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PILOT'S AND NAVIGATOR'S HANDBOOK FOR CIVIL AVIATION (SELECTED ARTICLES)

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Foreign Technology Division
Wright-Patterson Air Force Base, Ohio

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FOREIGN TECHNOLOGY DIVISION

PILOT'S AND NAVIGATOR'S HANDBOOK FOR CIVIL AVIATION
(SELECTED ARTICLES)

by

G. V. Markov and L. A. Ostrogskiy

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13. ABSTRACT

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3. During approach to the first point of the large rectangular route use the coordinates in the mode "GO" relative to the center of the RW based on the counters of current coordinates of units P-2 and P-3, on which the symbols "X" and "Y" are lit up.

THE NAVIGATION SLIDE RULE NL-10m

The purpose of the scales on the navigation computer (Fig. 95):

1, 2 - for the calculation of path time, of ground speed, for the solution of multiplication and division problems;

1a - for the calculation of the parameters of turn;

3, 4, 5 - for determining the trigonometric functions of angles, values of products a sin α and b tg β, for the solution of navigational triangle by the theorem of sines, and for the calculation of the radius of turn (roll angle);

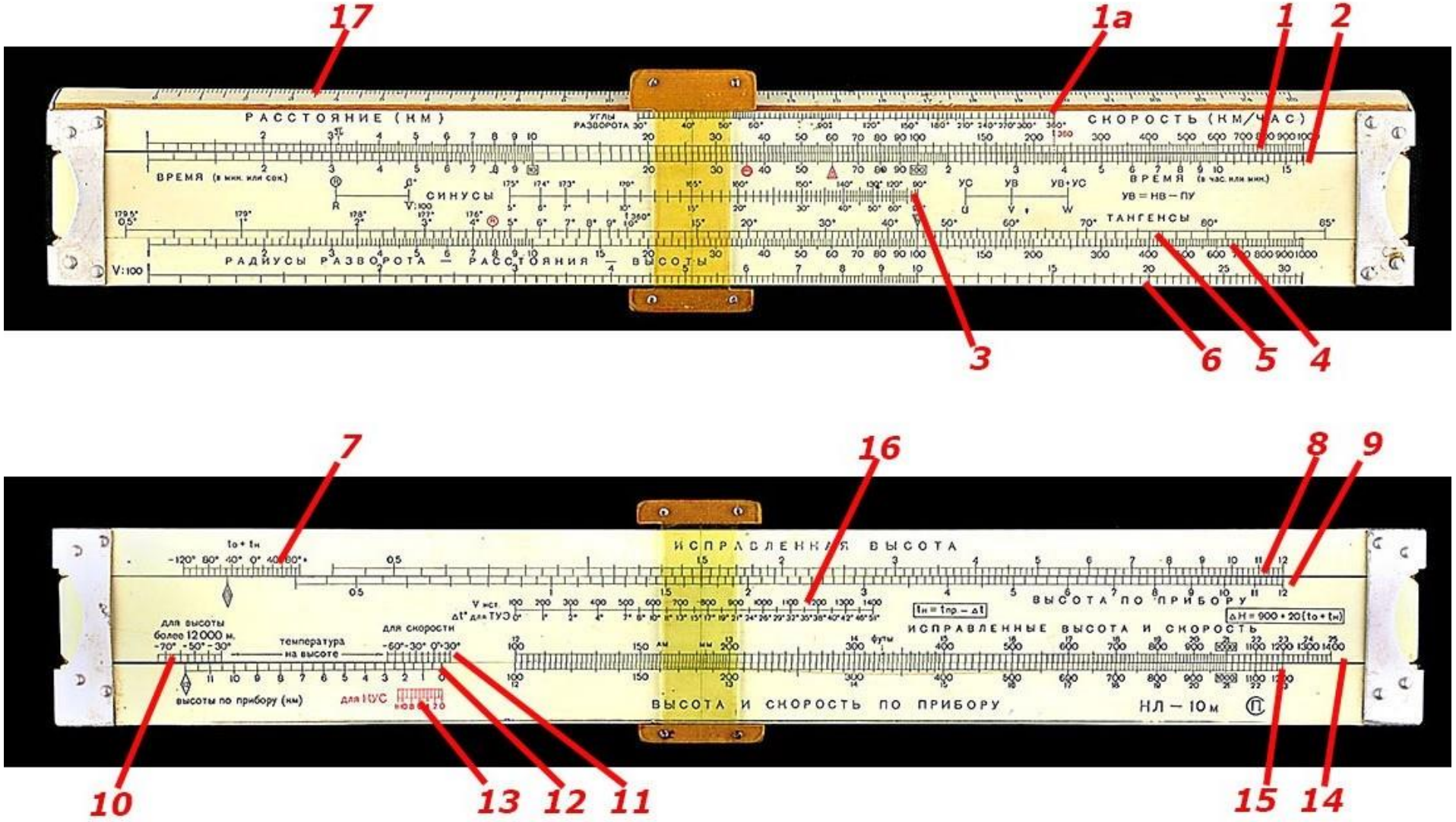
6 - for squaring and taking the square root (jointly with scale 5 or 1 and 2);

