IBM

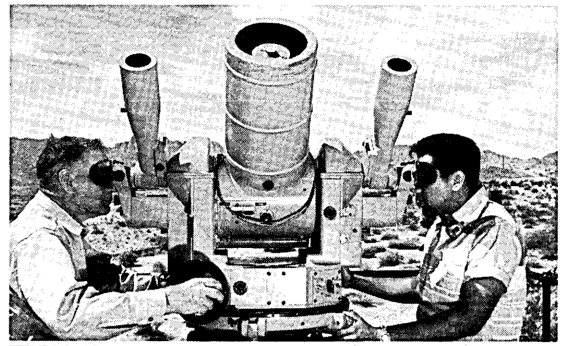
# computing report

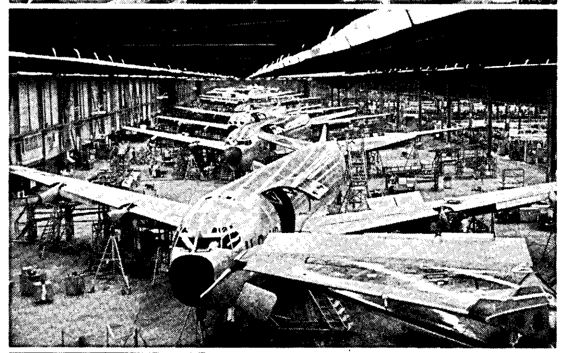
for the Scientist and Engineer

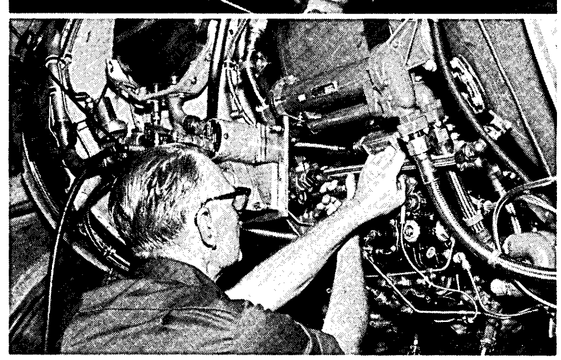
July 1967, Vol. III, No. 4

# Contents:









**Cover: Tracking a missile**

Research with guided missiles is important in both the scientific and military worlds. At the U. S. Army's White Sands Missile Range in New Mexico, a computer complex performs a variety of functions, including monitoring missile firings in real time. Cover printout shows torques recorded during the guidance phase of a missile flight. See *White Sands in real time* on page 3.

Picture credits: Cover, 2, 4, 5, 7, U.S. Army; 2, 9, 10, Leigh Wiener; 11, D. T. Sanders; 2, 13, 15, U.S. Air Force; 20, IBM Japan.


July 1967, Vol. III, No. 4
Computing Report
for the Scientist and Engineer





Published by
Data Processing Division
International Business Machines Corporation
112 East Post Road
White Plains, New York 10601

# White Sands in real time

## An unusual computer system at White Sands Missile Range controls missiles in flight and simulates them in the laboratory

A fiery roar shatters the desert solitude of eastern Utah as a long, slim Athena missile streaks skyward from the U.S. Army's launching site near the quiet town of Green River. Its flaming exhaust becomes a faint speck high in the southeast, then disappears from view as the missile climbs to an altitude of some 150 miles over the desolate Four Corners country, where the boundaries of Utah, Colorado, New Mexico, and Arizona meet at a common point.

Reaching its apogee, the Athena turns downward toward a carefully predetermined impact area in the sagebrush-dotted vastness of New Mexico's White Sands Missile Range (WSMR) 450 miles from Green River. At the optimum moment a set of re-entry rockets is fired, and the Athena, picking up speed, hurtles toward the earth with a velocity approaching Mach 20. Finally, in a spectacular display of fireworks, the missile's warhead burns up in the atmosphere.

Most missiles use rocket power only in their ascent, but the 49-foot-long Athena bores into the atmosphere under full thrust to simulate the re-entry of a full-sized ICBM. Its re-entry rockets are fired at precisely the right moment by a computer at White Sands headquarters, where each flight is monitored in real time. Instruments in the Athena and at surveyed locations on the ground transmit flight data continuously to the WSMR Computer Center. There the data is reduced and analyzed as part of an effort to develop more effective missile penetration aids.

The computer complex that monitors Athena firings—and handles many other jobs at White Sands—is an unusual configuration of two direct-coupled systems, each built around an IBM 7044 and an IBM 7094 II. Each direct-coupled system (DCS) can handle either real-time or batch-processing assignments, or, operating in a mixed mode, can perform real-time work and batch processing simultaneously.

During a "hot" real-time mission, such as an Athena firing, one entire system is devoted exclusively to the job at hand, while the other remains available for backup duty. The system begins receiving data a few minutes before launch and continues processing until impact or until the target is destroyed in the atmosphere.

In normal operation, the 7044 acts as a buffer and programmer, freeing the 7094 to process data at full speed without having to interrupt for any input/output functions. If the 7094 is working on an off-line problem, it can interrupt immediately for a real-time firing mission. The off-line problem is transferred to storage in the 7044, and then picked up at exactly the same point when the 7094 is free again.

### Real-time tracking

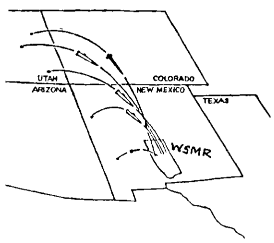
The real-time input to the system includes trajectory and attitude measurements in the form of radar data at 2,400 bits a second, telemetry data at an instantaneous 50,000-bit rate, and timing data. The input is processed and analyzed, and the output—in the form of correcting or other control commands—is transmitted to the vehicle in flight. WSMR's ability to provide this kind of support has resulted in considerable savings because ground support equipment to perform the control functions is no longer necessary.

A large part of the computer's real-time job during a missile firing is "to optimize the estimate of where the missile is in space and where it is heading," says Dr. Guenther Hintze, Chief of the Analysis and Computation Directorate at White Sands. The DCS transmits position information to tracking radars and makes continually updated impact predictions for the Computer Center's huge, automated plotting board. Should the board show that a missile is veering off course, the Range Safety Officer, implementing a Radio Command Control-Destruct System, immediately destroys it in flight.

The Analysis and Computation Directorate is responsible for all data processing and analysis at White Sands and for producing data reports on the missiles tested. It issues an average of 120 such reports a week, all compiled to help missile designers understand exactly how their missiles performed in flight.

The directorate also develops new testing techniques and provides consultant services for range customers in computer programming, numerical techniques, mathematical problem formulation, and automated computing procedures. Directorate personnel have developed a time-shared DCS program that enables the 7044 to handle checks of range instruments in real time while simultaneously feeding production jobs for execution by the 7094, receiving results from the 7094, and distributing the results to disk files, tapes, and printers.

"One of our goals," says Dr. Hintze, "is to make the real-time processing of missile flight data a standard procedure." Many kinds of missiles are tested at White Sands, at the rate of 10 to 20 a day, but real-time support is currently provided only for selected projects.




Such support is gradually being increased, however. One major real-time project, other than the Air Force Athena program, is testing the Army's Pershing missile. Like the Athena, the Pershing is launched from remote sites to land in impact areas on the range.

White Sands Missile Range is the largest military reservation in the United States, occupying about 4,000 square miles of south-central New Mexico. It is 100 miles long from north to south and is, throughout most of its length, some 40 miles wide. An additional 5,000 square miles of territory in New Mexico and Utah is used on a scheduled basis. Range headquarters, near the southern end of the area, is about 50 miles north of El Paso, Texas.

