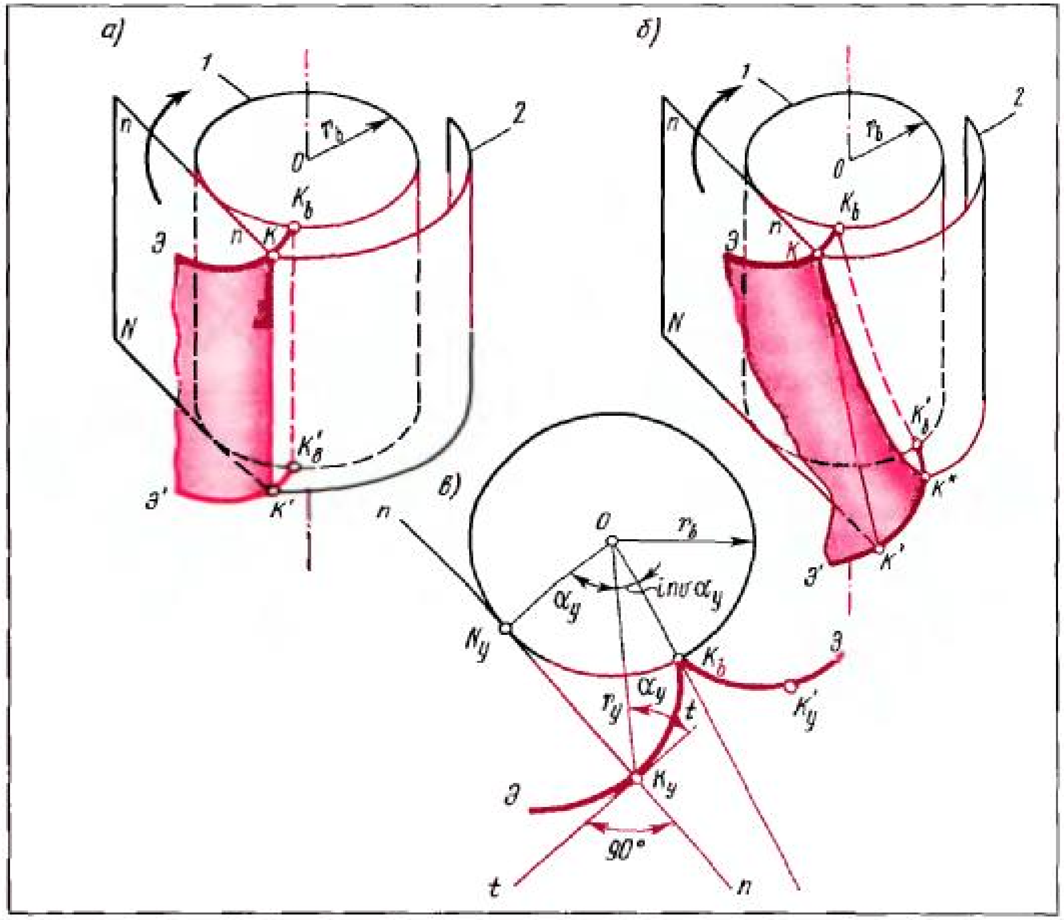
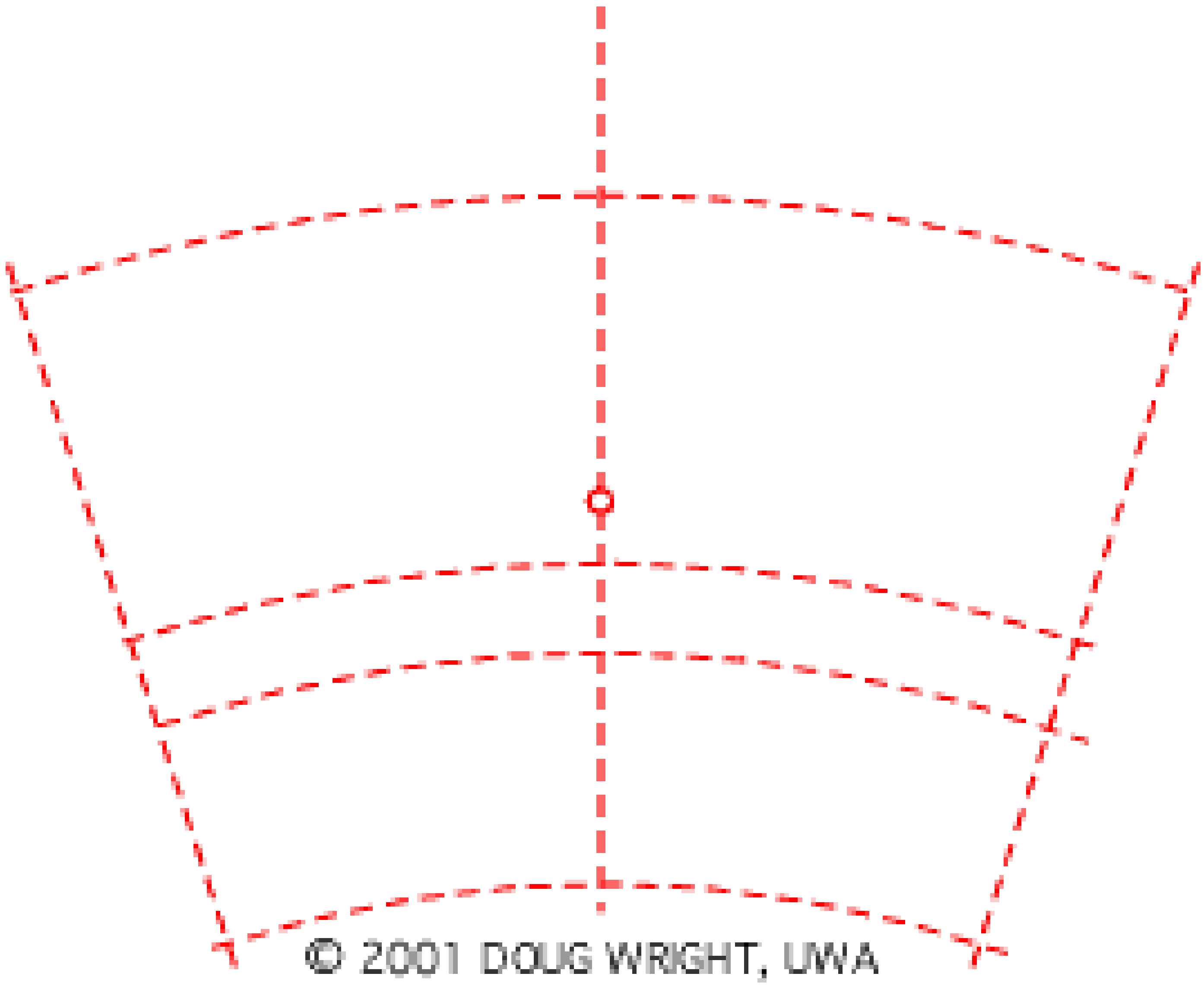
