ATLAS BASE ACTIVATION

CONVAIR (ASTRONAUTICS) DIVISION
GENERAL DYNAMICS CORPORATION

We should understand that the ballistic missile does not consist only of the missile itself. This would be like regarding the automobile, by itself, as a self-sufficient means of transportation. Yet, when we think about it for a minute, we see that every car we drive is backed up by a vast support structure indispensable to automobile operation — a support structure of highway networks, garages for overhaul and repair, filling stations for fueling and servicing, distribution centers for replacement parts — along with the production base symbolized by Detroit assembly lines.

By the same token, the ballistic missile requires for its operational capability its own vast support structure — launching pads, gantry cranes, blockhouses, tracking equipment, testing, maintenance and supply facilities, along with its own production base, the industrial plants of America.

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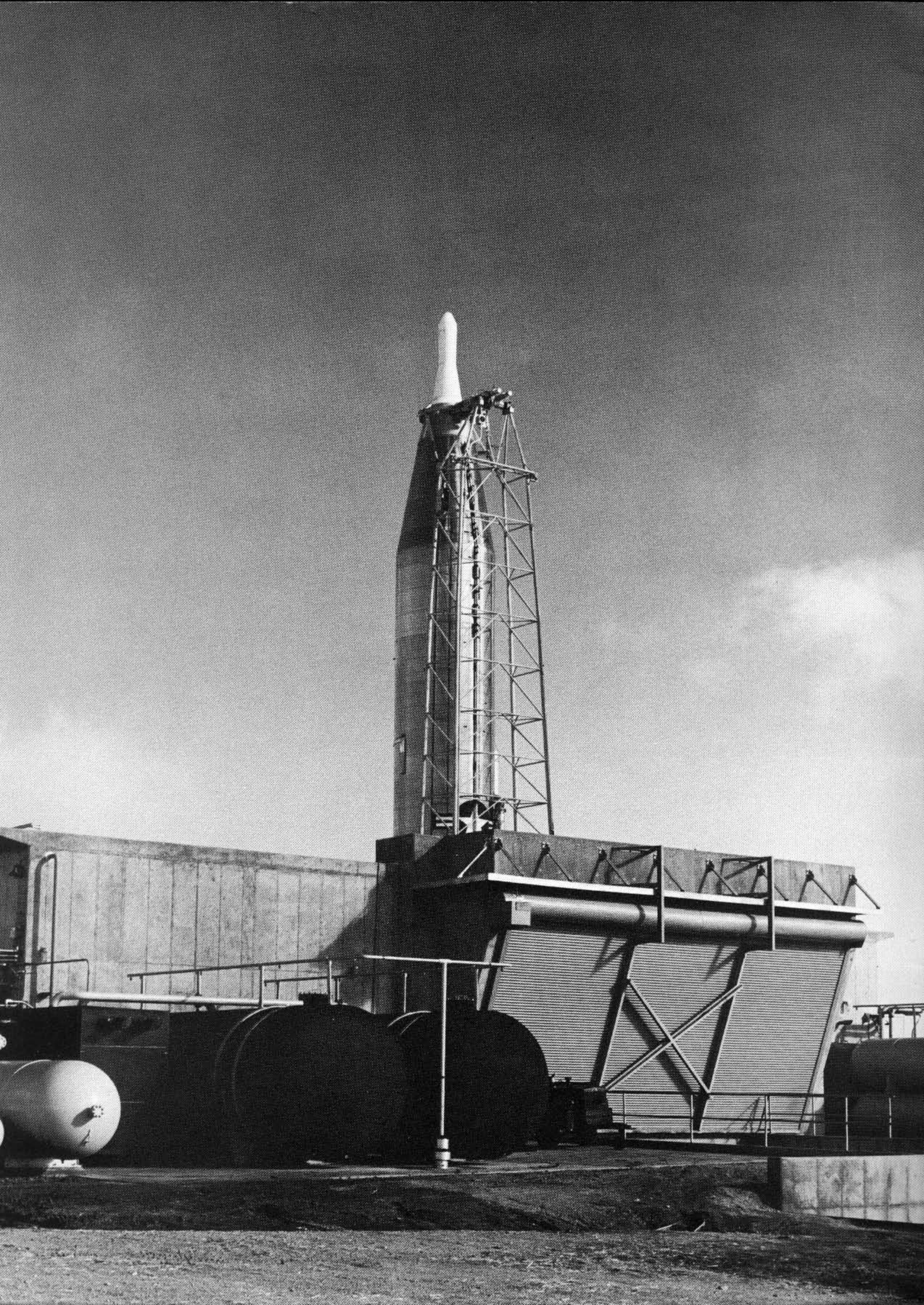


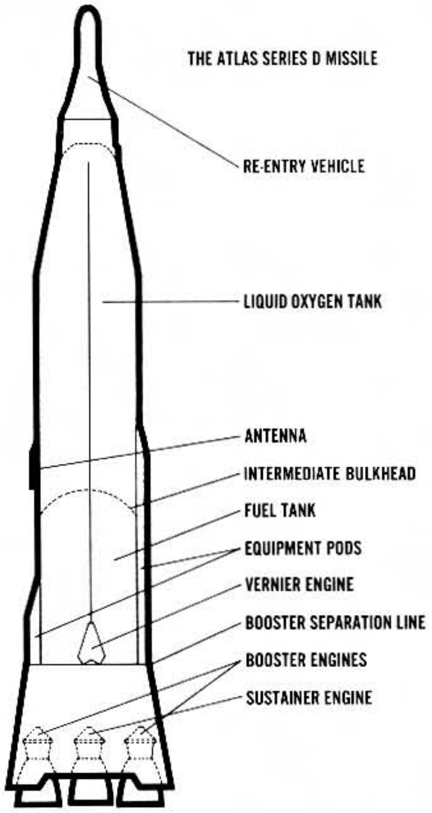
IN RECENT YEARS the thundering fire-streaked skies of Cape Canaveral have increasingly magnetized the attention of Americans as they follow the accelerating pace of our missile test program. And in the giant Cape Canaveral experimental laboratory, perhaps the single missile drawing most attention has been the "big one"— Atlas.

Yet while public attention has thus focused on Atlas test flights, another phase of the Atlas program has gone practically unnoticed. This is the design and construction of operational bases — the firing positions that are an inherent part of the total Atlas system, without which the Atlas is not a complete weapon.

A casual observer might find Atlas base construction work deceptively simple in appearance. For not readily apparent is the demanding discipline which the missile proscribes for every element of its launching emplacement . . . "a combination of watchmakers' precision, electronic mysticism, and steel and concrete shaped to laboratory precision."

The Atlas is indeed a proud and demanding being. Its engines could provide power sufficient to illuminate a city of 30,000. When ready for flight, it weighs as much as a four-unit diesel locomotive, yet its skin is thinner than a dime and many of its 30,000 parts are tuned to a hair-trigger response; and in its electronic brain — scarcely larger than a woman's hat box — resides a share of the intelligence formerly provided by the pilot, navigator, flight engineer, and their banks of instruments in the bombers of yesterday.

But while it is tethered to the ground, the missile can only be kept alive and ready for instant flight through the services of a host of attendant systems, employing highly advanced techniques of electronics, hydraulics, pneumatics, and mechanics. And should the moment of launch ever arrive — perhaps tomorrow, in months or years, but hopefully never — the ground systems must each function precisely, smoothly, in perfect coordination . . . to enable the bird to get away quickly and smoothly on its fateful flight of retaliation.



Thus these ground systems must be as carefully constructed, and must be as susceptible to fine tuning, as are the systems of the missile itself.

PLANNING Planning for Atlas bases began shortly after start of development of the missile itself. And just as with the missile, the technical task of invention was one of magnitude.

There was little heritage of technical development to draw upon. Our technology had passed through its ages of the wheel, sail, steam, and — to a considerable extent — the air. Much of this cumulative knowledge provided avenues of attack on the techniques of missilry, but in only few instances did past experience furnish ready-made answers.

Experience with aircraft, for instance, provided quite sophisticated navigational, guidance, and fuel systems . . . systems controlled or monitored from within the airplane by human beings, present to apply human judgment as it might be needed.

Now, with Atlas, the man no longer rode with the vehicle. The systems which he monitored in the airplane were now to be automated and miniaturized and put aboard the missile itself; or they were to be automated and semi-automated and put on the ground. And even those controls present on the ground—formerly in the cockpit—would need to be of such complexity, and the responses would need to be so swift and absolutely precise, that human judgment and human reaction could not be entrusted with their operation.

So the beginning task was to decide which of the systems would go in the missile, and which on the ground. And once that decision was reached, there was need to develop them simultaneously so that as flight testing proved out the missile itself, shortly thereafter the bases would be ready from which to launch the big birds.

There was need also to develop a basing doctrine, and then to perfect the techniques which would actuate that doctrine. How many separate launch pads would be required in order to provide a sufficient intercontinental retaliatory force to deter an enemy from overt attack upon us? Should they be placed in concentrated groups, dispersed throughout the nation, or what? Were there any existing government facilities which could be adapted to the missile's needs? How would the missile be housed against the time when it might be needed? How would it be kept ready at all times? How could one *know* that it was ready to fire at any given moment? How many spare parts would be needed as the months and years went by? How widely could the spare parts be distributed, in view of their high cost? How would the laboratory conditions of Cape Canaveral be duplicated in the field at scores of individual launch pads, and be maintained over extended periods of time?

Where were the men to come from who would service and operate these new birds? How would their competency to respond quickly to an emergency be measured, for a weapon which, if it ever needs to be fired in anger at all, will be fired but once? What about the matter of command control — how many launch pads should constitute a squadron, a wing, or a division?