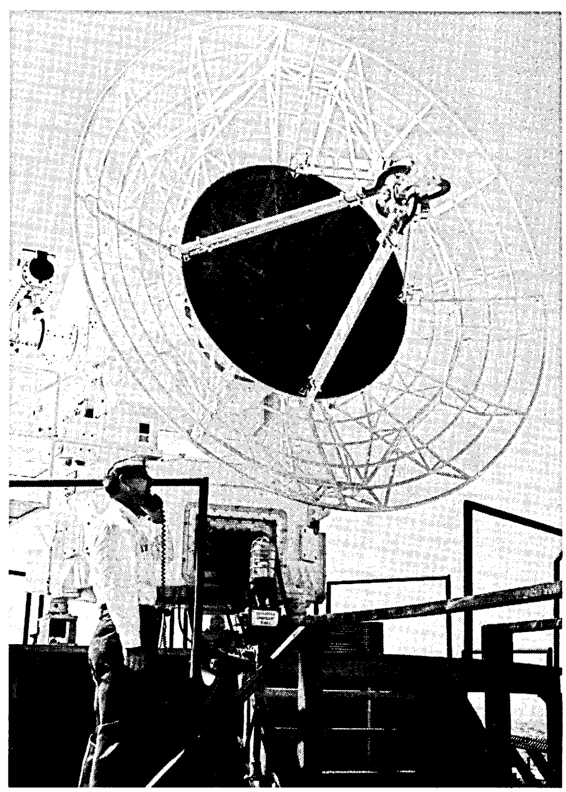
DR. HINTZE signs copies of his book *Fundamentals of Digital Machine Computing* (Springer-Verlag, 1966).

## Many jobs

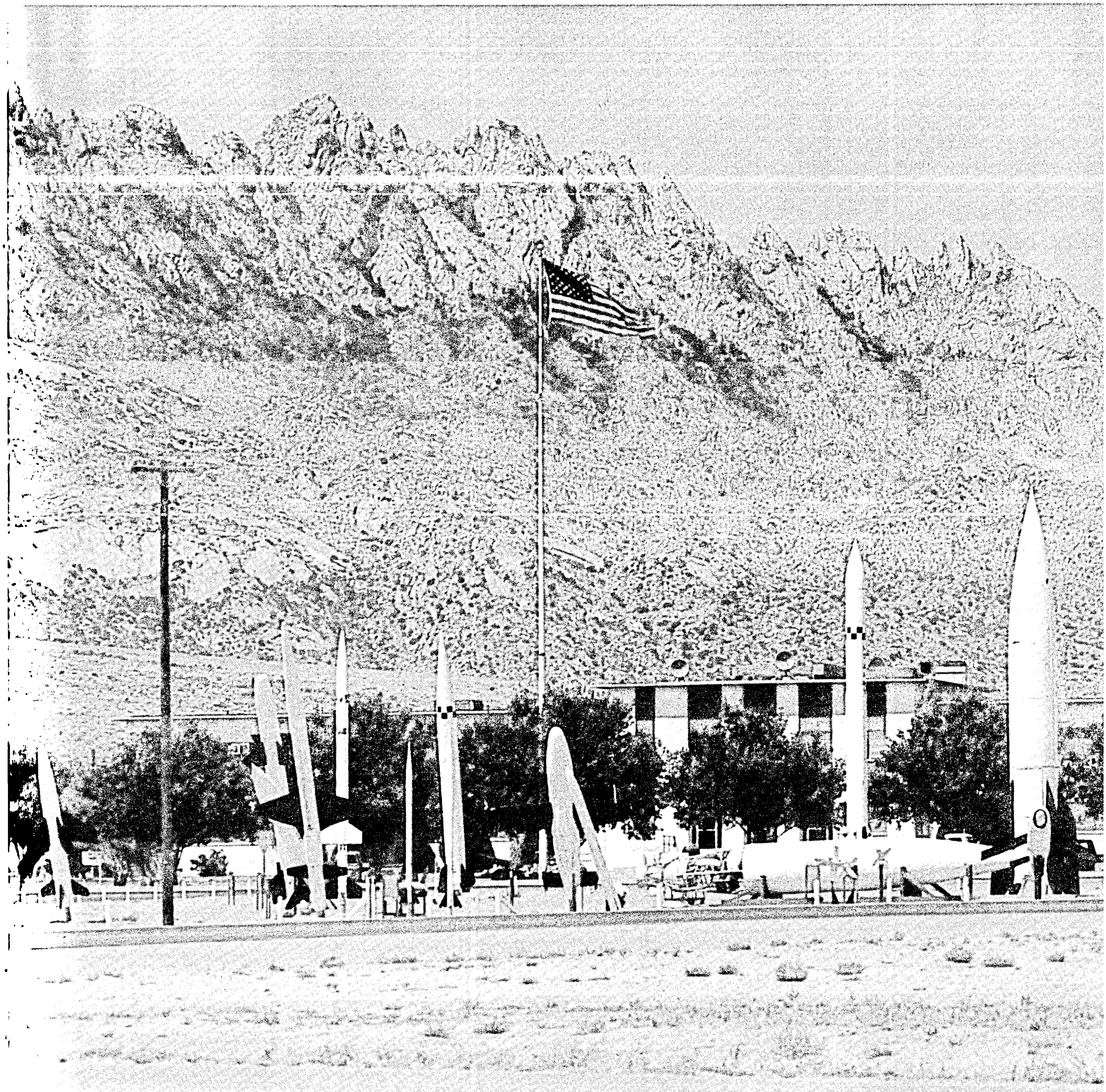
One of five national missile ranges, WSMR is charged with the responsibility of supporting missile test programs of the Army, Navy, and Air Force, and of the Department of Defense and the National Aeronautics and Space Administration (NASA). Its facilities are also available to other government agencies, and to commercial enterprises and foreign governments as well, if sponsorship of their programs is in the interest of the United States. The range is operated by the Army.

A wide variety of programs is carried out at White Sands, from one-time tests of rocket components to continuing projects, like Athena and Pershing, related to the development of complete weapons systems. The range continuously supports more than 100 separate programs, including ground-to-ground and ground-to-air missile testing, space-vehicle development, re-entry physics research, and upper atmosphere research.

WSMR is well suited physically to carry out its mission. The range is located largely in New Mexico's arid Tularosa Basin, where the terrain is generally flat and ground cover sparse, making



RADAR DISH, one of many at White Sands that transmit data to Computer Center, is set for a tracking mission.



MISSILE PARK at White Sands headquarters displays missiles of historical interest. Organ Mountains form a backdrop.

the recovery of missiles—or parts of them—relatively easy. Moreover, all year around the weather is mostly clear—a prerequisite for visual tracking. And the fact that the entire range is on land means that instruments can be located much more accurately than is possible on over-water ranges.

The range proper has more than 1,100 precisely surveyed instrument sites, some permanently occupied and others used on a temporary basis when needed. Missile-tracking instruments include conventional and doppler radars, a variety of cinetheodolites and fixed and ballistic camera systems, and powerful tracking telescopes. Data gathering stations and impact areas are connected by more than 1,160 miles of roads, 60,000 miles of wire and cable, and 340 miles of microwave and radio channels.

The first rocket firing at White Sands took place in 1945, when the U.S. Army launched its experimental Tiny Tim missile on what was then called White Sands Proving Ground. (Not far away, near Roswell, New Mexico, America's pioneer missileman Dr. Robert H. Goddard had conducted his early rocket experiments in the 1930's.) In 1946 the Army began working at White Sands with German V-2 rockets captured in World War II. The name "White Sands Missile Range" was adopted for the installation in 1958.

Dr. Hintze, who had helped develop the V-2 at Peenemünde, Germany, during the war, came to White Sands in 1946 as part of the Army's research team. After doing missile work at Fort Bliss, Texas, and the Redstone Arsenal in Huntsville, Alabama, he returned to White Sands in 1952 to work on design engineering evaluation programs for the Army's guided missile systems.

## Flight Simulation Laboratory

In 1955 Dr. Hintze organized a Flight Simulation Laboratory at White Sands. The laboratory's facilities included an IBM 704 computer and a large analog system. The laboratory today makes use of the 7044/7094 direct-coupled system.

"By simulating missile flights mathematically," says Dr. Hintze, "we can reduce the number of missile firings required for engineering evaluation, and hence literally save millions of dollars every year." Flight simulation, moreover, provides faster and more effective evaluations.

The Flight Simulation Laboratory is also involved in studies of missile-system reliability. In 1958 a major research project was begun in which the reliability of missile systems, subsystems, and components is studied with stochastic processes—that is, with computer simulations using probabilistic models. As Dr. Hintze puts it, "We do not want to conduct complicated missile experiments without simulating them first on the ground."

The use of computers in missile research has come a long way since the wartime days in Peenemünde. "We used electro-mechanical computers then to solve second-order differential equations for flight simulations," says Dr. Hintze. "Today we use the same principles, but with the advantages of combined analog-digital computer systems." □

## Recursive rocketry

In keeping with modern trends in computer development and missile testing, computer mathematics is currently undergoing a revolution at White Sands Missile Range. In particular, the techniques of discrete recursive estimation in the form of the Kalman-Bucy filter have been successfully developed for application to real-time and post-flight data processing and analysis. The application of the generalized theory opens up powerful methods of finding optimal solutions to data processing problems that formerly were dominated by older classical techniques.