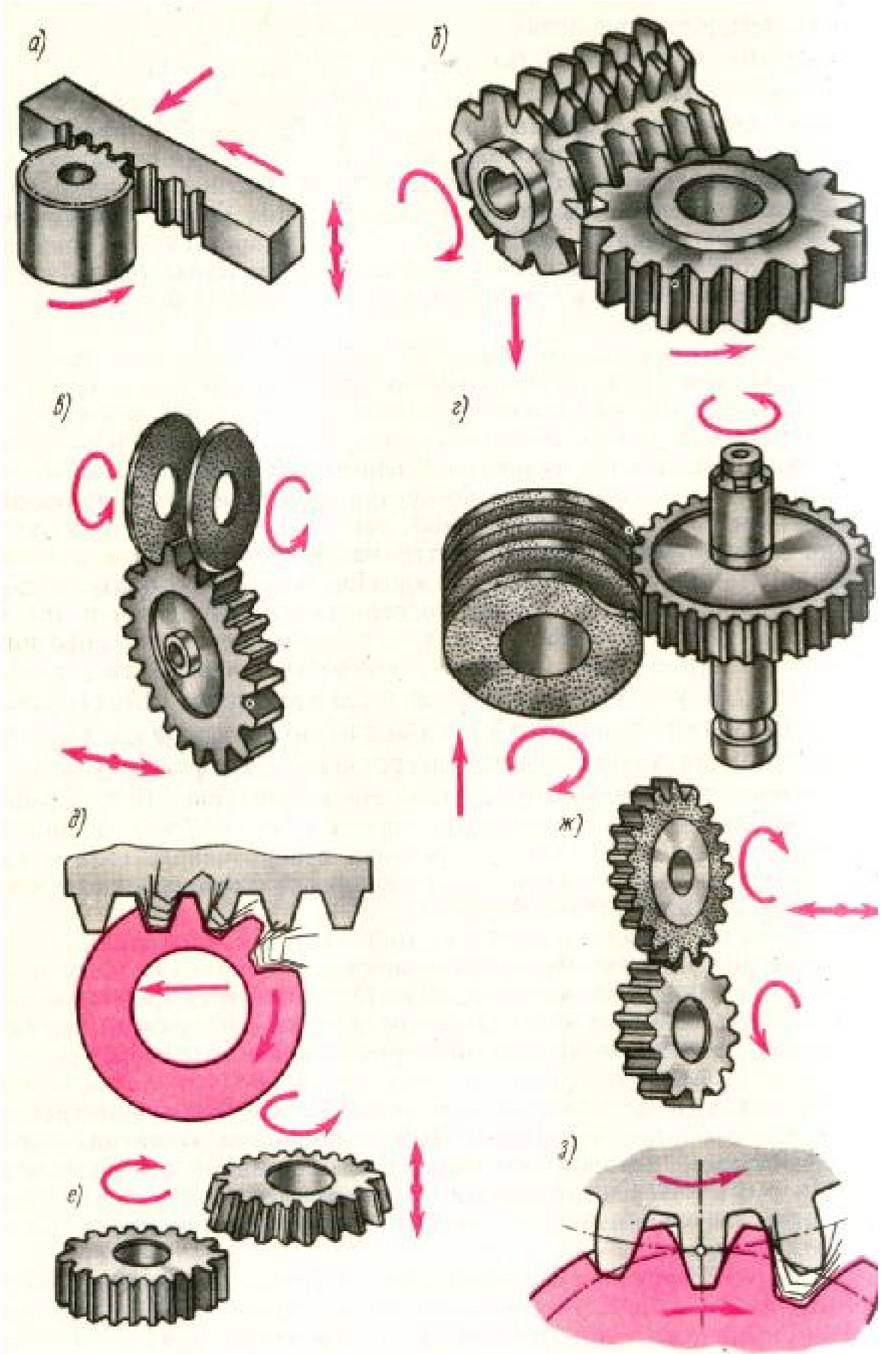
Формообразуване на еволвентни профили. Понятие за инструментално зацепване

