AD-A066 282 FOREIGN TECHNOLOGY DIV WRIGHT-PATTERSON AFB OHIO F/G 22/3

ONE CONTROL ALGORITHM FOR FINAL RATE OF DESCENT OF AUTOMATIC VE--ETC(U)

MAR 78 N M IVANOV, A I MARTYNOV

UNCLASSIFIED FTD-ID(RS)T-0196-78 NL

1 OF 1
ADA
066282

END
DATE
FILMED
5-79
DDC

FTD-ID(RS)T-0196-78

(1)

FOREIGN TECHNOLOGY DIVISION

AIR FORCE SYSTEMS COMMAND

ONE CONTROL ALGORITHM FOR FINAL RATE OF DESCENT
OF AUTOMATIC VEHICLES IN MARTIAN ATMOSPHERE

by

N. M. Ivanov, A. I. Martynov

FOREIGN TECHNOLOGY DIVISION

EDITED TRANSLATION

FTD-ID(RS)T-0196-78 28 March 1978

MICROFICHE NR: FTD-78-C-000440

ONE CONTROL ALGORITHM FOR FINAL RATE OF DESCENT OF AUTOMATIC VEHICLES IN MARTIAN ATMOSPHERE

By: N. M. Ivanov, A. I. Martynov

English pages: 18

Source: Uchenyye Zapiski TsAGI Vol. 2, No. 5, 1971, pp. 64-72.

Country of origin: USSR
Translated by: Marilyn Olaechea
Requester: FTD/SDBG

U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

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

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

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

ONE CONTROL ALGORITHM FOR FINAL RATE OF DESCENT OF AUTOMATIC VEHICLES IN MARTIAN ATMOSPHERE

N. M. Ivanov, A. I. Martynov

ABSTRACT Proposed is a simple control algorithm for the final rate of descent of automatic vehicles in the Martian atmosphere which gives a minimum speed at a certain final altitude. The lifting force vector is controlled by changing effective quality. Presented here are numerical results obtained from estimating the effectiveness of the proposed algorithm for two hypothetical landing vehicles having the same value of available quality $K_{расп} = 0.3$ but a different reduced load on the frontal surface: P_X = 80 kgf/m² and P_X = 250 kgf/m². END ABSTRACT

The rarefied Martian atmosphere complicates the landing of space vehicles on its surface when aerodynamic braking is used. In a number of studies (see, for example [1]-[3]) it has been shown that only in the presence of automatic guidance facilities assuring relatively accurate entry into the atmosphere (navigation corridor of entry with respect to altitude of conditional pericenter ΔH_π = 150 km) and in using landing vehicles (LV) with lifting force, can almost complete damping of the energy of the LV be achieved by using the atmosphere. Here one of the central problems is that of creating a system for controlling landing (LCS). The considerable scatter in entry conditions (primary with respect to altitude of the conditional pericenter of entry trajectory H_π), the high degree of indeterminacy in the value of atmosphere parameters [2] in combination with the requirement for maximal simplicity and reliability of the LCS complicate the solution to this problem.

The problem of controlling a LV in the Martian atmosphere, at least in the first stage, can be formulated as a problem of controlling the rate of descent $V_к$ at a given final altitude $H_к$. This rate should be minimal for creating the most favorable conditions for operation of a soft landing system (SLS). It is assumed that when $H=H_к$

the regime of steady-state descent has not yet begun. Flight range L plays no substantial role, and can be ignored. With automatic LV in mind, load factor limitations need not be considered.

Given in this article is an analysis of an automatic control algorithm for final speed, which has a simple structure and requires only simple measuring and calculation devices for its achievement. At the same time the algorithm does possess the necessary universality and flexibility for use under different conditions of approach to Mars. The proposed algorithm provides reliable and sufficiently accurate guidance of the LV to the assigned final altitude $H=H_{к}$ with a velocity value close to the minimal while maintaining the altitude limitation $H \geqslant H_{доп}^{min}$. Studied in this case was the equation using the angle of roll at which the effective aerodynamic equality

$$K_{эф} - K_{б} \cos\gamma,$$

where $K_{б} - K_{расп}$ is the value of quality at a balanced angle of attack, γ - of roll.