7, 8, 9 - for the recomputation of flight altitude at H < < 12,000 m;

10, 12, 14, 15 - for the recomputation of flight altitude at H > 12,000 m;

11, 12, 14, 15, 16 - for the recomputation of airspeed with the usual (non-combined) speed indicator

11, 13, 14, 15, 16 - for the recomputation of airspeed with a combined speed indicator;


17
1a
1
2
РАССТОЯНИЕ (КМ)
УГЛЫ РАЗВОРОТА
СКОРОСТЬ (КМ/ЧАС)
ВРЕМЯ (в мин. или сек.)
СИНУСЫ
УС
УВ
УВ+УС
ВРЕМЯ (в час. или мин.)
УВ = НВ − ПУ
ТАНГЕНСЫ
РАДИУСЫ РАЗВОРОТА — РАССТОЯНИЯ — ВЫСОТЫ
V:100
3
6
5
4
7
16
8
9
ИСПРАВЛЕННАЯ ВЫСОТА
to + tн
ВЫСОТА ПО ПРИБОРУ
Vист
Δt° для ТУС
tн = tпр − Δt
ΔH = 900 + 20(to + tн)
ИСПРАВЛЕННЫЕ ВЫСОТА И СКОРОСТЬ
для высоты более 12 000 м.
температура на высоте
для скорости
высоты по прибору (км)
для ТУС
ВЫСОТА И СКОРОСТЬ ПО ПРИБОРУ
НЛ — 10м
10
13
12
11
15
14