1. Еволвента



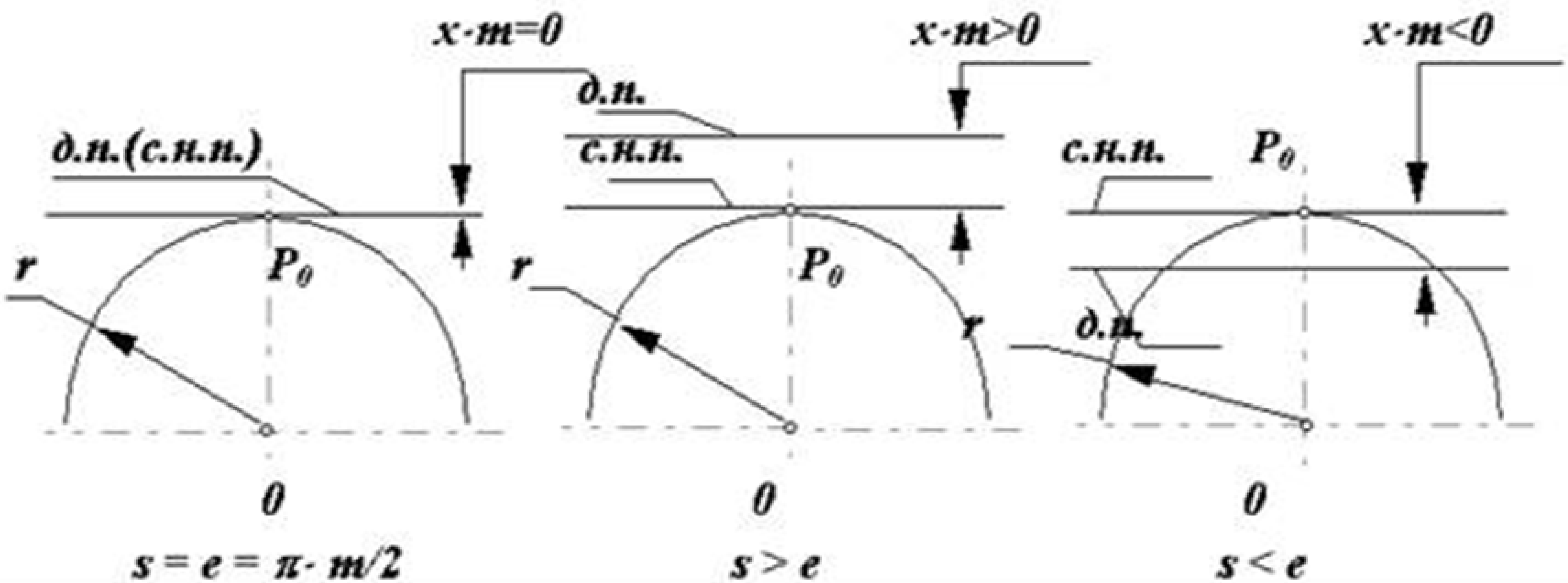
2. Формообразуване

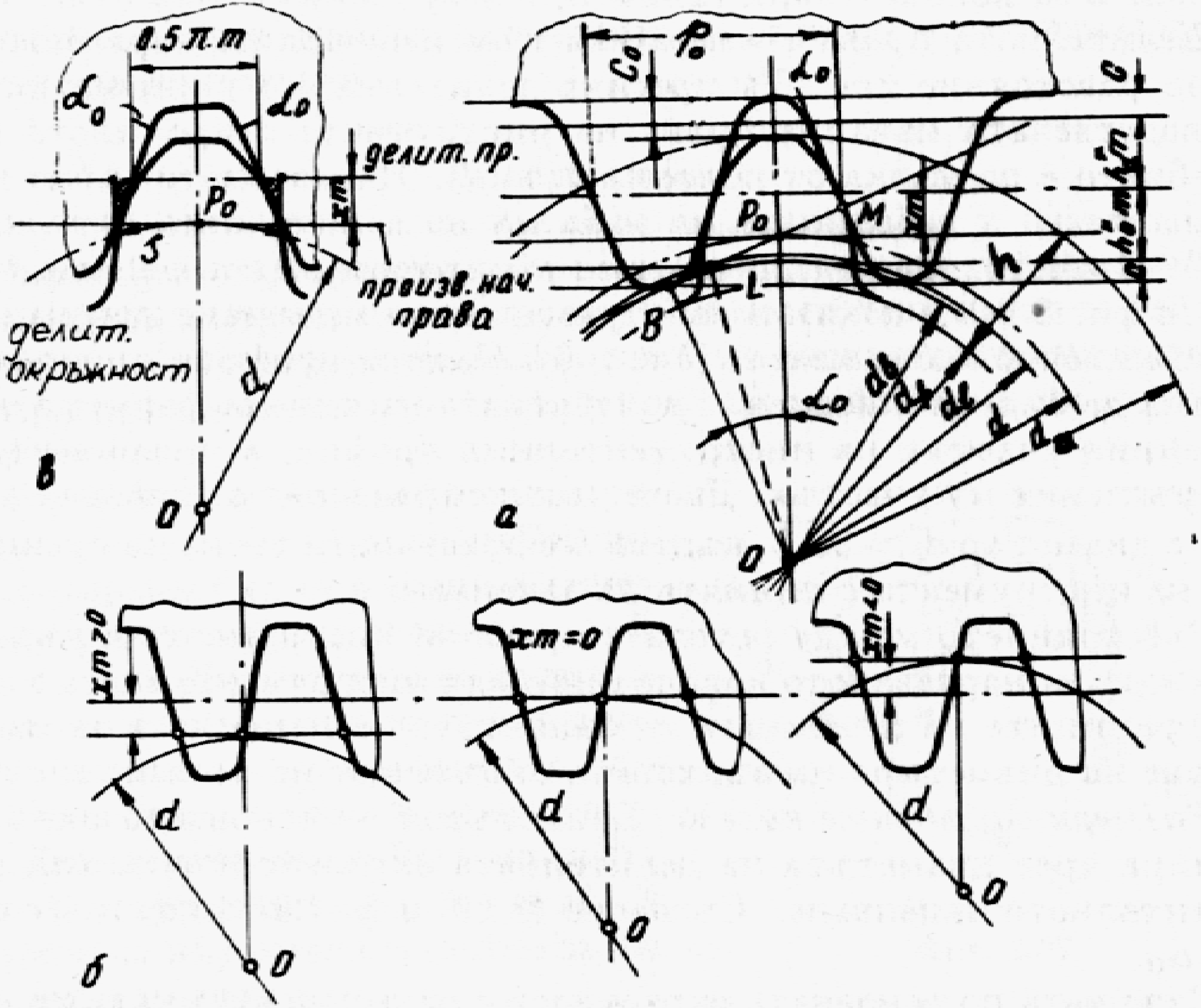



а)
б)
в)
г)
д)
е)
ж)
з)

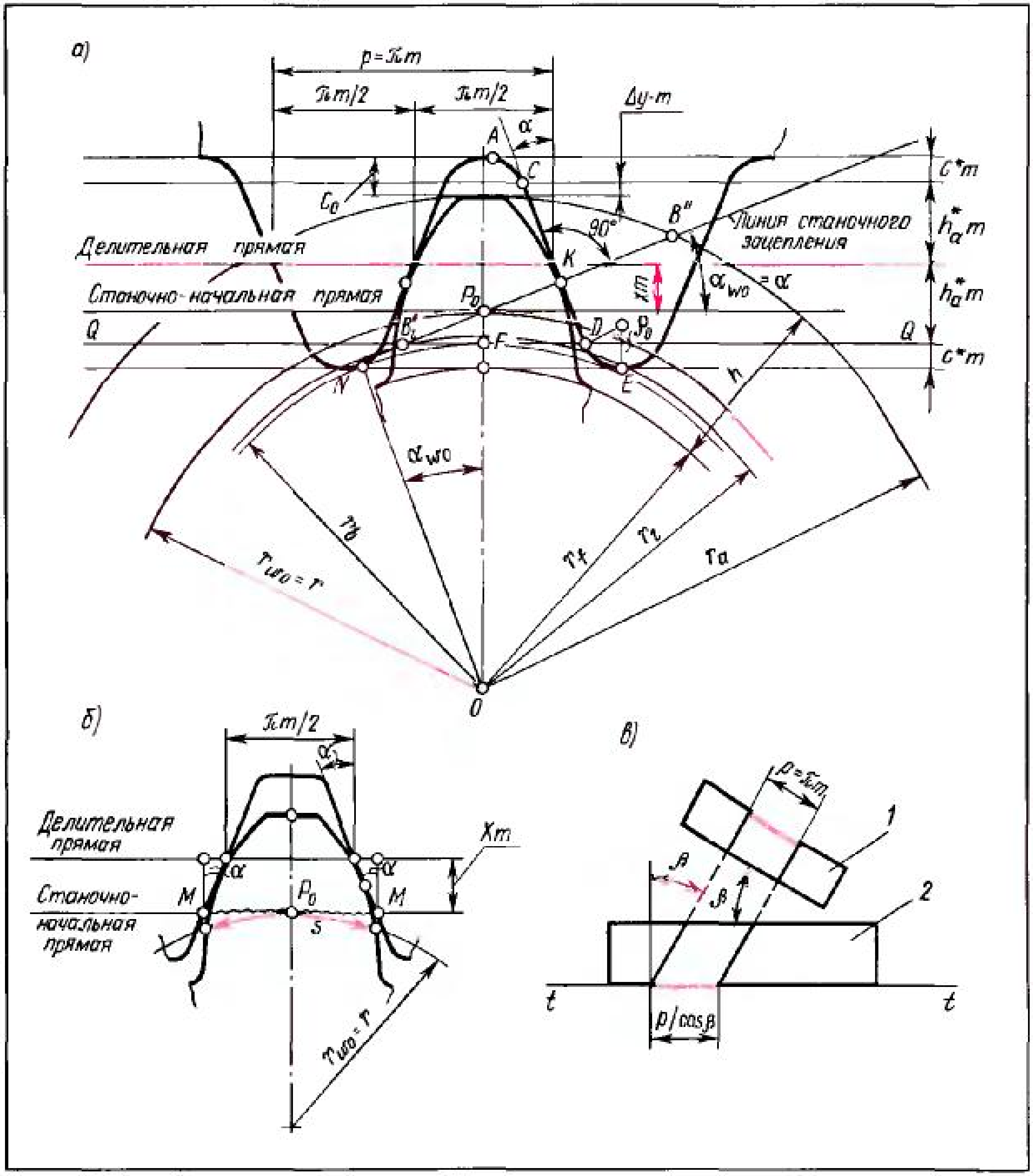
3. Изместване при инструменталното зацепване