Normal control program. Studies conducted earlier [3] showed that results close to optimal from the standpoint of obtaining $V_{к\,min}$ for LV with average values of reduced load on the frontal surface $P_{x} = G/c_{x}S$, provides a control program with a single switching of the roll angle. The LV enters the Martian atmosphere with a minimal value of effective quality $K_{min}(\gamma = \gamma_{max})$. At a certain moment in time there occurs the transition to flight with $K_{эф} = K_{max}(\gamma = 0)$. Thereafter vehicle movement occurs with a constant value of $K_{эф}$. Despite the fact that the position of the switching point is largely dependent on many factors (primarily on the parameters of atmosphere, initial entry conditions and characteristics of the vehicle), as a whole the control program is extremely simple and can therefore be used in the capacity of a nominal program for creating a control algorithm. For this purpose we must determine by onboard means a switching point which will satisfy the conditions of the problem which has been posed for obtaining $V_{к\,min}$ with the actual parameters of the trajectory, LV, and the atmosphere.

Selection of switching line. In the general case the switching point for each specific i-th trajectory can be assigned by coordinates V_{in}, θ_{in}, H_{in}, where θ is the angle of inclination of the trajectory to the horizon. As already mentioned, flight range L_{in} is not included in the number of parameters, since no limitations on the flight range of the LV are imposed by the conditions of the problems. The family of disturbed trajectories will have a corresponding family of switching points V_{in}, θ_{in}, H_{in}. Thus we can plot a certain surface for switchings of the roll angle in the space of phase coordinates V_{n}, θ_{n}, H_{n}. Generally it is difficult for onboard facilities to "memorize" such a surface, and in order to use it we must have a computer for calculating the current values of V, θ, and H aboard the LV.

Let us use the very widely employed method of transition from V, θ, H to certain, to some degree equivalent, parameters, which are more accessible to measurement by simple onboard facilities, for example, apparent velocity $V_S = g_0 \int_{t_0}^{t} n_x dt$, loadfactor n_x and the derivative from the loadfactor with respect to time $\dot{n}_x$. Obtaining $\dot{n}_x$ involves certain technical difficulties, and thus to plot the control algorithm we must first examine only two parameters V_S and n_x. In this case the three-dimensional switching surface V_{in}, θ_{in}, H_{in} breaks down into a certain curve in the plane of the phase coordinates V_{Sn} and n_{xn}. Parameter n_{xn} can be replaced by parameter t_n - switching time, which is calculated from a certain fixed value of loadfactor $n_x = n^*_x$ apparent velocity $V_S = V^*_S$.

The main factors which affect selection of the switching point for a LV with assigned characteristics and for a certain assigned entry speed are the scatter in altitude of the conditional pericenter of entry trajectories ΔH_{π}, indeterminancy in the value of atmosphere parameters $\Delta\rho$, error in the entry velocity of the LV ΔV_{ux}, scatter in the projected ballistic parameters of the LV ΔP_x and ΔK_{pacn}. The assumed maximum values of the disturbances which are given are given below:

Navigation error with respect to altitude of conditional pericenter ΔH_{π} .... ±150 km

Error in value of available quality ΔK...... ±10 %

Error in value of reduced load on frontal surface ΔP_x .... ±10 %

Error in entry speed ΔV_{BX} .... ±0.2 km/s.

Oscillations in atmospheric density are considered within the limits of the minimal and maximal models [2]:

$$\rho_{min}=0{,}012e^{-0{,}11H};\quad \rho_{nom}=0{,}013e^{-0{,}09H},\ \rho_{max}=0{,}019e^{-0{,}07H}.$$