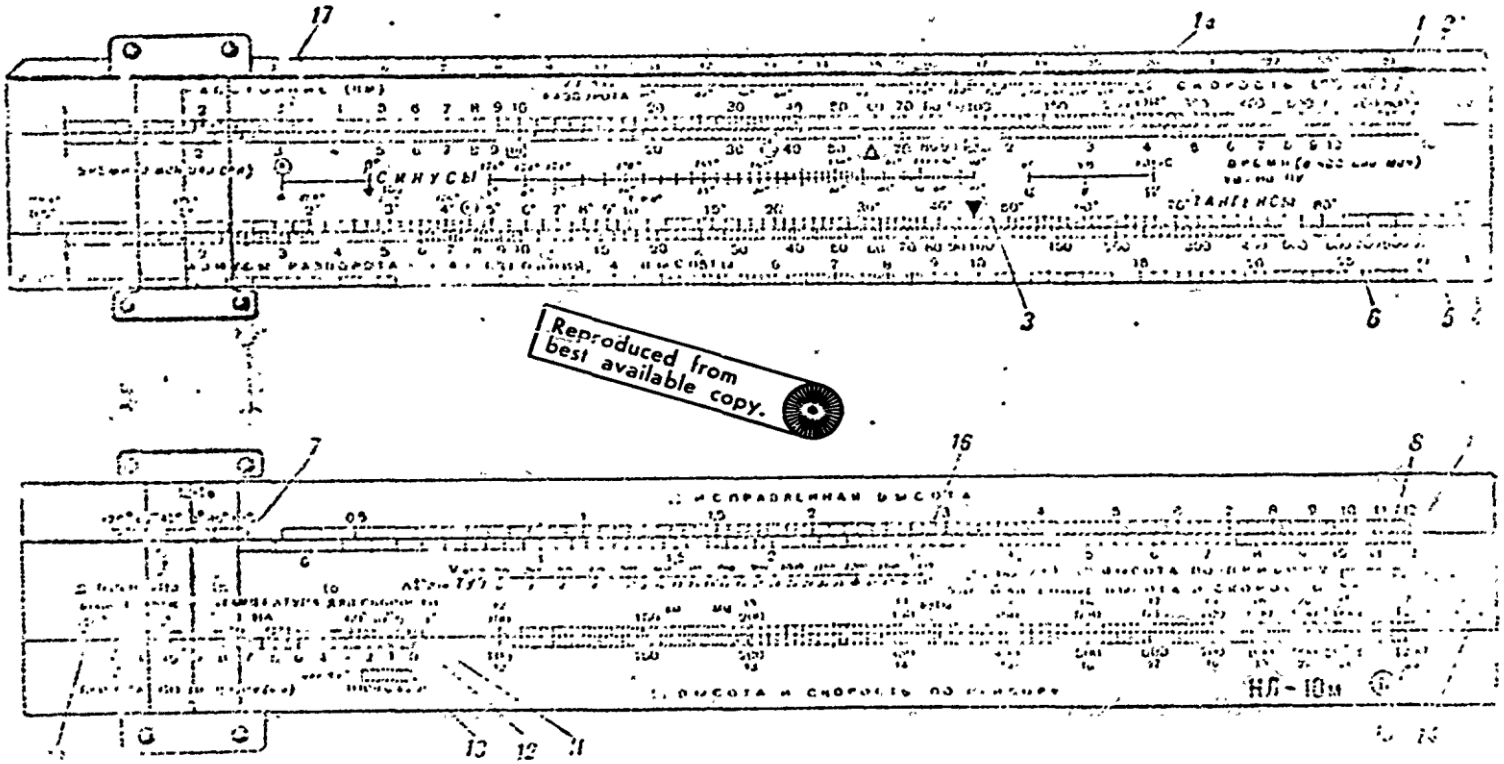


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Fig. 22. The navigation computer NL-10m
(a) Range (km); (b) Angle of turn; (c) Velocity (km/hr); (d) Time (in min or s); (e) Speed; (f) Time (in hr or min); (g) UV-MV-PU; (h) Tangents; (i) Radius of turn; (j) Range; (k) Altitude; (l) Adjusted altitude; (m) For altitude; (n) Temperature for altitude; (o) For velocity, (p) Instrument altitude (in m); (q) Instrument altitude and velocity; (r) Instrument altitude; (s) Adjusted altitude and velocity.

17 - for the measurements of distances on a map.

The Solution of Basic Problems on the NL-10m

1. The calculation of horizontal range by height and slant range. Key - Fig. 96.

Example. Given ND = 26 km; N = 9 km [Translator's note: НД = ND and H = N].

Find: α = 20.2 and then GD = 24.3 km.

2. Determining the radius of turn based on angle of bank and rate of turn. Key - Fig. 97.

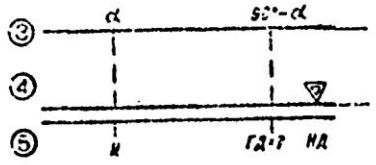

Fig. 96.

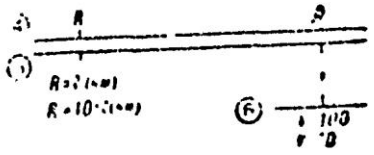

Fig. 97.

Example: 1. Given: V = 500 km/h; β = 15°. Find: R = 7.35 km.

2. Given: V = 250 km/h; β = 50°. Find: R = 415 m.

Note. Using the foregoing keys for the solution of problems, it is possible to find the value of any magnitude entering into the given problem based on two known values.

3. Calculation of the corrected altitude of flight according to the reading of a pressure altimeter.

Note. The value of temperature of height of flight taken from a thermocouple during all calculations of altitude and velocity must be corrected for the heat absorption of the sensitivity of the element of thermocouple according to scale 16 and calculated according to the formula found on the right of scale 16

$$t_{испр} = t_{пр} - \Delta t.$$

For altitudes up to 12,000 m (Fig. 98).

Example. Given $H_{пр}$ = 2200 m; t_0 = +25°; $t_{пр\ H}$ = +18°; V = = 560 km/h.

We find:

$$t_H = t_{пр_H} - \Delta t = +18 - 9 = +9°;$$
$$t_0 + t_H = +25 + 9 = +34°;$$
$$H_{испр} = 2270\ м.$$

4. The calculation of true airspeed according to the reading of a speed indicator for speed indicators of the type KUS-12[illegible] (Fig. 99) [Translator's note: НУС = KUS = combined airspeed indicator].