Нулеви – без изместване	Положителни – с положително изместване	отрицателни – с отрицателно изместване




0.5 π.m
делит. пр.
произв. нач. права
делит. окръжност
в
а
б

Размери на зъбните колела



Размери на зъбните колела

$$d_b = d\cos a_0 = mz\cos a_0$$

$$\frac{d_f}{2} = \frac{d}{2} + xm - \left(h_a^* + c^*\right)m$$

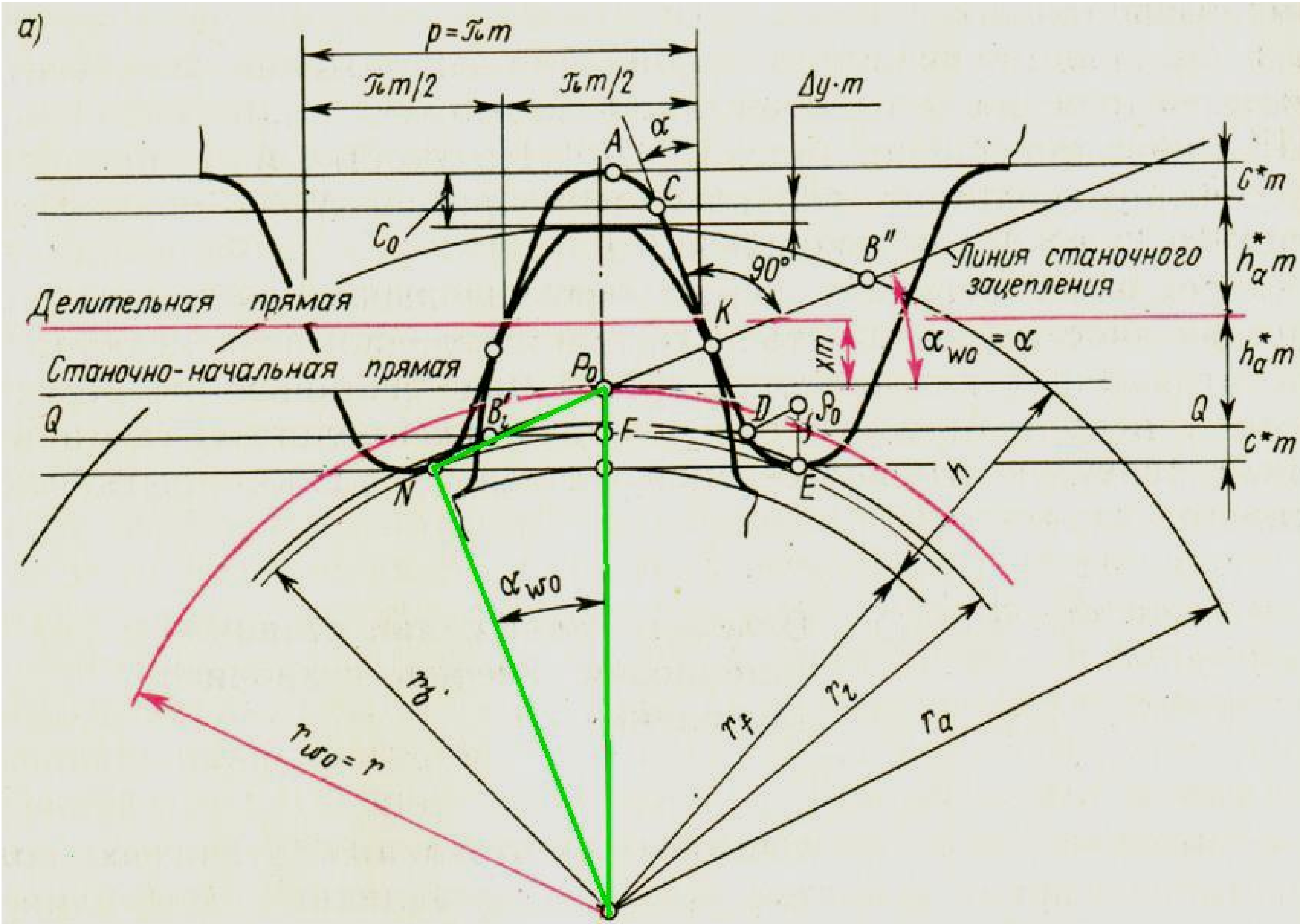
$$d_f = m\left[z + 2\left(x - h_a^* - c^*\right)\right]$$

