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planes

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INDUSTRY SLOWDOWN POSES PROBLEMS

Rocket Availability Proves Policy

Availability today of high thrust rocket engines to power ballistic missiles is due to the historic partnership between the U. S. Air Force and the aircraft engine industry.

An article in the *Air University Quarterly Review* describes the successful policy followed by the Air Force. "It was the conviction . . . that the rocket development program should be handled in a manner like that of other engine development programs. Traditionally, industry had always been regarded as a partner in these ventures," the article states.

"The former Air Corps' engine development programs, dating back to the days of the Hispano-Suiza and Liberty engines of World War I, had attempted to harness available sources of industry to development and production programs. The Air Force feels today that this was a wise decision," the article says. "The fact that the only successful large liquid-rocket engine programs in the United States have been Air Force programs is in no small measure due to this manner of operation. This policy has greatly eased transition from applied research to development to production and has minimized scientific stagnation."

The article pointed out that when the Army Ordnance Corps, in its missile development program, had no adequate engine available, the Air Force made the industry-developed engine available to the Army. In another Army missile program, the rocket engines were again made available to them.

"On the firm foundation of this continuous, vigorously prosecuted Air Force rocket development program, all the long-range and intermediate-range ballistic missiles now in development by the United States have been based," the article states.

High Landing

If you have a tendency to wince at the fees parking lots charge you just to get your car off the street, consider the plight of the airlines. The landing fee for a four-engine intercontinental airliner stopping in Great Britain is about \$160. The International Air Transport Association estimates this figure will at least double when international jet-powered airliners are operational.



Aircraft manufacturers have borrowed a technique from medicine to insure that their aircraft will meet rugged performance requirements. Hypodermic needles, similar to those used to administer penicillin or inoculations, inject adhesives into honeycomb panels to perfect the bonding between the exterior skins and interior cores where the regular process didn't take. The hypo process makes well-bonded panels that otherwise would be rejected for failure to meet rigid aircraft standards.

10th Anniversary—

Supersonic Flight—Yesterday's Sensation— Today Is Routine Military Operation

This month marks the tenth anniversary of man's penetration of the sound barrier, first accomplished by U. S. Air Force Capt. (now Lt. Col.) Charles E. Yeager in a rocket-powered, experimental aircraft.

Since that high moment of aviation a decade ago, experimental manned aircraft have attained speeds of Mach 3 (three times the speed of sound) and altitudes of 126,000 feet. The aircraft industry has produced hundreds of operational aircraft capable of supersonic flight which is now part of the routine operations of the Air Force and Navy.

The significance of these operations is underlined by the fact that these production aircraft are powered by turbojet engines, not rockets. For the future of manned flight there is the prospect of combinations of power—turbojet and rockets; ramjets and rockets;—which will push manned flight into the hypersonic

reaches at speeds up to Mach 10.

In addition to high-speed, manned flight, the aircraft industry has developed and produced a succession of missiles capable of speeds as high as 20,000 miles per hour.

The first operational supersonic fighters entered service in 1954 with the Air Force. The Navy's first faster-than-sound airplane was delivered about the same time.

Low Bridge

A jet tanker fuselage has accumulated 100,000 "flight" miles to date—all underwater.

The "flights" are made in a tank at an aircraft company as part of the exhaustive testing program for the new aircraft. The mileage, which is barely a start, was computed by mathematical analysis of hydrostatic cycling tests conducted on the fuselage.

Regaining Speed Is Difficult

By Orval R. Cook
President, Aircraft Industries Association

The last four months have seen a kaleidoscope of change in the aircraft industry brought about partially by the growing importance of guided missiles, but mainly by a most difficult fiscal condition within the Federal Government.

There have been contract cancellations, stretch-outs and cutbacks. Manufacturers have had to readjust suddenly to restricting orders that have come in rapid succession. There has already been a considerable reduction in employment by most contractors; there will be more.

Some facilities have been deactivated; others will be withdrawn later. Overtime has been cut to adjust to this reduced work load.

Aircraft subcontractors and suppliers in every state in the Union have already been affected in varying degree. They will be faced with additional cutbacks as subcontracting and supply requirements decline.

Part of this is attributable to mutations in emphasis on our air weapons systems. In mid-May, the industry learned from the military services that, because of important progress in guided missiles development, there would be a considerable increase in emphasis on these devices, at the expense of the manned aircraft program. Indeed, the Air Force had estimated that, ultimately, guided missiles would handle 90 per cent of all air defense missions, 50 per cent of the work of the Strategic Air Command and 30 per cent of the job of the Tactical Air Command. Thirty-five to 40 per cent of the Navy's expenditures for air weapons would be guided missiles in five years, it was estimated.

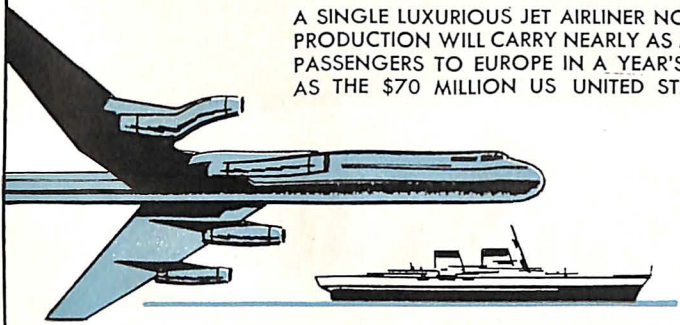
But on June 20, the top executives of the aircraft industry were called to Washington by the Air Force and were told suddenly that the rate of expenditure of defense funds was exceeding the available supply of money. Since the national debt ceiling is fixed at \$275 billion and there is no intention of exceeding it, it would be necessary for all Defense expenditures to stay under \$38 billion for fiscal year 1958, ending next June 30.

