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U. S. LEADS WORLD IN JET ENGINE OUTPUT

88,000 Units Produced Since 1942; Flying Hours Total 23.7 Million

No other nation in the world—including Russia—has produced as many gas turbine engines or has accumulated as many jet flying hours as the United States.

An Aircraft Industries Association survey of America's major engine producers indicates that a total of more than 88,000 jet and turboprop engines have been delivered to the Air Force and Navy since the first one was produced in 1942. As power plants for military fighters, trainers, transports, and bombers operating in this country and overseas, it is estimated that U. S.-built gas turbine engines have flown a minimum of 23.7 million hours. Hundreds of thousands of hours also have been recorded in ground tests.

Although an American-built experimental plane powered by a U. S.-produced jet engine first flew in 1942 and a jet-powered fighter started rolling off the production line in 1945, jet airplanes were still in the minority in the Navy and Air Force when the Korean War began in 1950.

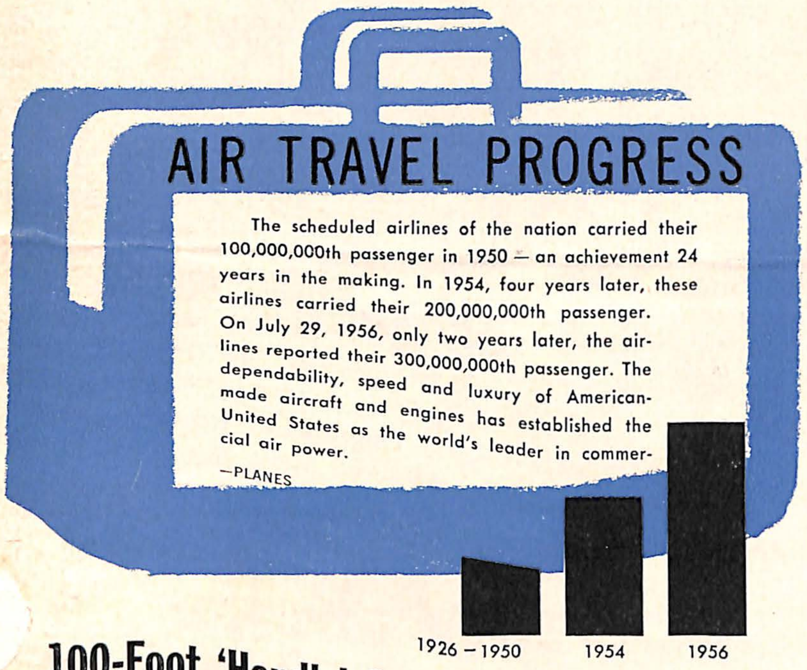
It was only in 1951 and 1952 that the go-ahead was given for mass production of gas turbine engines and the fighters and bombers to house them. As a result, most of the 88,000 jets produced in this country have been delivered in the last five years or less.

Estimates place the cost of developing a new high-thrust turbojet or turboprop engine at a minimum of $50 million, not counting the expense involved in tooling for production.

Aircraft engine builders and the military services must spend sums in this range to make certain that the gas turbine under consideration will prove satisfactory. But even the expenditure of $50 million is no guarantee of success. Because of unexpected problems, a very promising gas turbine engine occasionally cannot be readied for production in time and must sometimes be completely abandoned in favor of a more advanced design.

Despite the short history of aircraft gas turbines, manufacturers have discovered that the construction of about 12 prototypes is just about right for initial testing. Three or four of the jets are used for flight tests and about eight more undergo ground and wind tunnel tests. Each of these eight accumulates about 30 hours a month for a total of about 3000 hours per year. When 3000 hours or more have been run successfully on ground test stands, the gas turbine normally undergoes its

(*See TURBOJET, page 7*)



100-Foot 'Handle' On Screwdriver Permits Jet Engine Adjustments In Flight

Aircraft industry engineers have figured out a way for mechanics sitting in the cockpit of a giant bomber to make precision adjustments on its engines even though they may be a hundred feet away out on the plane's wing.

It was very simple. The engineers built a screwdriver with a one-hundred-foot handle.

With the new screwdriver the mechanic is now able to sit in the pilot's seat watching the plane's instruments and make precision adjustments of the fuel controls of a jet engine in its pod far out on the wing.

As you may have suspected, the contrivance is not a conventional screwdriver. Two screwdriver heads with electric drives are contained in a small box which is connected by a 100-foot cord to a control box. The screwdriver heads are then attached to the underside of a jet engine and ·tted into recesses of the fuel-control ·rews. The mechanic then takes the ·ntrol box on the other end of the ·vire into the plane's cockpit. There he watches instruments and adjusts engine operation to hairline accuracy while it is running at full power.

That's all there is to it. One man does the job. Formerly, two men with telephones were required and they worked under difficult conditions of noise and vibration.

Development of the device is typical of the ingenuity used by aircraft company engineers to save production dollars while building more quality into U. S. air superiority.

California Leads U. S. In Active Pilots

California has nearly 13 per cent of the active pilots in the United States, almost double the number of pilots in the next-ranking state, Texas.

A total of 298,076 men and women held valid Civil Aeronautics Administration pilot proficiency and medical certificates at the beginning of 1956, including 80,494 students, 132,525 private, 72,957 commercial and 11,774 airline transport pilots. In addition there were 100 helicopter, 128 glider and 98 miscellaneous pilots.

California was at the top of the list, with 37,960 pilots. Next in order were Texas with 19,792; New York with 18,543; Illinois with 17,773; Ohio with 15,025; Pennsylvania with 13,813 and Michigan with 12,296. All other states had fewer than 10,000 active pilots each.

Drop Of Water Solves Testing Problem

Search of the aircraft industry to find a method of determining the cleanliness of metal surfaces turned up a prosaic—and effective—solution: a drop of water.

A cleanliness test of metal panels in our modern jet bombers was necessary in their bonding. Clean surfaces permit full strength of the bonding material to be utilized. Former tests required a time-consuming, and expensive, tensile strength shear test of the metal panel bonds.

The problem was to devise a cleanliness test that would be simple enough to be done quickly at many different points on the panel.

Scientists knew that a drop of water on a clean surface will spread until it is almost flat. A drop on a dirty surface will retain its round shape because minute dirt particles dam up its outward movement.

The researchers developed a device that releases a single droplet of distilled water and places it on the metal to be tested before a microscope. An optical instrument measures the angle of elevation of the droplet to within one degree. The higher it stands, the dirtier the surface.

This simple, effective and inexpensive test is typical of the industry's efforts in devising new techniques that produce effective air power at the lowest possible costs.

Air Mail Capacity

America's air transport industry stands ready to carry the mail. A recent study by the Air Transport Association, the trade group representing the scheduled airlines, estimates that by 1970 even if all first-class mail went by air, it would still take up only 13 per cent of the airlines' excess capacity.

