ALTITUDE ENGINE RESEARCH

Speakers: William A. Fleming
Bruce T. Lundin

The background noise or rumble that you may notice here is caused by the operation of a turbojet engine in the test section of the altitude wind tunnel that will be used in a later part of our demonstration.

As essential phase, or part, of the over-all engine research program of the Lewis laboratory is research that is conducted with the complete, full-scale engine. It is this work with the full-scale engine that serves to bring together or integrate into the complete engine many of our research contributions on various engine components and to investigate the problems of interaction of one engine component on another. The processes of combustion in the engine are, for example, dependent upon the nature of the air flow delivered by the compressor and, conversely, the problems of compressor design are influenced by the operation of the turbine or the manner in which fuel is burned in the combustor.

In addition to these problems of component interaction, a modern aircraft power plant is a complicated and delicate piece of machinery and is sensitive to the environment in which it is operated. When an engine is operated in the upper atmosphere, where temperatures as low as -100° F and

pressures down to 1 or 2 inches of mercury are encountered, it does not perform exactly the same as on sea-level test stands or as may be predicted by theoretical studies. The operation of actual prototype engines in altitude facilities thus not only provides evaluation and further development of the application of fundamental research contributions to actual engines, but also serves to discover and solve many difficulties of operation that were not previously known or even anticipated. By working closely with the engine designers and manufacturers, this applied research has contributed greatly to the technical excellence of our country's engines and largely avoided the need for extremely costly, hazardous, and time-consuming engine development by means of flight testing. Some of the facilities required for this full-scale engine research work, such as this altitude wind tunnel or our altitude test chamber, have already been or will be subsequently described to you in the demonstration in our central control room. In addition to these large research facilities, accurate measurement of engine performance is necessary, which requires a multitude of complex and frequently unique instruments. Some of these instruments have been assembled for your inspection on the table at the rear of this room.

As representative examples of this work with full-scale engines, we have selected for your review today a demonstration of engine controls research and of research on tail-

pipe burners for turbojet engines. The first of these two demonstrations, that on engine-control systems, will be presented by Mr. Novik (Ketchum).

Thrust Augmentation

Speakers: Martin J. Saari
E. William Conrad

One of the most spectacular accomplishments in the field of aircraft propulsion in recent years has been the development of tail-pipe burners for turbojet engines. As with many important scientific contributions, the tail-pipe burner is characterized by simplicity of concept and application. It consists essentially of an enlarged tail pipe which incorporates a suitable fuel distribution system, a flame holder, a combustion chamber, and a variable-area exhaust nozzle. Fuel is injected into the gas stream leaving the turbine, and is burned, thereby increasing the temperature of the gases within the burner. The elevated temperature results in an increase in jet velocity which produces a much greater thrust than can be obtained with the basic engine alone. By application of tail-pipe burners in combat aircraft, the take-off distance is considerably reduced, the rate of climb greatly increased, and additional thrust is provided for high speed bursts during tactical maneuvers.

While the tail-pipe burner plays an important role in improving the performance of the subsonic airplane, it has become a vital and necessary integral part of the turbo-jet power plant for the supersonic airplane. This point

is illustrated in this chart (fig. 4), which shows the drag characteristic of a typical supersonic airplane and the thrust that can be obtained from its engines both with and without tail-pipe burners. Since the thrust must be greater than the drag to sustain level flight, it is evident that flight at supersonic speeds is impossible without the tail-pipe burner; in fact, the basic turbojet engine can furnish only half of the thrust required to overcome the drag in the region of sonic speed. On the other hand, the tail-pipe burner provides sufficient additional thrust to propel the airplane not only through the speed of sound, but far beyond into the supersonic speed range.

It is, of course, possible to obtain the thrust required for supersonic flight by enlarging the basic turbojet engine. With this possibility in mind, let us consider these models of two supersonic interceptor airplanes designed for the same flight conditions. This airplane is powered by basic turbojet engines which have been enlarged to provide the thrust required for supersonic flight. The extremely large engines required when tail-pipe burners are not utilized results in an unrealistic and impractical airplane having poor combat performance because of the great weight and high aerodynamic drag of the engines. In contrast, this airplane is powered by turbojet engines with tail-pipe burners, where the high thrust increase provided

by the tail-pipe burners permits the use of much smaller engines which impose smaller drag and weight penalties on the airplane. While many significant contributions have been made to the art of tail-pipe burning by utilization of the altitude research facilities at this laboratory, many operational problems must as yet be investigated to meet the ever present demand for flight at greater flight speeds and higher altitudes.

