IBM NEWS

Federal
Systems
Division

Lunar
Landing
Special

A Tribute to Teamwork

FSD President Bob O. Evans

Apollo 11 is a fantastic achievement. It marks the beginning of a new age of human exploration, and the men and women responsible for this achievement deserve a key place in mankind's history.

Great accomplishments of the past are usually identified with specific individuals: Columbus, Galileo, Pasteur, Lindbergh. In part, this is because such accomplishments often have been the product of one man's genius or determination. The technology of space travel, however, is so vastly complex that only through superbly coordinated team effort can real progress be made. Certainly Armstrong, Aldrin and Collins, as well as all of the other astronauts, must be recognized as courageous and skillful men of the highest order. But we must not forget that the men who walked on the moon were members of a far larger team.

That team can boast the most talented and dedicated human resources ever assembled in a common mission. It includes the people of NASA, the universities and more than 20,000 industrial firms.

I take enormous pride in knowing that 4,000 members of the team were IBM men and women of the Federal Systems Division. I know, too, of the sacrifices that the winning of this goal has demanded of those IBM people in terms of frustrations, difficult working conditions, long hours and time away from their families. In September 1962, as the Apollo program was just beginning, President Kennedy said: "We choose to go to the Moon in this decade and do the other things, not because they are easy but because they are hard; because that goal will serve to organize and measure the best of our energies and skills . . . ."

Now that goal has been achieved, and indeed it has organized and measured the best of our energies and skills. And I believe that you, the IBMers who participated, met that measurement with great distinction.

Congratulations!

IBM NEWS

Federal System Division
Lunar Landing Special
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The Cover:

The contribution of FSD's people to Apollo 11 is symbolized by the photograph on the front cover of this commemorative issue of IBM NEWS for the Federal Systems Division. From left, Owego, Houston, Goddard, Cape Kennedy and Huntsville are represented by individuals from those locations. For the full story, turn to Page 2.

Apollo People—the Cover Story

James E. Burkavage, enters information at the ground computer. Kenneth C. Marks, standing, is ready to assist.

Your new car won't start? Got a new house with water in the basement? A toaster that won't pop but a transistor that does crackle?

Think Apollo. Where's the difference?

In FSD it's people—individuals, groups, some handy with a soldering iron and others at home with Kepler, some who test, some who program—thousands who have one single goal: perfection—.9995 for reliability.

Typical of the FSD team that worked at five IBM datelines to help achieve that perfection for Apollo are the individuals selected for the cover photo in this special FSD issue of IBM NEWS.

Avis Fiacco, department technician in Owego's Aerospace Manufacturing; Lawrence K. Tharp, staff programmer from Houston's RTCC; Thomas L. Rogers, a computer operator specialist at Goddard; James E. Burkavage, senior launch specialist at Cape Kennedy, and George T. Vail, Sr., senior associate engineer from Huntsville. That's how they appear from left to right on the cover.

From 4:18 p.m. to 12:48 a.m., Mrs. Fiacco works on perfection for IBM. She's worked on Gemini, OAO and Saturn computers, always on second shift. She likes the time and the work. It fits with her roles as wife and mother of six. She's a bridge between generations of IBMers in her family. Her father, Carl Vollrath, an uncle, Gerald T. Richards and a brother, George, are employed by IBM, and her daughter, Patricia Toulson, is following her lead in Owego.

Tharp, who joined the company in 1964 at Bethesda, says he's in for a real letdown because "this mission has been such a part of me for 3½ years." He sits in the RTCC control area helping to massage data for presentation to NASA flight controllers and he keeps track of inputs to the computers for all the mission activities.

Another second generation IBMer is Rogers who began his FSD career in 1956 when he went to work on the Vanguard project in Washington, D.C. He has followed space projects ever since and likes feeling a part of this one—"being at Goddard, I do."

A member of the prime launch team at Cape Kennedy, Burkavage says, "We walked this one all the wa through from the time they starte stacking it."

His time for watching began at 2:3 before launch. At that point his tas in the firing room ended and the com puter in the Instrument Unit went o automatic "and we're home free."

He joined IBM in 1964 at Pough keepsie, and he's spent 4½ years a the Cape and helped with Apollo, Saturn 501, 502 and the winner 50 that flew under the designation of Apol lo 11.

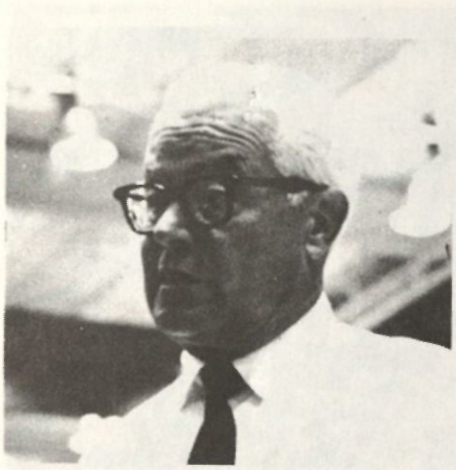
Pride in craftsmanship doesn't se Vail apart from the other cover people—he's just been at it longer fo IBM. He started at Endicott in 1941. He helped with development work on Gemini and Saturn computers in Owego, but he locked into IU work in 1964 when he transferred to Huntsville.

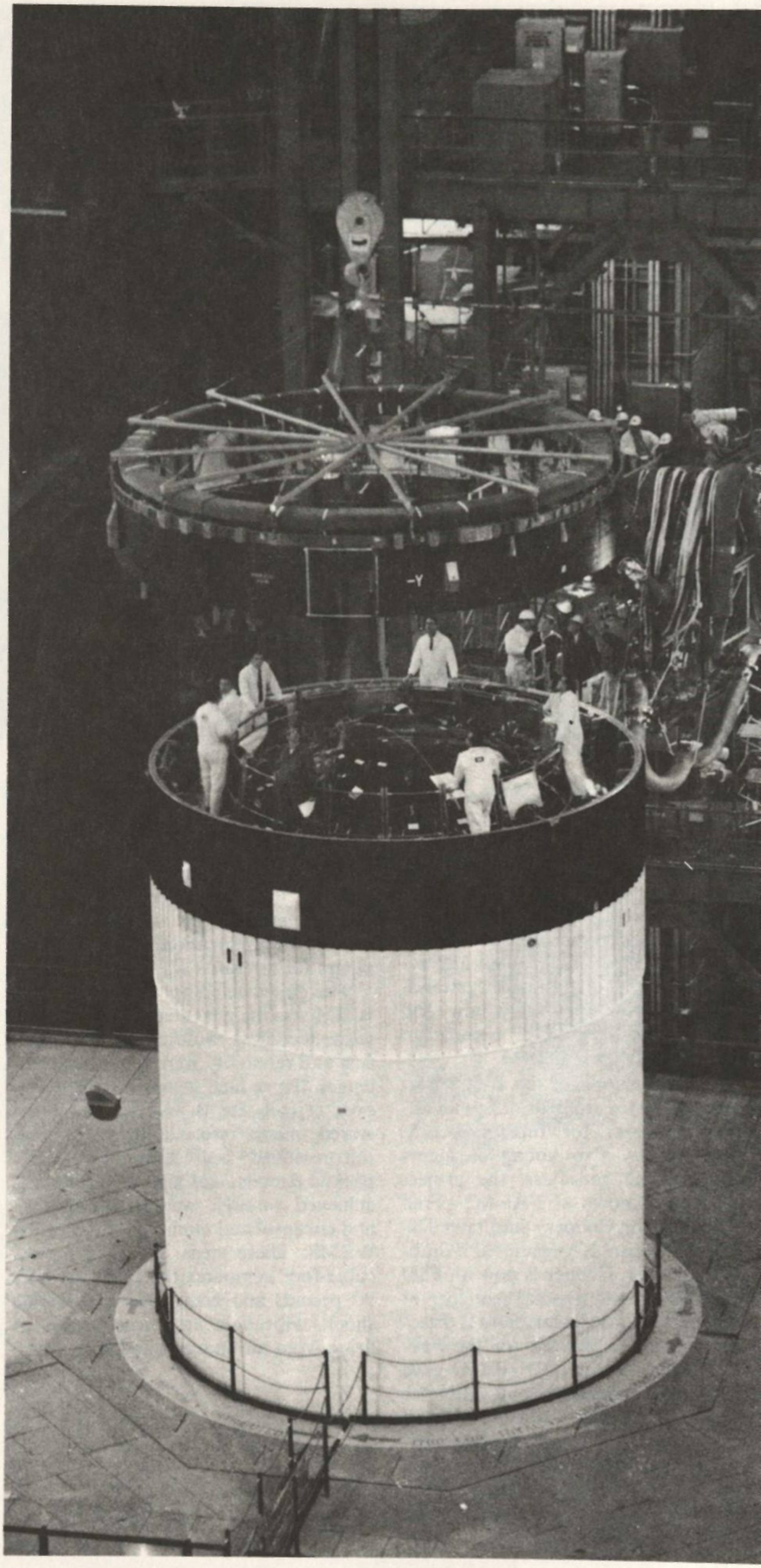
"It's a pretty delicate thing to ride on, really," Vail says, with a shake of his head as he talks about the IU. "All the strength is in the two aluminum skins that total .050 thick, .030 on the outside and .020 inside. The skins are separated by a honeycomb core."

These five IBMers represent the team that management turned to in FSD to produce perfection. Apollo 11 was the proof. □

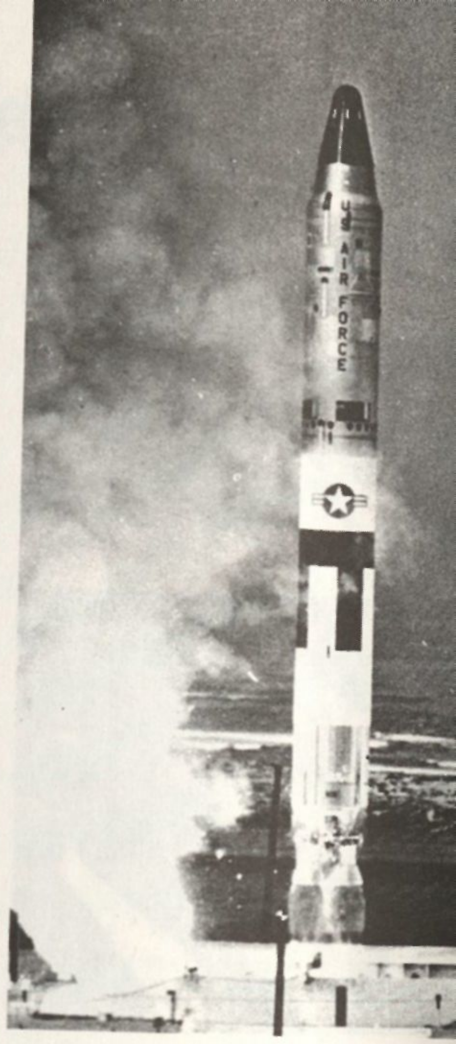
Avis Fiacco
Thomas L. Rogers
George T. Vail
Lawrence K. Tharp

The Instrument Unit that was destined to guide Apollo 11 on its start to the moon swings into place above the third stage of the Saturn at Cape Kennedy.





rises from a silo under guidance of IBM computer.



Trace of Technology

NOTE: The course to the moon has been charted by solutions to technical problems. Countless FSD people helped provide many of these solutions and they have helped make IBM a major factor in putting man on the moon. The technical achievements in developing IBM's spaceborne equipment are traced here.

"Build us a computer system that will work in an Air Force jet and take the burden off the crew without sacrificing accuracy and flexibility." This technical challenge tossed to the industrial world of the early '50s by the Strategic Air Command was a difficult one. IBM picked it up.

Curt I. Johnson, who recently retired as Corporate Manager of Quality and Reliability Assurance, tackled the job of developing a flyable computer system for the U. S. Air Force with a small team of engineers at Vestal, N.Y. Using an analog approach, this group developed what was later to become the bombing and navigation system for the B-52.

The B-52 program provided IBM with several new capabilities. One was learning how to build equipment that could operate in an airborne environment. This gave new meaning to words like "reliability" and "quality control." Tying together computers with other equipment like radars, displays and actuators required technical understanding beyond computer know-how and soon "systems integration" became an important new term in IBM.

A significant part of the B-52 effort was an advanced study to define an all-digital computer for future aircraft. Headed up by two young engineers named Cooper and Foss, the project was initially known as FAFAC (Fred A. Foss-Arthur Cooper) and later DINABOC (DIgital NAvigational BOmbing Computer). Cooper is now an FSD vice president and general manager of the Space Systems Center; Foss is director of Safeguard Systems for the Federal Systems Center. DINABOC gave new design experience in semiconductor circuits, lightweight magnetic drum memories, digital computer organization and a new science, at the time, called human factors—which meant making the machine compatible with the man who had to operate it.

