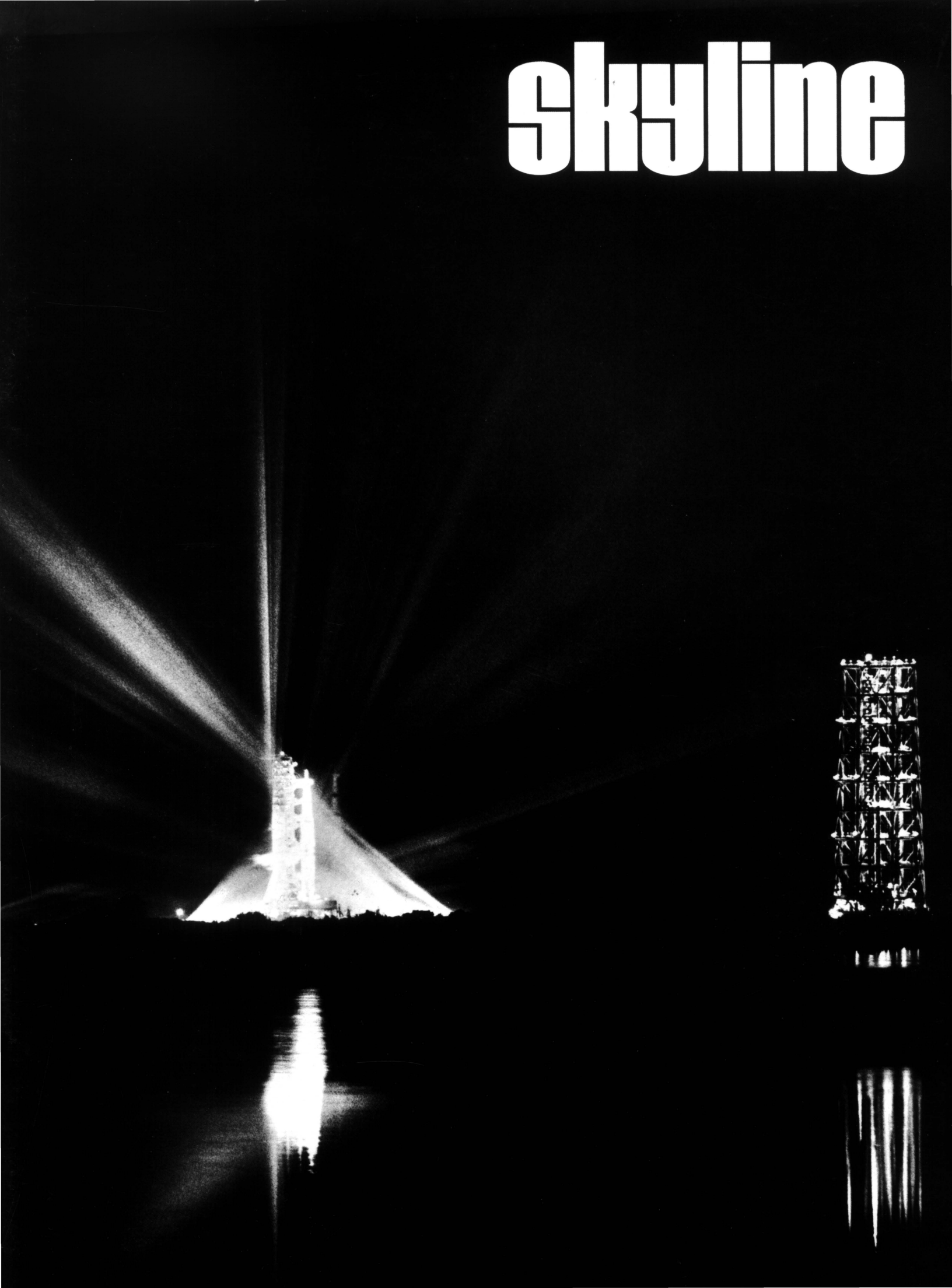
skyline



With a sustained roar that deluged nearby viewers in convulsions of sound and pressure waves, Saturn V number 506 is boosted off its pad, left, with more than 7.5 million pounds of thrust from its five clustered F-1 engines during the first tense seconds of the Apollo 11 voyage to the moon. The launch and mission climaxed years of all-absorbing effort by hundreds of thousands of Americans across the country, including a large percentage of North American Rockwell employees. And the eventual fulfillment of all goals, set forth in May 1961, touched off an enormous national sentiment of pride — in the daring boldness of the mission, in the master craftsmanship that produced the hardware, and in the courage and enthusiasm of astronauts Neil Armstrong, Edwin Aldrin and Mike Collins.

The Cover:

Flaring floodlight beams lend artistic image to the Apollo 11 space vehicle during the final hours of its countdown, leading toward launch at 9:32 a.m. EDT, July 16. For a profile of that historic day, see page 4.
Front and back cover photos by Bill Susoeff.

Contents:

skyline

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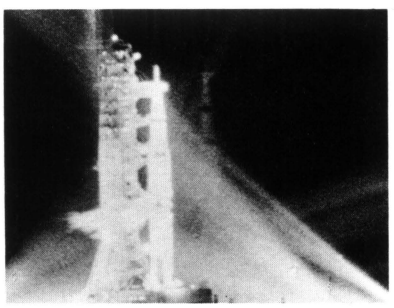
L. B. Taylor, Jr., *Editor*

Pages 5-10, NASA photos. Pages 28, 30, 31 and 33, U.S. Navy photos. Page 38 left, U.S. Air Force photo.
Art and Production, Executive Offices Services.

North American Rockwell
Aerospace & Systems Group

THE DAY APOLLO 11 WAS LAUNCHED

A Candid, at-the-Scene Account of Events Leading to Man's Grandest Adventure



Midnight. The terminal portion of the countdown for a launch that was committed as a national goal more than eight years ago has now been underway an hour. Liftoff — if each of thousands of items in the master countdown manual clicks off without a major "glitch" — will occur at 9:32 a.m. Eastern Daylight Time.

All five previous Apollo/Saturn V launches, four manned, have gone on the button. "You could set your watches by them," Rocco Petrone, NASA's director of Launch Operations at the Kennedy Space Center once noted. It has not been said openly, but the 450 engineers and technicians in Firing Room One of the Launch Control Center (LCC), want very badly to get this one—the big one—off on time. "We all have 'go fever'," one official acknowledges.

Three and a half miles to the east, on octagonal-shaped pad 39A, bordering the Atlantic Ocean, there is a surrealistic scene that dazzles the eye. Millions of candlepower focus on a sleeping giant, 36-story-tall Saturn V rocket number 506. More than a decade in planning, years in building, and months in assembling and checking out, it now stands alone and erect. Though the great white streamers of light paint a bizarre, incandescent scene that assaults the visual senses, (see cover), there is a near-total contrast aurally; an eerie calm. In the soft easterly breeze only the far off whine of generators can be distinguished. There is no sound to indicate the momentous event soon to come.

For half an hour the pad has been cleared of all personnel.

00:14 The first entry of July 16 recorded in the logbook of Bill Schick, test supervisor for the launch, states tersely: "Start S-IVB lox fill." Interpreted, this means liquid oxygen has begun to be pumped into the rocket's third stage. The propellant loading in all three stages of the vehicle will progress through the morning, with replenishing touches up to a minute or two before liftoff.

01:15 Lox fill into the cavernous, 81½-foot-tall S-II second stage is now 95 percent complete. Assembly of this S-II began more than two and a half years ago at North American Rockwell's Space Division facility in Seal Beach.