PLANES

Planes is published by the Aircraft Industries Association of America, Inc., the national trade association of the manufacturers of military, transport, and personal aircraft, helicopters, flying missiles and their accessories, instruments and components.

The purpose of *Planes* is to:
Foster a better public understanding of Air Power and the requirements essential to preservation of American leadership in the air;
Illustrate and explain the special problems of the aircraft industry and its vital role in our national security.

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Pushing Push Button Warfare

The United States aircraft industry and the military services have made great strides since World War II in the development of rockets and guided missiles.

Already the guided missile is playing a part in U. S. air defense operations where it is replacing anti-aircraft artillery; and it will one day compete directly with interceptor aircraft. In combat air operations of Air Force and Navy the air-to-air guided missile will soon replace the rocket and machine gun. Missiles and pilotless aircraft are already supplementing long-range artillery and the fighter bomber in ground support missions. And we are not too many years from adding medium and long-range missiles, both air breathing and ballistic, to the manned bomber for the strategic bombing mission.

But it is unlikely that guided missiles will completely replace manned aircraft in any mission areas during the forseeable future. Unlike present experience with manned aircraft, the science and engineering teams of the aircraft industry developing these new weapons have less history to lean upon; and therefore, the problems of their research, development and production are difficult.

For example, the problem of reliability in the guided missile after "the button is pushed" is staggering. There is no opportunity to test a specific missile in the same manner that an aircraft is tested. In industry parlance the missile is strictly a "go, no-go" item. The guided missile must work the first time; there are no repeat performances. And the very existence of the United States may well depend some day on the reliability of its guided missile arsenal.

There are thousands of components involved in the operation of a missile. Engineers estimate that using only 100 components (a fraction of the actual number) each must have less than one chance in a thousand of failing if the missile is to have better than 90 per cent reliability.

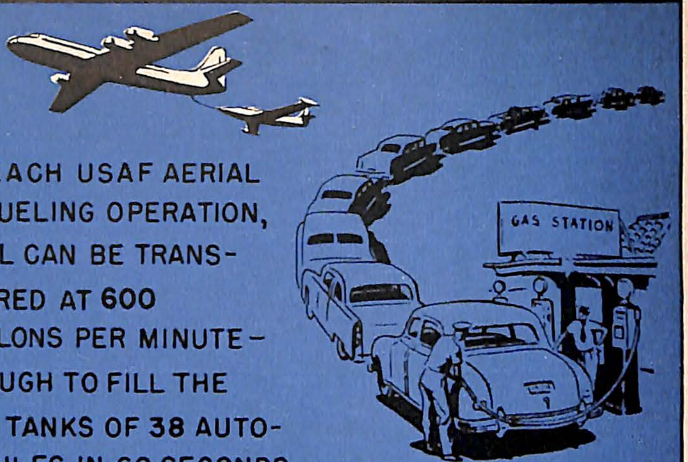
The aircraft industry's ability to design and manufacture thousands of precision-made jet bombers and fighters is not the main criterion upon which its ability to build missiles, guided and pre-set-breathing and non-air breathing, is based. The prime reason is in its ability in managing systems. An airplane is a system. The aircraft manufacturer is given a basic job and starts to work. He does not produce the aluminum, manufacture the engine, make the landing gear, communications equipment or hundreds of other components that make up the complete aircraft. Yet he manufactures the airplane. This is not merely an assembly job. The skill involved is in his ability to make all of these intricate elements work together to accomplish a specific task. This is the unique qualification in missile production.

So, with these radical new aerial weapons, ours is a technological race with our potential enemies. The most advanced design aircraft or guided missile in the world are worthless unless they are ready to be used when they are needed. In this age of supersonic speeds and devastating weapons, we cannot rely upon rear area build-ups cushioned by comfortable margins of time and distance. There will be no rear area. The fronts will be where our aerial weapons strike, and wherever the enemy may strike this nation—New York, Dallas or Seattle.

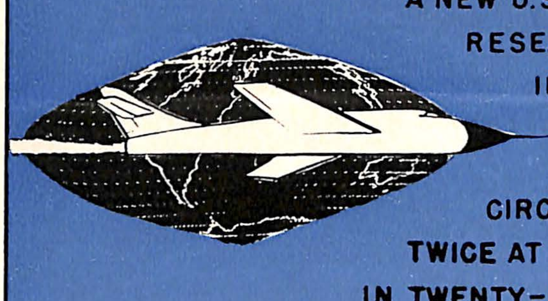
Men of science and engineering in the United States aircraft industry, the military services and other government research agencies, in unison, are doing their utmost to push research and development in push button warfare.

Plane Views

IN EACH USAF AERIAL REFUELING OPERATION, FUEL CAN BE TRANSFERRED AT 600 GALLONS PER MINUTE—ENOUGH TO FILL THE GAS TANKS OF 38 AUTOMOBILES IN 60 SECONDS.



A NEW U.S. SUPERSONIC RESEARCH PLANE, IF POSSESSING SUFFICIENT FUEL, COULD CIRCLE THE EARTH TWICE AT THE EQUATOR IN TWENTY-FOUR HOURS.



A "QUIET ROOM" USED IN REDUCING EQUIPMENT NOISE OF A U.S. AIRCRAFT MANUFACTURER IS SO SOUND PROOF THAT YOU CAN HEAR YOUR HEARTBEAT AS YOU AS YOU WALK THROUGH IT.

—PLANES

Industry Takes Over Supply Function

Close cooperation between the aircraft industry and the military services has produced a relationship that goes far beyond the normal business dealings of buyer and seller.

Latest innovation in industry-military relations is an arrangement on storing and issuing jet engines which makes the manufacturer responsible for these important functions during the development and early production stages. Formerly the military handled this parts assignment through its depot system.

The size of the project is illustrated by the fact that $30 million in parts is involved in this initial phase of a single engine program.

The new arrangement will permit incorporation of engineering changes in spares held by the manufacturer and in new items. This keeps the number of items becoming obsolete to a minimum. The new program also reduces the amount of initial packaging and transportation to depots and production schedules can be aimed at retaining only a 90-day stock level of spares.

