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ABSTRACT

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A program was conducted in the Jet Propulsion Laboratory Hypersonic Wind Tunnel to develop an operational technique for obtaining interference-free base pressure data. The technique developed utilizes a pneumatic launch mechanism to project the models into free flight and an electronic transmitter and receiver system to obtain base pressure data from the model. Both 10° and 15° half-angle cone configurations were tested.

Author

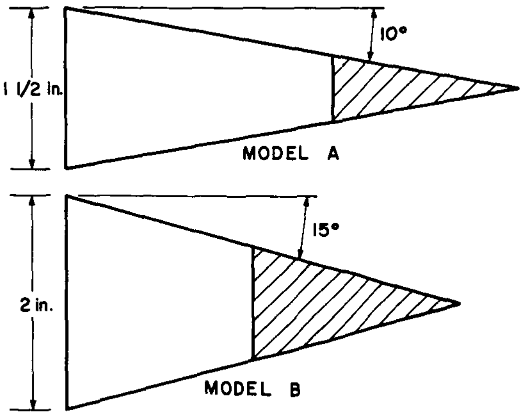
I. INTRODUCTION

It is often desirable in wind tunnel testing to obtain model pressure data that are free of model-support interference. Therefore, a program was conducted in the JPL Hypersonic Wind Tunnel for the purpose of developing an operational technique for obtaining interference-free base pressure data. The technique developed is easily adaptable to other model configurations and other pressures, e.g., model surface pressures. Other methods of obtaining support-free wind tunnel data have been investigated at JPL (Refs. 1 through 3) with emphasis on development of an operational method. Although the free-flight telemetry technique developed is considered operational, more sophisticated data reduction techniques are being developed for this type of testing.

II. MODEL DESIGN AND CONSTRUCTION

For this development program, the model configurations were limited to 10° and 15° half-angle cones (Fig. 1) launched at zero angle of attack. These were chosen for their simplicity of form and construction, and because comparable sting-mounted base pressure data were available.

The model noses were constructed of steel to prevent melting during flight, and to provide a proper center-of-gravity location. The bodies were constructed of injection molded styrene plastic (Fig. 2), and provided an interference-free signal path from the telemetry package to the antenna. The telemetry packages were supported



