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Remarks by Dr. H. L. Dryden,
Director of Aeronautical Research,
National Advisory Committee for Aeronautics
at First Annual Inspection
of the Flight Propulsion Research Laboratory,
Cleveland, Ohio,
October 8, 9, and 10, 1947

Distinguished guests:

I welcome this opportunity to tell you about the research program of the NACA, and to place in perspective that segment of it which you will meet today so that you will not be so absorbed in the detailed results which will be shown to you as to miss the general pattern.

The mission of the NACA is to "supervise and direct the scientific study of the problems of flight with a view to their practical solution." If such a study is to be effective the program must be something more than a collection of individual problems. The research program must have something of the characteristics of a living organism with a unity of purpose, with definite goals, and with continuous adjustments to its environment. On closer examination an adequate research program will be found to consist of major areas of effort with definite goals in each area and the major areas will be found to consist of more limited regions with more specific goals. Ultimately the program breaks down into specific tasks to be attacked by small groups or by individuals. At this stage the goal is often that of complete understanding of some natural phenomenon and the methods are those characteristic of so-called pure science. But through all stages there must be an interdependence and unity of purpose.

The environment of present-day aeronautical science is the technical revolution arising from the wartime development of jet engines and rockets. One of the major goals of aeronautical development is the attainment of supersonic flight of piloted and pilotless aircraft. The function of the NACA is to furnish the basic scientific and technical data which will make supersonic flight not only possible, but safe, reliable, and useful. The apex of this effort in aeronautical development is the cooperative study of piloted high-speed research airplanes in flight, by the military services, industry, and NACA.

You will see today a cross-section of that portion of the research program dealing with propulsion, since you are at the NACA Flight Propulsion Research Laboratory. Little work is in progress on reciprocating engines, because these engines have already reached an advanced state of development and the NACA must place its emphasis on those engines which show most promise for future development. The power plants which make possible the eventual attainment of supersonic speeds are the turbo-jet and the rocket engines. These engines have reached a state of practical utility, and research effort will greatly expedite their development. In a somewhat earlier state of development and use, is the ram jet. It is the most attractive power plant for speeds in excess of about 1.5 times the speed of sound where reasonable ranges are required. In fact we might divide the speed spectrum of our engines about as follows: The turbo-prop for speeds up to those at which high propeller

efficiencies can be maintained about 450 to 550 mi/hr with present propellers; the turbo-jet for speeds from 500 miles per hour to speeds of 1.5 times that of sound; the ram jet from sonic speeds to speeds of several times that of sound; the rocket for extremely high speeds, for short bursts of power, or for flight outside the earth's atmosphere.

The goals of research effort on turbo-jet and turbo-prop power plants are (1) to increase the performance of the power plant for a given size and weight, and (2) to increase the reliability and life of this type of power plant.

To increase the performance of a given size and weight it is necessary to improve the performance of the component parts of the engine, i.e., compressor, combustion chamber, turbine, and bearings; and to carefully match the components so that all attain their optimum performance under the same conditions. In particular, the compressor and turbine must operate at the same speed in the conventional turbo-jet engine, and hence their characteristics must be matched. Finally, the operating control must be designed to give the most efficient operation.

From the work in progress on compressors, you will hear something of the work on axial-flow compressors and of the operation of an axial-flow-compressor rotor in air at supersonic speeds, a development that promises drastic reduction in size and weight, but probably at first at some expense in efficiency. A variable component test unit which has

been very useful in the study of compressor performance will be shown. Some of the work on the mixed-flow type of compressor will be described, as well as the story of the improvement of a compressor now under development in cooperation with the military services and industry.

In the field of combustion, you will hear something of the difficulties encountered in maintaining a flame at high altitude and the part played by the NACA altitude wind tunnel in improving U.S. turbo-jet engines. There will be described to you the effects of the fuel used and of the geometry of the combustion chamber on the behavior of flames at altitude, on the limiting altitude at which a flame can be maintained, on flame speed, on ease of ignition, and on efficiency.

The performance of the turbine can be improved through improvement in blade design, and especially by operation at the highest possible temperature. Operating temperatures can be increased by cooling the blades and the rim of the turbine wheel or by the development of materials which will withstand higher temperatures. Work is in progress on metal alloys, or ceramics, and on new materials called ceramels, which consist of mixtures of metals and ceramic materials. You will hear about investigations in these fields, about bearing friction, matching of compressor and turbine, and about controls.

The goal of increased performance for given size and weight is of course an ever receding one. One definite numerical goal is set, however, by the fuel economy of the reciprocating engine, a goal difficult to attain

in the near future, but considered by no means impossible of ultimate accomplishment.

The second goal of the turbo-jet and turbo-prop work is to increase the reliability and life. From the investigations in progress in this field you will see something of the studies of blade stresses, of vibration and flutter, of causes of failure of turbine discs, and of methods of protection of turbo-jet engines against icing. A unique piece of equipment for this latter study is the ice tunnel, in which the actual icing conditions in the atmosphere can be reproduced.

You will see something of the work of the NACA on the rocket type of power plant. We are studying various high-performance fuels as a means of increasing the performance of rockets. The combustion process is being studied in an experimental glass-sided combustion chamber with the aid of high-speed motion-picture photography. Increased reliability and life is being sought by the study of sweat cooling.

Some work on ram jets will be in evidence, and on other items which it has not been possible to include in this brief review.

Having broken down the research program into specific fields of effort, it is necessary to bring together the results obtained in these specific fields in complete power plants to verify the practicability of application of the results. The NACA Flight Propulsion Research Laboratory has excellent equipment for studying the altitude performance of complete power plants of moderate size. Rather than go to the great

expense of building experimental engines to demonstrate the results of its research, the NACA has adopted the policy of using engines under development by the military services for research purposes, working in close cooperation with the military services and industry. By selecting engines intended for large-scale procurement, there is a tremendous benefit to the nation in obtaining early application of research results. You will see some of the results of this work on certain widely-used power plants.

Research on these power plants is characterized by development and extensive use of special instruments to measure the performance of all components of the engine. Such extensive instrumentation is not needed in the ordinary development and evaluation tests of over-all performance, and is the key to the difference between research and other activities. An exhibit of instruments has been arranged for your inspection at lunch time, but I believe you will notice their wide use throughout the laboratory if you are observant during the course of your inspection.

I hope that you will have an interesting and profitable day, and that this brief evaluation will give you the means of synthesizing the many views of our work into a unified picture.

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DIRECTOR OF AERONAUTICAL RESEARCH,
NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS
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