Recursive estimation (sequential estimation) is a method of computing generalized linear least-squares estimates in a recursive way. The unique economy of thought that the recursive model allows in reducing practical problems to a mathematical framework is unsurpassed. The recursive technique is ideally and naturally suited to solving estimation problems in real time when an up-to-date best estimate is required at each instant.

Some salient features of the Kalman formulation of the recursive-estimation method are as follows:

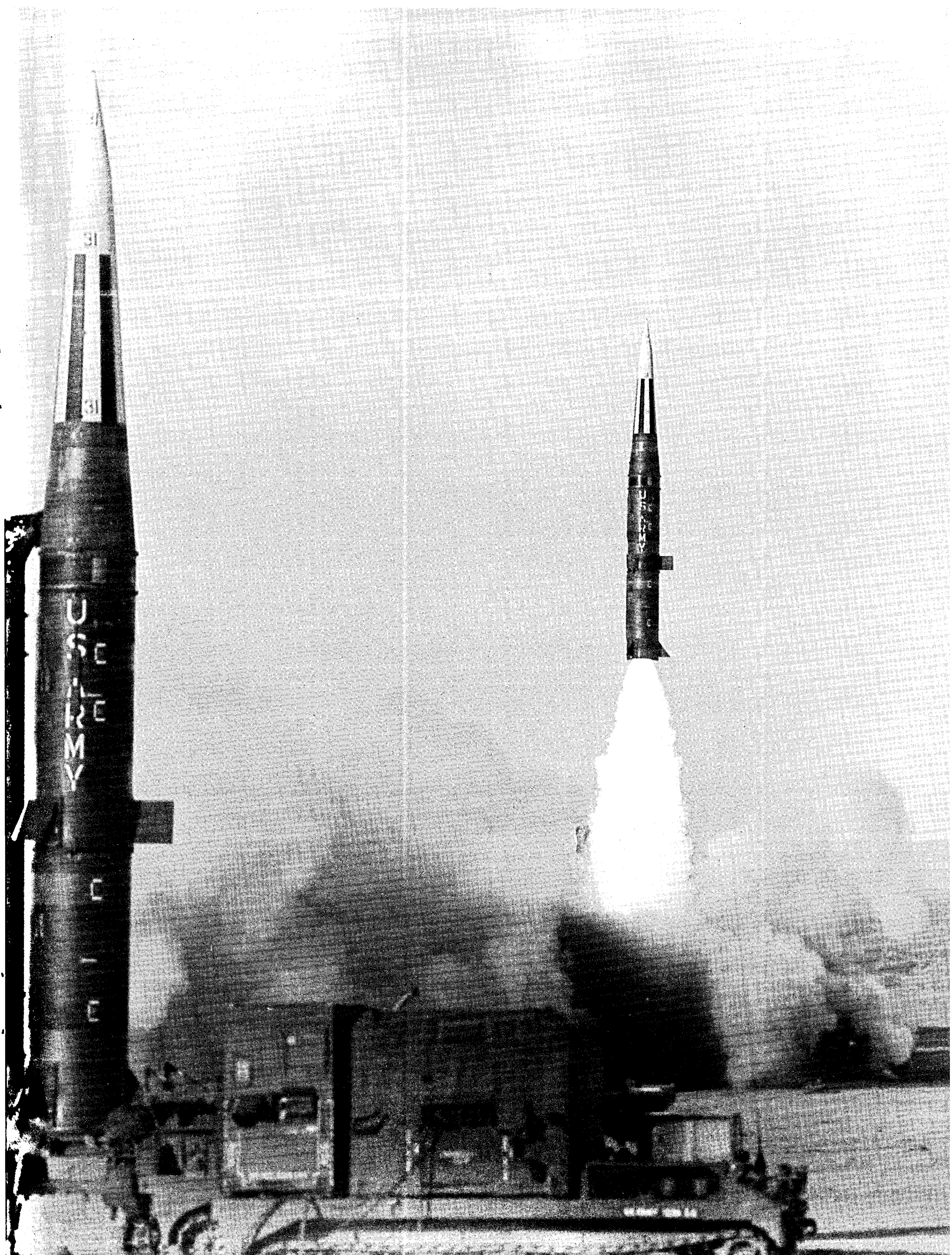
- Optimum predicted estimates of the state of the system can be obtained by using a model of the process (or plant).
- The model is adaptive and is influenced by measurement data sequentially.
- Characteristics of the noise associated with the measuring instruments can be ideally reflected in the filter.
- The filter uses all measurement data in a completely integrated manner, with no restrictions as to the type of instrumentation.

The mathematical structure of these procedures can be applied in automating the processing of range-instrument data. Vector and matrix models are being used to handle multiple sets of trajectory data from combined and independent radar and doppler systems.

With these new mathematical techniques, a big step is being made toward the more efficient use of the immense computer capabilities that are presently available.



PERSHING MISSILE ARTILLERY at Fort Bliss, Texas, near White Sands.


31

# Heartbeats and dipoles

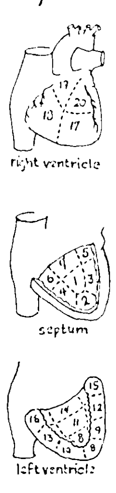
## A mathematical model of its electrical field provides clues to the heart's behavior

A sensitive diagnostic tool based on a mathematical model of the heart's electrical field may some day enable physicians to detect and define destructive changes in the heart long before they show up in electrocardiograms, and to follow their development even before symptoms develop. These are the goals of a research project headed by Dr. Ronald H. Selvester, a cardiologist at Rancho Los Amigos Hospital in Downey, California.

Working with Dr. Selvester are Dr. Robert Pearson, a physiologist; Dr. William Kirk, a biostatistician; Joseph Solomon, a physicist; and Thomas Gillespie, a mathematician and senior programmer. The last three are full-time consultants to the project from Medical Information Systems Corporation. The team has collaborated with experts at Loma Linda University, the University of Southern California, the Rand Corporation, and the Health Sciences Computing Facility at UCLA, where most of the computer work has been done.

Dr. Selvester believes that, in addition to its clinical applications, the computer model of the heart will enable medical science to look with a "finer grid" at such possibly heart-related problems as obesity, heavy smoking habits, high cholesterol levels, and the stress of one's occupation. It is also proving to be a valuable aid in training interns and residents in cardiology.

The heart divided into 20 segments




### Electricity in the heart

Two devices are used to record the electrical activity of the heart clinically—the electrocardiogram (EKG) and the vectorcardiogram (VCG), which is a three-dimensional electrocardiogram. Dr. Selvester's work is based on a computer simulation of the VCG, with the heart considered to be a set of 20 dipoles placed in a volume conductor, the human thorax.

The heart is a very complex electromotive source, or generative source, Dr. Selvester points out. Electrical events precede contraction of the heart muscle. The events start in the septum (the wall that separates the chambers of the heart) and move as wavefronts through the heart in a concentric fashion. The computer model was based on a definitive mapping study of the sequence of depolarization in a dog's heart muscle. The study was made in 1956 by Dr. Allen Scher, of the University of Washington.

Much more detailed mapping of the activation of the heart has been carried out recently in Dr. Selvester's laboratory. "We arm-chaired the first model, extrapolating to humans Dr. Scher's careful mapping of the wavefront of excitation in dogs," Dr. Selvester recalls. "The computer added the XYZ components from the 20-dipole model of the cardiac generator and plotted vectorcardiograms. The original analog computer solution was written for a set of 20 dipoles in a large unbounded medium of uniform conductivity. The first model that the analog computer drew was a normal vectorcardiogram.

### Simulated diseases

"To simulate a myocardial infarction, which is the death of a segment of heart-muscle tissue due to interruption of the blood supply, you simply knock out several adjacent dipoles. Enlargement of the left side of the heart, known as left ventricular hypertrophy, a relatively common condition in patients with high blood pressure, was also simulated with the computer by increasing the output from all left-ventricular segments. The computer model of this condition was markedly similar to the vectorcardiograms of patients with ventricular hypertrophy.