NOTE:
MODEL BODY IS PLASTIC
MODEL NOSE IS METAL

Fig. 1. Model dimensions

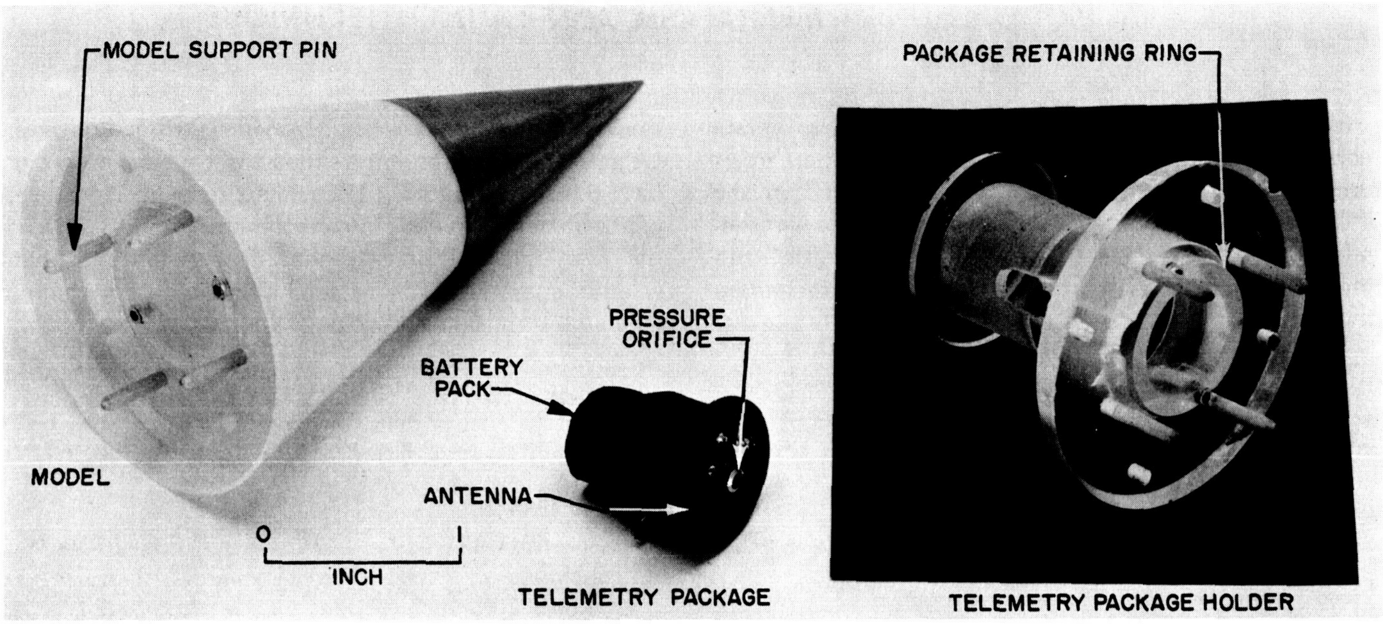


Fig. 2. Model and telemetry package

in the model by a Lucite holder (Fig. 2), whose design allowed the telemetry package to be easily installed or removed. Four symmetrically located wooden pins projected from the base of the model to provide support on the launch piston. These wooden pins, sometimes broken or damaged during flight, were easily replaced as were the plastic cone bodies and metal noses. The Lucite telemetry package holder, though sometimes broken during flight, usually provided sufficient protection to save the telemetry package from complete destruction. The model, however, was usually damaged or destroyed. A total of 134 runs was made with 12 telemetry packages.

III. TELEMETRY PACKAGE DESIGN AND CONSTRUCTION

The pressure telemetry package is 0.80 in. long, 0.80 in. in diameter at the inductor-antenna end, and 0.50 in. in diameter at the battery end. Total weight is ⅓ oz (Fig. 2 and Ref. 4).

The electronic circuit used is a Colpitts oscillator, consisting of a printed circuit inductor, a pressure sensitive capacitor, two small mercury cells, and other circuit components of the micro-miniature pellet type construction. The inductor also serves as the transmitter antenna.

Two sensitivity ranges have been used: 70-kc and 25-kc changes in frequency for a ΔP_b of 1 mm Hg. The package is insensitive to acceleration and thermal shock, and can be exposed to an ambient temperature of 800°F for at least 10 sec before an appreciable frequency shift occurs.

IV. MODEL LAUNCH MECHANISM AND LAUNCH TECHNIQUE

The model launch mechanism (Fig. 3) is similar to a configuration constructed for use in the JPL 20-in. Supersonic Tunnel (Ref. 5). The most outstanding difference is the addition of surface cooling for the higher temperature requirements of the Hypersonic Wind Tunnel. The complete launch mechanism consists of a pneumatic launching piston, and a model support and cooling shield assembly (Fig. 4). A constant model temperature of 150°F was maintained to the time of launch by discharging gaseous nitrogen over the model surface. Two thermocouples, one near the model surface and one near the model base, were monitored while the model was being cooled. The model surface temperature thermocouple is shown in Fig. 4. A reference pressure at the base of the model was sampled just prior to launch.

Launch sequence:

1. Model was mounted on the launch gun piston with the cooling shield in place (Fig. 3).
2. Test conditions were established in the tunnel test section.
3. Model support was retracted.
4. Base reference pressure was recorded.
5. Cooling shield was raised.
6. Launch piston retaining pin was released.
7. Launch piston moved forward and injected the model into free flight.
8. Model traveled to approximately the upstream edge of the test section viewing windows, then dropped to the floor and slid back into a catch basket at the rear of the test section.
9. Wind tunnel flow was then bypassed, and another run was initiated.