Now eight hours and 17 minutes from launch, the countdown has been running with remarkable smoothness.

02:53 Ominously, a trouble light flashes in LCC. Officials quickly decide the exact nature of the problem cannot be diagnosed without sending men into the pad area. A team is dispatched. Within three minutes they detect a faulty amplifier used in the relaying of signals from the pad to the LCC, and they reset it. The count continues.

03:30 Public Information Officer Jack King, providing running commentary on countdown events for the thousands of newsmen and VIPs who have begun to assemble on site, announces: "The weather is very satisfactory this morning. There is a thin cloud cover at about 15,000 feet. Temperature at launch time is expected to be 85 degrees."

Off on the horizon, perhaps 100 miles or so over the ocean, a thunderstorm brews. It will not come close enough to affect the flight.

04:15 In the Manned Spacecraft Operations Building, eight miles from the pad, astronauts Neil Armstrong, Buzz Aldrin and Mike Collins, probably the most rested men in the area, are awakened after an eight hour sleep. They shower, shave and breakfast on the traditional orange juice, steak and eggs. Then they begin the laborious task of suiting up.

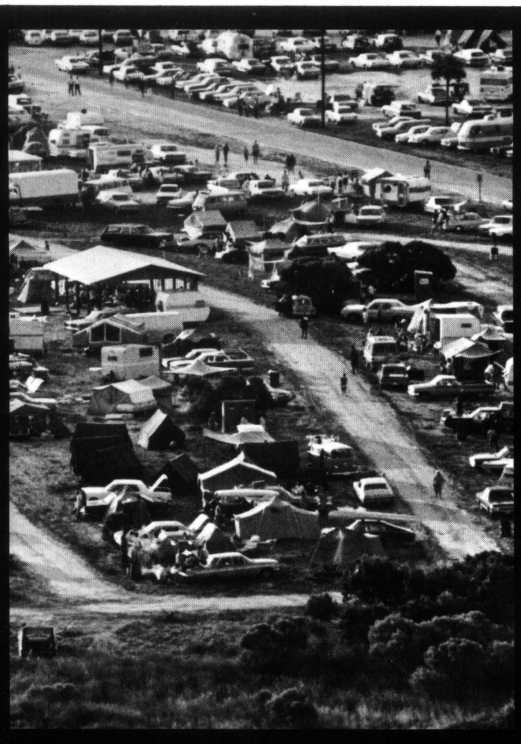
04:30 A built-in hold halts the countdown at T-minus three hours and 30 minutes. This is a planned final breather to allow for any catch-up work that might have to be done, before getting into the final phase of the count, when the tempo of action accelerates.

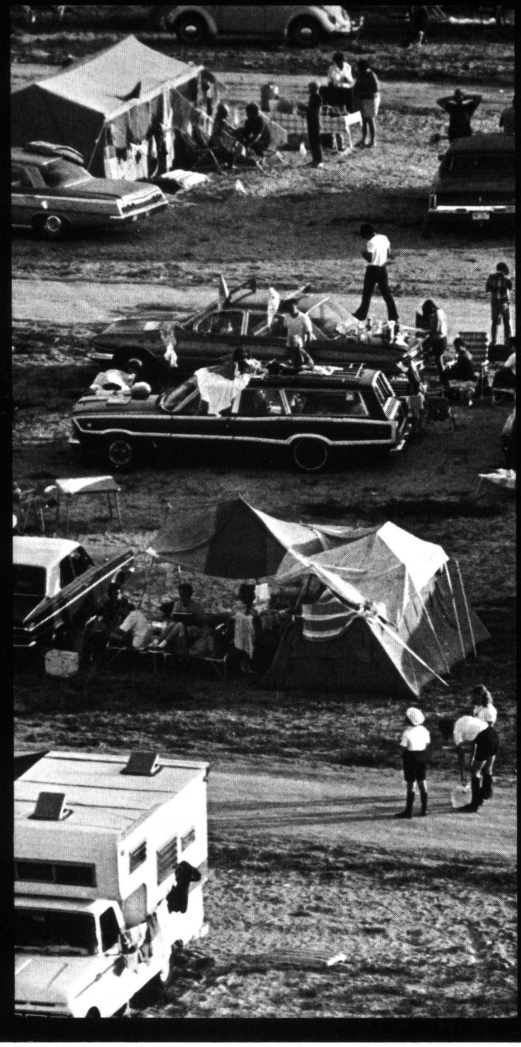
05:33 Things have gone so well thus far, the closeout crew — backup astronaut Fred Haise, NASA quality control inspector Cedric Chambers, and pad leader Gunther Wendt and technician John Grissinger of Space Division's Launch Operations—is dispatched from A-5 roadblock to the pad several minutes ahead of schedule. They proceed up the elevator to the 320-foot level in the tower, then cross over a swing arm to the "white room" which encloses Apollo spacecraft 107.

As they enter it, viewed on closed circuit TV by launch controllers in the LCC, they inexplicably dash about slapping at the air in a wild pantomine scene. Somehow, a moth, attracted by the dazzling lights, has entered the sterile-like environment. It is caught, and the work begins. A number of vital chores must be performed in a limited amount of time. Grissinger removes a boost protective cover and opens spacecraft 107's main hatch in preparation for the astronauts' entry. Water is chlorinated and equipment is set up for a cabin leak check.

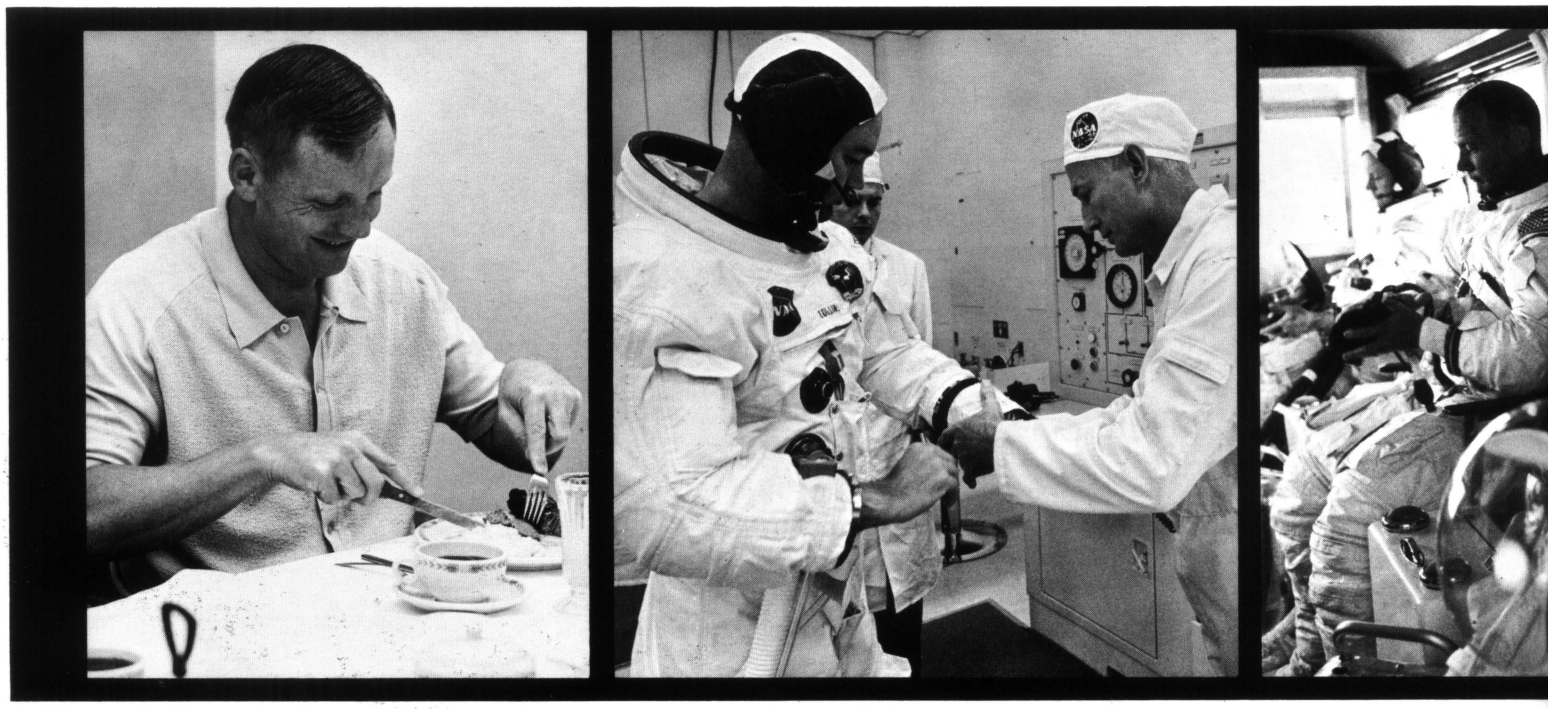
05:40 In the east, the sky slowly changes color from black velvet to midnight blue. As one walks about, there is a

