope to set: that if we can reach the moon, men can reach agreement." He added: "The two men we hope will set foot on the moon represent all mankind."

The American medals, several inches in diameter, honored Colonel Grissom, Colonel White and Commander Chaffee, who died in the Apollo fire at Cape Kennedy two and a half years ago.

The Soviet medals, which were smaller, honored Colonel Gagarin, the first man in space, who was killed in a plane crash in 1968, and Col. Vladimir M. Komarov, who died in 1967 when the parachute of his Soyuz spacecraft fouled and he plummeted to earth. These medals, which showed the men's heads in bas-relief, were given by the cosmonauts' widows to Col. Frank Borman, commander of the Apollo 8 moon-orbital mission, when he visited Moscow early in July. The widows asked that the medals be left on the moon by Apollo 11.

Before their telecast, the Apollo 11 crewmen spent a quiet but busy day checking out the spacecraft's systems, practicing navigation by star sightings and doing the everyday housekeeping chores of space flight. "The spacecraft is in good shape," said Mr. Charlesworth, the flight director.

The day's most critical test was the 2.91-second firing of the spacecraft's main rocket, the 20,500-pound-thrust engine housed in the rear of the service module. The firing took place at 12:17 P.M., when Apollo was more than 130,000 miles from earth.

"Looks like the SPS is definitely 'go,' " Mission Control radioed afterwards, alluding to the engine, known as the service propulsion system.

"Good to hear it," replied the taciturn Mr. Armstrong.

Flight controllers said their tracking data indicated that Apollo 11's course was so nearly perfect that an additional midcourse correction might not be necessary. Four such rocket maneuvers were planned, but the one might be sufficient.

The possibility was raised of starting the moon walk of Mr. Armstrong and Colonel Aldrin earlier than the scheduled time of 2:12 A. M. Monday. Asked about it, Mr. Charlesworth conceded that there was "some flexibility" in the plans, but said he doubted that there would be any major changes in the timing of events.

At 11:25 A.M., the combined vehicles of Apollo—the command ship linked nose-to-nose with the bug-shaped lunar craft—passed the midpoint in their lunar trajectory. Apollo 11, which left low-earth orbit at 24,200 miles an hour, had slowed down to 3,689 miles an hour at this time.

The continuing tug of earth gravity was causing the deceleration. But as the spacecraft came under the lunar gravitational influence, it would pick up speed again.

Except during the telecast and the midcourse correction, the three astronauts had little to say about their activities. A few times, flight controllers had to radio requests for status reports.

This was in marked contrast to the enthusiastic, if sometimes testy, remarks of Capt. Walter M. Schirra Jr. on Apollo 7, the expressions of awe and wonder from Colonel Borman on Apollo 8, the detailed engineering reports from Col. James A. McDivitt on Apollo 9 and the earthy chatter of Col. Thomas P. Stafford on Apollo 10.

Asked about the Apollo 11 crew's reserve, Mr. Charlesworth said, "This particular crew is just not talkative. I think that's pretty clear."

When the astronauts did talk, it was to relay a terse, businesslike recital of their many testing and housekeeping activities, for there is more to flying to the moon than jarring rocket blasts, the blinking lights of computer calculations and pictures from great distances.

One of the first things Mr. Armstrong did after awakening, for example, was to perform the simple chore of replacing the filter that removes carbon dioxide and odors from the cabin. This was one of two canisters of lithium hydroxide and activated charcoal. Each had a 24-hour lifetime.

The cabin's atmosphere was pure oxygen maintained at a pressure about one-third that of normal sea-level air. Flight controllers observed that a sensor indicating oxygen-flow rates was "acting up," but they said it should not present a problem.

A flip of a switch on the control panel recharged the command ship's three storage batteries. They had to be kept up at full strength as a backup source of electricity during the flight and as the sole source during the last 15 minutes of the mission, from re-entry to splashdown.

The astronauts also reported that they "purged" the fuel cells, which are the primary generators of electricity. The units are housed in the service module, attached to the rear of the command ship. The cells generate electricity by means of a chemical reaction between liquid oxygen and liquid hydrogen. Every day or so the units had to be thoroughly flushed out, or purged, by forcing a greater amount of liquid hydrogen through the system to wash out any impurities.

Unlike some of the previous Apollo crews, the astronauts had no complaints about their food. In fact, one of the astronauts—his voice sounded like Colonel Collins'—radioed, "My compliments to the chef. That salmon salad is outstanding."

The astronauts' food is prepackaged in individual servings, some of which must be reconstituted with water. Some of the more substantial dishes on their moon menu included chicken and rice, pork and scalloped potatoes, shrimp cocktail, spaghetti and meat sauce, brownies and butterscotch pudding. It was a far cry from the applesauce, malted-milk tablets and beef cubes that John H.

Glenn had with him on his flight, the nation's first earth-orbiting space mission in 1962.

In the telecast, Colonel Collins held up a food package and said, "Would you believe you're looking at chicken stew here?"

Colonel Collins reported earlier that they were making some hot coffee. "It's not piping hot," he commented, "but it beats stone-cold coffee."

Apollo 11 had hot and cold running water. It was dispensed through two pistol-like spigots at an ounce a shot.

"We have a happy home," Colonel Collins said during the telecast. "Plenty of room for the three of us. We're all finding our favorite little corners."

At one point Colonel Collins limbered up with a floating version of jogging, and once Colonel Aldrin radioed, "I'll tell you, I've been having a ball, floating around inside here, back and forth, up one place and back to another. It's just like being outside, except more comfortable."

He was describing the sensation of weightlessness, a condition in which it is possible with the slightest movement to float from place to place in the cabin, or for an object to remain suspended in midair.

On his first and only previous spaceflight, Gemini 12, Colonel Aldrin spent nearly two hours outside the earth-orbiting vehicle testing how much work man could perform under such conditions.

When he was "taking the afternoon off," as he said, Colonel Aldrin peered through a telescope at the receding earth below. "To coin an expression," the astronaut radioed, "the view is just beautiful. It's out of this world."

FRIDAY, JULY 18

Television from space, so clear it was possible to read dials on the lunar module control panel. "I can see Neil and Mike. It'd better be them."

Houston, Tex.

THE Apollo 11 astronauts entered the moon's sphere of gravitational influence, 39,000 miles from their goal, at 11:12 P.M. on the third day of their voyage. As the American spaceship closed in on the moon, the Soviet Union assured Colonel Borman that the Soviets' unmanned lunar-orbiting spaceship would not cross Apollo's path after the Apollo spaceship fired its main rocket engine to swing into its own lunar orbit.

The American craft, still dominated and held back by earth's gravity, had been losing speed as it neared the moon. But as Americans awoke Saturday morning, the moon would have won a tug-of-war with earth. Apollo's speed would pick up as it hurtled toward the moon.

A televised inspection tour inside the lunar landing craft showed that its interior, like that of the command ship, was apparently in perfect working order. "Everything looks good down there," said Colonel Aldrin, when he crawled through the connecting tunnel into the lunar module.

Mr. Armstrong accompanied Colonel Aldrin into the lunar module, while Colonel Collins remained behind in the command ship he was to pilot when the two other men descended for their landing on Sunday.

The Soviet assurances about Luna 15's orbit were conveyed in a cable from Dr. Mstislav V. Keldysh, president of the Soviet Academy of Sciences, to Colonel Borman. In his cable, Academician Keldysh said Luna 15 would remain in its initial orbit for two days—starting at 5 A.M. Thursday.

"The orbit of Luna 15," Dr. Keldysh said, "does not intersect the trajectory of Apollo 11 spacecraft announced by you in flight program." There was still no hint as to the purpose of the Soviet flight or what the next steps might be.

"In case of further change in the orbit of the probe," the Soviet cable said, "you will receive additional information."

From data the Soviet scientist provided, Apollo flight controllers determined that Luna 15 was circling the moon on a course ranging in altitudes from a low of 34.5 miles to a high of 126.5 miles. It completed a full orbit every 2 hours 30 seconds, swinging across the lunar equator at 45-degree angles.

Apollo 11 was scheduled to go first into an orbit 69 miles by 185.5 miles and then shift to a more circular orbit of 64 miles by 76 miles. It was to follow an equatorial course, completing a full orbit about every two hours.

Christopher C. Kraft, director of flight operations, said that engineers here were "cranking" the figures into computers and that there was no indication that the two vehicles would even come close to each other. Mr. Kraft said it was unlikely that the Apollo 11 astronauts would have either the time or the opportunity to attempt to see Luna 15.

It was Mr. Kraft who, after Luna 15 went into moon orbit Thursday, asked Colonel Borman to telephone the Russians for the information on the Soviet spacecraft's orbit.

This was the first time, as far as American space officials could recall, that the Soviet Union had communicated directly with the Americans about a Soviet mission while it was in progress. Under the United Nations Outer Space Treaty of 1967—one of three major space treaties signed by the two countries—the United States and the Soviet Union are bound to furnish the type of data given by Dr. Keldysh. The 1967 treaty was designed to preclude national claims to the moon and to avoid space mishaps.

Observers of the Soviet space program said they believed the newly born period of good feeling between American and Russian spacemen had diminished the cold-war overtones of the space race. But these specialists emphasized that it was too early to tell

if informative messages and good-will visits such as that of Colonel Borman earlier in the month heralded true cooperation between the two countries.

Some pointed out that despite the improved space relations, Anatoly F. Dobrynin, the Soviet ambassador to the United States, did not accept an invitation to watch the Apollo 11 blast-off.

The Apollo 11 astronauts awoke to the third day of their outward journey at about 9:30 A.M. after eight to nine hours of sound sleep. Unlike previous crews, the Apollo 11 men had no trouble sleeping.

"Good morning, Houston," Colonel Aldrin radioed, before turning immediately to business. "How do all our systems look?"

Flight controllers, monitoring the steady stream of automatically radioed data from the spacecraft, assured the crew "they're looking great." At the time, Apollo 11 was within 73,000 miles of the moon, a quarter of a million miles from earth.

Their spacecraft was coasting at 2,400 miles an hour, rolling slowly to keep any one part from overheating by remaining too long in the intense, unfiltered sunlight of outer space.

When Colonel Aldrin looked out his window, he could see North Africa, as well as clouds casting a shadow from Afghanistan to Pakistan. "Everything's getting smaller and smaller as time goes on," the Air Force colonel said.

After the astronauts finished such housekeeping tasks as charging batteries, dumping waste water and checking fuel and oxygen reserves, Colonel Aldrin made his inspection tour of the attached lunar module.

To do this, the astronauts had to open the hatch at the apex of the cone-shaped command ship. Mr. Armstrong then squeezed through the 30-inch-wide tunnel and opened the hatch at the other end, clearing the way for Colonel Aldrin to enter the lunar module.

The astronauts were beginning this operation when they went on the air with one of the clearest color television transmissions ever sent from space.

The telecast began at 4:44 P.M. and ran an hour and 36 minutes, during which time Apollo traveled 2,300 miles closer to the moon. Millions of viewers watched as Mr. Armstrong, wearing white flight coveralls, worked his way into the tunnel and fished out the docking probe, the pointed pluglike device used in latching the command ship and the lunar module together. "Mike must have done a smooth job in that docking," Mr. Armstrong said. "There isn't a dent or a mark on the probe."

The reference was to Mike Collins. He had steered the command ship on Wednesday, when this craft was maneuvered around and mated with the lunar module for the long journey toward the moon.

The transmission was so clear that it was possible to read dials on the lunar module control panels and instruction labels at the point where the ships were joined.

The lunar module—an ungainly 16½-ton contraption with an overall height of 22 feet, 11 inches, and a width of 14 feet, not counting the extended landing gear—is usually called the LM.

It serves as a moon ferry and has two stages. The lower is the descent stage, which contains the fuel and throttleable engine needed to rocket down to a soft landing on the moon. The upper is the cabined ascent stage, containing the fuel and rocket engine needed to lift men off the moon and enable them to redock with a mother ship cruising in orbit overhead. Hanging soft and crinkled over the LM's surface are layers of insulating foil that give it the properties of a Thermos bottle and protect it against extremes of heat and cold.

On the descent to the moon, Mr. Armstrong and Colonel Aldrin were to stand side by side at the controls of the cabin in the upper stage. In blasting off from the moon, they would leave the four-legged lower stage behind them, using that stage as a launching pad.

The Apollo 11 mission marked the third manned flight of the LM. The first manned test came in March on Apollo 9, an earth-orbiting mission; the second came in May, when the Apollo 10 crew flew the ferry down to within nine miles of the moon in a successful test of its rockets and guidance system.

Now Mr. Armstrong and Colonel Aldrin were inspecting the LM for the third and crucial manned test. Once they were satisfied it was in good shape, they crawled back into the command ship, latching the two hatches behind them. At one point during the telecast, Colonel Aldrin focused the camera down the tunnel from the lunar module to catch Mr. Armstrong and Colonel Collins at the other end.

"I can see Neil and Mike," he said. "It'd better be them."

SATURDAY, JULY 19

Apollo 11 found a perfect orbit, after only one slight correction in the 240,000-mile trip. "It looks very much like the pictures."

Houston, Tex.

APOLLO 11 swept into an orbit of the moon and was eagerly awaiting the mission's most critical and dramatic moment — the landing of two men on a desolate lunar plain.

Flight controllers said all systems on the moonship continued to function normally and that no technical problems stood in the way of the landing.

Meanwhile, the Soviet Union announced that the orbit of Luna 15 had changed. No reason was given for instituting the new, higher orbit. Tass, the Soviet news agency, said the craft was orbiting at a minimum distance of 59 miles from the surface and a maximum distance of 136 miles. There was still no reason to believe Luna 15 would get in the way of the men of Apollo 11.

After Apollo 11 entered its own moon orbit, Mr. Armstrong radioed across the quarter-million miles of space, "It was like perfect."

The commander reported that the spacecraft's main rocket, a 20,500-pound-thrust engine, had fired for the planned 6 minutes 2 seconds. This slowed the vehicle down so that it could be captured by lunar gravity.

The firing came at 1:22 P.M., after Apollo 11 had swung around the leading edge of the moon and disappeared behind it, out of radio contact with tracking stations on earth. For 33 minutes there was no signal from Apollo 11.

Flight controllers and visiting NASA officials waited anxiously at the Mission Control Center. If the rocket had failed to fire, Apollo 11 would have looped the moon and headed back to earth. If it had fired too long, the vehicle could have crashed into the lunar surface.

But the rocket performed almost flawlessly—just as it had on Apollos 8 and 10, the only two previous flights in which men had circled the moon.

Apollo 11's initial orbit of the moon ranged from a low altitude of 70 miles to a high of 195 miles.

After the astronauts circled the moon twice, the rocket was refired for 17 seconds to bring the spacecraft into the more nearly circular orbit required for the landing maneuver. The new orbit had a low point of 62 miles and a high point of 75 miles.

As the astronauts passed over the crater Messier for the first time, Mr. Armstrong looked out of his window and said he could see, 140 miles below, "good-sized blocks at the bottom of the crater."

The lunar panorama seemed to spark a flicker of emotion in the usually laconic Mr. Armstrong. He radioed to Mission Control, "The pictures and maps brought back by Apollo 8 and 10 have given us a very good preview of what to look at here. It looks very much like the pictures. But like the difference between watching a real football game and one on TV, there's no substitute for actually being there."

At 3:58 P.M., after Apollo 11 emerged from behind the moon on its second orbit, the astronauts began a 35-minute color telecast, showing the brownish-gray lunar surface and the landmarks they would pass over during their descent to the landing.

The pictures showed clearly the Smyth Sea, the Sea of Fertility, the Sea of Tranquility and the broad crater Langrenus with its prominent central peak.

After the telecast and the second rocket firing, Colonel Aldrin again crawled through the connecting tunnel to the lunar module for a two-hour inspection of the landing craft's systems.

The astronauts first sighted the moon shortly after they awoke at about 7 A.M. They were 15,700 miles away, traveling 2,755 miles an hour. "The view of the moon that we've been having recently is really spectacular," Mr. Armstrong radioed. "It fills about three-quarters of the hatch window and, of course, we can see the entire circumference, even though part of it is in complete shadow and part of it's in earthshine. It's a view worth the price of the trip."

By this time the sun had disappeared behind the moon. "It's a real change for us," Colonel Collins said. "Now we are able to see stars again and recognize constellations for the first time on the trip. The sky is full of stars, just like the stars out on earth."

The astronauts received a summary of the day's news, including the fact that a newspaper in the Soviet Union was calling Mr. Armstrong, the commander of Apollo 11, "the czar of the ship." In later radio conversation, Colonel Aldrin joked about his "czar."

The astronauts were also assured that a Houston astrologer had said that "all the signs are right for your trip to the moon." The flight dynamics officer seemed to agree. For he informed the crewmen that their aim on the moon was true enough to make another corrective maneuver unnecessary. Only one minor correction, made by firing the service module's rocket, was required during the 240,000-mile journey.

Once in lunar orbit, the three astronauts again checked out all systems of both the command ship and the landing craft. Flight controllers carefully monitored all the radioed data streaming into the control center.

They could find only one problem. During the rocket firing, they noticed data indicating a leak of the gaseous nitrogen used to open up valves controlling the mixing of the propellants. "This doesn't present any problem to us that we know of right now," said Mr. Charlesworth, the flight director.

He explained that nearly all systems in the engine, situated in the rear equipment unit, had backups built in. For subsequent firings of the engine, which would have to get the astronauts out of lunar orbit, it would be possible, if necessary, to use such a backup system.

The astronauts planned to circle the moon 13 times before they began their maneuvers for the landing. Each full orbit of the moon would take two hours. Mr. Armstrong and Colonel Aldrin would, therefore, make their historic touchdown the next day, when it would be Sunday afternoon in the United States.

The chosen landing spot was in the southwestern part of the Sea of Tranquility, a broad, dry plain that appears from earth as a dark spot on the right side of the moon—one of the facial features of the legendary man in the moon.

The landing site was selected because it is one of the smoothest areas along the moon's equator. The time of landing was set because the sun would be low on the horizon behind the astronauts. Thus it would not interfere with their vision and, moreover, it would cast shadows making it easier to see boulders and other surface irregularities.

During the astronauts' first telecast from lunar orbit, it was possible to see the craters and other landmarks on the approach path to the landing site. The sun had not yet risen over the landing site itself.

On the moon, because of its slow rotation, daylight lasts 14

earth days. And because of the lack of atmosphere to filter the sun's rays, the temperature gets up to 280 degrees above zero Fahrenheit at noontime.

SUNDAY, JULY 20

A tense hop over a boulder field. Then they were down. Six hours later, Neil Armstrong stepped on the moon. Exact time: 10:56:20 P.M.

Houston, Tex.

"HOUSTON, Tranquility Base here. The Eagle has landed." With those words, Mr. Armstrong announced the establishment of man's first beachhead on the moon. It took place at 4:17:40 P.M., Eastern daylight time. Mr. Armstrong and Colonel Aldrin steered the fragile, four-legged lunar module safely and smoothly to rest on a level, rock-strewn plain near the southwestern shore of the arid Sea of Tranquility.

About six and a half hours later, Mr. Armstrong opened the landing craft's hatch and stepped cautiously down the ladder. As he planted the first human footprint on the lunar crust, the Apollo 11 commander declared, "That's one small step for a man, one giant leap for mankind."

His first step on the moon came at 10:56:20 P.M., as a television camera outside the craft transmitted every move to an awed and excited audience of hundreds of millions on earth.

Mr. Armstrong's initial steps were tentative tests of the lunar soil's firmness and of his ability to move about easily in his bulky white spacesuit and backpack and under the influence of lunar gravity, which is one-sixth that of the earth.

"The surface is fine and powdery," the astronaut reported. "I can pick it up loosely with my toe. It does adhere in fine layers like powdered charcoal to the sole and sides of my boots. I only go in a small fraction of an inch, maybe an eighth of an inch, but I can see the footprints of my boots."

After a few minutes, Mr. Armstrong stood still and said of the scene before him, "It has a stark beauty all its own. It's like much of the high desert of the United States. It's different, but it's very pretty out here." After 19 minutes of Mr. Armstrong's testing, Colonel Aldrin joined him outside the craft. The two men busied themselves removing the television camera from the lunar module and setting it up some distance away, planting an American flag in the ground, scooping up soil and rock samples, deploying scientific experiments and hopping and loping about in a demonstration of their lunar agility.

They found working on the moon less taxing than had been forecast. Mr. Armstrong said he was "very comfortable."

People back on the earth found the black-and-white television pictures of the lunar module and the men tramping about it strangely unreal. The astronauts seemed more like toys than human beings.

During a break in the astronauts' work, President Nixon congratulated them from his oval office at the White House in what, he said, "certainly has to be the most historic telephone call ever made."

"Because of what you have done," the President told the astronauts, "the heavens have become a part of man's world. And as you talk to us from the Sea of Tranquility it requires us to redouble our efforts to bring peace and tranquility to earth. For one priceless moment in the whole history of man all the people on this earth are truly one—one in their pride in what you have done and one in our prayers that you will return safely to earth."

The President, who had spent much of the afternoon "glued to his TV set," seemed deeply moved as he said, "I just can't tell you how proud we all are of what you've done. For every American this has to be the proudest day of our lives. And for people all over the world I am sure they, too, join with Americans in recognizing what an immense feat this is."

Mr. Armstrong replied, "Thank you, Mr. President. It's a great honor and privilege for us to be here representing not only the United States but men of peace of all nations, men with interests and a curiosity and men with a vision for the future." Then both astronauts, looking like bashful boys padded up for a romp in the snow, clumsily saluted their Commander-in-Chief.

Mr. Armstrong and Colonel Aldrin returned to their landing craft and closed the hatch at 1:12 A.M., 2 hours and 21 minutes after the hatch was opened. While Colonel Collins kept his orbital vigil overhead in the command ship, the two moon explorers settled down to sleep.

At the beginning of their big day, all three astronauts were awake at 7 A.M. Their spacecraft emerged from behind the moon on its 10th revolution, moving from east to west across the face of the moon along its equator.

