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INVESTIGATION OF TRANSITION OF LAMINAR BOUNDARY LAYER INTO TURB--ETC(U)
AUG 78 B V BOSHENYATOV, V V ZATOLOKA
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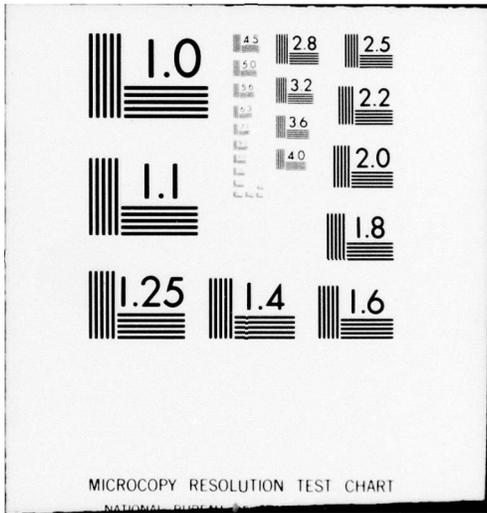
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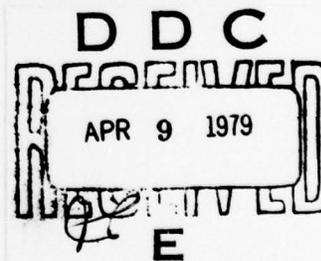
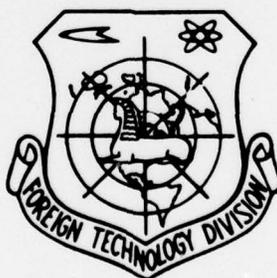
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INVESTIGATION OF TRANSITION OF LAMINAR BOUNDARY
LAYER INTO TURBULENT IN HYPERSONIC IMPULSE
TUNNEL IT-301 AT M = 8-11.5

by

B. V. Boshenyatov, V. V. Zatoloka
M. I. Yaroslavtsev



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FTD-ID(RS)T-1228-78

EDITED TRANSLATION

FTD-ID(RS)T-1228-78

11 August 1978

MICROFICHE NR: *FTD-78-C-001111*

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English pages: 5

Source: Aerofizicheskiye Issledovaniya Institut Teoreticheskoy i Prikladnoy Mekhaniki SO AN USSR, Novosibirsk, Nr 2, 1973, Page 89.

Country of origin: USSR
Translated by: Robert A. Potts
Requester: FTD/TQTA
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U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

Block	Italic	Transliteration	Block	Italic	Transliteration
А а	<i>А а</i>	A, a	Р р	<i>Р р</i>	R, r
Б б	<i>Б б</i>	B, b	С с	<i>С с</i>	S, s
В в	<i>В в</i>	V, v	Т т	<i>Т т</i>	T, t
Г г	<i>Г г</i>	G, g	У у	<i>У у</i>	U, u
Д д	<i>Д д</i>	D, d	Ф ф	<i>Ф ф</i>	F, f
Е е	<i>Е е</i>	Ye, ye; E, e*	Х х	<i>Х х</i>	Kh, kh
Ж ж	<i>Ж ж</i>	Zh, zh	Ц ц	<i>Ц ц</i>	Ts, ts
З э	<i>З э</i>	Z, z	Ч ч	<i>Ч ч</i>	Ch, ch
И и	<i>И и</i>	I, i	Ш ш	<i>Ш ш</i>	Sh, sh
Й й	<i>Й й</i>	Y, y	Щ щ	<i>Щ щ</i>	Shch, shch
К к	<i>К к</i>	K, k	Ъ ъ	<i>Ъ ъ</i>	"
Л л	<i>Л л</i>	L, l	Ы ы	<i>Ы ы</i>	Y, y
М м	<i>М м</i>	M, m	Ь ь	<i>Ь ь</i>	'
Н н	<i>Н н</i>	N, n	Э э	<i>Э э</i>	E, e
О о	<i>О о</i>	O, o	Ю ю	<i>Ю ю</i>	Yu, yu
П п	<i>П п</i>	P, p	Я я	<i>Я я</i>	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ë in Russian, transliterate as yë or ë.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	sinh ⁻¹
cos	cos	ch	cosh	arc ch	cosh ⁻¹
tg	tan	th	tanh	arc th	tanh ⁻¹
ctg	cot	cth	coth	arc cth	coth ⁻¹
sec	sec	sch	sech	arc sch	sech ⁻¹
cosec	csc	csch	csch	arc csch	csch ⁻¹

