AERONAUTICS

# Transonic Flying

**When flying as fast as sound, planes will be bucking an air-grip on the wings that will hold the craft back and even might destroy it with crushing pressure.**

### By A. C. MONAHAN

➤ WHEN we fly faster than sound, we will be bucking and beating the grasp of an air-grip on the wings of the plane that holds the craft back and even might destroy it with its crushing pressure.

This is the so-called barrier to fast flying that is met when the speed of the plane approaches that of sound. The air-grip is two pressure waves, one on each surface of the wing. They extend upward, downward and backward in a wide V-formation with the wing at the apex. They are the so-called shock waves.

It is the elastic limit of the air that limits the speed of sound. The sound waves travel as fast as the elasticity permits. These sound waves are pressure waves. Air can accommodate itself to pressure changes just so fast and no faster. Sound travels by a series of concentric waves, leaving the vibrating object that gives off the sound, normally in every direction, with the forward wave on the outside of an imaginary sphere. Whatever gives off sound is in vibration.

The waves cause pressure as they force their way outward, causing a molecular vibration in the air. Air, however, has a definite limit in elasticity. This is what the pressure changes meet, and what limits the speed of the waves and therefore of sound.

## Elasticity of Air

The elasticity of air varies with the temperature. The hotter it is, the greater the elasticity is. For this reason sound travels faster when the temperature is higher, and more slowly when the temperature is low. The speed of sound near the surface of the earth in average temperatures is about 760 miles an hour. Five miles above the earth where the temperature is around minus 67 degrees Fahrenheit, the speed of sound is approximately 660 miles an hour.

The velocity of an object flying through the air at the speed of sound is a variable because the speed of sound is a variable, depending upon the temperature. Speeds in the neighborhood of that of sound are called transonic, and range from around 600 to 800 miles an hour. It is in this transonic range that the real barrier occurs. Speeds above the transonic are supersonic. Those below are subsonic.

Ordinary flying is all in the subsonic, but the Navy Douglas Skystreak that recently beat the world's speed record by traveling at 650.6 miles an hour was in the transonic. Pilotless rockets and guided missiles have traveled in the supersonic. No plane with a pilot aboard has as yet traveled with the speed of sound.

Several planes have been designed and built with this in view, but none as yet has been put to the supreme test. One of the first was the Army XS-1, built by Bell Aircraft and theoretically capable of 1700 miles an hour, as far as thrust is concerned, at an altitude of 80,000 feet. It is powered by rocket engines so that it can fly far above the air supply needed with conventional and jet-propelled engines.

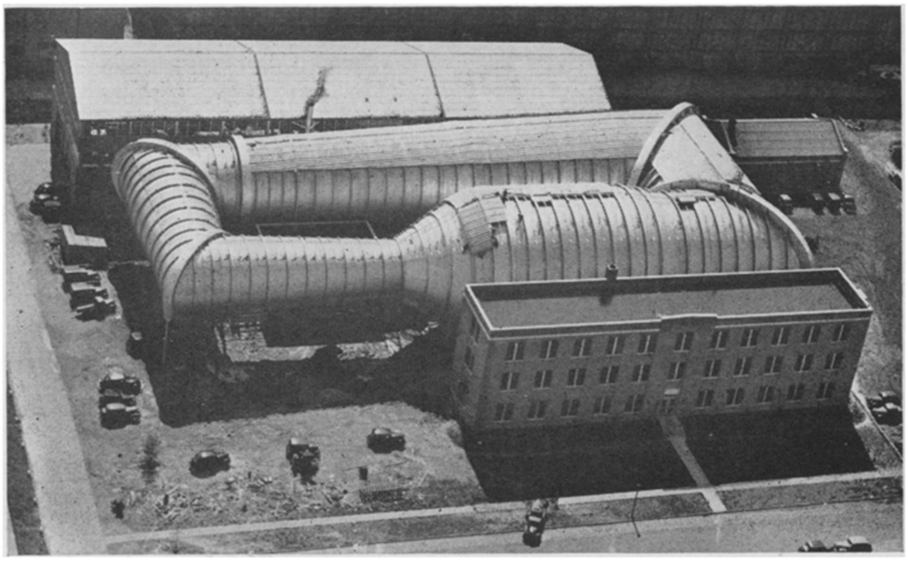
The XS-1, as first of a series of research planes, represents only one configuration, and does not by any means represent the latest data for supersonic flight. An improved plane, the XS-2, is under construction.

Then there is the Army Shooting Star, built by Lockheed, a version of which held the world's record before beaten by the Skystreak. There are others, including the English jet-propelled Gloster Meteor which has an official record of 606 miles an hour. One British plane which appears to have crushed and almost completely disintegrated in the air may have been flying at a transonic speed.