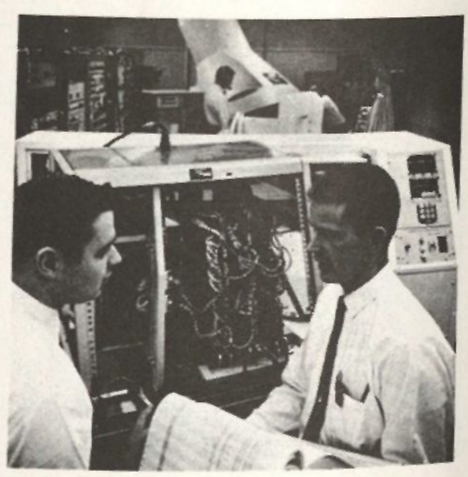
In designing DINABOC, a drum memory that would work in an aircraft was needed and developed. Special alloys were used to reduce weight and volume and air-floated read-write heads were developed to adjust automatically to changes in temperature and pressure. The drum was a major technical breakthrough, and a key factor in putting IBM on the doorstep to space.

Through DINABOC, IBM demonstrated that an airborne digital computer system was feasible and essential to future high-performance aircraft.

IBM's record on the B-52 program led to a contract for the all-digital Bombing Navigation and Missile Guidance System for the trisonic B-70 aircraft. The DINABOC concept was updated and refined into the first full-scale flyable digital guidance system. The computer featured printed circuit boards, silicon semi-conductor circuits, a magnetic drum memory and a complementary ferrite core "scratch pad" memory and a function-sharing dual computer concept for enhanced reliability.

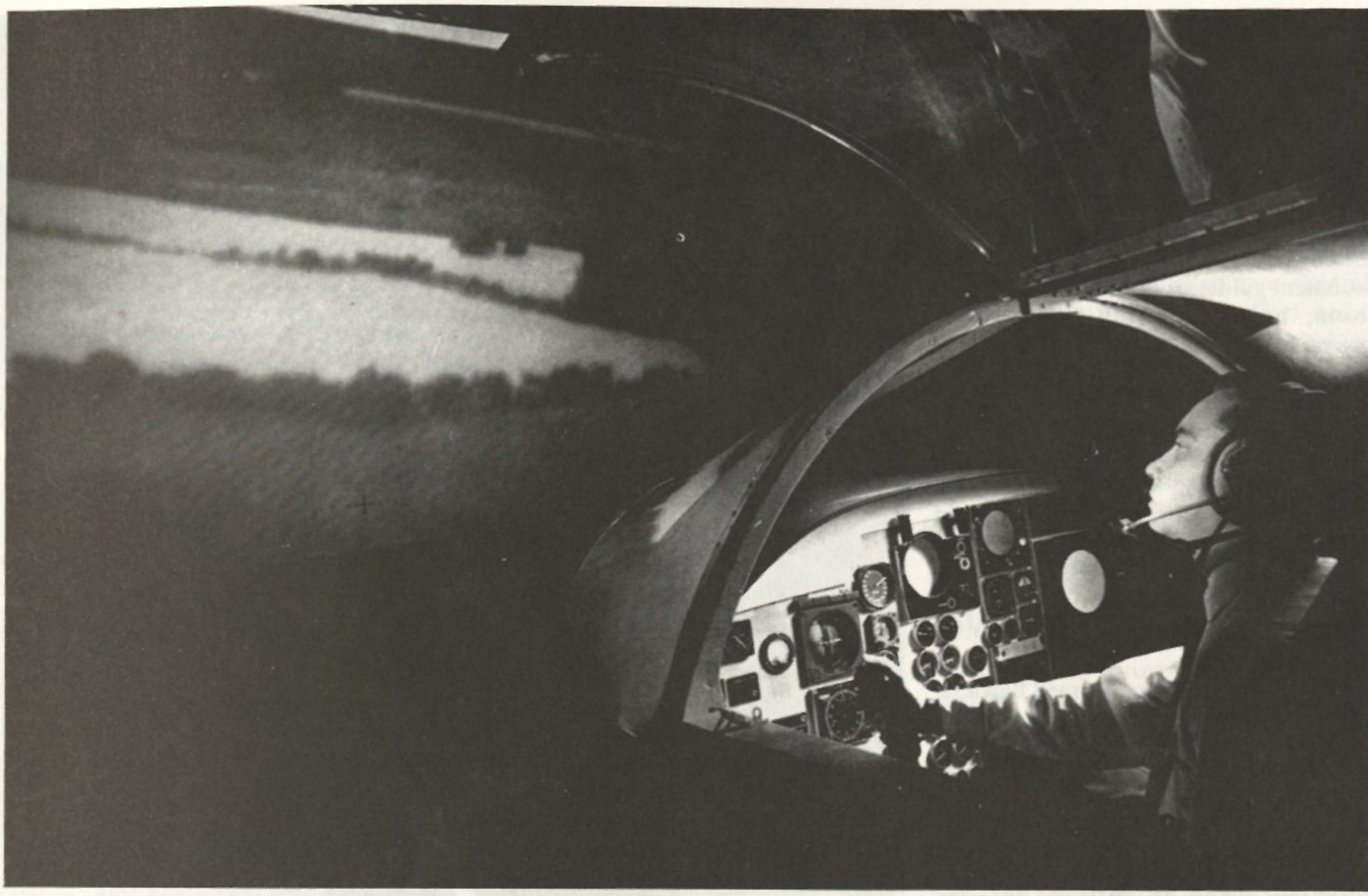
Like the B-52, IBM again managed a major contract in the B-70 avionics system. This program provided valuable experience with radar, stellar inertial sensors, displays, optics and human factors engineering. The program proved the application of digital computers for aircraft.

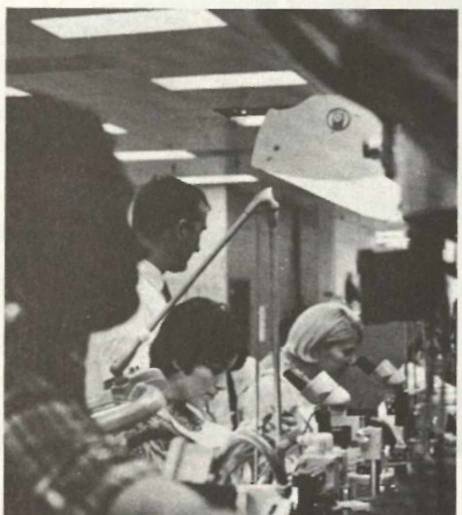
The guidance computer for the Titan ICBM was the next step in IBM's aerospace technical evolution. Miniaturization and reliability were the major challenges. To reduce volume, IBM developed a half-size B-70-type drum that stored more information. Air cooling removed heat from the tightly packed circuits, and high reliability was achieved through welded connections and encapsulated circuit modules called WEMS. These steps produced a two-cubic-foot computer that weighed only 90 pounds and could take the jarring shock, vibration and acceleration of firing from an underground silo.



Middle photo—clean room assembly at ESC; bottom—Gemini computer under test.

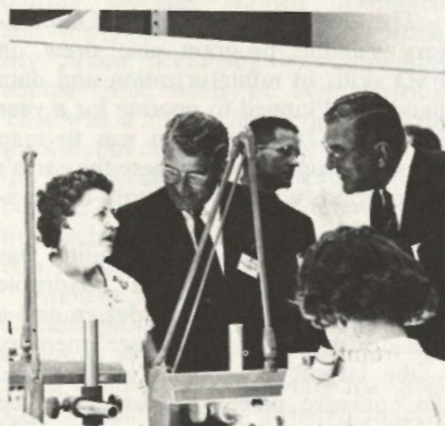
Airborne systems get simulator test at ESC.



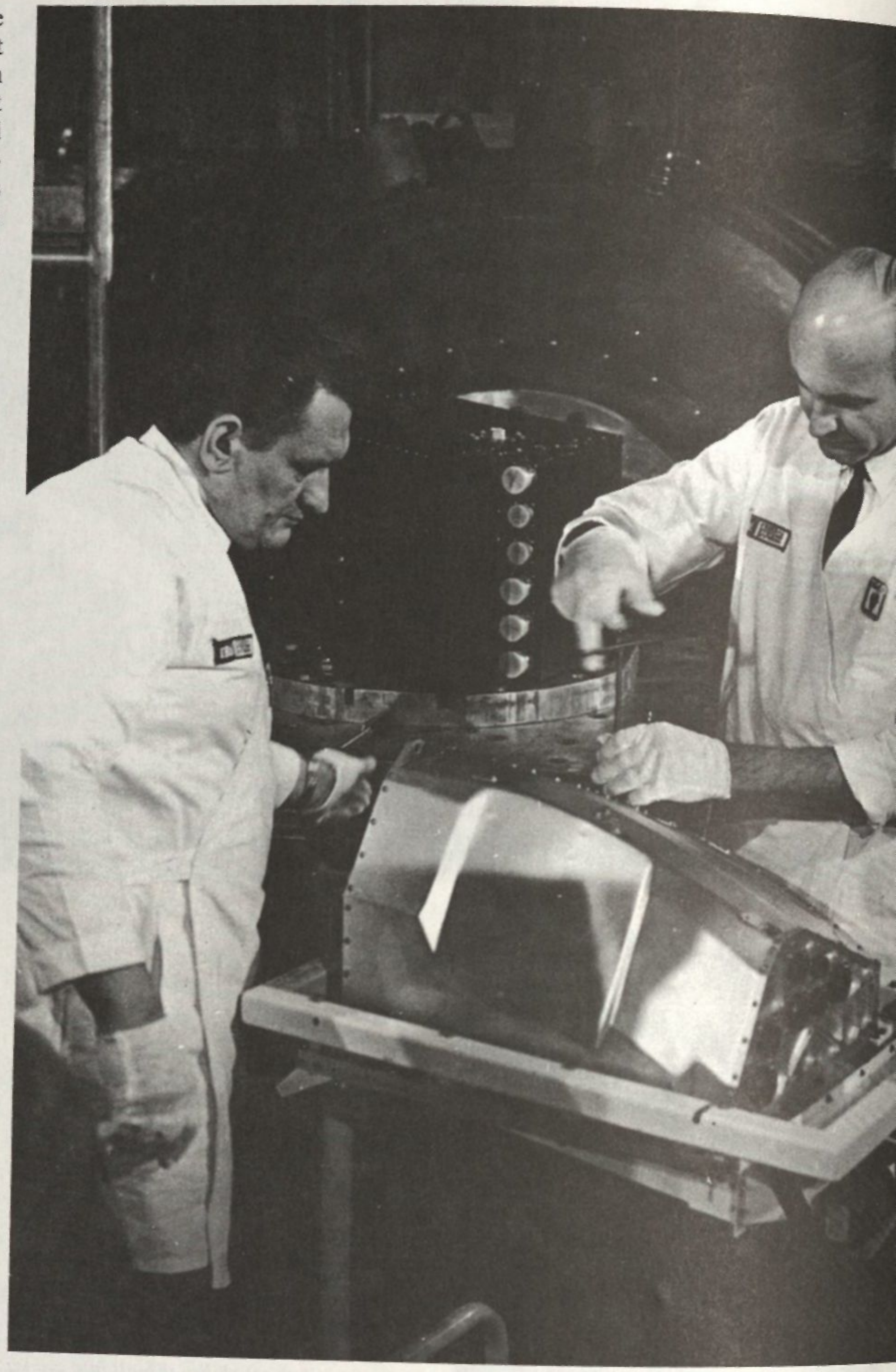


Left—circuit packaging under microscopes.

Right, Alice E. Ward, ESC, tells Dr. Wernher Von Braun, A. L. Williams and Arthur E. Cooper how reliability is built into circuits.



in background) and shiny Gemini computer (foreground) get gloved treatment in final ESC check.



Titan was the final stepping stone into the space program for IBM. Just as the Air Force had turned from analog to digital computers for aircraft guidance, Dr. Wernher Von Braun and his NASA team at Huntsville were beginning to evaluate digital techniques for the Saturn program, and IBM was asked to suggest a solution. Under the technical guidance of Monroe M. Dickinson, now director of Special Programs for CESC, a Titan computer was modified to satisfy space launch conditions and one unit was sold to NASA for competitive evaluation. As Cooper recalls, "We put the computer in the back of a station wagon, drove down to Huntsville, plugged it in at the old Redstone Arsenal, and it ran for a full year without failure." IBM won the competition and was given the contract for providing the guidance computers for the Saturn I.

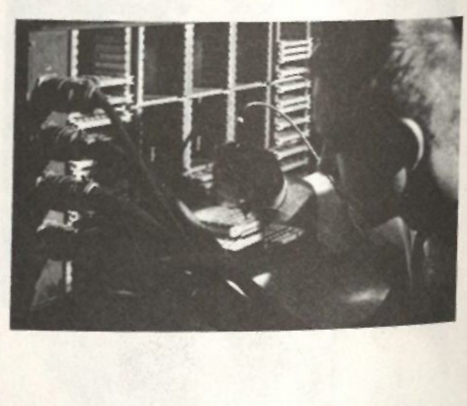
These computers performed flawlessly through the Saturn I series—so well in fact that, in a launch when one of the Saturn's eight engines failed and threatened the mission, the computer compensated for the change in thrust and aimed the other engines at appropriate angles to "save the day" according to NASA officials.

The Orbiting Astronomical Observatory satellite program also drew on FSD skills in miniaturization and data handling. Planned to operate for a year in space, OAO's mission was to map the stars from an orbit where the earth's atmosphere could not distort observations.