The problems of supersonic flight are of particular importance. To obtain the high thrust required for supersonic flight, the gas temperatures must be considerably higher than those previously employed. Inasmuch as no presently known materials will successfully withstand these temperatures, cooling of the burner shell becomes a vital necessity. Methods for providing cooling air with minimum losses in engine and airplane performance are being investigated at this laboratory.

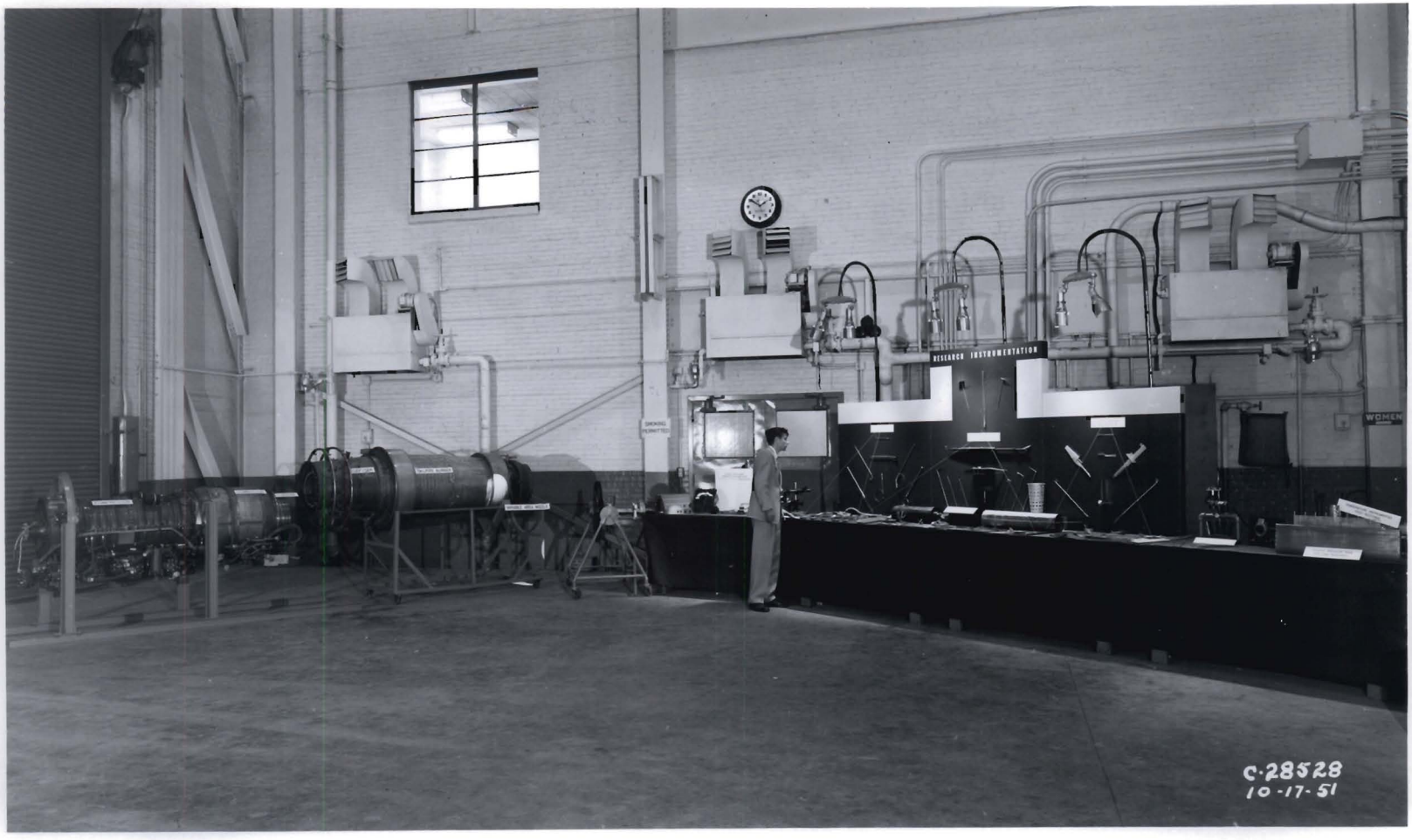
Also, since it is important to keep the tail-pipe burner as small as possible, problems of burning fuel efficiently at very high gas velocities and the elimination of combustion instabilities encountered under these conditions are also the subject of considerable research effort.