Russian English

rot curl
lg log

1228

INVESTIGATION OF TRANSITION OF LAMINAR BOUNDARY LAYER INTO TURBULENT
IN HYPERSONIC IMPULSE TUNNEL IT-301 AT $M = 8-11.5$

E. V. Eoshenyatov, V. V. Zatulovskaya, M. I. Yaroslavtsev.

In an impulse tunnel there is conducted a study of the phenomenon of transition of laminar boundary layer into turbulent on sharp cones at Mach numbers 8-11.5; $Re = 2-8 \cdot 10^7$ I/m. An optical method of determination of the transition is proposed, based on the property of the turbulent boundary layer to withstand without separation more intense pressure jumps than the laminar boundary layer [1, 2]. Fig. 122 shows the relationships of the separation angle β to the time in three different starts of the tunnel, distinguished from each other by the level of Re numbers at $M = 8.3$. On the graphs of $Re_e - \frac{p_{st}}{\mu}$ are placed points, corresponding to sharp decrease of the separation angle β . It is clear that sharp decrease of β occurs approximately at the same $Re_e(t) = (5-6) \cdot 10^6$ (spread ± 8 o/o).

The Reynolds numbers of the transition, determined in IT-301 by this method, agree (see Fig. 2) with data (Fig. 123) obtained in steady-state conditions. Data on the transition are compared taking into account the effect of single Reynolds number. For IT-301 $Re_n \sim 0.3-0.4$.

By investigations on the transition in IT-301 it is experimentally proven that in IT-301 there are achieved Re numbers, sufficient in order to obtain turbulent hypersonic boundary layer on models of medium dimensions (150-300 mm).

Furthermore, it is shown that the duration of the operating mode in IT-301 is sufficient for the study of flow with separation of boundary layer. In this case flow around the models also carries a quasi-steady character.

REFERENCES

1. J. P. Batham. An experimental study of turbulent separating and reattaching flows at a high Mach number. J. Fluid Mech., (1972), v.

52, part 3, pp. 425-435. Printed in Great Britain.

2. G. N. Abramovich, Applied gas dynamics. M., "Nauka" (Science),
1969.

CALCULATION OF FRICTION AND HEAT EXCHANGE IN NOZZLES WITH TURBULENT
SECONDARY LAYER DURING NONEQUILIBRIUM OUTFLOW OF PARTIALLY DISSOCIATED
AIR

Ye. G. Zaulichnyy.

During calculation of the expansion of dissociated air in nozzles at high parameters of stagnation and large Mach numbers the correct calculation of flow parameters acquires much significance in connection with the nonequilibrium character of the chemical reactions and oscillatory relaxation and distortion of the nozzle profile due to growth of the boundary layer at its walls [1-3].

For air in the region of temperatures up to 6000 °K and $10 \leq P_0 \leq 1000$ atm (abs.) it is sufficient to approximately consider the nonequilibrium character of inviscous flow in the nozzle by the method of "instant freezing", having taken the dissociation of oxygen in this case as the basic process [3, 4].

Using the Lighthill model for ideally dissociated gas and the assumption about isentropicity of flow taking into account equations of continuity, motion, energy for one-dimensional flow in nozzles, it is possible to easily obtain the condition of search of the "freezing section" and to determine the flow parameters along the length of the nozzle

$$\frac{(0.231 - C_3) \rho_3^{-2/T_3}}{C_3 (1 + C_3) T_3} = \frac{2}{F} \left(\frac{\alpha F}{\alpha x_1} \right)_3 \frac{U_3}{\Phi} \quad (1)$$

Here $\Phi = \frac{931 K_1 \rho_0 x_{1L}}{\mu_0^2 U_1}$ is the parameter characterizing the ratio of speeds of recombination to the speed of the stay of particles in the nozzle, K_1 - speed of recombination of oxygen atoms, for several reactions K_1 is written as total, μ_0 - molecular weight of air, x_{1L} - characteristic length of nozzle, C, ρ, U - concentration of dissociated atoms, their density and speed; F - area of cross section of nozzle; T - temperature, β - "freezing", α - dissociation; 0.231 - mass portion of oxygen in air.

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