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FLIGHT RAM-JET WORK

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Calculations indicate that ranges on the order of 2000 to 4000 miles may be obtained with ram-jet powered aircraft at flight Mach numbers between 2 and 4. However, in order to obtain such long ranges, the ram jet must be operated at high combustion efficiency and good inlet pressure recovery. Investigations of combustion problems have been conducted in flight at subsonic speeds here at this laboratory by means of a rectangular ram jet installed in a wing which is mounted beneath the P-61 airplane and a 20-inch circular ram jet extended below the B-29. The wing ram jet (has been) will be demonstrated to you during the fly-by of the P-61 (later) and the 20-inch ram jet which was mounted on the B-29 is standing on end here. On this engine and the wing ram jet on the P-61, measurements have been made of the combustion efficiency, blowout limits, and ignition limits over a range of altitudes from sea level to 30,000 feet, and combustion-chamber velocities from 60 to 150 feet per second. Various types of burners have been investigated in order to determine the effect of burner design on combustion efficiency and combustion limits. Several of the burners investigated by the flight group and by other groups of the laboratory are capable of burning over wide ranges of fuel-air ratios and combustion chamber velocities with reasonably high combustion efficiency. However, there is still room for considerable improvement in combustion efficiency, particularly for ram jets having short combustion chamber lengths and high combustion chamber velocities of the supersonic wing-type ram jet.

In order to extend the combustion study to supersonic speeds and to investigate other problems associated with the supersonic ram-jet engine such as diffuser efficiency, fuel control, and engine external drag, tests are being made in free flight of a series of supersonic ram jets similar to the one to your left. See Figures 40 and 41 The promising performance possibilities of the ram-jet engine as a power plant for medium or long range supersonic missiles and the almost complete lack of actual ram jet engine performance data at transonic or supersonic speeds makes the data obtained from this project of particular importance.

The complete test engine is 16 inches in diameter and 14 feet long and includes a central body in which is located an 8-channel telemeter, fuel tank and fuel control system. The method used to obtain supersonic speeds is to release the ram jets from the B-29 airplane at an altitude of about 30,000 feet and allow the engine thrust and the force of gravity to accelerate the units. These operations are conducted in cooperation with the Langley Field laboratory of the NACA and the engines are released over the ocean near Wallops Island on the Virginia Coast. Sufficient data are transmitted through the combination antenna and pitot-static tube to the telemeter receiving station on the ground to enable us to determine the engine acceleration thrust coefficient, drag coefficient, diffuser efficiency, combustion efficiency and overall engine efficiency.

The central body is located in the forward section of the outer shells as shown in this section view. A single oblique shock spike diffuser is used. Compressed nitrogen stored in a helical coil inside the fuel tank is used to pressurize the fuel. The fuel control regulates the nitrogen flow into the fuel tank to give the desired fuel pressure throughout the flight. Fuel spray bars and a flame holder are located to the rear of the central body. Burning is initiated by two flares just upstream of the flame holder. The combustion-chamber wall is cooled only by the air flow over the outside of the shell.

It is planned to investigate five designs having different inlet and outlet areas to provide a wide range of combustion chamber velocities and design flight Mach numbers. To date we have tested only the first design.

To give a little better picture of our ram-jet flight research, a short movie will be shown covering this phase of our work.

DESCRIPTION OF MOVIE

The wing ram jet is mounted beneath the fuselage of the P-61 by means of two streamlined struts. Here the airplane is shown in flight just before the ram jet is started. The engine starts smoothly and is operating at a fairly rich fuel-air ratio which results in a long flame. Operation at leaner fuel-air ratios is not shown because the pale blue flame at the lower fuel-air ratios were hardly visible on the film. A rake of water-cooled total head tubes is located at the engine outlet. The measurements obtained from these tubes and other measurements inside the engine enable us to calculate the engine thrust, combustion efficiency, and specific fuel consumption.

This is the B-29 in flight and the 20-inch circular ram jet is being extended into the airstream before starting the engine. Because of the small ground clearance of the airplane, it is necessary to retract the ram jet into the bomb bay for landing and take-off operation.

The ram jet operator in the airplane is preparing to start the engine. Starting was usually accomplished by means of a spark plug, but magnesium flares were necessary for starting at altitudes about 25,000 feet. The fuel-air ratio here is somewhat above stoichiometric. A water-cooled rake of total pressure tubes is also located at the outlet of this engine. Water is used to cool the combustion-chamber walls and steam issuing from the water jacket is visible above the flame. The fuel-air ratio is now about 0.025 and the flame is very short.