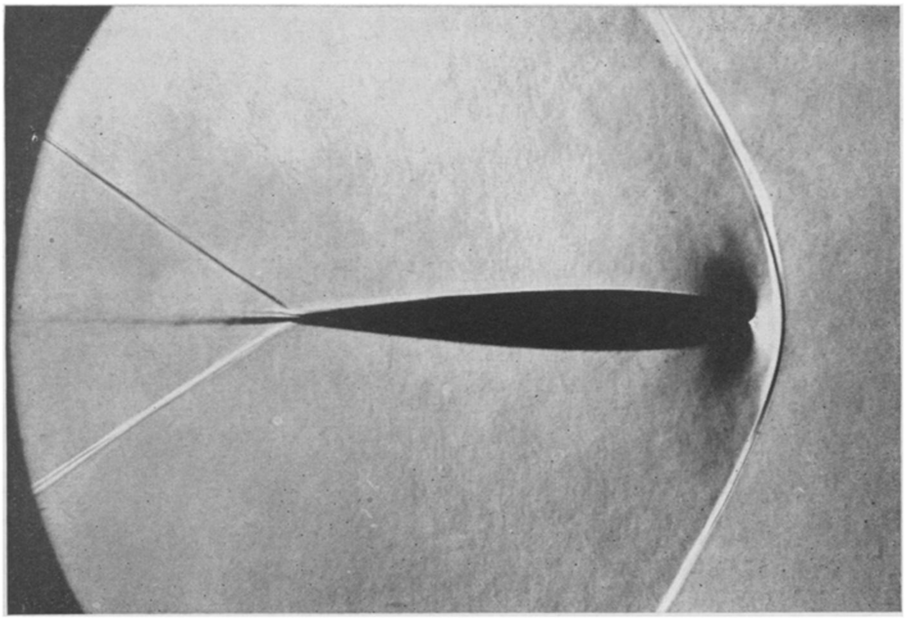
## High Speed Planes

The authority in the United States, and perhaps in the world, on the design of planes to beat the speed of sound is the National Advisory Committee for Aeronautics. It is the government agency for fundamental studies in aeronautical science. The XS-1 with its straight wings, and the XS-2 with its sweeping backward wings, are designed according to its advice. In fact, this federal organization, called NACA for short, has had a role in the design of practically every plane produced in America since 1915.

Wind tunnels play an important part in the NACA program of studying aerodynamics. This science has to do with



*WIND TUNNEL—This 19-foot tunnel of the NACA at Langley Field, Va., is not the largest or most modern of their pressure tunnels, but it shows the configuration of the supersonic speed equipment.*



*AIRFLOW PATTERN—This Schlieren photograph shows the bow wave formed when the blunt-edged wing is subjected to supersonic airflow. The wave is detached and stands out in front of the edge, instead of sweeping cleanly back as with the sharp-edged type.*

the laws of motion of gases, especially atmosphere, under the influence of various forces, and the mechanical effects of such motion.

The NACA has been working for 20 years on high speed flow of air in its giant wind tunnels and otherwise. It has amassed a lot of information of the mechanics of compressible flow, part of which is incorporated in the new Army and Navy planes and others to beat the speed of sound.

These tunnels are both high-speed and supersonic tunnels, which range from high subsonic speeds of 700 miles an hour, to supersonic speeds up to 2,000 miles an hour. In addition, the NACA has developed methods to obtain data all across the transonic range, which so far can not be produced in wind tunnels.

### Pressure Waves

As explained by an engineer of the NACA, an airplane moving through the air creates pressure waves in every direction. If the plane is standing still the pressure waves, perhaps from its propellers, would radiate in all directions in any given time. But when the plane is flying, it tends to overtake the waves spreading ahead and to leave behind those spreading rearward.

When a plane travels faster than sound, all pressure waves would actually be left behind because the source of the disturbance is traveling faster than the pressure waves. When the plane travels as fast as sound, that is, in the transonic range, the pressure waves can no longer outrun the source, and hence pile up to form one continuous standing wave that keeps pace with the plane.

### "Schlieren" Photographs

This shock wave is not just a theory. It can be seen by use of what are called "schlieren" photographs. These are made by sending parallel rays of light from a lens crosswise through a test tunnel in which a replica of a wing, or portion of a wing, is subjected to very high air speeds in the supersonic range.

The air in the wave is of different density from that in the other portions of the air flow and therefore refracts the light passing through it. The light leaving the tunnel is focused by a second lens. A sharp knife edge, placed at the focus of this second lens, acts as a "stop" for part of the light. The refracted ray, bent and no longer parallel to the others, does not converge on the focus. On a camera film it appears, in contrast to the general field, either as a light or dark spot.

Wing design is one of the most important factors in the development of transonic and supersonic planes. It is relatively easy to design wings or other airfoil or control surfaces for either the subsonic or supersonic ranges. The great difficulty is development of airfoils and control surfaces that will operate in both kinds of airflow. This is the present barrier.

The forward edge of the ordinary wing is more or less blunt and it pushes some air on ahead of it as well as forcing an airflow over and under its surfaces. For supersonic speeds, the forward edges of wings will probably have to be knife-sharp so that they will cut the air cleanly. A subsonic airfoil can be moved at supersonic speeds, but it is only at a great sacrifice of power.

The action with the subsonic blunt wing edge in supersonic speeds shows clearly in a schlieren photograph. The pressure wave is detached and stands out in front of the rounded leading edge of the wing, instead of sweeping cleanly back from the leading edge as in the sharp-edged type. With this latter the air suffers no deflection until it actually strikes the airfoil. But with the blunt rounded leading edge, the air is backed up and slowed down before it ever reaches the airfoil itself.

The shock wave thus formed represents a greater degree of deceleration and compression, and hence resistance, than that which occurs in oblique shock waves. Directly in front of the wing the

## Do You Know?

Male and female *turkeys* become sexually mature when about seven months old.

*Wheat* accounted for over half the total tonnage of foods exported from the United States during 1946.

*Fires* seldom occur in clean houses, stores and shops where there are no combustible rubbish accumulations.

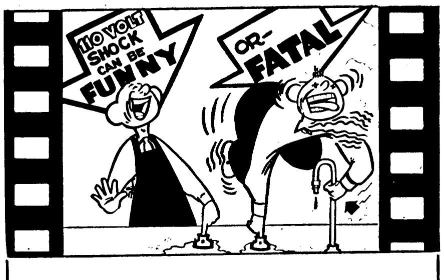
The hardness of *lead pencils* depends upon the amount of clay used in the graphite that constitutes the so-called lead.

*Smoke* belching from giant chimneys in certain factory cities creates a menace to flying due to decreased visibility above the cities.

Yarn and rope, made by weaving *coconut fiber,* have long been manufactured in Ceylon for domestic uses and export.

Most *cinnamon* used as a spice in America is the powdered bark of the cassia tree, which is more pungent than the bark of the true cinnamon tree.

There are today about 300 synthetic *detergents* or dirt removers, on the market, but only a few types promise to compete with soap in the household.



air is slowed down from supersonic to subsonic velocity, forming a second kind of shock wave, one which is perpendicular to the airflow. Both types of waves are called "bow waves" in this case. Because this second wave extends out beyond the area affected by the leading edge, it is swept backward by the supersonic speed and creates a large resistance.

Engines are available to propel planes at supersonic speeds, and the knife-sharp wing may go far in solving the supersonic problem. There is still the problem of a type of construction to withstand the high speeds and the shock pressures. The XS-1 and the Douglas Skystreak in their test flights are gradually being operated at higher and higher speeds. They are both successful at the speeds at which tested, but what will happen when the attempt to get through the transonic barrier is made is as yet unknown.

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PHYSICS

# Atomic Power Made Safe

**Special precautions necessary including the elimination of all dust. Wastes can't be dumped but must be cleaned up to last drop.**

➤ MAN CAN learn to live safely with atomic power installations, just as he has learned to live with high-pressure chemical retorts, high-voltage electrical machinery and high-temperature blast furnaces, predicted Dr. Karl Z. Morgan, director of the health physics division of the Monsanto Chemical Company's Clinton Laboratories at Oak Ridge at the New York meeting of the American Chemical Society.

This does not mean that old-timers in an atom-power plant can afford to become careless, any more than old hands in an electrical power plant can. They will just know the rules, stay within them, and be safe. Thus far, with all the atom-plant hands necessarily new hands, they are leaning over backwards in sticking to safety rules—and thus far not a single case of radiation damage has been reported from the plants at Hanford, Oak Ridge and Chicago.

Some new safety practices, peculiar to the handling of fissionable material, will have to be followed, the speaker warned. For example, whereas in most industries only excessive dust in the air is considered dangerous, in atomic plants any dust whatever must be regarded as a menace and eliminated.

Again, the easy-going custom that many industries have, of dumping liquid wastes down the drain and letting the fish in the river do the worrying about pollution, just won't do in plants where all wastes are radioactive. They will simply give a deadly metal plating to aforesaid drain, to the eventual undoing of some poor, unsuspecting plumber. Atomic industries of the future will have to clean up their own messes to the last microscopic drop and crumb.

Greater safety in one of today's pre-atomic industries will result from a new phosphorus conversion method described before the meeting by three TVA chemists, Phillip Miller, R. A. Wilson and J. R. Tusson, of Wilson Dam, Ala. They have developed a new and better way of turning white phosphorus, which is dangerous to handle, into red phosphorus, which is safe.

Phosphorus changes from the white form to the red upon heating. Conventional practice has been to heat it in one-ton batches; but this process is uneven, conversion is incomplete and subsequent purification difficult. In their new form, white phosphorus is melted and the heating continued until the mass is partly converted. Then a blast of hot gas evaporates the remaining white phosphorus (which is recaptured and remelted), leaving highly purified, safe red phosphorus.

*Science News Letter, October 11, 1947*