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WAR DEPARTMENT
AIR SERVICE
ENGINEERING DIVISION
McCOOK FIELD, DAYTON, OHIO
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REPORT

ON

THE PROBLEM OF LANDING.

BY

TECHNICAL DATA SECTION.

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WAR DEPARTMENT
ENGINEERING DIVISION
AIR SERVICE
McCOOK FIELD, DAYTON, OHIO

THE PROBLEM OF LANDING

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Date: February 1, 1922.

THE PROBLEM OF LANDING

(By E. Pistoiesi)

I. The Horizontal Flight at Ground LevelThe retarding force of the engine is designated by: $-K_x S V^2$ and the accelerating force by $\frac{-K_y S V^2}{Q/g}$.Taking $Q = K_y S V^2$, we have: $\frac{dV}{dt} = -\frac{g}{\eta} - I$, η being the ratio:

$$\eta = \frac{K_y}{K_x}$$

Transforming equation (I) to read

$$\frac{dV}{ds} \frac{ds}{dt} = -\frac{g}{\eta}$$

$$(II) \quad \frac{d(V^2)}{ds} = -\frac{2g}{\eta}$$

also (III) $s = -\frac{1}{2g} \int_{V_1}^{V_2} \eta d(V^2)$

when the integral ranges between the initial flying speed V_1 and the final speed minimum V_2 .

Equation (III) can easily be changed to read:

$$(IV) \quad s = \frac{Q}{2gS} \int \frac{1}{K_x} \frac{dK_y}{K_y}$$

as the integral with the initial and final K_y value.

Integrating either equation (IV) or (V) is much easier, especially when no graphic proceedings are used, providing that the polar equation remains within the initial and final points P_1 and P_2 respectively. (See Fig. 1). However, a simple equation curve can be substituted (parabola of ordinary n) of the following type:

$$(V) \quad K_x = K_0 + A K_y^n$$

K_0 representing the value of the relative abscissae at the point where the

elongation of the curve substituted for P_1 and P_2 meets K_x .

Substituting into equation (IV) the integral obtained we have:

$$(VI) \quad S = \frac{Q}{2gSK_0 n} \log \frac{K_{x1} K_{y2} 2^n}{K_{x2} K_{y1} n}$$

or

$$(VII) \quad S = \frac{Q}{2gSK_0 n} \log \frac{\eta_2 V_1^{2(n-1)}}{\eta_1 V_2^{2(n-1)}}$$

also (by $n = 1$) (VIII) $S = \frac{Q}{2gSK_0} \log \frac{\eta_2}{\eta_1}$.

(by $n = 2$) (IX) $S = \frac{Q}{4gSK_0} \log \frac{\eta_2 V_1^2}{\eta_1 V_2^2}$,

(by $n = 3$) (X) $S = \frac{Q}{6gSK_0} \log \frac{\eta_2 V_1^4}{\eta_1 V_2^4}$.

All preceding formulas approach the practice very close as may be seen from the following example:

Taking	$K_{x1} = 0.00225$	$K_{y1} = 0.020$	(point P_1)
	$K_{x2} = 0.005$	$K_{y2} = 0.047$	(point P_2)

The previous value gains from the polar in Fig. 1

$m = 1$	$S = 13.2 \frac{Q}{S}$
$m = 2$	$S = 13.8 \frac{Q}{S}$
$m = 3$	$S = 14.1 \frac{Q}{S}$

The difference in the various cases is not quite 7%. We may also post as average:

$$S = 14 \frac{Q}{S}$$

$$\frac{Q}{S} = 40, \text{ when } S = 560 \text{ m.}$$

$$\frac{Q}{S} = 50, \text{ when } S = 700 \text{ m.}$$

The preceding formula sounds a little complicated, and since we stop to consider the space S with great approximation, it is opportune to supply a more simple formula, that can be obtained to apply to the theory of mean value. So for equation (IV) we may write:

$$(XI) \quad S = \frac{Q}{2gS} \frac{1}{(K_x)_m} \log \frac{K_{y2}}{K_{y1}}$$

where by mean value $\frac{1}{(K_x)_m}$ we can simply say:

$$\frac{1}{2} \left(\frac{1}{K_{x1}} + \frac{1}{K_{x2}} \right).$$

Applying this to the previous example we find:

$$S = 13.75 \frac{Q}{S}, \text{ which also proves the admissibility of the proceeding.}$$

But the formula more simplified and expressive when used to apply to the theory of mean value (equation) is then:

$$(XII) \quad S = \frac{(\eta)_m}{2g} (V_2^2 - V_1^2)$$

When also, P_1 and P_2 in regards to the angle of minimum traction

($\eta = \text{minimum}$) is approximately in line, we can write η_{min} in line of

$(\eta)_m$ and we have then:

$$(XIII) \quad S = \frac{\eta_{\text{min}}}{2g} (V_2^2 - V_1^2)$$

or also: $\frac{V_1}{V_2} = \beta;$

$$(XIV) \quad S = \frac{\eta_{\text{min}}}{2g} V_2^2 (\beta^2 - 1)$$

Applied to the original example, we have:

$$S = 15.6 \frac{Q}{S},$$

a value somewhat greater than expected, but still approximately within 10%.