Air Quote

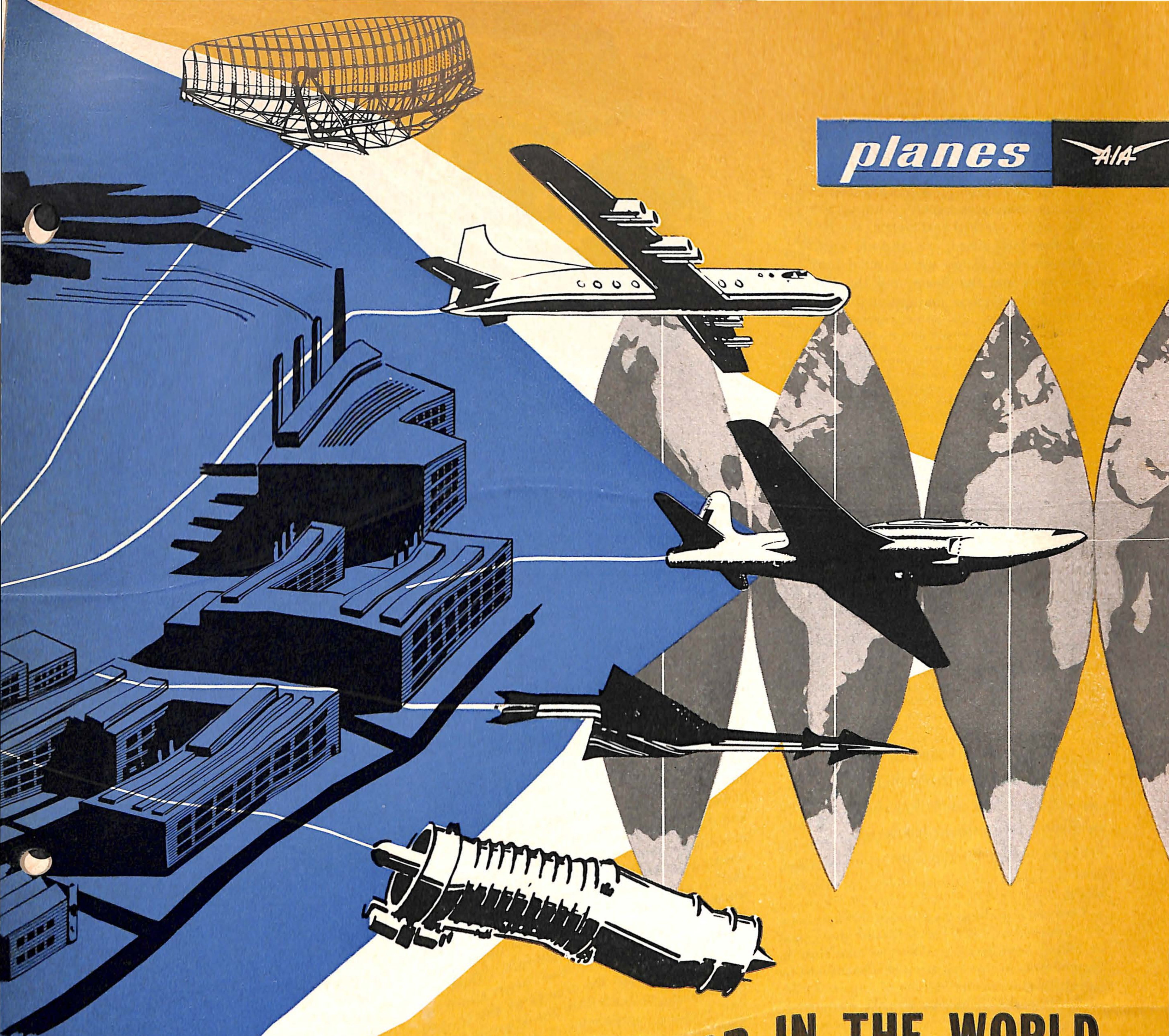
"While outstanding feats of test and development are important, I want to remind you once again that continued progress depends upon people, trained, experienced, skilled people in industry and in the military service.

"We speak continually of the importance of technological breakthrough. I know of no single breakthrough that I would trade for the assurance that the Air Force would get—and be able to keep—the skilled men it needs in the years ahead.

"However, I realize that the needs of the Air Force are only one part of the problem. The Army and Navy face similar difficulties. So does industry.

"The security of our nation in the years ahead depends as much on the wisdom and the skill of our engineers, scientists, and technicians, as it does on the courage of the fighting men in our Army, Navy, and Air Force.

"Let us not have to learn the hard way an even more important lesson—that a broadening scientific and technological base is equally vital to continued peace."
—*General Nathan F. Twining, Chief of Staff, USAF, Aug. 3, 1956.*



BIGGEST JOB IN THE WORLD

By James J. Haggerty, Jr.

I HAVE been to a great many air shows, but the one I saw this summer was somewhat different: the airplanes had large red stars on their tail sections. I was one of a fortunate few Americans who were privileged to attend the fly-by of the Soviet Air Force at Tushino Airdrome, where once a year the faithful gather to ooh and aah at what they consider tangible evidence of Soviet air supremacy.

All roads led to Tushino that day. As we jolted along the 30 kilometers from Moscow to Tushino over a rutty road that was new when the last of the Tsars was an apprentice, it seemed as though the whole population was en route to the airfield—afoot, on bicycles, in buses, overflowing the sides of trucks, a few of the privileged in the curtained Zis limousines used by official Moscow, a reminder that even in a classless Utopia there are degrees of classlessness. Huge posters along the route screamed the glories of the Red Air Force.

It was no day for an air show. A heavy overcast, with broken gray-black clouds scudding beneath it, blanketed the airdrome. A chill intermittent rain fell on the crowd of 100,000 or so air enthusiasts, but it failed to dampen their spirits. A holiday attitude prevailed; this was a Big Day. When, precisely at 10:30 a.m., as advertised, a large group of fighters flew over in very precise formation spelling out "Glory to the Communist Party,"

JAMES J. HAGGERTY, JR., aviation staff contributor for Collier's magazine, recently returned from Russia where he observed the Soviet Air Force fly-by at Tushino Airdrome and became the first correspondent to fly in the Tupolev 104, Russia's turbojet passenger transport. He is a former president of the Aviation Writers Association and has been active in aviation affairs since his service with the 15th Air Force during World War II.

a spectator nudged me smilingly and said something in Russian which I took to be "How do you like them apples, Amerikanski?"

The air show was, to a degree, impressive. The airmanship was superb. Despite the low ceiling and a marked turbulence, the Russian pilots flew high speed, low altitude formation as though their planes were riveted together. The Bisons and the Bears and the Farmers and the Frescoes were unquestionably modern planes. And yet, for some reason, possibly overanticipation, I and some of my colleagues of the press felt let down. It was a nebulous impression, difficult to translate into reason or to back with fact and figure. I felt something like a football coach scouting a future opponent, knowing that the opponent is playing under wraps, feeling nonetheless that my team is better.

USAF Chief of Staff Gen. Nathan F. Twining confirmed that vague impression after a week's tour of Russian air facilities, when he stated that the USSR is "certainly not abreast of us today." Qualitatively, at least, they still have some work to do. Numerically, we had little basis for judgment; the Reds did not confide in us as to numbers.