Irrepressible lure of eye witnessing history in the making brought hundreds of thousands of viewers into Brevard County for the launch. Many, below, camped out. Vice President Spiro Agnew, below center, led a VIP delegation that numbered in the thousands. He is flanked by Apollo 8 astronaut William Anders, left, now Executive Secretary of the National Aeronautics and Space Council, and Dr. Thomas Paine, NASA Administrator. Pre-launch activity in astronaut quarters is reflected in bubble helmet of Buzz Aldrin, bottom.





Traditional, launch morning breakfast of steak and eggs is downed by Neil Armstrong, below. Command module pilot Mike Collins receives finishing touches on arduous suiting up process. Each to his own thoughts: Apollo 11 crew members Armstrong, Aldrin and Collins enroute to launch pad in transfer van. Armstrong, far right, leads way across swing arm from mobile launch tower to Apollo nestled high in the Saturn V "stack" at complex 39.



strange sense of wonderment in looking back upon footprints in the sand. Soon, man will take similiar steps, and leave similar imprints—on the surface of the moon. It somehow seems unreal.

06:02 The built-in hold period ends. The count resumes.

06:07 Possible trouble. A valve leak is detected during final phase fueling of the rocket's third stage, at the 200-foot level of the launch tower. Calling upon the experience of five past Saturn V launches and the Countdown Demonstration Test (CDDT) for Apollo 11, officials quickly diagnose the problem. A similar leak occurred during the CDDT—a dress rehearsal of the final count that was held a few days before the launch date. A similar "fix" is thus recommended, and a technician, engineer and safety man are sent to the pad. The repair is soon made. The count moves on.

06:27 Bright, chipper and ready to go, Armstrong, Aldrin and Collins depart their quarters on Merritt Island for the trip to the pad. They give a thumbs up sign and are greeted with cheers and applause from hundreds of space workers and reporters who have been waiting to see them off. They climb into a special van, escorted by security police cars with flashing blue lights.

Several minutes later they arrive at the launch site. As they walk toward the elevator they pass four Burma Shave-type signs, spaced apart. They read: "The key . . . to the moon . . . will be found . . . soon." They ride the elevator up, cross the swing arm and enter the white room. A member of the closeout crew hands them a fire-proofed, foam-covered key inserted in a four-foot-long crescent-shaped moon. It brings smiles. The astronauts, too, have gifts for the closeout crew members: a free ticket for a space taxi between any two planets, and an eight-inch-long "trophy" trout mounted on a plaque. The trout is not stuffed, and the smell brings more smiles. Such tension-loosening exchanges have taken place since the early days of the Mercury Program.

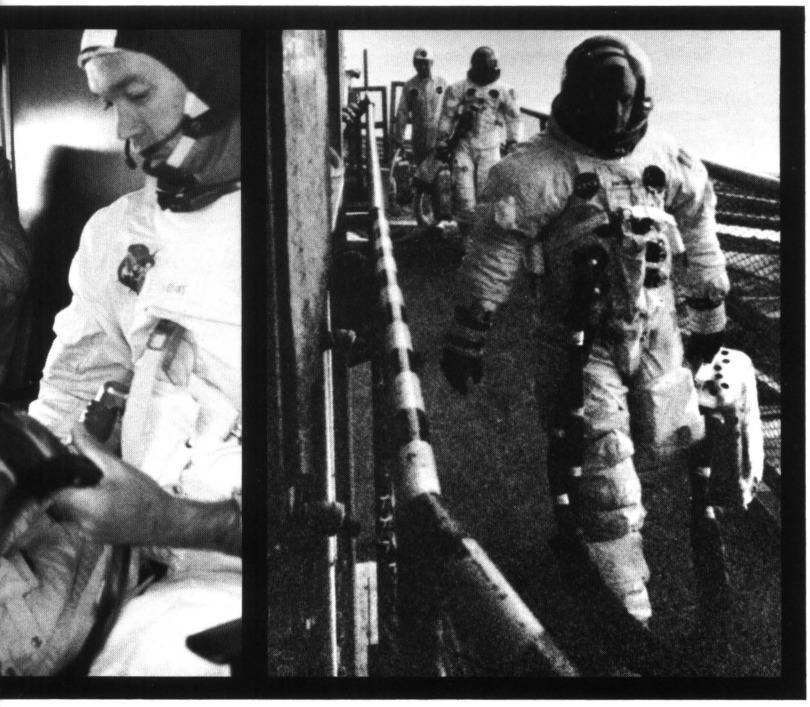
The astronauts begin entering their spacecraft, as fine a piece of precision machinery as man has ever fashioned; one that Space Division employees in Downey began assembling over three years ago, and Launch Operations specialists have been grooming at KSC since January.

07:25 The command module hatch is closed. Liftoff is two hours and seven minutes away. Outside, a bright solar fireball slowly rises above the ocean horizon.

07:30 Brevard County Civil Defense officials estimate there are one million people in the immediate area to witness the beginning of what has been described as "the most magnificent endeavor man has ever attempted." Causeways, surface streets and beaches are jammed. Some people have driven thousands of miles. Bumper strips read, "I was there when America put men on the moon." There is an almost carnival-like atmosphere in the surrounding cities of Cocoa Beach, Cocoa and Titusville.

One salesman has driven his wife and four children across the southland from Jennings, La., in a camper trailer, coinciding his vacation with the published launch date. "I just felt we ought to be here," he says. "I want my kids to see this." His feelings are widely shared. It is an exciting day to be an American.

One ponders the fact that this surely is the most prepublicized event in history. Past explorers, from Columbus to Lindbergh, sailed off in relative anonymity, receiving acclaim only after accomplishment.



There are 3,497 accredited newsmen on site. It is by far the largest number ever assembled at one time in one place for anything. More than 700 are foreign correspondents, representing 54 nations, ready to relay their accounts of the launch around the world by telephone, telegraph, radio and TV satellite.

A half mile north of the press site is the VIP area. Among the dignitaries are Vice President Spiro Agnew, Chairman of the National Aeronautics and Space Council, former President Lyndon Johnson, several members of the cabinet, hundreds of congressmen and more hundreds of foreign ambassadors and ministers, in addition to scores of celebrities.