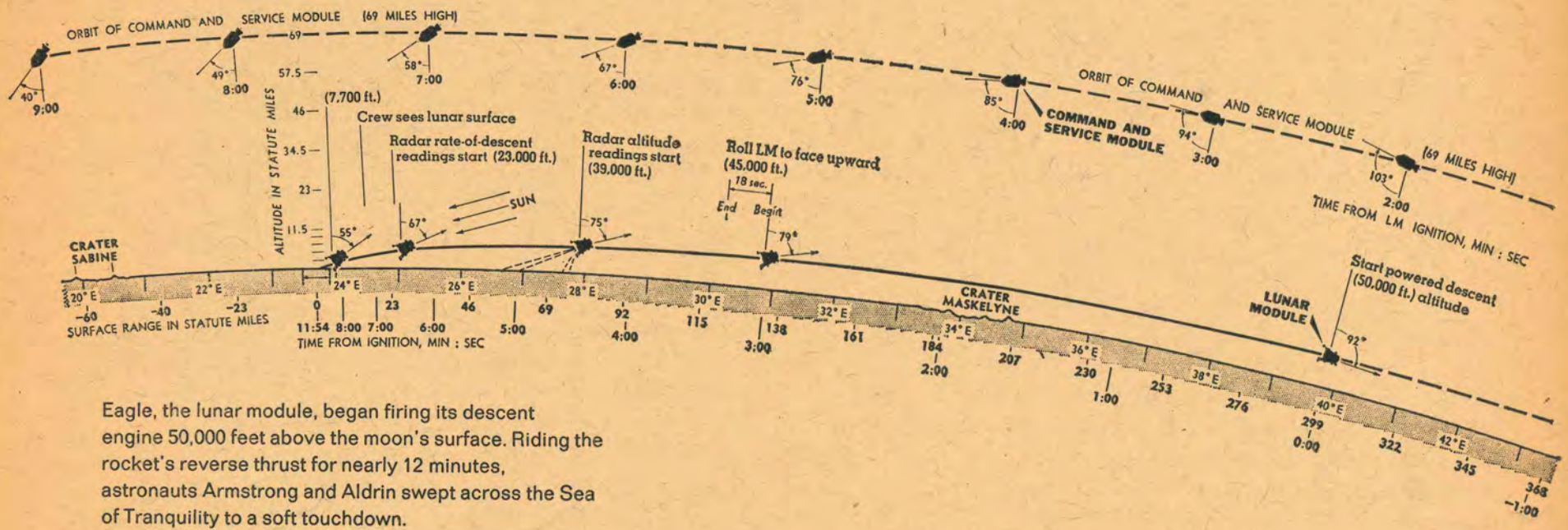
Their orbit was 73.6 miles by 64 miles in altitude, their speed 3,600 miles an hour. At that altitude and speed, it took about two hours to complete a full orbit of the moon.

The sun was rising over their landing site on the Sea of Tranquility. "We can pick out almost all of the features we've identified previously," Mr. Armstrong reported.

After breakfast, on their 11th revolution, Colonel Aldrin and then Mr. Armstrong, both dressed in their white pressurized suits, crawled through the connecting tunnel into the lunar module.

They turned on the electric power, checked all the switch settings on the cockpit panel and verified communications with the command ship and the ground controllers. Everything was "nominal," as the spacemen say.

While the astronauts were preparing themselves for their descent to the moon, an announcement came from Moscow that the



Eagle, the lunar module, began firing its descent engine 50,000 feet above the moon's surface. Riding the rocket's reverse thrust for nearly 12 minutes, astronauts Armstrong and Aldrin swept across the Sea of Tranquility to a soft touchdown.

orbit of Luna 15 had again been altered, bringing it to within 10 miles of the moon's surface.

The Soviet Union once again assured American space officials that Luna 15 would not interfere with the Apollo mission. But Tass, the Soviet press agency, would still say no more than, "the automatic station Luna 15 continues scientific exploration in the near-moon outer space." Americans continued to fix their attention on their own lunar mission.

The lunar module was ready. Its four legs with yard-wide footpads were extended so that the height of the 16½-ton vehicle now measured 22 feet and 11 inches and its width 31 feet.

Mr. Armstrong stood at the left side of the cockpit, and Colonel Aldrin at the right. Both were loosely restrained by harnesses. They had closed the hatch to the connecting tunnel.

The walls of their craft were made of finely milled aluminum foil. If anything happened so that it could not return to the command ship, the lunar module would be too delicate to withstand a plunge through the earth's atmosphere, even if it had the rocket power to make the plunge.

Nearly three-fourths of the vehicle's weight was in propellants for the descent and ascent rocket engines—Aerozine 50 fuel and nitrogen oxide, which substitutes for oxygen to make combustion possible.

It was an ungainly craft that creaked and groaned in flight. But years of development and testing had determined that it was the lightest and most practical vehicle for ferrying two men to and from the moon's surface.

Before Apollo 11 disappeared behind the moon near the end of its 12th orbit, Mission Control gave the astronauts their "go" for undocking—the separation of Eagle, the lunar module, from Columbia, the command ship.

Colonel Collins had already released 12 of the latches holding the two ships together at the connecting tunnel. He did this when he closed the hatch at the command module's nose. While behind the moon, he was to flip a switch on the control panel to release the three remaining latches by a spring action.

At 1:50 P.M., when communications signals were reacquired, Mission Control asked, "How does it look?"

"Eagle has wings," Mr. Armstrong replied.

The two ships were then only a few feet apart. But at 2:12 P.M., Colonel Collins fired the command ship's maneuvering rockets to move about two miles away and into a slightly different orbit from the lunar module.

"It looks like you've got a fine-looking flying machine there, Eagle, despite the fact you're upside down," Colonel Collins commented, watching the spidery lunar module receding in the distance. "*Somebody's* upside down," Mr. Armstrong replied. What is "up" and what is "down" is never quite clear in the absence of landmarks and the sensation of gravity's pull.

As Mr. Armstrong and Colonel Aldrin rode the lunar module back around to the moon's far side, the rocket engine in the vehicle's lower stage was pointed in the direction of flight. The two pilots were leaning toward the cockpit controls, riding backward and facing downward.

"Everything is 'go'," they were assured by Mission Control.

Their on-board guidance and navigation computer was instructed to trigger a 29.8-second firing of the descent rocket, the 9,870-pound-thrust throttleable engine that would slow down the lunar module and send it toward the moon on a long, curving trajectory. The firing was set to take place at 3:08 P.M., when the

craft would be behind the moon and once again out of touch with the ground.

Suspense built in the mission control room. Flight controllers stood silently at their consoles. Among those waiting for word of the rocket firing were Dr. Thomas O. Paine, the NASA administrator, most of the Apollo project officials, and several astronauts. At 3:46 P.M., contact was established with the command ship. Colonel Collins reported, "Listen, baby, things are going just swimmingly, just beautiful."

There was no word from the lunar module for two minutes more. Then came a weak signal, some static and whistling, and finally the calm voice of Mr. Armstrong. "The burn was on time," the Apollo 11 commander declared.

When he read out data concerning the start of the descent, Mission Control concluded that it "looked great." The lunar module had already descended from an altitude of 65.5 miles to 21 miles and was coasting steadily downward. Eugene F. Kranz, the flight director, turned to his associates and said, "We're off to a good start. Play it cool."

Colonel Aldrin reported some oscillations in the vehicle's main radio antenna, but nothing serious. Several times the astronauts were told to turn the vehicle slightly to move the antenna into a better position for communications over the 230,000 miles.

"You're 'go' for PDI," radioed Mission Control, referring to the powered descent initiation—the beginning of the nearly 12-minute final blast of the rocket that would lower Eagle to the lunar surface.

When the two men reached an altitude of 50,000 feet, which was approximately the lowest point reached by Apollo 10 last May, and about as high as military jets routinely fly above the earth, green lights on the computer display-keyboard in the cockpit blinked the number 99.

This signaled Mr. Armstrong that he had five seconds to decide whether to go ahead for the landing or continue on an orbital path back to the command ship. He pressed the "proceed" button.

The throttleable engine started with a gentle, one-tenth-power burst of fire from the lunar module's descent rocket, and then built up to the engine's full 9,850 pounds of thrust.

Eagle was still flying tail—or rocket nozzle—first. This way, the ignition of the engine had the effect of slowing the craft, causing it to "fall" out of lunar orbit and slant down toward its target in the Sea of Tranquility.

The time of ignition was 4:05 P.M., Eastern daylight time. The Eagle's landing site was 299 miles away. "Looking good," Mission Control radioed the men.

It was the computer, actually, that fired the engine for the astronauts. In fact, the computer, following further instructions fed through its keyboard, was to do all the throttling and all the squirting of the small attitude-control rockets until Mr. Armstrong partially took over the flying near the rugged lunar surface.

Since Eagle was moving tailfirst, the two astronauts were "standing" before their instrument panels and individual triangular windows, and were moving feet first when the final descent began.

"Standing" is perhaps inexact, since they were still weightless, without a meaningful "up" or "down." They had to be held in place by harnesses, shoe grippers and whatever support they might occasionally gain by grabbing handholds.

During the early moments of the final descent, the windows were turned downward so the astronauts could compare what was passing below with what their maps and other data had led them to expect. Pilots generally like to have the ground in view as long as possible.

During the Eagle's descent, it was not possible for long. As the craft descended to the 43,300-foot level, the computer rolled it over like a hot dog on a griddle, leaving the astronauts looking upward at the stars. This was necessary so that the four beams of the landing radar could point toward the lunar ground below. One beam was to tell the astronauts their altitude. The other three were to report their rate of descent.

Four minutes after the engine firing, the lunar module was down to 40,000 feet. After five and a half minutes, it was at 33,500 feet. At six minutes, 27,000 feet. "Better than the simulator," said Colonel Aldrin, referring to the astronauts' practice landings at the spacecraft center. Seven minutes after the firing, the men were 21,000 feet above the surface and still moving toward the landing site. The lunar module was slowing down. The entire powered descent to this point was part of what was known as the braking phase. Its main purpose was to kill off the bulk of the Eagle's speed. This phase ended at a point in space about 7,700 feet above the moon's surface and about five miles from touchdown. This point, known as "high gate," marked the beginning of the approach phase.

At about 18,000 feet, the craft had pitched up far enough for the moon's horizon to creep into the bottom of the window. Mr. Armstrong and Colonel Aldrin then had their first closeup view of the plain they were aiming for. It was about three and a half minutes to touchdown.

The brownish-gray panorama rushed below them—the myriad craters, hills and ridges, deep cracks and ancient rubble on the moon, which Dr. Robert Jastrow, the space agency scientist, called the "Rosetta Stone of the Universe."

"You're 'go' for landing," Mission Control informed the two men. The Eagle closed in, dropping about 20 feet a second, until it was hovering almost directly over the landing area at an altitude of 500 feet. The land beneath was littered with boulders. At this point, known as "low gate," the landing phase began.

With the landing site now in view, a prime aim of the two astronauts was to determine whether the actual touchdown point was free enough of craters and rocks for the landing to succeed.

The astronauts could pinpoint the landing site by reference to graduated vertical and horizontal lines on their windows. Called the "landing point designator," this combination of lines resembled the device used on fighter planes for aiming guns.

If the ground looked too forbidding, as it eventually did look to Mr. Armstrong, he could instruct the computer to shift the descent path to another location. He could do this simply by flicking a switch on his attitude controller.

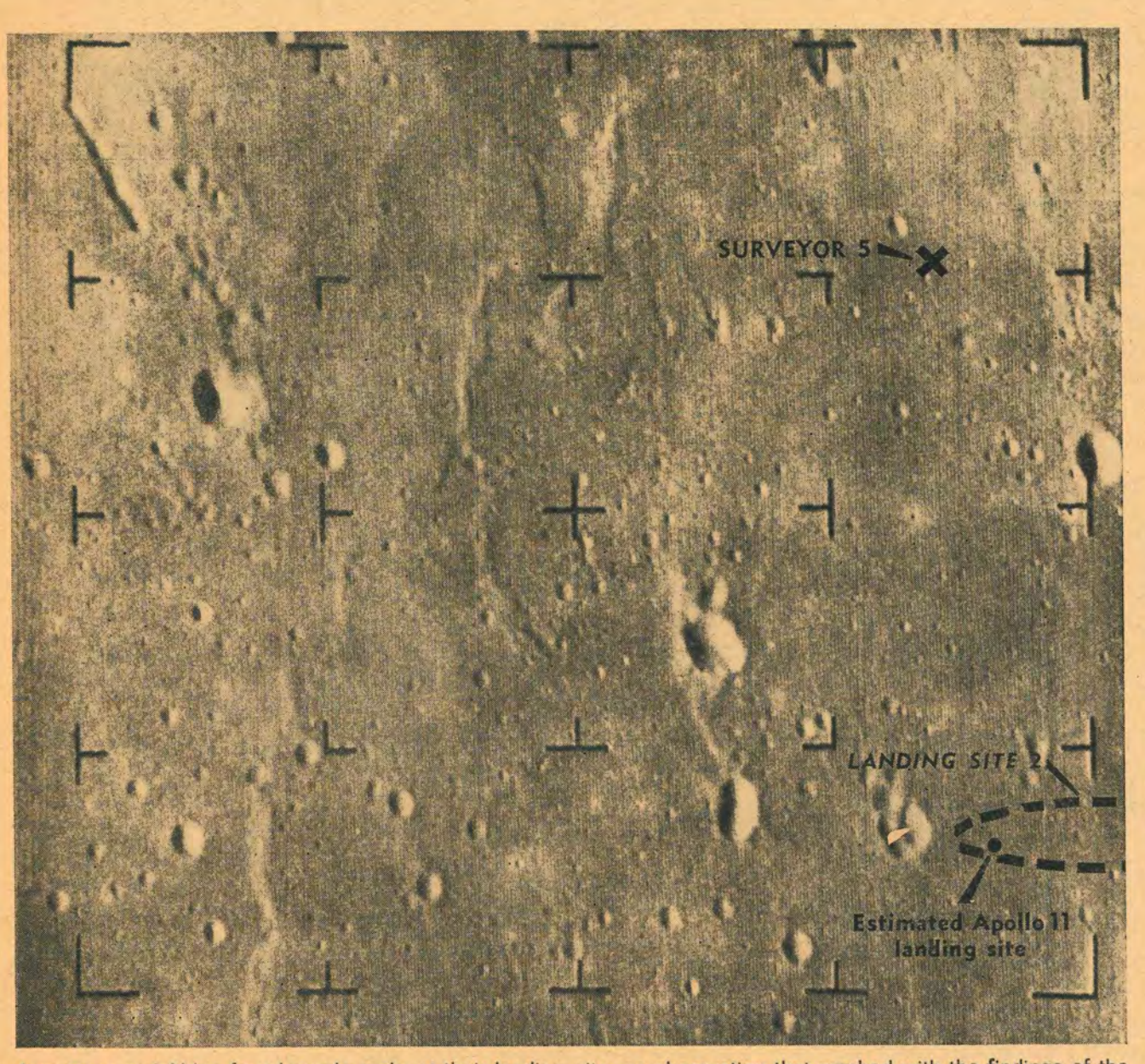
The big fear had always been that, in landing, one or more of the craft's four footpads might strike a sizable boulder or sink into an unseen crater. In either case, this could topple the craft onto its side or tip it so precipitously that the ascent engine would not be able to rocket it safely off the moon.

Just before "low gate" came another major decision point: a determination of whether the landing craft had at least six hours of "consumables" aboard. Flight controllers must be sure that leaks of oxygen or fuel had not developed and depleted these supplies. No problem.

At "low gate," Mr. Armstrong shifted from fully automatic to semi-automatic flight. That is, he stopped relying completely on the computer's translating programmed instructions into movements of the main throttle and into squirts through the attitude-control rockets.

He was able to change the rate of descent by increments of one foot a second by clicking a switch at his left hand up and down, and could control the attitude jets himself.

When the craft reached an altitude of 300 feet, Mr. Armstrong took over such semi-manual control for the rest of the way. He was expected to do this anyway, but the sight of possible disaster looming ahead at the touchdown point made it imperative. As Mr. Armstrong said later, "The auto-targeting was taking us right into a football-field-sized crater, with a large number of big



Armstrong and Aldrin found purple rocks at their landing site, an observation that meshed with the findings of the unmanned Surveyor 5 spacecraft, which landed 20 miles north and found evidence of purplish titanium.

boulders and rocks." For about 90 seconds, he peered through the window in search of a clear touchdown point. Using the lever at his right hand, he tilted the vehicle forward. This enabled the descent engine to deliver a slight forward thrust, thereby carrying Eagle past the danger spot to a smoother landing point.

"Down two and a half," came the radio report, probably from Colonel Aldrin. "Forward, forward, 40 feet, down two and a half, picking up some dust; thirty feet, two and a half down. Shadow. Four forward, four forward, drifting to the right a little." The fuel in the descent engine was now running low.

Finally, Mr. Armstrong found the spot he liked, and a blue light on the cockpit flashed to indicate that five-foot-long probes, like curb feelers, on three of the four legs had touched the surface.

"Contact light," Mr. Armstrong radioed.

He pressed a button marked "Stop" and reported, "Okay, engine stop."

There were a few more cryptic messages of functions performed.

Then Maj. Charles M. Duke, the capsule communicator in the control room, radioed to the two astronauts, "We copy. You're down, Eagle."

Then, the historic words: "Houston, Tranquility Base here. The Eagle has landed."

Whoops and shouts of happiness rocked the homes of the astronauts as these words reached the men's wives.

"Good, good, good," shouted Mrs. Armstrong, as she leaped from a bed covered with maps and charts on which she had followed the final minutes of the descent.

"I just can't believe it," said Mrs. Aldrin as she hugged her father.

"I thought it was fantastically marvelous," exclaimed Mrs. Collins.

Mission Control informed Colonel Collins, 70 miles above his crewmates, "Eagle is at Tranquility."

"Yes, I heard the whole thing," Colonel Collins replied. "Fantastic."

"I'll second that," came a voice from Tranquility Base.

The men at Houston were elated. "Be advised there are lots of smiling faces in this room and all over the world," they radioed to the men on the moon.

"There are two of them up here," Tranquility Base replied.

"And don't forget one in the command module," Colonel Collins piped up. Throughout the time his fellow astronauts were on the moon, Colonel Collins repeatedly tried to sight the shiny Eagle from his orbital viewpoint. But he never saw it.

Colonel Aldrin assured Mission Control it was a "very smooth touchdown." The Eagle came to rest at an angle of only about four and a half degrees. The angle could have been more than 30 degrees without threatening to tip the vehicle over.

The craft touched down four miles west of the aiming point of Latitude 0.799 degrees North, Longitude 23.46 degrees East,

continued

Voice Communication: Lunar Landing

HOUSTON: *You are go for landing. Over.*

EAGLE: Roger, go for landing. 3,000 feet. We're go. We're go. 2,000 feet.

HOUSTON: *Eagle, looking great. You're go.*

APOLLO CONTROL: *Altitude 1,600 . . . 1,400 feet, still looking very good.*

EAGLE: 35 degrees, 750, coming down to 23; 700 feet, 21 down, 33 degrees; 600 feet, down to 19; 540 feet, down to 15; 400 feet, down at 9, 3 forward; 350 feet, down at 4; 300 feet, down 3½, 47 forward; . . . 270 . . . 50, down at 2½, 19 forward. Altitude velocity lights; 15 forward, 11 forward; 200 feet, 4½ down, 5½ down, 6½ down, 5½ down, 9 forward; 120 feet, 100 feet, 3½ down, 9 forward, 5 per cent; 75 feet, looking good, down 2½, 6 forward.

HOUSTON: *Sixty seconds.*

EAGLE: Lights on; down 2½; forward, forward, 40 feet, down 2½, picking up some dust; 30 feet, 2½ down. Shadow. 4 forward, 4 forward, drifting to the right a little.

HOUSTON: *Thirty seconds.*

EAGLE: Contact light. Okay, engine stop. Engine arm off.

HOUSTON: *We copy. You're down, Eagle.*

EAGLE: Houston, Tranquility Base here. The Eagle has landed.

HOUSTON: *Roger, Tranquility, we copy you on the ground. You've got a bunch of guys about to turn blue. We're breathing again. Thanks a lot.*

TRANQUILITY: Thank you.

HOUSTON: *You're looking good here.*

TRANQUILITY: A very smooth touchdown.

COLUMBIA: How do you read me?

HOUSTON: *Columbia, he has landed Tranquility Base. Eagle is at Tranquility. I read you five by. Over.*

COLUMBIA: Yes, I heard the whole thing.

HOUSTON: *Well, it's a good show.*

COLUMBIA: Fantastic.

TRANQUILITY: Houston, that may have seemed like a very long final phase, but the auto-targeting was taking us right into a football-field-sized crater, with a large number of big boulders and rocks for about one or two crater diameters around it. And it required us to fly manually over the rock field to find a reasonably good area.