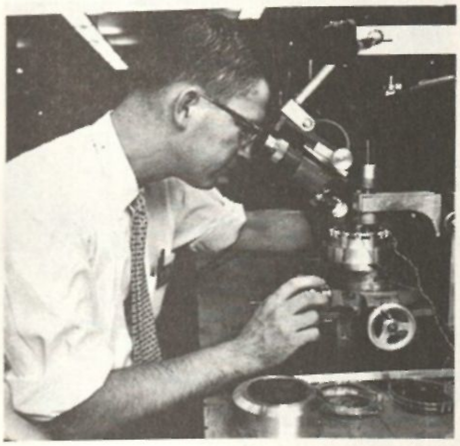
Extreme equipment reliability was required, and IBM used quadruple redundancy in the circuit design and a non-destructive-readout core memory —the largest of its kind at the time. To conserve precious power collected by OAO's solar paddles, the IBM equipment was designed to shut down automatically where possible during inactive periods.

Today an OAO satellite circles the earth in a 400-mile-high orbit. Under control of an on-board IBM processor, its telescopes constantly probe the universe for new knowledge. After seven months in space, OAO has already chalked up over 3,000 orbits and acquired a vast amount of new information about the sun and its planets, the stars and even distant galaxies. Information from each probe is recorded in OAO's large IBM memory and periodically relayed to earth for analysis and interpretation.

Concurrent with OAO, IBM devel-

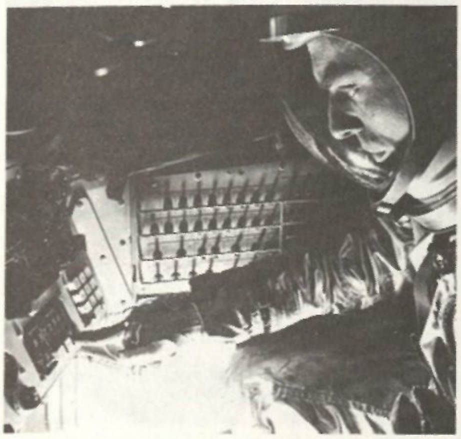


Saturn computer circuits are checked before mounting in case.



Left—Thermal properties of COMPASS computer were observed by microscope.

Below—John B. Jackson, Bob O. Evans and Clint Hundley unload Gemini 4 equipment from airplane for extensive tests at Owego.



Middle above—Gemini computer is tested in spacecraft simulator.

Above—Clint H. Grace follows Dr. Wernher Von Braun from NASA aircraft at Broome County Airport in New York.

Above—A Titan II computer undergoes inspection.

oped a computer to help guide the two man Gemini spacecraft. Combining th memory technology from OAO wit the high-speed logic circuitry and pack aging experience from Titan, a 60 pound space guidance computer wa developed that featured high reliability flexibility of application and compat ibility with launch and space environ ments. A major design innovation tha emerged from the Gemini effort was novel interconnection technique which used multiple layers of etched circui boards, laminated into a single three dimensional interconnecting back panel Perfecting the photo-etching process t produce these interconnecting board was an important breakthrough by IBM in Owego.

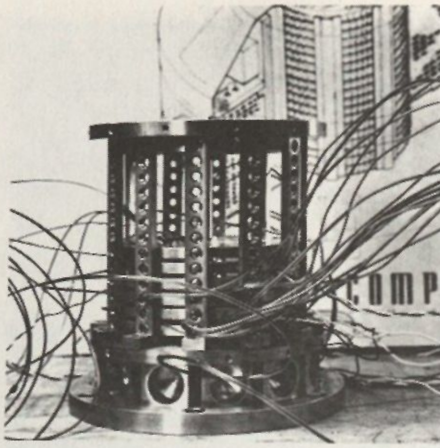
MIBS Shrink Size

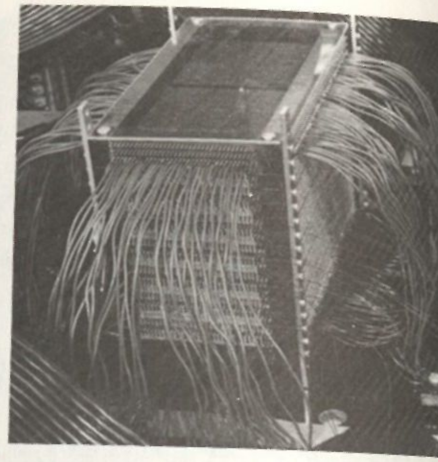
Experience proved that the mos serious cause of airborne electroni equipment failure was soldered con nections. Welded connections had to b used in Titan equipment to solve thi problem. But the new Gemini multi layer interconnection technology in sured space-age reliability, eliminate tedious hand welding operations re quiring specially trained assembler and also paved the way for high-den sity circuit packaging by eliminatin almost three miles of bulky wiring This was a major factor in shrinkin the Gemini computer down to size fo the spacecraft. Soon, this technolog became the base for the interconnec tion techniques now used in IBM Sys tem/360s.

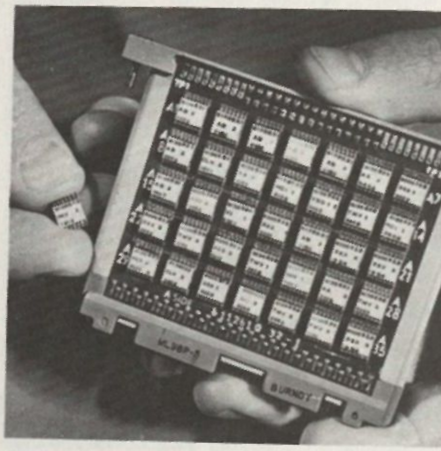
Another IBM responsibility on th Gemini program was to integrate th computer with the inertial platform an other equipment comprising the guid ance system. Again, experience pai off. The systems work done on th B-70 program required inertial know how that proved to be a valuable asse in helping perform the Gemini system' integration task.

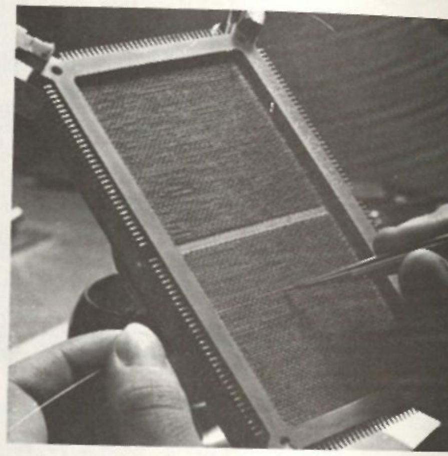
With Gemini, the need was seen fo advanced development, and a pilot pro gram was started to design a ne generation space computer known a COMPASS (COMPuter for Advance Space Systems). The new design fea tured a hybrid circuit technology simi lar to that developed for the initia System/360s. A major objective wa to use uncased semiconductors—tin silicon chips the size of a pin head— inscribe a circuit pattern on them an mount them on an interconnectin base. The circuit base was a quarte

Circuit miniaturization is apparent in space computers (clockwise from top left) COMPASS frame, Saturn storage, Saturn memory plane, Saturn page with logic devices.

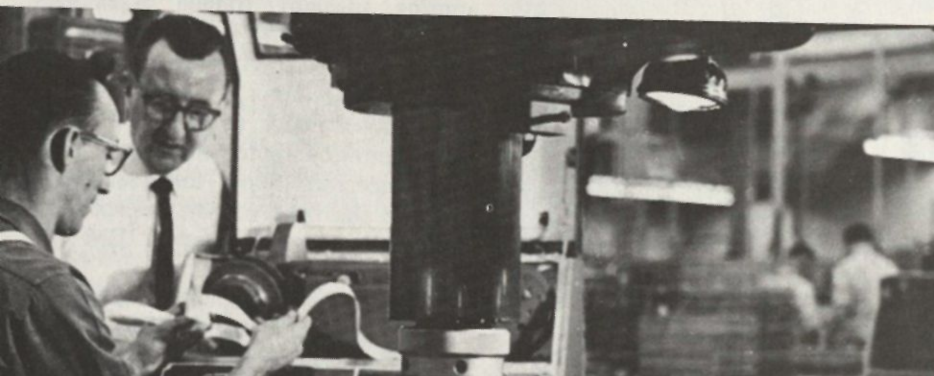








A tape-drive boring machine cuts out the frame for a Saturn computer.



Dual memory of Saturn modules undergoes test.

inch-square ceramic wafer about as thin as a dime, with a dip-soldered circuit pattern deposited on both sides. The chip semiconductors, with three microscopic lead-contact balls, were mounted on one side of the wafers by using a specially developed soldering tool, and resistors were silk-screened on the other side to complete the circuit. This was a departure from the System/360 Solid Logic Technology that required all components to be on one side of a half-inch-square circuit wafer.

Flawless Performance

After the flawless performance of IBM computers during the Saturn I program, Dr. von Braun and his NASA team at Huntsville were convinced that IBM was a major contender to provide the guidance system for the huge Saturn V moon rocket. Obviously, a computer system far more sophisticated than IBM had provided for earlier versions of Saturn was in order. To meet the challenge, Dickinson assembled a proposal team, and, using the experience gained from the COMPASS study, submitted a solution to the Saturn V guidance problem that exceeded all NASA specifications. In reliability, NASA required 25,000 hours mean-time-between-failures. IBM proposed 40,000. In component density, the standard at the time was IBM's Gemini computer with about 45,000 components per cubic foot. IBM promised a five-fold increase in component packaging—250,000 components per cubic foot. Coupled with these requirements was a severe weight restriction. In memory capacity, it added up to putting the equivalent of a System/360 Model 50 into the 90-pound Saturn package; the full computer was no bigger than a man's suitcase and used only 144 watts of power—less than any three-way lamp.

Dickinson and his team hit hard on three areas—reliability, miniaturization and produceability. To achieve the extreme reliability they promised, OAO circuit redundancy provided the answer. But if components and circuits are duplexed or triplexed, it would logically follow that miniaturization and weight reduction would be sacrificed. This was not the case. With imaginative logic design and the judicious use of triplex circuits in critical computer paths, NASA's reliability requirement was well surpassed on the drawing board and in the laboratory. The next step was to refine and mass produce the experimental COMPASS.

At first, it seemed an impossible manufacturing task. The tiny balls that held the pinhead-size semiconductors to the ceramic base shook loose under vibration tests. A gold alloy added to the balls solved the problem.

Oxidation on the outer layers of the multilayer interconnection boards (considerably refined from the Gemini forerunner) made mounting of the circuit modules difficult. Improved ventilation in the dip soldering and drying area was the solution.

During manufacturing tests, a small number of fractures were detected in some of the clips that held the ceramic circuit modules to interconnection boards. This was unacceptable for a manned mission, and the program came to a standstill.

For the first time, IBM performance threatened the delay of a Saturn launch, and an around-the-clock effort between Owego and the Components Division was launched by Cooper.

"I watched one of our young ladies soldering one of the circuits to the interconnection boards," Cooper recalls of a second-shift-visit to the manufacturing area. "I sat down and asked her to show me how to do the job." According to Cooper, "it took me 12 tries before I was able to produce what she said was a passable connection. This convinced me that each person was contributing tirelessly with their special skills, but we still needed a better engineering solution." Eventually an improved design with a redundant "S" clip solved the problem.

In passing this major obstacle and others, IBM was able to meet its commitments as prime contractor for Saturn's IU. IBM had earned its NASA wings and its "place on the moon." □

Complex of Systems

Amid the flames and smoke of Cape Kennedy's Launch Complex 39, there are some sentimental IBMers who claim that—just for an instant—they see an old red-brick factory that once housed Project High. The project was named for the street on the north side of Poughkeepsie where the onetime necktie plant was located. IBM's research and development efforts were focused there on a ground-based system that the Air Force called SAGE—Semi-Automatic Ground Environment.

Space history usually bypasses SAGE because it came of age before the first satellites were pitched into orbit, and it was a ground-based system. Why th do those sentimentalists see SAGE the steam on 39's pad?

SAGE forced IBMers into an acc erated learning curve—they learned respond quickly to very rigid requi ments and to perform within tig schedules. America's space progra had the same environment. There w another major point: SAGE was a rea time system based on computers, co munications, radars, displays and oth elements later incorporated in groun based space system complexes.

SAGE was well underway when IB started working with the Naval R search Laboratory in Washington, D.C to develop a mathematical orbital sy stem using an IBM 650.

The NRL work evolved into t Vanguard project. The IBM install tion was in a store-front building Washington, D.C.'s Pennsylvania Av nue. An IBM 704 grew to a 709 a finally a 7090 as the National Aerona tics and Space Administration's Go dard Space Flight Center launched Pr ect Mercury. FSD teams were ther too. Mercury helped to combine t talents developed under SAGE wi those uncovered in the Vanguard effo Under SAGE, an area-type surveillan of the airways was maintained so th

Air Force personnel monitor displays for the SAGE warning system.

People Who Helped Do It—And How They View It:

the Air Force would be ready to assess problems and alert defenses. Each site had a computer to control radars, digest information, display it and help direct appropriate responses. A long-distance network carried information from the radars to the computer and instructions from the computer back to the radars.