$$s = \frac{pm}{2} + 2xm\tan a_0$$

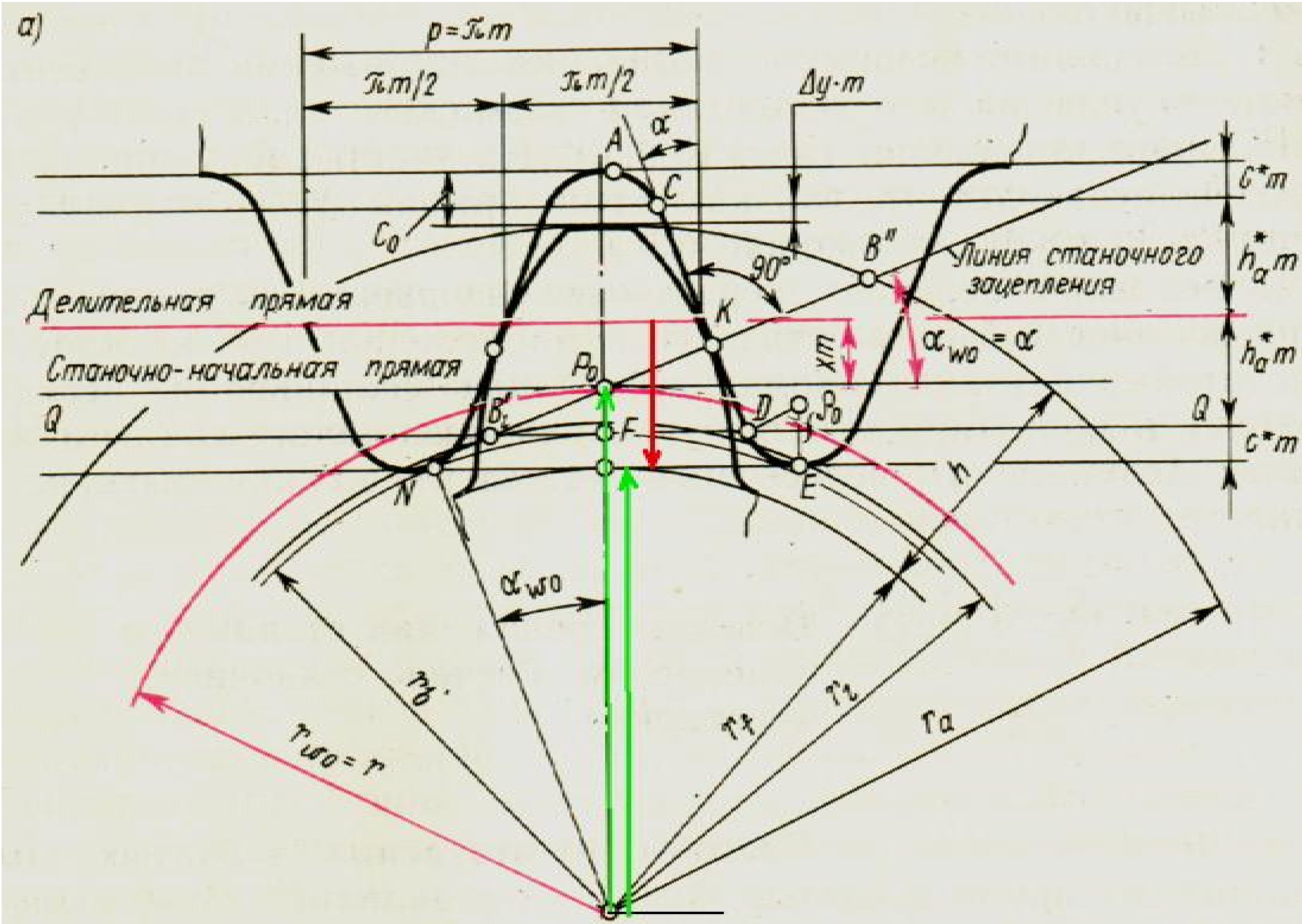
$$s_y = d_y\left(\frac{p}{2z} + \frac{2x\tan a_0}{z} + inv(a) - inv(a_y)\right)$$