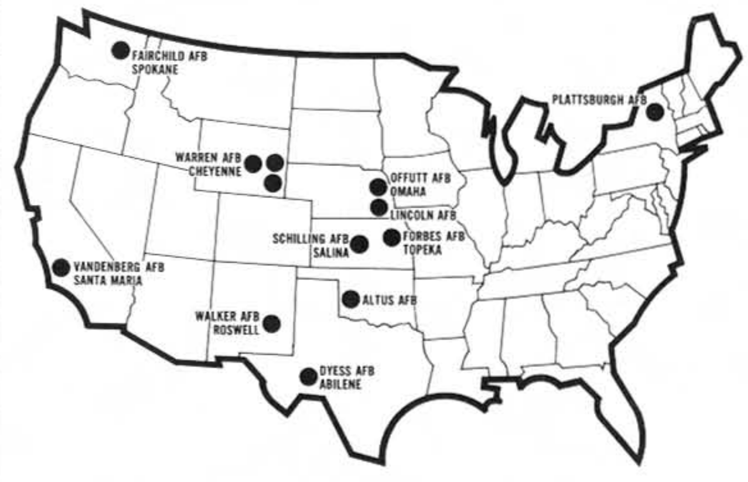
These were questions which not only had never been asked before; they were also questions whose answers would not wait for extended experimentation and trial and error. The defense of the nation demanded a rapid response.

DESIGN

Since design of Atlas bases proceeded simultaneously with development of the missile, under an extremely accelerated time schedule, new techniques of missilry, developed during the course of flight testing at Cape Canaveral, have generated steady improvement in the missile emplacements themselves.

The first three operational pads, at Vandenberg Air Force Base in California, are of an interim design, and hold the missiles continuously in an upright position. Servicing of the missiles is done from huge "gantry" towers of structural steel which are moved over tracks to a position alongside the missile, providing work platforms to the entire height of the bird.

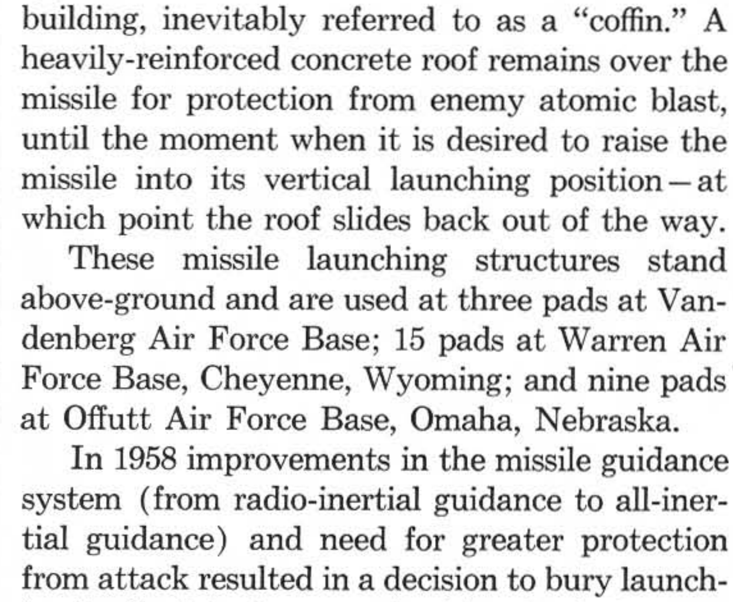
In the next group are launchers which store the missile on its side until the time for launch; then rapidly erect it and pump it full of liquid oxygen and RP-1 (the kerosene-like hydrocarbon fuel used by rockets) in a few minutes' time. This



type of missile launcher is housed in a concrete building, inevitably referred to as a "coffin." A heavily-reinforced concrete roof remains over the missile for protection from enemy atomic blast, until the moment when it is desired to raise the missile into its vertical launching position—at which point the roof slides back out of the way.

These missile launching structures stand above-ground and are used at three pads at Vandenberg Air Force Base; 15 pads at Warren Air Force Base, Cheyenne, Wyoming; and nine pads at Offutt Air Force Base, Omaha, Nebraska.

In 1958 improvements in the missile guidance system (from radio-inertial guidance to all-inertial guidance) and need for greater protection from attack resulted in a decision to bury launching "coffins" in the ground, with only their upper surfaces exposed. Nine such launching pads are



located at each of the following: Warren Air Force Base, Cheyenne, Wyoming; Fairchild Air Force Base, Spokane, Washington; and Forbes Air Force Base, Topeka, Kansas.

Evolution of Atlas launching systems continued with development of the "silo" emplacement, in which the missile and all its attendant systems are buried in a vertical cylindrical hole 174 feet deep and 52 feet in diameter. The hole is capped with 30-inch-thick steel and concrete doors, which open rapidly at time of launch. The launch control center is in a small underground room off to the side of the main silo, which provides protection for the three-man launch control crew. Launching pads of this type are being constructed at Schilling Air Force Base, Salina, Kansas; Lincoln Air Force Base, Lincoln, Nebraska; Altus Air Force Base, Altus, Oklahoma; Dyess Air Force Base, Abilene, Texas; Walker Air Force Base, Roswell, New Mexico; and Plattsburgh Air Force Base, Plattsburgh, New York.

All three types of Atlas emplacements are designed so that any given missile can be fueled and launched within 15 minutes, or perhaps less (in the case of silo launchers).

ORGANIZING

In order to design and produce Atlas bases in the short time required, the Air Force enlisted a wide spectrum of military and civilian skills, just as it has done with development of the missile itself.

Design, development, and proving of the operational bases; change authorization; and installation of the early bases, is under the guidance of Ballistic Missile Division, Air Research and Development Command, USAF. Contract negotiation and fund allocation is the responsibility of Ballistic Missiles Center, Air Materiel Command, USAF; BMC also has responsibility for overseeing activation of Atlas bases subsequent to Offutt AFB. San Bernardino Air Materiel Area, Air Materiel Command, USAF, is responsible for logistical support. Western Region, Air Materiel Command, USAF, is responsible for contract compliance. Troop training requirements and procedures have involved the Air Training Command, USAF. The United States Army Corps of Engineers is responsible for overseeing the "steel and concrete" portion of Atlas base construction. Strategic Air Command is responsible for operation of the bases as they become complete for operational use.

An equally arresting array of industrial organizations is enlisted in the base activation program.

Convair Division of General Dynamics Corporation, as principal associate contractor for the Atlas missile, is called upon to lay down basic requirements for the launching bases, in company with the base requirements of the other associate contractors: Rocketdyne Division of North American Aviation, *rocket engines;* General Electric Company and Burroughs Corporation, *radio-inertial guidance — to be followed by* American Bosch Arma Corporation, *all-inertial guidance;* General Electric Company, *re-entry systems;* Avco Mfg. Corporation, *re-entry systems;* Kellogg Switchboard and Supply Company, *base communication equipment;* Arthur D. Little Co., *high rate propellant loading.*

The Air Force, having approved the base designs, employs architects and engineers to convert the plans to specific construction drawings. These drawings are then provided to the Army Corps of Engineers to build the missile sites.

Once the emplacements at any given site are completed, Convair and the other associate contractors for Atlas move in to install and prove out the electrical, electronic, hydraulic, pneumatic and mechanical systems which, linked with the missile, make a launching base complete. When this has been done, troops of the Strategic Air Command take over the sites for operational use.

But this only begins to scratch the surface of American industrial participation. Ballistic Missile Division employs Space Technology Laboratories of Thompson-Ramo-Wooldridge Corporation as technical advisor. The Corps of Engineers, in carrying out its responsibilities for construction, contracts with specialized construction firms, who in turn draw upon the resources of additional hundreds of subcontractors, suppliers, manufacturers, and service organizations, and their attendant labor resources.

In performing their share of the base activation work, Convair and the other associate contractors also enlist the specialized skills of subcontractors and suppliers who can most appropriately and efficiently perform a share of the base activation task, or provide equipment, parts, and supplies.

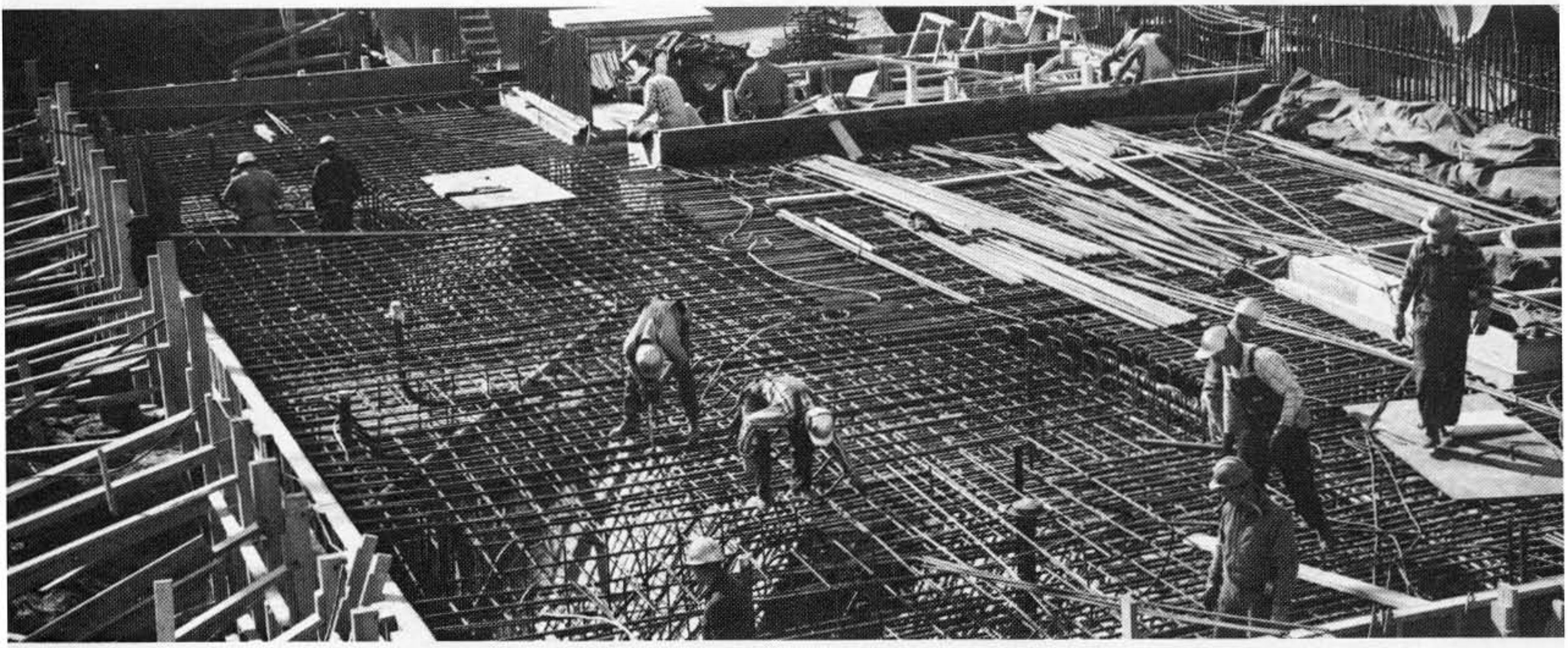
So, in the course of building the 129 Atlas launch pads now scheduled, it is estimated that more than 5,000 private organizations—varying in size from some of the largest in the nation to some of the smallest — are making a contribution to the Atlas base program; and that in the course of completion of the program, the work from at least two million persons will be involved. As many as 3,000 people work at a single base at one time, and a total of 3,850 is employed by the time each base is completed.