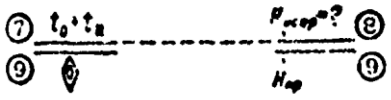

Fig. 98.

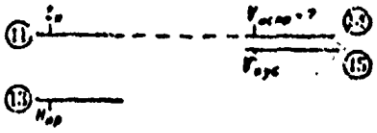

Fig. 99.

Example. Given: $t_{пр\ H}$ = +5°; $V_{НУС}$ = 650 km/h; $H_{пр}$ = = 4500 m. We find: t_H = +5 - 11 = -6°; $V_{испр}$ = 660 km/h.

5. Determining the time of turn and on an angle different from 360°.

Example 1 (Fig. 100). Given: V = 500 km/h; R = 3000 m; YP = 100°. We find: t_{360} = 2 min 17 s; t_{YP} = 38 s.

Example 2 (Fig. 101). Given: t_{360} = 2 min 17 s; YP = 60°. We find: t_{YP} = 23 s.

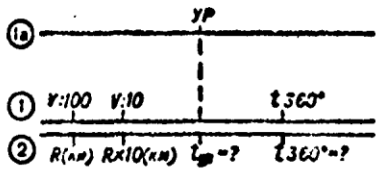

Fig. 100.

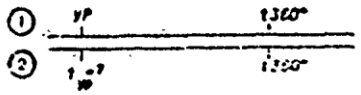
Fig. 101.

6. Determining the time of turn of an aircraft on 360° from the angle of the bank and rate of turn and on an angle different from 360°.

Example 1 (Fig. 102). Given: V = 600 km/h; β = 20°. We find: t_{360} = 290 s.

Example 2 (Fig. 103). Given: t_{360} = 290 s; YP = 110°. We find: t_{YP} = 89 s.

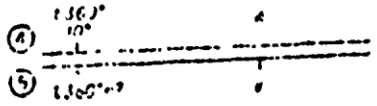
Fig. 102.

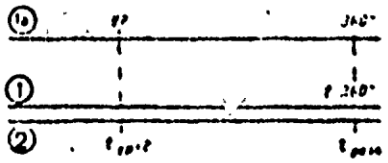
Fig. 103.

Determining the relationships between flight speed and M number with the help of the NL-10M

On scale 12 of the "Indicated altitude (km)" slide rule a graduation line is plotted which corresponds to the flight altitude 3250 m, the continuation of which is designated by a circular index. When the air temperature at the altitude of flight according to scale 11 "Temperature at altitude for speed" is set against this reference line, on scales 14 "Corrected altitude and speed" and 15 "Altitude and indicated airspeed" the relationship between air speed in kilometers per hour (scale 14) and M number (scale 15) is automatically calculated. On scale 15 the Mach number, equal to a unit, has a corresponding rectangular index with numbering 1000 (airspeed on scale 14 against this index is equal to the speed of sound).

In order to determine the speed of sound expressed in meters per second on scale 15 it is necessary to plot the graduation mark which corresponds to division 277.5, and designate it by index "a." Opposite this index according to scale 14 the speed of sound in meters per second is read off.

At the end of scale 14 it is necessary to place a supplementary designation "1" (true speed), while at the end of scale 15 - the designation "M."

Example. Air speed is limited by M number = 0.83, the air temperature at the flight height -45°C, determine the maximum value of airspeed.

Solution. Opposite the round index on scale 12 we set the air temperature according to scale 11, equal to -45°C. M number = = 0.83 corresponds to an air speed of 900 km/hr. The speed of sound at this temperature is equal to 1085 km/hr, or 302 m/s.

Calculation of landing approach on a rectangular route with a left-hand turn in a cross wind from the moment of passing the outer marker beacon [DPRM]

1. Determine the value of the wind angle to the runway [RW] (ВПП) - $УВ_{пос}$ using the formula

$$УВ_{пос} = \delta - ПМПУ.$$

[landing (magnetic) track angle [PMPU] (ПМПУ)]

2. Determine the value of the lateral component of wind velocity to the landing strip - $\Delta U_б$ (Fig. 104)

$$\Delta U_б = U \sin УВ_{пос}.$$

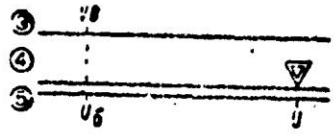

Fig. 104.