Spending at the time was at a rate

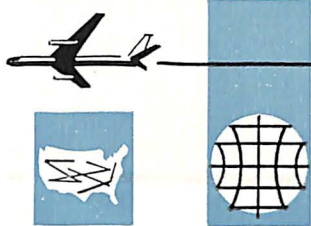
(See SLOWDOWN, Page 7)

Plane Views

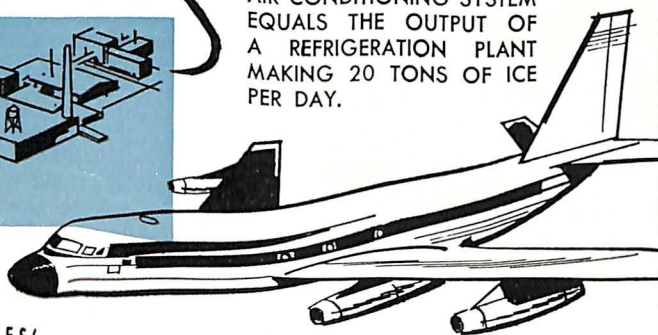
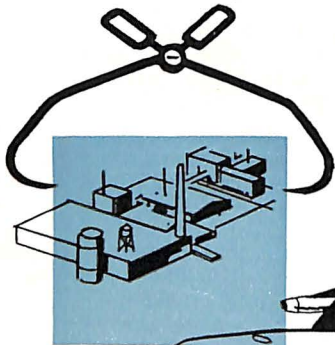
A SINGLE LUXURIOUS JET AIRLINER NOW IN PRODUCTION WILL CARRY NEARLY AS MANY PASSENGERS TO EUROPE IN A YEAR'S TIME AS THE \$70 MILLION US UNITED STATES.



AIR TRAVEL WITHIN UNITED STATES BORDERS ACCOUNTS FOR APPROXIMATELY ONE-HALF OF THE WORLD'S TOTAL AIR TRAVEL.



COOLING CAPACITY OF A NEW U. S. JET AIRLINER AIR CONDITIONING SYSTEM EQUALS THE OUTPUT OF A REFRIGERATION PLANT MAKING 20 TONS OF ICE PER DAY.



'PLANES'

AIR QUOTE

The Soviet Sputnik now circling the globe every 96 minutes, their firing of a test intercontinental ballistic missile, their explosion of a hydrogen bomb at high altitude underscore the cogency of a warning issued more than four years ago by the late General Hoyt S. Vandenberg after his retirement as Air Force Chief of Staff.

Gen. Vandenberg said:

"What I now fear most is complacency in the midst of inexorably rising peril. There occurred the other day a happening that should give us all serious pause. I refer, of course, to the explosion of a hydrogen device in the depths of the

Soviet Union.

"Whether this explosion was a test article or a bonafide weapon is, in the long run, academic. If Russia does not now actually have such a weapon, she will soon have one. And its addition . . . will further narrow the margins of power on which we Americans have so far counted for safety. . . .

"But if we doze, if in our complacency we forget the deadly earnestness of the enemy, his ever-increasing technical competence, and his undoubted ability to deliver his new weapons, then, I say, our strength will not avail us."

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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Facts and Fears

The avalanche of publicity regarding ballistic missiles may have obscured the true posture of our air power in the public's mind.

Where do we stand?

First, we have no proof that Russia has intercontinental missiles with operational units. Development of test vehicles is only the first step in a lengthy process of bringing these weapons into military inventories.

Second, defense programs are not carried out on a moratorium basis. We must be prepared today as well as tomorrow. Manned aircraft will continue for many years to be our principal weapon with ballistic missiles being phased into air operations as quickly as they are proven for service. We must not be stampeded into abandoning proven weapon systems before more advanced systems become operationally feasible.

The glamorous reports on ballistic missiles have largely ignored the long, hard step between experimental firings and operational readiness at a base.

An idea of this long, hard step can be obtained from a comparison with a highly advanced manned aircraft. The Air Force estimates that a supersonic aircraft which incorporates all possible technical advances requires an average of nine to ten years to be placed in the inventory with full operational status. However, the prototype of this aircraft can be built and flying within two to three years. The balance of the time is consumed by testing, proving, training, base preparation, establishing communication nets, and production of the aircraft. Finally, after the aircraft is in volume production, more than a year is required for operational squadrons to learn the characteristics and abilities of the aircraft. The numerous problems involved in bringing ballistic missiles to operational status will require at least as much time and probably more.

The term "ultimate weapon," which has been applied to the ICBM, is a gross overstatement. There are severe operational limitations. One such is lacking. Once an ICBM is fired, there is no means of changing its course. This inflexibility is another limitation.

There are several defenses against the ICBM being pursued. A number of companies are working on an anti-missile missile. The very nature of a ballistic missile—its adherence to a precommitted course—makes it possible to compute its course, and effect an interception. Further, a defense study shows that an ICBM has a relatively small approach corridor to be defended for any target. The ICBM flight path that could strike a particular target area in the U. S. from any launching site in Russia would be an elliptically-shaped, curving cone inclined toward Russia at an angle of 30 degrees. A defense system could keep this cone under constant watch and intercept missiles coming through it.

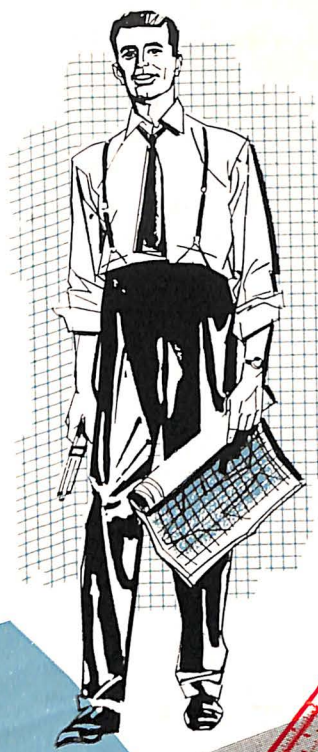
An outstanding characteristic of an ICBM warhead—its speed—may provide a solution to its defense. Recent investigations indicate that at very high impact velocities very small "projectiles" have an explosive effect completely out of proportion to the impact effect normally expected. This suggests the possibility of using a dense cloud of sandlike particles over the approach flight cone of the ICBM to explode the warhead.

Another defense possibility lies in the intense thermal heat generated by the warhead during its re-entry into heavier atmosphere. Devising a nose cone to resist this heat has been one of the knottiest problems in developing an ICBM. The ICBM nose cone would probably operate close to its thermal tolerance, and any material increase in the temperature of the air through which it passes could cause the warhead to consume itself in meteor-like fashion. A nuclear fireball could generate such heat, or a nuclear radiation field cast across the flight path could either disarm the warhead or destroy it. And there are other defense schemes against the ICBM.