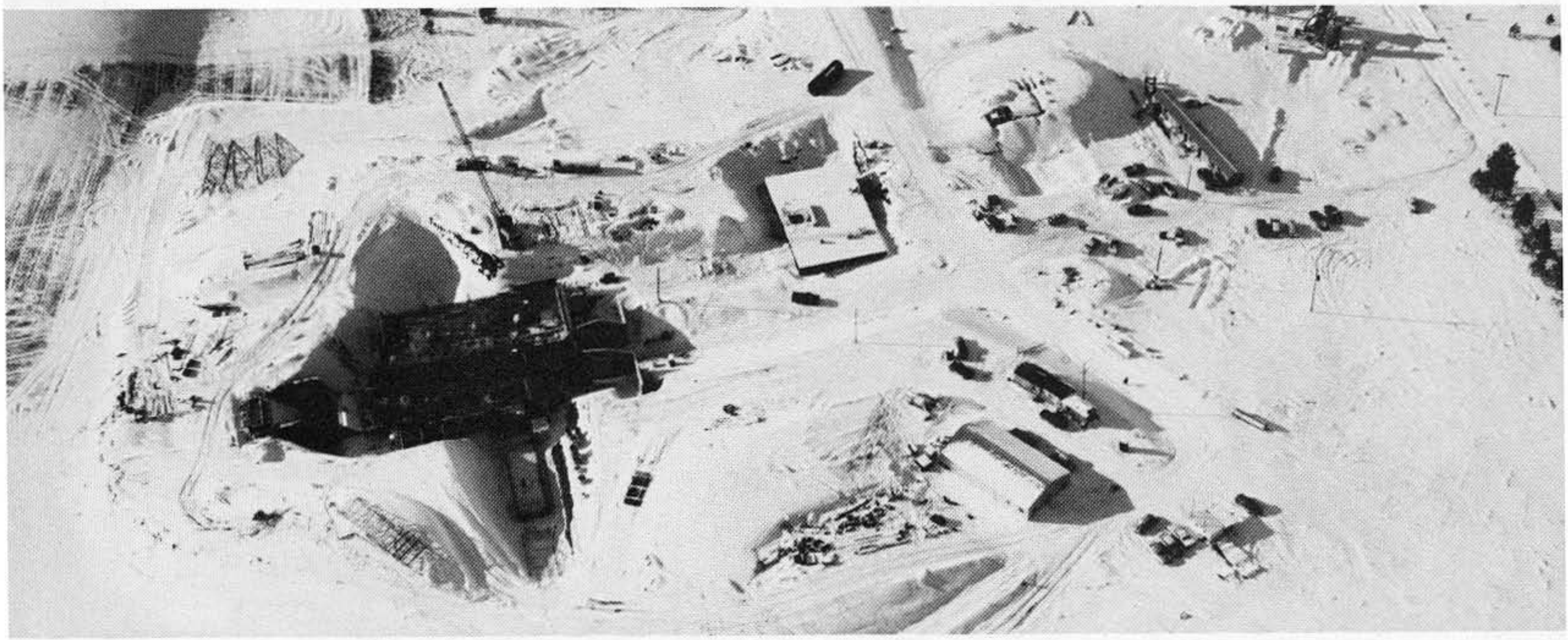
And for almost every person or firm involved in this effort, the demands of Atlas have presented new challenges of techniques and skills.

Commonplace things such as concrete floors in certain critical areas are poured to a level of tolerance not heretofore encountered. Routine appurtenances — such as lug bolts — require a precision in their placement which is unique in the construction trades. Certain plumbing lines are run to un-