08:11 In the sealed spacecraft, Neil Armstrong runs through a series of guidance system alignment checks. Everything is running so smoothly Tom O'Malley, NR director of Apollo/CSM operations in Florida, is concerned about keeping his people on their toes. "The only thing out of the ordinary is the fact there's nothing out of the ordinary," comments Tom Baggette the company's spacecraft test conductor.

A thousand miles west, at NASA's Manned Spacecraft Center in Houston, Pat Hanifin, manager of structural and mechanical design for Apollo, Downey, and others around him busy themselves by posing "what if" problems. They speculate what could go wrong at any point and try to anticipate fast solutions. Hundreds of engineers and technicians, scattered throughout the nation, sit and wait — ready for a possible summons from Mission Control to troubleshoot "anomolies" that might arise during the count, or later, in space.

Hanifin is in MSC's support room, as are two NR experts for each of Apollo's major subsystems. Also available for instant counsel, if needed, are such executives as William Bergen, Space Division president; Dale Myers, vice president; and George Jeffs, Apollo program manager. Linked to them by hotline are another 100 technicians and systems experts at Downey, providing additional banks of expertise to draw upon. In Florida, launch site veterans such as O'Malley, Buz Hello, vice president of Launch Operations, and Al Martin, director S-II operations in Florida, stand by with members of their staffs.

But this morning their talents and knowledge are not needed. It continues to be a remarkably smooth count.

08:22 The closeout crew, their work completed, leaves the pad 15 minutes early. Now there are only three men left on 39A, and they will travel half a million miles before touching Earth again.

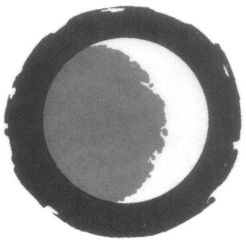
08:37 T-minus 55 minutes and counting. Swing arm 9, extending from the launch tower to the spacecraft, retracts. Should a catastrophic condition arise now, the astronauts would fire their escape rocket and be catapulted out of the danger zone inside Apollo.

08:49 Countdown sequence events in LCC are moving swifter. The pace quickens as key items on the master checklist are ticked off, one by one: "Command carrier on . . . attitude command test complete . . . power transfer test complete . . . lunar module is on internal power."

There is an indescribable aura of tenseness—a subconscious submission to the fact this is the big one—but professionalism overrides this. There is no choking up. The monitoring, the checking, the testing runs quickly through the final hour of the count. All boards flash green.

09:10 "This is really when we earn our money," Petrone says. "Up to now it's been important. But the last 22 minutes, when the gases start to flow, we start to chill, start our subcooler, start our recirc pumps, that's when we're watching the values. We've trained the team. We know what numbers we want to see, and I must say, personally, I sweat them out every time."

In sterile-like confines of "white room" surrounding the spacecraft, an Apollo 11 astronaut prepares to enter, aided by North American Rockwell member of the closeout crew.



09:27 Five minutes to liftoff. Over the intercom in LCC, final status reports ring off:

"Spacecraft, test conductor."

"Go."

"Launch operations manager."

"Go."

"Launch director."

"Go."

"Lunar module test conductor."

"Go."

09:27:40 Test supervisor Schick gives the word: "Cleared for launch."

09:28:50 "Firing command on." The automatic sequencing system is initiated. Events during the last three minutes and 10 seconds are done automatically by computer. Engineers and technicians eye their consoles, alert for any warning signal, any red light flashing, which would probably mean a halt in the count and a recycle to T-minus 22 minutes. There are no red lights.

09:30 T-minus two minutes. Saturn V's propellant tank vents have been closed and the stages are pressurizing.

09:31 T-minus 60 seconds. In the LCC, NASA's launch vehicle operations director, Dr. Hans Gruene, a veteran of three decades in rocketry dating back to the early days of Peenemuende, thumbs the lapel of his threadbare "lucky" blue suit. He has worn it to more than 100 launchings—all successful—since 1955.

09:31:30 T-minus 30 seconds. The astronauts report everything is fine. At the press site, the VIP site, throughout Brevard County and across the nation and world, a hush sets in, as a million people in person and tens of millions more, via television, watch the launch pad. It is a tingling silence.

It is "apasionada intrega" — (moment of truth) for hundreds of thousands of dedicated workers—at Space Division in Downey, Seal Beach and Florida, at Rocketdyne, at the Tulsa Division and Autonetics, and at thousands of other plants across the nation. It is the culmination of years of these people's work, their long hours and dedication, their devotion and pride in workmanship. Man has done everything humanly possible to make Apollo/Saturn V a perfect vehicle. Now that grand effort is to be tested against the most ambitious physical goal ever set.

09:31:45 T-minus 15 seconds and counting. A thousand motorized cameras are set in motion. Dramatically, over the loud speaker system comes the voice of Kennedy Launch Control: "T-minus 10 . . . 9 . . ." The ignition sequence on the five giant, Rocketdyne booster engines commences.

"7 . . . 6 . . . 5 . . ." Torrents of eye-smarting, bright, peach-colored flame funnel down an asbestos-coated reflector and swoosh out for hundreds of yards on two sides of the pad. An instant later sound catches up to fury as a sustained, rolling shock wave of thunder whooms across the flatlands surrounding complex 39, sending scores of birds on the wing.

"4 . . . 3 . . . 2 . . ." Now all engines are running full bore. Powerful holddown arms, which have held the straining rocket, now generating more than 7.5 million pounds thrust, retract.

" 1 . . 0 . . . Liftoff! We have a liftoff at 32 minutes past the hour." At this instant, the moon is precisely 218,096 miles distant.

"Fantastic," someone utters. "Beautiful." Superlatives are overtaxed. Others stand and watch in silent awe. "My God," a woman exclaims, "they're going to the moon!" From the VIP viewing site Senator Edmund Muskie says: "If I ever needed any extra reason to be proud of America, this would be it."

Liftoff comes 724 milliseconds—less than three quarters of a second—late, and that only because the automatic sequencing system has to be tripped in the middle of a second. The timing is so near to absolute perfection, officials joke that the astronauts must be replaying a practice tape.

Inching ever so slowly upward, Saturn V, weighing more than six million pounds before ignition, begins the odyssey set forth in 1961 by John F. Kennedy. The thirsty F-1 engines gulp propellants at a prodigious rate—2,230 gallons a second. By the time the rocket has cleared its launch tower—10 seconds after liftoff—it has already lost 300,000 pounds of its burden. Riding a cascading waterfall of flame nearly a thousand feet long, its acceleration increases at a startling rate, shoving the three astronauts hard against their contoured couches inside the command module.

09:33 "All is well at Houston. You are good at one minute," reports ground capsule communicator Charlie Duke.

Traveling at nearly half a mile a second, Apollo 11 quickly passes through "Max Q"—the region about 40,000 feet up where maximum aerodynamic pressure grips the rocket—without incident. Moving faster than the speed of sound now, Apollo 11's passengers can no longer hear the roar of the rocket's engines.

09:34:30 In two and a half minutes the booster has shoved Apollo 11 to a speed of 6,198 mph and an altitude of about 40 miles. Its job is done. The engines shut down and the massive first stage separates and falls back into the Atlantic Ocean. Within seconds, the five Rocketdyne J-2 engines on the second stage, producing more than one million pounds thrust, ignite to continue the drive toward Earth orbit. At an altitude of 60 miles, Apollo 11's launch escape tower, no longer needed, is jettisoned.