There is little news from Russia to provide comfort or cheer for the Free World. But a recent statement by Communist Party Chief Nikita Khrushchev could prove a source of comfort. Khrushchev flatly said that "fighter and bomber planes can now be put into museums."

Certainly no such plan exists in the United States. The manned bomber force we possess today is still the world's most potent force for peace. Our bombers are being equipped with an air-to-surface missile that permits the bomber to approach its target and then release a guided missile with great accuracy from a distance beyond the target defense perimeter. This wedding of the guided missile and the manned bomber, in the long run, may prove to be a more devastating weapon than the ICBM, and less easy to defend against. The manned bomber can attack from any direction around the long, vulnerable Russian boundary.

The ballistic missile is a weapon of great power, but even it is susceptible to the immutable pendulum of offense and defense. The aircraft industry will continue to develop, test and produce ballistic missiles at the greatest possible speed. But for the foreseeable future our reliance must be on a balanced, flexible force of aircraft and missiles with each doing the assignment for which it is best qualified.



BREAKING THE KNOW HOW BARRIER

By Maj. Gen. William O. Senter, USAF

MAJOR GENERAL WILLIAM O. SENTER



is the Director of Procurement and Production of the USAF's Air Materiel Command. This is the world's largest buying organization, spending about \$16 billion a year on some 1,375,000 different items ranging from complete weapon systems to the smallest stop-nut.

Gen. Senter is a graduate of West Point and has an Aeronautical Engineering degree. He has served in a succession of both command and staff assignments overseas and in the U. S., and immediately prior to assignment at AMC headquarters in August 1957, he was commander of the Oklahoma City Air Materiel Area. He is rated a command pilot and technical observer and has been awarded the Legion of Merit with an Oak Leaf cluster.

THE United States has today at the Air Materiel Command Headquarters near Dayton, Ohio, nearly half of the world's supply of sheet beryllium, suitable for aircraft use and which is a promising member of the new family of exotic materials.

Beryllium is six times stronger than steel, on a strength-to-weight ratio, weighs about one-third as much as aluminum and will maintain its properties at 1200 degrees Fahrenheit.

An intercontinental missile constructed of beryllium could be fired into outer space, miles above its presently designed altitude, using today's powerplants. The super stiffness of beryllium would simplify the involved ICBM guidance system, since the missile would be completely rigid in flight without the flexing and rippling caused by the "give"

in softer materials used today. The guidance system would not be required to correct and recorrect for each small change in direction.

A Mach 2.5 fighter made of beryllium would weigh 16,000 pounds less than the same fighter fabricated from steel. Translated into operating capabilities, this means the beryllium aircraft would have an 8 per cent superiority in altitude and an increase in range of 16 per cent, aside from its great heat resistant properties.

Now, why don't we start at once to use beryllium in today's aircraft and missiles?

First, this "stockpile" of sheet beryllium is less than half the size of the page on which this article appears. We keep it in a file cabinet. Aside from the supply problem, there are other serious disadvantages. It is highly

toxic; machining operations would require an ultra-effective evacuation system to protect workers. It is almost like machining glass, and is very abrasive to all known cutting tool materials. Bending a piece of beryllium is as difficult as bending a sheet of plate glass.

AND today beryllium would cost about \$200 a pound or more installed on an aircraft or missile frame.

Bringing beryllium out of the laboratories and onto the production lines is just one of the hundreds of problems faced by the Air Force and aircraft industry today.

The latest designs for air weapons are aimed at speeds in excess of Mach 20 (twenty times the speed of sound). This speed

The Air Force is no longer interested in buying aircraft that fly a hundred miles faster or a thousand feet higher than the preceding model. Development and production of aerial vehicles by orderly evolution has given way to revolutionary development and production. We use Mach numbers to measure our speed requirements.

These revolutionary requirements demand a revolution in manufacturing techniques. New manufacturing processes and techniques normally are developed and financed by private industry. The Air Force finances projects in manufacturing methods only when the development is beyond the normal risk of a company and cannot be financed. The aircraft industry has done an admirable job in meet-

Air Materiel Command — the Manufacturing Methods Branch. This branch is composed of nine officers and thirty-one civilians with a budget that is small when cast against the task assigned. The calendars on the desk of this branch do not read "1957"; they are turned forward to 1965 and 1970. In effect, this branch is looking over the shoulders of the advance designers and planners to anticipate and meet the materials and manufacturing problems of tomorrow.

THE organization of the Manufacturing Methods Branch reflects the general problem areas that are the concern of the aircraft industry and the Air Force. There are four sections: Machine tools, basic industry, methods engineering and electronics.

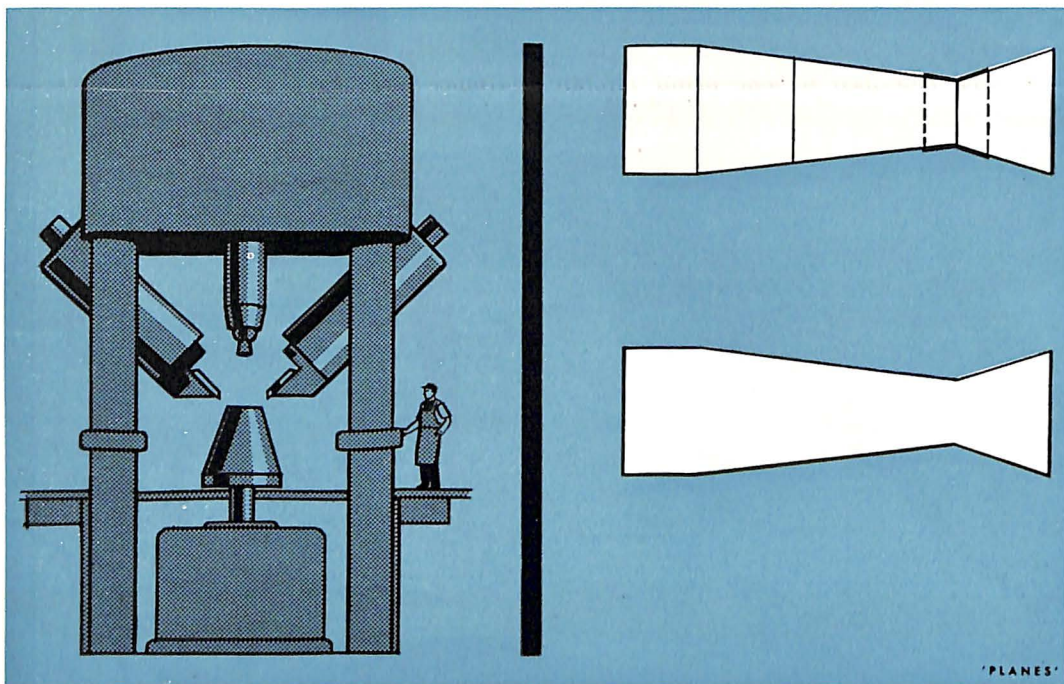
The problems facing the aircraft industry in machining are immense. A World War II fighter aircraft required only 12 per cent of the total manufacturing effort for machining operations. This requirement has increased to an estimated 30 per cent for some of today's combat aircraft. Apparently, there exists today an almost linear relationship between machining hours per aircraft pound and the Mach number of the vehicle. A very high performance aircraft could require something on the order of three machining hours for each airframe pound. This amount of machining is obviously prohibitive.