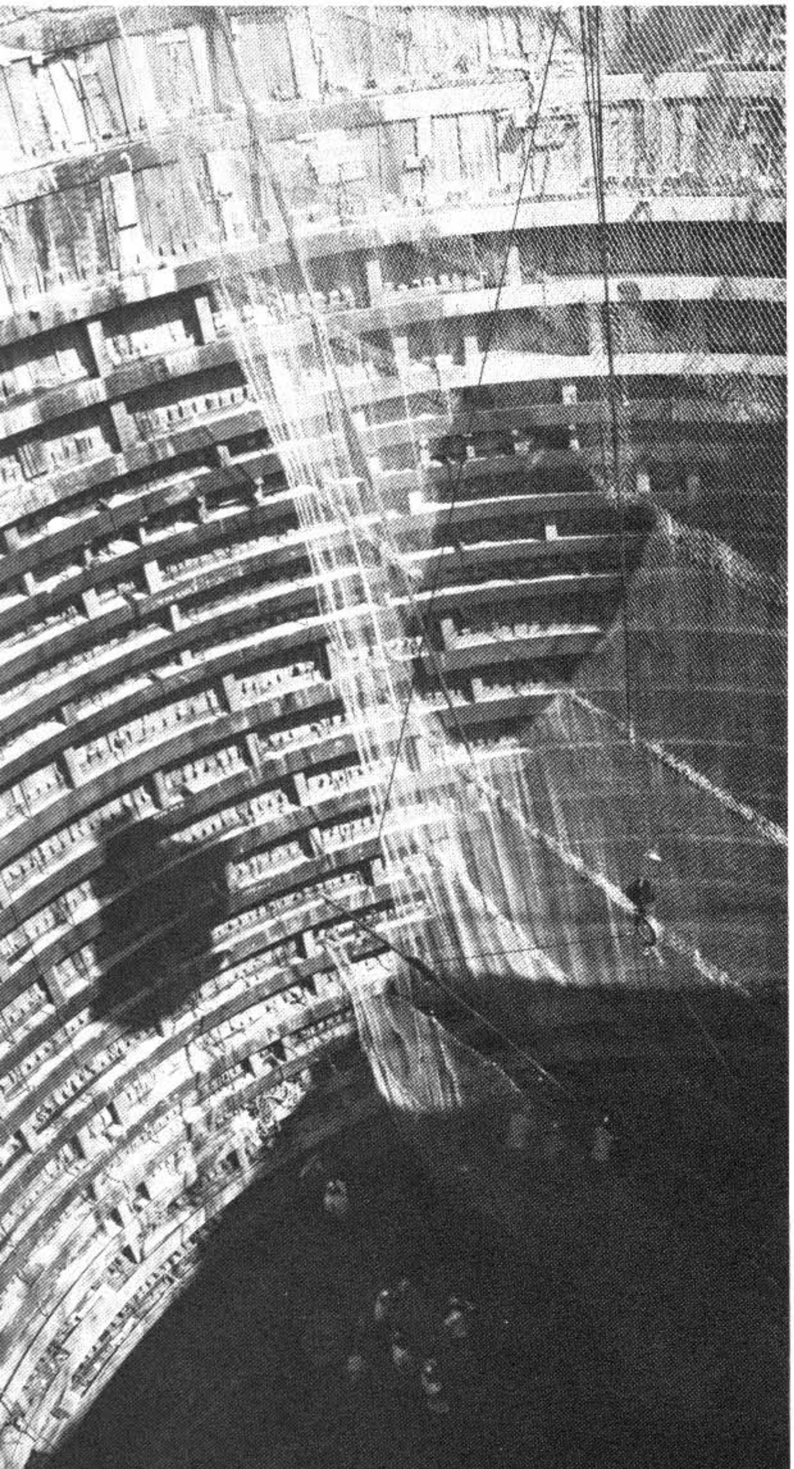
TEXT CONTINUED ON PAGE 17

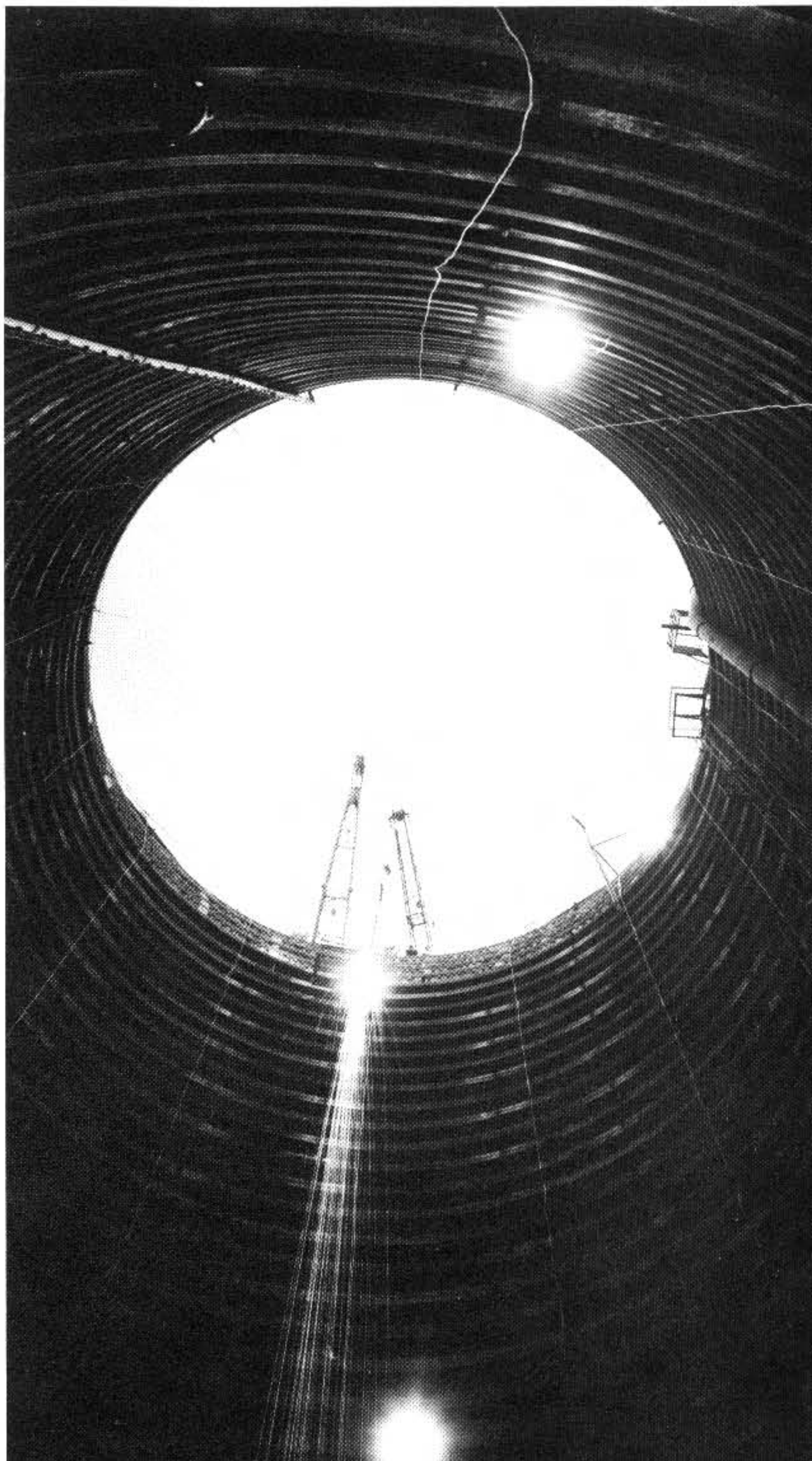
Upper two photos: Construction work on horizontal missile launchers; *lower*, vertical "silo" launcher. A total of 129 launch pads is currently scheduled for Atlas. Thirty months are required to construct each launch pad, install and check out its equipment; work of 3850 persons required to construct each base.



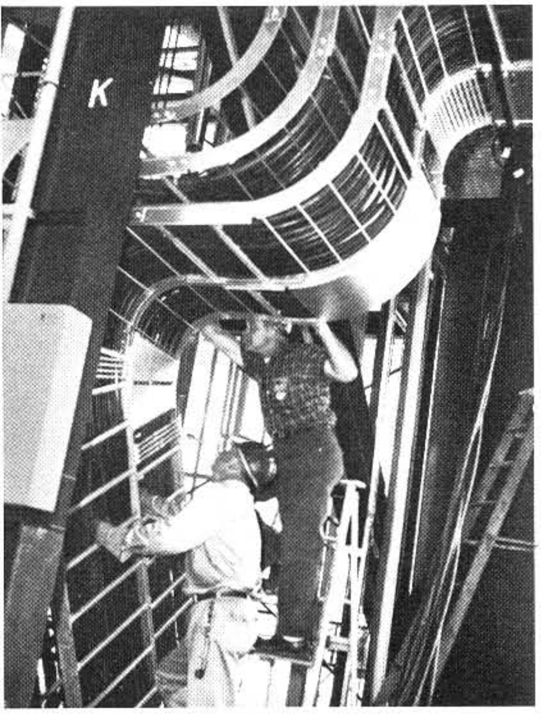


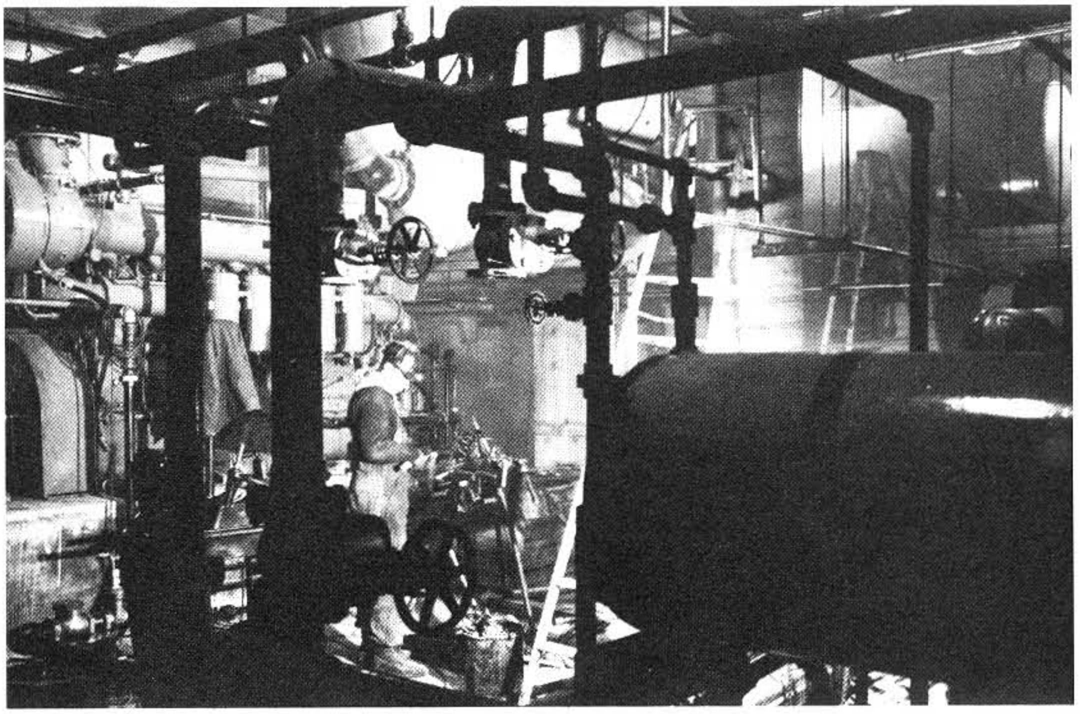
Vertical "silo" launch emplacements are 174 ft. deep, 52 ft. is diameter, house complete missile system. Each requires 3200 cu. yds. concrete (to minimum wall thickness of two-and-a-half ft.), 600 tons of reinforcing steel. Quick-opening doors capping the silo are 30-inch-thick steel and concrete, weigh over 140 tons.