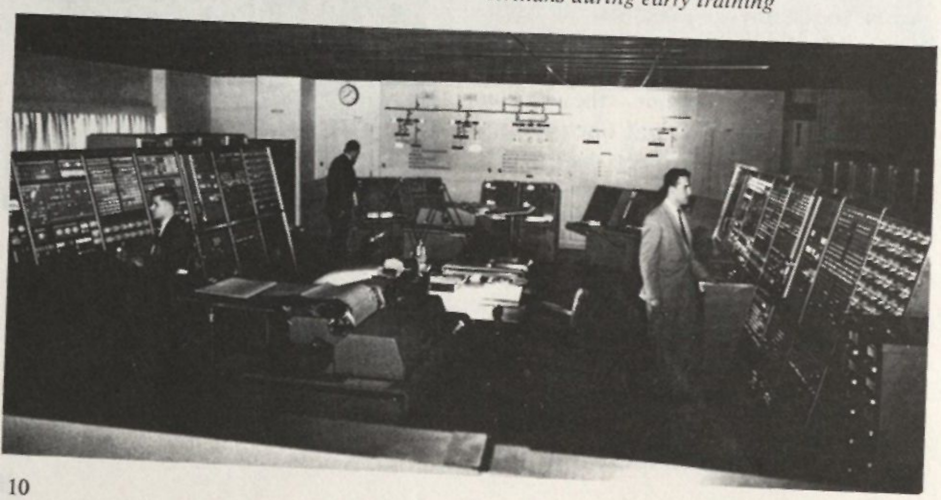
Tracking and communications were critical functions of FSD's initial mission on Mercury. The central computation facility at Goddard's Greenbelt, Md., location was built specially to handle them. Radar sites could be checked individually or as part of a total tracking system. Eventually the facility became the information link with the spacecraft—transmitting instructions to the vehicle and handling data that streamed back to ground control.

With Mercury going well, NASA began looking for a location suitable for the Manned Spacecraft Center for the Apollo program. Houston was finally selected. FSD again drew upon its skills to work with NASA there.

Mercury, Defense Communications Agency and Air Force work honed FSD skills. When the one-man Mercury flights ended in 1964, the Real Time Computer Complex in Houston was set for Gemini with a battery of IBM 7094s. Gemini's two-man craft called for giant steps in the American progress toward the moon. It permitted space walking, rendezvous and docking—all essential to the Apollo moon plan. Each new step called for more sophisticated equipment and programs.

In Houston, the '94s were upgraded to Model IIs, and finally the IBM System/360 Model 75s—five of them—were moved in to give the power needed for Apollo. □

Consoles for SAGE equipment were manned by civilians during early training



Rosa M. McMahan
It All Came Out in the Wash

There are some things in this life that a woman is naturally closer to. One is babies. Another is cooking. And running a close third has got to be laundry. Therefore, to Rosa M. McMahan, secretary in Logistics Support at Cape Kennedy, it was right in her bailiwick when everything started "coming out in the wash." The "everything" was flame retardant added to coveralls worn by people assigned to the Instrument Unit at Cape Kennedy. Workers with tailored, personalized coveralls were reluctant to toss them down the official and impersonal Cape Kennedy laundry chute. Although home laundering was definitely getting the dirt out, the vital flame retardant went down the drain, too. Mrs. McMahan, wise to the ways of washing, had an idea. She suggested that a "Flame Retardant Treated" statement be stamped to the coveralls with washable ink—this way only treated, official laundry would bear the stamp of approval. Maybe a woman's work is never done, but for sticking to her laundry, Rosa M. McMahan, secretary, received a well-earned Manned Flight Awareness Award.

The series of 15 illustrations starting at the right on Page 11 was prepared by the National Aeronautics and Space Administration to depict the historic steps of the Apollo 11 trip to the moon from the time the men transferred to the Lunar Module until they were back in the Command ship for return to earth.

Clement D. Kovalich
Pride Shows

Clement D. Kovalich, a project engineer manager at ESC, can tell you a lot about the interests and pride people have shown all along in the Saturn/Apollo launches and the part their own work played in the project. "After the second orbital flight," Kovalich said, "many employees were asking me what computer (LVDC) was in the launch vehicle, what modules were aboard and the serial numbers of the subassemblies." They want to know when their work flies. □

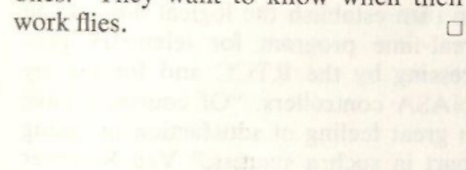
John A. Layton
"Ten years of real hard work . . . . "

When John A. (Al) Layton says he knows some of America's astronauts personally, he's not just dropping names. He's expressing pride in the space program and of his part in it. Layton, a senior associate systems analyst, Mission System Test in Houston Operations, has met many of the astronauts. And having been a member of the space team for a decade, he feels a kinship with all the men who have orbited the earth and moon and with the two who have at last set foot on the lunar surface. Layton was part of Project Mercury in 1959. Today, as part of a computer control team, Layton mans the data select console.

To Layton, the successful lunar landing meant "ten years of real hard work culminating in perfection." He said that when President Kennedy set the moon landing goal for this decade he had his doubts. "I wondered if I would actually be part of the space program when this mission was accomplished. I'm gratified to have been part of this great success," he said. □

G. Louis Murphy
"Typical of American ingenuity an ability."

G. Louis Murphy, senior associat programmer in Houston Operation Spacecraft Guidance department, pretty well convinced that we can d just about anything we try to do. H says of the Apollo 11 success, "This typical of American ingenuity and abi ity. When we combine our resource and talents and work as a team, w just achieve whatever we undertake. Since joining IBM in 1965, he ha worked with spacecraft guidance an simulation programs. Murphy and h co-workers have also developed mathematical model of the moon fo training astronauts to simulate sigh ings and make readings to ensure sa lunar landings. Now, he says he's look ing forward to some of those huntin trips he's been postponing, in favor c helping Apollo 11 set down on th moon.



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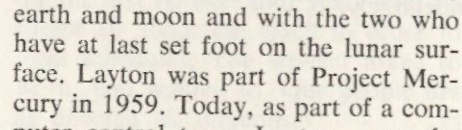
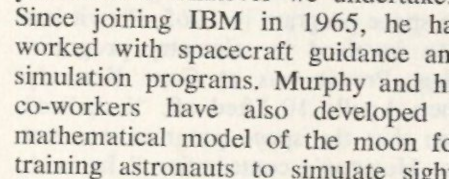


CSM/LM Separation



Landing on Moon

Eugene D. Prewit
"Comparable to the first airplane flight . . . ."

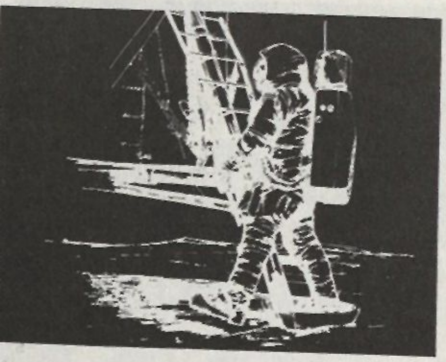
Eugene D. (Dee) Prewit is a man who took the success of Apollo 11 completely in stride. "The moon landing wasn't a surprising development," said Prewit, who is Vehicle Systems Test manager in Houston Operations. "We've been working toward that goal since Project Mercury and proved we could do the job in the Apollo 8 and 10 missions." Since joining IBM and the space program in 1965, Prewit has been involved in telemetry programming. Prewit was at Cape Kennedy when Apollo 10 lifted off. "I realized then that the space program was not just Houston's contribution," he said. "I saw another group from the same team in action from close range and was amazed at how well everything and everyone functioned to meet the final goal, and how few problems there were in relation to the number of people involved." □

Peggy A. Weems
". . . should be continued . . ."

IU Applications Secretary Peggy A. Weems is glad IBM has taken an active part in the space program and is excited about future applications of the IU. She feels that "Apollo 11 is not an ultimate goal, but a step in finding and achieving further, unknown goals. Each mission is a vital step in continuing our technology and know-how and should be continued indefinitely." □

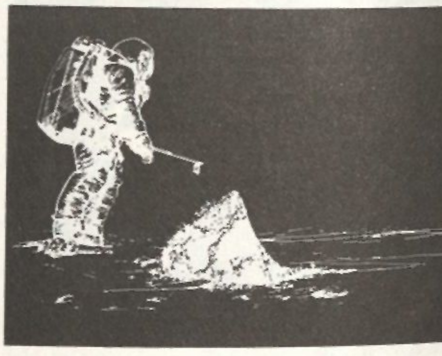
Ralph Van Kummer
"The beginning of a great adventure."

If Ralph Van Kummer took a little deeper interest in Apollo 11 than the average citizen, it was probably because, like hundreds of others at Houston, he was directly involved in the mission. Van Kummer, Vehicle Systems Development manager, had responsibility for the real-time aspects of the telemetry subsystem, developing the series of off-line programs that construct data control tables. The tables in turn establish the logical flow of the real-time program for telemetry processing by the RTCC and for use by NASA controllers. "Of course, I have a great feeling of satisfaction in taking part in such a success," Van Kummer says. "This only marks a beginning of a great adventure and challenge with missions of much longer duration for the exploration of more distant planets and a greater knowledge of our earth." Van Kummer joined FSD in 1963 at the Goddard Space Flight Center. He came to Houston Operations as a programmer before the Gemini 4 mission in 1965. □



First Step

Commander on Moon



Contingency Sample

Lois Lindsay
". . . exciting."

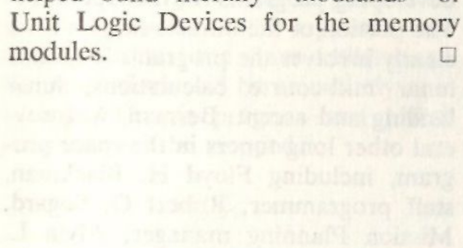
Lois Lindsay, an assembler for the past 13 years at Owego, thinks ESC's contribution toward putting men into space is "exciting." Lois has been with the Saturn Program since it began, initially wiring planes for Saturn arrays. Over the years she proudly says she has helped build literally "thousands" of Unit Logic Devices for the memory modules. □

Bob E. Elston
". . . devoted as surgeons."

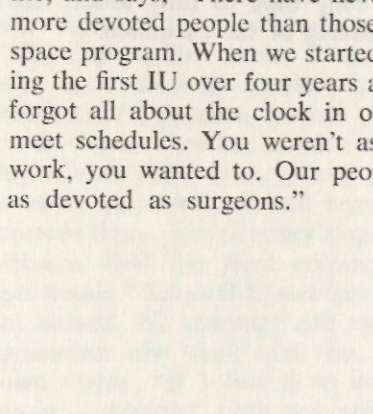
Bob E. Elston, senior associate engineer in Engineering Program Planning and Change Control in Huntsville, was a member of Dr. Wernher von Braun's first group in 1958 at NASA Marshall Space Flight Center. Elston worked on the Redstone missile, the first U.S. satellite, and says, "There have never been more devoted people than those in the space program. When we started building the first IU over four years ago, we forgot all about the clock in order to meet schedules. You weren't asked to work, you wanted to. Our people are as devoted as surgeons." □

Kathleen Bell
An Eye Toward the Red Planet

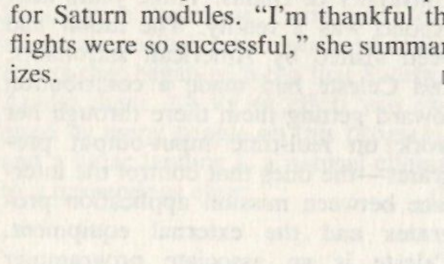
"I want to see them land on Mars, Kathleen Bell says. Mrs. Bell is an as sembler at ESC and has been with Sa urn/Apollo for several years. Peerin patiently through a microscope, she no solders System/4 Pi arrays. Before tha she assembled planes and flexible tape for Saturn modules. "I'm thankful th flights were so successful," she summar izes.



Sample Collection



Bulk Collection



Experiment Placements

Celeste E. Felix
"I'm proud to know that I've taken part."

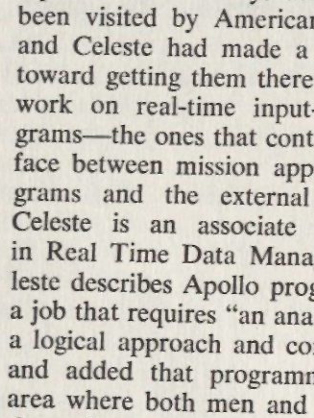
When Celeste E. Felix first came to Houston in 1966, a lunar landing in 1969 seemed to her "not very realistic." The Apollo program was just emerging. Celeste was a new graduate from the University of Dallas. Three years later Apollo was a reality. The moon had been visited by American astronauts, and Celeste had made a contribution toward getting them there through her work on real-time input-output programs—the ones that control the interface between mission application programs and the external equipment. Celeste is an associate programmer in Real Time Data Management. Celeste describes Apollo programming as a job that requires "an analytical mind, a logical approach and concentration" and added that programming is one area where both men and women can share the same opportunity and challenge. □

Fletcher E. Davis
". . . constantly amazed . . ."