The output of the telemeter antennas on the first of the 16-inch ram jets is being checked preparatory to flight. The operation of the fuel-control system was checked just prior to mounting the engine on the airplane. The airplane is now flying at 30,000 feet and the ram jet will be released as soon as the engine operator starts the engine and determines that it is operating satisfactorily. During the fall, telemeter data are being recorded at the ground station and the engine is being tracked by radar. No attempt is made to recover the engines after striking the water. A splash is visible on the film as the engine strikes the water. Close examination of the film shows that the burning in the engine was satisfactory all the way down. Of course, no attempt is made to recover the engine at the end of the flight.

Part of the data obtained from the telemeter and radar records of the flight are shown here. Fig. 42 The end of the flight occurred about 43 seconds after release. The Mach number at the end of the flight was about 1.4. The acceleration was increasing rapidly as the flight speed increased and had a value of 2.5 g at the end of the flight.

The difference between the thrust and drag coefficient at a Mach number of 1.4 was 0.16.

GK:jb

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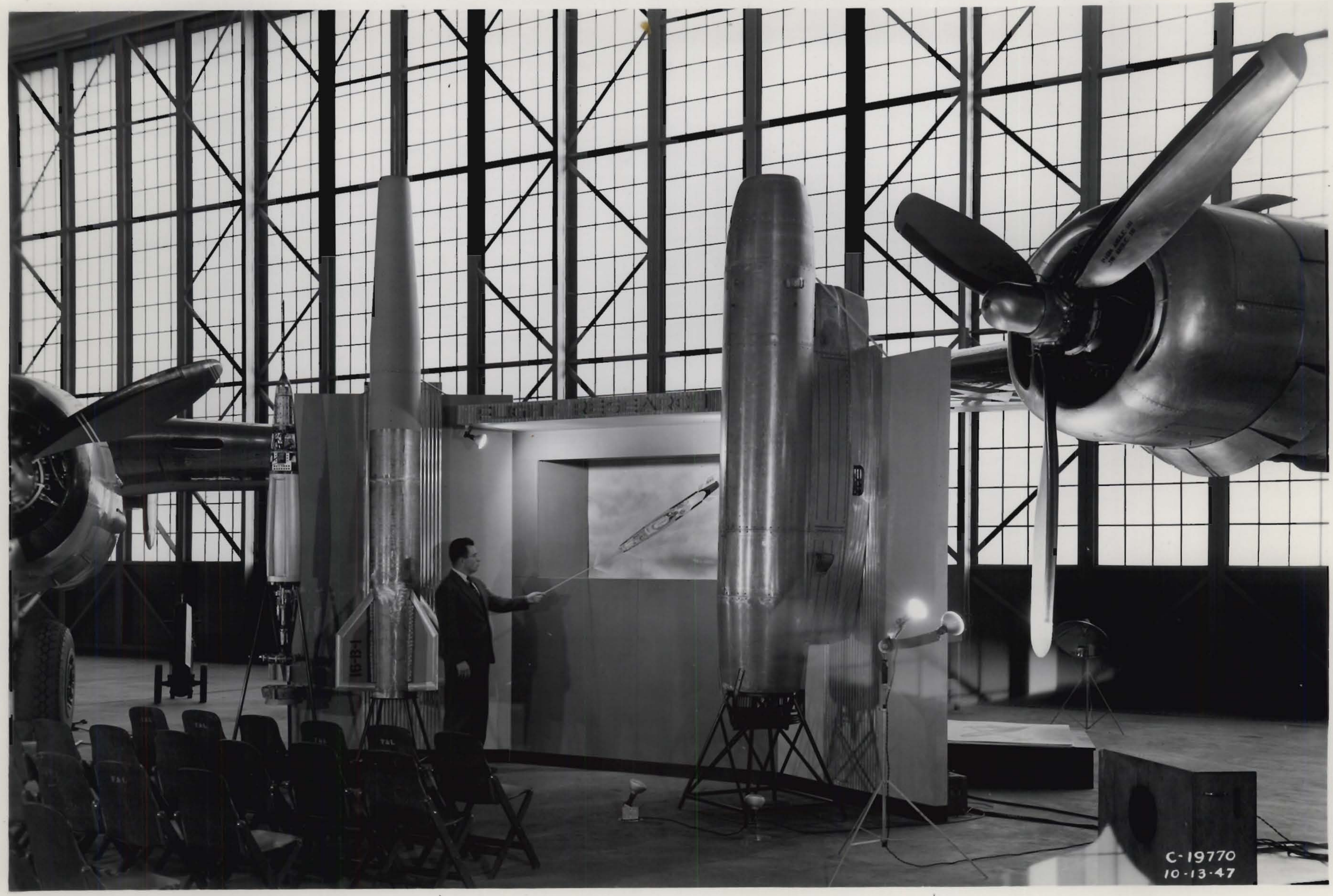