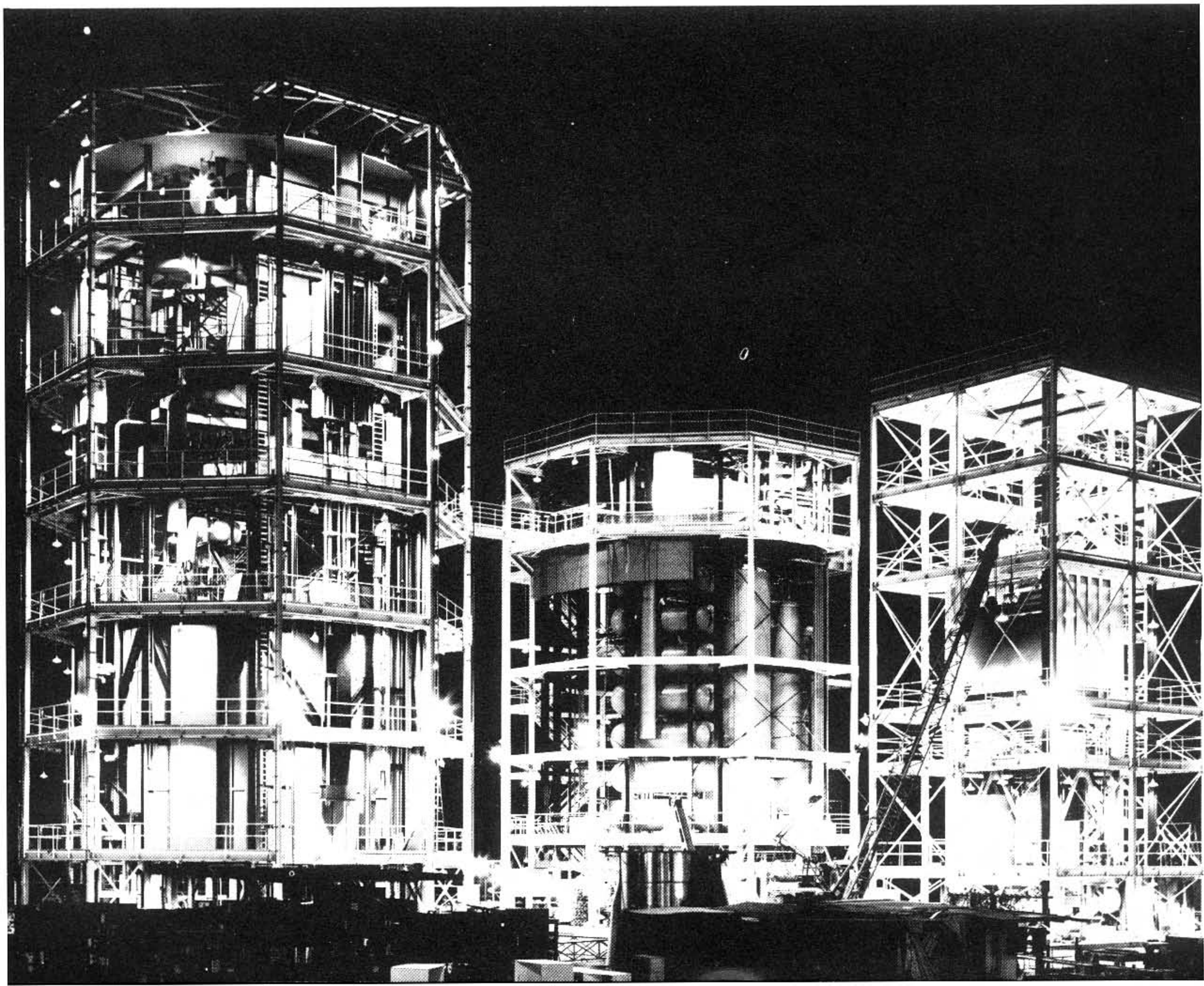




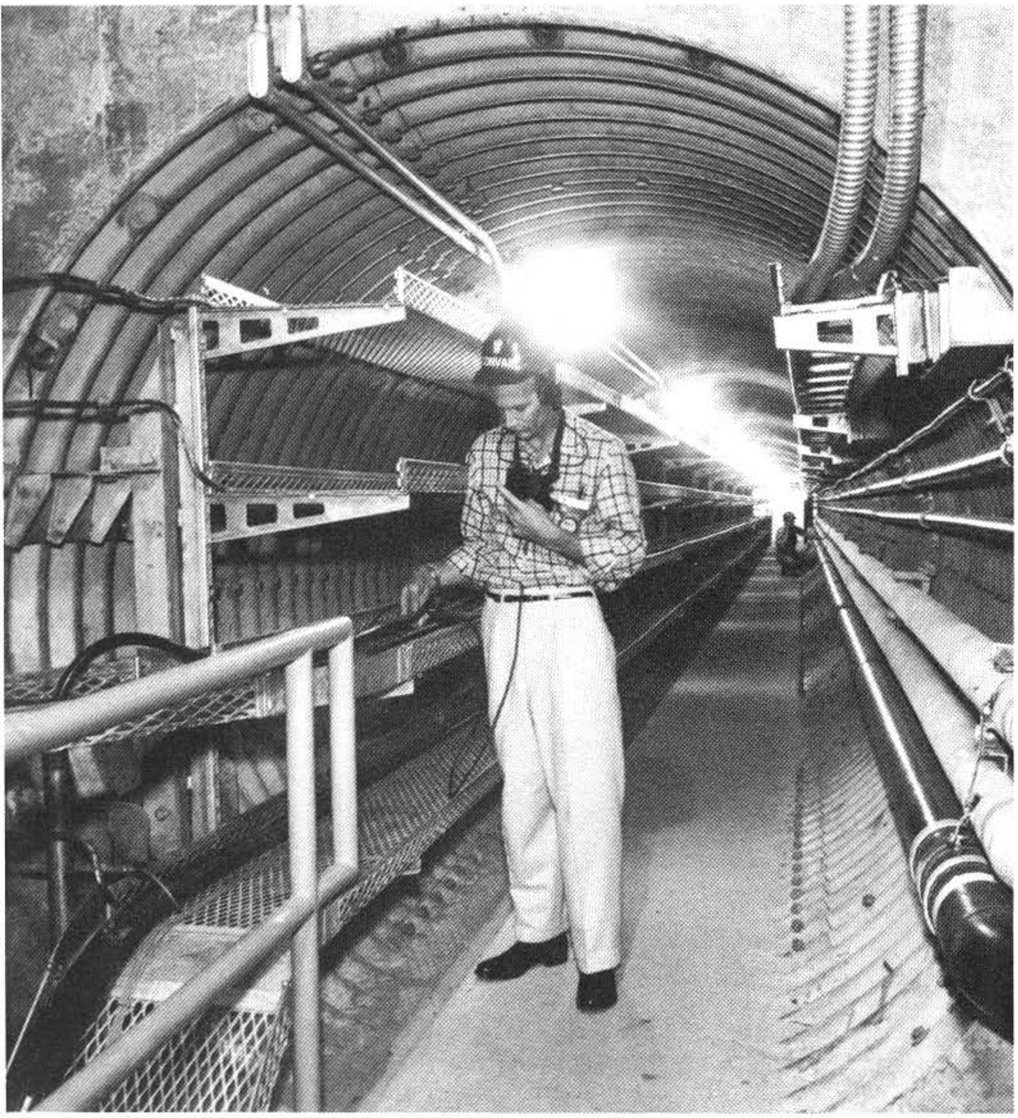
To expedite field installation, all ground systems attendant upon the missile (such as shown in upper pictures) are simulated in full-scale "mock-up" at Convair-Astronautics plant in San Diego. In actual installation, segment shown at left, in lower picture, rests atop segment in center, fills 174 ft. "silo" cavity.

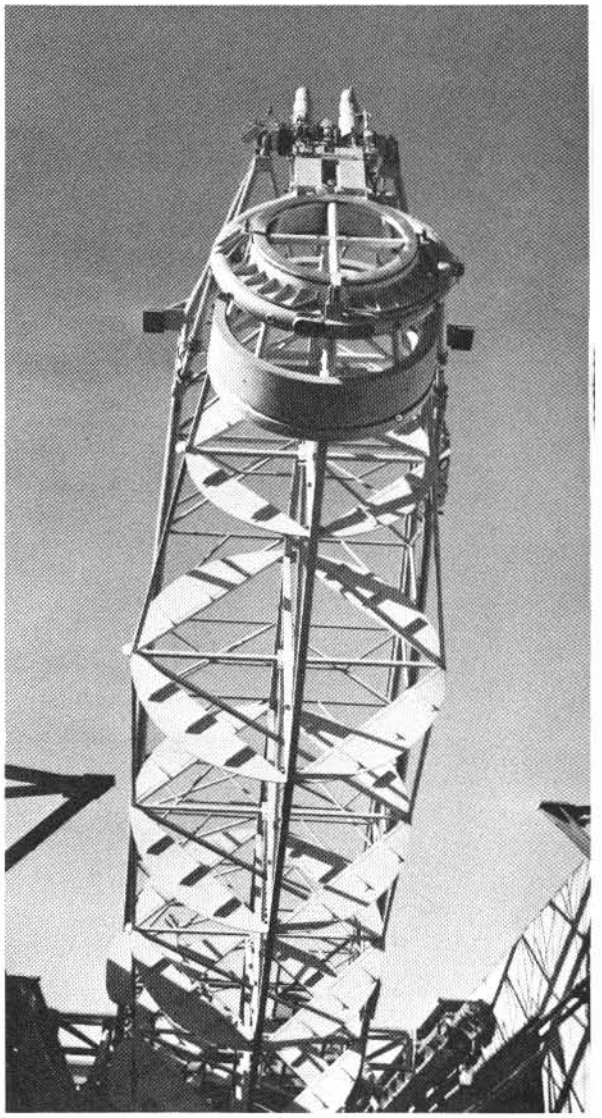






Upper left: When installation is complete, shelves at left carry scores of specially-shielded and grounded electrical circuits between "silo" and launch-control room. Technician is shown checking out a circuit. *Upper right:* "Whalebone" shape simulating actual Atlas, used to check horizontal launcher mechanism.





"Ballistic Sentries of the Atomic Age" – Operational A

Upper left: Optical tooling instrument used to locate structural components at a fixed point in space with maximum precision, in order to insure correct alignment with close-tolerance missile ground equipment which will be installed later. *Upper right:* Mechanical equipment room of horizontal launch building.