3. Determine the value of the counter component of wind velocity to the RW - $\Delta U_в$ (Fig. 105)

$$\Delta U_в = U \sin (90 - УВ_{пос}).$$

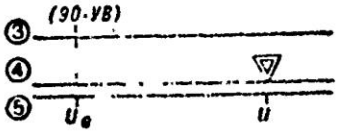

Fig. 105

4. Determine the value of the drift angle for a straight line from the beam of the outer marker beacon to the beginning of the third turn (Fig. 106)

$$\operatorname{tg} УС_з = \frac{\Delta U_б}{V}.$$

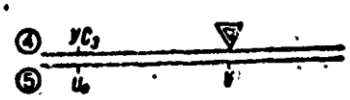

Fig. 106.

5. Determine the value of lead for the beginning of the third turn (Fig. 107)

$$t_{упр} = \frac{\Delta U_в (t_{пр} + t_{разв})}{W_{пр}},$$

where $t_{упр}$ - lead time;

$t_{пр}$ - flight time from the beam of the outer marker beacon in a calm;

$t_{разв}$ - time for the third turn;

$W_{пр}$ - ground speed from the beam of the outer marker beacon before the beginning of the third turn ($V_и + V_в$).

6. Determine the time of onset of the third turn using the formula

$$t_{нач.\ разв} = t_{нач.\ разв.\ шт} - t_{упр}.$$

7. Determine the value of the drift angle for a straight line from the third to the fourth turn - US_3 [$УС_3$] (Fig. 108)

$$\operatorname{tg} УС_3 = \frac{\Delta U_в}{V}.$$

8. Determine the value of magnetic course for a straight line from the third to the fourth turns - $MK_3 = MPU_3$ [$МПУ_3$] - US_3.

9. Determine the KUR for the beginning of the fourth turn - KUR_4 by the formula

$$КУР_4 = КУР_{шт} + УС_3 \pm (\Delta^{\circ}_{КУР}).$$

Δ_{KUR} - is determined on the NL-10 (key see on Fig. 109),

where S - the distance from the beam of the outer marker beacon to the straight line between the third and fourth turns;

BU [БУ] - (lateral deviation) - the product of the time of turn ($t_{разв}$) by the lateral component of wind velocity to the landing pattern ($\Delta U_б$);

Δ_{KUR} - is taken with the "plus" sign at $\Delta U_б$ incidental and "minus" - at $\Delta U_б$ counter to the straight line from the third to the fourth turns.

10. Determine the value of the drift angle for the last straight line - $US_{пос}$ (Fig. 110).

$$\operatorname{tg} УС_{пос} = \frac{\Delta U_б}{V_{ср}}.$$

11. Determine the value of the magnetic course for the last straight line - $МК_{пос}$ using the formula

$$МК_{пос} = ПМПУ - УС_{пос}.$$

12. Determine the distance to the RW from the entrance point to the glide path - $S_{ТВГ}$ (Fig. 111)

$$S_{ТВГ} = \frac{H_{вх.гл}}{\operatorname{tg} УНГ}.$$

[ТВГ - entrance point to glide path]

where $H_{вх.гл}$ - altitude of entry to glide path;

UNG [УНГ] - angle of tilt of glide path.

13. Determine the time of flight from the outer marker beacon to the RW - $T_{пол}$ (Fig. 112)

$$T_{пол} = \frac{S}{V_{ср}}.$$

14. Determine the vertical rate of descent from the outer marker beacon to the RW (Fig. 113)

$$V_{верт} = \frac{H}{t}.$$

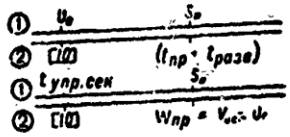

Fig. 107.

Fig. 108.

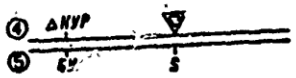

Fig. 109.

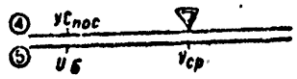

Fig. 110.

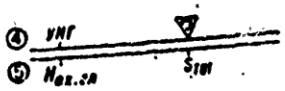

Fig. 111.

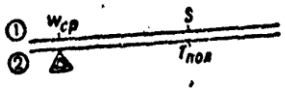

Fig. 112.

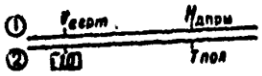

Fig. 113.

NRK-2 NAVIGATIONAL COMPUTER

Purpose and performance data

The NRK-2 navigational computer developed by M. V. Kalashnikov is a computing instrument intended for making navigational calculations during preflight operations and in flight.

With the help of the navigational computer the following problems are solved: