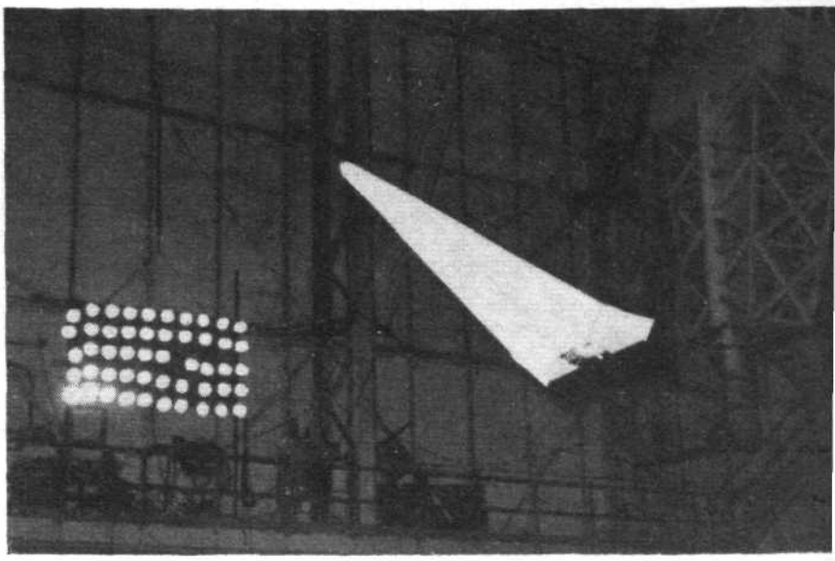


One of the many configurations studied is the slender delta. This example is being tunnel tested by the U.S. National Aeronautics and Space Administration, in an open-jet tunnel at the Langley laboratory

HYPERSONICS

Vehicles Intended for Controlled Flight at 15,000 m.p.h. : Some British and American Suggestions

EARLIER this year a Symposium on Hypersonic Flow was sponsored by the Colston Research Society, and held at the University of Bristol. From the many papers there presented, we have chosen two for abstraction in order to provide an outline of the type of craft which may become familiar within 20 years.

The first paper was presented by H. Metcalfe of the G.W. aerodynamics department, Bristol Aircraft. He opened his paper by postulating generally accepted limits for sustained flight at about 15 to 40 lb/sq ft wing loading and equilibrium skin temperatures of 1,000 to 1,200 deg K for steel airframes. In certain circumstances, ablation, insulation, heat-sink or refrigeration techniques enable reasonably sustained flight to be achieved at higher skin-temperatures. Strategic ballistic missiles penetrate the equilibrium skin-temperature limit on re-entry. A range of low-altitude flight conditions is shown in Fig. 1.

Fig. 1. Flight regimes for ballistic missiles

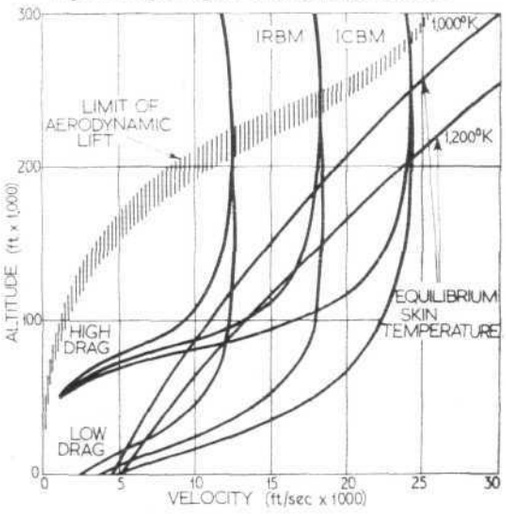
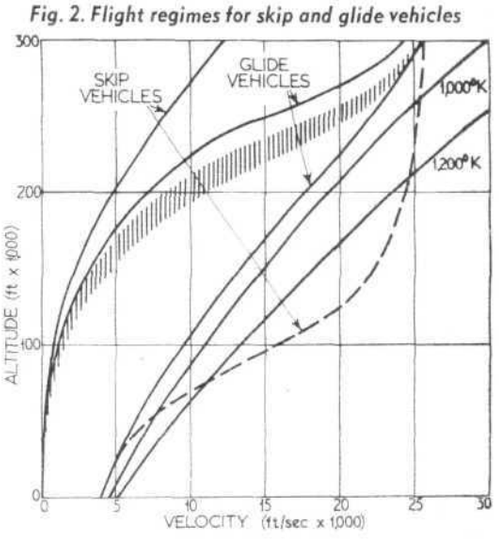


Fig. 2. Flight regimes for skip and glide vehicles



Glide and skip vehicles for space-ferry missions (Fig. 2), do not need aerodynamic lift over parts of the trajectory—for instance, when the glide vehicle is spiralling in, and when the skip vehicle is moving along a ballistic trajectory. The glide vehicle would presumably be so designed that the equilibrium temperature would be marginally inside the limits shown for reference; the skip vehicle is a more severe case, but the high-temperature condition is transient.

In Fig. 3 is shown the standard flight envelope for sustained flight with air-breathing power units and, superimposed, a possible envelope for anti-missile missiles where insulation techniques for the main structure are an economical proposition. Table I summarizes characteristics for eight types of vehicle.

In hypersonic flight, a good initial lifting capability is achieved with a thick wedge-type wing, and high aspect ratio is not important. Hypersonic vehicles can thus best be formed out of simple shapes such as cones and wedges, the whole volume being used for payload. A whole family can be constructed from simple transformations of the basic forms of sphere, cylinder, or cone (Figs. 4 and 5). Certain characteristics depend on cross section as well as planform; in particular, stability requirements may well lead to a distribution of the total volume so that a quasi-body appears as part of one surface of a wing.

Lifting capability for a given body volume (and hence roughly for a given weight) for a family of simple shapes is shown in Fig. 6. The effects of section stand out compared with those of planform. The results shown are for a nominal 30 deg

TABLE 1: CHARACTERISTICS FOR SIX TYPES OF VEHICLE

	Heating	Order of weight (lb)	Design altitude (ftx1,000)	Max. C_N	C_{Do}	Max. C_{Di}	L/D	Manned	Normal (lift.) 'g'	Longitudinal (decel.) 'g'
Ballistic re-entry:										
Low drag	Very severe	10^3-10^4	40-100	Z	S	Z	Z	No	Z	VL
High drag	Severe	10^3-10^4	70-150	Z	L	Z	Z	No	Z	VL
Skip vehicles:										
Long range	Intermittently severe	10^4-10^5	100-250	VL	M	L	L	No	L	M
Orbital re-entry	Intermittently severe	10^4-10^5	150-300	VL	M	VL	S	Yes	L	M
Glide vehicles:										
Long range	Moderate	10^3-10^5	180-240	L	M	M	L	No	S	S
Orbital re-entry	Moderate	10^4-10^5	200-300	VL	M	VL	S	Yes	S	M
Sustained flight	Moderate	10^5-10^6	80-150	M	S	M	L	Yes	S	VS
Anti-aircraft and anti-missile missiles	Possibly severe for short time	10^3-10^4	40-100	L	S	M	M	No	VL	L

Abbreviations: Z, zero; S, small; M, moderate; L, large; VL, very large.