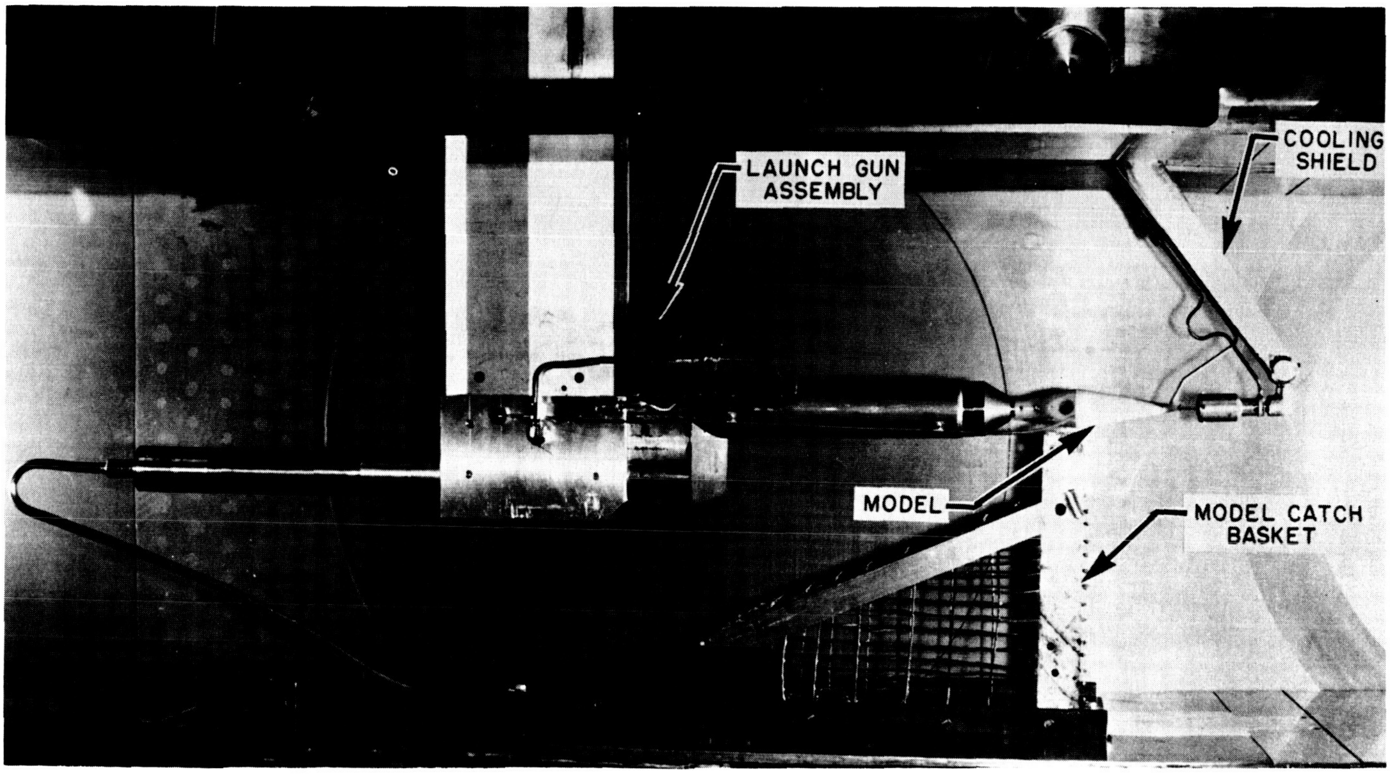


Fig. 3. Launch gun-cooling shield assembly

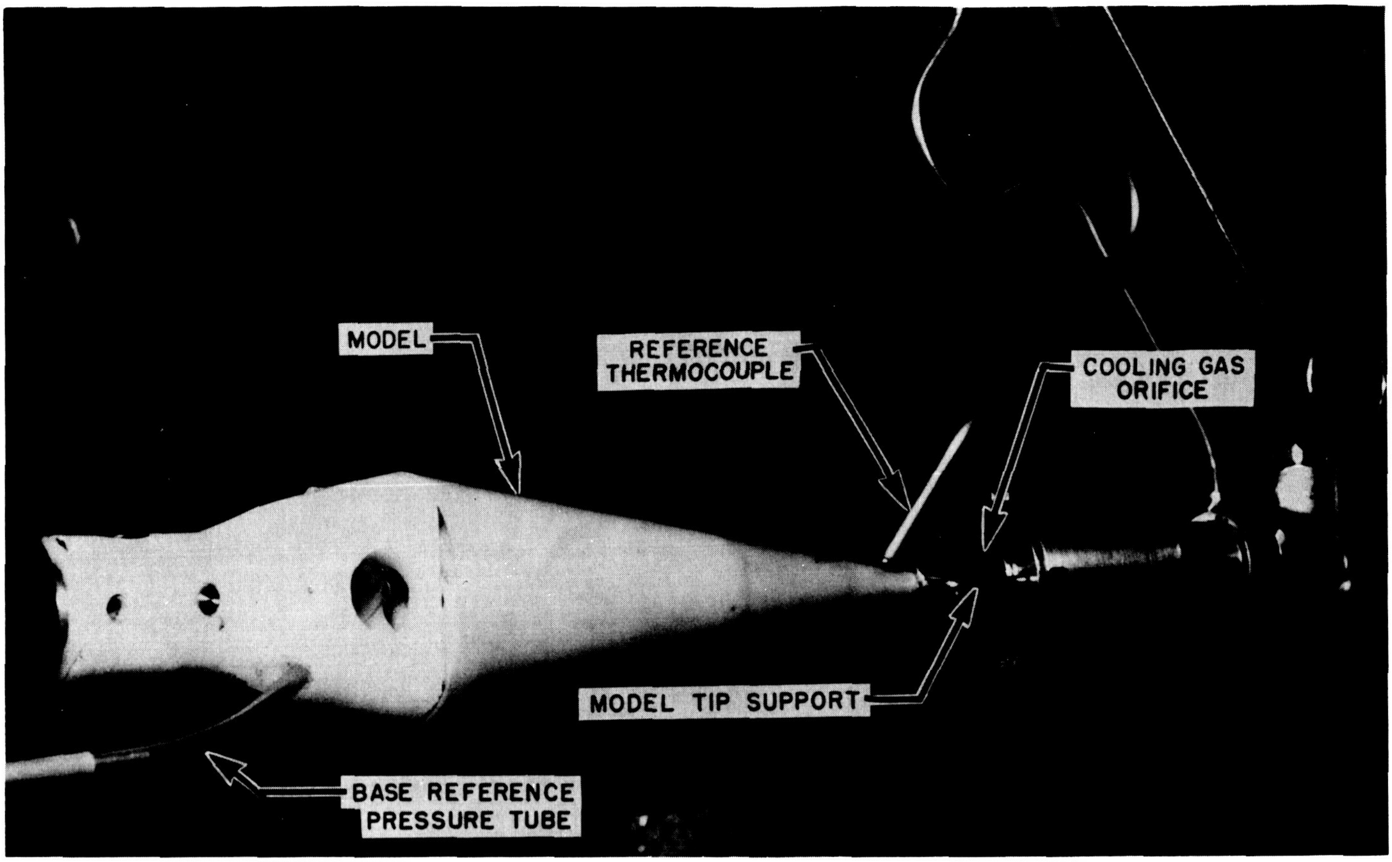


Fig. 4. Model mounted on launch gun

V. DATA ACQUISITION

The telemetry signal was received by a standard McIntosh FM tuner Model MR71. The receiving antenna was a half-wave loop attached to the test section window. In order to prevent interference from local FM stations, the tuner was realigned to receive the telemetry package signal (110 to 115 Mc). The output of the tuner was fed to an oscilloscope which was triggered by an event timer. The scope trace was photographed for each flight (Fig. 5); also shown in Fig. 5 is a sample antenna effect tare run. When the antenna effect could not be eliminated, these tares were applied as corrections to the pressure data. Tuner signal was simultaneously recorded on a CEC Visicorder (recording oscillograph). Prior to launch, tuner output was compared with model base reference pressure.