—PLANES

IT WOULD be folly of the nth degree to assume that the Union of Soviet Socialist Republics is anything but a first rate air power. They are definitely major league. Yet, despite an American air power policy which has wandered all over the lot from production famine to near prosperity, a harassment the Soviets need not brook, they are still Number Two in the league.

It is this fact more than any other which has preserved the tenuous peace we have today, for no one knocks the chip off his enemy's shoulder if he knows he might have to eat it later. Only the most rabid anti-aviationists will argue this point: American retaliatory striking power in the air has been the primary deterrent to the forcible imposition of Communist dogma on the peoples of the free world.

There are perhaps two major reasons why the Soviets have not yet achieved their goal of taking over the Number One position in the air. One is the fact that, at what might be called the start of the Soviets air power build-up in 1945, the U. S. was already a couple of laps ahead in the race. Although a good deal of this advantage was dissipated in the years immediately following, when we happily ran tractors over our accumulation of air power in the firm belief that democracy had once more been preserved, the Soviets still had a much longer way to come in the post-bellum decade.

The second reason is the ingenuity of the American aircraft industry, which, despite stringent budgetary limits and the absence of a solid air power program, somehow managed to maintain a qualitative edge.

The military air forces are, of course, the nation's first line of defense. But they can never be any better competitively than the planes they fly, and in that respect the industry has become the second line of defense. It is no longer an adjunct to national security; it is a full-fledged partner of the military. It enjoys a position of responsibility unparalleled in the history of private industry, for, operating under handicaps, as well as the advantages, inherent in the democratic form of government, it must match and better the achievements of its Communist counterpart in research, development and production of aircraft and missiles. The future of the world hinges upon its ability to do so.

THE maintenance of this air power arsenal is a task which imposes extraordinary demands on the industry, but its record has been such as to instill confidence in even the meanest skeptic.

The atomic blasts that leveled Hiroshima and Nagasaki and brought World War II to a sudden, dramatic end produced a corollary reaction in the U.S. aircraft industry. A year earlier, at the wartime peak of its production, the industry had rolled out onto the flight lines of great, teeming plants all over the country nearly 100,000 military aircraft. Then, as though those A-bombs had been aimed at the industry itself, the wheels of the world's greatest single industrial force ground to a halt under an avalanche of cancelled orders. The old war was over, and, except to a visionary few, the new one had not yet appeared on the horizon. The industry found itself in the sadly familiar position that had plagued it since its birth: in the valley after the peak. In the year after the twin mushrooms blossomed over Japan, military plane output dropped to slightly more than 1,500 units.

The next few years were slim ones. The production curve rose to a hillock only slightly higher than 1945's bottom of the valley. Research and development programs limped along with little money to back them. There were, nonetheless, solid accomplishments during the five year period following Nagasaki. Some first-rate jet fighters and bombers had been designed, developed and produced. *Some* is the word — they were in very short supply. The bulk of the American air striking force was piston powered; it consisted largely of aircraft which had seen combat in a war that had ended a demi-decade earlier. Air power advocates repeatedly pointed out that the U. S. had the equivalent of only *one* fully-equipped combat wing.

In June 1950, a skeleton force of 262,500 employes was turning out a niggardly 215 aircraft a month when suddenly an imaginary line on a map of a distant country, the 38th Parallel, became an immensely important geographical landmark for the democratic peoples of the world. A Communist army moved across that parallel and the U. S. moved immediately to stop the aggression. For the second time in a generation, the American aircraft industry was called upon to recreate its lost air-power —and quickly.

For the emaciated industry, the task was a formidable one. Modern aerial weapons required techniques still undeveloped, skills largely unacquired, components and materials that did not exist. As one model moved along the revitalized assembly lines, industry was designing and preparing for production new aerial weapons of vastly greater combat capabilities.

In addition, the industry shouldered the responsibility of marshalling thousands of new subcontractors, insuring the quality of their products and phasing deliveries so that the right part arrived at the right time; many of these suppliers had never before manufactured the intricate parts required for a modern airplane. The airplane became the most complex product of a highly industrialized society. Its architects created a new term to describe modern aircraft—they became "weapons systems."

BY the end of the Korean war, the nation's air power had more than doubled. More important, the industry demonstrated its ability to develop quality as well as quantity —one Air Force jet fighter rolled up a 14 to 1 kill ratio over its Communist opponent, the Russian designed MIG-15.

This time, the end of a war was not the signal for a let-down, but rather for an increased build-up. Korea was not a war in itself, only a battle of a greater war. It demonstrated conclusively that the disciples of Marx and Lenin will never rest until they have imposed their doctrines on the rest of an unwilling world. It demonstrated, too, that the most effective measure against this program is the maintenance of a strong counter-force. And so the build-up continued.

Within six years from the start of the Korean conflict, the industry, together with its partners, the Air Force, Navy and government and civilian research agencies, had brought about a revolution in aerial arms. From air forces built around the piston engine, a complete change was made to the turbine engine. Since June 1950, the industry has produced or readied for production 10 fighter aircraft capable of supersonic speed in level flight, turned out 1,800 medium jet bombers, started production on a near-sonic intercontinental jet bomber. Early this fall it will roll out its first supersonic bomber. In addition, it brought into the active inventory a new weapon: the guided missile. There are now nine missiles in operational status and another score in various stages of development. Significantly, most of this progress was made under a peacetime economy without the priorities for men and metal usually associated with such accomplishments.

IN spite of this progress, it has been only in the past three years of the post-war decade that the aircraft industry has had anything like a stabilized planning base. The production curve looks like a profile of a roller coaster. The authorized strength of the Air Force, for instance, was changed seven times—from 66 wings to 55, then, in rapid sequence, to 48, 95, 143, 120 and finally 137, each change bringing its attendant crop of grey hairs to industry planners. The effect of this roller coaster programming was stated very succinctly early this month by General O. P. Weyland, commander of the USAF's Tactical Air Command.

"This stop-and-go planning reminds me of a game of 'crack-the-whip' on ice skates," General Weyland told the Air Force Association convention. "The anchor man and those near him do receive some reaction of the movement and stopping or cracking of the whip, but nowhere near the magnified impact on that poor little individual on the extreme end of the whip."

The aircraft industry was certainly well out toward the end of that whip—but it managed to stay on its feet.

THE role of the aircraft industry today is even more critical than it was during those hectic down-again up-again years of the post World War II decade. If the problem were only to maintain a degree of readiness for the "day the balloon goes up" and then swing again into heavy production, it would, while far from being a simple matter, at least admit of a concrete basis for planning. Twice in fifteen years the industry has demonstrated its ability to rise to an emergency and there is no question but that it could repeat the performance if the occasion demanded. But the advent of nuclear and thermonuclear weapons has thrown a new factor into the complicated equation of manning an air arsenal: no time for build-up.