"Then progressing to later models of the VCG, this same cardiac generator was placed off-center in a sphere. This problem was too complex computationally to be handled on an analog computer, so a digital-computer simulation was developed. More recently, a complex iterative digital-computer simulation has been developed that includes a normal human torso boundary."

Not long ago at the University of Milan, an Italian scientist named Bruno Taccardi laboriously plotted, over a period of many months, the contour lines of electrical potential from a cardiac generator on the surface of the torso of a normal human adult male. Simulated body maps with a male-torso boundary in the computer tracked

Taccardi's maps to their limit of resolution. Since the present computer simulation does not include internal inhomogeneities, this simulation would tend to indicate that such inhomogeneities are not of major importance in influencing the equipotential-map contours in normal subjects. On the other hand, this simulation does not represent absolute potential values, the inputs to the cardiac-generator model being only relative or proportional to each other.

"It is clear from examination of the mathematics and physics of this simulation," Dr. Selvester points out, "that the resultant contour maps would be changed considerably by a significant change in torso geometry, such as one sees in children, females, males that are obese or tall and thin, and various clinical conditions that affect the volume of the torso."

This is where the research project is now, refining the simulation of various torso and cardiac geometries. An IBM 1800 Data Acquisition and Control System, installed recently at Rancho Los Amigos Hospital, is being used to record VCG data. A telephone data link connects the hospital with the Health Sciences Computing Facility at UCLA. At one time data had to be carried 20 miles by automobile for processing at the facility, but now it is Tele-processed directly into UCLA's new System/360 Model 75 computer.

Computer research has already tended to disprove the theory, long accepted by cardiologists, that there are electrically silent areas in the heart where a lesion would not show up on electrocardiograms. "It appears," says Dr. Selvester, "that an infarction of less than a cubic centimeter *does* affect the surface electrocardiogram and that it may be possible to detect such a tiny scar anywhere in the heart." □

IN SHIELDED ROOM, Dr. Selvester and technicians attach sensors to patient's chest in preparation for VCG recording.

# Enhancing a small computer

## New features of the 1130 Computing System provide greater speed and more storage capacity

The power of IBM's small 1130 computer has been greatly increased in terms of storage capacity and processing speed, and more and faster peripheral equipment has been made available. The new system was demonstrated for the first time in April at the Spring Joint Computer Conference in Atlantic City, New Jersey.

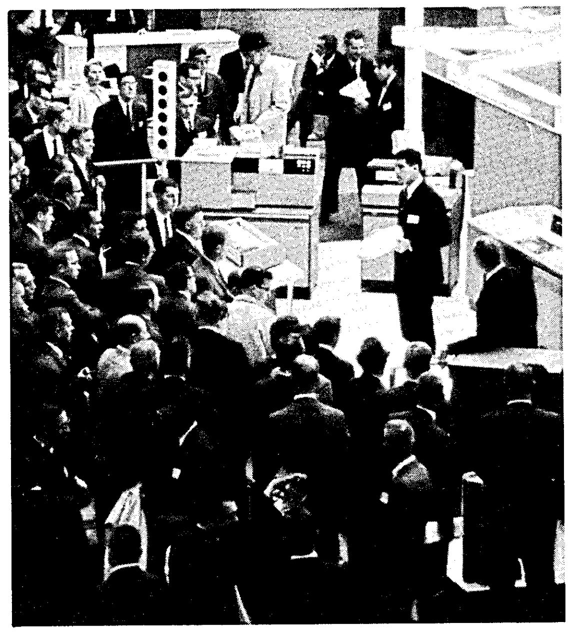
A compact, stored-program computer designed especially for scientists and engineers, the 1130 now offers five times the disk storage of the original model, four times the magnetic-core memory size, 40 per cent faster processing speed, and a number of new input/output devices. The peripheral equipment includes an optical mark reader, high-speed printers, card and paper-tape readers and punches, and a plotter for graphic output. Printing speeds up to 600 lines a minute and card reading speeds up to 1,000 cards a minute are now available.

The flexibility and power of the new 1130 fills a gap between the requirements of small-scale and large-scale computer users. Those whose data processing needs are growing, but who do not require the power of an IBM System/360 computer, can use the 1130 to meet their needs in both technical and commercial areas. Moreover, a communications adapter is available which permits the 1130 to function as a communications terminal. With the new adapter, the 1130 can be connected by leased telephone lines, or on a dial-up basis, to any System/360 computer, enabling the 1130 user to tap the power of the larger system with ease.

### 32K storage

The central processing unit of the 1130 is a single-address, high-speed binary unit with parallel arithmetic, indirect addressing, and three index registers. It can perform 200,000 additions a second with a new 2.2-microsecond memory, or 120,000 additions a second with the original 3.6-microsecond memory. Core storage options include 4,096 words, 8,192 words, 16,384 words, or 32,768 words of 16 bits each.

If more storage is needed, up to five disk drives can be added to accommodate the interchangeable IBM 2315 Disk Cartridge. Each cartridge can store 512,000 words and can be changed quickly and easily to provide a virtually unlimited amount of off-line storage. On-line storage can be as much as 2,560,000 words.



NEW 1130 FEATURES were shown at SJCC, Atlantic City.

In addition to FORTRAN and the Disk Monitor System, extensive programming support has been developed for the 1130 in the form of more than 250 application programs. They are available in 13 packages, including applications in civil engineering, petroleum engineering and exploration, statistics, matrix manipulation, simulation, optical systems design, graphic data presentation, structural analysis, and project planning control and supervision. Further, a new Commercial Subroutine Package has been announced to aid in the programming of such jobs as payroll preparation, billing, and cost accounting.

The 1130 computer will continue to be manufactured at IBM plants in San Jose, California, and Greenock, Scotland. Deliveries of systems with the new features are scheduled to start early in 1968. ◻

# More mileage from jet engines

## With the aid of a computer control system, the U.S. Air Force overhauls more than 300 jet engines a month at one facility

Maintaining jet engines at top performance is one of the most vital functions in the Air Force. Colonel Frederick D. Berry, Jr., Director of Maintenance at the Oklahoma City Air Materiel Area (OCAMA), believes it is "the most important support activity in the Air Force today."

More than 80 per cent of the jet engines of Air Force planes are sent to the sprawling OCAMA headquarters at Tinker Air Force Base, near Oklahoma City, to be overhauled. Following overhaul, each engine is subjected to an exacting performance test prior to its return to an operating squadron. Engines of all B-52 bombers and KC-135 tankers go to OCAMA. Other engines processed there are those powering the F-105 Thunderchief fighter and the C-141 troop carrier. This adds up to more than 300 engines a month, all of which go back to the "field" in good-as-new condition.

### Flying high—by computer

Central to the testing function is an IBM 1710 computer control system. The computer "flies" the engines on a test stand: it adjusts throttle settings and operates the trim control. It takes readings from scores of sensors as each engine is taken on a simulated flight from sea-level idling to high-altitude "military" setting, which means running the engine "flat out." The computer monitors 40 sensing devices, and every 3.6 seconds it checks eight critical values. If a dangerous condition develops—a runaway engine, for example—the computer flashes a warning message before things get out of hand. And at the end of each test, a complete printout is available for analysis.

The testing crews constantly strive to shorten test time and, as they become sharper in diagnostic capability, to lengthen the service life of the engines between overhauls. "If this system adds just one hour of usable life to every jet engine between overhauls, it will save more than $6 million," says Major General Melvin F. McNickle, OCAMA commander.