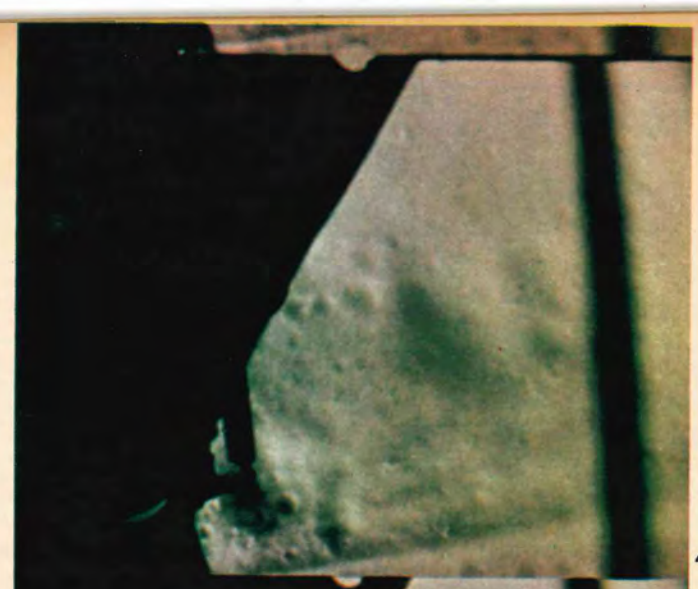
HOUSTON: *Roger, we copy. It was beautiful from here, Tranquility. Over.*


1

2

3

A 16-mm movie camera, mounted inside the Eagle's cabin, caught the landing sequence. In the strip above, frame 1 came early in the final descent; frames 2 and 3 contain the "football-field-sized crater" that Neil Armstrong was forced to avoid. Frames 4 through 8 (right) record the last few seconds before touchdown: beginning in frame 5, the vehicle's shadow slides across the ground below—first the probe beneath one of the footpads, then all the landing gear and, lastly, the bulk of the lunar module itself.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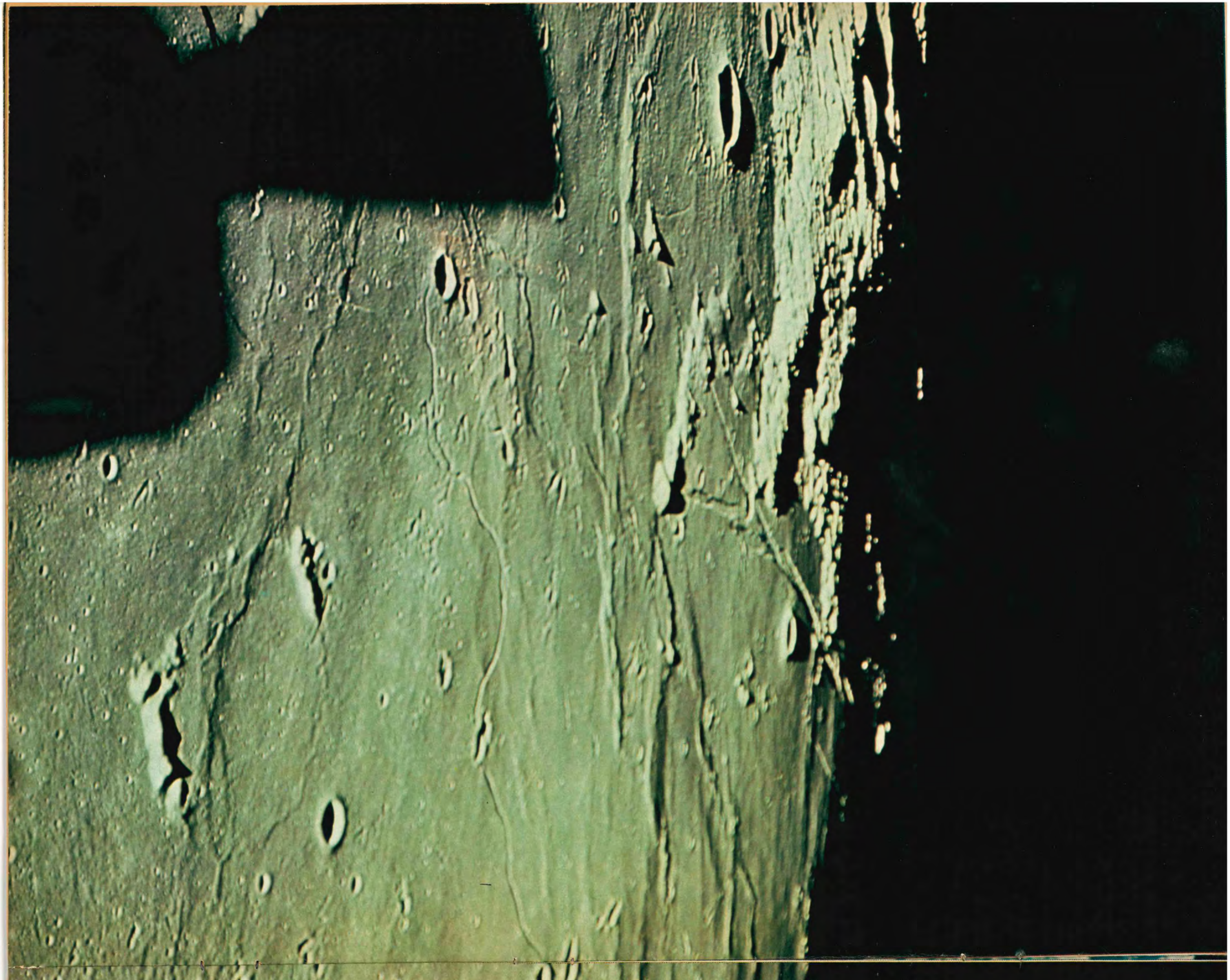
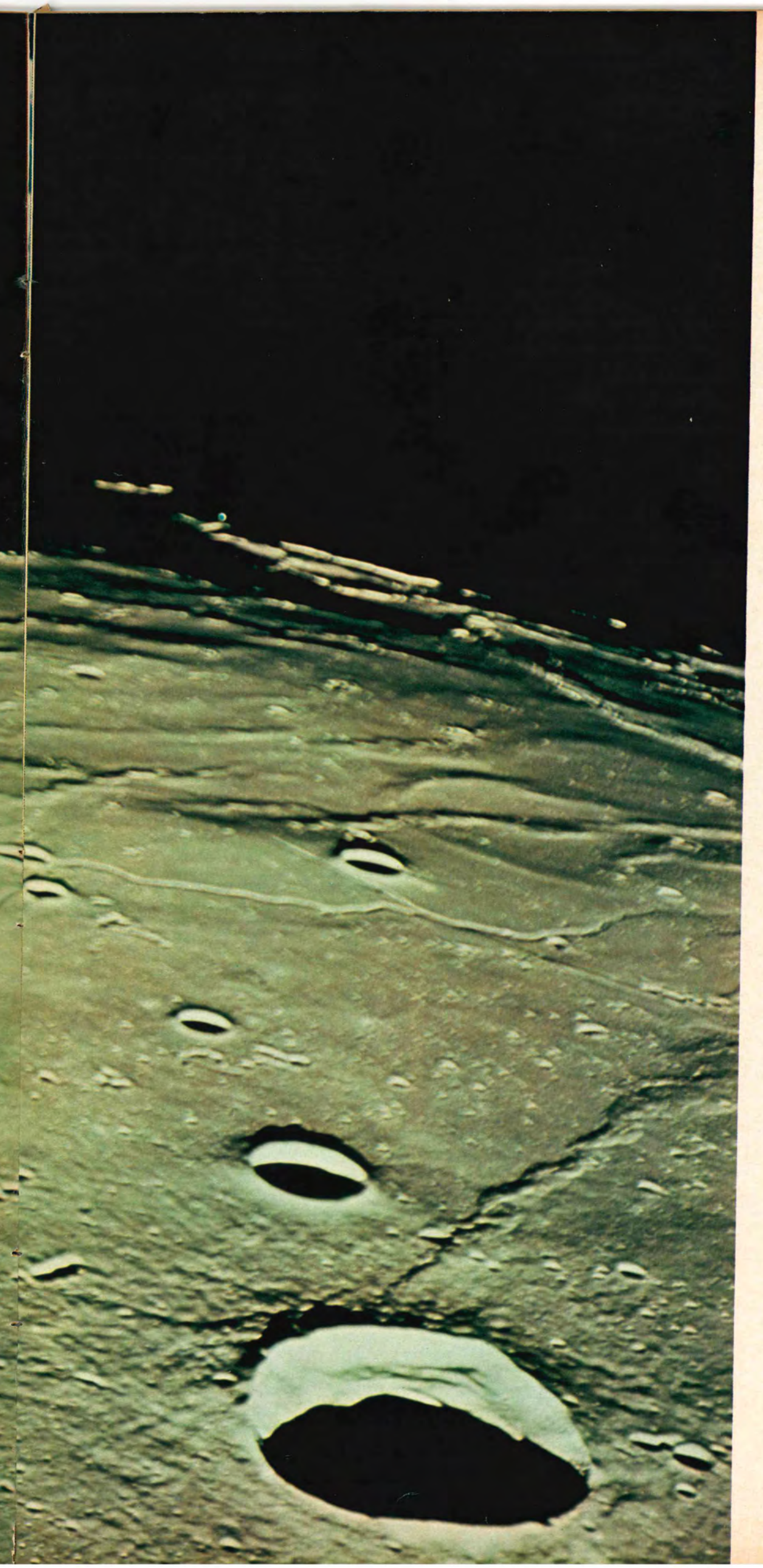
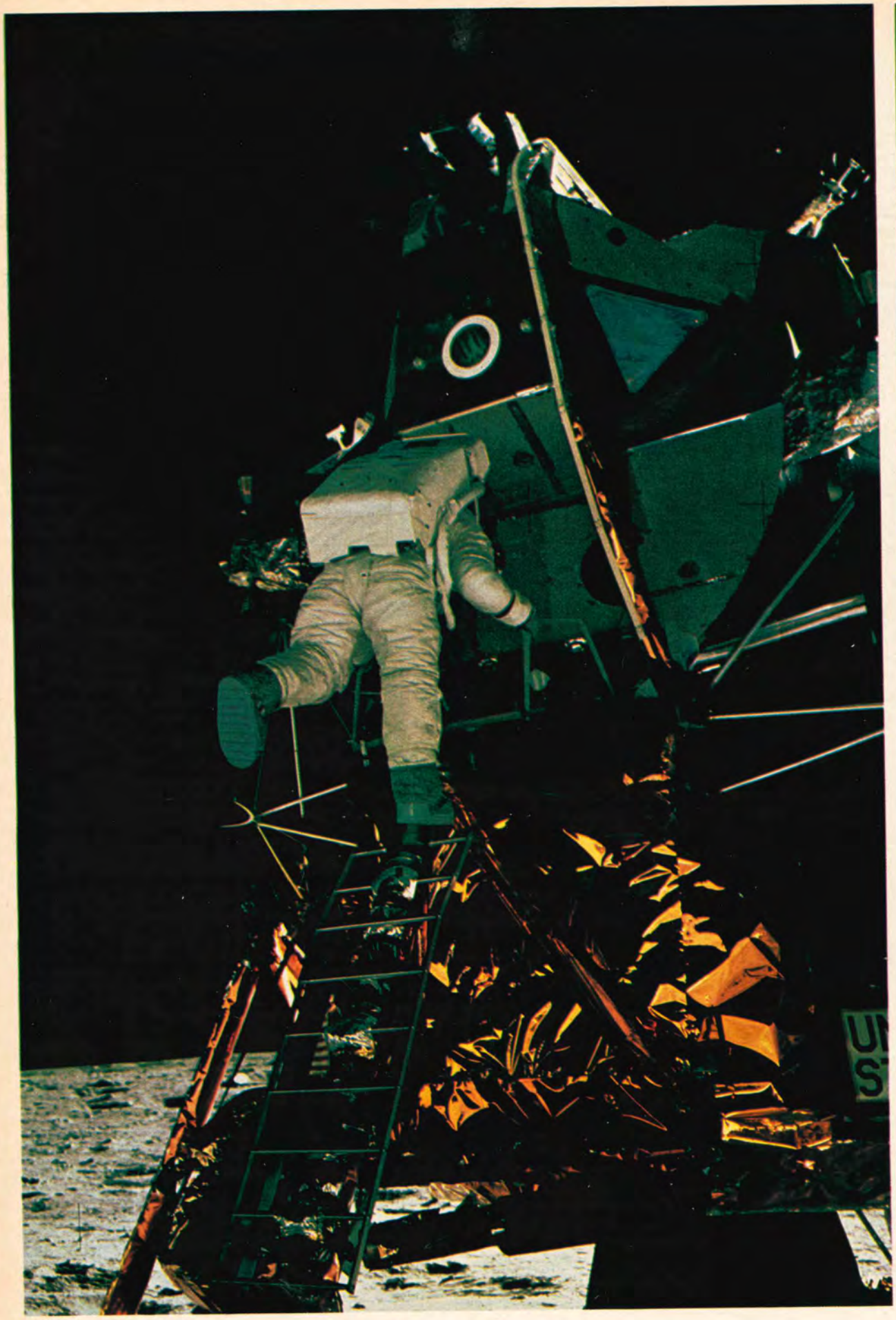
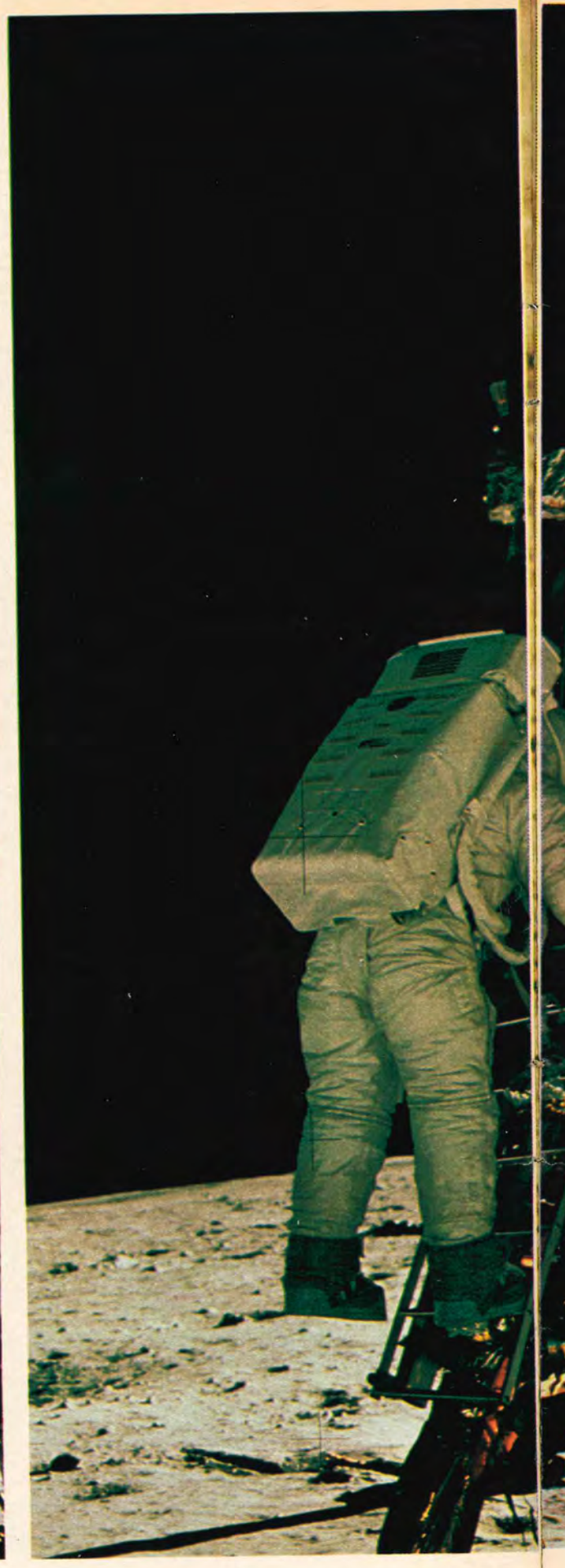


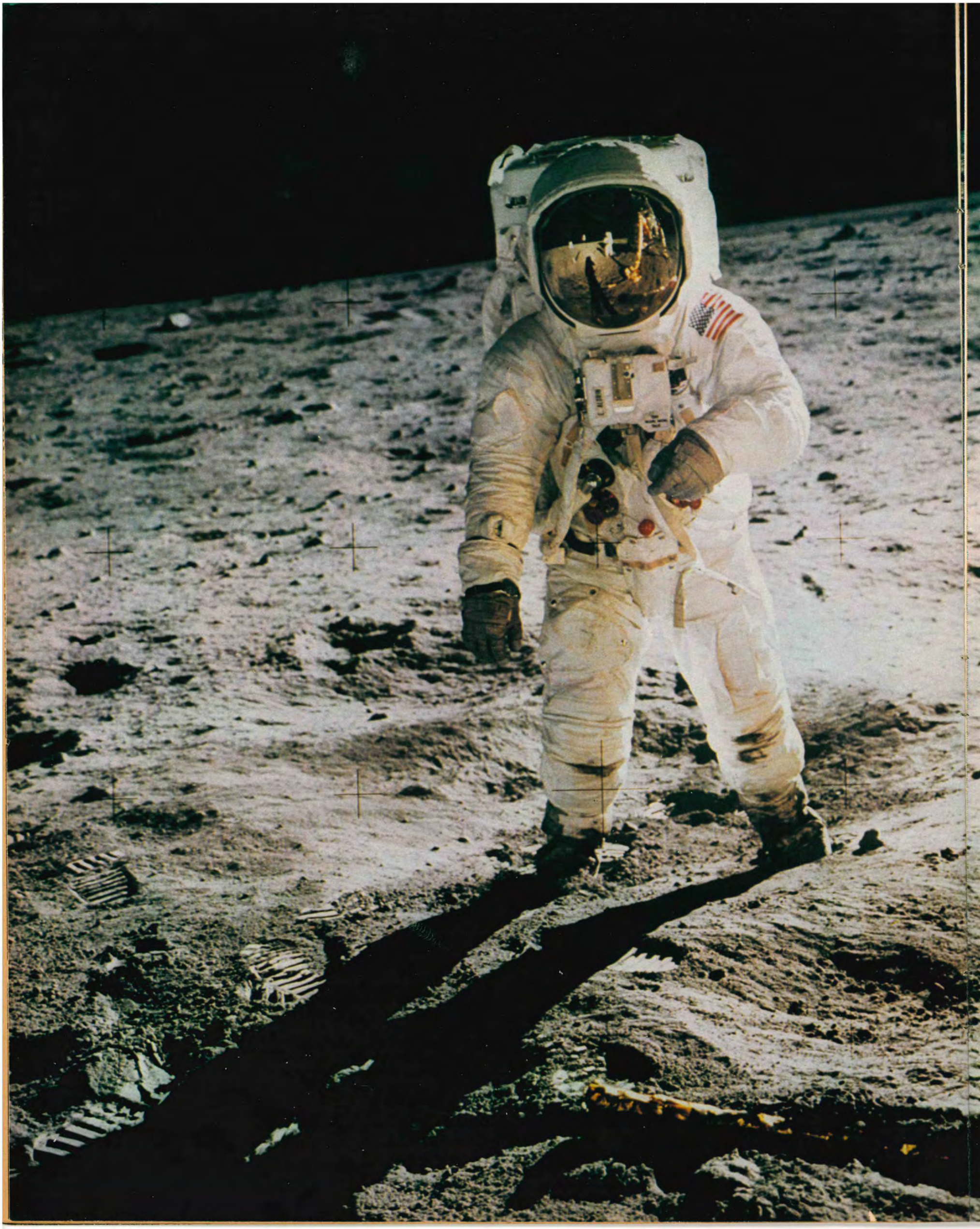


From lunar orbit, astronauts Armstrong and Aldrin looked west, past the silhouette of a maneuvering rocket. The open space near the center of the picture at the edge of darkness is Landing Site 2, where the men later set down. Hypatia Rille, now known to millions as U.S. 1, runs into the blackness at the upper left center. Just to the right (north) of it is the crater Moltke. This view is from an altitude of about 70 miles. The large crater at lower right is Maskelyne.





ALDRIN: I'm on the top step. It's a very simple matter to hop down from one step to the next.
ARMSTRONG: You've got three more steps and then a long one. . . . There you got it. That's a good step.
ALDRIN: About a three footer. Beautiful view.
ARMSTRONG: Ain't that somethin'?



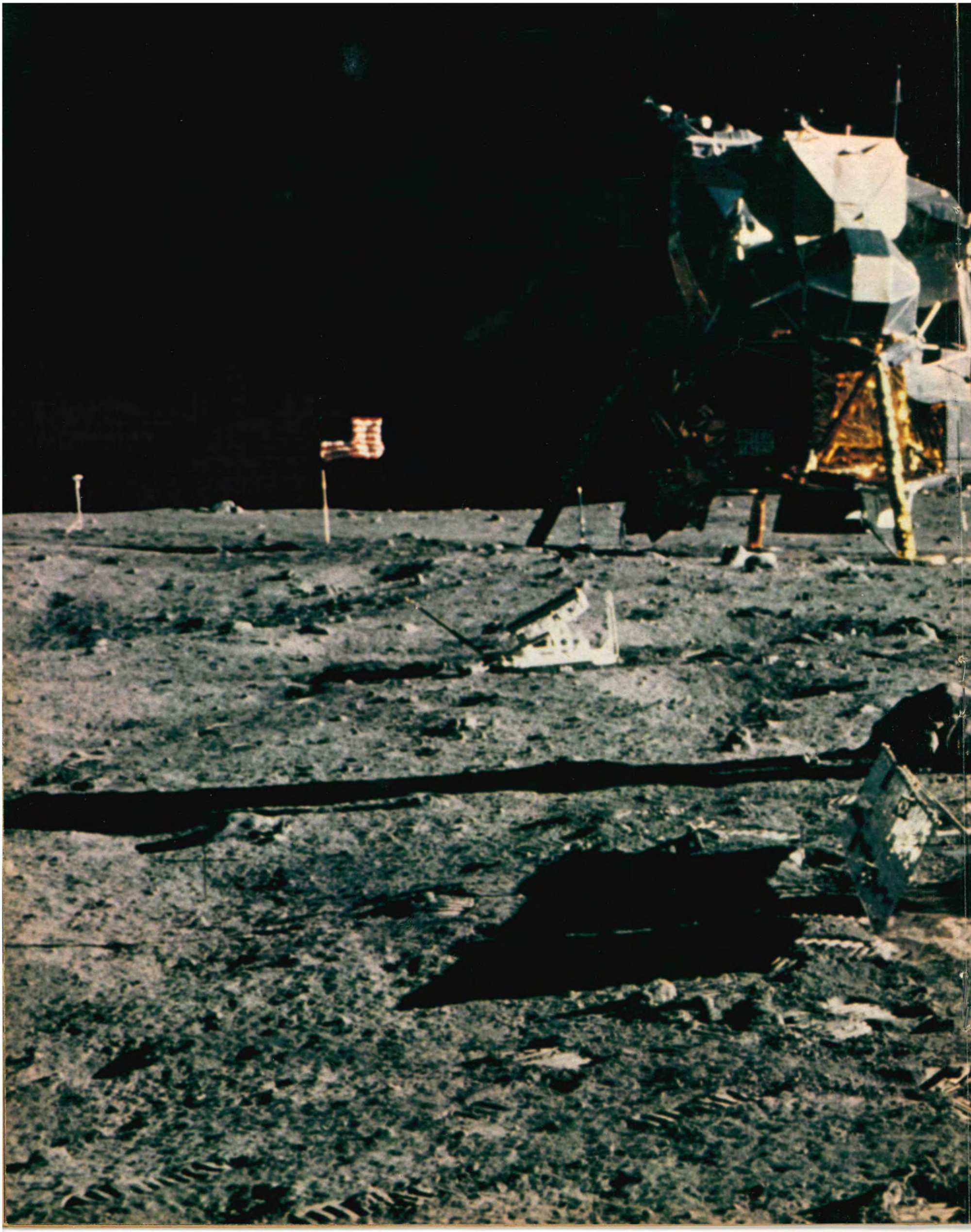
As the astronauts raised the Stars and Stripes, held unfurled by a wire in the breezeless vacuum, the scene was caught by the movie camera shooting through the lunar module's right-hand window.

