Supersonic Research In the U.S. Navy

By Rear Admiral Charles A. Nicholson, USN

In the Fairchild Pegasus

AS YET, there is no assurance that we can live permanently at peace with all nations of the world. For national safety, we must exert our efforts to remain abreast, at least, of other nations in air strength. To do that, it is necessary to increase our understanding of the physical and engineering laws which govern the behavior of aircraft at speeds in the neighborhood of the speed of sound and as far above the speed of sound as it appears practicable to investigate at this time.

The necessity for greater speed stems from the very natural and basic axiom that, all other things being equal, the faster airplane will be able to get to its destination quickest and will be able to overtake or outdistance an adversary.

When World War II ended, the fastest operational airplane was the German Me262, a jet fighter-bomber capable of 550 mph top speed. Its effectiveness against our bombers was several times as great as the Fw 190 which was a reciprocating engine powered fighter in the 400-mile-an-hour class. Today, the world's speed record is 670.9 mph, which is held by Major Richard Johnson, USAF, in a North American F-86 experimental jet fighter.

Presently available types of jet engines give us sources of almost unlimited power. It is no longer true that a bomber or an attack plane must be the slow lumbering work horse of the past. Now a bomber can be as sleek as a fighter. The past disparity in their speeds is fast dwindling. Our current fighters will do well to have 50 mph greater speed than the latest jet bombers. Until other means of defense against very fast attacking airplanes is developed, we must continue to increase the speed of our fighters. Similarly, greater speed must be built into our attack aircraft since speed might become their greatest defensive asset.

The present world record of 670.9 mph is approximately 85 per cent of the velocity of sound under the conditions which prevailed during the flight. As the speed of sound is approached the airplane is confronted with increasing effects of the phenomenon of **compressibility.**

At speeds below approximately 70 to 80 per cent of the speed of sound, the energy which the airplane imparts to the molecules of air in moving them out of its way is transferred into additional velocity of the air molecules. The true velocity of the air molecules with respect to a point on the airplane is then the sum of the airplane speed plus the additional speed of the air. When the sum of these two speeds is equal to the speed of sound a compression wave of air results. Its occurrence is so rapid that it is called a compression **shock wave** and the general term for it is known as the onset of compressibility. It manifests itself to the airplane in a fairly rapid increase of resistance to motion through the air.

The drag rise is not the only problem associated with the onset of compressibility. The conditions which bring on shock waves exist in what is called the transonic region, or from about 0.8 the speed of sound to about 1.3 times this speed. One can readily imagine that the flow of the air about the airplane in this velocity region is not steady or uniform. Consequently, the kind of flow which is normally present around the wings to furnish lift and around the tail surfaces to give control forces, no longer exists. The lift on the wings might drop off to such low values that the airplane cannot maintain its altitude.

Control surfaces which behave in a normal and desirable manner at low speeds might become useless and might conceivably impart a motion to the airplane opposite to that intended. To overcome these problems, it is necessary to investigate many kinds of airfoil contours, wing shapes, tail shapes, and bodies in order to discover the types which will give us desirable characteristics for the entire speed range in which they must operate. The relative location of wings, bodies and tail surfaces to one another as well as the manner in which they cause interaction with each other are extremely important and must be investigated.

The power plants which will most likely be used in operational aircraft in the transonic region are essentially engines which increase the velocity of a quantity of air that passes through them, thereby producing a thrust. Here again we are confronted with many problems, the answers to which will require a great deal of investigation. The design of air intakes and exits, compressor and turbine blades, and combustion chambers are a few of the problems.

As the airplane moves through the air at very high speeds, the friction of the air molecules against it causes a rise in temperature. Cooling means must be provided to avoid roasting the pilot and crew. Enabling personnel to bail out from a very high speed airplane is also a serious problem.

Those are some, but by no means all of the questions which must be answered to permit us to operate at transonic speeds. It must be stated, however, that no physical phenomenon is known to exist which would preclude flight at or in the neigborhood of the speed of sound. Speeds of twice and three times this speed have been attained by various types of missiles.

Supersonic speeds, which is the term generally applied to velocities of 1.3 times the speed of sound and above, present obstacles, but not necessarily barriers, of much greater magnitude than those in the transonic region. Many of the perplexing questions which must be answered by research for successful airplane design

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The Curtis-Wright XF-87 Blackhawk, powered by four Westinghouse 24C jet engines mounted in pairs under each wing, is designed for all-weather operation in the 600 mph class. A feature is the side - by - side seating of the two-man crew for operating efficiency.

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bruises and buckle marks, I felt no ill effects from the jump.

Two days later, however, I made another ejection at twice the speed, i.e., 440 mph, but with very different results. On this ejection I held my breath as I went up through the slipstream. By the feel of its blast in that split-second upward thrust, I knew that the aircraft certainly was pushing the air behind it. I had the same impression as on the previous ejection, the explosion and the lift, etc., only things happened so fast that it was difficult to record distinct impressions. (The speed of the seat is about 60 feet per second. It takes only one-fifth of a second to clear the cockpit).

As the seat rose clear of the aircraft, my feet were torn out of the footrests and my legs swung to the side of the seat. I hung onto the blind as hard as I could, but started to slide.

The opening of the small drogue contributed to this, and when the main canopy opened, the braking power was so great that it shot me almost completely through the Sutton harness.

In Perilous Position

When the main chute had completely developed, I found myself hanging below the seat, almost through the safety straps, with one hand still gripping the blind handle, the other stopping the release box of the Sutton harness from choking me. (I still bear the scar on my chin to this day where the release box dug in).

Well, I didn't feel too worried about that at the moment, as I knew the position I was in would not interfere with the jettisoning of the seat, but, as the small of my back was where the bend in my knee should have been, I knew something had gone wrong.

I knew that for the moment I was safe, as I could hear the main canopy rustling above me, and I could feel the speed of descent through the air, and far below me I could see the airfield. I had all the time in the world, there was very little drift, and I was falling quite steadily.

Still hanging on to the blind handle with my left hand, I reached round to check my seat pack. I think every emotion but fear stopped within me when I felt nothing where my seat pack should be. I strained my arm and felt again. Instead of feeling the neat firm outline of the seat pack all I had was a handful of rigging lines!

I craned my neck and I knew that I had really had it when I saw the white folds of my open chute wrapped round the seat.

I do not believe that any test jumper in the world, (even if given to name his own price) would have voluntarily landed in the seat, especially if he had seen the dummy bounce as I had. But there again, I knew that I had no other choice. I thought of trying to drop clear but changed my mind.

Apparently the rip cord had been pulled by the violent sliding action as I slipped through the seat harness. (Subsequently, a small safety strap was fitted across the rip cord ring to eliminate the risk of accidental release.)

Fortunately, with the larger canopy open, the seat was descending more slowly than normal, although still at a dangerous speed. I had no control of the drift, however, and in the final 100 ft. I lost all track of my position.

My luck must have been completely out that day for I crashed onto the concrete of the same runway from which I had taken off in the Meteor. My heels touched first then I fell onto my left side, tearing the ligaments of both knees, and found myself lying on the concrete beside the seat with a terrific pain across my shoulders.

As this is written, I am in my 10th week in the hospital making a recovery and glad to be alive. Meantime, with the results of my experimental jumps, forced ejection development has gone ahead. A successful jump has been made from an aircraft travelling at 505 mph. Forced ejection is the standard RAF system of escape from high speed aircraft.

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in the transonic region are magnified many times in the supersonic region.

As an example, let us consider the problem of heating of the airplane because of its motion through the air. At velocities in the neighborhood of the speed of sound, it is expected that the cockpit would heat up to such an extent that a pilot could not survive in it for any appreciable time if there were no refrigerating provisions. Yet the material from which the airplane is constructed would be relatively unaffected. At supersonic velocities, on the other hand, the surface of the aircraft might be heated to such an extent that the materials would lose their strength. We must, therefore, undertake extensive programs of research into heat transfer phenomena and strength of materials at elevated temperatuures.

The undertaking of a research program is not a simple matter. First of all, top flight scientific and engineering people are needed. Many types of facilities such as wind tunnels, propulsion laboratories, test ranges, and many types of instrumentation are essential prerequisites of any aeronautical research program. Without research facilities, it would be necessary to build full scale models of airplanes for testing. They would be designed on a "by guess and by thumb" basis since insufficient information on which to base a successful design would be available.

Experience has proved that such a procedure is the most expensive in time, money and effort and that it is the least likely to succeed.

Flight at transonic and supersonic velocities is an astonishingly complicated problem. The basic physical laws governing the motions of particles, processes of combustion, energy release and compounding of elements must be thoroughly understood. Only with the facilities described can we hope to control conditions and instrument the experiments to the extent that dependable information would be obtained.

A sound aeronautical industry is necessary to provide us with experimental models and equipment, as well as the successful production models which are developed from the knowledge gained by experimentation. The industry must have sufficient practice in the construction of transonic and supersonic aircraft so that it could expand rapidly in case the need should arise.

Financial support is required to carry out the various phases of research programs. A wind tunnel which has a working section of six feet by six feet and is capable of moving the air through that section at a velocity of twice the speed of sound is estimated to cost more than $6,000,000.

For various technical reasons the largest model which can be tested in a six feet by six feet tunnel will be only a few inches across its largest dimension when the air velocity through the tunnel is near the speed of sound. When the information from that model is applied to an airplane whose corresponding dimensions are many feet across, serious discrepancies might result.