$$s_b = d_b\left(\frac{p}{2z} + \frac{2x\tan a_0}{z} + inv(a)\right)$$

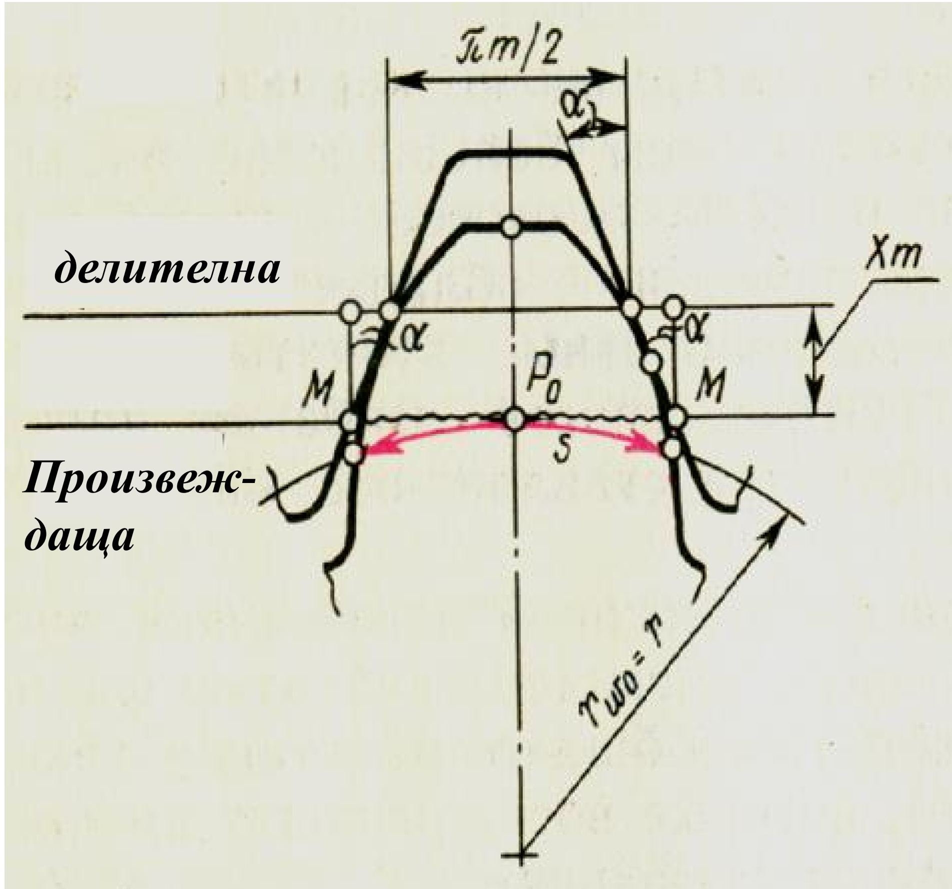
$$\Delta = 2x\tan a_0$$



$$d_b = d\cos a_0 = mz\cos a_0$$

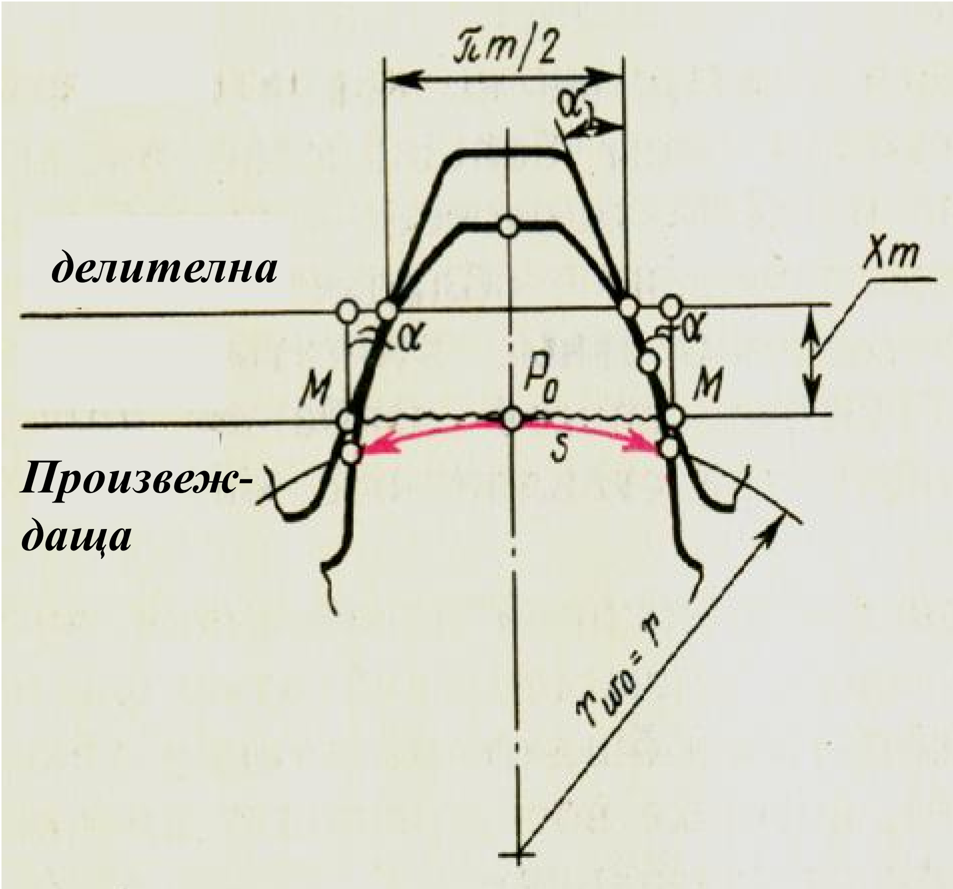


$$\frac{d_f}{2} = \frac{d}{2} + xm - \left(h_a^* + c^*\right)m; \quad d_f = m\left[z + 2\left(x - h_a^* - c^*\right)\right]$$



$$s = \frac{pm}{2} + 2xm\tan a_0; \;\; s_y = d_y\left(\frac{p}{2z} + \frac{2x\tan a_0}{z} + inv(a) - inv(a_y)\right);$$

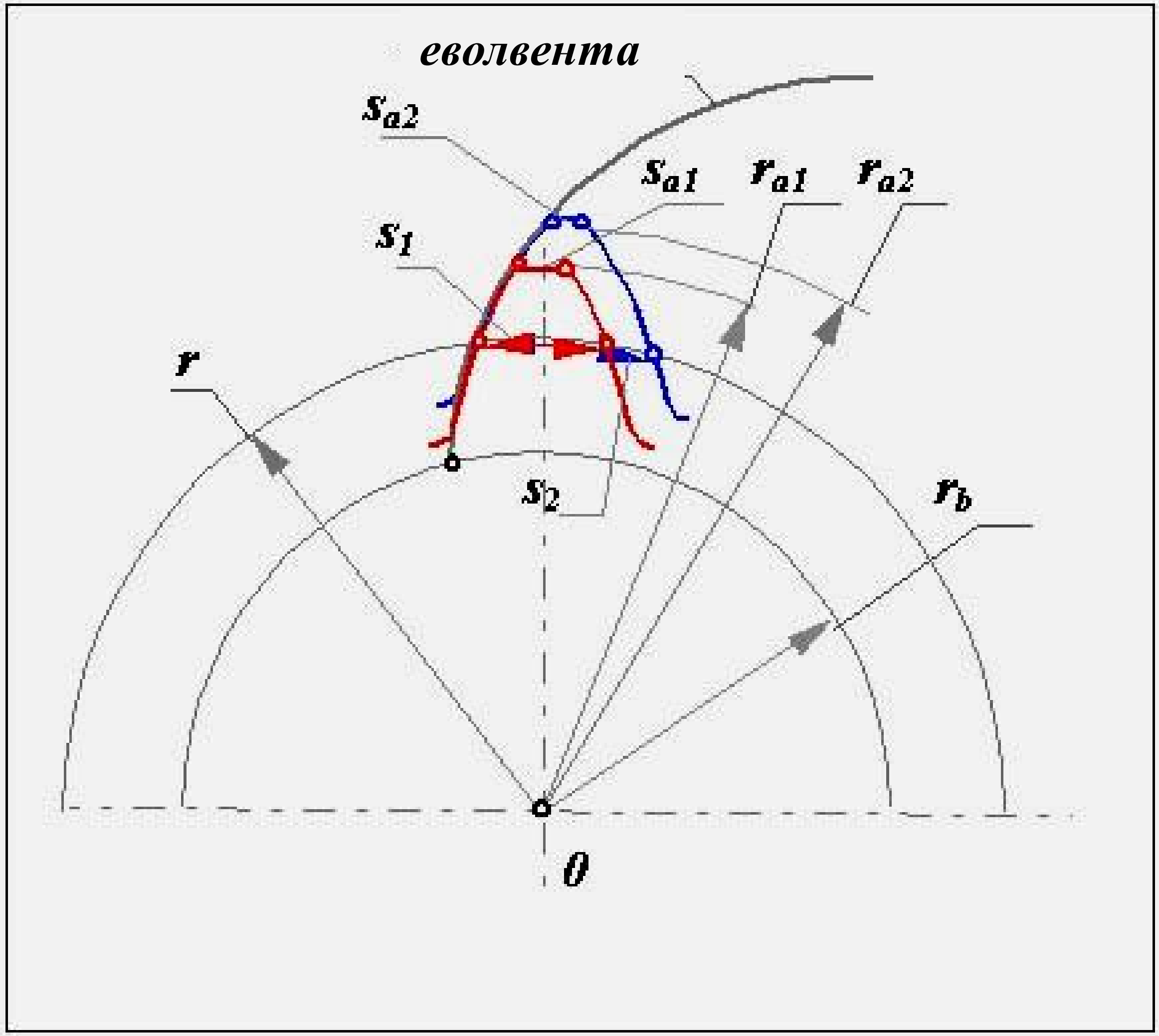
$$s_b = d_b\left(\frac{p}{2z} + \frac{2x\tan a_0}{z} + inv(a)\right)$$