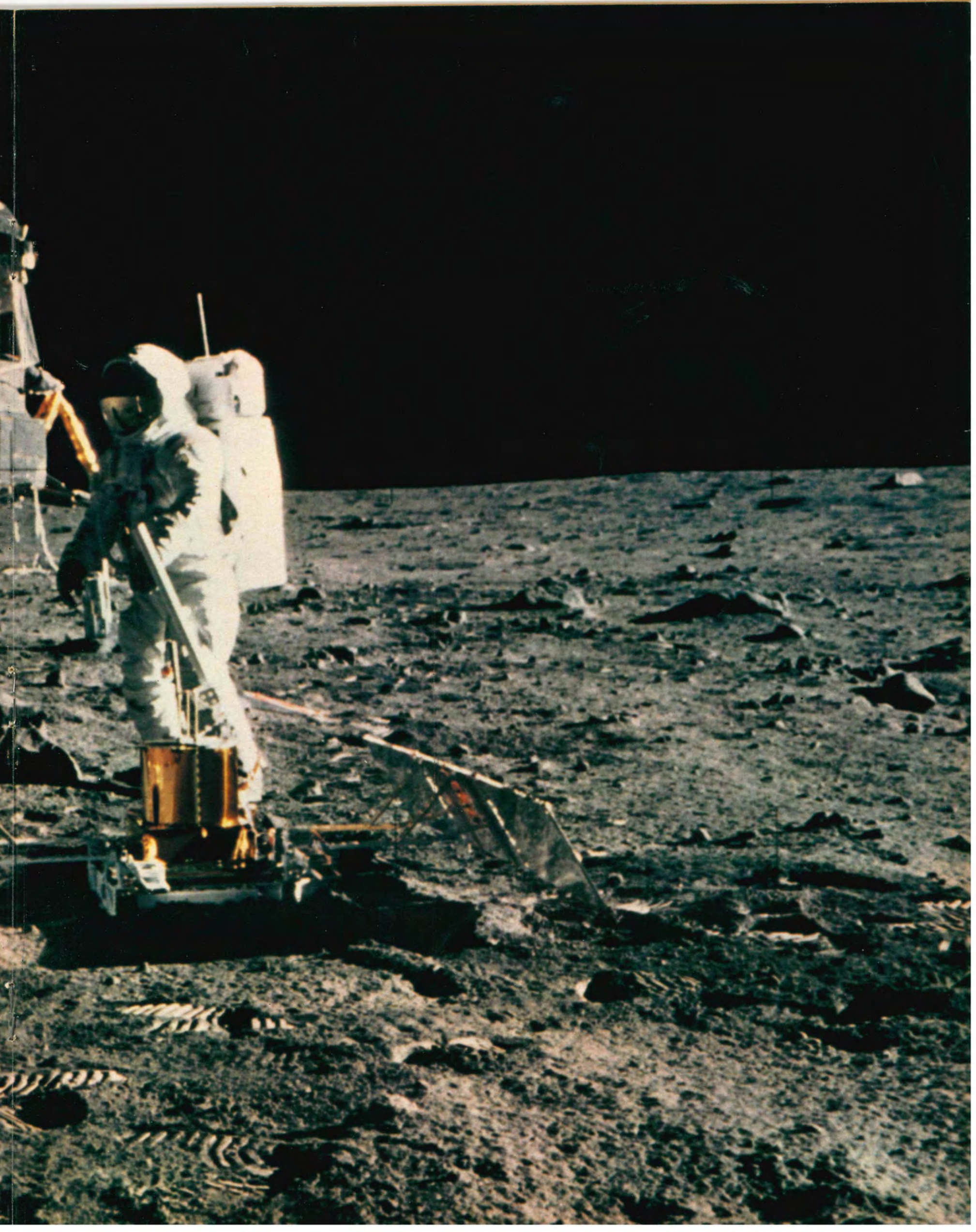
Buzz Aldrin's visor (opposite) clearly mirrors the TV camera and the flag, the lunar module and part of the scientific package, and Neil Armstrong, the photographer.

Looking like a white-suited peddler
with his satchels, Aldrin heads
out from the LM to deploy two parts
of the EASEP, the collection of
experiments the men set up.
Surprisingly, they
found that working on the
moon was easier than they'd expected.

Below, Aldrin sets up the Passive Seismic Experiments Package, a gadget to transmit data about moonquakes back to earth. He planted it a safe distance from Eagle, and it began beaming information immediately.

Overleaf, a sweep of the arid land around Eagle, showing some very sophisticated litter. From upper left to lower right: the television camera, the flag near the lunar module, the laser reflector, and Aldrin, looming over the miniature seismic station.





There was not much time for idle wandering in the ghostly light up there, but here is Buzz Aldrin, walking as if bemused, near the lunar module's golden leg. Aldrin had already described the moon as "magnificent desolation."

One of the ironies of carrying the camera is that you seldom get into a picture yourself. That happened to Neil Armstrong on the moon. Here, he recorded Buzz Aldrin near the flag Aldrin had set up in the powdery, slippery lunar soil.

The area near Landing Site 2 was basically flat, but there was a shadowy crater near the lunar module (left). Above: the astronauts' steps on the moon were silent, but they made an impression in the granular lunar landscape.

There had been some earthly squabbling over what flag to plant on the moon. This is the one they left, standing on trampled ground in the harsh lunar light. Armstrong and Aldrin also left behind the patch of the Apollo 1 crew, above, honoring the men who did not live to see the moon reached.

Almost incidentally, the astronauts made one of the best pictures yet of earth (overleaf). The darkest blue above the center is the Mediterranean. Africa bulks below in orange-rust.

A man a little weary, but happy in his work. Buzz Aldrin made this picture of Apollo 11 commander Neil Armstrong after the two had walked on the lunar surface, talked to the President of the United States, and loaded the first box of moon rocks aboard Eagle.

Text continued

but well within the designated area about 20 miles southwest of the crater Maskelyne, on the right side of the moon as seen from earth.

Describing the landing site to ground control, Mr. Armstrong noted "a fairly large number of craters of the 5-to-50-foot variety —and some ridges, small, 20 to 30 feet high, I would guess."

"Sounds like it looks a lot better than it did yesterday," Colonel Collins chimed in from above. "At that very low sun angle, it looked rough as a cob then."

Tranquility Base answered him, "It really was rough over the targeted area."

"When in doubt, land long," Colonel Collins said.

"Well, we did," came the answer.

Although Mr. Armstrong is known as a man of few words, his heartbeats told of his excitement. At the moment the descent rocket ignited, his heartbeat rate registered 110 a minute—77 is normal for him—and it shot up to 156 at touchdown.

But within seconds of the lunar landing, the condition of both Mr. Armstrong and Colonel Aldrin told the world that man could indeed live on an extraterrestrial body. The astronauts' breath was short and their pulses raced, but both heart and respiration rates were within the limits that had been predicted and considered safe.

"They're in excellent physical condition," Apollo doctors said three hours after the touchdown. A steady stream of chatter from the astronauts indicated that they were standing up well to the physical ordeal of landing, despite having been weightless for more than 100 hours.

"I don't think we noticed any difficulty at all adapting to one-sixth G," Mr. Armstrong radioed in a somewhat surprised voice. The term "one-sixth G" refers to the fact that the moon has only that fraction of the earth's gravity, or G. At Mission Control, Dr. Charles A. Berry, the astronauts' chief flight surgeon, nodded happy agreement as he monitored the 10 oscilloscopes and dials telling him that, a quarter of a million miles away, the two most important patients of his career were all right.

Dr. Berry was even happier when he heard Colonel Aldrin say, "One-sixth G is just like an airplane." Flight surgeons had been particularly concerned about the effect of lunar gravity because it could be simulated on earth for only five seconds at a time, in airplanes. This was almost useless for drawing serious conclusions about the effect.

Immediately after the landing, Dr. Paine, the NASA chief, telephoned President Nixon in Washington to report: "Mr. President, it is my honor on behalf of the entire NASA team to report to you that the Eagle has landed on the Sea of Tranquility and our astronauts are safe and looking forward to starting the exploration of the moon."

At about the same time, Mr. Armstrong asked Colonel Collins to "just keep that orbiting base ready for us up there, now."

"You're looking good in every respect," Mission Control told the two men of Eagle after examining data indicating that the module should be able to remain on the moon a full 22 hours.

Upon checking the spacecraft and finding it in good condition, Mr. Armstrong and Colonel Aldrin made their decision to open the hatch and go outside hours earlier than originally scheduled. The flight plan had called for the moon walk to begin at 2:12 A.M.

Flight controllers said the early moon walk did not mean the astronauts would also leave the moon earlier. The lift-off was still scheduled for about 1:55 P.M. Monday.

The astronauts' emergence from the lunar module was delayed for a time when they had trouble depressurizing the cabin so they could open the hatch. All the oxygen in the cabin had to be vented. Once the pressure gauge finally dropped to zero, they opened the hatch and Mr. Armstrong backed out on the small platform at the top of the module's nine-step ladder. "Okay, Houston, I'm on the porch," he reported, and began his descent.

On the second step from the top, he pulled a lanyard that released a fold-down equipment compartment on the side of the lunar module. This deployed a television camera that transmitted the dramatic pictures of Mr. Armstrong's first step on the moon.

That step was the realization of centuries of dreams, the fulfillment of a decade of striving, a triumph of modern technology and personal courage, the most dramatic demonstration of what man can do if he applies his mind and resources with single-minded determination.

The moon, long the symbol of the impossible and the inaccessible, was now within man's reach, the first port of call in this new age of spacefaring.

Outside the Eagle, Mr. Armstrong and Colonel Aldrin moved very cautiously at first, but soon found that they could walk across the lunar surface easily in bounding, almost floating, steps.

They seemed to have a little difficulty in adjusting their vision to the moon's deep shadows, but their depth perception appeared not to suffer at all, nor did their appreciation of the scene.

The astronauts found a bleak but beautiful world. It was just before dawn, with the sun low over the eastern horizon behind them. The chill of the long lunar night still clung to the boulders, craters and hills before them.

"Magnificent desolation" was the phrase Colonel Aldrin used in describing the view. He said he could see "literally thousands of small craters" and a low hill out in the distance. But most of all he was impressed initially by the "variety of shapes, angularities, granularities" of the rocks and soil around Tranquility Base.

"The colors vary pretty much depending on how you are looking relative to the zero phase length," the astronaut continued. "There doesn't appear to be too much of a general color at all. However, it looks as though some of the rocks and boulders—of which there are quite a few in the near area—it looks as though they're going to have some interesting colors to them."

Soon Mr. Armstrong was bounding across the surface in easy kangaroo hops. His heavy spacesuit and life-support pack im-

peded his movements very little. "You do have to be rather careful to keep track of where your center of mass is," Mr. Armstrong said after bounding across the surface for several yards.

Although the astronauts' steps made no sounds at all on the airless surface of the moon, their running conversation with each other and with the earth, more than 200,000 miles away, seemed to keep them from feeling isolated.

They spoke of light and dark grays as the principal, but not the only, colors. They said they found a purple rock.

The television pictures showed deep black shadows and glaring sunlight. Because there is no atmosphere on the moon, there is nothing to soften the glare or to diminish the sun's fierce brightness and ultraviolet radiation. Mr. Armstrong said he had some trouble adjusting his vision to the deep shadow when he walked to the dark side of the lunar module.

Even though the astronauts were protected by their water-cooled spacesuits, they said they could feel a difference when they went from shadow to sunlight or the reverse.

The scene the astronauts showed when they moved their television camera toward the horizon was just what had been expected —an almost flat, crater-pocked, undulating surface. No lunar mountain or ridge could be seen in the pictures.

The American flag, held outspread by a wire supporting its top, hung motionless in the harsh sunlight.

Moving easily through their brightly lighted surroundings, the astronauts readily set to the tasks of collecting soil specimens and deploying scientific experiments to help scientists perhaps answer a wide range of unanswered riddles about the moon.

With almost gay agility, they carried a miniature seismic station to what was hopefully a safe distance from the Eagle, then implanted it to detect and transmit to earth data on moonquakes. It began functioning immediately.

They also set up a reflector to bounce laser beams back to earth. By means of this device, physicists hope to resolve a debate concerning the constancy of gravity. One theory says it is slowly weakening. The reflectors should make it possible to detect variations in earth-moon distances as small as six inches. This, in turn, could provide the most sensitive tests to date of Einstein's General Theory of Relativity.

Almost immediately after he descended to the surface of the moon, Colonel Aldrin set up a banner of aluminum foil facing the sun. The purpose was to capture the nuclei of atoms blowing out from the sun in the "solar wind." The foil is to be analyzed by a Swiss laboratory, which is looking in particular for nuclei of the "noble gases," such as neon, argon and krypton.

The top priority assigned to the astronauts was the collection of moon samples. After years of inconclusive debate about the moon, it had become apparent that only with a representative collection of lunar rocks and soil samples could the correct answer be finally determined.

If the moon was torn from the earth, that should be evident in the composition of its rocks. If it is, in effect, a giant meteorite,

continued

Voice Communication: Moon Walk

TRANQUILITY: Houston, this is Tranquility. We're standing by for cabin depress.

HOUSTON: *You are go for cabin depressurization. Go for cabin depressurization.*

TRANQUILITY: Okay, the vent window is clear.

HOUSTON: *Buzz, you're coming through loud and clear, and Mike passes on the word that he's receiving you and following your progress with interest.*

TRANQUILITY: Cabin repress closed. Now comes the gymnastics. Air pressure going toward zero. Standby LM suit circuit 36 to 43. That's verified . . . pressure about 4.5, 4.75 and coming down. We'll open the hatch when we get to zero.

APOLLO CONTROL: *Coming up on five minutes of operation of Neil Armstrong's portable life support system now.*

HOUSTON: *Neil, this is Houston. What's your status on hatch opening?*

ARMSTRONG: Everything is go here. We're just waiting for the cabin pressure to bleed to a low enough pressure to open the hatch. It's about point one on our gauge now.

ALDRIN: I'd hate to tug on that thing.

HOUSTON: *We're seeing a relatively static pressure on your cabin. Do you think you can open the hatch at this pressure?*

ARMSTRONG: We're going to try it. The hatch is coming open.

ALDRIN: Hold it from going closed and I'll get the valve turned.

ALDRIN: Your window cleared yet?

ARMSTRONG: It has, yeah.

ALDRIN: Mine hasn't cleared yet.

ALDRIN: Okay. Glycol pump secondary circuit breaker open. Back to lean—this way. Radar circuit breakers open.

ARMSTRONG: Well, I'm looking head-on at it. Okay, my antenna's out.

ALDRIN: Your visor.

ARMSTRONG: Yep.

ALDRIN: Your back is up against the porch. Now you're clear. Over toward me. Straight down, to your left a little bit. Plenty of room. You're lined up nicely. Toward me a little bit. Down. Okay. Now you're clear. You're catching the first hinge.

ARMSTRONG: The what hinge?

ALDRIN: All right, move. Roll to the left. Okay, now you're clear. You're lined up on the platform. Put your left foot to the right a little bit. Okay, that's good. More left. Good.

ARMSTRONG: Okay, Houston, I'm on the porch.

HOUSTON: *Roger, Neil.*

ALDRIN: Halt where you are a minute, Neil.

ARMSTRONG: Okay.

ALDRIN: Everything's nice and straight in here.

ARMSTRONG: Okay, can you pull the door open a little more?

ALDRIN: Right.

HOUSTON: *We're getting a picture on the TV.*

ALDRIN: You've got a good picture, huh?

HOUSTON: *There's a great deal of contrast in it and currently it's upside down on monitor. But we can make out a fair amount of detail.*

ARMSTRONG: Okay, will you verify the position, the opening I ought to have on the camera.

HOUSTON: *The what? We can see you coming down the ladder now.*

ARMSTRONG: I'm at the foot of the ladder. The LM footpads are only depressed in the surface about one or two inches, although the surface appears to be very, very fine-grained as you get close to it. It's almost like a powder. It's very fine. I'm going to step off the LM now.

That's one small step for a man, one giant leap for mankind.

The surface is fine and powdery. I can pick it up loosely with my toe. It does adhere in fine layers like powdered charcoal to the sole and the sides of my boots. I only go in a small fraction of an inch, maybe an eighth of an inch, but I can see the footprints of my boots and the treads in the fine sandy particles.

There seems to be no difficulty in moving around this and we suspect that it's even perhaps easier than the simulations of one-sixth G that we performed in various simulations on the ground. Actually no trouble to walk around.

It's quite dark here in the shadow and a little hard for me to see if I have good footing. I'll work my way over into the sunlight here without looking directly into the sun. Looking up at the LM, I'm standing directly in the shadow now looking up at . . . in the windows and I can see everything quite clearly. The light is sufficiently brightly backlighted into the front of the LM that everything is clearly visible.

I'll step out and take some of my first pictures here.

ALDRIN: Are you going to get the contingency sample? Okay. That's good.

ARMSTRONG: The contingency sample is down and it's up. Like it's a little difficult to dig through the crust. It's very interesting. It's a very soft surface but here and there where I plug with the contingency sample collector I run into very hard surface but it appears to be very cohesive material of the same sort. I'll try to get a rock in here.

HOUSTON: Oh, that looks beautiful from here, Neil.

ARMSTRONG: It has a stark beauty all its own. It's like much of the high desert of the United States. It's different but it's very pretty out here. Be advised that a lot of the rock samples out here, the hard rock samples have what appears to be vesicles in the surface.

ALDRIN: Ready for me to come out?

ARMSTRONG: Yeah. Just stand by a second, I'll move this over the handrail.

ALDRIN: Okay?

ARMSTRONG: All right, that's got it. Are you ready?

ALDRIN: All set.

ARMSTRONG: Okay. You saw what difficulties I was having. I'll try to watch your PLSS from underneath here. The toes are about to come over the sill. Now drop your PLSS down. There you go, you're clear. And laterally you're good. About an inch clearance on top of your PLSS. You need a little bit of arching of the back to come down.

ALDRIN: How far are my feet from the . . .

ARMSTRONG: You're right at the edge of the porch.

ALDRIN: Small little foot movement. Porch. Arching of the back . . . without any trouble at all. Now I want to back up and partially close the hatch—making sure not to lock it on my way out.

ARMSTRONG: Good thought.

ALDRIN: That's our home for the next couple of hours; we want to take care of it. I'm on the top step. It's a very simple matter to hop down from one step to the next.

ARMSTRONG: Yes, I found that to be very comfortable, and walking is also very comfortable, Houston. You've got three more steps and then a long one.

ALDRIN: I'm going to leave that one foot up there and both hands down to about the fourth rung up.

ARMSTRONG: A little more. About another inch. There you got it. That's a good step.

ALDRIN: About a three footer. Beautiful view.

ARMSTRONG: Ain't that somethin'?

it should contain such formations as chondrules (tiny, rounded inclusions that often look like rice grains scattered through the rock). Chondrules are not found in any earth rocks.

If the moon was once molten inside, allowing the iron and other heavy materials to sink to its core, as occurred on earth, the lighter material would have risen to the surface, like scum, to form lighter rocks, like those of North America. This would be evident if any granites were found.

Perhaps the greatest surprise was the hardness of the lunar surface. It was covered with a very fine powder, but the footpads of the lunar module penetrated only a few inches.

The surface powder was dark, almost carbonlike, in appearance. The rocks were coated with it, making them slippery in the deep vacuum. This made it more difficult to pick up the rocks with the special tongs provided for the purpose. Millions of watchers on earth were able to witness this first celestial geological prospecting. The long-handled tools—tongs and scoop—could clearly be seen as Colonel Aldrin made his selections.

Some of the rocks were described as vesicular, that is, full of small cavities. This is characteristic of certain forms of lava, but does not definitely establish the rock as a lava fragment.

Another rock was said to resemble biotite, a dark green or black form of mica that is characteristic of continental rocks on earth. Its presence on the moon could indicate that the history of the moon had features in common with that of the earth. However, definite identification, as the astronauts pointed out, would have to await their return.

The samples were placed in two airtight boxes to be hauled aboard for transport home. They would be isolated from exposure to oxygen in the spacecraft or to air upon arrival on earth, then carefully rationed out to scientists all over the world.

Although the discovery that they were coming down in the middle of a boulder-filled moon crater may have given the two Apollo astronauts a few anxious moments, it will likely result in scientific boons.

Some of the boulders were presumably blown out of the lunar depths when the crater was formed, probably by the explosive impact of a large meteorite. These boulders represent rock buried perhaps 100 feet or more below the surface—far beyond the reach of the two men's sampling tools.

Other rocks probably were thrown from the horizon by more massive impact and thus are specimens from other regions of the moon. Since the moon has no air and its gravity is only one-sixth as strong as earth's, explosive impacts sometimes blow debris halfway around the moon.

One of the last acts of the Apollo team was to drive coring tubes into the lunar surface, to capture material deep enough to be free of any exposure to exhaust gases from the rocket that lowered the LM to the surface. These core samples should also show any subtle layering of material near the surface. Colonel Aldrin pointed out to the onlookers how hard he had to work to drive the tube into the resistant surface.

When the Apollo astronauts landed on the Sea of Tranquility, the temperature at their touchdown site was about zero degrees Fahrenheit in the sunlight, even colder in the shade.