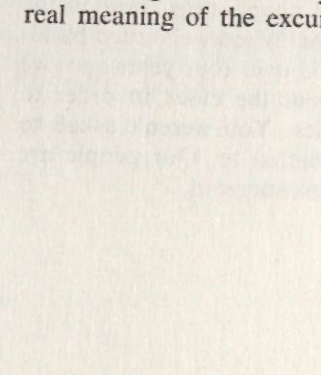
Fletcher E. Davis, Operational Analysis, Huntsville, feels "just like a small child, constantly amazed at the scope and magnitude of the achievement. We have prepared ourselves for the impact of the landing on our society, but I think it will really take our culture a long time to fully absorb the real meaning of the excursion." □

Bernard H. Berman
"You couldn't put Apollo 11 out of your mind."

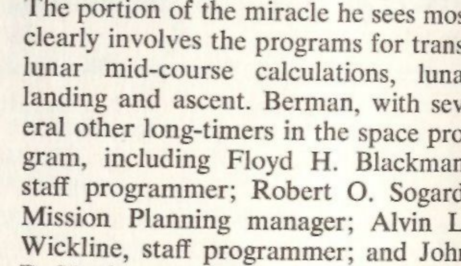
"I'm still awed when I realize that my involvement and participation in such a large group effort helped get men to the moon." Bernard H. Berman, a staff programmer in Houston Operations, was commenting on almost six years work developing programs for the Apollo 11. The portion of the miracle he sees most clearly involves the programs for translunar mid-course calculations, lunar landing and ascent. Berman, with several other long-timers in the space program, including Floyd H. Blackman, staff programmer; Robert O. Sogard, Mission Planning manager; Alvin L. Wickline, staff programmer; and John D. Yonkers, senior associate programmer, shares the fruits of persistence in continual planning, writing and testing programs. When Apollo 11 blasted off from Cape Kennedy, Berman, with scores of others, felt involved. "You couldn't put Apollo 11 out of your mind," he explains. □



TV Camera



Passive Seismometer



Return to LM

Patricia J. Poehler
". . . progress can't be stopped . . ."

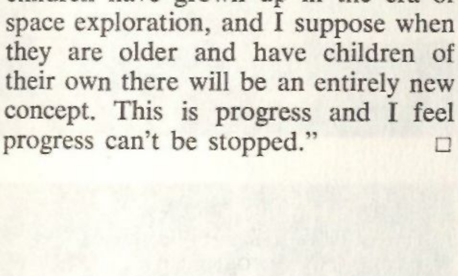
Patricia J. Poehler, Accounting Control cashier, Huntsville, says, "The space program is more than just landing a man on the moon. We have far more to learn from it. I know when I was a child, the use of airplanes was not as commonplace as today. My teenage children have grown up in the era of space exploration, and I suppose when they are older and have children of their own there will be an entirely new concept. This is progress and I feel progress can't be stopped." □

James A. Grimmet
"I wouldn't make any other decision."

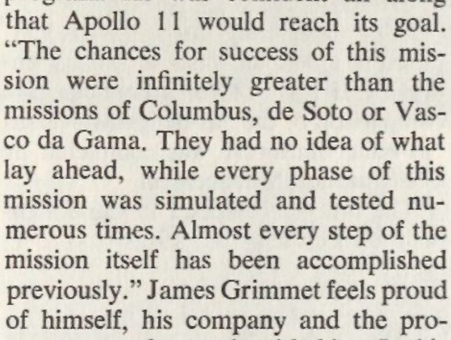
"We have the best group of programmers in the world at the RTCC." That's how James A. Grimmet, a senior associate programmer who works in Orbit Trajectory Computations, sees it. Grimmet takes a lot of pride in his fellow programmers and in the space program. He was confident all along that Apollo 11 would reach its goal. "The chances for success of this mission were infinitely greater than the missions of Columbus, de Soto or Vasco da Gama. They had no idea of what lay ahead, while every phase of this mission was simulated and tested numerous times. Almost every step of the mission itself has been accomplished previously." James Grimmet feels proud of himself, his company and the programmers who work with him. In his own words, "If I had it to do over again, I wouldn't make any other decision." □

Reuben E. Long
"earthbound too long . . ."

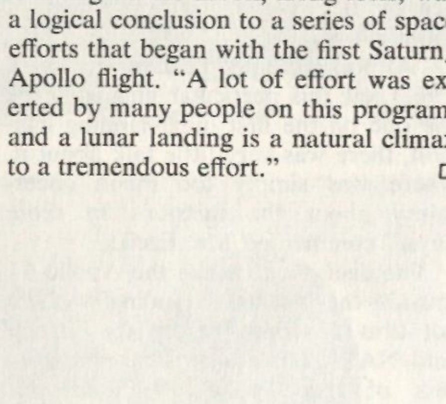
"We've been earthbound too long,' Reuben E. Long says. Long has beer program manager of the SSC Saturn/ Apollo Project at Owego. "It's necessary for the program to advance the frontier of knowledge and to expand man's capabilities in space," as he sees it Landing on the moon, Long feels, was a logical conclusion to a series of space efforts that began with the first Saturn/ Apollo flight. "A lot of effort was exerted by many people on this program and a lunar landing is a natural climax to a tremendous effort." □



Ascent Stage Launch

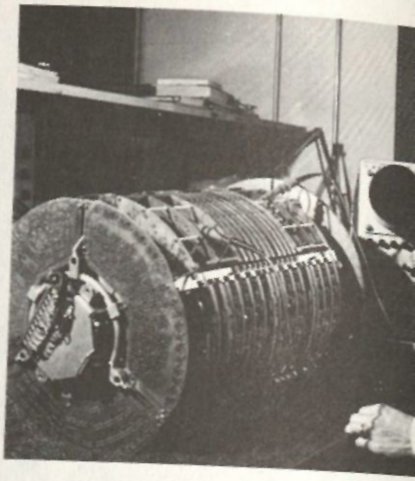


Rendezvous and Docking



LM Jettison

Right—Saturn 506 IU—the ring through which Apollo 11 started to the moon.



506 Was the One

HUNTSVILLE, ALA.: The Instrument Unit which guided Apollo 11 on its maiden moon-landing mission was Instrument Unit (IU) 506, one of a family of 27 IUs assembled and tested at IBM's facility here.

"We didn't know when the three basic aluminum and honeycomb segments of the IU arrived here that these would house the guidance and control system of the launch vehicle on the historic mission," says Charles T. (Chuck) Ezell of Program Planning and Surveillance, who was assigned the specific task of monitoring progress on 506.

The three 120-degree structural segments arrived in Huntsville in the fall of 1967, just before the first Saturn V launch for an unmanned earth-orbital mission.

In an evolutionary program such as Apollo/Saturn, each new mission is heavily dependent on the success of the previous one.

"Although the people associated with 506 knew this particular unit could be the one on the first lunar-landing mission, there was very little talk about it. There was simply too much uncertainty about the missions in those days," commented Mr. Ezell.

The decision to make the Apollo 11 mission the first lunar landing was still not firm a month before the launch until NASA officials analyzed the success of the Apollo 10 lunar-orbit "dress-rehearsal" mission.

In retrospect, casual dates became significant to Huntsville people. They are the milestones that measure their participation.

Fabrication of 506 began on October 31, 1967, and it was spliced into a circle by November 17, 1967.

Cabling assembly began on January 11, 1968. By February 7, 1968, the cold plates had been installed, along with the ST-124 Platform Mounting Frame, quick-disconnect brackets and manifold clamps.

"In early 1968," says Mr. Ezell, "we were still having problems with deliveries of several components and many work-around plans were devised."

By late March, all the cables were installed, and about 90 percent of the total assembly effort was completed. On April 6, 1968, 506, now completely assembled, was moved to the checkout stand for pressure and leak testing.

Bob N. Beaber, assigned as 506 test coordinator, led the initial systems test of the unit. Checkout began on April 30, 1968, and was completed on June 20, 1968.

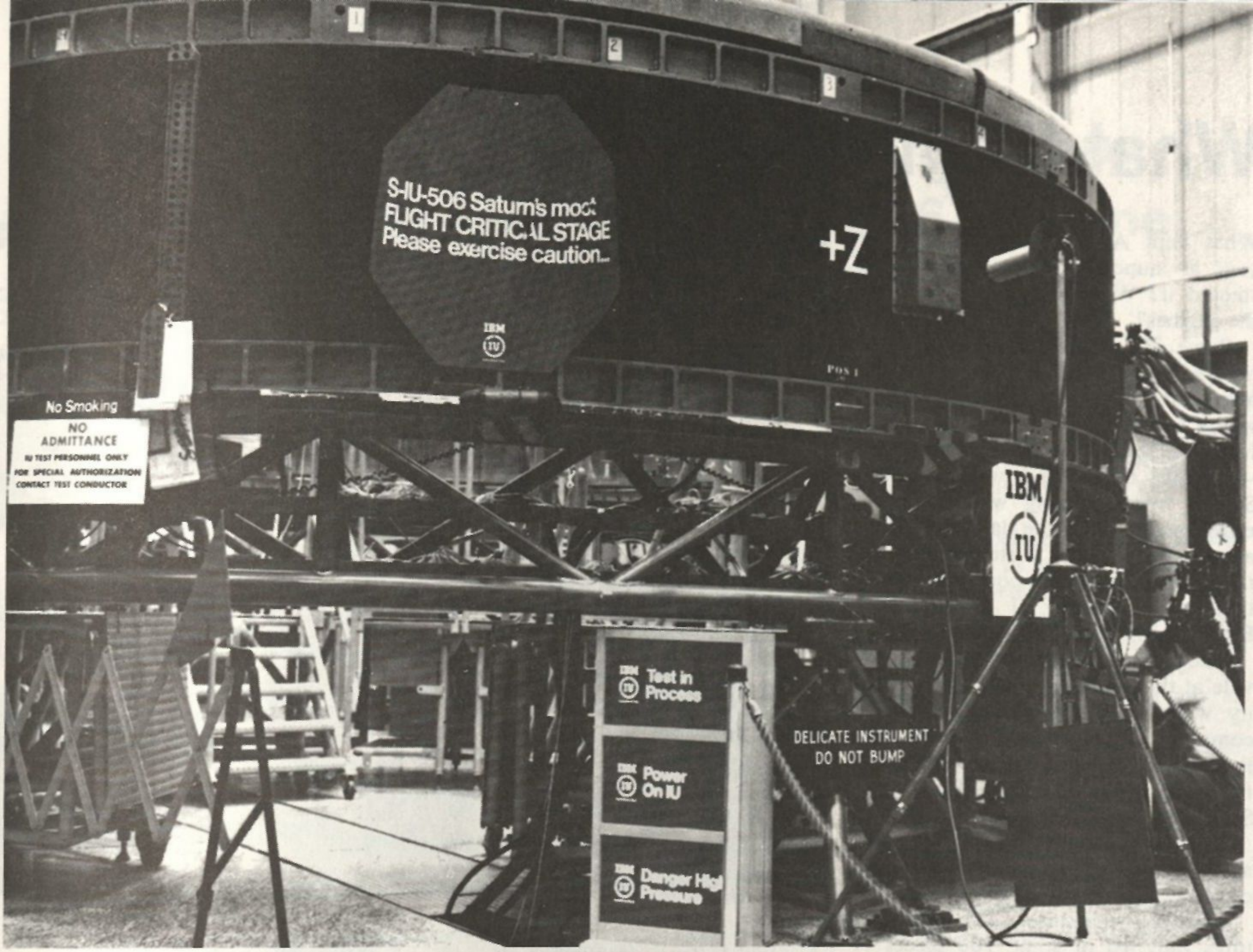
A retrofit period followed during which a number of engineering changes were incorporated. These changes were sufficiently extensive to require retest of the unit.

Retest was completed on December 23, 1968. Although several vehicles previously went through extensive retest at Cape Kennedy because of engineering changes installed after checkout, either at Huntsville or at Cape Kennedy, NASA wanted 506 to go to Cape Kennedy as a clean vehicle—with very few engineering changes remaining to be incorporated. This was accomplished through intensive effort by engineers, manufacturing, product assurance personnel and administrators at Huntsville.

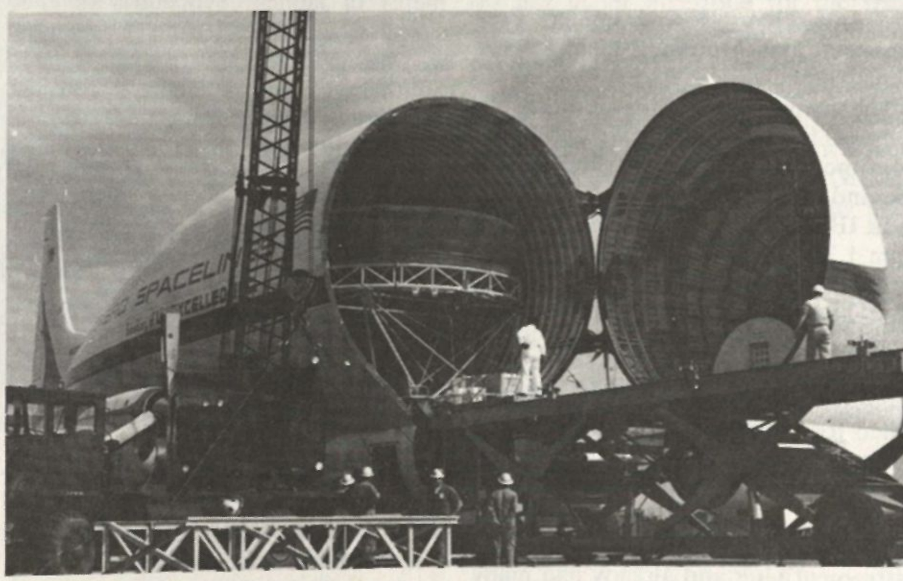
Prior to delivery, the unit was subjected to a detailed shake-down inspection by IBMers. Also, a configuration comparison of the "as-designed" versus "as-built" hardware was completed by Configuration Management.