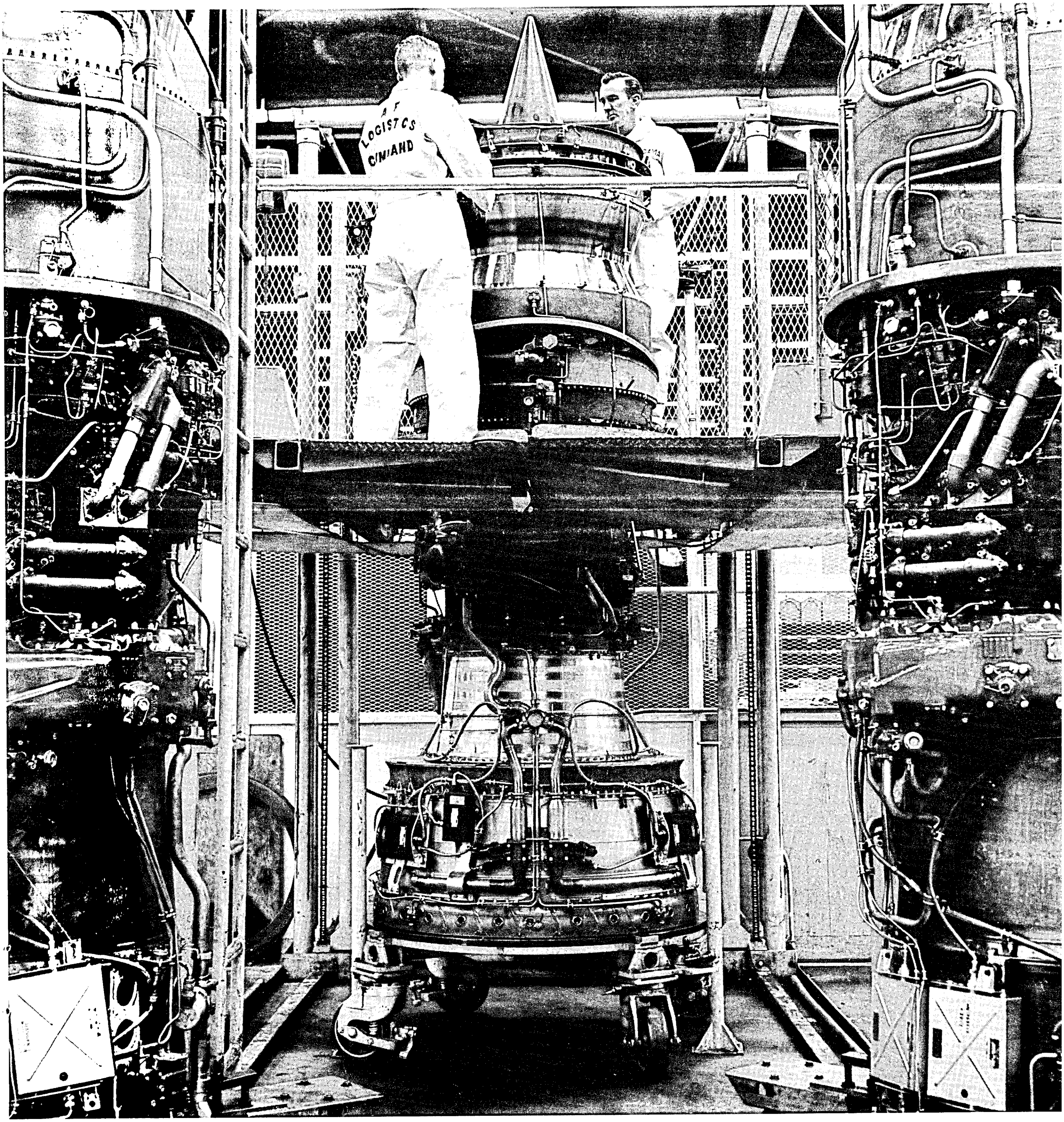
Clovis G. Davis, Deputy Director of Maintenance, believes that the diagnostic capacity of the computer is its most important feature. Bugs in an engine, whether minor or major, develop most often either just after the engine has left the production line or just before it is scheduled for overhaul. There are fewer maintenance problems in between. Mr. Davis describes the maintenance frequency in terms of a graph shaped like a deep dish. "What we're trying to do," he explains, "is to broaden the dish—to extend the time between overhauls and reduce the incidence of mechanical troubles."

Charles Stueve, Project Leader of the Engine Testing Group, can attest to this primary effort, having been with the project since the initial study effort. "We are interested in an efficiently balancd operation of the engine," Mr. Stueve says. "Pumps, valves, fuel control systems, governors, afterburners, and many other mechanical and electrical features, all have to be functioning correctly, within tolerance, or we have a defective engine." Depending on how defective it is, the engine is either repaired while on the test stand or taken off and put on the "penalty line" for major reworking.

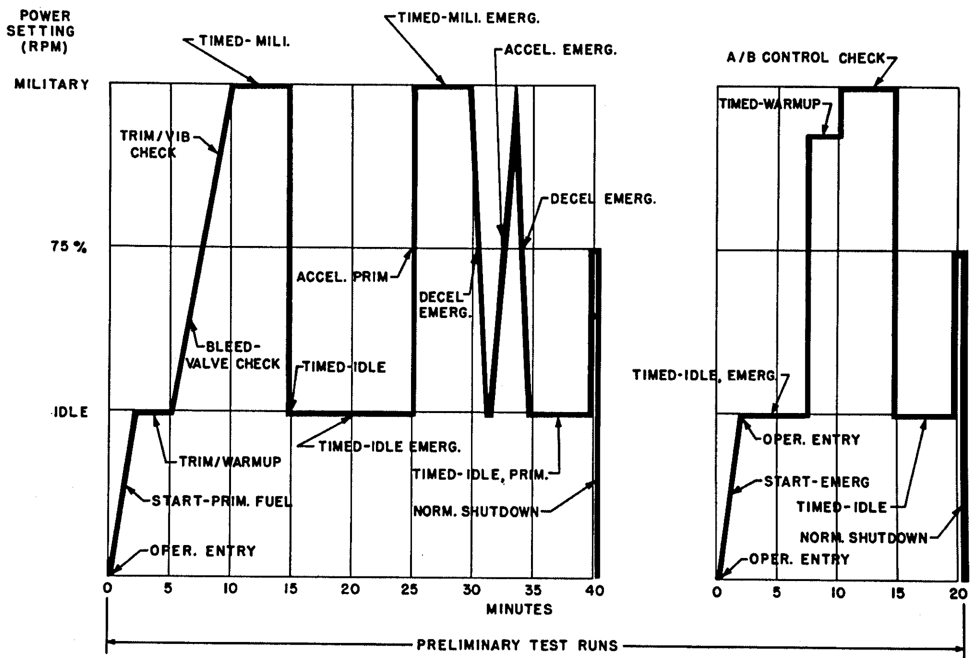
The system when fully implemented will have the capability to conduct engine tests in all eight of OCAMA's test cells simultaneously, each engine being tested independently of all others. At present only two test cells are operational under the 1710, primarily because of the many types of engines that are being tested at OCAMA. Programs have to be written and tested and be completely operational for each type of engine before the automatic jet engine testing system can assume operational control of all eight cells.

### Three-part test

An engine test normally consists of three segments: a preliminary checkout, a series of performance runs, and a final shakedown. All are completely under computer control. In the first segment, after an engine has been "dry run" (that is, operated without actually firing the ignition) the engine is started and the fuel control system is trimmed for proper engine operation at idle speeds. During the start phase, the engine is



EVERY PART OF EVERY ENGINE is removed, inspected, and refinished or replaced during the pre-test overhaul at OCAMA.




FLOWCHART shows length of time engine runs at various speeds during preliminary stages of computer-controlled test.

checked for many out-of-limit conditions which might affect subsequent operation. Checks are made for oil pressure, exhaust-gas temperature, vibration, speed, and bearing-vent pressure.