During a lunar night, which lasts 14 earth days, temperatures plunge as low as 280 degrees below zero. Unlike earth, the moon, having no atmosphere to act as a blanket, is unable to retain any of the day's warmth during the night.

During the equally long lunar day, temperatures rise as high as 280 degrees above zero. By the time the Eagle departed from the moon, with the sun higher in the sky, the temperature would rise to about 90 degrees. To protect their thin human skins from these extreme temperatures, the astronauts wore costumes that weighed more than they did and that were almost as self-contained as their spaceship.

These lunar spacesuits were much more than garments because they carried their own atmospheres, and protected the men against not only total vacuum and extremes of temperature, but the risk of puncture by hurtling micrometeoroids. Yet they were flexible enough so that the astronauts could walk, climb, dig and set out their instruments, although the men could only reach an inch or so above their heads and only as far down as their knees.

The astronauts, for example, could not have stooped over to tie shoelaces–even if they had had them–and they probably could not have gotten up unaided if they had fallen down.

Each suit weighed 185 pounds, earth weight. Mr. Armstrong and Colonel Aldrin weighed about 165 pounds each when they left home. But on the moon, each man, fully suited, weighed only a little more than 58 pounds, a sixth of what he would have scaled on earth.

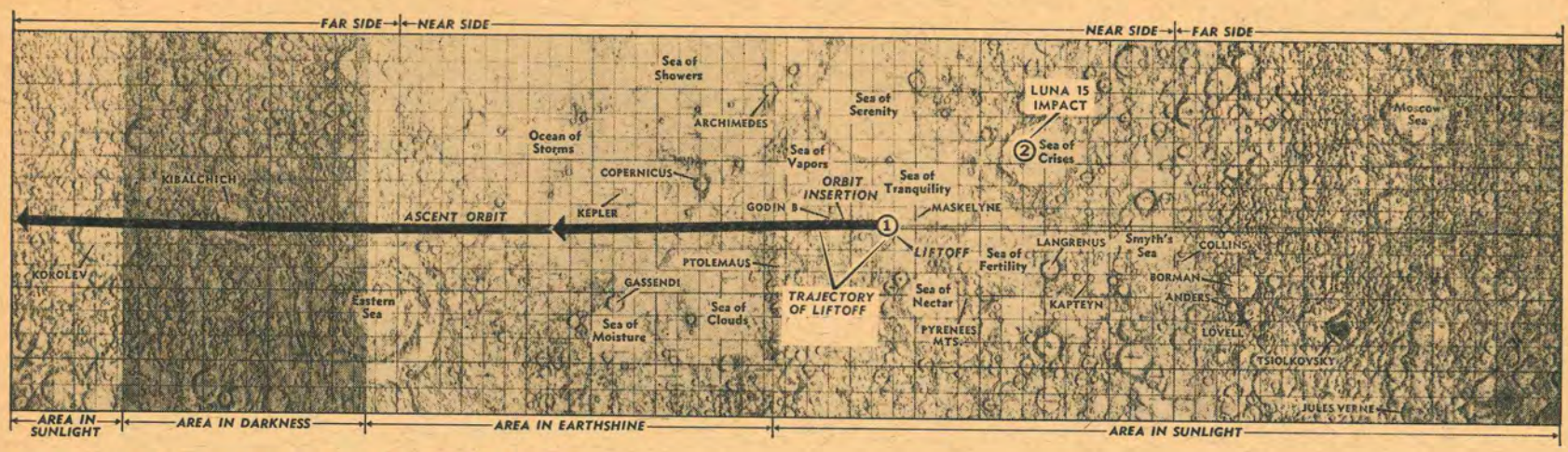
The materials of the spacesuits and their life support packages included plastics, synthetic fibers, artificial rubber and several metals, including silver and gold.

Each costume carried its own supply of electricity, water and oxygen. Each had a fan, a refrigeration element and a sophisticated two-way radio. Even when the astronauts were not talking, the radios kept up a constant chatter of automatic signals to the lunar module and thence to earth.

From this chatter, mission controllers received nine different kinds of information: battery current and voltage, oxygen supply pressure, suit pressure, four other readings of temperature and pressure in the life support system and the astronauts' electrocardiograms, which showed the natural electrical activities of their hearts.

The particular landing site that Mr. Armstrong and Colonel Aldrin landed on, loped on and left from was one of five selected by Apollo project officials after analysis of pictures returned by the five Lunar Orbiter unmanned spacecraft.

All five sites are situated across the lunar equator on the side of the moon always facing earth. Their being on the equator reduces the maneuvering required to get the astronauts there. Their being on the near side of the moon, of course, makes it possible to communicate with the explorers.



Armstrong and Aldrin lifted off from Tranquility Base (1) two hours and eight minutes after Luna 15 dropped out of lunar orbit and fell into the Sea of Crises (2). What Luna's purpose had been was still a mystery to Americans.

It was during one such communication, as the astronauts prepared themselves to walk upon the alien world that lay so bewitchingly outside their windows, that Colonel Aldrin said to earth, "I'd like to take this opportunity to ask every person listening in, whoever, wherever they may be, to pause for a moment and contemplate the events of the past few hours and to give thanks in his or her own way."

Some on earth bowed their heads. Some raised them to the stars. And they thought it over.

MONDAY, JULY 21

The work on the moon was over. It was time to see if Eagle's engine would put them in orbit. If not, three days to live.

Houston, Tex.

MR. ARMSTRONG and Colonel Aldrin left the moon 21 hours and 37 minutes after landing on it. "You're cleared for take-off," Mission Control radioed the astronauts shortly before 2 P.M. "Roger. Understand. We're Number One on the runway," replied Mr. Armstrong.

A quarter of a million miles away, millions of people listened with tense anxiety. For if the 3,500-pound-thrust rocket in the upper half of the lunar module failed to fire, the two men would be stranded with only a three-day supply of oxygen. "Okay, I assume we're go for lift-off and will proceed with the ascent feeds," one of the astronauts radioed.

Moments later, the message to Mission Control continued: "Nine, eight, seven, six, five, first stage engine on ascent. Proceed. Beautiful, 26, 36 feet per second up. Little pitch over, very smooth, very quiet ride."

On earth, the tension drained away. The engine had fired at 1:55 P.M., on time and at full thrust, lifting Eagle's upper stage and then sending it into a long orbital path toward a rendezvous with Colonel Collins in the command ship.

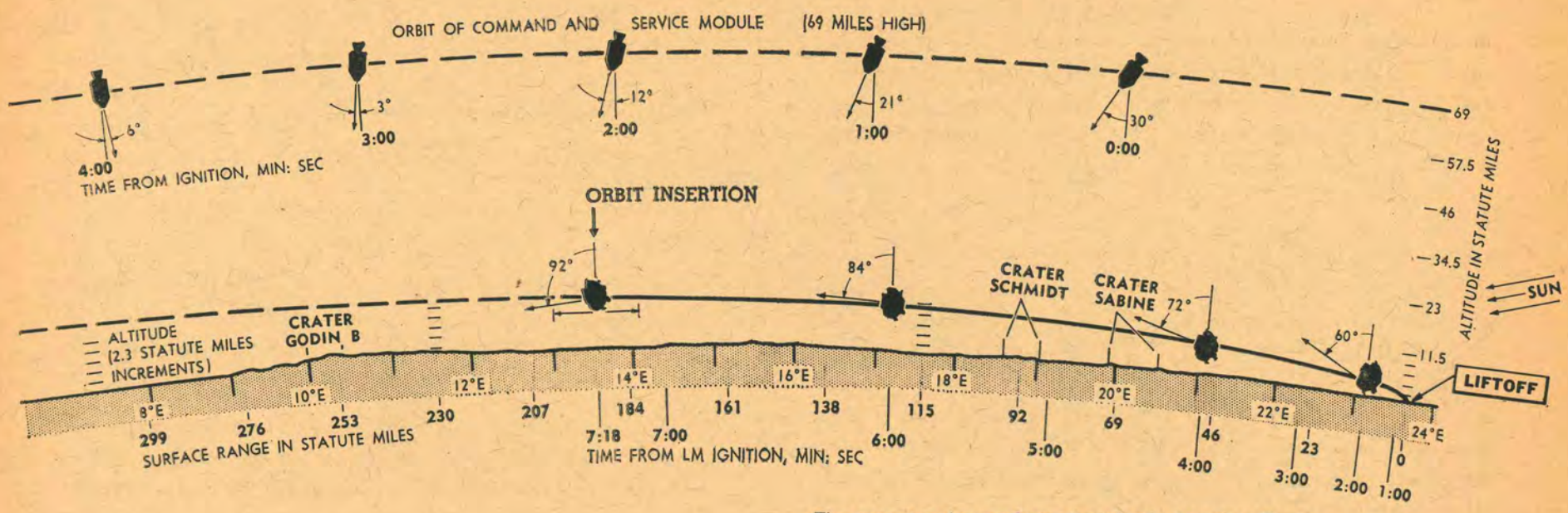
"Twenty-six hundred feet altitude, Eagle," Mission Control told Mr. Armstrong and Colonel Aldrin. "One minute, and you're looking good. A 130 feet [per second] vertical rise rate."

Soon the Eagle radioed: "Right down U.S. 1." That is the astronauts' nickname for Hypatia Rille, a canyon near the moon's equator.

Two hours and eight minutes before the Eagle blasted off the moon, the Soviet spacecraft, Luna 15, dropped out of orbit and fell onto the moon's Sea of Crises. Tass said the craft's work had "ended," at last killing the speculation that Luna might try to scoop up lunar soil and return it to earth. But part of the mystery remained. What had been the craft's purpose?

Luna, however, was at best of passing concern to Mr. Armstrong and Colonel Aldrin as they went about their departure from the moon. Within eight minutes after lift-off, the Eagle was in orbit. And at 5:35 P.M., some 70 miles above the moon, Colonel Collins' command ship joined its nose with the top hatch of the lunar module. It was an unaccountably rough docking.

"That was a funny one," Colonel Collins reported to Mission Control. "You know, I didn't feel us touch, and I thought things were pretty steady . . . and that's when all hell broke loose." Apparently, as the two vehicles moved in close to each other, their aim was slightly off. "Somehow or other we got off attitude [position]," Mr. Armstrong explained. "It was squeezing there for a couple of seconds," Colonel Collins said. Flight con-



The ascent rocket performed perfectly, boosting Eagle straight up at first, then propelling it into an arcing trajectory. Seven minutes and 18 seconds after lift-off, Eagle was again in orbit.

trollers had no immediate explanation for the trouble. They reported that the two craft were docked securely about three minutes after they were scheduled to do so.

Later, Mr. Armstrong and Colonel Aldrin crawled through the connecting tunnel to rejoin Colonel Collins in the command ship. The hatch was shut and the lunar module jettisoned to become a piece of junk orbiting the moon.

The three astronauts then stowed their gear and prepared for the firing of the spacecraft's main rocket, to break away from the moon's gravitational grip and head for earth.

Behind them, on the site of man's first moon landing, was the forlorn descent stage of the lunar module with its four spindly legs planted on the powdery surface, the plaque announcing man's arrival attached to the forward leg.

Around it, like the clutter left by some campers, were the cameras, walking boots, equipment boxes, an aluminum pole, two backpacks, urine bags and other equipment the astronauts had pitched out to lighten their load for lift-off.

When the heavy backpacks were tossed out, their impact on the surface was detected by the seismometers left at the site by Mr. Armstrong and Colonel Aldrin. Transmission of the data encouraged scientists here, who will monitor the seismometers to pick up signs of moonquakes and other subsurface activity.

Between their moon walk and the lift-off, the two astronauts took time to report in more detail on the nature of their landing site. Mr. Armstrong said he had collected about 50 pounds of soil and rock samples from several areas around the landing craft. Most of the samples he scooped off the surface, but he went as deep as three inches for some soil. There was no significant change in the soil composition at that depth. He did not hit any hard bed.

When he was outside, Colonel Aldrin noticed that the descent rocket's blast had turned up and scattered lunar dirt from directly under the nozzle. It left only a shallow crater. "It seems as though the surface had been baked in a streak fashion," Colonel Aldrin said, describing the area under the bell-shaped nozzle.

The Air Force colonel also reported that when he gathered core samples by driving a hollow tube into the ground with a hammer, he had no trouble going in about two or three inches. Then he had to pound the tube "about as hard as I could."

Colonel Aldrin drove the tube about eight or nine inches into the surface. Then he noticed something puzzling. For some reason, he said, the tube "didn't seem to want to stand up straight. I'd keep driving it in and it would dig some sort of a hole but it wouldn't penetrate in a way that it would support itself," he said.

The material in the tube was "quite well packed, a good bit darker, and the way it adhered to the core tube gave me the distinct impression of being moist."

The moon's surface is waterless. So what he saw was probably the same phenomenon observed when the Surveyor soft-landing vehicles took closeup photographs and probed the lunar surface with a mechanical scoop. In those cases the soil's texture was like clods in a freshly plowed field.

Because of the absence of erosion by wind and water, particles of lunar soil are believed to have sharper, more angular edges that, in a vacuum, such as on the moon, tend to lock more easily together. There also may be some electrostatic charge on the moon that binds particles.

The astronauts estimated that the boulder-filled crater they flew over during the final approach to their landing was about a half mile east of them, or behind them. This was the crater, described as being as big as a football field, around which Mr. Armstrong had to steer the lunar module.

At about 5 A.M., while still on the moon, the two men settled down to rest. Since there were no couches in the lunar module cabin, Colonel Aldrin stretched out on the floor of the cockpit and Mr. Armstrong sat on top of the ascent engine's cover and leaned back against a cabinet. Doctors here reported that Mr. Armstrong's heartbeat rate indicated that he was only dozing fitfully, not sleeping.

When they awoke, Mr. Armstrong resumed his descriptions of the geology of the landing site and radioed, "We are landed in a relatively clear crater field . . . of circular secondary craters, most of which have rims irrespective of their rays and irrespective of their size. There are a few of the smaller craters around which do not have a discernible rim. The ground mass throughout the area is a very fine sand to a silt. I say the thing that would be most like it on earth is powdered graphite." The Apollo commander said there was a wide variety of rocks and that the boulders were generally about two feet high.

When the astronauts were preparing for the lift-off, flight controllers instructed them to keep the rendezvous radar system off during the early part of the ascent. They wanted to avoid overloading the on-board computer. Such overloading during the descent had set off alarm lights several times and at one point caused mission controllers to consider aborting the landing.

Eagle's lift-off was the first launching of a manned rocket craft without the benefit of all the familiar accouterments, such as concrete bases and steel gantries. The descent stage of the lunar module served as the launching pad. The two sections were separated prior to lift-off by the firing of explosive bolts.

The guidance computer aboard the ascent stage triggered the ignition after Mr. Armstrong pressed the "proceed" button. "Very smooth," Mr. Armstrong radioed, as the roundish ascent stage rose vertically from the moon. The rocket firing lasted 7 minutes and 18 seconds. In 10 seconds, at an altitude of 250 feet, computer-controlled firings of maneuvering jets pitched the lunar module forward.

The astronauts gained altitude at an angle. They picked up speed quickly. "We've got Sabine to our right now," Mr. Armstrong said, passing over a familiar crater. "There's Ritter out there." About 193 miles down range, the lunar module reached an altitude of 10 miles and was in orbit. The engine cut off.

From that low point in the orbit, the two men rode the lunar module across the face of the moon, from east to west, coasting higher and higher. Behind the moon, the craft reached the high point—52 miles.

Mr. Armstrong and Colonel Aldrin closed in for the rendezvous with Colonel Collins in a series of four maneuvers with the lunar module's small thruster jets. These maneuvers raised and circularized the vehicle's orbit, then slowed its flight so it could ease in close to the command ship.

The two vehicles flew in formation until they emerged from behind the moon and quickly established radio communications with ground controllers.

Voice Communication: Lunar Lift-off

HOUSTON: *You're cleared for take-off.*

TRANQUILITY: Roger, understand. We're No. 1 on the runway.

HOUSTON: *A little less than 10 minutes here. Everything looks good.*

HOUSTON: *Eagle, you're looking good to us. We'll continue to monitor now at 3 minutes 12 seconds away from ignition as crew of Eagle goes through their prelaunch check list. Guidance reports both navigation systems on Eagle are looking good.*

TRANQUILITY: Nine, eight, seven, six, five, first stage engine on ascent. Proceed. Beautiful, 26, 36 feet per second up. Little pitch over, very smooth, very quiet ride. There's that one crater down there.

HOUSTON: *A thousand feet high, 80 feet per second vertical rise.*

HOUSTON: *2600 feet altitude. Eagle, Houston. One minute, and you're looking good. A 130 feet vertical rise rate.*

EAGLE: A little bit of slow wallowing back and forth. Not very much thruster activity.

HOUSTON: *Mighty fine.*

HOUSTON: *Eagle, you're go at three minutes. Everything's looking good.*

EAGLE: Right. This is . . . this is H dot max now. Right down U.S. 1.

APOLLO CONTROL: *Height's now approaching 32,000 feet.*

HOUSTON: *Eagle, four minutes. You're going right down the track. Everything is great.*

EAGLE: Horizontal velocity approaching 2,500 feet per second. We've got Sabine to our right now.

APOLLO CONTROL: *Some 120 miles to go until insertion.*

HOUSTON: *Eagle, Houston. You're still looking mighty fine.*

EAGLE: Eagle is back in orbit, having left Tranquility Base, and leaving behind a replica from our Apollo 11 patch with an olive branch.

HOUSTON: *Roger, we copy. The whole world is proud of you.*

By this time the lunar module, which had started the mission weighing 33,000 pounds, was down to 5,800 pounds, with most of its fuel expended and its lower half back on the moon.

The momentary alignment problem toward the end may have startled Colonel Collins, but it apparently caused no concern among ground controllers. One guidance officer said they detected "no deviations" in the lunar module during the ascent rocket firing or the rendezvous.

TUESDAY, JULY 22

The reunion with Columbia had been bumpy, but good. So was the burn to push the astronauts home. Now there was only a wait for re-entry.

Houston, Tex.

WEARY but happy, the men of Apollo 11 started home. Behind the moon, 56 minutes into their seventh day in space, Mr. Armstrong, Colonel Aldrin and Colonel Collins fired the main engine of the command ship to break out of lunar orbit. The two-and-one-half-minute firing started them on a 60-hour coasting voyage toward a splashdown in mid-Pacific.

"Open up the LRL doors, Charlie," Mr. Armstrong said when the spaceship reappeared from behind the moon after the firing and reestablished communications with earth. The LRL—Houston's Lunar Receiving Laboratory—is a sealed building where the astronauts were to remain in post-flight quarantine against the remote possibility they were bringing back some deadly lunar organisms against which man has no immunity.

"Beautiful burn," Mr. Armstrong added. "They don't come any finer." Immediately after the engine firing, Lieut. Gen. Samuel C. Phillips, the Apollo program director, declared, "The men and equipment that are Apollo 11 have performed to perfection. Perfection is not too strong a word."

Although Apollo project officials cautioned that the flight was not over until splashdown, they could hardly contain their relief and pride as the spaceship began its homeward course.

Later in the day, Dr. George E. Mueller, the space agency's associate administrator for manned space flight, added his optimism to that of General Phillips. "It seems quite clear," he said, "that the planets of the solar system are well within our ability to explore, both manned and unmanned, at the present time."

And President Nixon, in an equally ebullient mood, told a group of students gathered on the lawn of the White House that "in the year 2000 we on this earth will have visited new worlds where there will be a form of life."

After firing their engine and heading home, the astronauts rested. They slept late and spoke little throughout the day.

At six in the evening, Houston roused the travelers to see how they were feeling. Apollo answered: "So what's new?" "Oh, we were wondering what was new with you up there," Houston said. "Oh, very quiet," Apollo replied. "Nice to sit here and watch the earth getting larger and larger and the moon smaller and smaller."

Shortly after 9 P.M., the astronauts transmitted a 20-minute color television program that concluded with a picture of the earth as a half-sphere more than 175,000 miles away.

Mr. Armstrong pointed out the two boxes containing the samples of lunar rocks and dirt that the astronauts were bringing back for scientific analysis. Colonel Aldrin demonstrated how easy it was to apply ham spread to a slice of bread, which he grabbed out of midair in the cabin. Colonel Collins took a playful drink by holding the water gun a few inches from his mouth and squirting the water in, much as a Spaniard drinks from a wineskin.

In ending the telecast, Mr. Armstrong observed, "No matter where you travel it is nice to get home."

The spacemen's craft continued to function smoothly, and their health was reported good. However, the moonquake detector they left behind on the moon's surface was overheating, and there were fears it might not survive the week.

While the astronauts were coasting home, the nation that dispatched them on their epic voyage laid plans for a heroes' welcome that included big parades in New York and Chicago and a public reception in Los Angeles—all in a single day, Aug. 13. The astronauts were scheduled to describe their mission at a news conference here on Aug. 12, the day after they were to be released from their post-flight quarantine.