The unit was shipped to Cape Kennedy on February 27, 1969. □

At Huntsville—George V. Lateur checks the flight control computer, George D. Care studies component stress relief and Wilma K. Davis wires a distributor.



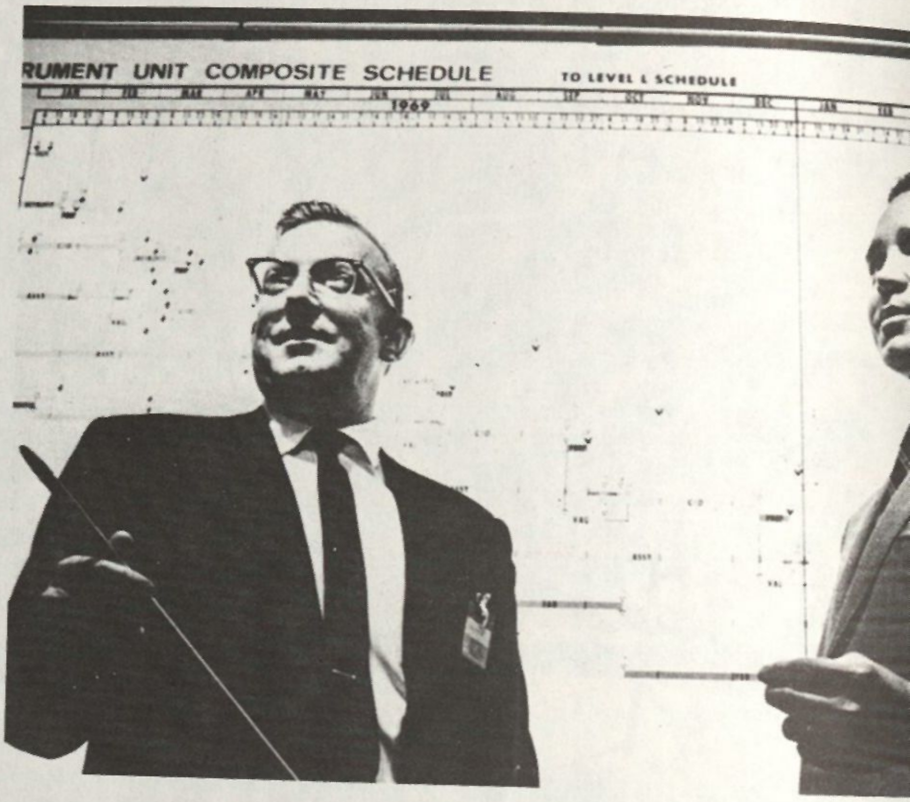
Above—A portable "clean room" hangs over IU when units are mounted inside ring.



Draped and mounted on a traveling cradle, the IU nests in the Super Guppy at the start of a journey from Huntsville to the Cape.

What IS the IU?

Charles T. Ezell and Eugene J. Rodriguez of Program Planning and Surveillance in Huntsville handle day-to-day program aspects of 506.



What kept Apollo 11 from toppling over at launch? Was it aimed? Who steered it? What started and stopped the engines?

Some 20 stories above Cape Kennedy sand, a three-foot high ring nested atop the third-stage Saturn engine where the vehicle's girth measured 21 feet. This was the IBM Instrument Unit—the IU that found ways to keep Saturn from toppling when it lazily eased away from the launcher. This aimed the booster; it steered; it controlled the 7.5 million pounds of thrust that headed Apollo 11 to the moon. But what is the IU?

The IU gets its IBM brand in Huntsville at the Space Systems Center facility where it is "manufactured." The computer and data adapter that provide the heart of the IU's guidance and control system are made at the Electronics Systems Center in Owego.

But the IU is more than a computer and a ring of thin aluminum honeycomb.

"Strictly speaking, IBM manufactures only 10 of some 100 pieces of functional equipment that comprise the IU," says Henry K. Alexander, Procurement and Materials manager for Huntsville.

The facts bear out his observation. Some 90 functional items are purchased from more than 50 major subcontractors, and the remaining parts and equipment IBM needs to deliver an IU come from 1,300 other suppliers.

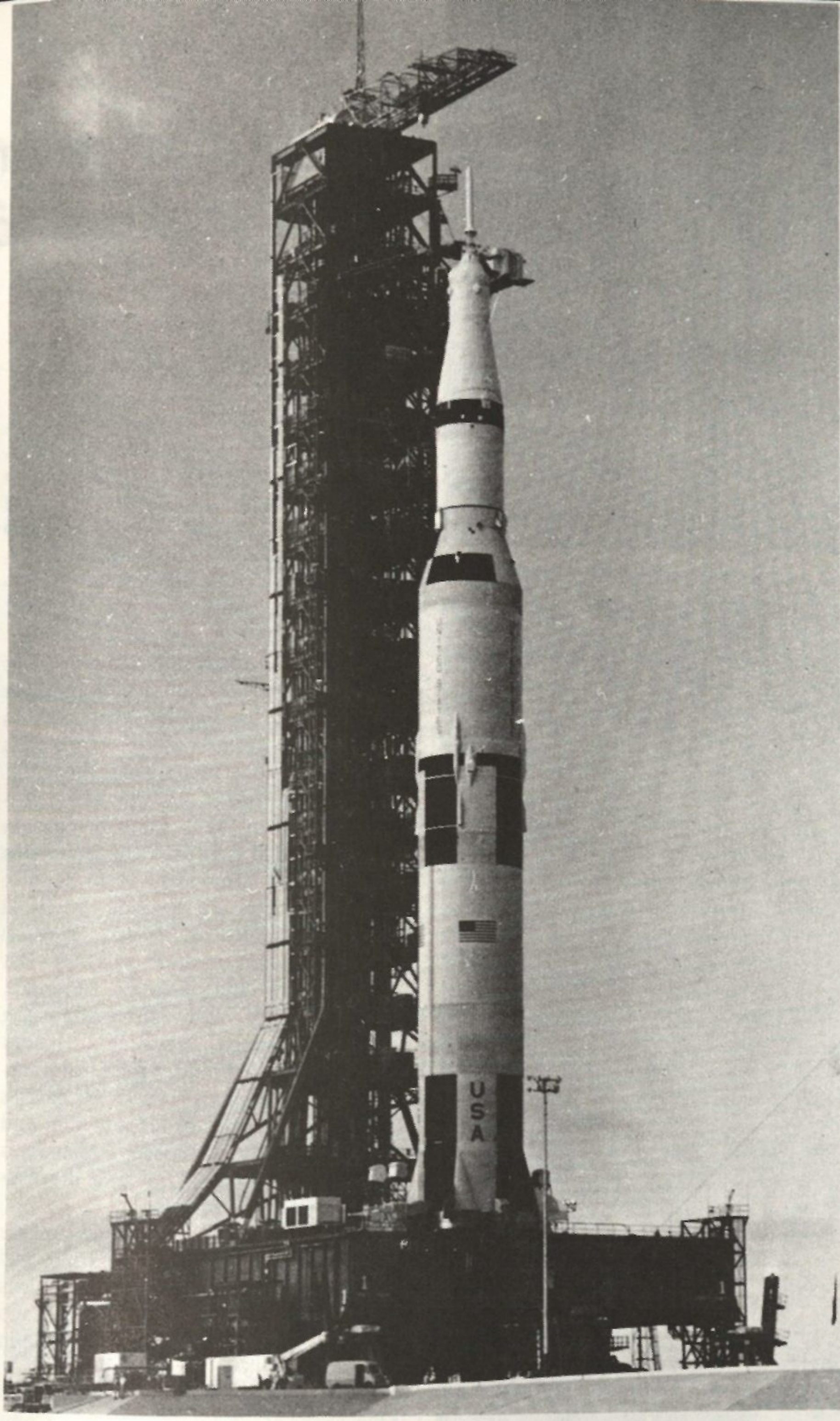
IBM assumed the responsibility of the IU when the Marshall Space Flight Center in Huntsville gave the facility a letter contract in August of 1964. A definitive contract (March 31, 1965) called for IBM to assume all responsibilities in procurement, fabrication, assembly, test, checkout and delivery of 27 IUs.

MSFC designed and developed the Instrument Unit and already had many suppliers and specifications defined when IBM was given the job. MSFC's work was continued, and new suppliers were awarded contracts in competitive bidding. Included in the IU's equipment complex are devices to sense attitude, acceleration, velocity, position and the computer to lay out the desired course and give control signals to the engines to steer the Saturn on that course. It is the IU's gentle directional control of the Saturn engines that keeps the slender vehicle from toppling in the moments of launch. Subcontractors and suppliers are spread from Washington to Massachusetts and from Florida to Southern California. There is constant pressure and concern that each unit does its intended job. Design engineers in Engineering work closely with the buyers. Manufacturing and Methods engineers assist subcontractors in solving many complex process and manufacturing problems. Procurement Quality Assurance, headed by Dallas M. States, follows up with intensive supplier surveillance to insure that specified manufacturing methods and processes are accomplished.

Three purchasing managers, Victor J. Ward, Robert E. Bargetzi and Del Craft headed the procurement teams of the IU subcontractor effort.

According to Alexander, most components and parts for the IUs that remain to be built are in stock. Other parts, configured to meet particular mission requirements, will be delivered as required to support the program. □

Henry K. Alexander tells of IU procurement at Huntsville.



Apollo 11 stands on Pad 39A at Cape Kennedy where it was made ready for the moon journey.

Apollo Capsule

NASA schedules list a minimum of three additional lunar landing missions, one in late 1969 and at least two in 1970. Lunar scientific experiment packages have been developed for each of the three missions. The schedule is shown below:

Mission	*IU*	*Planned Launch*
Apollo 12	507	Mid-Nov. 1969
Apollo 13	508	Mid-March 1970
Apollo 14	509	Mid-July 1970

At the Cape 506 Became 'Their Baby'

CAPE KENNEDY: The SSCers here looked upon 506 as "their baby." They had been closer to this special vehicle than most and would readily plead guilty to getting emotionally involved as checkout became countdown and finally liftoff.

On the pad before liftoff, 506 looked much the same as its predecessors. But as one launch veteran put it: "Knowing this would be the one to go all the way made a lot of difference in how you looked at it out there—and how you felt about it, standing there, ready to carry men to the moon at last."

IBM's lead test conductor for Apollo 11, Thomas R. Kitchens, earlier had noted an "increased awareness" of the vehicle's significance among launch support team members as integrated tests of the booster stages and Apollo spacecraft moved toward countdown.

A flawless Countdown Demonstration Test two weeks before launch was the last major milestone for the IBM team and its NASA/industry counterparts. A rehearsal of the final countdown to the last nine minutes before liftoff, the Test checked the operational readiness of the maze of launch support equipment in the Saturn Ground Computer Complex required to start the vehicle into space.

The 506 Instrument Unit was delivered to KSC on March 6. Although it had been checked out before leaving Huntsville, it was checked and rechecked after arrival. The IU underwent hundreds of tests, both alone and in conjunction with other vehicle stages, before it was considered flight ready.

While IU testing was going on, other members of the SSC team at the Cape were making sure that the elaborate Saturn Ground Computer Complex—needed to test every system on 506 and transmit the command for ignition on launch day—was ready to do its job.

Two and a half hours into the mission, the IU's onboard command and control function was completed. It navigated 506 into earth orbit, initiated the required engine burns and cutoff, commanded booster stage separation and started the Apollo spacecraft into translunar injectory. □

The Apollo payload swings into position above the IU in the final stacking at Cape Kennedy.

Programmers Chart Makers

How does Apollo achieve nee threading accuracy?

To a rocket expert, it's the engi To a guidance man, it's the gy sensors and on-board computer. E discipline has a valid claim to a sh in the perfection, but there's an F breed at the Cape, Goddard, Hous and Huntsville that agrees on a co mon answer: programming, the c cipline that in this special case tra lates esoteric space equations, fli dynamics and celestial mechanics i an organized procedure that enab computers to provide answers to laun teams, flight controllers and astronau

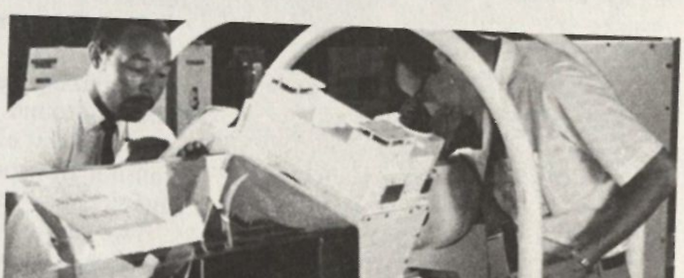
The main thrust of the FSD pr gramming effort takes place in Houst where five IBM System/360 Model 7 handle all of the information to gi flight controllers the answers they ne to keep Apollo on course and target for each manned mission. B Apollo can't fly without Goddar Cape Kennedy and Huntsville. T worldwide space tracking netwo must be checked and tuned to tran mit data to Houston—that's Goddard job. Programmers at Huntsville an Cape Kennedy concern themselve with the Instrument Unit and the mi sion of the Saturn booster.