Since many of you have not had the opportunity to see a tail-pipe burner in operation, we will conclude this presentation by demonstrating a burner in action. The engine

and tail-pipe burner will be run in the test section of the altitude wind tunnel and a television camera will transmit the view across the burner nozzle to the screens indicated by the lights. A microphone located at the test section will give you an idea of the noise generated.

Setup - Altitude Engine Research

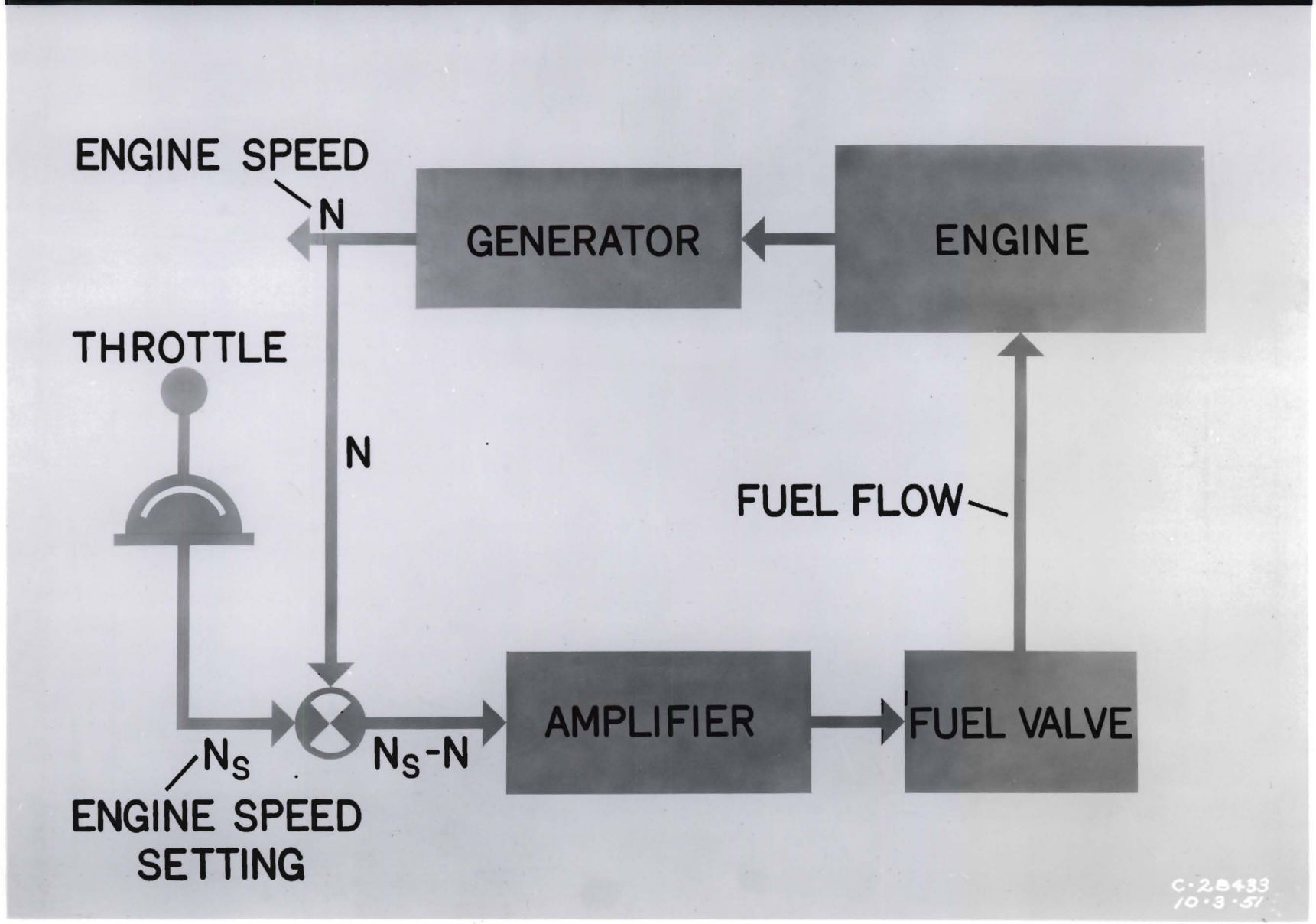
NACA