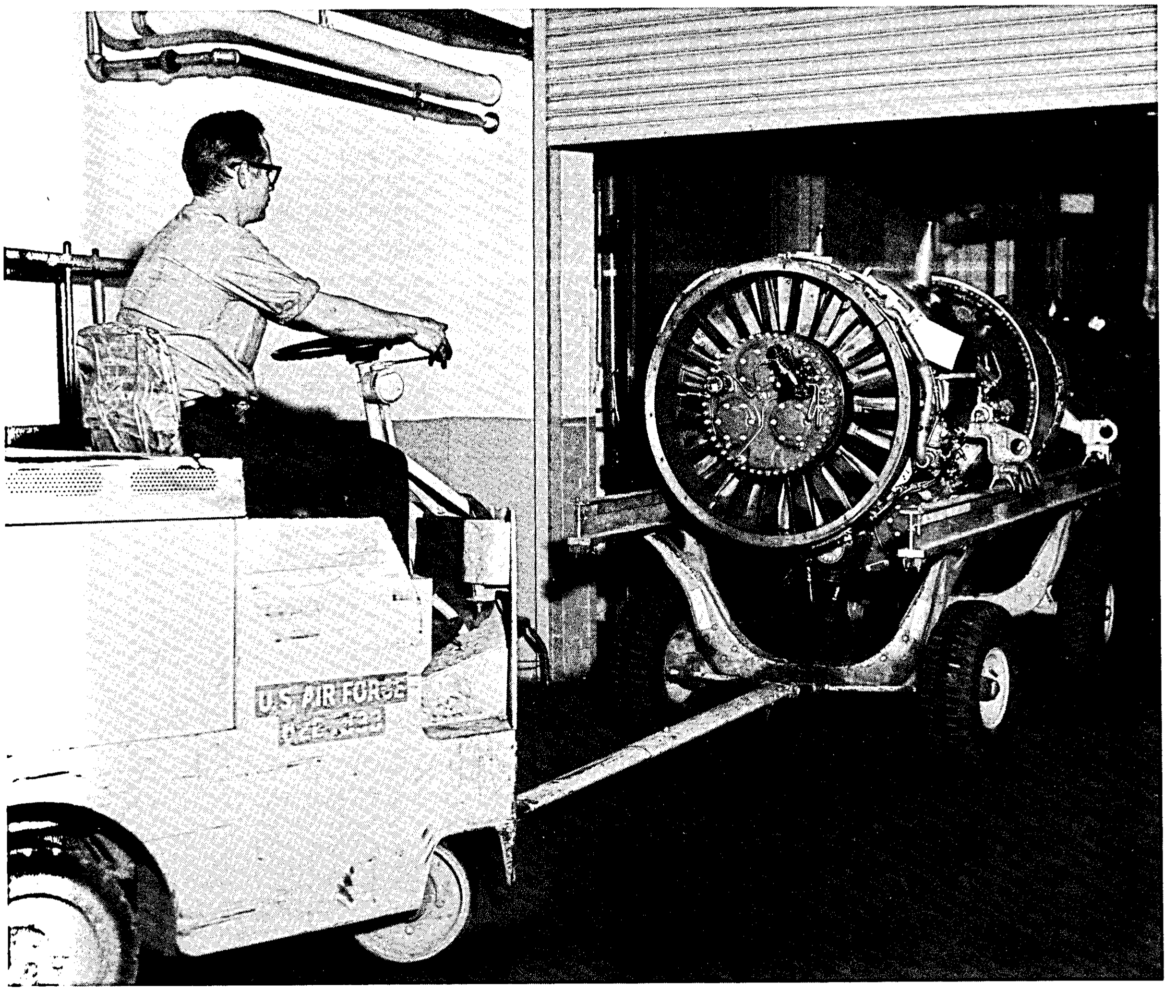
During a subsequent phase of the preliminary checkout, the engine is checked for proper bleed-valve operation and is then trimmed at the "military" (maximum) throttle position, followed by a check of the anti-ice system.

Next the engine is run through a series of acceleration and deceleration phases in both the "primary" and "emergency" fuel control systems, with timed runs being made between them for stabilization purposes. The last phase of the preliminary checkout is a simulated afterburner run, in which the afterburner system is operated but, in most cases, not actually fired. To complete the preliminary checkout, the engine is shut down and a physical inspection is made to find any oil or fuel leaks, contamination of strainers and filters, or similar faults.

### Phase two—performance

When all is ready, the engine is restarted for the performance runs, which are more comprehensive insofar as prescribed operating characteristics are concerned. Specific fuel consumption as a function of thrust, rotor speeds, and internal pressure ratios must prove to be within the limits established for the engine by the manufacturer. Normally, three power runs are made between 75 per cent of normal rated speed and "military" speed, and the results are plotted by an IBM 1627 Plotter for a visual determination of acceptability. Each of these runs lasts ten to twenty minutes, and all data must be corrected to standard-day sea-level conditions for proper comparison.

To complete the test, the final shakedown con-




J-57 JET ENGINE is towed from a test cell after having passed the exacting tests imposed by OCAMA's computer system.

sists of another series of timed runs interspersed with acceleration, deceleration, vibration, and exhaust-gas temperature checks followed by another physical inspection after shutdown.

The entire test normally takes about six hours to complete, and the computer is never very far away. Even though the system can physically operate only one engine at a time, it has been programmed to check all engines operating in all eight cells every 3.6 seconds for major fault conditions. It can take immediate action to shut down an engine should something go wrong.

What happens when an engine does not meet requirements? "If the trouble is major," says Lloyd G. McCraw, Chief, Industrial Engineering Division, "the engine goes to the penalty line where top-rated mechanics and machinists make the necessary repairs and adjustments. Then the engine goes through test again."

The overhaul that every engine gets at OCAMA leaves nothing to chance; indeed, it would almost seem that testing is anticlimactic. The overhaul of a single engine takes about three weeks. During that time it is disassembled right down to its basic components. Its thousands of parts are either remachined and replated or else replaced, so that the engine, when reassembled, is as fine a piece of equipment as when new.

OCAMA's engine testing insures a quality product. "That's the primary objective of testing," says Mr. McCraw. "Also, the data logged from many thousands of engines can be analyzed to provide a picture of performance patterns, showing how engines function under different conditions and how pilots might better handle them to get more mileage." Thus engine maintenance is continually improving, which is the same as getting more for your money each time around. □

# Of chips and masks

## IBM researchers speed the design and fabrication of masks for making integrated-circuit chips

Scientists in IBM's Research Division have applied computer techniques to designing and fabricating integrated-circuit masks, eliminating many time-consuming manual steps. Using an experimental computer language, the researchers have created finished masks in a tenth of the time formerly required. The key elements in the new technique are a computer-assisted layout method and an accurate, high-speed artwork generator called the "light table."

The masks are used in making integrated-circuit chips from silicon wafers. The wafers are approximately an inch in diameter, and some 150 chips can be made from a single wafer. Each chip contains 100 or more standard logic circuits (NOR circuits) incorporating either field-effect or bipolar transistors.

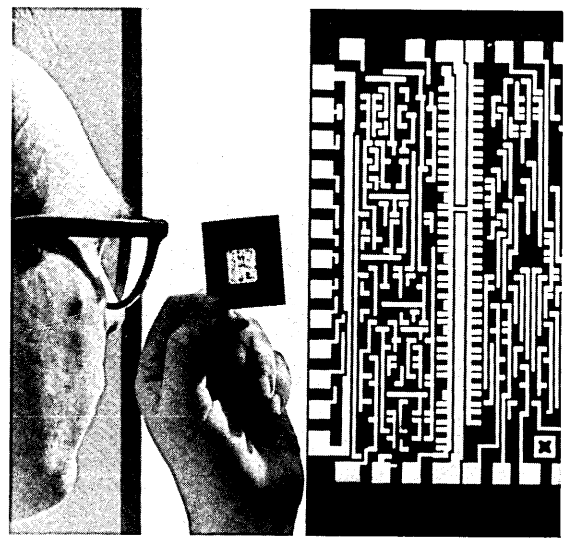
Circuit masks are normally made by a laborious process involving several manual steps. First, from a rough sketch of the desired circuit layout, a draftsman makes an exact scale drawing that is 200 to 500 times larger than the final size of the mask. Then the drawing is separated into a set of overlays, one for each processing step: coating the silicon with metal conduction lines, diffusing the desired impurities into the silicon, forming contact holes, and so forth.

Next, each overlay is transferred to a sheet of opaque material, and the desired pattern is cut out. Finally, each pattern is reduced photographically to 10 times the size of the final mask.




At this point the pattern is ready to be photographed by a "step-and-repeat" camera, which moves in precise increments between exposures so that the pattern of the mask is repeated on a single negative. This negative is used to expose the desired patterns on a silicon wafer, which is then cut into individual integrated-circuit chips.

In the new process, the designer draws a rough pencil sketch of the desired circuit layout and translates the sketch into digital form by describing the circuit symbolically in a newly-developed experimental computer language. Then he enters the description into a computer through a typewriter-like input terminal. The new language enables the designer to specify the circuit layout in skeleton form, forgetting about such details of geometry as line spacing and diffusion widths.



CIRCUIT MASK in man's hand was made by new process. Hand-made mask at right must be reduced 200 times.

The computer processes the data and generates a set of commands that drive a "light table," which, operating much like an X-Y plotter, exposes the patterns for each mask on a photographic plate. The patterns on the plate are 10 to 20 times the size of the final masks and are ready to be photographed by a step-and-repeat process like that described above.

In the light table, the photographic plate is mounted on a platform that moves in two directions, along X and Y axes. The movements of the platform are controlled by two "stepping" motors, which, in turn, are controlled by the computer. As the platform moves—in steps of ½ mil at a rate of 200 steps a second—a light from a xenon flash lamp "draws" the mask pattern on the photographic plate. The flash lamp is also controlled by the computer.