What is being done to overcome this problem? There is a fruitful competition between the tool industry and the makers of precision casting, forging and extrusions to avoid wasting stock. Tools work toward the efficient and economical removal of stock, while the basic metal industry works to avoid chip production.

One form of machining that is proving of great value is the chipless method. These processes include chemical milling, electro-grinding, electro-spark, electrolytic and the ultra-sonic. All of them utilize one or more of mechanical, chemical or electrical phenomena to remove metal.

An engineer in the aircraft industry conceived the chemical milling method in 1953 and the most frequent application has been on aluminum; however, present development work is aimed at extending the chemical milling application to tougher metals. There are no cutting tools used in this process. The portion to be worked is left blank while an inert masking material protects the portion not being changed. The chemicals simply etch the desired pattern on the exposed area.

The electro-spark method looks particularly promising as we move toward harder materials. In this method there is little or no relative motion between the workpiece and the "cutting" tool. The cutting tool is actually an electrode that produces the desired contours by pulsating charges of electrical energy which disintegrate the surface of the metal. There is apparently no limit to the complexity of parts that can be machined



Power roll forming offers manufacturing savings. The ramjet combustion chamber shown at top is spotwelded, requires 40 hours of labor. Roll forming of one-piece would require only 4 labor hours.

would carry a missile from New York to Los Angeles—a distance of 2,600 miles—in coffee-break time, about 12 minutes. Today these designs must be marked not only SECRET but also theoretical. This means they are possible — if. This "if," simply, is how do we make it and what materials do we use. The "how" and the "what" constitute a formidable know-how barrier.

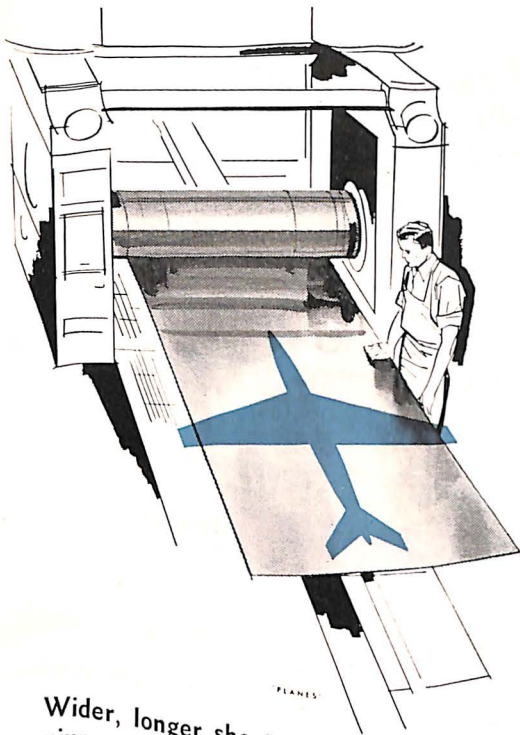
The plain fact is that we have nearly exhausted today's bag of manufacturing tricks. It means little if a designer can conceive, even prove, an advanced design, if it cannot be produced.

The bridge between sophisticated design and producibility is manufacturing methods — the economical, timely translation of idea to hardware.

The "how and what" burden is heavy and critical. We seek answers in a course that offers only new questions. This burden is unique in the history of manufacturing. Through progress, the aircraft industry has found today's tried-and-true method is tomorrow's failure.

ing new production demands. Supersonic aircraft and hypersonic missiles in production today could not have been built by the production methods used as little as ten years ago. Production of turbojet engines of 10,000 pounds thrust was only a gleam in a manufacturer's eye eight years ago. Today the aircraft engine industry is producing turbojets rated at 15,000 pounds of thrust. Titanium, now in general use throughout the aircraft industry, five years ago was in the same stage of development as beryllium is today. The problems of producing and working this one-time "wonder" metal were just as awesome to our engineers a few years ago as beryllium appears today. And it is a safe bet that in the near future, when the solutions to beryllium are known, we will come up with another superior material that will raise production and fabrication problems piling those we face today.

THE major efforts of the aircraft industry in meeting the production problems of the next generation of aircraft and missiles is supplemented by a little-known group in the



Wider, longer sheets of steel and titanium alloys held to close thickness tolerances are a prime requirement.

and, due to its inherent characteristics, the harder the metal the better the performance of the process.

ULTRA high speed cutting is receiving intensive attention at the present time. The high strength materials necessary for the hypersonic aircraft and missiles of tomorrow are approaching the impossible to machine. Aluminum is an easy material to machine. Cutter speeds up to 15,000 surface feet per minute are practical. Hardened titanium alloys today are machined at less than 100 surface feet per minute. A recent study estimates that machining high strength, heat-resistant alloys by conventional methods would require four to ten times the number of machines, floor space and man-hours now required for the same quantities of aluminum alloys.