The base reference pressure was obtained with a 5-psia Statham transducer and was recorded by the wind tunnel central data system.

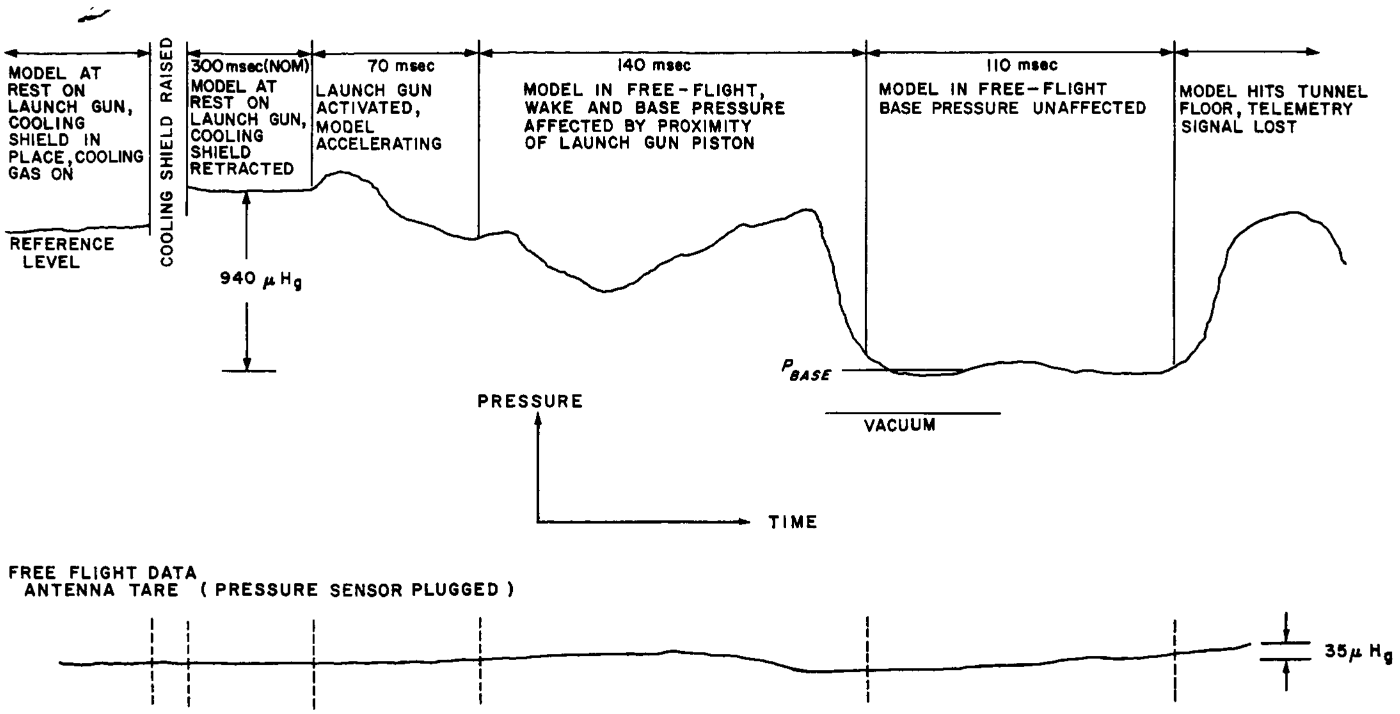


Fig. 5. Sample oscilloscope traces

High-speed motion pictures of each flight were taken with a Fastax movie camera at approximately 5,000 frames/sec. These optical data were used to determine model attitude during flight. Significant model oscillation was present in only two of the runs presented as data (Table 1).