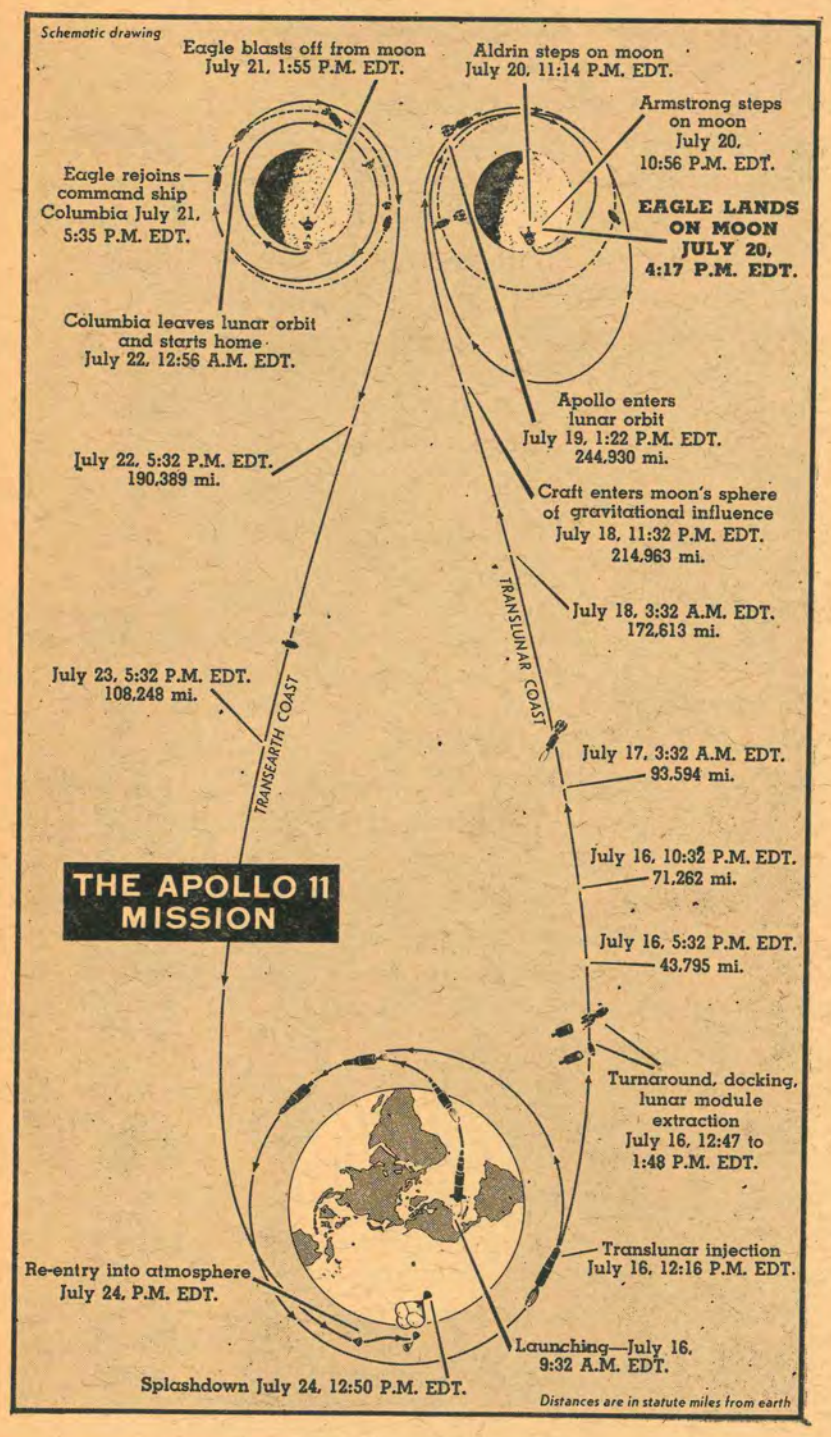
At 1:39 P.M., Apollo 11 crossed the point in space, 36,800 statute miles from the moon, where lunar gravity ceased to have the dominant influence and the earth's gravity began reeling the spacecraft homeward.

Under the earth's influence, the spacecraft began speeding up gradually from 2,720 miles an hour. By the time it plunged back into the atmosphere, the craft would be traveling 24,670 miles an hour.

When Apollo 11 had reached a speed of 2,780 miles an hour —and was 194,170 miles from the earth—its maneuvering rockets were fired for 10½ seconds to alter its trajectory slightly. The firing, referred to as a "tweaking burn," came at 4 P.M. and succeeded in making the necessary course correction.

Apollo 11 aimed for a July 24 splashdown about 1,200 miles southwest of Honolulu, Hawaii. President Nixon planned to be on the aircraft carrier U.S.S. Hornet, to greet the astronauts.

Until the last few hours before splashdown, the astronauts had little work to do except to monitor spacecraft systems and perform housekeeping chores. Flight controllers let the tired crewmen sleep until 1 P.M. before awakening them for their first full day of the return trip.



After their "good mornings," Mission Control radioed the day's news, including the fact that only four nations—Communist China, North Korea, North Vietnam and Albania—had not yet informed their citizens of the moon landing.

Mission Control also reported the latest war developments in Vietnam, new fighting in the Middle East, votes in Congress, the weather and assorted sports news. Just then, Colonel Collins asked them to look up the Dow-Jones Industrials. "Roger. Stand by," Houston controllers replied. A few minutes later, they came back with a report that the market was off 11.05 at the time. (It closed down 11.90 at 834.02.) Colonel Collins, who probably had a bit of time to think things over during more than 27 hours of orbiting the moon alone, concluded philosophically, "Well, every flight has to have some disadvantages, I guess."

A little later, Colonel Collins got back to serious business when ground controllers asked him to explain what had happened during the link-up between the command ship and the lunar module to make him say, "all hell broke loose."

Colonel Collins said that, as he was steering the command ship's nose into the connecting ring of the lunar module, following the rendezvous after the lift-off from the moon, the capture latches snapped shut as required. Then he flipped a switch to retract the connecting probe, which would complete the link-up.

"At that time a gyration began between the two vehicles," he went on. "I thought that we were not going to get a successful retraction and hard dock." Both Colonel Collins and Mr. Armstrong, who was steering the lunar module, steadied their ships with short bursts of the thruster jets to stop the gyrations and come to a secure connection. "At this point we do not fully understand what the problem was," said Mr. Charlesworth, the flight director. "It was in no way an emergency."

Commenting on how few problems had occurred in the flight, Mr. Charlesworth said Apollo 11 "is probably the cleanest spacecraft we've flown to date."

But things were not going so well with the seismometers on the moon. John W. Small, coordinator of the lunar surface experiments, said that the instruments' temperature had reached 215 degrees above zero Fahrenheit—45 degrees higher than they were designed to withstand. Mr. Small suggested that the seismic unit might have been charred or otherwise damaged by the rocket exhaust when the astronauts lifted off the moon. If it were charred, it would absorb more of the sun's heat. Nonetheless, the seismometers were recording and transmitting a number of "events."

Scientists were not sure yet whether these were indications of volcanic tremors, micrometeorite impacts or perhaps some venting of fuels from the half of the lunar module that remained at the landing site.

Mr. Small said it was his "best guess" that the seismometers might not survive the heat of the noon sun on the moon. In four days, the sun would be directly over the landing site. A lunar day lasts the equivalent of 14 earth days.

The sun was kinder to the spacefarers themselves. Some

fears had been expressed before the flight that a major solar eruption, or flare, might endanger the two astronauts on the moon while they were outside the Eagle.

However, solar observatories from around the world reported that the sun had been docile throughout the flight. They had expected the sun to roar throughout this year of lunar exploration, yet it remained quiet during the Apollo 11 mission.

Two other strange occurrences were also noted. Mr. Armstrong and Colonel Aldrin reported that while they were in lunar orbit, they saw a puzzling white light with a yellow tinge. They wondered if it might have been a beam of intense laser light. A project scientist here said that if it were a laser beam, it was not from any station connected with Apollo. He suspected that it might have been a reflection of light, but he said he could not be sure until he got a better description from the astronauts.

At another point, communications from the spacecraft to the control center here were interrupted briefly with a sharp, eerie whistling signal. Flight controllers were at a loss to explain it.

The final mystery of the day was perhaps the most intriguing of all. "For $64,000 we're still trying to work out the location of your landing site, Tranquility Base," Mission Control radioed to the astronauts. Pleading for more details that might help them figure out the location, they asked, "Do you still have those charts on board?" "They're packed," an astronaut replied. A conversation about coordinates, lunar landmarks and second guessing ensued, but no one seemed to be able to determine precisely where the Eagle had nested.

Back on earth, NASA officials were also kept busy handling a huge volume of mail asking for souvenirs. One letter, from a Montana boy, said: "I just want a piece of the moon—I don't want it for any scientific purpose, I just want a piece of the moon."

The astronauts, untouched by such problems, settled down at a half hour past midnight for a night's sleep.

WEDNESDAY, JULY 23

A quiet, coasting flight, with news bulletins. There was also time for the last color television, and a verse from the Eighth Psalm.

Houston, Tex.

PICKING UP speed by the minute, Apollo 11 hurtled toward the end of its epic voyage. The spaceship and its three occupants passed the halfway point of their return trip from the moon at 3:58 P.M. After sleeping late to rest up from their busy two days on and around the moon, Mr. Armstrong, Colonel Aldrin and Colonel Collins spent a quiet time of coasting flight. They kept an eye on their craft and its intricate systems, took pictures and tracked stars for navigation.

So silent were they that at one point Mission Control began to wonder if they had disappeared. "Apollo 11, this is Houston," a capsule communicator radioed. "Are you still up there?" "Roger," Colonel Collins replied. "We're still up here, but not quite as high as we used to be." "I just wanted to make sure you fellows hadn't gone back to sleep again," Mission Control said, "and I also have a little bit of late news here."

Among the news items conveyed to the crewmen was this one: "Back in Memphis, a young lady who is presently tipping the scales at 8 pounds, 2 ounces was named Module by her parents, Mr. and Mrs. Eddie Lee McGee. 'It wasn't my idea,' said Mrs. McGee. 'It was my husband's.' She said she had balked at the name Lunar Module McGee because it didn't sound too good, but apparently they have compromised on just Module."

In the Pacific, the aircraft carrier U.S.S. Hornet was standing by to pick up the moon explorers and their precious cargo of lunar rocks and soil. But a possibility of violent storms in the planned splashdown area, some 1,200 miles southwest of Honolulu, forced mission controllers to change the planned landing point. "The weather," Mission Control radioed the astronauts, "is clobbering in at our targeted landing point due to scattered thunderstorms. We don't want to tangle with one of those."

New instructions for the landing called for the astronauts to shift the attitude of their spacecraft slightly so that it would acquire more lift as it sped through the atmosphere and land 247 miles closer to Hawaii.

As the Hornet steamed toward the new target, it carried on its hangar deck a snug, shiny, stainless-steel house trailer without wheels, in which the astronauts were to live for three days after they landed. This Mobile Quarantine Facility, or MQF, was designed to protect the world from contamination by any possible "moon germs" while the astronauts, their equipment and the lunar samples they collected were transported from the mid-Pacific, first by ship and then by airplane, to the Lunar Receiving Laboratory in Houston.

Some of the first scientific results of the moon expedition reached Houston while the astronauts were still thousands of miles out in space, and the results provoked a genteel controversy.

The seismometers placed on the moon by Mr. Armstrong and Colonel Aldrin recorded a five-minute tremor in the moon's crust, and scientists immediately split into two camps over the tremor's cause. One camp believed the tremor was caused by the impact of a meteor. The other believed a moonquake was responsible. If the latter view turned out to be correct, then the case of scientists who had been maintaining the moon had a "live" interior would be strengthened.

While the mild disagreement went on, Mission Control said Apollo 11 was functioning as smoothly as at the start of the mission a week earlier. The three astronauts awoke to the last full day of their earthward coast at 12:30 P.M. They were told that their

trajectory was accurate enough so that they could skip the next scheduled midcourse correction.

At 7:03 P.M., the astronauts transmitted the final color television show of the flight, in which they delivered some of their reflections on the mission. "This trip of ours to the moon may have looked simple and easy," Colonel Collins said. "I want to assure you that this has not been the case."

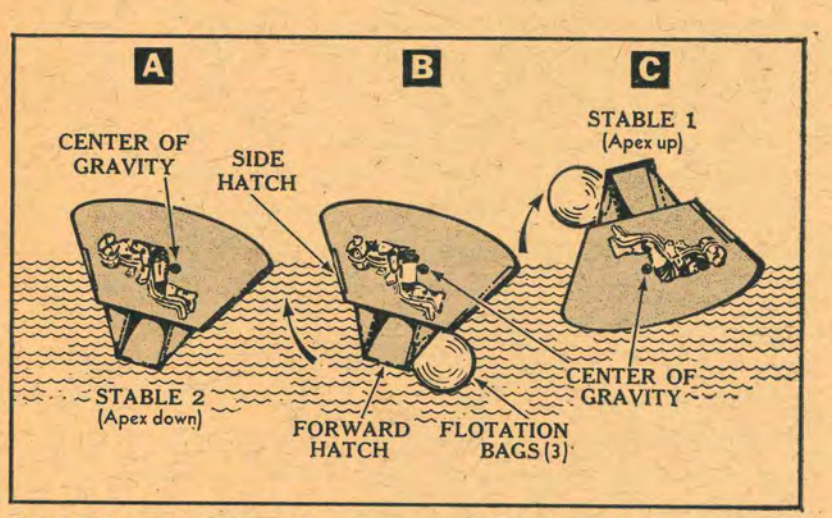
He paid tribute to the complex equipment that made the mission possible, from the Saturn 5 rocket for the launching to the guidance computer with its 38,000-word vocabulary, and the "blood, sweat and tears" of thousands of American workers, scientists and engineers.

"All you see is us," the astronaut said, "but below the surface are thousands and thousands of others, and to all of them I would like to say, 'Thank you very much.' "

When the camera switched to Colonel Aldrin, he said, "We've come to the conclusion that this has been far more than three men on a voyage to the moon, more still than the efforts of a government and industry team, more even than the efforts of one nation. We feel that this stands as a symbol of the insatiable curiosity of all mankind to explore the unknown."

He said the flight made him recall a verse from Psalm 8, which he quoted: "When I consider the heavens, the work of Thy fingers, the moon and the stars which Thou hast ordained: what is man that Thou art mindful of him."

Concluding the moving telecast, Mr. Armstrong said, "We'd like to give to all the Americans who built this spacecraft, who did the construction, design, tests and put their hearts and all their abilities into those craft–to those people tonight, we give a special thank you. To all the other people listening and watching, God bless you and good night from Apollo 11."



The Apollo command module turned upside down (picture A) just after splashing into the Pacific Ocean at the end of its journey. Three flotation bags inflated (B) and righted the craft (C).

THURSDAY, JULY 24

Splashdown. A greeting from President Nixon. Then they sought more isolation, this time to stave off the chance of "moon bugs."

Aboard U.S.S. Hornet,
in the Pacific

APOLLO 11 approached the earth at more than 30 times the speed of sound, arcing down over Australia and shedding its service module as it went. At 12:35 P.M., as the command module with its human passengers and its cargo of moon rocks sped on a northeasterly course 80 miles above the Gilbert Islands, it slammed into the atmosphere and streaked like a flaming meteor toward a soft landing in the water below.

Fifteen minutes later the command ship's three parachutes lowered it gently, at 21 miles an hour, into the Pacific 950 miles southwest of Hawaii, 2.7 miles from its aiming point and 13.8 miles from the carrier Hornet, the recovery ship. Man's first expedition to another world was over.

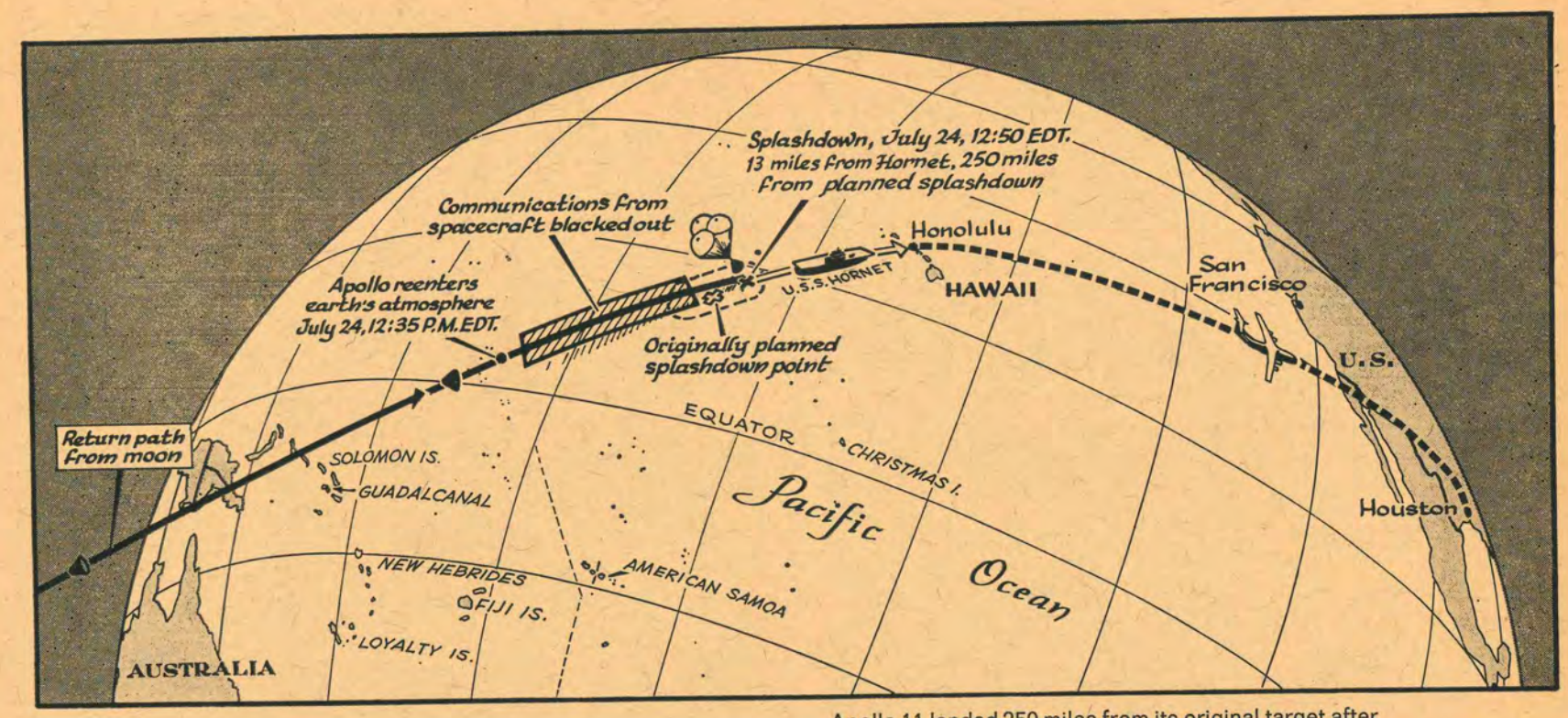
President Nixon watched the recovery from one of the Hornet's two bridges. He caught a glimpse of the spaceship's fiery re-entry into the atmosphere, but shared in the disappointment of the crew and millions of television viewers when the craft splashed down out of sight of the ship.

The command module turned upside down immediately after it hit the sea and was righted when large balloons attached to the module—known as flotation bags—were inflated beneath the ocean's surface.

Once their craft was righted by the balloons, the astronauts radioed: "All three of us are excellent. Take your time." The recovery team, however, moved quickly into a procedure practiced 18 times during the previous three weeks. The entire recovery process was completed in three hours and three minutes, faster than in any of the practice exercises.

The first recovery swimmer, Seaman John M. Wolfram, 20 years old, jumped into the water from one of two helicopters that had been circling, waiting for the splashdown. He attached a sea anchor to the command module and was joined in the water by Lieut. (j.g.) Wesley T. Chesser, 24, and Quartermaster 3d Cl. Michael G. Mallory, 23.

The three attached a flotation collar around the spacecraft and hooked a raft to it. Lieutenant Chesser remained near the spacecraft while the others swam away. A second raft was dropped upwind of the module, where the two swimmers waited. Sharks were reported to be in the area, but the noise of the helicopters'



Apollo 11 landed 250 miles from its original target after maneuvering to avoid stormy seas. The Hornet took the astronauts to Hawaii, from where they were flown to Houston.

rotors kept them away from the spacecraft.

From one of the helicopters, Lieut. Clancey Hatleberg dropped into the water. With him dropped several containers of decontaminant, along with biological isolation garments for himself and the astronauts. The decontaminants and the BIG's, as the isolation garments came to be called, were part of a quarantine program designed to protect the world against what was considered the unlikely possibility of contamination by lunar organisms. The garments, dull green coveralls, were topped by hoods and face masks.

Once in the water, Lieutenant Hatleberg donned one of the garments. The other swimmers helped him attach the second raft to the spaceship, and then he was left alone at the hatch. Through the window, he signaled the astronauts to open the hatch and take their isolation suits. That accomplished, the hatch was closed and the astronauts pulled the isolation garments on. When they signaled that they had finished dressing, they climbed one by one from the module into one of the rafts, wearing inflated, orange life preservers similar to water wings.

Lieutenant Hatleberg sprayed the module with Betadine, a decontaminant, and then turned to the decontamination of the astronauts. Using sodium hypochloride and a glove, he scrubbed the astronauts' suits and, in turn, was scrubbed by Colonel Aldrin.

While a helicopter hovered over the raft, Mr. Armstrong was hoisted aboard first, then Colonel Collins and finally Colonel Aldrin.

Mr. Nixon watched from the bridge as the helicopter approached and landed. A ship's band played "Columbia, the Gem of the Ocean." The helicopter was lowered on an elevator to the cavernous hangar-bay area, one deck below the carrier's flat top, where the astronauts' quarantine trailer was waiting. The astronauts had not emerged from the helicopter on the flight deck; and when the door of the 'copter slid open, they were only a few feet from the trailer. They waved, then moved quickly inside.

They would stay there with a physician, Dr. William R. Carpentier, and John Hirasaki, a NASA engineer who would be their aide, while the Hornet took them to Pearl Harbor, Hawaii. In Hawaii, an Air Force C-141 cargo plane would take the mobile quarantine trailer aboard and fly it to Ellington Air Force Base, Texas, near Houston's Manned Spacecraft Center. Astronauts Armstrong, Aldrin and Collins, Dr. Carpentier and Mr. Hirasaki would then enter the Lunar Receiving Laboratory at the space center for a quarantine period of 18 days, or 21 days from their lunar blast-off on July 21.

About an hour after their splashdown, the astronauts were pronounced in good condition by Dr. Carpentier. By 4 P.M., the command module had been hauled aboard the carrier. The spaceship was pulled on a wagon frame to a plastic tunnel connected to the quarantine trailer. Mr. Hirasaki climbed a small ladder inside the tunnel to the module's hatch, opened it, unloaded the two containers of lunar samples, and took them inside the trailer. Then he removed magazines of photographic film, magnetic data tapes, and the waste left by the astronauts. He photographed the interior of the module and removed more objects, including the astronauts' personal belongings.