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Fig. 40

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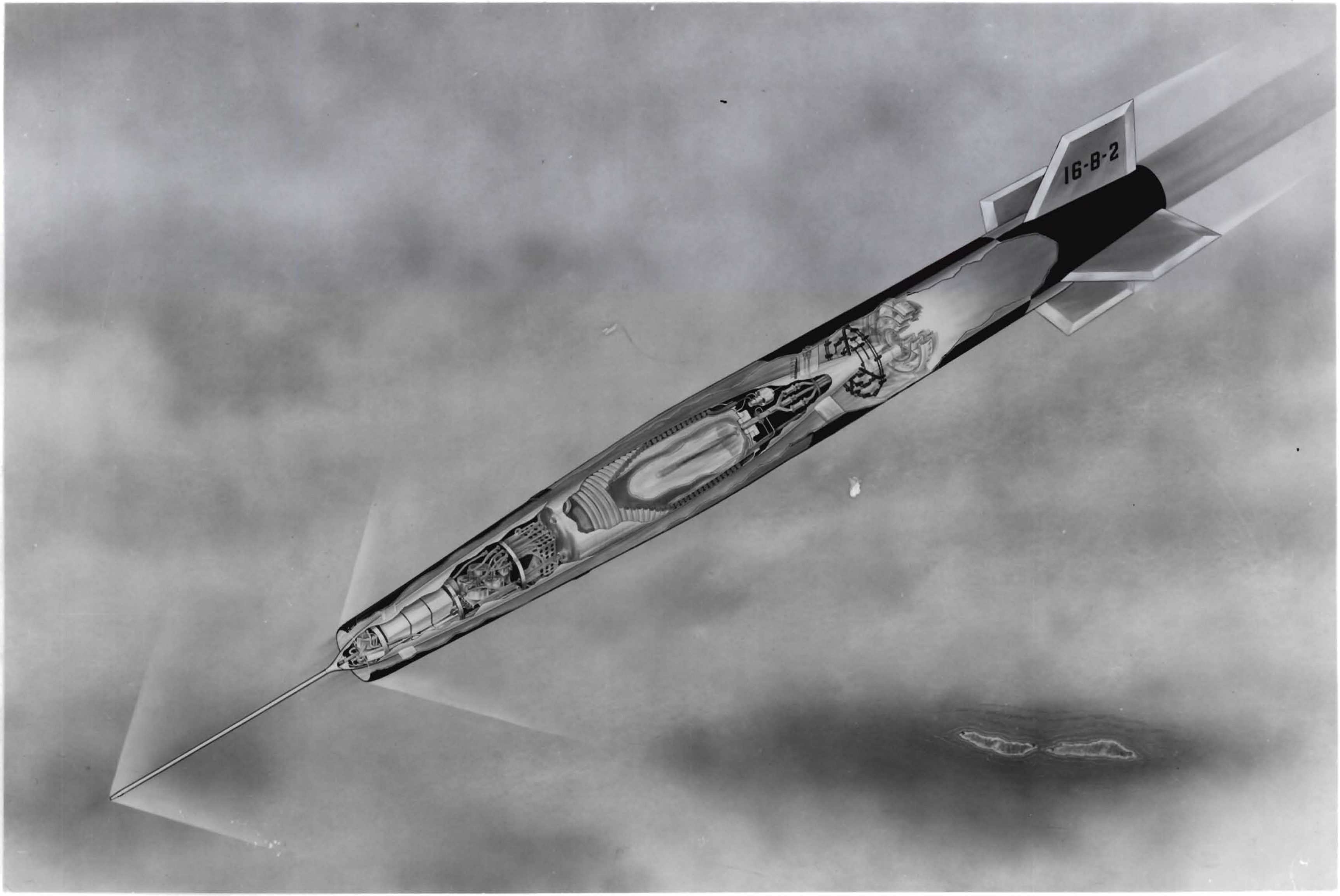