The "approved concept" of modern aerial warfare, as stated recently by General E. W. Rawlings, commander of the USAF's Air Materiel Command, is: *the decisive phase of any future war will be the first 30 to 60 days.*

"I am not saying," Gen. Rawlings enlarged, "that the war will be fought to the end within two months, but we believe its decisive phase will be over by that time. So, for all practicel purposes, the Air Force probably will have to fight with the equipment that is ready to go when the bell rings."

This concept provides a new challenge to the aircraft industry. Since no one can predict when that bell will ring, if indeed it ever will, the industry's mobilization day is right now. But the task has changed. The nation's peacetime economy cannot supply funds for the mass production of aircraft on a World War II scale, so the industry has a different job: to bring forth the most advanced aircraft possible and get them into the active inventories of the military air forces in the shortest possible time. The task is paradoxical, for advanced aircraft, by the very nature of their complexity, dictate ever increasing rather than decreasing lead times. Thus, the industry must accent its research and development programs. One of any weapon is not enough.

The aircraft industry has long recognized its responsibility in the field of research and development. It does not have to be pushed into such programs. More often than not it leads the way. For example: long before the Air Force formally stated a requirement for a jet tanker to refuel the bombers of the Strategic Air Command, one airframe manufacturer was designing a prototype. This company invested $16,000,000 of its own money, with no assurance that the Air Force would ever buy the plane and no guarantee that the investment could be recouped in the commercial market. The gamble paid off, to the company in terms of a production order, to the Air Force in a dividend more valuable: another time edge in the technological race.

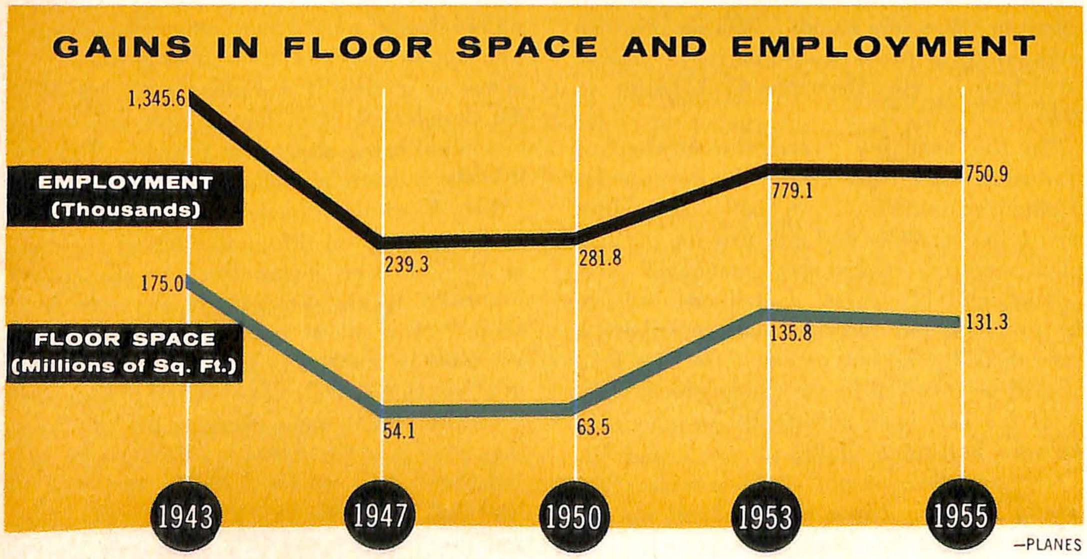
Such investments are the rule rather than the exception in the aircraft industry. Despite their close alliance with the military, the companies which compose our air arsenal are private firms whose management realize only too well that failure to maintain an aggressive research and development program means loss of future business in an intensely competitive field. This high degree of competition has been a major contributing factor in the maintenance of a technological lead over the Soviet Union. It has paid a big dividend to the government. Since World War II the industry has expended $1 billion of its own funds in research and development projects. In the coming five years it plans to spend another billion.

RESEARCH and development of new aviation equipment is almost unbelievably expensive and the amount of money available will always play an important part in the degree of technological advance the industry is able to achieve. But at least we know the nation has the financial resources. Perhaps a more pressing problem is the shortage of brain power, which cannot be alleviated simply by opening the coffers.

The soaring technical gains made in the past decade and the new avenues of inquiry they produced created an insatiable demand for engineers and scientists. The industry's utilization of scientific and engineering talent literally ranges from "A" to "Z"—aerodynamicists to zoologists. Progress has opened up new fields that did not exist a generation ago. To quote Dr. Alan T. Waterman, director of the National Science Foundation: "Fifteen years ago, 'help wanted' ads which are commonplace today would have sounded strange to our ears—such ads as: 'Wanted: physical scientists, engineers, to work in such specific areas as radar, weapons systems, guidance, telemetering, instrumentation, miniaturization, nuclear physics,' and so on through the lists which fill columns in today's classified ads."

One of the industry's greatest obstacles in its quest for greater and greater technological advances is that there are so few qualified people to answer these ads.

In this field, too, the industry is doing its utmost. First, it is utilizing the talent presently available by "stretching" their capabilities. Engineers have, for the most part, been relieved of administrative duties. Technical aides now take readings from instruments and do the data recording operations, leaving the professional engineer free to assess the information and conceive its best possible use. Some companies are helping solve the problem through a twist of the specialization



—PLANES

technique, wherein an engineer who specializes in wing design is used to design wings for all aircraft under consideration instead of devoting his time exclusively to a single airframe project.

In its efforts to stimulate the output of engineers and scientists, the industry has demonstrated what might be called "industrial statesmanship." It has devoted a good deal of time and money toward encouraging high school students to take up the "art of the slipstick" and toward improving the course of studies.

A survey of some of the larger aircraft, engine and parts companies showed that, during the 1955-56 academic year, these firms spent more than $480,000 to provide scholarships for undergraduate students. The program will be expanded next year when the companies plan to spend $800,000 for 720 students.

In this education program, the industry reaches both above and below the level of the baccalaureate engineer. In the 1955-56 school year the larger aircraft companies spent $1,125,000 to assist graduate students, and several are planning to increase their grants during the coming year.

IN reaching below the bachelor level, to the junior high and high school student, the industry sponsors essay and scientific projects, promotes field trips to aircraft plants, provides lecturers for "Career Days" and donates teaching aids for science, mathematics and mechanical drawing courses, all with an eye toward awareness of aviation engineering as a profession.

The industry itself is a huge educational system. New designs and new materials are constantly bringing about new requirements for technical and manufacturing skills.

During 1955, the companies surveyed conducted more than 1,500 courses for personnel employed in occupations ranging from electronic technician to expeditor. These courses were taken by more than 200,000 workers, representing more than 6,400,000 man-hours of training or 32 hours per employe. It is estimated that these in-plant training programs cost the industry $13,000,000 in addition to expenses for instructors, facilities and materials.