Altitude Engine Research -- Display

NACA

ENGINE SPEED CONTROL



Altitude Engine Research -- Figure 1

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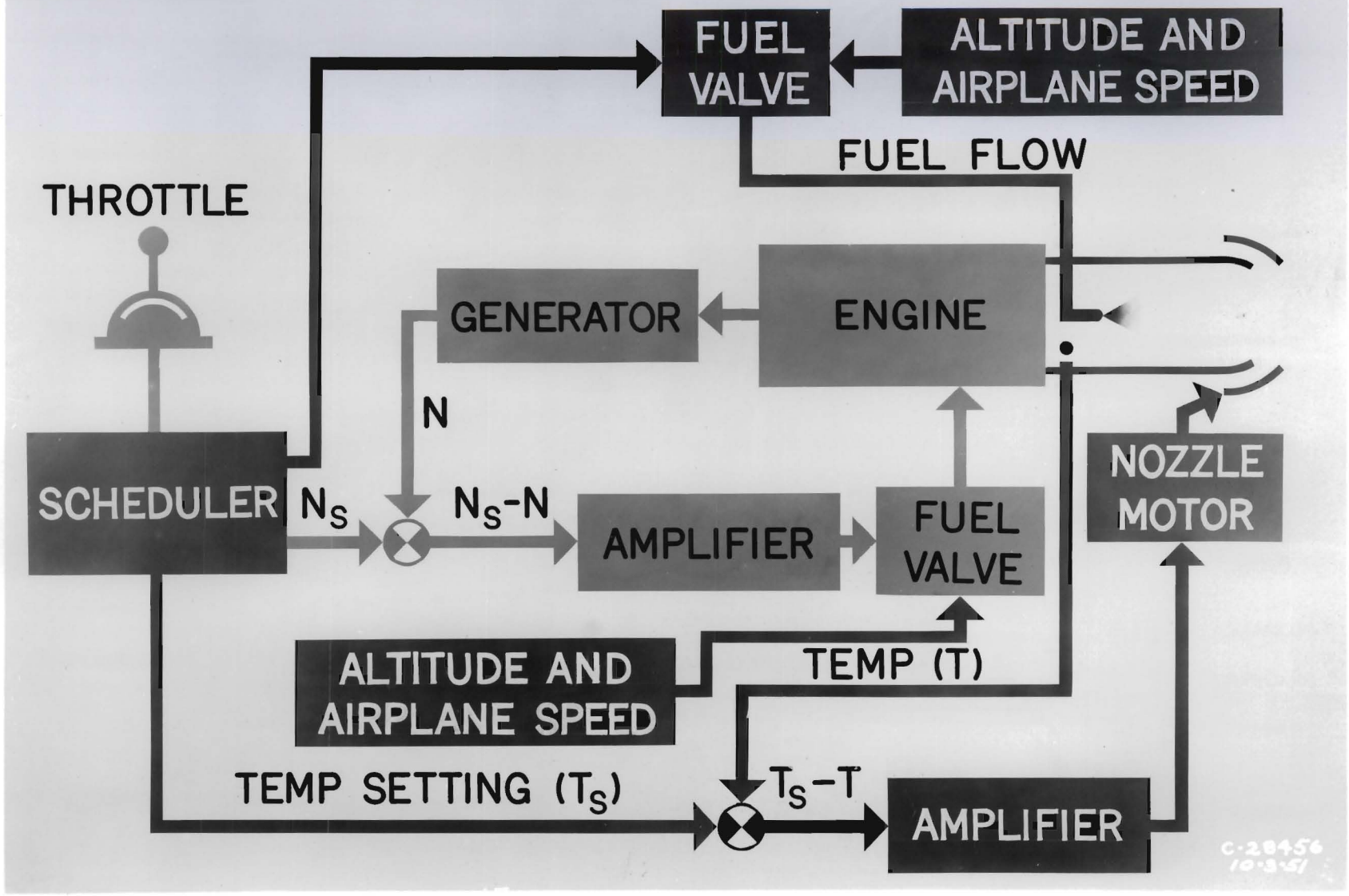
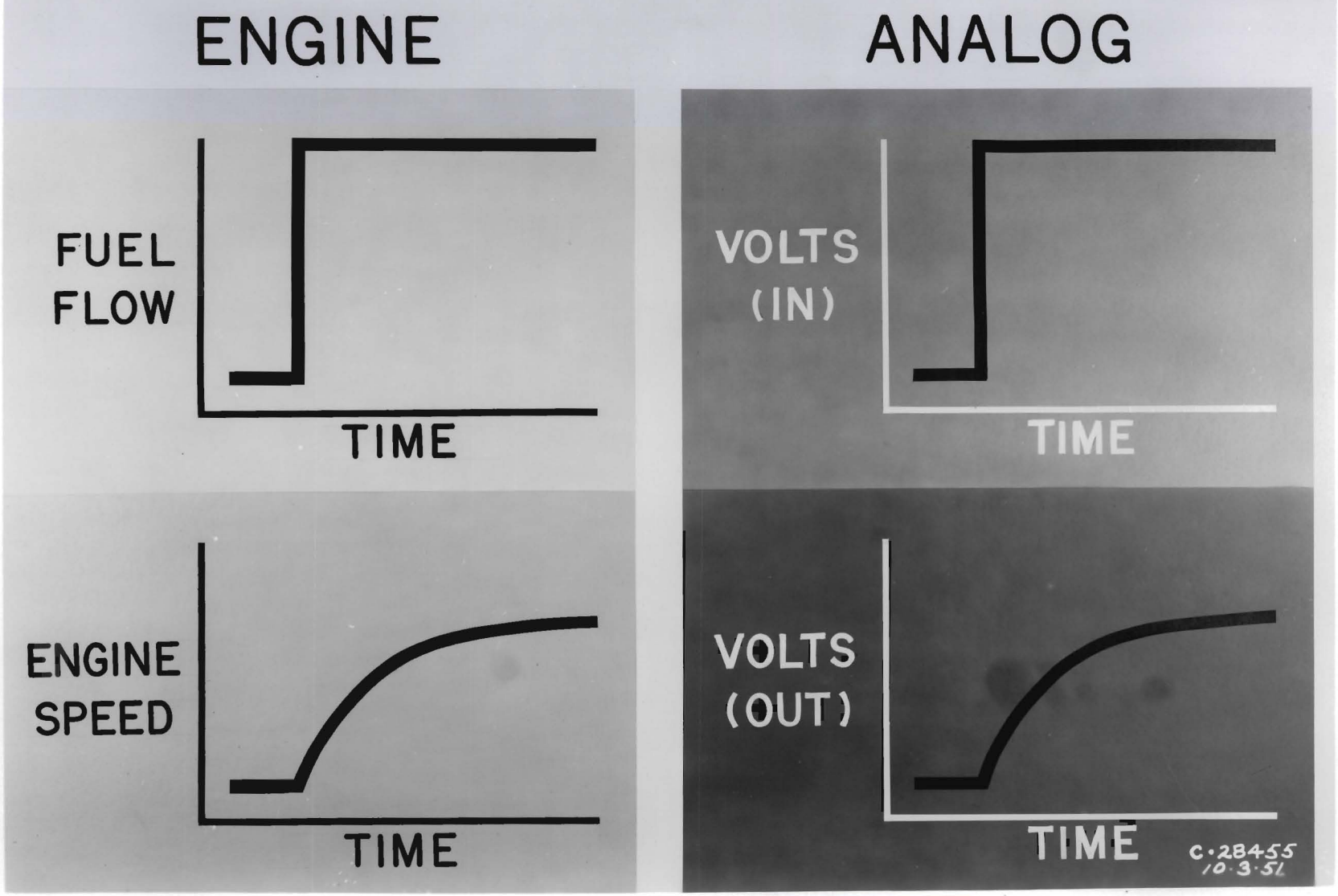
CONTROL FOR ENGINE WITH TAILPIPE BURNER