Mr. Hirasaki's next task was to "power-down" the space-

craft, a job that involved cutting off power to different systems. When he was finished, Mr. Hirasaki backed slowly out of the module and sealed the hatch. He sprayed decontaminant on the area, and the tunnel was slowly withdrawn into the trailer and the five men were isolated for the long trip home.

Once inside, the lunar sample containers and the film and tapes were quickly processed in the trailer's decontamination lock, passed to the outside and flown to Johnston Island.

A C-130 plane was waiting there to relay the moon rocks to the laboratory in Houston, where they were to be studied by scientists from several countries.

The almost perfectly executed odyssey of Apollo 11 seemed unreal to some. In McGehee, Ark., 81-year-old Mrs. Barbara Marion Hopkins Day was so unimpressed by the moon landing that she believed it to be a hoax, contrived for mere publicity. She slept through the moon walk on Sunday and did not turn on her television set during the entire lunar voyage. "I don't believe it," she said. "I don't believe they've ever been there."

Flying to the moon was somehow offensive to her, partly because she considered it impossible and partly because it was far outside the perimeter of her interest. Beyond that, she saw the whole business as morally questionable. "If God had intended for us to go to the moon," she said firmly, "He would have built a ladder up there."

To the citizens of McGehee, technological progress has little to do with computers and other electronic wonders. Instead, it means electric lights in place of kerosene lamps, piped-in water that does not taste of iron, machines that plow eight times faster than grandfather's single-stock plow and two bales of cotton to the acre instead of one.

Yet for all of that, and for all of Mrs. Day's disbelief, the flight of Apollo 11 drew the sleepy delta town of 5,101 closer to the rest of the world than it had been before, at least momentarily.

The patrons of Mrs. Day's boarding house, thanks to television and the exploits of Mr. Armstrong, Colonel Aldrin and Colonel Collins, were one with the patrons of Le Pavillon in New York City, even though the patrons of Le Pavillon might not have been aware of it.

Because of the flight, the humblest farmer around McGehee was almost as knowledgeable about laser beams and rockets as about tractors. Ben Glosup, a bony-faced farmer of about 60 years, was talking about the moon shot a few hours before Apollo 11 splashed down, and he suddenly fell silent. When he looked up, he said, "They say it will take two and a half years to get to Mars," and the look in his eye could only be described as contemplative and far away.

McGehee was not much different from a thousand other little towns in the United States. The moon shot probably inspired the same mood of wonder and philosophical musing in all of them.

For more than a week, Apollo 11 had caused much of the world to wonder and marvel. After the splashdown, bells pealed,

Aboard the Hornet, Dr. Paine and President Nixon awaited the astronauts' return.

champagne corks popped, men and women cheered and prayed, firecrackers exploded.

In Houston, the men of Mission Control stood up at their consoles, cheered, waved American flags and talked of flying men to Mars, as had Mr. Glosup of McGehee, Ark. Dr. Gilruth, the director of the Manned Spacecraft Center, said in a low, emotion-choked voice, "We here at the Manned Spacecraft Center have a feeling of elation, relief, and we're supremely happy."

Dr. Mueller, the head of NASA's manned space flight office, said that as a result of the moon landing "we now stand at what is undoubtedly the greatest decision point in the history of this planet."

"Four billion years ago," Dr. Mueller said, "the earth was formed. Four hundred million years ago, life moved to the land. Four million years ago, man appeared on earth. One hundred years ago, the technological revolution that led to this day began.

"All of these events were important, yet in none of them did man make a conscious decision to follow a path that would change the future of all mankind.

"We have that opportunity and that challenge today. For today at 11:49 A.M., Houston time, in the middle of the Pacific Ocean, we conclusively proved that man is no longer bound to the limits of the planet on which he has lived for so long.

"We will return to the moon first in November [on the Apollo 12 mission] and then at regular intervals in the coming year. But these trips are only the first steps. There remains for mankind the task of deciding the next step."

He made it clear he thought the next step should be a manned

Safe, triumphant, but isolated in a special van lest they spread any "moon germs," Armstrong, Collins and Aldrin greeted an admiring world.

landing on Mars, which might come "some time after 1980."

In New York, cheers for the safe return of the astronauts erupted on the crowded floors of the New York and American Stock Exchanges; and a new message flashed across the Big Board: "Astronauts Armstrong, Aldrin and Collins, so proudly we hail you."

In Birmingham, Ala., where city employes gathered for prayers of thanksgiving, Mayor George Seibels asked that church bells, automobile horns and whistles be sounded to convey "the ecstasy that I know abounds within us all."

Some individuals remained indifferent to the space exploit or were contemptuous of it. In lower Manhattan, Pat Jones, a government worker, termed the Apollo 11 mission "totally unrelated to problems in the United States," adding, "it doesn't do anything to help the poor."

Many Negroes either ignored Apollo 11 or were angered by it. On Sunday, the word that Eagle had touched down on the moon brought boos from an estimated crowd of 50,000 persons who flocked to the Harlem Cultural Festival, a soul-music concert, at Mt. Morris Park.

"There ain't no brothers in the program where they can get into some of that big money," said an angry black worker in a Harlem bar. "The whole thing uses money that should be spent right here on earth and I don't like them saying 'all good Americans are happy about it.' I damn sure ain't happy about it."

And the last line in an editorial in the Amsterdam News, the Harlem weekly, said simply, "Yesterday the moon. Tomorrow, maybe us."

But the dominant mood, both in the United States and abroad, nevertheless appeared to be one of excitement and ad-

U.S. and Soviet Manned Space Flights

SPACECRAFT	DATE	ASTRONAUTS	REVOLUTIONS	FLIGHT TIME	FLIGHT HIGHLIGHTS
U.S.S.R. **Vostok 1**	Apr. 12, 1961	Yuri A. Gagarin	1	1 hr. 48 mins.	First manned flight.
U.S. **Mercury-Redstone 3**	May 5, 1961	Alan B. Shepard Jr.	Suborbital	0 hrs. 15 mins.	First American in space.
U.S. **Mercury-Redstone 4**	July 21, 1961	Virgil I. Grissom	Suborbital	0 hrs. 16 mins.	Capsule sank.
U.S.S.R. **Vostok 2**	Aug. 6, 1961	Gherman S. Titov	16	25 hrs. 18 mins.	More than 24 hours in space.
U.S. **Mercury-Atlas 6**	Feb. 20, 1962	John H. Glenn Jr.	3	4 hrs. 55 mins.	First American in orbit.
U.S. **Mercury-Atlas 7**	May 24, 1962	M. Scott Carpenter	3	4 hrs. 56 mins.	Landed 250 miles from target.
U.S.S.R. **Vostok 3**	Aug. 11, 1962	Andrian G. Nikolayev	60	94 hrs. 22 mins.	First group flight. (Vostok 3 & 4)
U.S.S.R. **Vostok 4**	Aug. 12, 1962	Pavel R. Popovich	45	70 hrs. 57 mins.	Came within 3.1 miles of Vostok 3 on first orbit.
U.S. **Mercury-Atlas 8**	Oct. 3, 1962	Walter M. Schirra Jr.	6	9 hrs. 13 mins.	Landed 5 miles from target.
U.S. **Mercury-Atlas 9**	May 15-16, 1963	L. Gordon Cooper Jr.	22	34 hrs. 20 mins.	First long flight by an American.
U.S.S.R. **Vostok 5**	June 14, 1963	Valery F. Bykovsky	76	119 hrs. 6 mins.	Second group flight. (Vostok 5 and 6)
U.S.S.R. **Vostok 6**	June 16, 1963	Valentina V. Tereshkova	45	70 hrs. 50 mins.	Passed within 3 miles of Vostok 5; first woman in space.
U.S.S.R. **Voskhod 1**	Oct. 12, 1964	Vladimir M. Komarov Konstantin P. Feoktistov Dr. Boris G. Yegorov	15	24 hrs. 17 mins.	First 3-man craft.
U.S.S.R. **Voskhod 2**	Mar. 18, 1965	Aleksei A. Leonov Pavel I. Belyayev	16	26 hrs. 2 mins.	First man outside spacecraft in 10-minute "walk" (Leonov).
U.S. **Gemini 3**	Mar. 23, 1965	Virgil I. Grissom John W. Young	3	4 hrs. 53 mins.	First manned orbital maneuvers.
U.S. **Gemini 4**	June 3-7, 1965	James A. McDivitt Edward H. White 2nd	62	97 hrs. 48 mins.	21-minute "space walk" (White).
U.S. **Gemini 5**	Aug. 21-29, 1965	L. Gordon Cooper Jr. Charles Conrad Jr.	120	190 hrs. 56 mins.	First extended manned flight.
U.S. **Gemini 7**	Dec. 4-18, 1965	Frank Borman James Lovell Jr.	206	330 hrs. 35 mins.	Longest space flight
U.S. **Gemini 6-A**	Dec. 15-16, 1965	Walter M. Schirra Jr. Thomas P. Stafford	16	25 hrs. 52 mins.	Rendezvous within 1 foot of Gemini 7.
U.S. **Gemini 8**	Mar. 16-17, 1966	Neil A. Armstrong David R. Scott	6.5	10 hrs. 42 mins.	First docking to Agena target.
U.S. **Gemini 9-A**	June 3-6, 1966	Thomas P. Stafford Eugene A. Cernan	44	72 hrs. 21 mins.	Rendezvous, extra-vehicular activity, precision landing.
U.S. **Gemini 10**	July 18-21, 1966	John W. Young Michael Collins	43	70 hrs. 47 mins.	Rendezvous with 2 targets; Agena package retrieved.
U.S. **Gemini 11**	Sept. 12-15, 1966	Charles Conrad Jr. Richard F. Gordon Jr.	44	71 hrs. 17 mins.	Rendezvous and docking.
U.S. **Gemini 12**	Nov. 11-15, 1966	James Lovell Jr. Edwin E. Aldrin Jr.	59	94 hrs. 33 mins.	3 successful extra-vehicular trips.
U.S.S.R. **Soyuz 1**	Apr. 23, 1967	Vladimir M. Komarov	17	26 hrs. 40 mins.	Heaviest manned craft; crashed, killing Komarov.
U.S. **Apollo 7**	Oct. 11, 1968	Walter M. Schirra Jr. Donn F. Eisele R. Walter Cunningham	163	260 hrs. 9 mins.	First manned flight of Apollo spacecraft.
U.S.S.R. **Soyuz 3**	Oct. 26, 1968	Georgi T. Beragovoi	60	95 hrs.	Rendezvous with unmanned Soyuz 2.
U.S. **Apollo 8**	Dec. 21, 1968	Frank Borman James Lovell Jr. William A. Anders	Moon orbital (10 orbits)	147 hrs.	First manned voyage around moon.
U.S.S.R. **Soyuz 4**	Jan. 14, 1969	Vladimir A. Shatalov	45	71 hrs. 14 mins.	Rendezvous and docking with Soyuz 5.
U.S.S.R. **Soyuz 5**	Jan. 15, 1969	Boris V. Volynov Aleksei S. Yeliseyev Yevgeny V. Khrunov	46	72 hrs. 46 mins.	Rendezvous and docking with Soyuz 4; Yeliseyev and Khrunov transfer to and return in Soyuz 4.
U.S. **Apollo 9**	Mar. 3, 1969	James A. McDivitt David R. Scott Russell L. Schweickart	151	241 hrs. 1 min.	Docking with Lunar Module.
U.S. **Apollo 10**	May 18, 1969	Thomas P. Stafford Eugene A. Cernan John W. Young	Moon orbital (31 revolutions)	192 hrs. 3 mins.	Descent to within 9 miles of moon in Lunar Module.
U.S. **Apollo 11**	July 16, 1969	Neil A. Armstrong Edwin E. Aldrin Jr. Michael Collins	Moon orbital for command module (31 revolutions)	195 hrs. 18 mins.	Armstrong and Aldrin, in Lunar Module, land on moon.

miration. In many European cities, bells tolled to mark the end of the moon voyage. The village of Amiens, France, where Jules Verne, the 19th-century science-fiction writer, once lived, decided to make all three astronauts honorary citizens. One hundred and four years before the flight of Apollo 11, Verne wrote his famous fictional account of a trip to the moon. In it, three explorers took off from a base in Florida. Upon their return they landed in the Pacific and were recovered by an American warship.

Some of the loudest applause came from the Soviet Union. So much interest in Apollo 11 had been generated that the Kremlin allowed about 12 minutes of Eurovision's live broadcast of the splashdown to be shown. The Russians had not made such a gesture before.

Moscow radio told its listeners, "Man's first flight to the moon has been completed. The glorious dream of visionaries and scientists has come true." Nikolai V. Podgorny, the Soviet president, sent a message of congratulation to President Nixon and added his personal best wishes to the "courageous space pilots." A portly Russian in the Aragfi Restaurant, the finest in Moscow, did not yet know about the safe recovery. But he came up to an American, shook his hand, and said, "Colossal!"

There were indications that the enthusiastic reaction of the populace in the Soviet Union and the Communist countries of Eastern Europe was counterbalanced by gloom and embarrassment within the Moscow leadership. Whether because of overconfidence, technical problems, or a shift of Soviet political priorities away from space and toward domestic matters, the Russians had been beaten to the moon. In the days following the splashdown of Apollo 11, there would be reports of a lively controversy within the Kremlin, with some of the recriminations reportedly involving Leonid I. Brezhnev, General Secretary of the Soviet Communist party.

Back aboard the Hornet, Mr. Armstrong, Colonel Aldrin and Colonel Collins removed their isolation garments and crowded around the window of their quarantine trailer to listen to President Nixon, who stood a few feet away.

The tanned, exuberant President told the spacemen they looked "great." All three men did appear relaxed and happy. Colonel Collins had grown a mustache during the eight-day trip.

"Frank Borman says you're a little younger by reason of going into space," Mr. Nixon said. "Is that right? You feel a little younger?" "We're all younger than Frank Borman," quipped Colonel Collins.

Then, seriously, Mr. Nixon told the astronauts that "this is the greatest week in the history of the world since the Creation." He continued, "As I travel into Asia and Europe, I'm going to find that as a result of what you've done, the world is closer together. We can reach for the stars as you have."

And so one American president, about to embark on a world political tour, reaped the harvest of prestige that another president, once Mr. Nixon's adversary, had been seeking when he committed the United States to landing men on the moon before 1970.

After their triumphant Pacific splashdown, the astronauts donned special isolation garments and were taken by helicopter to the U.S.S. Hornet. The officer in charge of getting them out of the water, Lieut. Clancey Hatleberg, then decontaminated the rubber raft they had used, took off *his* isolation garment and straightaway sank both items. The other recovery swimmers picked him up and stood on the command module's flotation collar as Columbia was slowly towed alongside the Hornet (opposite).

THE DECISION

Politics, as much as scientific zeal, made John Kennedy decide to send men to the moon. In part, it was an answer to the flight of Yuri Gagarin.

By JOHN M. LOGSDON

"NOW it is time to take longer strides—time for a great new American enterprise. I believe we should go to the moon." On May 25, 1961, in these words, President John F. Kennedy asked the Congress and the nation to accept a commitment to send Americans to the moon "before this decade is out." This request was a manifestation of his decision to use space achievement as an instrument of national strategy, a means of advancing American purposes in the world.

Although Mr. Kennedy's lunar landing decision was primarily political, it rested on a relatively firm scientific and technological foundation. By 1961, Americans had been thinking for some time and in some detail about how to go to the moon.

During the late 1950's, in the process of attempting to justify a military space program, the Air Force and the Army studied problems associated with manned flight to the moon. One Air Force plan in 1958 called for a high-priority effort to land a man on the moon before the end of 1965. The Air Force at this time was even considering strategic interplanetary systems, which might be required to protect American scientific bases on the near planets.

Until 1959, Dr. Wernher von Braun and his team of German rocket engineers worked under Army direction. At the Army Ballistic Missile Agency at Huntsville, Alabama, they prepared elaborate plans for manned space flight. Dr. von Braun was a consistent advocate of a program to land men on the moon as soon as possible.

One proposal prepared in 1959 by the Huntsville team called for a landing in April, 1965, followed by the establishment of a 12-man lunar base in November, 1966. To accomplish this, an estimated 149 Saturn-class booster launchings were needed, according to the proposal. This worked out to an average of more than five Saturn launchings a month!

The National Aeronautics and Space Administration was inaugurated in 1958. A first order of business for the new space agency was getting America's first manned space flight program, Project Mercury, under way. Then, during 1959, space agency planners considered what manned program should follow Mercury. They had two broad alternatives: a program aimed at constructing an orbital space station and one aimed at developing the capability for flights to the moon.

Basing their decision solely on scientific and technological criteria, the planners decided, almost two years before Mr. Kennedy approved their choice, that the better second-generation manned flight program was that intended to send men to the moon.

Further studies of the lunar mission were conducted throughout 1960, and by February, 1961, a NASA task force headed by George M. Low concluded that a manned lunar landing was feasible before 1970.

While Dwight D. Eisenhower was President, he never approved any plans advanced for a manned expedition to the moon or for the intermediate steps leading to that goal. President Eisenhower consistently followed a policy of calm conservatism with regard to space. He did not believe that the political and psychological impacts of space achievements were important factors in international politics, and he refused to allocate resources to any program justified primarily in such terms.

President Eisenhower's scientific and economic advisers supported his attempt to limit the funds spent on space spectaculars, preferring to concentrate American efforts on unmanned scientific, commercial, and military space projects.

When, in 1960, the space agency asked White House approval for Project Apollo (then aimed at a circumlunar flight by 1969), Mr. Eisenhower asked his President's Scientific Advisory Committee to study the proposal. The committee report reached the President in December. It concluded that "man-in-space cannot be justified on purely scientific grounds" and that a space program targeted on a 1975 lunar landing goal would cost between $34-billion and $46-billion.

Mr. Eisenhower, upset by these cost estimates and unconvinced of the scientific justification for the proposal, refused to approve NASA's plans for Project Apollo. He announced in his final budget message that "further tests and experimentation will be necessary to establish if there are any valid scientific reasons

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for extending manned flight beyond the Mercury program."

When John Kennedy became President in January, 1961, the future of the nation's space program was uncertain. Project Mercury was undergoing severe difficulties; the success of the project in launching an American into space was not yet assured. The space agency had no manned flight program to follow Mercury. The Air Force had stepped up its campaign to gain control of a greater share of the manned space program. The continued existence of NASA as an agency with expensive operational programs was in some doubt.

The new Administration did little at first to resolve these uncertainties, although Mr. Kennedy had stressed the "space gap" as well as the "missile gap" in his election campaign. His Vice President, Lyndon B. Johnson, was known as a vigorous supporter of a large civilian space program.

After the election, Mr. Kennedy had assigned Mr. Johnson special responsibility for the space program. The man selected to head NASA, James E. Webb, had a reputation for strong leadership. From these indications, it seemed that Mr. Kennedy would pursue a more aggressive space policy than had Mr. Eisenhower.

There were contrary indications, however. A task force commissioned by the President-elect to recommend a new space policy was sharply critical of NASA's manned flight programs.

The scientist heading this task force, Jerome B. Wiesner, became Mr. Kennedy's science adviser. Many of the members of the President's Scientific Advisory Committee, already on record as critical of manned flight, continued to serve under Mr. Kennedy. A committee panel was formed to review Project Mercury, with the possibility that the project might be canceled rather than risk the death or injury of an astronaut.

For the first two months of his Administration, Mr. Kennedy did not actively involve himself in space policy. But at the end of March, Mr. Kennedy, though deep in deliberations over whether to intervene with American troops in Laos, was forced to turn his attention to the space program.

The Bureau of the Budget had disapproved a large addition to the NASA budget, which included items that implied approval of Project Apollo. The space agency refused to accept the Budget Bureau's decision, and requested a meeting with the President.

On March 22, the President met with NASA officials to hear their arguments for immediate approval of Apollo (by now aimed at circumlunar flight by 1967, and a lunar landing in 1969 or 1970). Mr. Kennedy deferred decision at this time, indicating that he would not decide on the future of NASA's manned programs until later in the year, after several Project Mercury flights.

Events in April convinced Mr. Kennedy of the need to compete with the Soviet Union in space on an urgent basis. On April 12, the Soviet astronaut Yuri A. Gagarin became the first man in space. World reaction to the Soviet achievement was almost unanimous praise and admiration. The Soviet Union was quick to capitalize on the propaganda significance of the flight, declaring that it demonstrated the superiority of the Communist system.

President Kennedy and Vice President Johnson got a briefing from Dr. Wernher von Braun during a 1962 visit to Huntsville, Alabama.

The American reaction to the Gagarin flight was disappointment and chagrin. For many, the flight came as almost as much of a shock as the Sputnik I flight of 1957. Many in Congress demanded an immediate response.

Mr. Kennedy told an April 12 news conference that "no one is more tired than I am" of the United States being second in space. On April 14, Mr. Kennedy called a meeting to discuss the options for an American effort to compete with the Soviet Union in space. At the end of the meeting, Mr. Kennedy said that there was "nothing more important" than winning the space race.

During the following week, Mr. Kennedy talked to hundreds of people about the appropriate United States response to the Soviet space achievement and about the proper direction and pace of the United States space program. By April 20, the President had become convinced, according to Dr. Wiesner, "that space was the symbol of the twentieth century."

On that day, the President asked the Vice President to conduct a study aimed at answering these questions: "Do we have a chance of beating the Soviets by putting a laboratory in space, or by a trip around the moon, or by a rocket to land on the moon, or by a rocket to go to the moon and back with a man? Is there any other space program which promises dramatic results in which we could win?"

At the same time, the United States became involved in the Bay of Pigs operation. Dr. Wiesner recalls that the Bay of Pigs put Mr. Kennedy "in a mood to run harder than he might have."

Ted Sorensen suggests that the United States' loss of prestige in Cuba coupled with Soviet prestige gains following the Gagarin flight "pointed up the fact that prestige was a real, and not simply a public relations, factor in world affairs."

During the two weeks following April 20, Vice President Johnson conducted the study of the space program Mr. Kennedy had requested. On April 22, NASA told Mr. Johnson that "there is a chance for the U.S. to be the first to land a man on the moon and return him to earth if a determined national effort is made."