Table 1. Data summary

Run	Mach No.	P_T, cm Hg	T_T, °F	σ, deg	α_m, deg	P_b/P_∞ Mean	$\Delta P_b/P_\infty$	Frequency of, pressure oscillation during flight, cps	Number of model oscillations during flight	$R_{D\infty} \times 10^{-6}$	Supply air moisture content, ppm
37	6	108	200	10	0	0.319	±0.047	12	0	0.069	1400
77	6	451	300	10	0	0.237	±0.028	120	0	0.237	1600
130	6	449	300	15	0	0.264	±0.048	0	0	0.314	960
131	6	451	300	15	0	0.210	±0.071	0	0	0.316	910
132	6	452	300	15	0	0.230	±0.058	0	0	0.316	1000
133	6	449	300	15	0	0.209	±0.057	0	0	0.314	1250
104	8	405	560	15	0	0.215	±0.055	0	0	0.086	1400
107	8	400	560	10	0	0.174	±0.091	0	0	0.063	2300
108	8	401	560	10	0	0.165	±0.100	0	0	0.063	2300
109	8	1000	670	10	<5	0.246	±0.038	60	2	0.135	1550
112	8	401	560	15	<2	0.340	±0.100	0	0.5	0.084	2100

VI. RESULTS AND CONCLUSIONS

The data curve shape with respect to model flight position is shown in Fig. 6; in Fig. 7, several erroneous data curves are compared with a typical usable curve. The data spread is caused by the linear or sometimes sinusoidal variation of the base pressure during the usable portion of the flight (Fig. 5). It is felt that this pressure variation is not due to model oscillation, since there was no oscillation for the majority of the flights. For the flights in which the model did oscillate, model oscillation and pressure oscillation did not coincide. The majority of the runs indicates a linear change in base pressure rather than a pressure oscillation. The limited amount of usable data obtained is plotted in Fig. 8 and tabulated in Table 1. The amount and accuracy of these data are considered sufficient to establish the advantages of this data gathering technique.