Using the new method, IBM researchers created four masks for a chip containing 122 circuits in about an hour. More than 100 hours would have been required to do the same job by ordinary methods. □

# Newsfronts

**Numerical control tapes** for the operation of automated contour milling machines, as well as other machine tools, are being prepared with the aid of an IBM 1130 computer at Rock-Mill Inc. of Rockford, Illinois. The company manufactures milling and other precision machines. "We provide a wide variety of numerical control tapes for users of our machines," says Emil Hahn, the firm's data processing manager, "and tape preparation that would require days of manual work takes only minutes on the computer." Adds Karl Lindmark, Rock-Mill's president, "Because of the speed and economy of the 1130 the company can produce more control tapes without increasing overall costs."

**Programmers** can now document System/360 programs with the help of the computer they are programming—by using a new Type II application program called System/360 Flowchart. Programmers normally spend days or weeks drawing detailed flowcharts to plan and organize the work to be done by a computer. With System/360 Flowchart, once the flowchart input is prepared, the computer itself can produce the diagrams in minutes. The programmer simply writes the flowchart steps using a symbolic, problem-oriented language, and then, with punched cards, enters the statements into the computer.

The system combines features of earlier flowcharting programs, such as Autochart, with additional capabilities. The new features include free or fixed-form input, three lines of header information, the ability to link elements automatically from symbolic labels, a choice of IBM Autochart or USASI block shapes, and the ability to include footnotes and branch tables.

**A computer that orbited the earth** for eight days in a Gemini spacecraft is flying again in tests of a Navy airborne weapon system. Called TIAS (Target Identification and Acquisition System), the new weapon system is being developed at IBM's Electronic Systems Center in Owego, New York, under contract from General Dynamics/Pomona, the prime contractor. The purpose of TIAS is to locate and destroy enemy radar sites.

The computer is the one that in 1965 guided the second longest Gemini flight, which completed 120 orbits before splashing down in the Pacific Ocean. Recovered, the computer was shipped to Owego and bathed in distilled water to remove salt from the splashdown. Then it was vacuum-dried for 30 hours.

BEAMS OF INFRARED LIGHT are carrying high-speed messages in two experimental applications at Canada's Expo 67. In one application, a light beam transmits stock-market quotations from the 19th floor of the Montreal Stock Exchange to closed-circuit television units in the Canadian Government Pavilion—a distance of almost two miles. Another beam travels a half mile from the IBM Computer Room in the Canadian Government Pavilion to a 2250 Display Unit in the Man the Producer Pavilion. The technique, developed by IBM engineers, involves the conversion of electronic signals to variations in the intensity of infrared light, which is invisible. In the photograph above, retouching depicts a light beam entering the receiving unit. The data carried by the beam is reconverted to electrical impulses for display on the 2250 terminal.

**Teachers in Kansas** have 142,000 fewer tests to score each year thanks to an IBM 1130 computer recently installed at Kansas State Teachers College in Emporia. "We are using the computer and an IBM 1230 mark scoring reader to speed the scoring and analysis of a variety of tests administered by public schools and the college," explains Dr. John E. Visser, college president. "In addition, we have virtually eliminated human error, so critical in the scoring of tests that are used in evaluation and placement work."

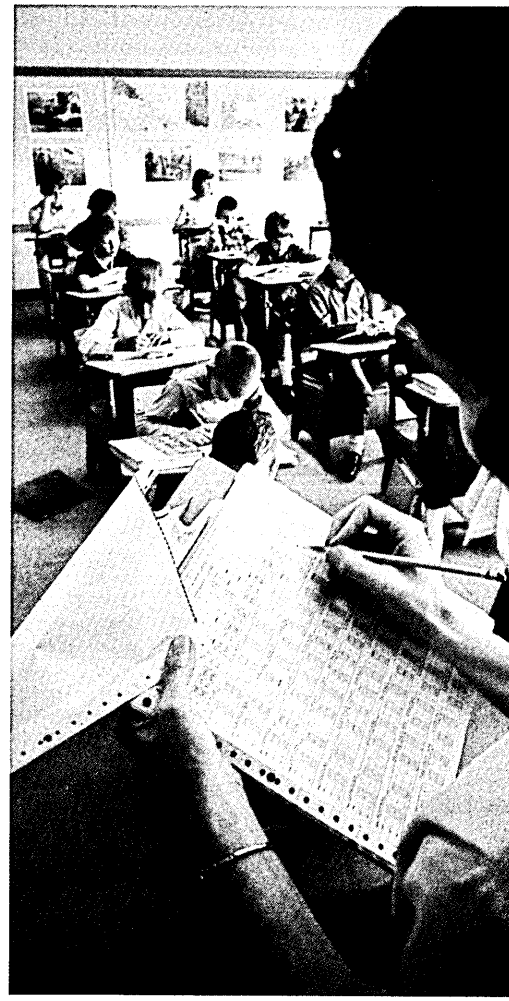
The 1130/1230 system also allows the Kansas Bureau of Educational Measurements to offer a broader range of scoring services while reducing costs and providing greater control. The bureau services 1,800 schools in the state, scoring placements tests, differential aptitude tests, high school comprehensive tests, and college departmental tests.

**John W. Backus,** an IBM Fellow at the University of California (Berkeley), received the 1967 W. Wallace McDowell Award in April at the Spring Joint Computer Conference in Atlantic City, New Jersey. The award is given annually by the Institute of Electrical and Electronics Engineers for outstanding professional work in the computer field. Mr. Backus was cited for his contribution to the higher-level computer languages, specifically for his leadership in the first FORTRAN development project and for his contribution to the development of ALGOL. (See "The man behind FORTRAN," *Computing Report*, Vol. II, No. 4, November 1966.)

The McDowell award was established last year and named for W. Wallace McDowell, a resident vice president of IBM in Endicott, New York, in honor of his work in computer development.

**Integrated switching circuits in germanium** have been made experimentally by scientists in IBM's Research Division. The new devices are two-input emitter-follower current-switch logic gates. Despite their relatively early stage of development, the new circuits are faster than the fastest silicon circuits so far reported. Electrons in crystals of germanium can move several times faster than those in silicon crystals, giving germanium faster switching speeds. Until now, however, it has been difficult to make circuits in germanium.

The technique requires that selected areas of the germanium be protected by an impervious layer. With silicon, this protection is provided by an easily-formed layer of silicon dioxide. But easily-formed oxides of germanium are unstable. To make the germanium circuits, therefore, IBM researchers had to develop many new techniques, including new ways of depositing masking and insulating films, new diffusion techniques for making planar-device structures, new metal-film processes for making contacts and interconnections, and new methods for making compatible thin-film resistors.



PUBLIC SCHOOL TEACHERS in three Atlanta, Georgia, schools, starting this fall, will use optical scanners and an IBM System/360 Model 40 computer to process student registrations, attendance and lateness records, and withdrawals. Within three years the Atlanta School Board plans to include all 157 of the citys public schools in the system, which will print out all records required by the state for "student accounting." Teachers will simply make pencil marks on computer-printed forms to indicate a change in a student's status. Periodically the forms will be fed through high-speed optical scanners to enter their data directly into the computer. Says Dr. John Letson, School Board Superintendent, "The new system will save teachers, alone, about 110,000 hours of clerical work a year—the equivalent of more than twelve years of time that can be devoted to the primary job of educating our children."

# For further reference

## Publications available on request from local IBM sales offices

Readers desiring more information on subjects covered in *Computing Report* should address inquiries to local IBM sales offices. Listed below, with their form numbers, are specific publications pertaining to topics in this issue, along with some new or revised publications of general interest.