The space agency suggested 1967 as a possible target date for the earliest attempt at such a feat. On April 24, Mr. Johnson heard representatives of the military services and Dr. von Braun discuss their views on the space program.

Sitting with Mr. Johnson at this meeting were three close friends: George Brown, of the Houston construction company of Brown & Root; Frank Stanton, president of the Columbia Broadcasting System, and Donald Cook, of the American Electric Power Corporation.

Air Force Gen. Bernard Schriever told the group that a manned lunar landing program should be adopted because "it would put a focus on our space program." Dr. von Braun said that the United States had "an excellent chance of beating the Soviets to the first landing of a crew on the moon," probably by 1967 or 1968.

On May 3, Mr. Johnson met with the chairman of the Senate space committee, Senator Robert S. Kerr, and its ranking Republican, Senator Styles Bridges. Space agency officials briefed the Senators on possible means of accelerating the space program. NASA had not yet specified what degree and direction of acceleration it favored; by the end of the meeting Mr. Johnson was demanding that NASA come forth with specific proposals.

The agency had been hesitant to recommend specific proposals. One reason was that Dr. Webb wanted to insure that both Congress and the President would indeed support a program with the scope of a lunar landing project. He also wanted to be sure the program adopted was technologically valid, rather than being only a response to the President's request for a spectacular first in space, and to the Vice President's desire for a full-blast space effort.

On Thursday, May 4, Mr. Johnson learned that he would be leaving the following week on an inspection tour of Southeast Asia. He asked NASA and Department of Defense officials to meet over the weekend to prepare detailed recommendations for submittal to the President.

On the next day, Alan B. Shepard was successfully launched on a 15-minute suborbital flight, becoming the first American in space. A mood of national euphoria following the flight removed whatever political obstacles might have remained to a dramatic acceleration of the American space effort.

On Saturday, space and defense officials met at the Pentagon. They agreed that the nation should undertake space programs for prestige, as well as for other reasons. They also agreed that the first program with a large prestige pay off in which the United States had a chance to be first was the lunar landing project.

If the United States decided to undertake such a project, they thought that it should be publicized in some dramatic fashion, such as setting a lunar landing as a national goal.

In picking the lunar landing as the central feature of an accelerated space program, the Pentagon group had no firm intelligence estimates on whether the Soviet Union was already embarked on a similar undertaking.

The group formulated a program calling for United States preeminence in space. Not only would the United States undertake to beat the Soviet Union to the moon, but other space programs in which the United States could excel would also be accelerated. These included communications and meteorological satellites and nuclear propulsion, as well as scientific programs.

These recommendations were incorporated in a memorandum signed by Dr. Webb and Secretary of Defense Robert S. McNamara. The memo was delivered to the Vice President on May 8; Mr. Johnson added his approval and forwarded the memorandum to the President on the same day. On May 10, Mr. Kennedy ratified the recommendations, without change.

One remaining area of controversy was the schedule that Mr. Kennedy should announce for the lunar landing. Budget plans were based on a 1967 target date. The first draft of Mr. Kennedy's speech announcing the decision mentioned that year as a goal.

The space agency, realizing the difficulty of meeting distant target dates, suggested that the President should set the date for the landing as within the decade, and the White House accepted the suggestion.

On May 25, Mr. Kennedy announced his decision. In the following months, Congress approved the acceleration of the space program, almost without dissent.

The lunar-landing decision was the product of a long and complex process, one typical of the way in which major national decisions are reached. As in all such decisions in the pluralistic American political system, a wide variety of interests were served by the decision to go to the moon.

For those who had always favored a large space program, the lunar-landing project provided a focus around which that program could grow. For those planning future space flights, the moon was the logical first step in the exploration of the universe.

For the American nation, stung by continued Soviet space firsts and insecure in its position as the leading world power, the lunar-landing decision was a congenial means of restoring national pride and of once again demonstrating the superiority of the American way of life.

All of these views converged on the White House. John Kennedy, at first uncertain but finally convinced that the United States should accept the Soviet challenge and seek to be first in space, calculated the costs, weighed the need, and finally decided that "we should go to the moon."

SO THERE HE IS AT LAST. Man on the moon. The poor magnificent bungler! He can't even get to the office without undergoing the agonies of the damned, but give him a little metal, a few chemicals, some wire and twenty or thirty billion dollars and, vroom!, there he is, up on a rock a quarter of a million miles up in the sky.

Ask him, "Man, why are you up there on that rock?" And the best reply he can give you is a tired old wisecrack. "Because it's here." He doesn't even know what makes him tick.

What he is doing up there is indulging his obsession with the impossible. The impossible infuriates and tantalizes him. Show him an impossible job and he will reduce it to a possibility so trite that eventually it bores him.

Because it was impossible to make the night blaze with light, he did it. It was impossible to put the world in a box in the living room, so he did it. Because it was impossible to fly, he flew. Impossible to bring the sun's power to earth? Of course. So he released nuclear energy.

The impossible he does with dispatch, but do not bore him with requests to try the possible. He believes with Browning that a man's reach should exceed his grasp, and he is very good at reaching. What he is capable of grasping, however, he has little stomach for.

Like Ahab on the doomed Pequod, he would rather die attempting to assert his mastery of fate than cope with the workaday excitement of doing the possible. This is why the triumph of man on the moon is diluted with so many banal ironies. How ingenious, we may rightly marvel, that man was able to provide himself on this adventure with a pure atmosphere to breathe on that airless rock.

How ironic that while he was contriving to breathe pure air on the moon, he was at the same time poisoning the sweet air of the home rock with the by-product garbages created by old impossibilities overcome.

IT IS ENTIRELY, DULLY, BORINGLY POSSIBLE, of course, to preserve the air of the home rock, which is why man has so little appetite for doing it right now. Later, when he is told authoritatively, with the proper Doomsday voice, that it is impossible to salvage enough air here to keep him alive, his blood will stir and he will start trying.

The same principle applies to the other possibilities he declines to pursue because they are "too expensive," or "too complex," or because somebody—industry, labor, kids, parents, blacks, cops, the Establishment, the Russians, etc.—"wouldn't stand for it."

The public school system, for example, was allowed to decay for years when it was possible to do something about it and will probably rot a few more before it is pronounced "impossible" and man's juices begin to flow at the challenge.

When the juices do begin to flow, man is a formidable fellow indeed. Cranking up for one of his impossible feats like going to the moon, he immediately creates for himself the kind of environment necessary for him to perform at his peak. This of course is the same kind of environment he could easily live in at home if doing the possible were not such a bore.

The space vessel must take air. Shall it be the kind of air he breathes in his cities? Good God, No! Get us some air that's fit to breathe. How about some water from one of the great American rivers or lakes? Insanity! Men's lives will be at stake.

Shall we cut corners on rocket development in order to hold down costs, as we do with programs for mass transportation and city maintenance? Congress, President and public wouldn't dream of it. The lives of three men would lie on their consciences. Let the billions be poured.

No one would dream of asking three men to stake their lives on a program financed as parsimoniously as the programs affecting the lives of the multitudinous poor and city dwellers.

No one would dream of manning the rocket with the product of the typical ghetto school, or of fitting it with equipment of the shoddiness that goes into millions of cars and home appliances.

Doing the impossible, man contemptuously abandons the standards of the shabby everyday world he inhabits, a world made shabby by his blundering refusal to tackle the possible. And now he is up there and marvels at himself. They said it couldn't be done, so he did it. And if somebody points out something else that can't be done, he'll show them by doing that too.

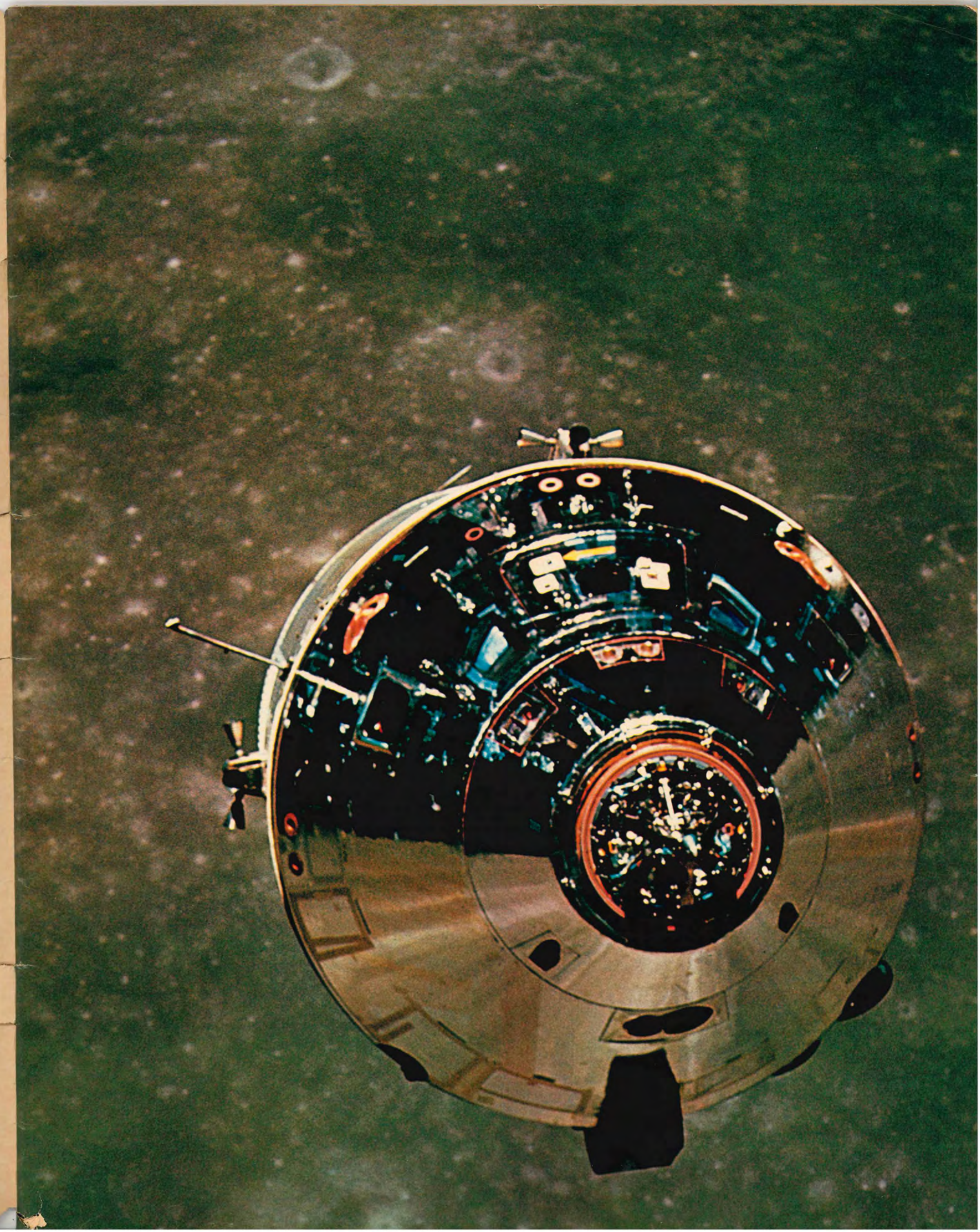
IT IS HARD NOT TO LIKE HIM UP THERE. Moby Dick got away from Ahab, but now man is having another last word by bringing back the big one.

("Look what I got in there." "Hey, isn't that—?" "That's right, Jack, that's the old June-croon-moon itself. Bigger than the white whale and twice as dead.")

What courage! What ingenuity! What excellence! What a shame that he will now come back to the mother rock and continue to shirk its possibilities.

And why did he do it? Because it was there? Not really. He did it because it is intolerable to him to know that there is any place in the universe where man can not leave his tracks and boast to an astounded posterity that "Kilroy was here."

By RUSSELL BAKER



THE FUTURE

The time will come when the cost of a lunar journey may be comparable to that of round-the-world jet travel today. Then: moon pollution?

By ARTHUR C. CLARKE

FOR thousands of years the moon has signified many things to mankind: a goddess, a beacon in the night sky, a celestial body, an inspiration to lovers, a danger to beleaguered cities, a symbol of inaccessibility —and finally, a goal.

In only 10 years, this last image has become dominant, but the change has occurred with such explosive speed that most of the world has not yet made the necessary emotional and mental adjustments. The stunning impact of the first closeup photographs still seems only yesterday; last Christmas, the crew of Apollo 8 swept over the far side of the moon and sent their greetings back to earth, 240,000 miles distant. Now, even before the wonder of that event has abated, we have landed.

There may be setbacks—perhaps even disasters—in the years ahead; it is unreasonable to suppose that the conquest of a new and strange environment will not demand its toll. But men have never hesitated to pay the price, in blood as well as treasure, of exploration and discovery. Nor will they hesitate now, as they stand, for the second time in a thousand years, on the frontiers of a new world.

Like all human achievements, travel to the moon will pass through three phases: impossible, difficult, easy. The parallel with the development of commercial aviation will be close, though the time scale may be longer because the challenge is so much greater. But it is naive to imagine that lunar flight must always be an enormously expensive operation and that astronauts will always be highly trained pilots, scientists, or engineers.

If you run your car for a day, the engine does enough work to take you to the moon; the actual cost of the energy involved for the trip is only about $10. The fact that the present cost is millions of times greater is the measure of our present ignorance and the primitive state of space technology; the time will come, through the use of reusable boosters, orbital refueling, nuclear propulsion and other foreseeable developments, when the cost of a lunar journey may be comparable to that of round-the-world jet flight today.

It is obviously impossible to predict in detail just what we shall do with an Africa-sized world, the resources of which are still almost entirely unknown. However, the moon provides such tremendous opportunities for so many types of research that every effort will be made to establish temporary bases there as soon as possible, analogous to those already set up in the Antarctic and those that may be established on the seabed.

Beyond the immediate deployment of small instrument packages, we may eventually expect physics laboratories and astronomical observatories. At first, they will be remote-controlled and visited from time to time by servicing crews; later, they will be permanently manned.

The moon might have been designed as the ideal site for an astronomical observatory. Its almost total absence of atmosphere means that seeing conditions are always perfect, not only in visible light, but also in the vitally important ultraviolet, X-ray and gamma-ray regions of the spectrum, which are totally blocked by the earth's atmosphere. The low gravity and absence of wind forces will also greatly simplify the design of large instruments; and the slow rotation means that objects can be kept under continuous observation for two weeks at a time.

These advantages, great though they may be for the optical astronomer, will be even more overwhelming for the radio observer, who can also find another bonus on the moon. At the center of the far side, he will be permanently shielded from all the electrical noise and interference of civilization by 2,000 miles of solid rock. A hundred years from now optical and radio astronomers will find it hard to believe that serious observing was ever possible on earth.

To the geologist, the moon represents a bonanza of more value than all the gold mines ever found. Until now, he has had a single example of a planet to study. How much would a biologist know of life, if he had been allowed to examine only one specimen of our planet's teeming flora and fauna?

The evolution and geological history of the moon may be wildly different from that of the earth; we are not even sure whether the two bodies were once combined or whether the moon had an independent origin and was later captured. One recent theory suggests that it is a residual 'drop', a sort of umbilical

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Mr. Clarke is a British scientist and writer on space exploration and of science fiction, including "2001: A Space Odyssey." He was one of the first to suggest the use of satellites for long-distance communications.

fragment left over when the earth and Mars split asunder from an ancient protoplanet.

Whatever the facts, we can be sure that the moon will provide many exciting and valuable surprises. Indeed, it has already done so. In the astronomy books of only a decade ago, it was described as a dead, unchanged world. Now we know that there is a good deal of activity there. Orbiter photographs have shown the tracks of rolling rocks, startlingly like footprints, down (and sometimes up) the lunar slopes. There is evidence of immense lava flows, and even what looks like dried-up river valleys. If this is the case, water may still be there, locked in permafrost a few meters underground, where the temperature is constant and far below the freezing point.

The discovery of easily available water or ice would be of the greatest importance to lunar explorers. Electrolyzed, it would provide both oxygen for breathing purposes and fuel for returning spacecraft. Obviously, this last development would not be possible until large-scale engineering operations could be carried out on the moon. This is not likely for some decades, but eventually it will completely transform the economics of space flight. For a remote comparison, imagine that today's trans-Atlantic aircraft had to carry the fuel they needed for the round trip. The cost of a ticket would be reduced by a factor of perhaps a hundred as soon as it became possible to refuel in Europe. So it will be with lunar operations.

After air and water, the third immediate necessity of life is food. Many plans have been drawn up for growing totally enclosed, or hydroponic, crops on the moon, using the materials that may be found there. This idea looks particularly promising, now that the Luna and Surveyor spacecraft, in closeup views of the lunar surface, have revealed that it is neither rock nor dust, but nice, crumbly dirt.

Some years ago I suggested that it might be possible to develop plants resembling earth's with tough, impermeable skins that could grow unprotected on the lunar surface and I am delighted to discover that the National Aeronautics and Space Administration now has a project investigating this idea. Perhaps a transparent plastic sheet may be necessary to minimize the escape of water vapor; but it is at least conceivable that we may start farming on the moon without having to build pressure domes and hermetically sealed greenhouses.

The lunar vacuum, so valuable to the astronomers, may turn out to be a much exaggerated hazard to the explorers. The old myth that a man exposed to the vacuum of space will blow up like a deep-sea fish still dies hard; hopefully, the movie "2001: A Space Odyssey" may have spread the news that this is simply not true. Obviously, an unprotected man in space will die from lack of oxygen, but this takes an appreciable time. Animals have survived up to four minutes in a vacuum, and anything an animal can do, a trained and prepared man can do better. There will be many emergencies, in space and on the moon, where the 10 or 15 seconds of consciousness that a man can expect in vacuum will

make the difference between life and death.

Whether the moon has any indigenous life of its own is a question that may be answered shortly. No one expects to find higher organisms, but microscopic forms of life are a remote possibility. Hence the elaborate precautions of the Lunar Receiving Laboratory, intended to establish a quarantine in both directions.

Even if the moon is sterile, it may be avid for life. Those terrestial bacteria that have managed to thrive in boiling sulphur springs or at the bottom of oil wells should find the moon a delightfully benign environment, with consequences that may be annoying to future scientists.

It has been estimated that the combustion products and cabin leakage from only 20 landings of the Apollo type could double the mass of the very tenuous lunar atmosphere. When mining, food-production and similar activities begin, the rate of contamination will be much increased and though it may seem early to worry about lunar smog, it could be a matter of great concern to the physicists.

At the moment, the moon's surface provides a vacuum laboratory of unlimited extent. It would be the ideal place for many types of electronic and nuclear experiments. One can even imagine that the great particle accelerators of the future would be wrapped around the moon, so that the vacuum will be provided automatically, and there will be no need for today's elaborate enclosures and pumps.

This sort of experimenting, which may well revolutionize the many branches of physics concerned with vacuum phenomena, may be possible only in the early stages of lunar occupation. For sooner or later, as industry, commerce and tourism spread across the face of the moon, it will begin to acquire an atmosphere of its own.

And if it turns out, as some have suggested, that the expectation of life is considerably increased in low gravitational fields, there will be a move to give the entire moon a breathable atmosphere, probably by using biological systems to unlock the immense amounts of oxygen (probably about 50 per cent by weight) bound up in the crust. The astronomers and physicists will have to move elsewhere in search of ideal conditions, just as on the surface of this planet they have had to retreat from the lights of the cities.

And a century or so after that, as I gloomily predicted in "The Promise of Space," there will be committees of earnest citizens desperately trying to preserve the last vestiges of the lunar wilderness.

ACKNOWLEDGEMENTS

The New York Times' coverage of the Apollo 11 mission was supervised by Henry R. Lieberman, Science News Coordinator. Chief correspondent of The Times' task force was John Noble Wilford. The day-by-day account of the mission, as it appears in this special issue, was adapted by William K. Stevens, assisted by Sandra Blakeslee and Nancy Hicks.

In addition, The Times' task force at Cape Kennedy, Fla., and Houston, Tex., included Science Editor Walter Sullivan, Richard D. Lyons, Richard Witkin, Harold M. Schmeck Jr., Bernard Weinraub, Charlotte Curtis, Douglas Kneeland and Douglas M. Dederer. James T. Wooten reported from the carrier U.S.S. Hornet in the Pacific and Bernard Gwertzman followed the activities of Luna 15 in Moscow.

John M. Logsdon, Arthur C. Clarke, and Russell Baker, Times columnist, were among the special contributors. Maps and diagrams: The Times' map department headed by Andrew Sabbatini. Photos, other than those by the Apollo 11 astronauts and provided by the National Aeronautics and Space Administration: UPI, Wide World, Stanley Tretick of Look.

This book was designed by Allen Hurlburt, Director of Design of Cowles Communications, Inc. Editorial coordination with The New York Times: David Maxey, Washington Editor of Look, John Kronenberger, Edith Schur.

Picture Research: Sam Young, Photographic Editor of Look, and Myra Schachne.

Production: William Rosivach, Art Production Manager of Look, Norman Hotz, and Leemarie Burrows Bernstein.

Published by Cowles Communications, Inc.
488 Madison Avenue, New York, New York, 10022.

Coming:
space stations
and tomorrow's answer
to the DC-3.

If the moon did not exist, the Apollo program would still be necessary—to establish the manned "space stations" of the 1970's. Communications and meteorological satellites have proved that many earthly problems can be solved *only* in space. And from thousands of miles above the turning globe, orbiting electronic eyes have already disclosed new resources of land and sea beyond the reach of ground observation. But we cannot exploit the full potential of space until men can operate there. Fifty million dollar satellites have failed because of a single small component—expensive proof that we need repair and maintenance crews in orbit. To get them there cheaply will require spacecraft that—unlike today's rockets—can be flown over and over again. Such reusable vehicles (perhaps stubby, winged ships that can land at ordinary airfields) are already on the drawing boards. They will be the DC-3's of the Early Space Age—for they will herald the true dawn of interplanetary commerce.

FROM "APOLLO & BEYOND,"
BY ARTHUR C. CLARKE, LOOK, JULY 15, 1969.


UNITED STATES
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B-3
A-3
4
UNITED STATES

"That's one small step for a man . . . one giant leap for mankind."