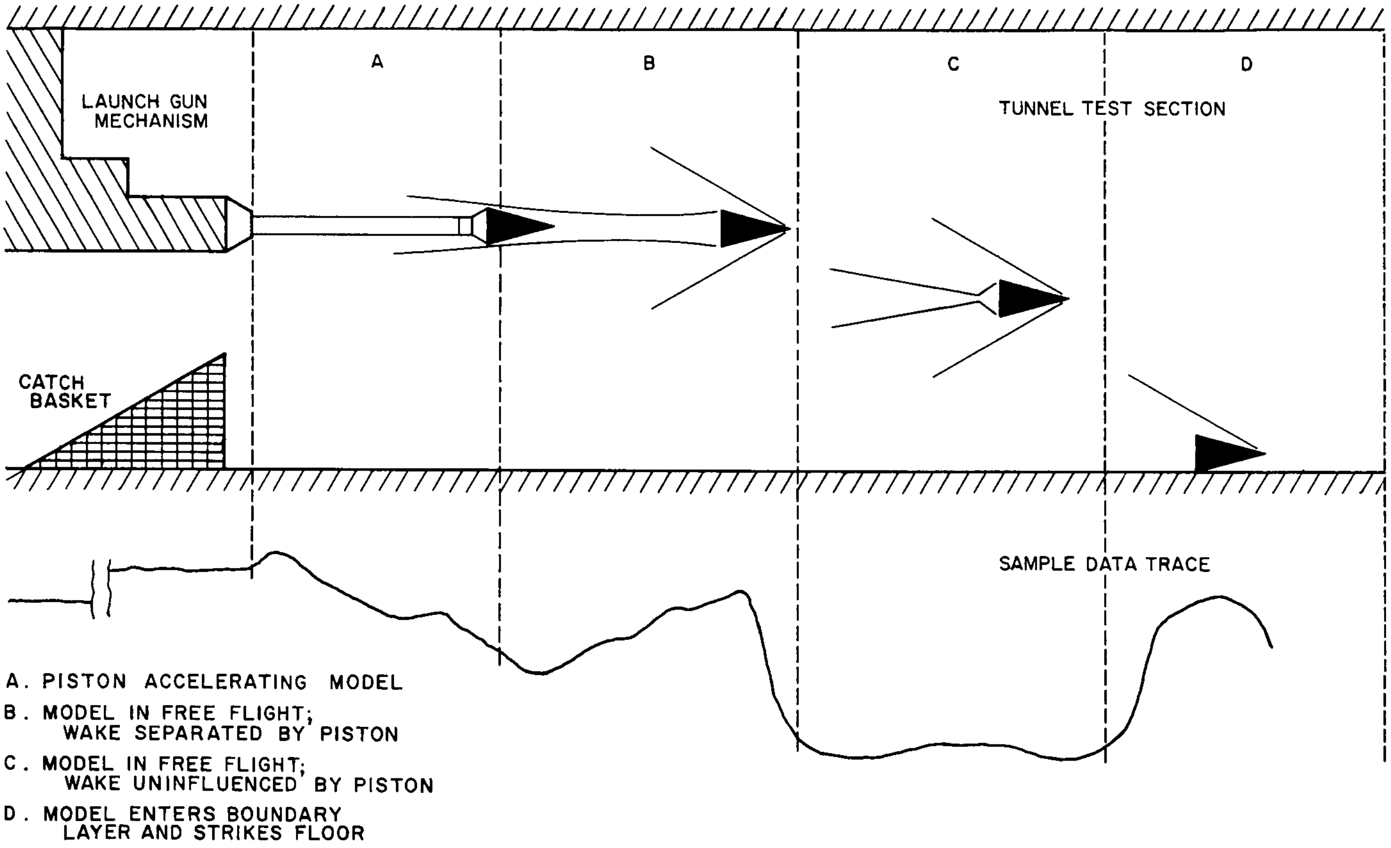


Fig. 6. Telemetry data curve with corresponding model flight position

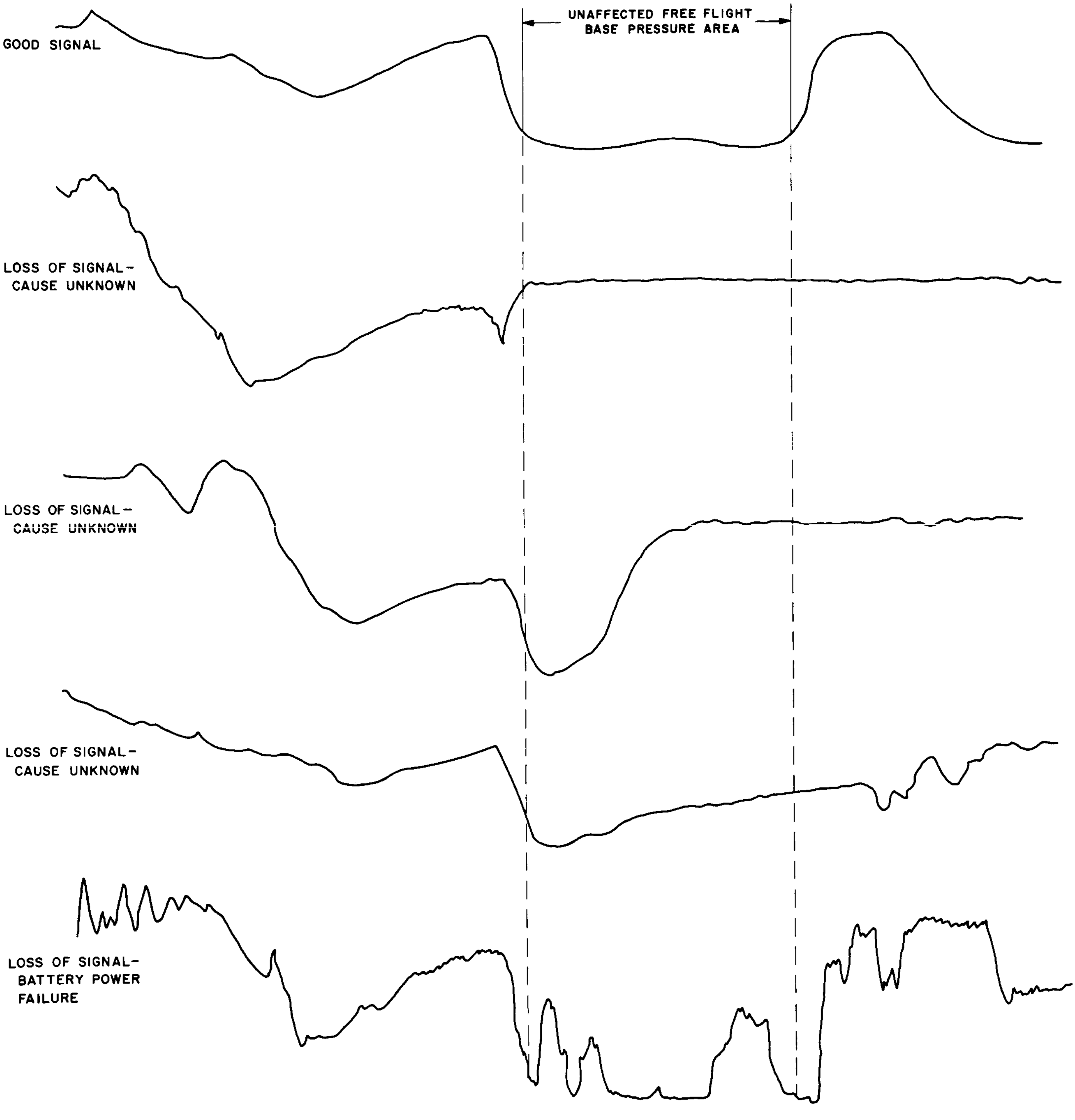


Fig. 7. Examples of erroneous base pressure telemetry signals

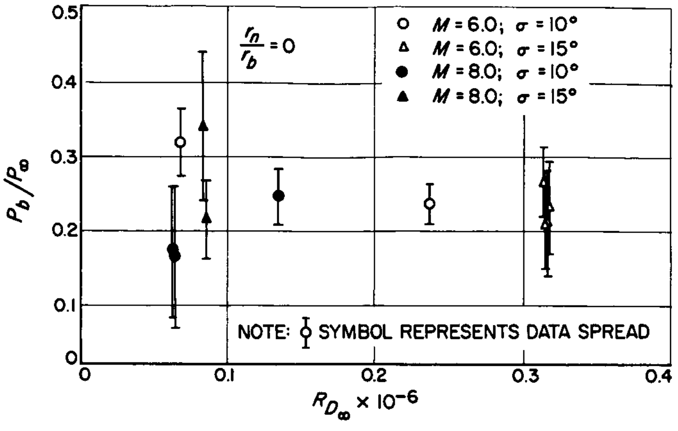


Fig. 8. Base pressure ratio versus Reynolds number

NOMENCLATURE

α_m	maximum model angle of attack during flight
P_T	supply pressure
P_b	model base pressure
P_∞	free stream static pressure
ppm	parts per million water vapor by volume
r_b	model base radius
R_{D_∞}	Reynolds number based on model diameter
r_n	model nose radius
σ	cone half angle
ΔP_b	model base pressure variation

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