Goddard phases into action when th checkout of the 17 tracking stations an four NASA ships take place. This ge underway 28 days before launch an continues until the last check is made i the final six hours of countdown.

The program by which the net i checked and approved is called Com putation and Data Flow Integrate Subsystem—CADFISS. The program includes more than 300 tests for th stations that circle the globe. It com pares responses with various ratings and scales them to determine if th remote sites are performing at unac ceptable, degraded but acceptable o normal levels. Goddard engineers ca see at a glance how stations are oper ating by looking at the giant displays where the CADFISS results are posted.

IBM engineers, systems analysts and programmers have helped evolve the programs—among the most sophisticated ever written—in their support of Goddard for a decade.

Dozens of displays help the launch team take the pulse of Apollo from the Cape Kennedy firing room.



Ernest O. Barganier and Kenneth B. Comer check out stabilizer systems.

the Space Explorers

Launch and the flight of the Saturn booster are closer to Huntsville and Cape Kennedy programmers.

On January 24, 1969, Huntsville's flight programmers learned what was expected of them for Apollo 11's mission. Concepts were outlined by Robert E. Poupard, Systems Engineering manager. NASA's mission requirements had been given to the systems people to develop an equation-defining document, the basis for the Saturn flight programs. Flight programmers delivered their product to NASA May 26. Similarly, Saturn Launch Computer programmers in Huntsville wrote ground computer programs for the Operating System and Test Programs.

The programming efforts for Apollo 11 included IU checkout programs, Launch Computer Complex programs, and Launch Vehicle Digital Computer programs.

The work evolved from effort that started in 1962 when programs were started for an ASC-15 computer that flew with a Saturn I in 1964.

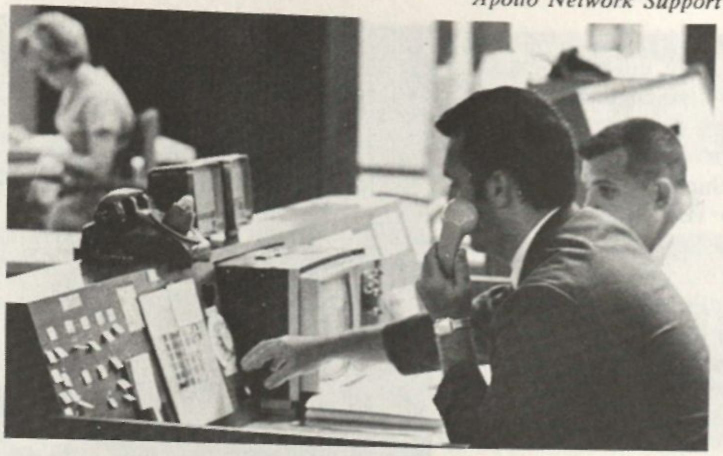
In the summer of 1964 program work for the IU's first flight started, and IU 201 flew a successful mission on February 24, 1966.

The first moon rocket left the pad on November 9, 1967, when Apollo/Saturn 501 was launched from Cape Kennedy. "This was our first experience with restart of the S-IVB engines and something different from earth-orbit missions," says Winston P. Newton. "This provided us with the basis for programs for all subsequent Saturn V vehicles."

"For IU 203, it was the first time the on-board computer actually performed any orbital guidance in a vehicle exercise," Newton says.

A graphic display terminal and an IBM System/360 Model 44 were combined to enhance flight programmer capability so that a flight programmer can use the graphic terminal to control the entire system. He can start action, monitor flight software performance in real time and accomplish digital analysis during a post-flight phase. For 506 it was the first time this facility was used in a systematic program checkout scheme.

Jack Hasenei and Dick Janowitz of Goddard coordinate the Real Time System effort with the Apollo Network Support team.



Five IBM System/360 Model 75s in Houston's Real Time Computer Complex keep track of mission detail for flight controllers and astronauts.

Jack Dabrusim and Michael L. Banks follow mission detail in the RTCC control area in Houston.

Although Apollo 11 flight programs were not significantly different, excitement and pride were ingredients.

When programs for Saturn ground computer systems and the Instrument Unit's launch vehicle digital computer are delivered to IBM Cape Kennedy from Huntsville, Software Operations checks them out.

The department's eight programmers verify that documentation accompanying the programs and the information on their tapes agree, then deliver them to appropriate systems personnel to load.

Cape Kennedy's programming role meshes with Huntsville's. The Cape checks the delivered software and sends the on-board computer programs to Flight Computer Systems and the operating systems tapes to the Ground Computer Systems department.

Clarence R. Boswell, Software Operations manager, explains that testing with ground support equipment occasionally uncovers a program problem. When this occurs, the correction is made by Huntsville.

Saturn Support Prorgamming writes post-processing programs for launch vehicle checkout and countdown procedures.

Saturn Diagnostic Programming writes programs to maintain and check out launch complex computers for which IBM is responsible.

After Saturn and the IU were separated, the Huntsville-Cape Kennedy work was done, but Houston's had barely started. The effort at the Real Time Computer Complex in NASA's Manned Spacecraft Center was massive. It could be measured only by the complexity and the detail of the mission itself. Each correction, the lunar orbit, detail for command and lunar vehicles, liftoff, rendezvous and return were in the Houston plan.

For example, the reentry trajectory was simulated approximately 400 times during the mission before the actual return home.

With each change or update in the mission profile, the reentry is recomputed once again by the IBM System/360 Model 75s. Critical parameters like velocity, flight path angle, times of maximum forces, times of communication blackout and time and position of impact are evaluated.

The combination of programming effort at the four FSD locations helped Apollo 11 achieve its accuracy. □

This is the Mission Operations Control Room at the Manned Spacecraft Center in Houston.

Donald A. Ritch
Apollo 11: "Fantastic!"

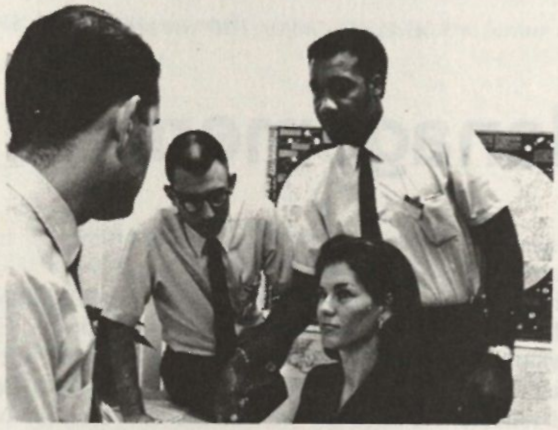
During a typical Apollo flight, Donald A. Ritch simultaneously monitors five plot boards, four display boards and between eight and ten telephone conversations in his work at Goddard. Any resemblance between Ritch and a one-man band is strictly an illusion. This blur of activity in several directions at the same time is all part of Ritch's job in mission support, a slot he describes as one where there's just "no time to get bored."

As for Apollo his one word for it is "fantastic!" □

Gary A. Turk
"Something man has accomplished."

Gary A. Turk began building rockets in high school not long after the first Russian and United States satellites were sent into orbit. Gary's rockets were only models then, and a lunar landing was a dozen years or so away. Turk's job is in Systems Assurance for the Goddard Real Time System/360 control program, which provides support at Goddard for data analysis and checkout of the worldwide tracking network. □

John Morton, Cal Packard and Thomas Proctor monitor display as Morton enters data in translunar program at Goddard.



Jerry P. Burns, Donald G. Rhorer, Laray Johnson and Janice L. Kagy discuss Simulation printout in Houston.

Sandra J. Elliott and Deanna C. Ulrich keep track of documentation in the Real Time Operating System library in Houston.

Roy H. Williams, Leroy Hall and Ralph T. Myers discuss system operation during a simulation in the RTCC control area.

Equipment System Verification people at Houston—Roberto Gonzales, George C. Becker, Sadie L. Stanley and Rosalie Beaudrot confer.

The Apollo Success Proved the Space and Ground-based Systems as Well as

Arthur E. Cooper, FSD vice president and SSC general manager.

Men of Management

"We compressed time; it was as simple as that," says Arthur E. Cooper, FSD vice president and SSC general manager, as he describes how IBM evolved a solution to a gigantic development and production problem five years ago. The problem: create and build reliable hardware and software for the Apollo/Saturn lunar landing program.

"Our pre-Apollo/Saturn record—Titan, Mercury and Gemini—was a great base to work from," he says, "but the complexity and deadlines for this country's 'man-on-the-moon' program left no time for error or second guessing."

Bringing the IBM space team through the turmoil, excitement and hurrahs of a lunar landing has been a major management task. It was decision after decision with the next milestone known but no clear path to reach it. But reach it they did, and Cooper led SSC's team in making good IBM's commitments to help land men on the moon before 1970. In the past five years, there have been bold management decisions; engineering, software and production innovations, and advances in the state-of-the-art that are now providing the impetus for new space- and earth-oriented programs.

"Many times, though, it was like managing in a gold fish bowl," Cooper explains. "Everyone was looking over your shoulder."

"Oh, there were problems," he continues, "but all you could do was to make the best decision based on the information you had. We followed through, modified the answer if necessary, but we never stewed over our decision." This attitude often led to direct action.

"Cooper was not above tackling the problem directly," recalls Monroe E. Dickinson. Dickinson headed the Saturn computer development effort in Owego in 1964 and is now director of Special Programs for the Communications and Engineering Sciences Center in Gaithersburg.

"After we committed ourselves to a Saturn computer for NASA's 201 vehicle, we began to have second thoughts. Normal production time for an operational model was 12 months; but, at the time we said 'yes' to NASA's question, 'Can you build one?' we were only six months from liftoff.

Although the schedule slipped from November to February 1965, the launch vehicle digital computer, a vital part of the IU's guidance system, was not the pacing hardware.

As a space frontiersman, Mr. Cooper counts many of the astronauts as personal friends. "Knowing them brings the program close to home. We want to do our absolute best, not only because of who we are and the company we represent, but once you're exposed to these guys, you have another incentive to do well for them and the cause they believe in."

He feels space is manifestly important to man. "These programs mean much to man's progress. Space is on the cutting edge of technology. We cannot ignore it because ignoring space projects would be like denying progress. We can never stop learning, never stop accepting challenges. These are the hallmarks of a great nation."

Philosophizing as he does, Coop is still pragmatic. He ties tomorrov dreams to the real world as he emph sizes how each IBMer's part was important to Apollo/Saturn's succe

"I remember a remark the late G Grissom made during a 1963 visit Owego," Cooper says. "In an addre to the employees, Gus said . . . 'in t final analysis the job is up to the pe ple working in the plant. They sold the joints, build the gear and put it together knowing that the part th build is going to work.'

"And our products did work, f they had quality and reliability bu in. With Apollo 11 successfully behi us, we have reached a point in reali that only 'yesterday' was a dream. Bu instead of an ending, I see this sh and the whole space program, as a b ginning. Space is the leading edge tomorrow's technology; it's our tick not only to further achievements space but also to accelerate the growt of our economy for the benefit of al

"Experience is always the be teacher, and we have built a fantasti 'experience bank' in the Apollo/Satur program. These efforts have alread begun and will continue to pay bi dividends," he concluded.

Ammon G. Belleman, Jr.

Clint H. Grace shows IU work to Walter Schirra, former astronaut.

CAPE KENNEDY: "Every one of us can walk a little taller, a little prouder for having helped make the lunar landing a reality," says Ammon G. Belleman, Jr., IBM facility manager here.

Although success is shared by the nation, IBMers here who have played key roles in checkout and test and countdown and launch see the fruits of their efforts with more reality than those at other FSD locations.

Space is a daily diet here. The Vehicle Assembly Building and towering launch pads dominate the endless horizon. The gradual buildup, the countdown and the launch are inescapable.

"Large and small, our individual contributions counted," he continues, noting that "hard work, headaches even heartaches" underscored personal dedication of many individuals.

Belleman has been in charge of the FSD effort at Cape Kennedy since May, 1965, with responsibility for Instrument Unit checkout and Apollo/Saturn launch support activities.

"In the four years since the facility as we know it was established," he explains, "we have developed the experience and expertise to do a businesslike job in our launch operations assignment."

"It was a new kind of business for IBM," Belleman explains. "There were several nagging problems. Solutions were achieved by developing ways to schedule events and have everything come together at the right time. It took a lot of hard work and long hours for most of the people here, but eventually our system proved we were on top of our responsibilities." □

"It's been the finest program that I have been associated with in my 18 years with IBM."

That's how Clint Grace, the affable, easy-smiling manager of IBM's Huntsville facility talks of his job. His primary role since 1964 has been to manage IBM's Instrument Unit program; and, when he reminisces about the last five years, the gleam of satisfaction is apparent in his eyes.

Grace arrived from Owego in March 1964, not too many days after he had led the team that presented IBM's "IU-build" program to Dr. Wernher von Braun and other NASA officials.