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Fig 41

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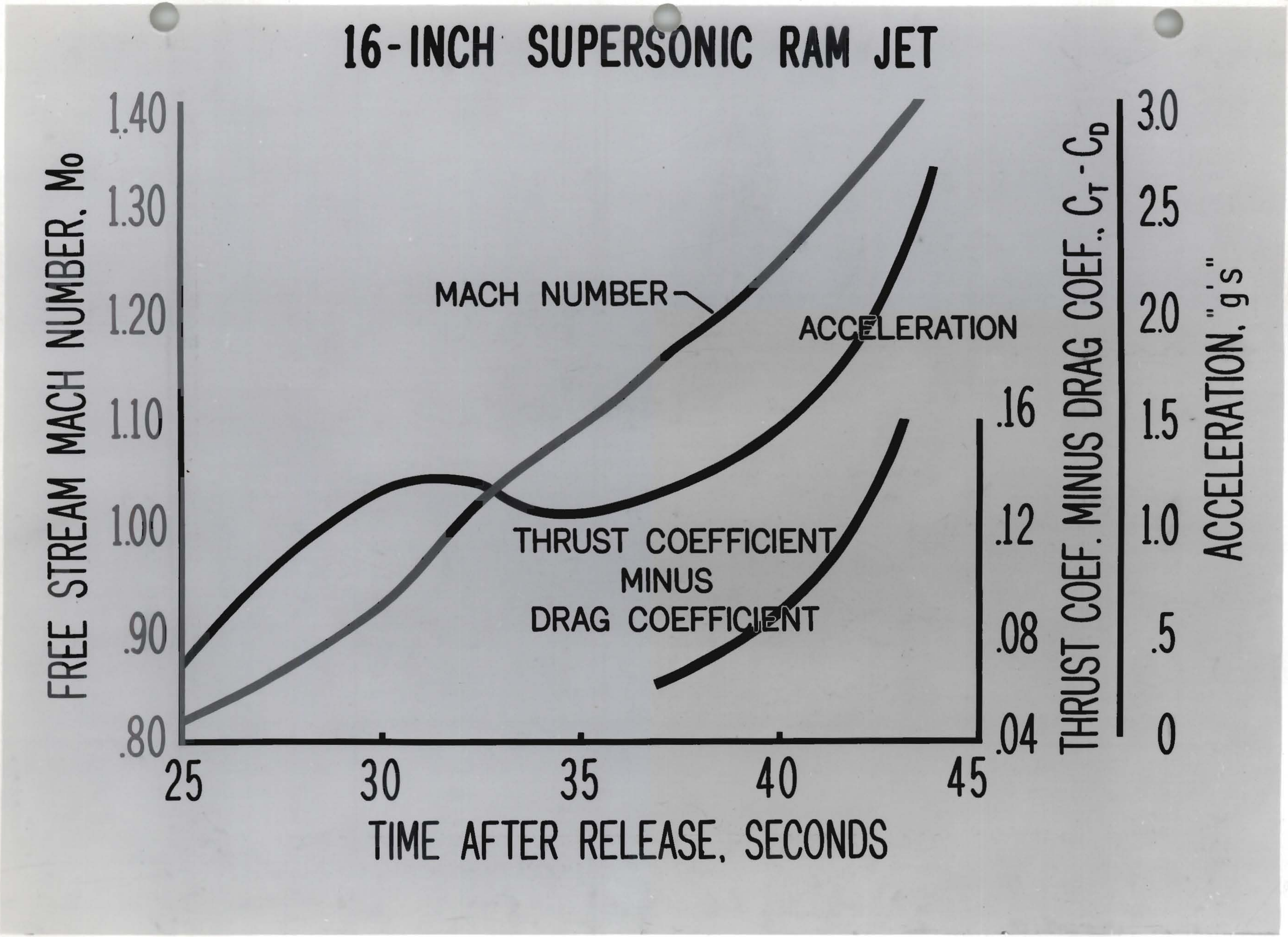

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Fig 42

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FLIGHT INSTRUMENTS
PRESSURE RECORDING INSTRUMENT
(MULTIPLE UNIT)
SIX ELEMENT PRESSURE RECORDER
NINE-POSITION PRESSURE SWITCH
SIX-SPEED TRANSMISSION
AUTOMATIC SEQUENCE CONTROL SWITCH
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