Despite these measures, the shortage persists while the demand continues to rise. During World War II, about four per cent of all employes in the aircraft industry were engineers. Today it is nine per cent—and going up. Were the situation less serious, one might smile at this extraordinarily perceptive prediction by the Department of Labor in 1945:

"In the next few years, the number of graduates will greatly exceed the demand for graduate engineers. . . . Schools could admit even fewer students and still provide an adequate supply of engineering personnel."

Hindsight, of course, contributes little to the problem, but foresight can contribute a great deal, for no one can say just how long we will be involved in the technological race.

"If we had been sufficiently prophetic at the very beginning of the jet age," said Dr. Waterman, "we might have avoided the present dilemma. Since we were not, we can only hope that we shall act with sufficient foresight and wisdom now, so that the age of atomic power, or solar power, or whatever ages the future may hold will not also be pondering a shortage of scientists and engineers."

The Soviet Union apparently had the needed foresight some time ago, for it is apparent that they have been placing a great deal of emphasis on scientific and engineering training. There are a large number of establishments devoted to such training and apparently they are of high caliber. General Twining visited one such school—the Zhukovskii Air Engineering Academy—and came away impressed by the quality of the instructors and the advanced type of equipment and facilities available.

HERE is a brief evaluation of Soviet air power, taken from General Twining's report to the Congress on his return from Russia:

"The USSR . . . can and is progressively narrowing the technological lead of the West generally and of the United States in particular. The factors supporting this judgment include their emphasis on a thorough technical training of a large number of carefully selected personnel; the widening variety of aircraft under development; their ability to squeeze the maximum potential from a jet engine of western origin and at the same time to develop powerful new engines of their own; and the rapid rate of progress they have shown during the last few years in the research and development field.

"Furthermore, given the heavy emphasis which the Russians are placing upon the forced development of a new technical generation, beginning with primary education and carrying through basic research and engineering development, we must in prudence reckon on the possibility of their achieving a scientific breakthrough and consequent technological surprise in new weapons."

Therein lies the job of the aircraft industry—if there are to be any "breakthroughs" we must make them first. The industry must lead the way, with, of course, the full cooperation of all its partners and of the Congress, the guardians of the coffers. While the military forces are "on the ready," the industry, in a sense, is already at war, a technological war in which it is giving away a good deal of weight to an enemy counterpart who knows no restrictions of material, manpower or money. It is a silent war, devoid of the thunder of atom bombs, but one whose loss could bring about that thunder. Winning it is the industry's challenge.

Gen. Rawlings summed it up:

"The winner of this technological race will be the one who makes the best use of the resources at his disposal. If we were in a short sprint, all of our resources would be available in maximum quantities. But we are in a race that stretches far beyond the horizon. . . . This nation faces dangers for tomorrow that are yet to be counted. That is why it is imperative that we set a steady pace for the long pull. We must be ready today, tomorrow and the day after that."

Turbojet Development is $50 Million; Exhaustive Tests are Necessary

(*Continued from page* 1)
50-hour military endurance test. Once this is successfully accomplished, another 3000 hours or so of ground tests are run before the engine is put into full-scale production. And even then, experimental test running continues at the rate of about 3000 hours a year to check on new materials and design changes made in the engine to take care of other problems discovered in flight and during overhaul.

Even before the first engines are put together, however, each component undergoes a performance check and changes are made to make it acceptable. These performance checks are frequently followed by hundreds of hours of component durability testing in special rigs to discover weaknesses before they show up in the completed engine. Lead time from initial idea to the stage when a jet is ready for mass production is therefore at least five years and often more.

Joint study groups, made up of engineers from the aircraft companies and producers of steel, aluminum, copper, titanium, tantalum, columbium, cobalt, nickel and numerous other metals and plastics, are constantly striving to evolve materials which can withstand the high temperatures found in jet engines for longer periods. In the same way, aircraft power plant engineers coordinate their studies with oil industry researchers to provide better gasoline, kerosene-type, liquid oxygen and other propellants for jets, turboprop and rocket engines.

Military experience with jet and turboprop engines is being used as the basis for U. S.-built gas-turbine-powered commercial transport planes which will be making their appearance at the nation's airports in 1959 and 1960. Three types of jet airliners and one turboprop transport have been designed by American airframe builders and ordered by air carriers in this country and abroad. Virtually all of them will be powered by commercial versions of jet and turboprop engines originally built for the military services, although a few foreign carriers have specified foreign-built turbojet engines for the American airframes because of the dollar shortage.

By the time the three commercial jet engines and one turboprop are installed on commercial planes now on order, they will all have recorded hundreds of thousands of hours on military fighters, bombers and transport/cargo planes.

But the civil gas turbines will not be exact replicas of military engines. The powerplant producers, after adding substantial sums of their own to Navy and Air Force outlays to evolve successful military engines, are investing additional money to make their products even more efficient for the airlines which will use them.

One of the biggest problems involved in the production of gas turbine engines is the speed with which they tend to become obsolete.

In the case of the reciprocating engine, which underwent refinement and continual improvement over a period of years until it approached perfection in performance and economy, the basic design has tended to remain in production for more than a decade. One piston engine still in production for military and airliner use dates back to before World War II. And a forerunner of an advanced reciprocating power plant now in wide use on fast four-engine passenger planes first came off the assembly line in the same era.

Thus, it is basically the same piston engines which carried B-26 and B-29 bomber crews over Germany and Japan during World War II that are now transporting commercial travelers between the two coasts and across oceans and will be doing so for years to come.

Turbojets and turboprops, on the other hand, are currently roughly in the stage of development of the 18-horsepower piston engine in the 1903 Wright Brothers' airplane. The 1942 turbojet of about 1600 pounds thrust quickly yielded to the 3400-5000 pound thrust engines being delivered four or five years later. By the time of Korea, thrust ratings had climbed to 6000 and 6500 pounds and engines delivering 8000-12,000 pounds are now virtually standard. Soon to follow will be turbojets of 15,000 pounds thrust while power plants providing 25,000 pounds and more are already being designed to take care of future military and civil needs.

Similarly, the 1750-horsepower turboprop of 1945 has been supplanted by today's 3750-5700-horsepower engines for large cargo planes, and much more powerful jet-props are under development for air freighters of the future.