$$s = \frac{pm}{2} + 2xm\tan a_0$$

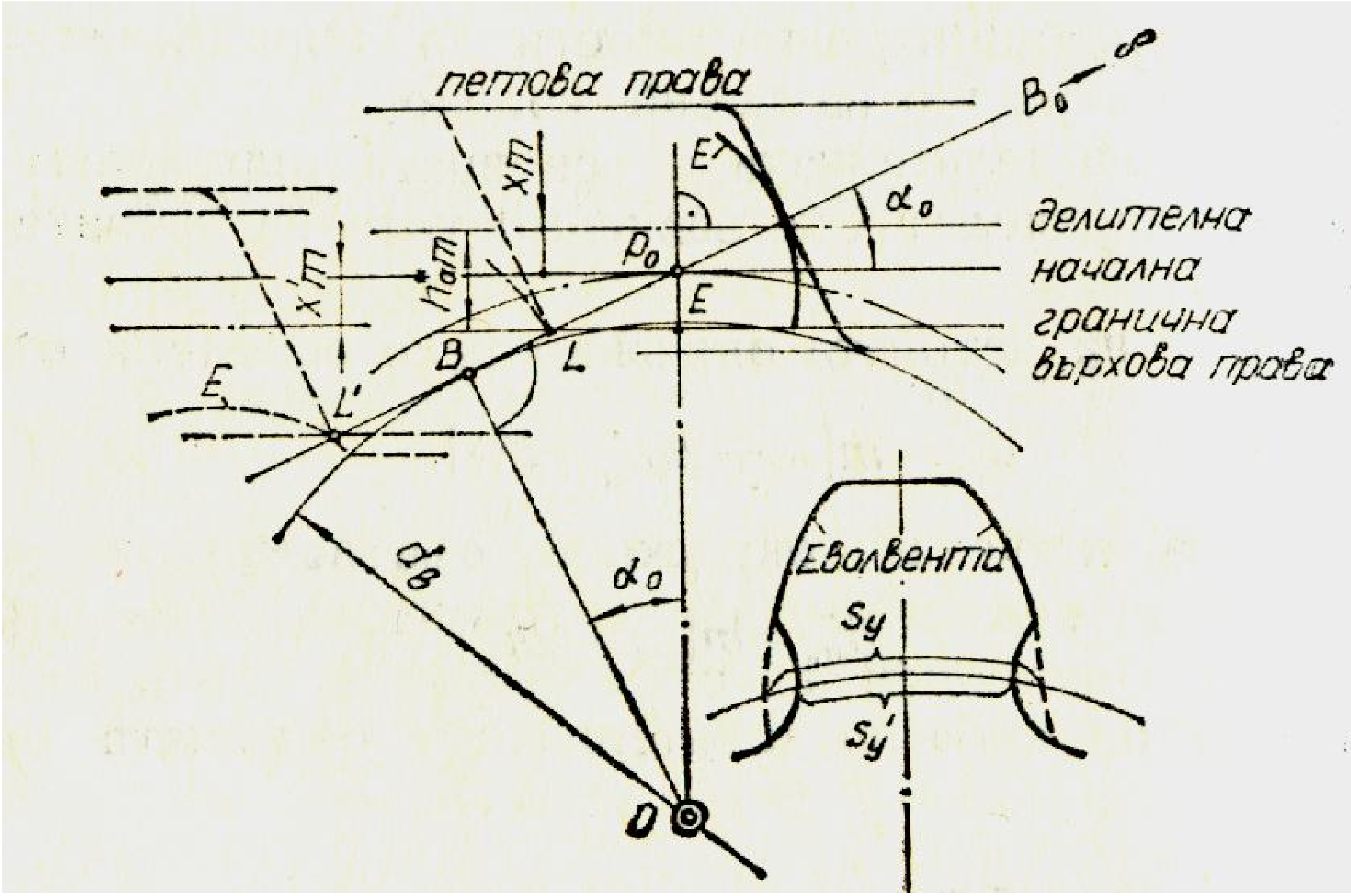
$$s = \frac{p}{2} + \Delta s = m\left(\frac{p}{2} + \Delta\right); \;\; e = p - s.$$

$$\Delta = 2x\tan a_0$$



$$s_y = m\frac{\cos a}{\cos a_y}\left[\frac{p}{2} + \Delta - z\left(inv\left(a_y\right) - inv\left(a\right)\right)\right].$$