09:41 After more than six minutes of powered flight, the second stage engines shut down and the stage is separated and falls away. The spacecraft and the S-IVB third stage are now soaring at a near-orbital velocity of more than 15,000 mph, about 117 miles above Earth. The S-IVB's single J-2 engine lights, to provide the final burst of speed needed to reach Earth orbit. Conversation between the spacecraft and ground goes like this:

"Outboard engine cutoff—and ignition."

"Engine confirmed, thrust is go."

"And we have a good third stage."

Cryptic, hand written notes record commencement of man's greatest adventure: pages from the logbook of Apollo 11 test supervisor Bill Schick. Press representatives from all over the world covered launch, below. At instant of liftoff, Launch Control Center personnel, bottom, watch journey's beginning. Intense concentration marks profiles of Kennedy Space Center Director Dr. Kurt H. Debus and Launch Director Rocco Petrone, bottom right. Petrone recently was named Apollo Program Manager, succeeding Lt. Gen. Samuel Phillips.

82

WEDNESDAY APOLLO 11 FULLER
7-16-69 LAUNCH COUNTDOWN SCHICK/STRAY

0910 S-II START TNK CHILLDOWN IN PROGRESS

0918 S-IVB START TANK IN PROGRESS.

0920 ATTITUDE RATE CARDS COMPLETE

0922 S-IVB TRUST CHAMBER CHILL IN PROGRESS

0923 HELICOPTER WANTS TO TAKE OFF FROM PRESS SITE (EMERGENCY).

0924 72° 03' 34" FIRING AZIMUTH.