### Statistics

| | |
|---|---|
| *Outline of Statistical Techniques, Applications, and Programs for Industry, Engineering, and Science* | C20-1645 |
| *Concepts and Applications of Regression Analysis* | E20-0180 |
| *1130 Statistical System User's Manual* | H20-0333 |

### Miscellaneous new or revised publications

| | |
|---|---|
| *Applications and Techniques of Operations Research—a Bibliography* | C20-1671 |
| *Proceedings of the 7th IBM Medical Symposium—1965* | 320-0940 |

### 1130 application programs—selected

| | |
|---|---|
| *Casing Design* | H20-0405 |
| *Civil Engineering Coordinate Geometry* | H20-0143-3 |
| *Commercial Subroutine Package* | H20-0221-2 |
| *Continuous System Modeling Program* | H20-0209-1 |
| *Data Presentation System* | H20-0235-1 |
| *Decline Curve Analysis* | H20-0409 |
| *Dipmeter Program* | H20-0457 |
| *Economic Evaluation of Petroleum Projects* | H20-0401 |
| *Gas Deliverability* | H20-0425 |
| *Gravity and Magnetic Continuations* | H20-0445 |
| *Linear Programming System* | H20-0238 |
| *Multi-stage Flash Calculation* | H20-0429 |
| *Optical System Design* | H20-0234 |
| *Petroleum Exploration* | H20-0137 |
| *Project Control System* | H20-0211 |
| *Quantitative Log Analysis* | H20-0453 |
| *Schilthuis Material Balance* | H20-0417 |
| *Scientific Subroutine Package* | H20-0225 |
| *Statistical System* | H20-0141 |
| *Structural Engineering System Solver* | H20-0237 |
| *Synthetic Seismogram* | H20-0441 |
| *Tarner Material Balance* | H20-0413 |
| *Theoretical Gravity of a 3-D Mass* | H20-0449 |
| *Two-dimensional Waterflooding* | H20-0421 |
| *Type Composition* | H20-0139-1 |
| *Velocity Functions from Time-depth Data* | H20-0433 |
| *Wave-front Ray-path Determination* | H20-0437 |

### Older manuals still available

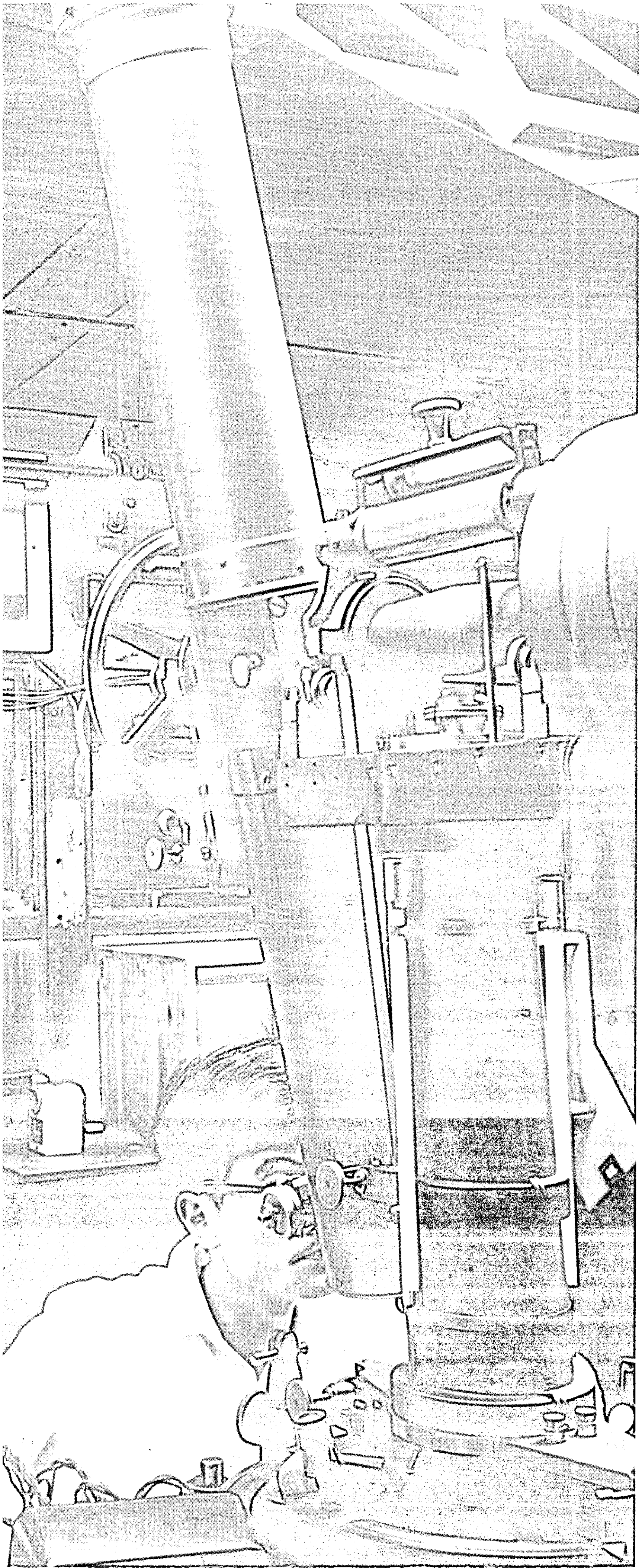
| | |
|---|---|
| *Decision Tables—a System Analysis and Documentation Technique* | F20-8102 |
| *Hybrid Computing Systems* | E20-0053 |
| *Index Organization for Information Retrieval* | C20-8062 |
| *Principles of Data Acquisition Systems* | E20-0090 |
| *Random Number Generation and Testing* | C20-8011 |
| *An Introduction to Engineering Analysis for Computers* | F20-8077-3 |
| *An Introduction to Linear Programming* | E20-8171 |
| *Bibliography on Simulation* | 320-0924 |
| *Numerical Techniques for Real-time Digital Flight Simulation* | E20-0029 |
| *Introduction to Real-time Digital Flight Simulation* | E20-0034 |
| *Flight Simulation Experience Using a New IBM Numerical Technique* | E20-8186 |

### New 1130 features

| | |
|---|---|
| *Functional Characteristics* | A26-5881-3 |
| *I/O Units* | A26-5890-2 |
| *Installation Manual—Physical Planning* | A26-5914-3 |
| *System Configurator* | A26-5915-1 |
| *SRL Bibliography* | A26-5916 |
| *System Summary* | A26-5917-5 |
| *Disk Monitor System Version 2 Introduction* | C26-3709 |

### Tele-processing and data collection systems

| | |
|---|---|
| *Tele-processing Systems Summary* | A24-3090-3 |
| *1050 Data Communications System—System Summary* | A24-3471-1 |
| *1080 Data Acquisition System—System Summary* | A26-5574 |
| *1030 Data Collection System* | A24-3018-5 |
| *General Information—Binary Synchronous Communications* | A27-3004 |
| *1060 Data Communications System* | A24-3034-2 |
| *1070 Process Communication System* | A26-5989-1 |
| *1001 Data Transmission System* | A24-1029-4 |
| IBM *SRL Bibliography Supplement—Tele-processing* | A24-3089-5 |



# A wobbling world

The earth wobbles on its axis like a spinning top. But a top's rotation axis completes each "wobble" in, say, three seconds, whereas the earth's axis takes some 26,000 years to make a round trip.

This phenomenon, called precession, is caused by the gravitational pull of the sun and moon on the bulge at the earth's equator, which is inclined 23½ degrees to the ecliptic (the plane of the earth's orbit). The pull on the equatorial bulge tends to tip the earth toward the ecliptic—but, like a gyroscope, the spinning earth resists the tendency. Hence the wobbling of the axis.

The radius of the wobbling at the north and south poles amounts to only about 30 feet. Insignificant as the motion seems, it is important not only in astronomy but also in studies of the earth's internal composition. The nature of the motion is related to the density and structure of materials inside the earth. Scientists, therefore, are anxious to measure the earth's precession as precisely as possible.

Since the latitude of points on the earth is defined as their angular distance from one or the other of the poles, the easiest way to measure polar motion is to calculate the changes in latitude that the motion causes. Such calculations are made from data obtained with zenith telescopes, which measure the positions of stars as they cross the meridian. Thirty-six observatories around the world send such data to a central bureau at the International Latitude Observatory at Mizusawa, Japan, which has a zenith telescope of its own (picture at left).

The many complex calculations that must be made from the celestial data are handled by a 7090 computer at the office of IBM Japan at Sendai, near Mizusawa. The observatory's scientists have been using the data processing facility in Sendai since 1958, when an IBM 650 computer was installed there. They report not only greater speed in their calculations, but substantially greater accuracy as well.


International Business Machines Corporation
Data Processing Division
112 East Post Road
White Plains, N.Y. 10601
*Return Requested*




FE Branch Manager 11
IBM Corp. (Mfg. & Dist.) 396
P. O. Box 3658
340 Market St.
San Francisco, Calif. 94119
8