The Air Force is supporting a project to determine the feasibility of ultra high speed machining in the range of 30,000 to 50,000 surface feet per minute with the new hard materials. One test of this theory of high speed machining is interesting. An engineer placed a tool bit in the muzzle of a rifle and then fired a work piece across the tool bit to study the cut and plastic deformation. It is unlikely that we will be machining metal by firing it from a cannon, but then I wouldn't bet against it.

Actually, explosive forming techniques are being developed now. Basically, the explosive method releases energy by a powder charge or formed before it knows what happened. It is used to work materials so tough or brittle that they can't be handled any other way. The Air Materiel Command plans to extend this development project beyond machining into the field of extrusions and forgings.

Power roll forming is another method that has proven successful in forming sheet stock or blanks. Rollers traverse the sheet while it rotates on a mandrel. The finished part is strong and has an excellent surface smoothness. Shapes and forms of most turbojet engine and missile components are round and symmetrical, and roll forming has extensive applications in these fields. And look at the savings. To produce identical parts, the forging machining method would require a 369-pound blank while the roll forming method requires only a 65-pound flat blank. The finished weight for the part is 50 pounds. Roll forming savings on material alone would amount to about 83 per cent. If the material were titanium, the dollar savings would be about \$2,400 for each 50-pound part.

NUMERICAL control of machine tools has been described by one major aircraft manufacturer as the most radical manufacturing improvement in the life span of his company. Simply, numerical control is the guiding of a tool over a piece of metal, without human intervention, by a series of instructions which were previously recorded in numerical code on tape, film or cards. Numerical controls have been applied to skin mills and profile and contour milling machines. It is being extended to cover such operations as point-to-point positioning in jig boring equipment and spot welders.

Studies indicate that the numerically con-

trolled tools will show an increased performance ratio from three to ten times as great as conventional production methods. There are other benefits, such as less set-up time, greater accuracy of dimensions, elimination of human error and less material scrap. Numerical control is being widely adopted throughout the aircraft industry to produce a better part more economically.

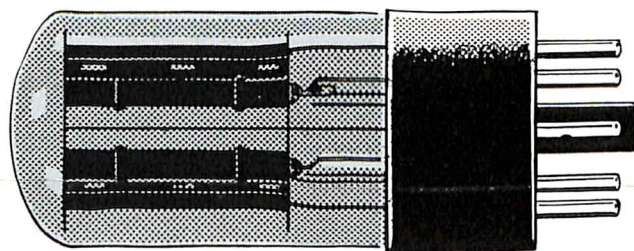
THE story of electronics problems and progress takes us to another area of manufacturing methods where we are concerned with miniaturization, high reliability, automatic assembly and, of course, lower costs since nearly 50 per cent of the Air Force procurement dollar today goes for electronics and associated components.

The operational capabilities brought about by electronics cannot be exaggerated. Electronics has increasingly replaced the functions of the pilot to an extent that only the irreplaceable factor—human judgment—remains beyond electronic solution.

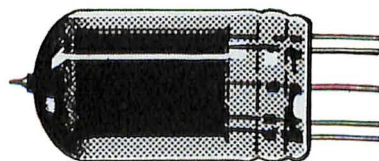
Tubes in electronic assemblies have been a trouble spot. Severe shock, vibration and temperature conditions, apart from the great problem of reducing size and increasing performance, are some of our tube problems. Ceramic tubes have provided a few solutions. Receiving tubes made of ceramic, now in limited production, perform satisfactorily at temperatures of 350 degrees Centigrade and can withstand shocks of 1,000 times the pull

TUBE MINIATURIZATION

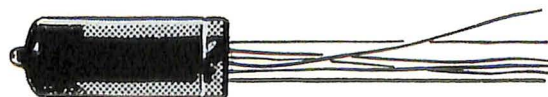
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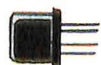
ORIGINAL CONVENTIONAL TUBE



MANUFACTURING METHODS 1st STAGE



MANUFACTURING METHODS 2nd STAGE



FINAL TRANSISTORIZED

of gravity. The first ceramic tubes produced by laboratory methods cost \$150 each. The estimated cost by pilot line production is less than \$5 each. The Air Force has a requirement for 100,000 of these tubes each year. Regarding size, an illustration on this page dramatically reveals the progress made in making a tube smaller while increasing production.

THE oldest form of the metal working art is casting. The methods we are using today are a far cry from simply pouring metal down a hole in a sand pile. Special sands, using an organic binder, today produce castings of surface smoothness and accuracy of dimensions that were undreamed of a few years ago. Beyond this casting technique we are experimenting with molds made of pure ceramic materials which are fired and glazed under very high temperatures to produce a mold of great accuracy and a finish as smooth as the best chinaware.

The casting process offers the best chance to produce a part that will closely approximate the finished part. This cuts down the amount of machining required and permits the use of more general purpose machines, rather than the huge, specialized machines required to finish crude castings. For example, a landing gear door made from a one-piece casting, replaced 55 stampings held together by more than 1,600 rivets. In another case, a landing gear fork was made from a single casting which was 5 per cent stronger and 25 per cent lighter weight than three forgings formerly required.

Casting has a vital role in the manufacturing revolution that is now taking place.

Melting materials is another facet of basic industry where encouraging progress is being made. The vacuum furnace has been greatly improved and today we are melting titanium, zirconium, high alloy steels and other materials which are remarkably free of impurities and possess improved properties. These high performance metals are used in turbojet engines, missiles and atomic reactors.

A furnace is in operation today which utilizes an electron beam emitted by tungsten filaments under high voltage and in a high vacuum as a source of heat. This is the era of the electron beam furnace, and a solar furnace utilizing the fantastic heat of the sun is the next step. Beyond this is a neutron furnace which will convert the metal to gas and reconvert it to a purity at temperatures far beyond today's considerable magnitudes. Laboratory curiosities today are swiftly becoming tomorrow's realities.

Mill problems are another segment of manufacture where improvements are urgently needed. The aircraft industry requires titanium alloy sheets, stainless steel sheets and steel alloy sheets that are longer and wider and held to a precise thickness tolerance. If we were to use the present commercial thickness toler-

ance on a wing surface of 4,800 square feet, there would be almost 2,000 pounds of overweight. Longer and wider sheets will produce better load distribution and weight reduction. Joints increase weight and, by reducing or eliminating them, engineers can design toward the ultimate.