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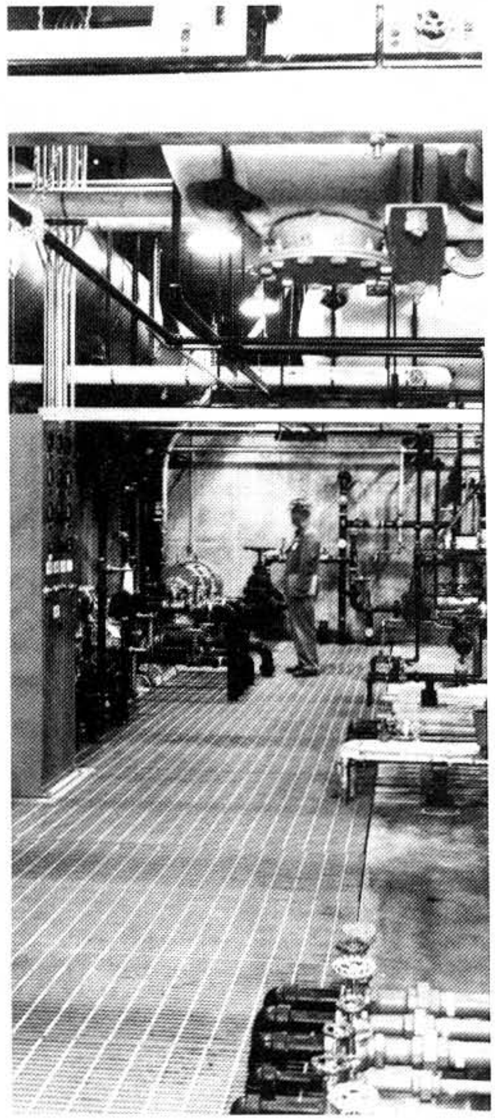
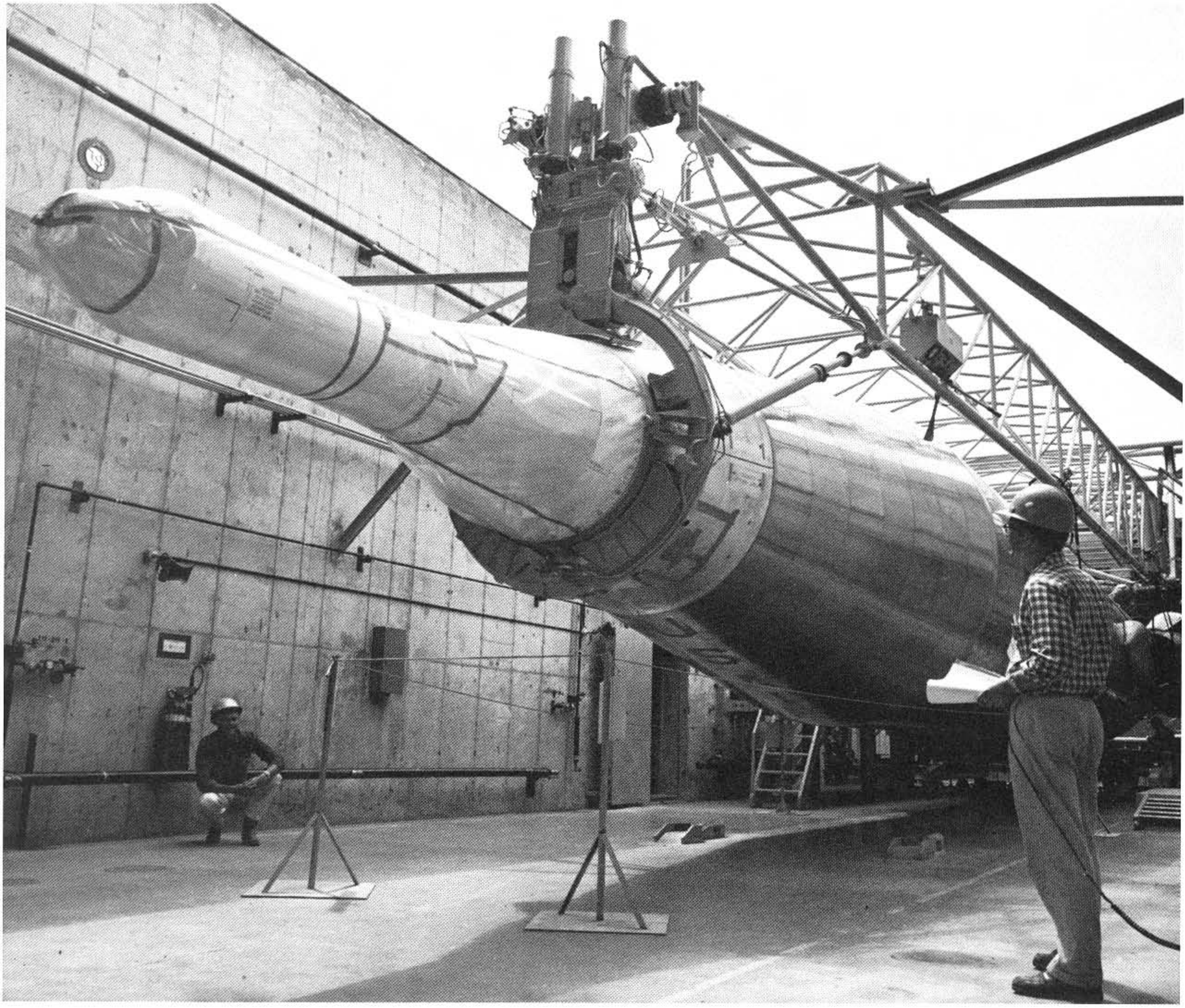
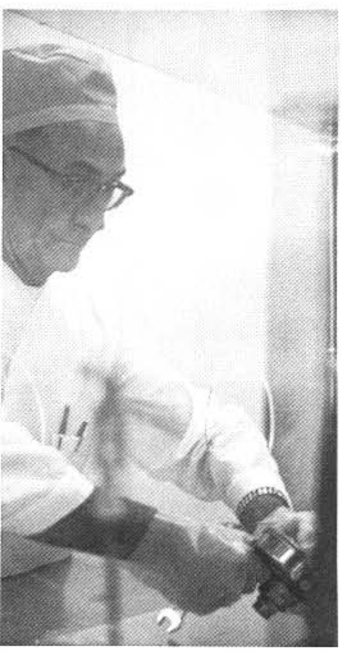


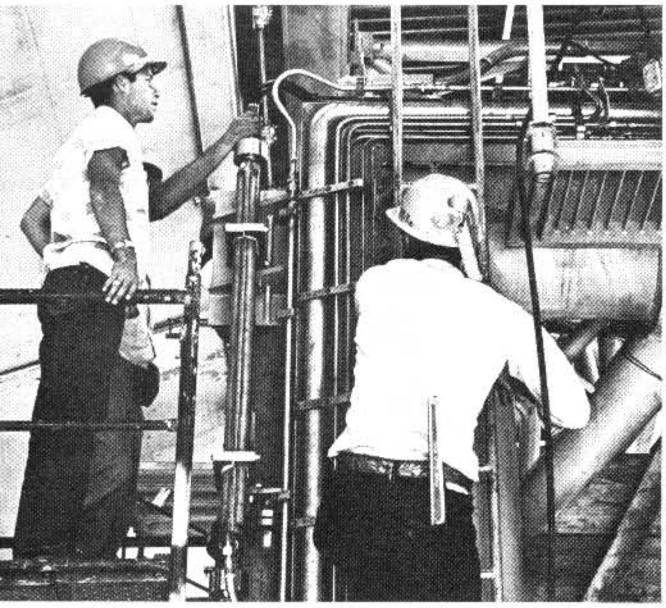
tlases at Warren Air Force Base, Cheyenne, Wyoming.

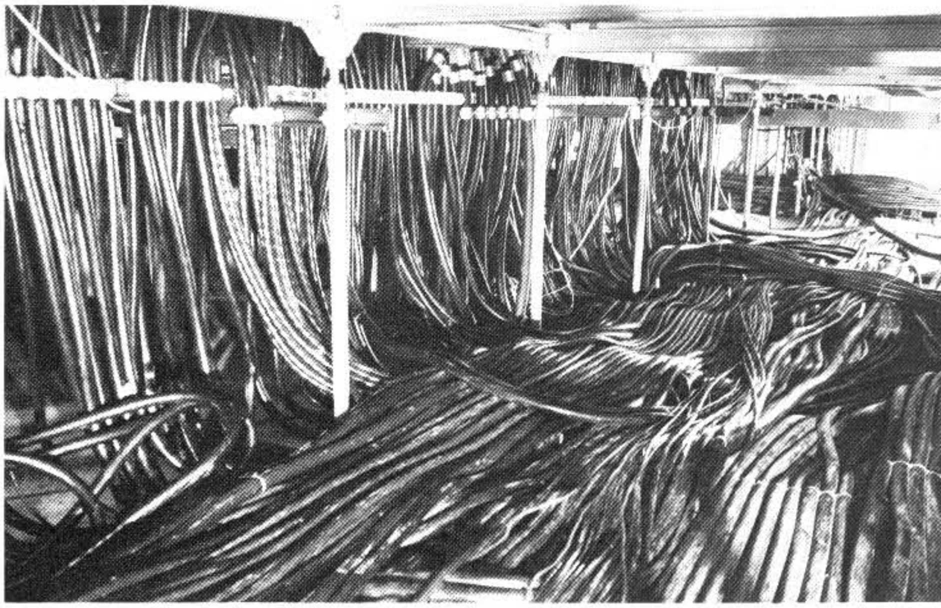
Above: Final checkout of a missile in horizontal launcher before turning it over to Air Force for operational use. *Below:* Cleaning and sterilizing stainless steel tubing before installation. Microscopic cleanliness of hundreds of feet of tubing, plumbing, tanks and valves insures reliable Atlas missile performance.