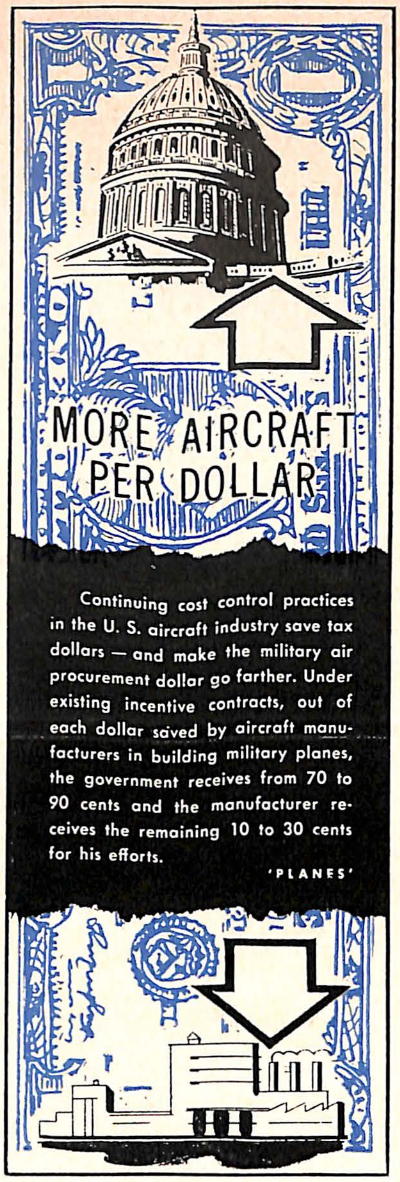
The piston engine, which has virtually reached its ultimate objective of just under one pound of weight for each unit of horsepower, is expected to continue in production until about 1960. It will undoubtedly be used in great quantity for a number of years, but is unlikely to be an important aircraft power plant 40 years from now.

Turbojets and turboprops, however, are still in their infancy. Present technical knowledge permits the construction of gas turbine engines which weigh only one pound for each 10 pounds or more of thrust they deliver. Having fewer moving parts than the piston type, the gas turbine engine has already started showing signs of being more reliable.

But today's jet engines (and presumably those of the future) have one basic shortcoming. They are designed to be operated at altitudes of 30,000 feet and higher to obtain the best possible fuel consumption. Once a jet-powered military or commercial airplane takes to the air, it quickly climbs to a high altitude, flies toward its destination at high speed and descends and lands in a hurry. Anything which causes the plane to fly at lower altitudes means a jump in fuel consumption. A turbojet gobbles up nearly twice as much fuel when it flies at or near sea level as when it flies at ideal altitudes. The turboprop—basically a jet engine turning a propeller—is considered advantageous for aircraft up to about 500 miles per hour.

Output of gas turbines for military aircraft is expected to increase in the years ahead. The Air Force, for example, has reduced the number of piston planes in use by 2800 since 1953 and expects to add 9000 jet aircraft by July of 1957. Similarly, the USAF flew only 1.77 million jet hours in 1953 but has scheduled 4.7 million jet hours during the current fiscal year.

Another indication of the wider use of gas turbine engines by the military services is the number of engines accepted. In 1954, 67 per cent of all aircraft power plants accepted by the Air Force were turbojets; in 1955, the figure was 77 per cent, averaging out at 8800 pounds of thrust. The remainder were piston engine spares to replace those presently in use. And Maj. Gen. Thomas P. Gerrity, in the Office of the Deputy Chief of Staff for Materiel, reports that the 1957 Air Force budget contains not a single dollar for the purchase of piston-powered aircraft.



Aviation Booklets For The Kids

Aware of the urgency of education's need to keep pace with a changing world, the National Aviation Education Council has now begun to step up its program to encourage the interest and enthusiasm of American youth in aviation.

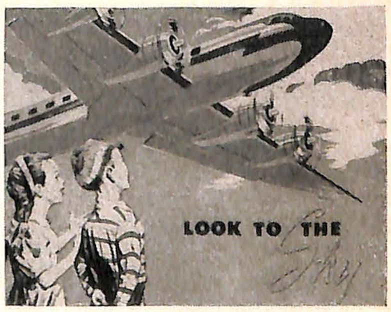
Comprised of a distinguished group of educators, this non-profit organization has as its principal interest the general study enrichment features of aviation education. It is their aim to increase the student's understanding of aviation and its relation to the varied pursuits of American life. They are performing this vital public service by trying to reach through to youngsters in the school and in the home.

In line with this program, the Council has published several teacher-prepared booklets with a sound educational and an accurate aviation point of view. The first of these is *Look To The Sky*, a delightful pictorial presentation of basic aviation facts.

Designed for children in the 4 to 8 age group, this charming picture booklet depicts various facets of aviation—different types of aircraft, some of the parts of a plane, manufacturing a plane, various uses, preparing for flight, and passengers in the plane. Containing also questions and concept-developing explanations, the booklet is designed for instruction, as well as entertainment.

Membership in the National Aviation Education Council is available to everyone at an annual fee of $5.00, and entitles the individual to receive a variety of publications and services. Included are the first eight publications of NAEC—*Look To The Sky, Jets, Helicopters, Tilly The Tiger, A Day In The Life Of A Jet Test Pilot, Aircraft Number 116, Aviation Activities* and *Farmer's Wings*. These booklets are entertaining sources of enlightenment for children of all ages.

Additional booklets will be sent to members as published. Members will also receive subscriptions to various publications dealing with aviation, including PLANES, the official publication of the Aircraft Industries Association, which is a sponsor of the organization.



Look To The Sky may be obtained for 30 cents by writing to Dr. Evan Evans, Executive Director, National Aviation Education Council, 1025 Connecticut Ave., N.W., Washington 6, D. C.

Intricate Network Protects U. S.

Security is the key word in the nation's air defense setup these days and each passing month brings with it more of the same.

During World War II, defense against enemy planes involved little more than picking up the attackers on a radar scope and sending fighter planes using machine guns for armament into the air to shoot them down if possible.

The principle is the same today but the techniques involved are infinitely more complicated. It is expected that a fleet of enemy bombers flying over the North Pole to attack American cities would first be picked up by improved radar sets of the Distant Early Warning (DEW) line now being constructed across the top of North America, thereby giving Continental Air Defense Command headquarters in Colorado Springs adequate warning.

If DEW line radar should fail to detect the bombers, the Mid-Canada (McGill Fence) and Pinetree Chain (paralleling the U. S.-Canada border) radar networks would presumably accomplish the mission. Meanwhile, all of the radar data would be fed into the SAGE (semi-automatic ground environment) system now being installed to improve the chances of a successful intercept.

SAGE is tied in with another electronic system—Missile Master—which directs the firing of batteries of the Army's Skysweeper antiaircraft guns and the Nike surface-to-air-missile.