Methods engineering embraces such prob-

lems as production of jewel bearings, fuels, lubricants, plastics, welding, inspection devices and the hundreds of other problems that haven't a more convenient category. Jewel bearings, which are a vital part of our advanced guidance and control systems, provide an example of our efforts in manufacturing methods. During World War II, Switzerland was our only source of supply for jewel bearings. Getting the bearings out of Switzerland was a cloak-and-dagger exercise that rivals the Hollywood versions of undercover warfare. Today we are completely relieved of dependence on a foreign supply of jewel bearings. We have mechanized the production of synthetic jewel bearings to a point where we are able to produce 55,000 blanks in an eight-hour day with one machine, compared to a former rate of production of 300 to 400 a day by one person.

AERODYNAMIC HEATING

	VELOCITY	TEMPERATURE RISE (due to speed)
MISSILE	3000 MPH	1613°F
FIGHTER	754 MPH	180°F
AIRLINER	300 MPH	16°F
AUTOMOBILE	60 MPH	0.6°F

'PLANES'

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Sandwich materials—using very thin gage sheet metal exteriors with honeycomb or corrugated cores—have provided a solution to today's search for structural material with a favorable strength-to-weight ratio. Sandwich materials are being extensively used, but there is a need for automatic fabrication machinery to lower the costs.

THE whole field of manufacturing methods would require volumes to describe. These brief highlights indicate only a few of our problems, along with the direction some of our efforts are taking to solve them.

What will the speeds, altitudes and temperatures be tomorrow? Today we have reached speeds just beyond Mach 2 in manned aircraft; tomorrow that speed will be Mach 5, and in missiles the speed will

Altitudes today are peaked at about 160 miles. There is no limit on the altitudes we will be using tomorrow, and with these limitless heights will come the problems of interstellar dust, cosmic rays and unknown fields of force.

THERE are literally thousands of avenues to explore in our search for new materials. Here are some of the new exotic materials we are concerned with today: Zirconium, niobium, palladium, lanthanum and columbium. ARDC is also doing work with radioactive isotopes to study the changes that occur in basic metals when they are subjected to nuclear radiation. Tungsten may be changed to some yet-unnamed material that will have greatly enhanced properties. We have today 98 elements and more than 300 isotopes for building new materials.

There probably never will be a production aircraft or missile made from a single material. Designers will specify materials for a given area where its properties are best for the job to be done, and in addition to metals, we will be using ceramics and plastics.

The ultimate material we are seeking, of course, is practically weightless; infinitely strong; resists any degree of heat; mills, machines, casts, extrudes and forges with great ease, and the cost is negligible. We haven't found this material yet, but we do have a name for it. We call it "unobtainium."

Though we recognize the very formidable problems before us and the fact that much work needs to be done, we do feel that we are on the path to success in many of our efforts.

Slowdown Brings Major Problems

(Continued from Page 1)

of about \$40 billion for the year. This meant that expenditures by the military services would have to be reduced. As a consequence, many military aircraft contracts were stretched out, cut back or cancelled, with the results mentioned above. In addition to manpower, facilities and overhead reductions already affected, the industry must make more. As far as possible, employment decreases will be made by normal employment turnover and reduced hirings, but it becomes obvious that this will not be quite enough. There will have to be more layoffs, perhaps heavy ones.

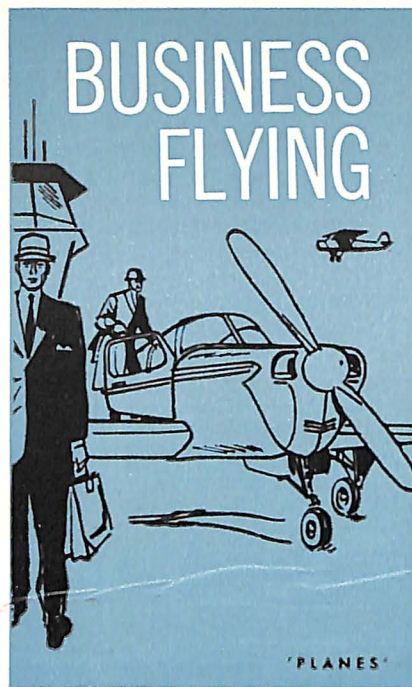
The first contract reductions, decreed in July and August, were not enough. The expenditure rate did not go down to the extent expected, so a few weeks ago the aircraft industry was told by the Air Force that existing contracts would be paid for only to the extent that the Services could afford to pay—on a monthly basis through December, and quarterly thereafter. This means that, regardless of cost, any amount on any contract over the allotted payment, maintaining the present level of effort, will have to be financed by the companies themselves, with reimbursement by the Government postponed to some undetermined future time. The Navy, of course, is also taking steps to reduce expenditures.

Just what this will mean to the aircraft, engine and systems and components contractors, and their subcontractors and suppliers, has not been fully determined.

If the amounts to be privately financed are as large as some companies fear, then it becomes a question of whether there is enough money available from the private banks to take care of the difference, or whether the lines of credit will stretch that far. If not, then it appears obvious that the work loads of the individual companies will have to be further reduced. This would mean that more reductions in the aircraft and missile programs would have to be made. To add to the problem, the Government does not allow interest on borrowed funds as cost of contract. It must come out of earnings, which are already hardly more than half the national industry average.

Under normal and ordinary circumstances this problem is one that is considered by both the Government and the contractor before a contract is signed. Interest charges on abnormally large loans under extraordinary circumstances which the contractor had no part in creating constitute a burden which some contractors may find impossible to carry.

What effect all of this may have on our defense capabilities, I am not prepared to say. Certainly, we of the aircraft industry can have no valid opinions of what our force



MILLION HOURS FLOWN

1946 1

1956 5

PRIVATE AIRCRAFT

1954 18,600

1956 23,000

The business use of utility and executive type aircraft has shown a spectacular growth in the last ten years, having increased from about one million hours flown in 1946, to about five million hours in 1956. Today, business flying represents approximately 50 per cent of all general aviation activities. In 1954, there were 18,600 privately owned and operated aircraft flying the nation's airways. By 1956, this number had increased to 23,000. This is ample evidence that the speed, safety, and comfort of air travel is becoming an increasingly indispensable tool to American business.

levels should be. It is our job to develop and produce the best military aviation equipment in whatever amounts and on whatever schedules are deemed necessary by the Services themselves.