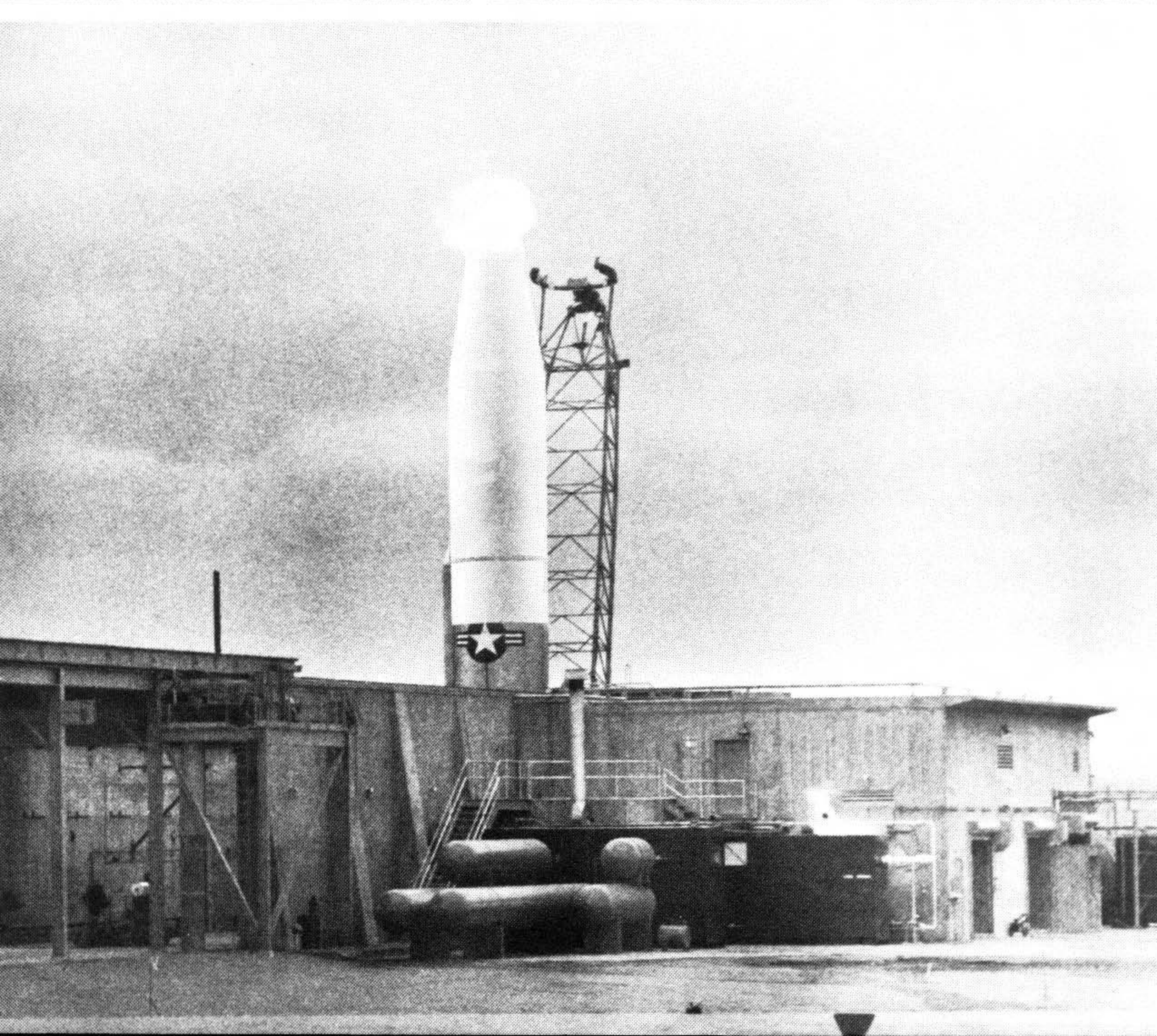




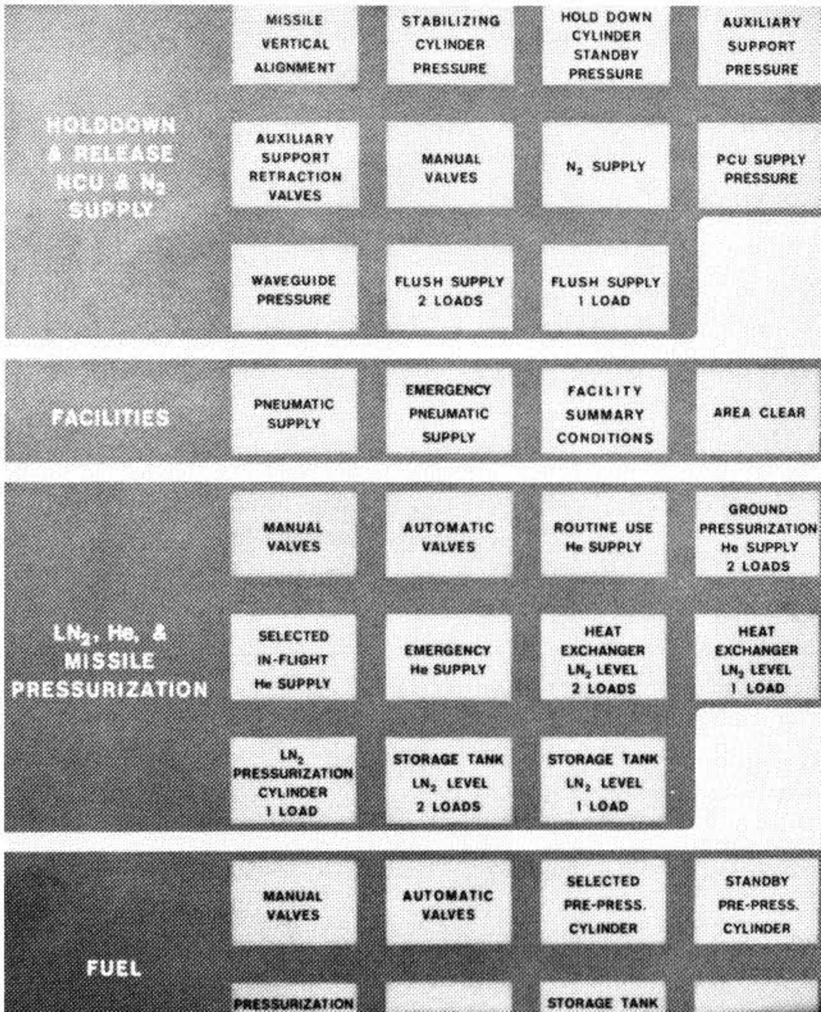
Above, left: Final inspection, portion of horizontal launcher assembly. *Above, right:* Portion of cabling which connects launch pad with control center. *Below:* Practice tanking test of combat-ready Atlas. Vapor plume at top is from oxygen vent valve; frost on upper tank caused by low temperature of oxygen.



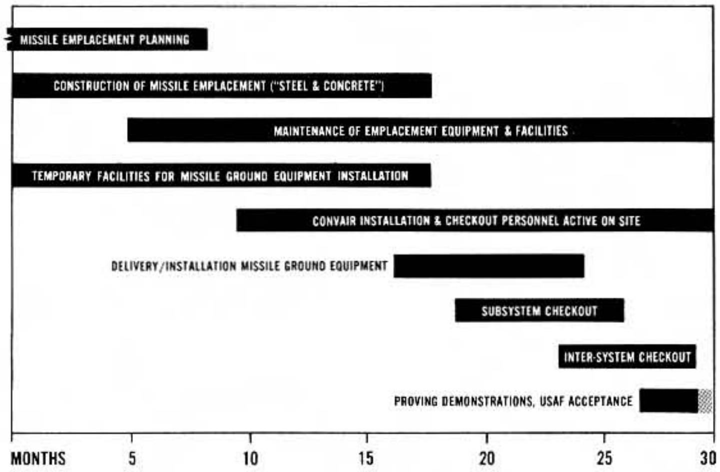




Above, left: Launch control consoles at operational Atlas base. *Above, right:* USAF personnel maintaining Atlas in horizontal launcher. *Below, left:* Nitrogen control unit at operational launch complex. *Below, right:* Portion of the launch-control standby status panel in Atlas control room at operational base.



usually fine tolerances to coincide with installation of other equipment. Lines and valve systems for helium, nitrogen, and liquid oxygen are constructed routinely; while in the past, such plumbing has been done only in specialized military or industrial locations.



PRINCIPAL ACTIVITIES IN ACTIVATING AN ATLAS SQUADRON

Some structures are erected at a fixed point in space so precisely that the work can be done accurately only with optical tooling equipment—previously used only in precision manufacturing operations, seldom, if ever, in the field. Each pad includes hundreds of electrical circuits, installed under conditions of shielding and grounding which have previously been confined to laboratories and specialized industrial installations. Tanks and control systems for liquid oxygen, and hundreds of feet of plumbing connecting them with the missile on each pad, are manufactured, delivered to the field, and installed under conditions of cleanliness as acute as those encountered in sterile drug manufacture.

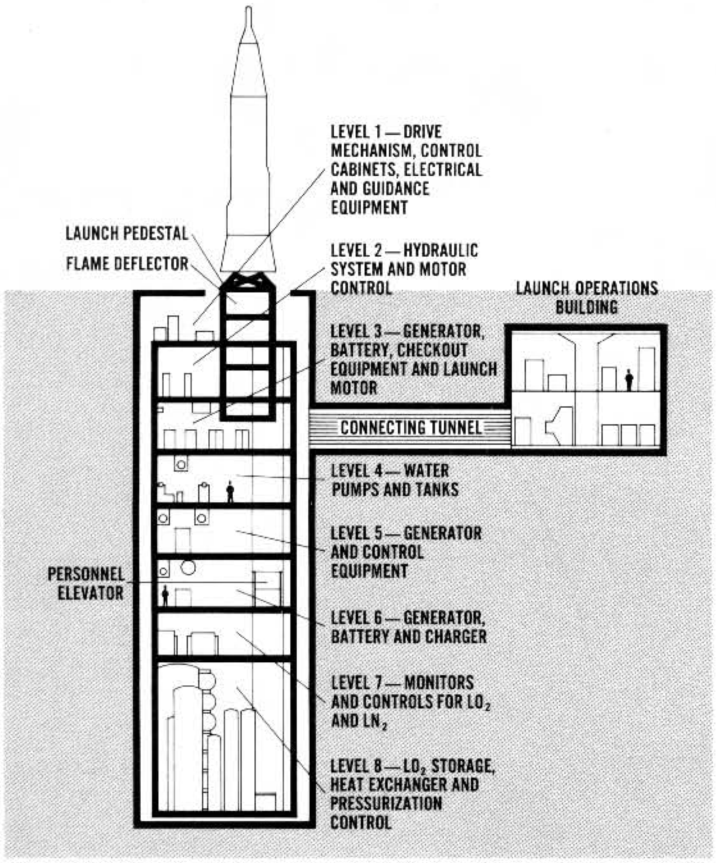
(And even though the liquid oxygen system is installed with great care and inspected assiduously, the moment when it is first tested is one of tension. So as to eliminate the danger of human injury from explosion due to possible hydrocarbon contamination, portable remote television equipment is provided during this phase of each pad's construction so that first tests of each liquid oxygen system can be observed remotely).