"Research Park was barren the first time I drove through," he remembers. "IBM had purchased about 25 acres within the newly created industrial area, and construction was only a dent in Alabama's red clay. . . .

"As I stood there, it struck me that we were 18 months from that deadline and I was looking across a weed-filled vacant lot. There were no buildings, no tools or equipment and only a handful of employees."

The IBMers that were here, however, became the nucleus for today's 1,800-man facility. They had been here since 1962 working with Marshall Space Flight Center's Astrionics Laboratory in the IU design program. With their help, and the help of untold others, the challenge was met.

Fabrication and assembly of S-IU 201 was started in January 1965. Ten months later Dr. von Braun helped to dedicate the facility, and two days later the first IU was on a NASA barge, floating down the Tennessee River on its way to the Cape—on schedule.

"It was tremendously gratifying to me to know that we'd kept our promise, especially when there was so much to be done.

Grace makes a point of recalling the visit of Astronauts Wally Schirra, Don Eisele and Walt Cunningham, the crew of Apollo 7.

"That did wonders for our morale," he explains. "They were so personable and identified with the people so quickly. It was easy to establish a rapport with them; they were dedicated and motivated and certainly recharged the spirits of all of us."

He calls the Program Control Center "one secret to our success." A specially equipped conference room, the center is the hub of management decisions. Data from all facility areas flows to this center.

"We really got a handle on things after we adopted this concept," Grace says. "The way it functions gives us detailed status reporting; we can anticipate problems and offer solutions before the schedule is forced to grind to a halt because of a missing 'widget,'" he emphasizes.

"We've built a tremendous technical capability here, one that has brought great credit to the IBM company. Truly, it was a team effort. We had to learn new skills, find qualified personnel from all over the country, and mesh people, talent and time into a reliable product. It was done. Our nation, I feel sure, is in the space business to stay, and we'll put forth our efforts in that endeavor for some time to come," he says. □

Larry Sarahan, assistant general manager, FSC.

Requirements at Goddard and Houston Draw on Top Talent

Talk Apollo with Larry Sarahan and it quickly becomes crystal clear why there are no Lindberghs in space. Teamwork is the word.

Calm, soft-spoken, he's the prototype of the team man he speaks of when he credits the Apollo success to a "case of finding a whole lot of very good people who could take and do their part of the job on the Real Time Computer Complex.

"They really accepted responsibility for their parts and consequently, as a total, we did a bigger job than any of us expected from the start. I think there's no question that we ended up solving a very big problem. I'm not sure that I or anyone else really realized how big it was at the time we started or maybe we'd have been a little reluctant to start."

Now assistant general manager for FSD's Federal Systems Center, he traces his involvement in space programs to the engineering of some special equipment for the Vanguard project more than a decade ago through his work in Houston in helping build the RTCC that provides NASA flight controllers and astronauts with the information they need for navigation, course correction and every one of the minute steps required for a successful flight.

He views Vanguard as an early key step in solution of real-time systems, but his personal involvement with computer systems traces back to work with the Naval Research Laboratory in Washington, D.C., prior to joining IBM in 1952. Work on SAGE, the 650 and 700 and 7000 series extended his knowhow in large real-time systems and prepared him for 1963 when he was given the tough RTCC building assignment. In 1965, the facility went operational, providing backup support for Gemini 3.

RTCC was his prime responsibility until 1967 when he became director of FSC's Technical Development department. A year later, he assumed his present position.

"I think we've gotten quite good in doing the programming and testing according to specification and knowing that our system is going to perform according to the mathematics that NASA supplies," he says with a matter-of-fact confidence. Then he adds:

"The ultimate proof is always in flying the mission, and that makes each one have its own unique thrill."

He views success as a result of the balance of NASA skills and talents with those of IBM in celestial mechanics, spacecraft and aerodynamics that produced the equations and the programs.

Sarahan doesn't see Apollo as a dead end for specialized talents. "The jobs people learned to do and the responsibilities they learned to accept are important to them and to the company. "Proving that RTCC could be perfected and that they could write the programs that exist in Houston will give encouragement in areas where programs of that size are needed to solve problems.

"We did it." □

Thomas J. Welch

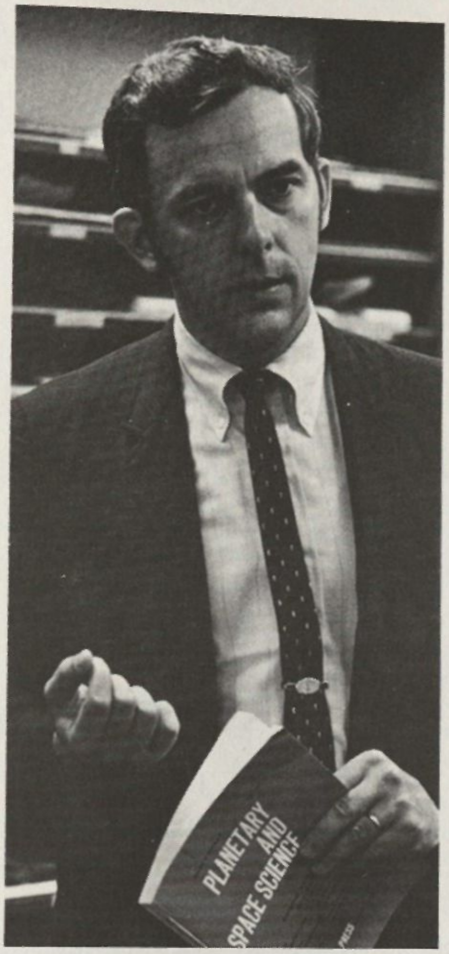
"Apollo 11 represents a great success for the Houston Operations IBM team. Each and every one of us shares in this historic moment." Thus Thomas J. Welch, the man with management responsibility in Houston for the Federal Systems Center effort in support of NASA and the Real Time Computer Complex, views touchdown back on earth.

He also sees it as far more than just an historic event. He feels caught up in the heady feelings of pride and patriotism that mix with satisfaction of performance.

"This has to be the most exciting moment of my career," he says. "I feel immensely proud—to be an American, to be a part of the space program and to be an IBMer."

His comments mirrored the reaction of the 700-man FSC team in Houston. Welch has been in the front-row work for NASA since November 1967 when he became manager of Houston Operations. He assumed his post in Houston the same month that the first mighty Saturn V moon rocket was tested. He has been there for every milestone flight since.

A 14-year IBMer, he joined the company as a programmer for the SAGE system in 1955. He traces his career through the Military Products Division that was absorbed into the larger FSD organization that was formed in 1959. It was a natural evolution that brought him into the space effort, and he sees opportunities to apply the skills developed in Houston to further large-system effort as part of a continuing progress. □



Dr. Claude E. Walston

"Elated."

For Dr. Claude E. Walston, manager of FSC's Goddard Operations, that one word sums up his personal reaction to Apollo 11. The word also speaks for the 400 IBMers at the NASA area northeast of Washington, D.C.

Dr. Walston is quick to point out that although only 150 of the 400 IBMers at Goddard have been concerned with Apollo 11, every individual is vitally involved in space.

"Goddard's responsibility is an important one for Apollo. It is historic, significant and essential. Tracking ships, communications links, radar sites around the world—Goddard is responsible for all of these.

"An IBM system checks the network and if it is decided that the resources are not capable, the mission won't go.

"We have the responsibility to see that accurate data flows to Houston."

Time has not by-passed Goddard, he emphasizes, despite the fact that responsibility for the manned space effort is in Houston. Goddard controls the scientific satellite launches—scores of them—and has reduced much of their information to important new knowledge for mankind.

"Goddard has one of the largest, if not the largest, computation complexes in the world. It controls one IBM System/360 Model 95 at the Goddard Institute of Space Sciences in New York City and another in Maryland where a Model 91, three 75s, a 65 and even one IBM 7094 are located. The '94 is doing off-line computation now.

"As a matter of fact this is the first manned flight that will go it alone without a '94. Apollo 10 used 7094's in conjunction with the two 75s we are now using to manage the space network," Dr. Walston relates.

Walston joined IBM in 1953 with Project High, a SAGE effort. He moved to his present Goddard assignment in 1966.

"The SAGE experience was perfect. It provided the systems experience necessary to understand the complexity of the space systems that have been developed at Goddard to support manned flight and scientific satellite missions," he says. □

West Was There, Too

WESTLAKE, CALIF.: Westlake IBMers like to think they have helped significantly to chart the way for Apollo's trip to the moon. Although virtually all of their work has been associated with unmanned exploration, their efforts for the NASA Space Flight Operations Facility at the Jet Propulsion Laboratory, located at the California Institute of Technology in Pasadena, added to the store of knowledge that sent Apollo to the distant satellite.

IBM was selected by JPL to study requirements for the Space Flight Operations Facility Control Center. It was here that Ranger, Mariner and Surveyor missions as well as spacecraft test operations were controlled.

IBMers also helped develop the computing facility for JPL's centralized Space Flight Operations Center.

IBMers also studied the data handling requirements of the center and designed a data handling system to provide simultaneous control for two spacecraft and monitoring of a third spacecraft.

During the historic moon flight of the Ranger 7 spacecraft five years ago on July 31, 1964, FSD systems played an invaluable part in guiding the vehicle to its target on the moon.

But IBMers contributed more than a system to handle data. They sharpened their calculations on the exact position of the moon by a factor of 10—a significant achievement when you want to get there. They produced a new lunar ephemeris—a tabulation of predicted positions of the moon through year 2000—by applying corrections specified by Dr. Wallace J. Eckert of IBM's Research Laboratory and JPL scientists to the earlier tabulation. The table was checked against ranging data obtained from Lunar Orbiters I and II.

IBMers are also assisting JPL to develop a set of programs to fit a mathematical model of the motions of Mercury, Venus, Earth and Mars to actual visual and radar observation data.

One of the most interesting contributions that helped to pave the way for Apollo was enhancement of Surveyor I photos to give clearer pictures of the surface of the moon.

IBM FSD-Westlake programmers used an IBM System/360 Model 44 to provide JPL with a clearer picture of the moon than had been transmitted from the spacecraft. □

During the flight of Apollo 11, the IU calculated 500 different flight paths—each aimed at the moon—to make sure the astronauts took the most precise, shortest route there. Every two seconds during second and third stage burn, the Instrument Unit calculated a new flight path. Each path calculation, requiring less than a half second, involved solving 135 complex equations and processing more than 6,100 instructions. This gargantuan task used about a quarter of the computer's time; the remaining computation time was devoted to processing navigation, control and telemetry information. □

Guiding 3,500 tons—equivalent to 28 diesel locomotives—is the job performed by Saturn's smallest stage—the Instrument Unit. □

How powerful is Saturn? Powerful enough to toss a U.S. Navy destroyer 50 miles high. □

Fuel pumps for the five F-1 first-stage engines push fuel with a force of 30 diesel locomotives. Enough liquid oxygen is contained in the first-stage tanks to fill 54 railroad tank cars. The F-1 engines generate 160,000,000 horsepower, about double the amount of potential hydroelectric power that would be available at any given moment if all the moving waters of North America were channeled through turbines. The interior of each of the first-stage fuel tanks is large enough to garage three large moving vans side by side. □

The Instrument Unit weighs as much as a big station wagon despite lightweight aluminum honeycomb construction and the miniaturization of the space-age components clustered on its inner skin.

At 2.2 tons it is not heavy for the functions accomplished. The Instrument Unit guides the launch vehicle by tracking its motion and controlling engine cutoff, measures several hundred critical factors and sends this information back to earth by radio. It has its own electrical supply and maintains component temperatures at 60°F, despite a 200°F temperature swing outside in space. □

Bits from Spac

Cryogenic tanks aboard the servi module are so well insulated that i cubes placed inside would take 8! years to melt.

The IU makes up to 2,342 measur ments during the flight of the Satur launch vehicle, it commands stage sep arations and also is employed for pr flight checkout of the Saturn vehic at Cape Kennedy.

Over 10 billion instructions were need ed to carry out RTCC programs for th orbit determinations during Apollo 11 To do this, multiple processing of mor than 60,000 frames of low-speed rada tracking data (collected between Eart orbits) was necessary. Continuous cov erage of Apollo 11 in the transluna and trans-earth phases of the flight pro duced approximately 500,000 individ ual observations (range, doppler, an gles) that were tested for validity prio to use for orbit determination. Abou 6000 manual inputs were made at th tracking data console for the RTCC computers to help control the orbit determination sub-system during the mission. □

An almanac of exact dates and times at which any given station in the worldwide radar tracking network can receive data from the experiment packages left on the moon is generated by the Almanac program prepared by Houston Operations programmers. The program tells when the moon's position makes possible transmission to specific radar stations. This is how data from the experiment package on the lunar surface will be returned to earth. In addition to logging transmission times in relation to position, the program also determines if the package's batteries are charged enough for transmission. □

RTCC programs help determine orientation of the space vehicle for each of the many tasks and experiments conducted in space, including the correct position of the spacecraft window so that TV cameras can be aimed at their targets. The guidance optics program computes the rotation angles required to position the window and displays the angles to the flight controller who relays them to the spacecraft. The program also informs the flight controller when a target will not be visible. □

'. . . One Giant Leap for Mankind'

Neil Armstrong, astronaut

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