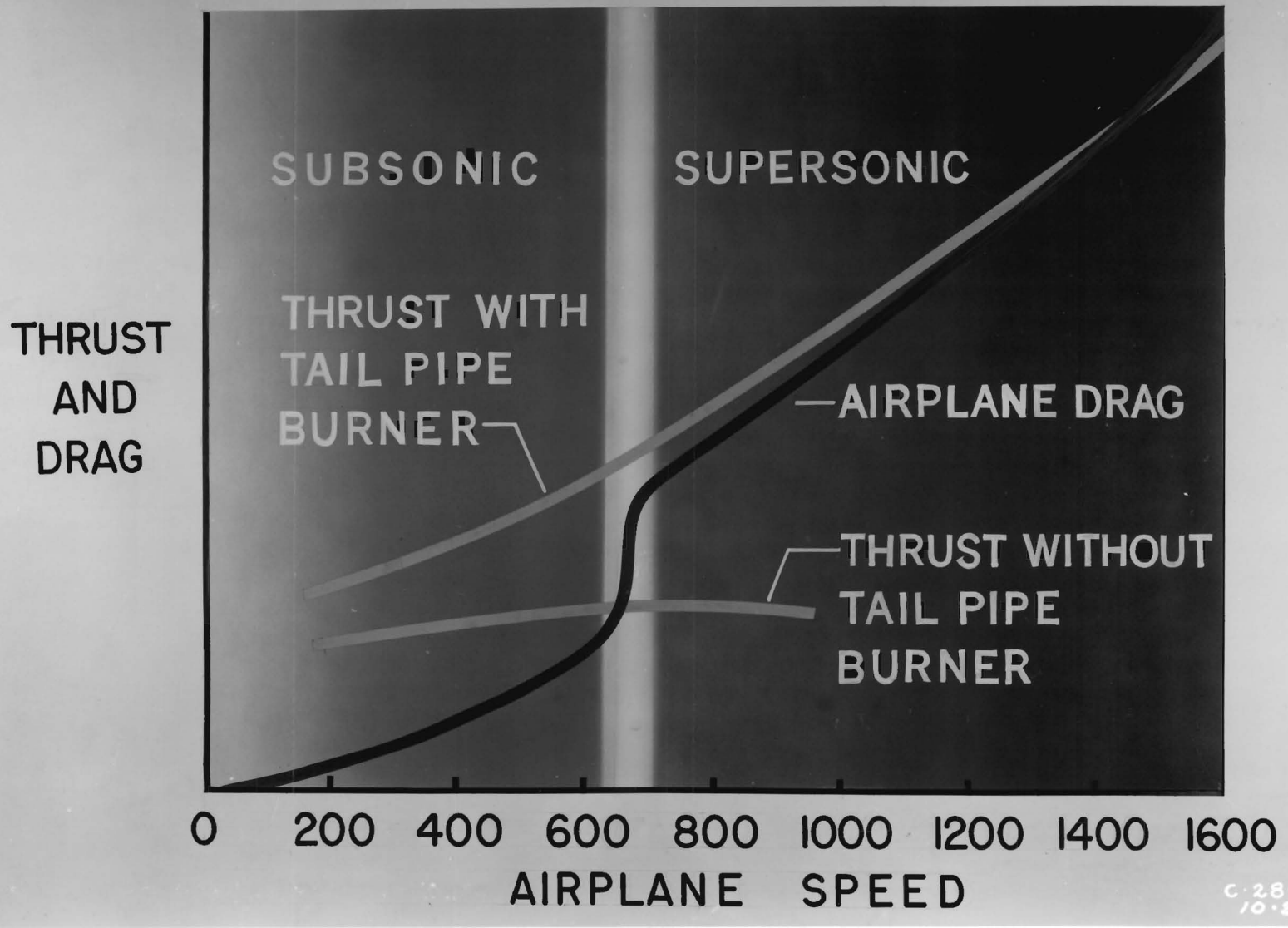
Altitude Engine Research -- Figure 2

COMPARISON OF ENGINE AND ANALOG



Altitude Engine Research -- Figure 3

ENGINE THRUST REQUIREMENTS



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Altitude Engine Research -- Figure 4

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