In all, completion of each of the early launch pads involves the installation of approximately 7,500 mechanical parts; 1,100 hydraulic parts; 1,375 pneumatic parts; 650 miles of electrical wire connected to 27,000 terminals; and 1,500 items of miscellaneous equipment.

Each of the many "silo" launch pads requires 3,200 cubic yards of concrete, to line the holes to a minimum thickness of two-and-a-half feet; 600 tons of reinforcing steel—some as thick as a man's arm—stiffen the structure. The counterweight on the missile elevator weighs 208 tons. Electrical power required at each launch pad is sufficient to supply the needs of a city the size of Lawrence, Kansas.

Additionally, there are "before-and-after" events connected with this work. Specialized equipment needed on the base during the activation phase includes such diverse items as chemistry laboratories and machine-shop equipment. And once the operational equipment is installed, it must be shown to work satisfactorily . . . first each individual component, then groups of components and elements together, until finally the entire symphony of interrelated systems is made to perform in smooth coordination.

DEMANDS As might be expected, the demands for accuracy and precision are entirely new to many of the people drawn into the project. And the requirements have at times been greeted with some skepticism. There was the instance where masons, well pleased to have placed an anchor bolt within a quarter-inch of a specified point, were told that this was about 50 times too far off the mark. These were craftsmen with pride in their skill, who had built dams



and bridges and buildings to much less precise measurements with commendable results. It is easy to understand why they felt that the missile engineers were insisting upon standards which were preposterous.

On the other hand, the missile people were equally flabbergasted to find structures built to tolerances measured in inches, when the equipment to be connected with those structures was built to standards of thousandths of an inch.

But one thing they shared in common—a heritage of American ingenuity and pride in achievement that has resulted in ever-increasing understanding between the technician-engineer and the construction worker. At one base, a remarkable improvement in progress of the work resulted when the engineers and the construction men adopted the habit of opening their lunch boxes under the same tree; it is from such typically American man-to-man relationships that there have come understandings which can never be quickly achieved by brittle directive.

Putting this diverse, highly-skilled military and industrial team into harness has been perhaps the most remarkable part of the Atlas base program. There were some volatile factors inherent in the situation:

Bases for big missiles had never been built before. While the work employs many construction and installation techniques derived from experience on other types of projects, they have been combined in a new way for Atlas bases, and on a scale surpassing anything that has gone before.

Activation of Atlas bases has required field installation of many types of facilities and equipment to standards of accuracy and precision previously encountered only in closely-controlled missile factories, or in laboratories.

Because base design and construction have proceeded concurrently with proving flights of the missile itself, design changes in the bases have been numerous, to include better ways of doing things that have been revealed in the test program.

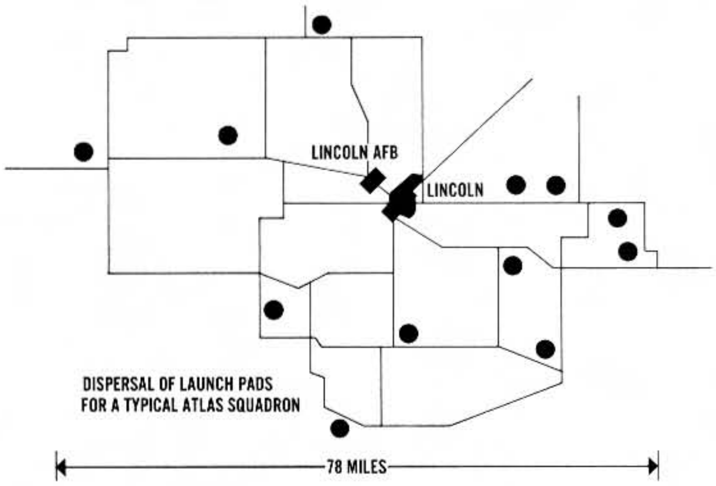
The many technical and construction disciplines involved in base construction have each brought with them their own "lingo." For instance, missile engineers and civil engineers have found that the jargon of their two disciplines is not always the same—that even in some instances they traditionally don't use the same symbology on their blueprints. So one of the offshoots of base activation has been development of new methods of mutual communication, both numerical and verbal—and in many cases entirely new jargons are developing in this "melting pot" of technologies.

The new technologies of the missile have often created new blendings of work which cross traditional lines of labor jurisdictions. For example: safe handling of liquid oxygen requires specialized techniques. The oxygen is delivered to bases in tank trucks, manned by drivers specially trained in handling the stuff. Yet hook-ups from tank trucks to pipelines had traditionally been done by plumbers—none of whom had had oxygen experience. New inter-union agreements have been required to meet situations of this type.

The work on the bases is spread across the face of America, so that the line of communication between them is 10,000 miles long. And even at each of the 13 squadron locations, individual launching pads are widely dispersed (at one typical base, a trip to each of the nine launch pads requires 680 miles of road travel). Yet each launch pad must be as nearly identical to others of its type as possible . . . a need that has required new and imaginative surveillance and control techniques, both on the part of the military and industry.

To keep tab on the status of this diverse task, means have been developed, and are still being refined, for evaluating, step-by-step, each particular element of work being carried on, by each of the military and civilian organizations involved, during the varying stages of progress on each of the 129 Atlas launching pads. Convair alone, in carrying out its share of the work, isolates about 500 tasks in activation of each launch pad—each in its proper sequence, and each properly coordinated with other elements of work which are going on simultaneously.

CONTROL In the Convair master control room in San Diego, the status of work on each of the launch pads then in progress is continuously posted, and compared with the master schedule. Inevitably, there are revealed certain items of work which have not been completed according to plan—because of weather, late or early delivery of parts, mistakes in installation, unavailability of the type of labor needed at that particular point in time, changes developed in the test program, and so on. Each such item of work is analyzed and rescheduled in such a way that it will cause a minimum of interference with other work in the closely dovetailed master plan. In a typical week from 5,000-10,000 specific tasks are reported to the central control room.



As the pace of base activation has increased, and as the total scope of the program has become apparent, management emphasis on base activation at Convair has greatly increased, as has the total number of employees involved. In some cases, innovations inherent in the base activation task and the speed with which it has been put into effect, have revealed need for strengthening various elements in the Convair organization, as it has in most of the organizations connected with the program. Prompt and aggressive action to correct these problems, on the part of all organizations involved, follows the tradition of weapons development, where rapid advances in technology have placed unforeseen demands upon organizational structures and talents.

PURPOSE Even a cursory tour of a few of the Atlas bases under construction, and even a slight insight into the dedicated human effort and money which is being poured into the program, can often lead the thoughtful observer to wonder, "What are we trying to do here?" "Is this all worthwhile?"

The answer is a resounding affirmative. The Atlas gives America its first weapon which can place atomic warheads on any spot in the globe, from American bases, with invulnerability from enemy defensive weapons. Consider the quantum leap in weapons technology which this represents:

In its swift globe-spanning flight, Atlas exceeds 15,000 mph — more than 150 times the speed of the Wright airplane, more than 10 times the speed of the fastest modern bomber.

The Atlas today greatly exceeds — in payload and range — original design requirements (the first Air Force weapon in history to do so); and Atlas capabilities continue to grow as the test program continues.*

Work on the Atlas missile and Atlas bases has provided invaluable information for later generations of missiles; missiles whose capabilities, once they are in service, will supplement the basic ballistic power of Atlas.

Those close to the program were greatly encouraged when Atlas achieved initial operational capability on Sept. 9, 1959, nearly a year earlier than had been thought possible in the study by the Von Neumann Committee in 1954.

And it is a source of great satisfaction to many Americans that Atlas has also emerged as a dependable "work horse" of space exploration. Atlas will serve as booster for the first American manned earth-orbiting Mercury flights; as booster for Atlas-Able, Project Samos, and Project Midas space vehicles; and as first stage for the Centaur, a true space machine which is being produced by Convair for the National Aeronautics and Space administration, in part from existing Atlas tooling.

It thus seems likely that in the years to come, Atlas in retrospect will assume a pivotal stature in American defenses, as well as in American space exploration . . . as a brainy giant, first of all a defender of the nation, yet also a resourceful adventurer beyond the confining shell of the earth's atmosphere.

But there is no need to anticipate history's appraisal in order to evaluate the evidence clearly at hand . . . that, epitomized in the Atlas base program, our American civilization has the vigor, the wit and the strength to put its military and civilian resources into close harness, under a punishing time schedule, on exacting work of tremendous scope and importance . . . and is getting this job done under traditional American concepts of free enterprise enlisted in the cause of the common defense.

Thus the Atlas story is an old story: the story of individual Americans of many callings, applying their efforts to a mutual and difficult goal . . . just as they have since they drew together at Lexington green and Concord bridge.

Working together on the Atlas program, they are creating a statement of American strength and freedom in the specific terms the enemy understands and respects . . . at one of the most crucial periods of world civilization.

*The Atlases as flown 9,000 statute miles on May 20, 1960 and Sept. 19, 1960 were identical to those missiles in place on present operational bases, except for extra test equipment; on December 18, 1958 an entire Atlas put itself into earth orbit, and became the famous "talking satellite" from which President Eisenhower's Christmas peace message was broadcast to the world; as of early Fall 1960, there had been nearly 60 Atlas test flights, of which only 16% were unsuccessful, or nearly so; during the test flight program, 21 consecutive successful launches were made, an all-time record.

Operational Atlas squadrons are one facet of the total retaliatory force of the Strategic Air Command, whose control center is in the "Underground," command post at SAC Headquarters, Offutt Air Force Base, Omaha.

"This, if you want, is a warning... Don't forget that the United States is no longer far from the Soviet Union and Soviet artillery can give necessary support to Cuba if need be. Let the Pentagon remember the last rocket tests in which we proved we can hit a target at a distance of 13,000 kilometers."

NIKITA KHRUSHCHEV
July 9, 1960