The approximation naturally would be greater, unless P_1, P_2 are much restricted and in particular P_1 near the point of minimum traction.

Applying this to our practical example, we have:

$$V_2 \text{ (speed at landing) } = 32 \text{ m/sec.}$$

$$\eta \text{ min} = 10$$

$$V_1 = 1.5 V_2 = 48 \text{ m/sec.}$$

also:

$$s = 640 \text{ m.}$$

It is interesting to note that equation (XIII) expresses in arrangement a dissipation of the live forces, the work in performing the gravity, unless the arrangement is accompanied by a constant inclination $\frac{1}{\eta \text{ min.}}$.

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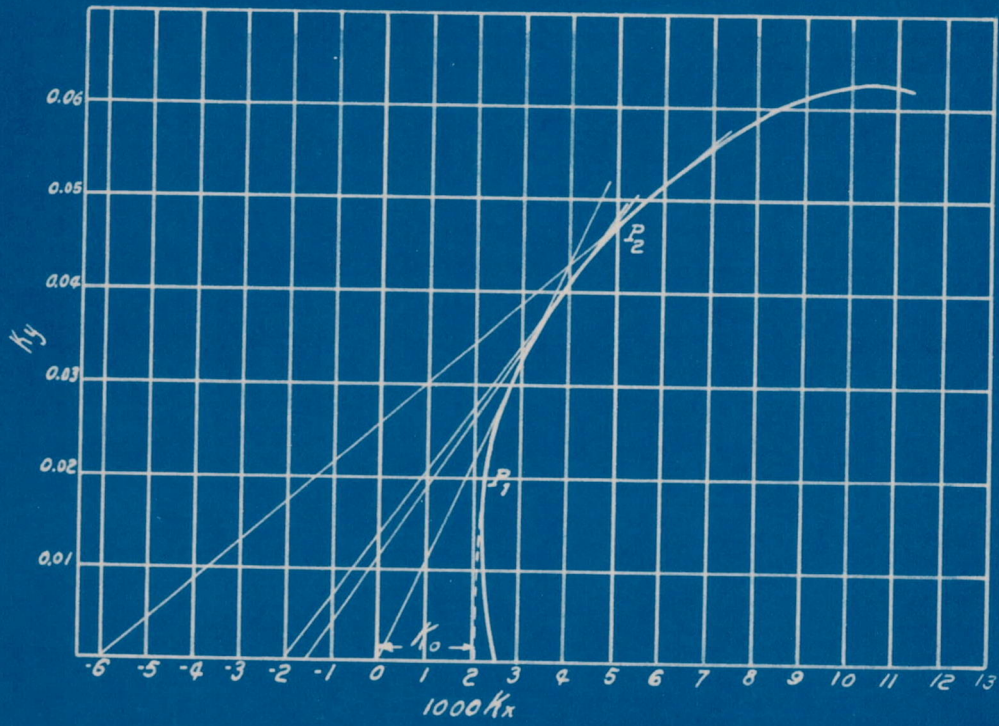


Fig. 1.

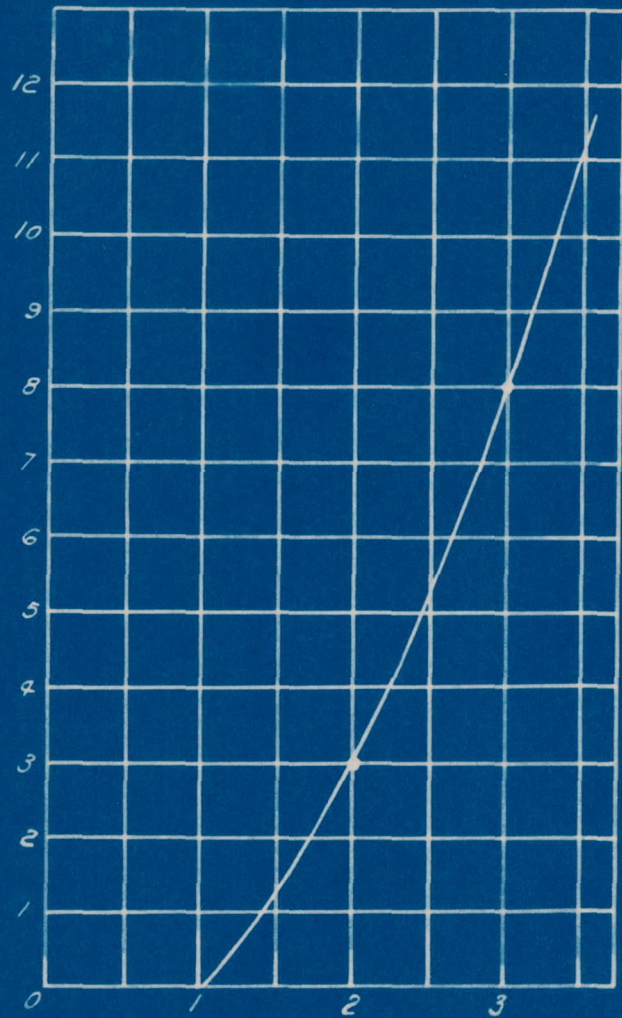


Fig 2