In the case of a disturbance of any one type (for example, disturbance with respect to ΔH_{π}) we will have a certain switching line in the form of the dependence $n_{xn}(V_{Sn})$ or $t_n(V_{Sn})$. For example, in Fig. 1 for a LV with P_x = 80 kgf/m² we have a family of switching lines for the main disturbances (all switching disturbances are assumed to be independent with a normal law of distribution). Here we see that the position of the switching point is mainly influenced by the change in parameter in H_{n}. The switching line corresponding to this case (we call it nominal) will also be used to plot the control algorithm (Figs. 2-4). The position of the nominal switching line in plane $n_{x\text{n}}$, $V_{S\text{n}}$ (or t_{n}, $V_{S\text{n}}$) must be determined taking into consideration the dynamics of motion of the vehicle about the center of the masses. Therefore, after we have selected the switching line on the basis of analyzing nominal trajectories which call for instantaneous switching of the roll angle, we must replot this line, this time considering the turning dynamics with respect to the roll angle (see Figs. 2-4). Exact determination of the location of the LV within the navigation corridor of the entry (ΔH_{n} = ±100-±150 km) would make it possible to further define the switching moment of the roll angle and focus attention on other disturbing factors, thus assuring that we obtain a minimal value for a final velocity at the assigned final altitude. However, existing methods for independently determining entry conditions (in the simplest form) do not allow us to solve this problem. Thus, for example, the method which uses information on the nature of change in any parameter measured on board the LV (loadfactor, integral from loadfactor, etc.) over a certain time interval [4], produces error in determining H_{n} on the order of 150-170 km in flight near the lower boundary of the navigation corridor of entry. For this reason we present below a synthesis of control without specification of the initial entry conditions.

The studies, part of the results of which are shown in Figs. 2-4, indicated that the nominal switching line can be approximated with sufficient accuracy by simple linear or quadratic dependences of loadfactor $n_{x\,n}$ or time t_n on apparent velocity:

$$n_{x\,n}=\sum_j (c_j V_{S\,n}^2 + b_j V_{S\,n} + a_j); \quad (1)$$

$$t_n=\sum_j (m_j V_{S\,n}^2 + k_j V_{S\,n} + l_j), \quad (2)$$

where j is the number of approximation segments; $a_j, b_j, c_j, l_j, k_j, m_j$ - constant coefficients.

Control algorithm. The control algorithm is as follows. The LV enters the dense layers of the atmosphere $K_{эф}=K_{min}(\gamma_{max})$. At a certain moment $n_x = n_x^*$ measurement of the current values of loadfactor $n_{x\,тек}$ or time $t_{тек}$ and apparent velocity $V_{S\,тек}$ begins on board the LV. Calculated simultaneously is the value of the loadfactor $n_{x\,n}^{расч}$ or time $t_n^{расч}$ at which the transition to flight should be made with $K_{эф}=K_{max}(\gamma=0)$:

$$n_{x\,n}^{расч}=\sum_j (c_j V_{S\,тек}^2 + b_j V_{S\,тек} + a_j); \quad (3)$$

$$t_n^{расч}=\sum_j (m_j V_{S\,тек}^2 + k_j V_{S\,тек} + l_j). \quad (4)$$

where $V_{S\,тек}$ is the current value of apparent velocity, measured on board the LV. During the descent process the current measured parameters $n_{x\,тек}$, $t_{тек}$ are constantly compared with the calculated $n_{x\,п}^{расч}$, $t_{п}^{расч}$. As soon as the current value of loadfactor or time becomes greater than the calculated

$$n_{x\,тек} \geqslant n_{x\,п}^{расч}; \quad t_{тек} \geqslant t_{п}^{расч}, \tag{5}$$

the command is issued to switch $K_{эф}$ from $K_{min}(\gamma_{max})$ to $K_{max}(\gamma=0)$. To increase the working reliability of the control system this command is issued with a certain delay time, during which the conditions of (5) are checked. Then there begins the process of transition of the LV to flight with $K_{эф}=K_{max}$, the duration of which depends on the parameters of angular stabilization and external conditions. Thereafter the flight of the LV is stabilized with $K_{эф}=K_{max}$ until the soft landing system is activated.

Evaluating efficiency of control algorithms. The efficiency of the control algorithm was evaluated as follows. The main disturbances, whose maximal values were given above, are assumed to be random, independent of one another, and having a normal law of distribution:

$$\left.\begin{aligned} H_к &= \overline{H}_к + A_1 \Delta H_{к\,max}, \quad K = \overline{K} + A_2 \Delta K_{max}, \\ P_x &= \overline{P}_x + A_3 \Delta P_{max}, \quad V_{вх} = \overline{V}_{вх} + A_4 \Delta V_{вх\,max}, \quad \rho = \bar{\rho} + A_5 \Delta \rho_{max}. \end{aligned}\right\} \quad (6)$$

Here $\overline{H}_к$, $\overline{K}$, $\overline{P}_x$, $\overline{V}_{вх}$, $\bar{\rho}$ represent the nominal values (mathematical expectations) of the altitude of the conditional pericenter of the entry trajectory, the quality of the LV, load on the frontal surface, entry velocity, and density, respectively; $\Delta H_{к\,max}$, ΔK_{max}, $\Delta P_{x\,max}$, $\Delta V_{вх\,max}$, $\Delta \rho_{max}$ — the maximal value of the expected deviation of the corresponding parameter from the nominal value; A_{1-5} - random values with nominal law of distribution, zero mathematical expectation, and mean square deviation of 1/3. Accuracy in determining the final speed was estimated using the method proposed by B. G. Dostupov [5]. Here the value of the mathematical expectation of the final velocity $M(V_к)$ and the triple mean square deviation $\Delta V_к = \pm 3\sigma$ were determined with the control system working and with the sum effect of all disturbances.

Numerical results. The effectiveness of the work of the control algorithm was estimated according to the described method for two types of LV with the same value of available quality $K_{расп}$ = 0.3 but with different values for the reduced load on the frontal surface: $P_x = 80$ kgf/m² and 250 kgf/m². The maximal value of the roll angle was assumed equal to $\gamma_{max} = 180°$ for LV with $P_x = 80$ kgf/m² and $\gamma_{max} = 135°$ for LV with $P_x = 250$ kgf/m².

The movement of the LV (taking into account turning dynamics with respect to roll) and the control algorithm were calculated on the digital computer. Here we dealt with direct entry into the Martian atmosphere $(V_{\text{вх}}^{\text{ном}}=6$ km/s). The minimal permissible flight altitude was assumed equal to the final altitude $(H_{\text{доп}}^{\min}=H_{\text{к}})$.

The effect of disturbances on the value of the final velocity was estimated for two variations of the control algorithm, the first of which uses a switching line in the form of dependence $n_{x\,\text{п}}(V_{S\,\text{п}})$ (see Figs. 3 and 4), the second - in the form of $t_{\text{п}}(V_{S\,\text{п}})$ (see Fig. 2).

In the first case the switching line is approximated with sufficient accuracy by a straight line for the LV with $P_x=80$ kgf/m²:

$$n_{x\,\text{п}}=-V_{S\,\text{п}}+12{,}5$$

and a polynominal of the 2nd degree for a LV with $P_x=250$ kgf/m²:

$$n_{x\,\text{п}}=1{,}1V_{S\,\text{п}}^2+11{,}1V_{S\,\text{п}}-3{,}5.$$

In the second case the switching line is best approximated by two straight lines for the LV with $P_x=80$ kgf/m²:

when $V_S<1.88$ km/s $t_{\text{п}}=18.9\,V_{S\,\text{п}}+20.79,$

when $V_S > 1.88$ km/s $t_n = 23.6\ V_{Sn} + 0.2$.

The values of the final speed which the vehicle attains at a certain final altitude $H_к$ under the influence of different types of disturbing factors in the case of controlled descent using the described algorithm, are shown in the table.

The mathematical expectation $M(V_к)$ and triple mean square deviation of the final velocity $\Delta V_к = \pm 3\sigma$ for the combined action of all disturbances, determined by the method of B. G. Dostupov, are, respectively:

for algorithm with switching line $t_n(V_{Sn})$

$H_к = 3{,}5$ км, $P_x^{ном} = 80$ kgf/м², $M(V_к) = 246$ m/s, $\Delta V_к = 3\sigma = 47$ m/s;
$H_к = 2$ км, $P_x^{ном} = 80$ kgf/м², $M(V_к) = 208$ m/s, $\Delta V_к = 3\sigma = 32$ m/s;
$H_к = 5$ км, $P_x^{ном} = 250$ kgf/м², $M(V_к) = 444$ m/s, $\Delta V_к = 3\sigma = 42$ m/s;

for algorithm with swtiching line $n_{xn}(V_{Sn})$

$H_к = 3{,}5$ км, $P_x^{ном} = 80$ kgf/m², $M(V_к) = 237$ m/s, $\Delta V_к = 43$ m/s;
$H_к = 2$ км, $P_x^{ном} = 80$ kgf/m², $M(V_к) = 206$ m/s, $\Delta V_к = 33$ m/s.

If we compare the work of the control algorithm under "real" conditions (taking into consideration the turning dynamics of the LV, effects of various disturbances) with "ideal" control (instantaneous turning of the LV, optimal switching point for each specific trajectory), then we note that possible error in the work of the algorithm for control of the final speed is (3σ):

on a vehicle with P_x = 80 kgf/m² and K_{pacn} 0.3: $H_к$ = 3.5 km, $\Delta V_к$ = 68 m/s when $t_n(V_{s\,n})$; $H_к$ = 2 km, $\Delta V_к$ = 45 m/s when $t_n(V_{s\,n})$; $H_к$ = 3.5 km, $\Delta V_к$ = 55 m/s when $n_{x\,n}(V_{s\,n})$; $H_к$ = 2 km, $\Delta V_к$ = 44 m/s when $n_{x\,n}(V_{s\,n})$;

on a vehicle with P_x = 250 kgf/m², K_{pacn} = 0.3: $H_к$ = 5 km, $\Delta V_к$ = 56 m/s when $t_n(V_{s\,n})$.

Shown for comparison in the table are data for the case where in place of the switching line a single switching point is used. This corresponds to entry along the center of the corridor. Apparently in this case it is virtually impossible to achieve reliable descent of the LV onto the surface of the planet.

These materials show that the effectiveness of the working of a LCS using the proposed algorithm is virtually independent of the method of assigning the switching line in the form of $n_{x\,n}(V_{s\,n})$ or $t_n(V_{s\,n})$. The maximal scatter in the value of the final velocity for the working control system decreases with a decrease in the final altitude $H_к$ at which the soft landing system makes its entry. Methodological error constitutes a value on the order of 50 m/s.

The proposed control algorithm can be used in plotting control systems of final descent speed for vehicles with an average value of reduced load on the frontal surface and with a low value of available quality at various rates of entry into the Martian atmosphere. The algorithm can be achieved by using simple measuring devices (for example, the accelerometer, integrator, clocks) and a simple computer for arithmetic and logic functions. The control system can be adjusted by a simple conversion of the coefficients which approximate the switching line and are stored by the onboard computer.

Manuscript received 2 January 1971

BIBLIOGRAPHY

1. McLellan Ch. H., Pritchard E. B. Use of lift to increase pay-load of unmanned Martian landers. J. Spacecraft and Rockets, v. 3, No. 9, p. 1421—1425, 1966.
2. Основы теории полета и проектирования космических аппаратов. Справочник под ред. Г. С. Нариманова, т. I, М., „Машиностроение", 1971.
3. Иванов Н. М., Мартынов А. И. О максимально допустимой нагрузке на лобовую поверхность аппаратов, осуществляющих аэродинамический спуск в атмосфере Марса. „Ученые записки ЦАГИ", т. II, № 3, 1971.
4. Алексеев К. Б., Бебенин Г. Г., Ярошевский В. А. Маневрирование космических аппаратов. М., „Машиностроение", 1970.
5. Казаков И. Е., Доступов Б. Г. Статическая динамика нелинейных автоматических систем. М., Физматгиз, 1962.

Fig. 1. KEY: (1) kgf/m², (2) km/s.

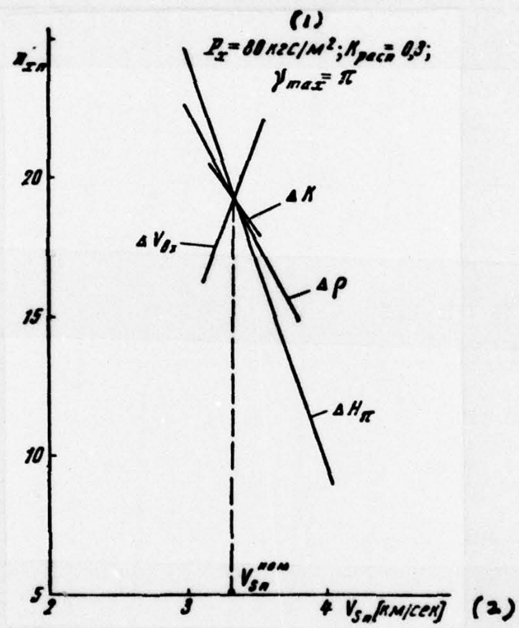

Fig. 2. KEY: (1) s, (2) kgf/m², (3) km/s, (4) Switching line $t_n(V_{S_n})$ without γ dynamics considered, (5) Swtiching line $t_n(V_{S_n})$ with γ dynamics considered, (6) km/s.

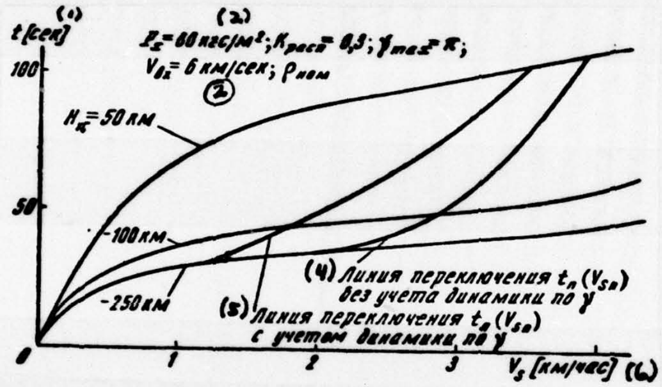

Fig. 3. KEY: (1) Switching line without γ dynamics considered, (2) km, (3) Switching line with γ dynamics considered, (4) km/s.

Fig. 4. KEY: (1) Switching line without γ dynamics considered, (2) Switching line with γ dynamics considered, (3) kgf/m², (4) km/s.

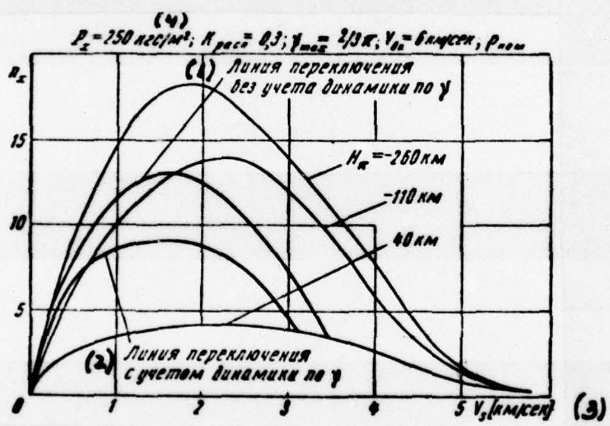

Fig. 3.

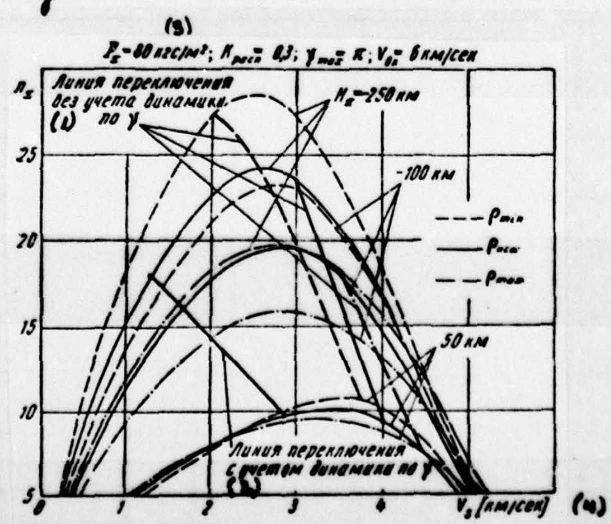

Fig. 4.