0925 S/C READY FOR LAUNCH

0926 ALL GO FOR LAUNCH

0927 S/A'S FULLY RETRACTED.

0927 S-IVB CHILLDOWN COMP.

0927:60 CLEARED FOR LAUNCH

0929 FIRING CMD ON

0930 T-2 MINUTES.

83

0931.10 TWR X-FER

0932 T-0 LIFT-OFF

1000 AAS PURGED DOWN

1040 EST 1130 FOR CREW 3 TO GO INTO PAD (DAMAGE ASSES)

1158 HOUSTON GIVES GO FOR TLI

1212 EXPECT PAD OPEN IN 20 MINUTES

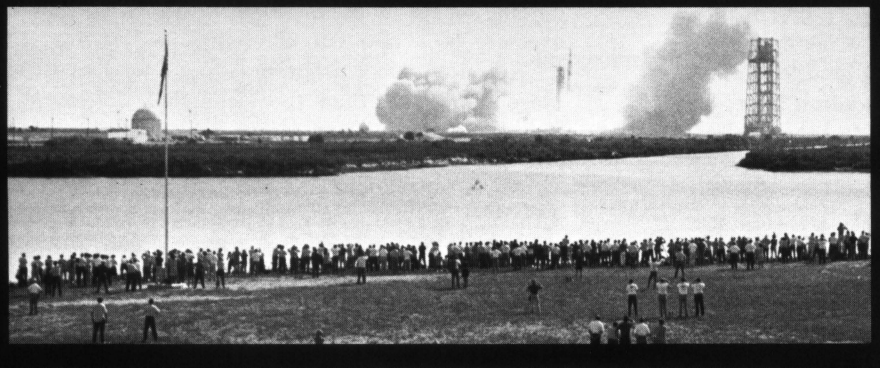
1216 TLI

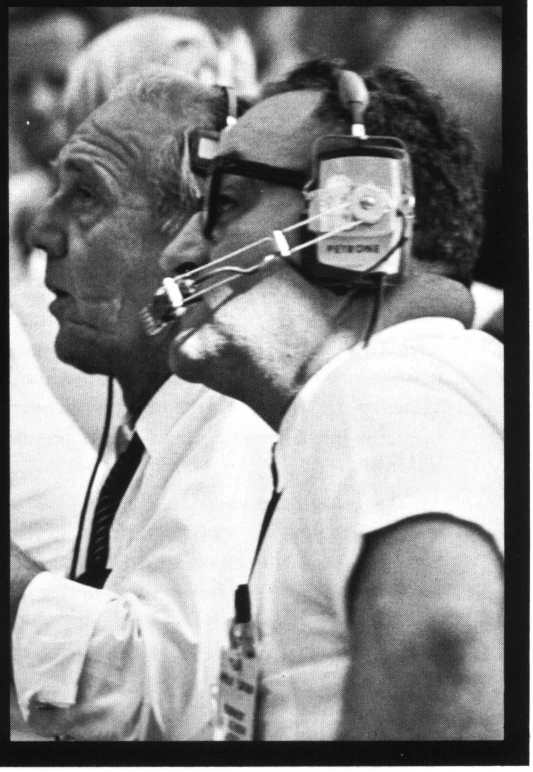
1222 S-IVB CUTOFF

1222 REPORT OF MAN HURT ON THE 60' LEVEL - AMBULANCE DISPATCHED

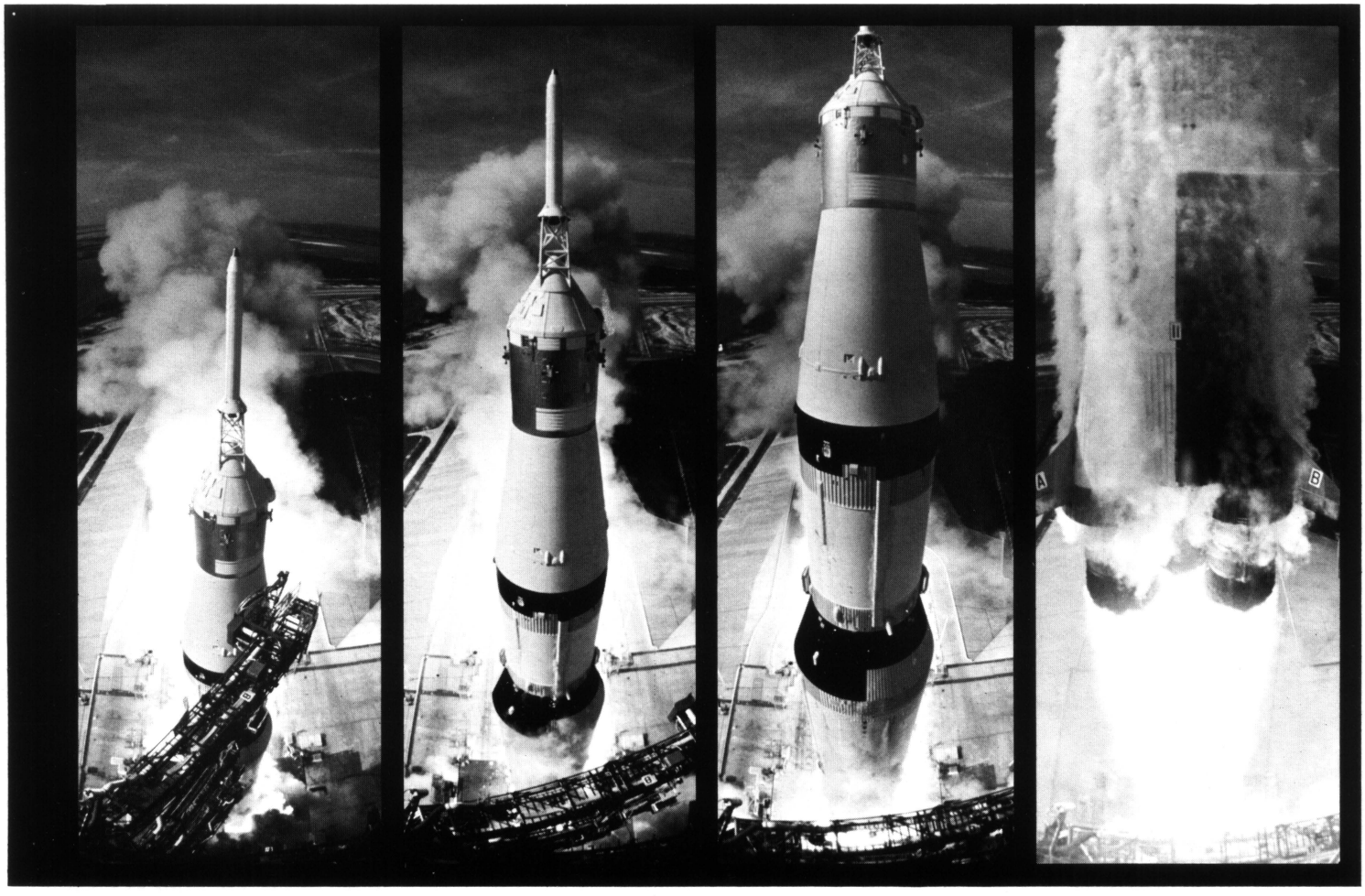
1225 P.A PAD A IS OPEN FOR NORMAL WORK

1249 SIVB-CSM SEPARATION





Earth-shaking power of five Rocketdyne F-1 booster engines, producing more than 7.5 million pounds thrust, is dramatically captured in this film sequence by remote camera placed in the mobile launch tower. Engines were consuming 2,230 gallons of propellants per second.



09:43 Less than 12 minutes after liftoff, Apollo 11 enters into orbit 118 miles up at a speed of 17,686 mph.

In the Launch Control Center there is a loud, collective cheer as the orbit is assured. Petrone is to admit later: "I have to say, there's no question, you could feel the tension. Everyone knew this was the big one, the one we've worked so hard for all these years. And let me say, once we got into orbit we did have a few moments of relaxation in the firing room. There was elation and lots of pride."

Dr. George E. Mueller, NASA's associate director for Manned Space Flight, tells the launch team: "I must say that this is the most professional countdown, the most professional operation, most professional crew and the best viewing in the history of our program. Six successful launches on time is a record that has never been achieved before.

"As I look forward in the months and years ahead to other missions to carry men from this planet to other planets—first the moon and then to Mars and on, I'd like to say that I can't think of a better foundation than the efforts and perseverance and the dedication of all you people in these many years that have made this possible."

Eyewitness Vice President Agnew is moved to comment: "With the liftoff of Apollo 11, America enters a new age of discovery. As today marks the beginning of man's landing on the moon, the flight of Apollo 11 represents the overture to a new era of civilization.

"America's space program is first a mission of the spirit. More impressive than the technological triumph of our industry and the valor of our astronauts is the historical promise of this moment.

"Never before has a free society mobilized its resources with such energy with only peace and pure knowledge as objectives. Our national space program is tangible proof that a society can succeed in pushing back the barriers of ignorance, penetrating ancient mysteries, producing man-made miracles.

"We celebrate Apollo 11 as a milestone which marks the beginning and not the end of man's role in space.

10:08 The flight surgeon reports heartbeats of the three astronauts as: Armstrong, 110; Collins, 99; Aldrin, 88. These are much lower than each of the three men experienced on their first flights in space.

Securely in orbit, the crew now begins checking all systems in preparation for the kick to the moon—Trans Lunar Injection (TLI). It is a busy time.

12:16 After everything has been checked out, on the second orbit, over the Gilbert Islands in the Pacific, the third stage's J-2 engine is restarted. For five minutes and 47

seconds it powers Apollo 11 to a speed of more than 24,000 mph. When it shuts down, three men are out of Earth orbit and enroute to the moon. TLI has been achieved.

In the Apollo Automatic Checkout Equipment (ACE) area at the Kennedy Space Center, Tom Baggette reports there is a big grin on everyone's face. The scene is repeated in LCC, in Houston, and in the mission support area at Downey.

"Hey Houston," Neil Armstrong beams, "this Saturn gave us a magnificent ride."

12:46 The four large panels of the lunar module adapter, built by NR's Tulsa Division, are detonated. Next, the command and service modules separate from the LM and S-IVB, and the astronauts, calling upon years of practice and experience, carefully maneuver the CSM around in space by firing small thruster rockets, to dock nose-to-nose with the LM. A few minutes later the hookup, which allows crewmen to transfer from one vehicle to the other, is completed.

14:12 After the docked spacecraft have severed their connection with the S-IVB, a three-second burn of the service module's single, 20,000-pound-thrust engine drives the crew a safe distance from the third stage in what is called an evasive maneuver. A ground signal then sends the S-IVB rocketing off to eventually soar behind the trailing edge of the moon and into solar orbit.

14:55 From more than 20,000 miles in space, one of the astronauts says: "I think today is the birthday of California and I believe they are 200 years old and we send them a happy birthday."

15:42 Because the TLI angle was so accurate, Apollo 11, now nearly 28,000 miles distance from Earth, does not need to perform a mid-course correction.

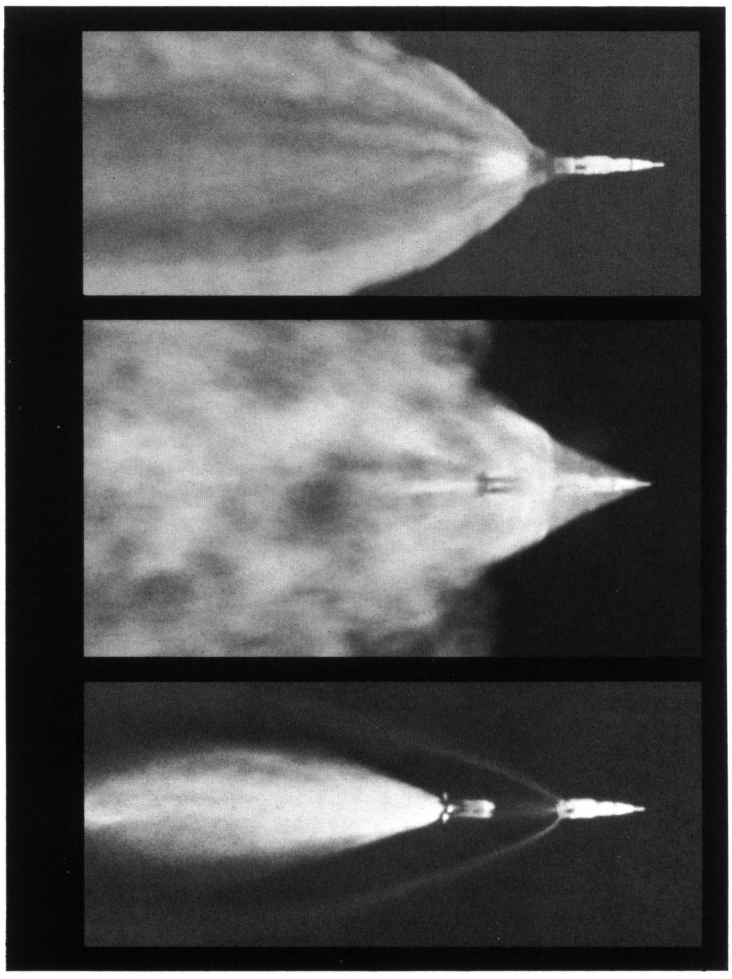
20:04 Apollo 11 transmits an unscheduled, 16-minute color television show from space. "We can clearly see the western coast of North America, the United States, the San Joaquin Valley, the High Sierras, Baja California, and Mexico down as far as Acapulco and the Yucatan Peninsula, and you can see on through Central America to the northern coast of South America, Venezuela and Colombia," Armstrong narrates as the pictures flash on TV.

20:52 Flight controllers in Houston say goodnight to the three astronauts, whose day began more than 16 hours earlier. "We don't expect to hear a great deal more from the crew tonight," says a NASA public affairs spokesman. "The last conversation we had we received a status report that they were 'fit as a fiddle'."

Still to come, of course, are the events that will astound the world . . . the lunar landing . . . the steps into history . . . the "giant leap for mankind" . . . the safe return home, ending an incredible journey eight days in duration, eight years in preparation.

23:57 All three astronauts are asleep as their spacecraft, now 77,992 miles from Earth, continues on course.

24:00 The day ends.



Forty miles up, two and a half minutes into the flight, the booster stage separated and fell away, as seen in these spectacular photographs taken by a 70 mm camera aboard an Air Force EC-135N aircraft at an altitude of 40,000 feet.

THE MOON...

In the Never-Ending Pursuit of Knowledge, Scientists Hope to Exploit Man's Newly-Gained Capability of Reaching the Lunar Surface

EARTH'S BOOK OF LIFE?

Now that man has successfully landed on the lunar surface and returned, scientists across the nation and in many foreign countries are eagerly investigating data related to the historic Apollo 11 mission.

Specialists in well equipped laboratories are carefully probing samples of the moon's surface, while others are collecting and analyzing exciting information being relayed to Earth from instruments left on and in the lunar terrain by astronauts Neil Armstrong and Edwin Aldrin.

It will take months, perhaps years to properly evaluate all this data and put together meaningful pieces of the infinite puzzle that is the Universe.

Still, no matter how much is learned from these first physical returns, it will but whet the scientific community's appetite for more complete knowledge of the moon and its relationship to the Earth; to escalate the search for answers to questions as old as man.

Much of this more advanced information, it is hoped, will emanate from a series called Apollo Lunar Exploration Missions (ALEM), using an upgraded version of North American Rockwell's command and service modules.

"These flights are designed to capitalize on the basic capabilities developed by Apollo," says Dr. Wilmot Hess, former NASA director of Science and Applications at the Manned Spacecraft Center in Houston.

"Now that we have proved the ability to land men on the moon and return them, we want to extract as much scientific information as possible in the remaining missions. On the ALEM flights we will probably move into a new set of landing site classes. We will try to go to confined areas of specialized interest, say an unusual crater, or a specific region of tectonic or volcanic interest."

A more sophisticated package of remote sensing experiments will also be operated in lunar orbit from the Apollo spacecraft. "The idea here is to get more comprehensive coverage, to explore the moon in a more complete sense and tie this data in with that collected in confined areas on the moon's surface," Dr. Hess says.

There is much to be learned from such a program.

Geologists will seek, from the more detailed information ALEM will provide, the ultimate goal of determining the origin and history of the solar system. This may come through a more thorough examination of the moon's composition and structure, and an attempt at determining the age of lunar materials.

Geophysics experts say the study of the Earth's interior has provided many important clues to the understanding of the origin and evolution of this planet and the solar system. Similar work on the moon would greatly enhance their knowledge. Broadly speaking, they are interested in three important aspects: (1) a study of the moon's internal structure such as layering and lateral variation; (2) determination of the physical conditions and makeup of the interior; and (3) dynamics of the interior, involving such things as the energy budget (mechanical and thermal) and response of the moon to internal and external stresses.

One of nature's eternal mysteries concerns the origin of the moon. There are three popular theories: that the moon originated completely separate and was later captured in orbit

by Earth; that the moon and Earth essentially originated at the same time as twin planets; and that the moon originated from the Earth and was torn from it eons ago.

Geochemists believe that by various means of comparing the compositions of the Earth and moon, important clues pertaining to the origin of the lunar body may be uncovered. Unlike the Earth's surface, the moon's face affords an opportunity to find and study structures and materials that may date to the early days of the solar system.

Bioscientists say detailed knowledge of the amount, distribution and exact molecular structure of any organic molecules, micro-organism fossils, and preserved microbial forms is of utmost importance in seeking answers relating to the origin of life, the origin and history of the moon, and to the relationship of the moon to the Earth and the solar system. They will search for such evidence in non-contaminated, well-preserved samples of lunar terrain.

Geodesists and cartographers are enormously interested in a set of vitally interrelated topics: the moon's size and shape; its gravitational field; the lunar ephemeris describing the position of the center of mass of the moon; and the angular motion about the center of mass.

Scientists interested in the lunar atmosphere say that although it is known to be exceedingly tenuous, knowledge of its density and composition should provide valuable information concerning the lunar interior chemistry and radioactivity, the possible volcanic processes, and the chemical and physical compositions of the solar wind.

Specialists in Particles and Fields hope to learn more about the moon's magnetic and electric fields, and information pertaining to low-energy-charged particles, and solar and galactic cosmic rays.

Finally, it is believed the moon may offer an attractive and possibly unique base for astronomical observations.

It is a major objective of ALEM to gather as much information in these related physical sciences as possible. To insure this, NASA sought proposals for experiments from the scientific community. Many overall goals were spelled out at the 1967 summer study of Lunar Science and Exploration in Santa Cruz, Calif. Proposals are evaluated by special committees appointed by NASA's Office of Space Science and Applications in Washington, D. C.

Data will be collected by specialized equipment housed in the Apollo service module, through expriments to be placed on the lunar surface, and by examination of moon samples brought back by astronauts.

It has long been planned to make full use of existing spacecraft hardware for this "second generation" of landings. Specifically, the program will involve five flights—the last five of 10 scheduled manned lunar landings. The first ALEM mission—using a modified Apollo spacecraft—is tentatively scheduled for launch in April 1971. Subsequent flights will occur at five month intervals. Each is designed to allow more time in the vicinity of the moon for exploration and experimentation. Apollo 11 astronauts were on the lunar surface 22 hours. Future crews may spend up to 72 hours there, and will be able to cover far more territory if plans to use a wheeled surface vehicle are realized.

"I'm enthused about the series," says Kenneth Kleinknecht, NASA-MSC manager for the Apollo command and service modules. "The spacecraft was designed for lunar landing missions and it has been successful. Therefore, for the advancement of lunar science and exploration, we ought to exploit to the fullest extent a vehicle that has demonstrated such capability."

Kleinknecht and a team of NASA specialists have been working closely with Space Division personnel under project manager John Eslinger for the past several months. Their job, essentially, is to modify Apollo to meet the new set of requirements for ALEM. It involves spacecraft 112 through 115A. Numbers beyond this have been assigned to the Apollo Applications Program.

"We're approaching this a little differently," says Kleinknecht. "We knew certain modifications would be required, but these probably wouldn't be spelled out in explicit detail until after the first manned landing on the moon. To avoid unnecessary hardware changes later, we initially authorized engineering and development tests which included detailed design, specimen tests and limited procurement of long lead time hardware and tooling. This, we feel, will contribute to a more orderly, stable transition from the baseline Apollo into ALEM."

Some of the equipment to be used on the first flights has already been identified. "We will fly a 24-inch focal-length panoramic camera, and gamma ray, X-ray and alpha particle

In spacious, 12-foot-deep bay 1 of Apollo's service module, above right, experiment packages will be stored. Project manager John Eslinger, left, and John Montgomery of Space Division, view area. Right, Kenneth Kleinknecht, center foreground, NASA-MSC manager, Apollo command and service modules, leads design review session.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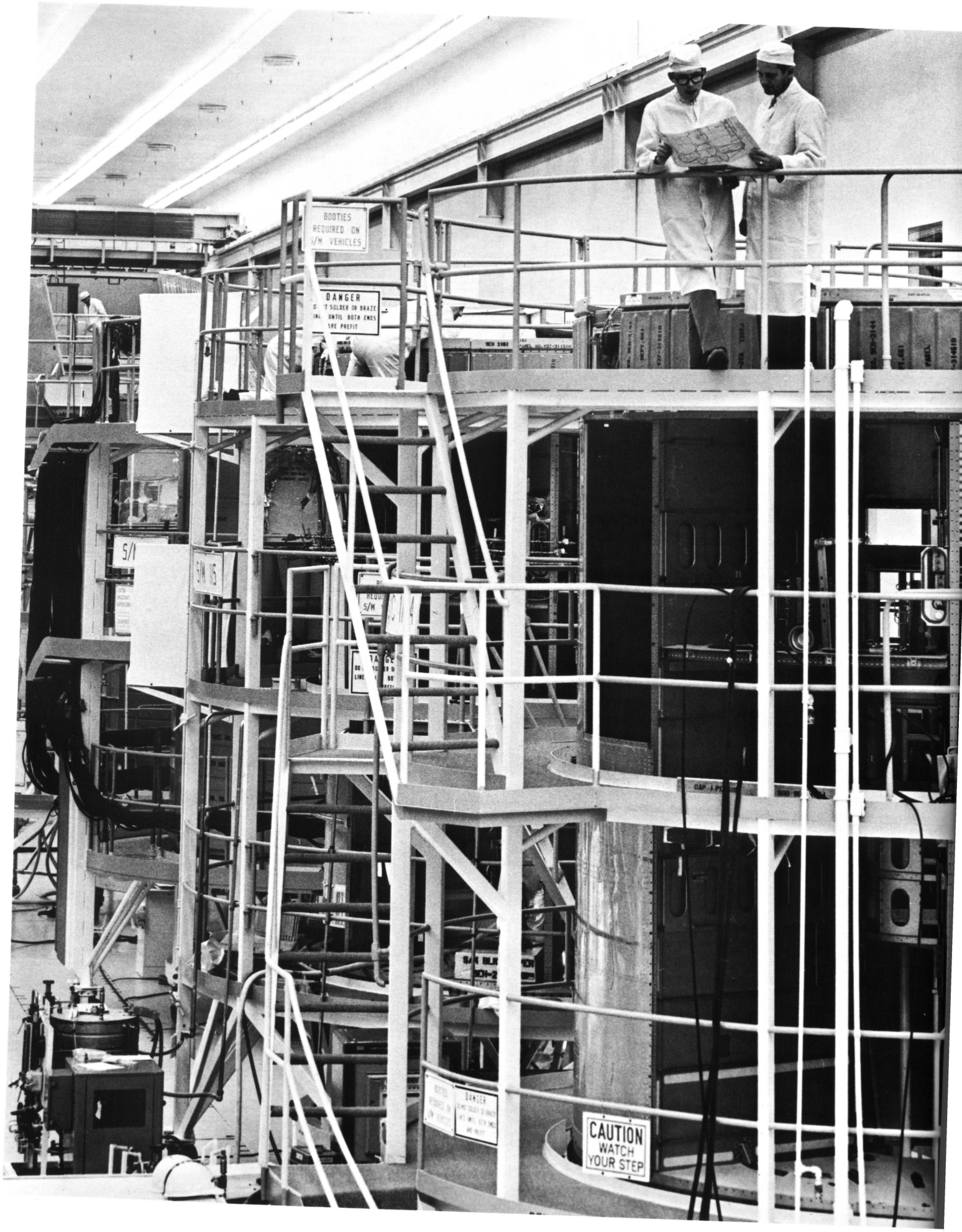
BOOTIES
REQUIRED ON
S/M VEHICLES
DANGER
CAUTION
WATCH
YOUR STEP

spectrometers," says Bruce Jackson, NASA's manager of the Advanced Systems Office at MSC.

The camera will serve as a science planning tool for future landing missions. It will gather detailed photographic information on highland sites which may be selected for later exploration. The three spectrometers, geo-chemical in nature, will seek data on the elemental constituents—the makeup of the lunar surface.

Additionally, S-band transponders will be used to help determine the exact shape of the moon by precise tracking. Also, there may be a metric camera system—to help establish a geodetic controlled network on the moon to pinpoint the relative location of various lunar features and an infrared scanning radiometer—to obtain a surface temperature map and gather data on local hot spots, thermal balance, and determine whether or not the moon is receiving or giving off heat.

Because of the far-sighted flexibility planned into the basic spacecraft design, no major structural changes will have to be made for the experiments. The overall conical shape of the command module will remain the same.

Modifications center around one of the six wedge-shaped bays or sections of the service module. To allow for future expansion capabilities, bay 1 has remained empty throughout the initial phases of the Apollo Program. It is in this 12-foot-high by five-foot-wide area that the Scientific Instrument Module (SIM) and extra cryogenic tanks will be installed, adding roughly 2,000 pounds to the payload. Another 4,000 pounds will be added to the lunar module. Rocket booster engine thrust times have been upgraded to handle the extra weight without problem.

Though most of the changes needed will be confined to a relatively small area, it will be a complex and difficult operation, requiring exacting, delicate work.

"About 12 experiments will be installed in the bay," explains Eslinger. "These require special structural mountings. Some, for instance, will be extended on 20 to 25-foot booms to afford an unobstructed field of view."

Eslinger says fitting everything into the bay properly involves a complex problem of integration. To accomplish this a team of company engineers is working closely with experiment manufacturers at sites across the country to develop a smooth coordination of efforts.

For astronauts to conduct the experiments, additional display and control panels and electrical distribution systems must be added to the command module. The spacecraft's data acquisition system will also have to be uprated to handle the information the experiments will collect. Extra storage space will be needed, too, for the return of photographic film. Some of this will be retrieved in space by crew members during periods of extra vehicular activity (EVA).

Eslinger says the added cryogenic tanks will produce 50 percent more electrical energy from the fuel cells to support the experiments and longer flights. (Regular Apollo missions have been designed for a nominal duration of 10.7 days. On ALEM, systems will support flight up to 16 days.)

Life Support Systems on the spacecraft will remain essentially the same, although more consumables, such as food, water and air purifiers will be stored onboard for longer flights.

Following extensive engineering design, test hardware manufacture began about Aug. 1. The work is expected to carry into 1972, with delivery date of the first modified spacecraft targeted for August 1970.

How much more will be learned through the ALEM program findings, and what will it all mean? Dr. George E. Mueller, NASA Associate Administrator for Manned Space Flight, summed up some of the "reasons why" in a statement to Congress earlier this year:

"To the scientific world, there is great interest in the origin and history of the moon and its relation to Earth and to the solar system. Was it formed with the Earth, or captured later? Are there clues to the origin of life? To quote the President's Science Advisory Committee, 'Answers to these questions may profoundly affect our view of the evolution of the solar system and its place, as well as man's in the larger scheme of things.'

"Many planets have moons, but ours is the largest in relation to its planet. This implies that the two bodies may have been formed in the same manner at the same time. If true, the moon may be a book containing the secret of the Earth's first billion years of life."

Five spacecraft — 112 through 115A — will be modified for the ALEM program. Following extensive engineering design, test hardware manufacture began at Downey, left, weeks ago. Planned delivery date of first spacecraft is August 1970.