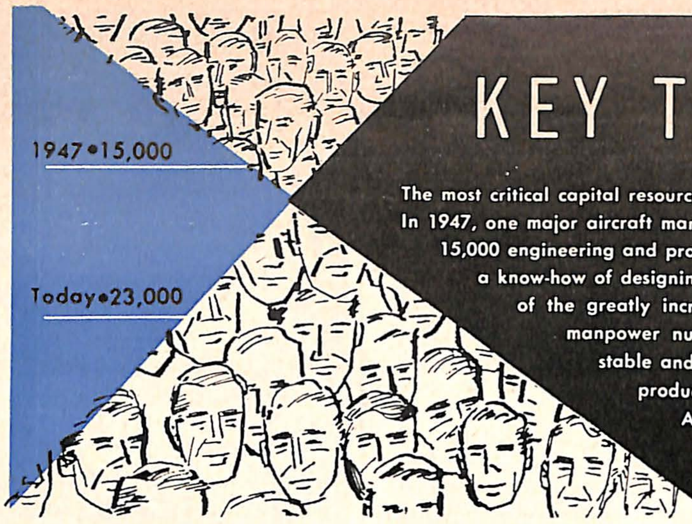
While the computers are getting data, officials at Colorado Springs, preparing for an attack, would order the launching of high speed interceptor planes loaded with electronic fire-control equipment. These electronic brains not only locate the enemy plane by radar but also lock on it and fire the cannon, machine guns, rockets or guided missiles to bring it down—frequently without the interceptor pilot making visual contact with the attacking bomber.

Today, the Air Force's Air Defense Command utilizes three types of interceptors. All are effective aircraft but none are supersonic. And only one version of one of the three types of interceptors is able to carry and fire air-to-air missiles.

But already coming into the Air Force's inventory is a supersonic delta-wing missile-launching interceptor. And a second plane with similar abilities will be entering service next year. Coupled with these two manned aircraft will be two interceptor missiles now under development. One of the missiles has a longer range than the existing Nike and a second (termed an area defense weapon) has a range of several score miles.

The electronic concept of air defense is still in the early stages, however. Air Force planners now foresee the day when 90 per cent of the Air Defense Command's mission will be handled by guided missiles.

All of these projects are the basic responsibility of the aircraft industry and allied manufacturers.



KEY TO SECURITY

The most critical capital resource of the aircraft industry is its skilled people. In 1947, one major aircraft manufacturer determined that a manpower nucleus of 15,000 engineering and production personnel was required merely to preserve a know-how of designing and building a modern bomber. Today, because of the greatly increased complexity of modern bomber planes, the manpower nucleus now required has risen to 23,000. Only a stable and continuous long-range research, development and production program provides the key to maintaining American air superiority.

'PLANES'

Aircraft Industry Ingenuity Gives USAF Several Models For Price Of One

The U. S. Air Force frequently gets two, three or more aircraft for the price of developing one as a result of the ingenuity of aircraft industry engineers.

Each basic airframe is analyzed for all potential uses when it is still in the design stage and even after it enters the military inventory to determine whether it can serve in roles other than the one originally planned. Among the examples:

- A straight-wing jet fighter of the early post World War II years has evolved into two designs, a two-seat interceptor and a jet trainer.
- A second straight-wing jet fighter-bomber was first modified into a reconnaissance plane. Later its wings were swept back and a more powerful engine installed to give it better performance both as a fighter-bomber and for photographic work. A variant is powered by experimental turboprop engines.
- Another jet fighter, originally a day fighter, is also serving as an all-weather interceptor, a fighter-bomber and as a Navy and Marine Corps carrier-based fighter. In another form it is being built for use as an all-weather interceptor by friendly European nations.
- One of the supersonic jet day fighters now in the Air Force's combat units is also being delivered in two fighter-bomber configurations and as a supersonic trainer.
- Another supersonic single seater was designed to escort bombers over long distances but is also being purchased as a reconnaissance plane and as a two-seat interceptor.
- A forthcoming fighter-bomber will also be built as a supersonic reconnaissance plane.
- In the bomber category, a big intercontinental bomber is now serving as the mother ship for a number of fighter-bombers and is also flying with a nuclear reactor. It is also a long-range reconnaissance aircraft.
- A straight-wing tactical day bomber is also being produced as a night intruder, reconnaissance aircraft, in a version to tow targets and has also been proposed as a passenger transport.
- Another tactical bomber is being built in two reconnaissance versions. It is similar to an attack bomber being purchased by the Navy.
- As far as medium bombers are concerned, the standard AF plane in this category is also delivered as a reconnaissance aircraft and was once considered as a jet tanker. Two have also been modified to take turboprops.
- A heavy jet intercontinental bomber now in production is being accepted in several configurations, including one which is convertible from bombing to reconnaissance.
- In the transport field, on basic piston airframe is used by the Air Force to carry personnel, as an electronics trainer and as a prototype to test turboprop engines. It is also being purchased by the Navy with a "beefed-up" floor to haul cargo.
- Another transport/cargo aircraft serves also as a refueling plane for medium bombers. And a third type of passenger aircraft has also been equipped with large radar bulges to serve as an early warning signal for both the Navy and Air Force. Both of the latter four-engine aircraft are also flying as test laboratories for turboprop aircraft.

Future 'Copters To Use Turbine Engines

Commercial and military helicopters will be powered by gas turbines, much like fixed-wing aircraft, in the not-too-distant future.

Although every rotary-wing aircraft produced in quantity to date has been powered by reciprocating engines, the shaft-turbine whirlybird will soon be coming into its own.

Similar to the turboprop (jet engine turning a propeller) power plants starting to be used on military and commercial passenger and cargo planes, the shaft turbine (sometimes known as the turborotor) principle is gradually being adopted for helicopters.

Turborotor helicopters have been flying experimentally for about two years, and one utility helicopter recently ordered into production by the Army is definitely set to use a gas turbine engine to turn its rotors.

Missiles May Assume New Reconnaissance, Photographic Roles

Various types of surface-to-surface guided missiles may soon be serving in a secondary role—photography and reconnaissance—for the military services.

Although designed primarily for the destruction of enemy targets, guided missiles have such a capability. Military planners are now studying the feasibility for using them to assess targets and report on damage.

Aircraft industry and military experts have worked up techniques whereby a missile might be radio-controlled back to its base after being launched. This was done to save as much money as possible while missiles were being evaluated before being ordered into production.

By an extension of this radio-controlled testing program, it might be possible to send reconnaissance missiles, equipped with automatic still and motion picture cameras, and possibly television, over enemy installations.

Under the present setup, photography and reconnaissance are scheduled to be handled by special versions of existing bombers and fighters. But if an enemy target were subjected to a nuclear attack and a quick evaluation of the damage was considered vital, a reconnaissance missile might be superior to a manned aircraft; first, because it might be able to reach the target area faster than a plane and secondly, because no crew members could be subjected to possible radiation.

Navy Reduces Models In Active Inventory

Because the aircraft industry is constantly coming up with better airplanes, the military services always have many different models in the inventory—some being phased in and some going out. The Navy, for example, had 72 basic models in service in 1946. This dropped to 51 in 1949 but climbed to 70 in 1955. This year it will drop to 67 models and will be reduced to 64 and 63, respectively, in 1957 and 1958.