Table. KEY: (1) Value of final velocity under influence of various disturbing factors, (2) kgf/m², (3) m/s, (4) km/s, (5) Switching lines, (6) Switching points.

(1) Величины конечной скорости при действии различных возмущающих факторов	$P_x^{ном} = 80$ кгс/м² (2); $\gamma_{max} = 180°$; $K_б = 0,3$								$P_x^{ном} = 250$ кгс/м² (2); $\gamma_{max} = 135°$; $K_б = 0,3$					
	$H_к = 3,5$ км; $V_к^{ном} = 225$ м/сек (3)				$H_к = 2$ км; $V_к^{ном} = 195$ км/сек (4)				$H_к = 5$ км; $V_к^{ном} = 450$ м/сек (3)					
	$H_к^{ном} = -100$; $V_{вх}^{ном} = 6$ км/сек (4)								$H_к^{ном} = -110$; $V_{вх}^{ном} = 6$ км/сек (4)					
	(5) Линии переключения										(6) Точки переключения			
	$t_п (V_{S п})$		$n_{x п} (V_{S п})$		$t_п (V_{S п})$		$n_{x п} (V_{S п})$		$t_п (V_{S п})$		$t_п^{ном} = const$		$n_{x п}^{ном} = const$	
$\Delta H_к$ [км]	150	−150	150	−150	150	−150	150	−150	150	−150	150	−150	150	−150
$V_к$ [м/сек] (3)	227	290	245	260	217	211	197	221	460	460		3780	2380	3420
$\Delta V_{вх}$ [м/сек] (3)	200	−200	200	−200	200	−200	200	−200	200	−200	200	−200	200	−200
$V_к$ [м/сек] (3)	230	285	233	285	215	222	216	220	455	430	523	487	481	514
P	P_{max}	P_{min}	P_{max}	P_{min}	P_{max}	P_{min}	P_{max}	P_{min}	P_{max}	P_{min}	P_{max}	P_{min}	P_{max}	P_{min}
$V_к$ [м/сек] (3)	196	252	225	240	185	205	196	198	360	475	373	3260	385	2240
ΔP_x [кгс/м²] (2)	8	−8	8	−8	8	−8	8	−8	25	−25	25	−25	25	−25
$V_к$ [м/сек] (3)	270	220	275	215	245	165	235	170	450	425	475	486	530	472
ΔK	0,03	−0,03	0,03	−0,03	0,03	−0,03	0,03	−0,03	0,03	−0,03	0,03	−0,03	0,03	−0,03
$V_к$ [м/сек] (3)	260	247	228	218	215	215	215	212	460	460	510	542	515	560

DISTRIBUTION LIST

DISTRIBUTION DIRECT TO RECIPIENT

ORGANIZATION		MICROFICHE
A205	DMATC	1
A210	DMAAC	2
B344	DIA/RDS-3C	8
C043	USAMIIA	1
C509	BALLISTIC RES LABS	1
C510	AIR MOBILITY R&D LAB/FIO	1
C513	PICATINNY ARSENAL	1
C535	AVIATION SYS COMD	1
C591	FSTC	5
C619	MIA REDSTONE	1
D008	NISC	1
H300	USAICE (USAREUR)	1
P005	ERDA	1
P055	CIA/CRS/ADD/SD	1
NAVORDSTA (50L)		1
NASA/KSI		1
AFIT/LD		1

ORGANIZATION		MICROFICHE
E053	AF/INAKA	1
E017	AF/ RDXTR-W	1
E404	AEDC	1
E408	AFWL	1
E410	ADTC	1
E413	ESD	2
	FTD	
	CCN	1
	TQIS	3
	NIA/PHS	1
	NICD	2