One thing is certain, however, in view of these cutbacks and stretch-outs, and this is an inevitably sharp rise in the cost of each unit produced.

The effects of these changes on the aircraft industry are extremely serious. The industry expected a gradually declining rate of production of airplanes, but we are in the midst of what we consider to be a sudden drop, with little time to adjust to it. It has all happened over the last three and a half months.

No accurate reading of the fall-off in employment in the industry can be forecast. If, as some estimates hold, the industry employment total will drop to around 800,000 from some 900,000 now, then it will bring us back to where we were early in 1956. But these effects will not be uniform. Some companies will feel them more than others. In any case, the aircraft industry still has a tremendous job to do, designing, developing and producing the airframes, engines and components for both our manned and unmanned aircraft in all services.

The aircraft industry is trying in every possible way to cooperate with the Government in this time of financial distress, even though some manufacturers are hard hit. In assuming the abnormal and extraordinary burden arising from this problem, particularly rapid reduction in output, one extremely important effect in the national interest cannot be ignored and that is—sudden brakes cannot be put on this great and complicated industry with the expectation of rapid acceleration when the trouble has passed. Once slowed, it will take an awful lot of time before we can pick up speed again.

In modern America, a community's airport may fairly be regarded as its gateway to the future.

Heat and Noise of Supersonic Flight Duplicated in Cockpit Test Program

As supersonic aircraft continue to fly higher and faster, can man's frail system continue to cope with the problems of cockpit heat, noise and other distractions?

In order to find out, one aircraft manufacturer is conducting a series of tests in a gadget-loaded cockpit of a "Century Series" fighter, tied down in a test laboratory. Using banks of infra-red lights, the researchers can duplicate in the cockpit actual friction heating conditions encountered in flying Mach 2 (twice the speed of sound) fighter aircraft.

Tape recordings pipe into the cockpit the actual noise inside the

'PressureCooker' Bonds Wing Assemblies

A pressure cooker big enough to roast the legendary Paul Bunyan's Blue Ox, Babe, has been installed at a western aircraft factory. Instead of turning out such savory dishes as roast beef or lamb stew, however, this pressure cooker performs a metal-bonding operation on trailing edge wing assemblies for a new turboprop airliner.

The new 100,000-pound, king-size pressure cooker is more properly referred to as an autoclave. It is eight feet in diameter and 22 feet long. It works on the same principle as a kitchen pressure cooker, applying the heat and pressure necessary to join component parts into assemblies.

Parts to be bonded are placed inside, the lid is fastened, and the "cooking" is done at 350 degrees Fahrenheit and at pressures up to 200 pounds per square inch. The aircraft manufacturer reports that the new autoclave metalbonding method for joining assembly parts is rapidly gaining favor over riveting and welding methods. Furthermore, metalbonding by the autoclave is considered vastly superior to that done by hydraulic press, attaining a more even distribution of pressure for the bond.

"office" of a production fighter in flight. Various other distractions can be introduced at will by the research team. Humidity and wall and air temperatures can be controlled.

Within the shrouded cockpit sits a test pilot, attired in a flight suit and helmet. Everything is just as it would be in flight, with two exceptions—the pilot never leaves the ground, and he is adorned with a maze of wires and rubber tubes connecting him to an impressive bank of recording instruments.

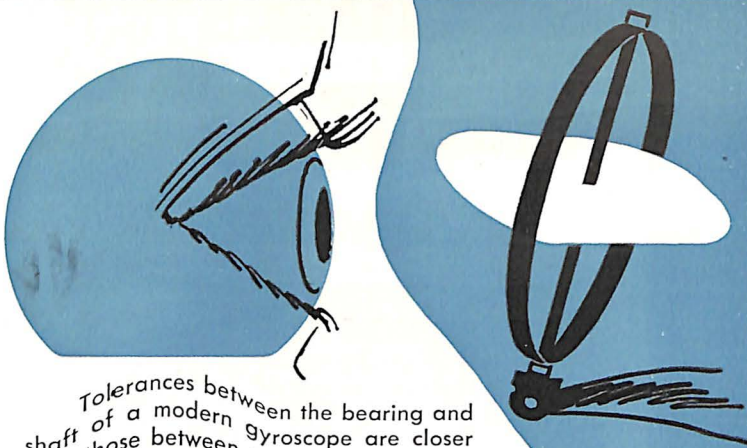
The scientists watch such items as pulse, respiration, body temperatures from several locations, blood pressure, heart action and general body efficiency. Psychological as well as physiological reactions are observed during the test runs. The pilot is asked to perform a complex mental task while under heat and noise conditions, and the scientists simultaneously record the accuracy of his performance.

This helps the researchers establish the point at which cockpit heat and noise and the resultant discomfort begin to cut into a pilot's mental and physical efficiency. According to one of the leaders of the test group, the purpose of the research is "to help our designers to build an airplane in which pilot efficiency is just as much a factor in performance as top speed, rate of climb, and all the other essentials."

Flameout Finish

Jet engine flameouts—one of the few remaining hazards peculiar to jet flight—may become a thing of the past by means of a simple automatic jet engine reigniter. The new device is little more than a platinum-alloy rod smaller than a cigarette, and with no electrical connections or moving parts. The rod, which has heat retentiveness, is kept at combustion temperature by the jet engine's regular operations, and acts as an automatic "glow plug" when a flameout occurs.

EYE ON PROGRESS



Tolerances between the bearing and shaft of a modern gyroscope are closer than those between a human eye and its covering. And a speck of soot could cause friction between the two parts making them inoperable just as the same speck could affect the human eye. Production of precision components has placed manufacturing demands on the aircraft industry unexceeded in any other manufacturing process.

'PLANES'

Laboratory Huffing and Puffing to Guarantee Pressurized Comfort for Airline Passengers

There's a smoke-filled room at a West Coast laboratory and not a single politician around.

All this puffing of cigarettes and pipe tobacco is aimed at insuring the flying comfort of passengers in America's new air conditioned and pressurized transport aircraft.

Engineers found that cabin pressure regulators and valves collect tiny smoke particles which, in time, could cause an air conditioning system to freeze, making the cabin stuffy and uncomfortable.

The altitude laboratory simulates in one day all the smoke airline passengers will puff in 10 years. The pressure regulator or valve is placed in the altitude chamber to simulate flight conditions.

Outside the chamber, pipe tobacco is burned at the rate of one pound every four minutes. The smoke is ducted through one end of the chamber, through the regulator or valve, and drawn out the other end by a vacuum pump.

After the unit has undergone this thirty-hour test, it is then checked. Technicians find that tiny tar particles on the units would ordinarily hamper their function except for one reason. Engineers make allowances in tolerances for the tar particles.

In addition, a filler is installed on

all control elements of the systems which block harmful tobacco elements. These filters are so effective that if used in cigarettes, a smoker would not inhale any smoke.

These smoke contamination tests are only one of thousands of tests made on aircraft systems that mean dependability for U. S.-built aircraft.

Surgical Garb Needed In Missile Assembly

Builders of missile control systems, which are delicately sensitive to dust particles, may be confused in the future with surgeons, so similar is the working garb they are to be issued.

According to orders posted recently by one missile components firm, each missile control system employee will wear a surgeon-type cap, white, dust-and-lint-free coveralls and crepe-soled white loafers. Each worker will be given his own pair of shoes, which he will slip on in "dust locks" just outside the doubly-enclosed area where the miniature assemblies will be put together. Dust-free disposable handkerchiefs will be issued each person assigned to such areas. Each person must wash his hands in the dust lock before entering the restricted work areas, and no loose personal articles may be taken inside except billfolds.

All prints and specifications will be printed on material free from harmful wood fibers. Ball point pens will be used exclusively, eliminating lead pencils and erasers—often the source of dust.

Such precautions are vitally necessary in maintaining surgical cleanliness in the work areas for missile control systems.

'Self-Sacrificing' Metal Coat Protects Vital Plane Parts from Corrosion

A new "self sacrificing" metal coating process has been developed by the aircraft industry to protect vital aircraft parts against corrosion and loss of strength.

Cadmium, the "martyr" metal, allows itself rather than the airplane part to become oxidized.

The cadmium coating is applied to landing gear parts, bolts, fittings and fasteners throughout the airplane. The plane parts are "plated" with cadmium inside huge vacuum chambers 5 feet long and 5 feet in diameter.

The process is applied to components made of ultra-high-strength steels which are capable of with-

standing 140-ton loads per square inch.

Customary electrolytic plating involved using a liquid cyanide bath as a carrier of electricity-activated plating materials. But that required complex and expensive process controls to avoid embrittlement of the part.

The new method involves placing a high-strength part in an airtight chamber along with a cadmium-filled crucible; evacuating the chamber to one-half micron of mercury pressure (virtually a complete vacuum); then boiling the cadmium until it vaporizes and condenses on the airplane part.

The vacuum-plating will last as long as the service life of the part itself. Aircraft industry engineers spent two years in perfecting the vacuum process which has been in gradually increasing production use for six months.

U.S. Aviation Today Now 'Best Seller'

The 1957 edition of *U. S. Aviation Today*, a comprehensive, pictorial account of aviation in the United States has become one of the nation's "best sellers."

Evan Evans, Executive Director, National Aviation Education Council, reports that he believes that the booklet has found such wide reader acceptance because it presents a complete but succinct account of each aircraft in production in the United States.

Published by the National Aviation Education Council and prepared in cooperation with the Aircraft Industries Association, the 94-page booklet with a bright three-color cover contains photographs and three-view drawings of all aircraft produced in the United States during the past year, together with specifications and performance data of each.

In addition there is a section devoted to aircraft, aircraft engines, systems and components scheduled for future production as well as significant developments in the missile field. The booklet also records pictorially significant aviation awards made during 1956.

Ideal for school and college classrooms and libraries, *U. S. Aviation Today* is one of several booklets published by the National Aviation Education Council, a non-profit organization comprised of the nation's leading educators. NAEC booklets are designed to enrich the curriculum of our schools and stimulate the interest of American youth in aviation careers.

U. S. Aviation Today may be obtained by writing to the National Aviation Education Council, 1025 Connecticut Avenue, N. W., Washington 6, D. C. Price is 35 cents per copy. For orders of 100 copies or more, cost is 20 cents per copy.

Aircraft Firm Aids Teacher Shortage

A southwestern aircraft firm has inaugurated a novel "do it yourself" scheme for beating the engineering shortage. Learning that many high school students in the plant area were interested in becoming scientists and engineers but were held back by the lack of qualified physics instructors in the high schools, the aircraft manufacturer looked into the manpower pool at his own plant, and came up with four professional engineers qualified to teach high school physics.

Each of the four now holds down two jobs at once. The engineers commute to the local high schools each day, teach a class in physics, then return to their aircraft plant jobs. The result is that nearly 100 burgeoning scientists and engineers will get a chance to earn college engineering degrees because one aircraft firm had the foresight to "do it yourself" in beating the teacher shortage.

Cool Motor

The aircraft industry has developed a small cam piston air motor capable of operating at temperatures of 1,000 degrees Fahrenheit without conventional cooling.

Utilizing hot air, the new air motor is a positive displacement, fluid drive power device. A typical motor weighs 22 pounds, produces 18.5 horsepower at low revolutions per minute and has a fast acceleration of less than .05 of a second.

The motor is gearless, resembles a large rolling pin. It is about 3 inches high and 13 inches long.

The new device has numerous applications as a new power source for actuation of thrust reversers, control surfaces and exit nozzles as well as other industrial and nuclear uses.

Problems of high temperature operation without lubrication have been minimized by using extremely hard, wear resistant alloys.

Shelling Out Jets

For the Now-We've-Hard-Everything Department: At Tinker Air Force Base in Oklahoma City, jet planes are getting their "throats" swabbed out with a mixture of aluminum oxide and, of all things, walnut shells. It seems that after prolonged firing, the jet tubes get fouled up with dirt, soot and grease. The aluminum oxide plus walnut shell mixture is shot through the tubes under high air pressure, scouring as it goes.