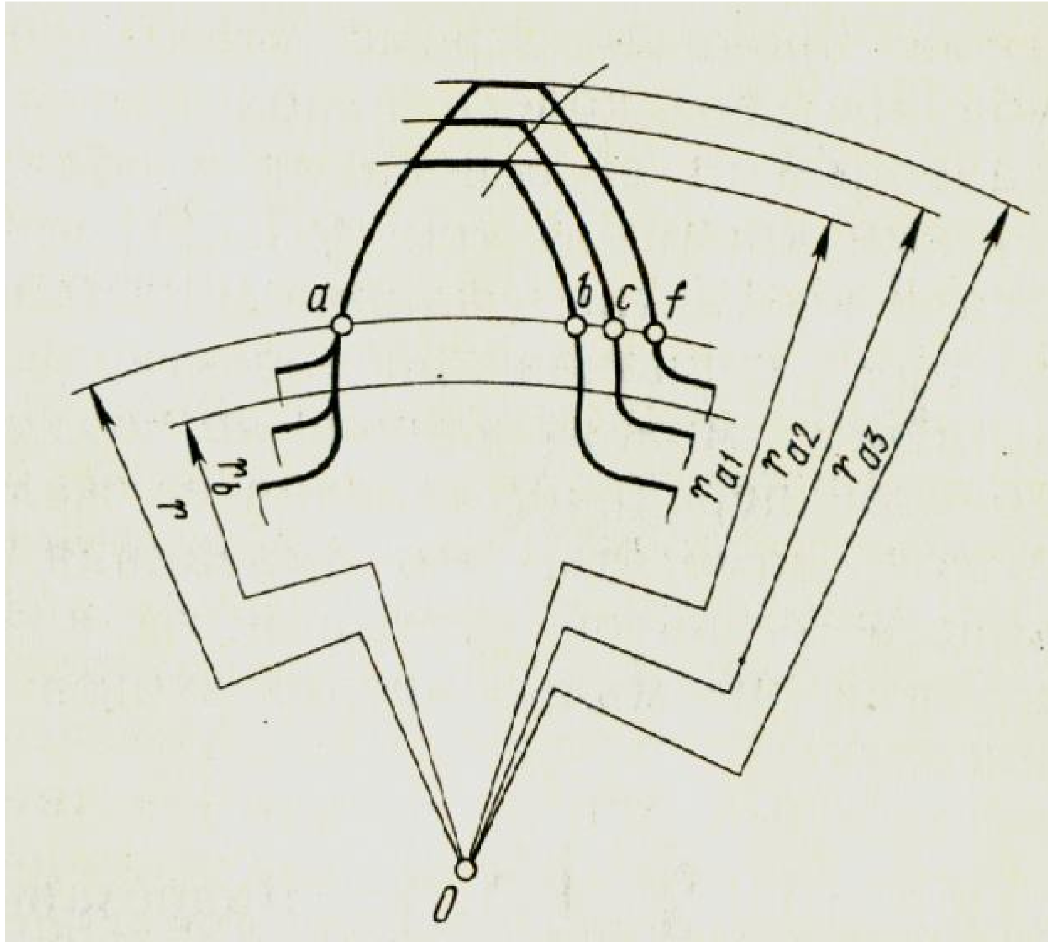
5. Подрязване. Минимален брой зъби



$$\overline{P_0L} = \frac{\overline{P_0E}}{\sin a_0} = \frac{\left(h_a^* - x\right)m}{\sin a_0}; \quad \overline{P_0B} = \overline{P_0O}\sin a_0 = \frac{mz}{2}\sin a_0;$$

$$\frac{mz}{2}\sin a_0 \geq \frac{\left(h_a^* - x\right)m}{\sin a_0}; \quad z \geq \frac{2\left(h_a^* - x\right)}{\sin^2 a_0}; \quad z_{\min} \geq \frac{2h_a^*}{\sin^2 a_0}$$

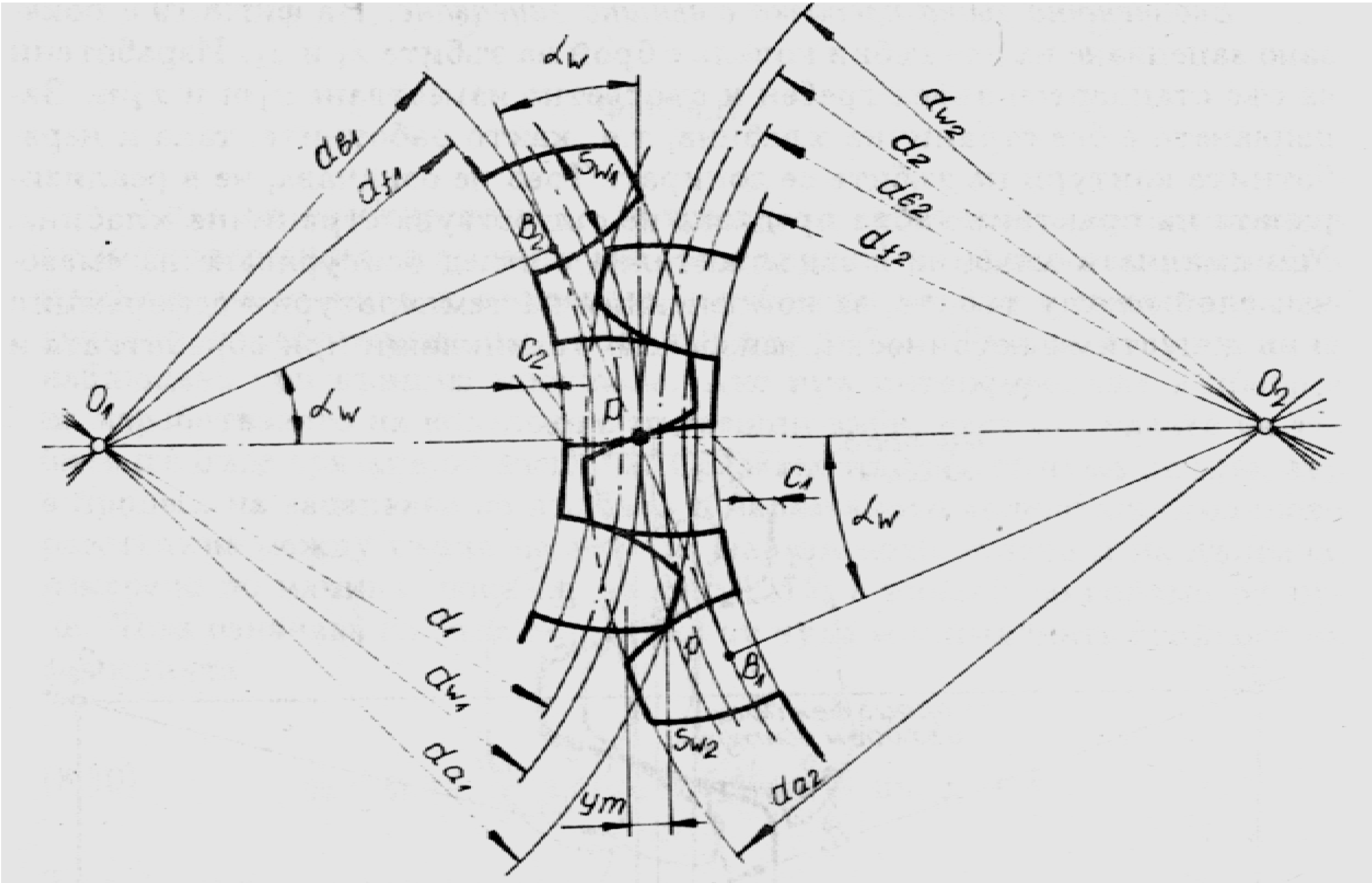
6. Заостряне



$$s_a = d_a\left(\frac{p}{2z} + \frac{2x\tan a_0}{z} + inv(a) - inv(a_a) \right)$$

$$a_a = \arccos\frac{d_b}{d_a}; \quad s_a^{\min} = 0.2m$$

7. Еволвентна зъбна предавка без хлабина



$$p_w = s_{w_1} + e_{w_1} = s_{w_2} + e_{w_2} = s_{w_1} + s_{w_2};\; p_w = \frac{pd_{w_1}}{z_1} = \frac{pd_{w_2}}{z_2}$$

Еволвентна зъбна предавка без хлабина

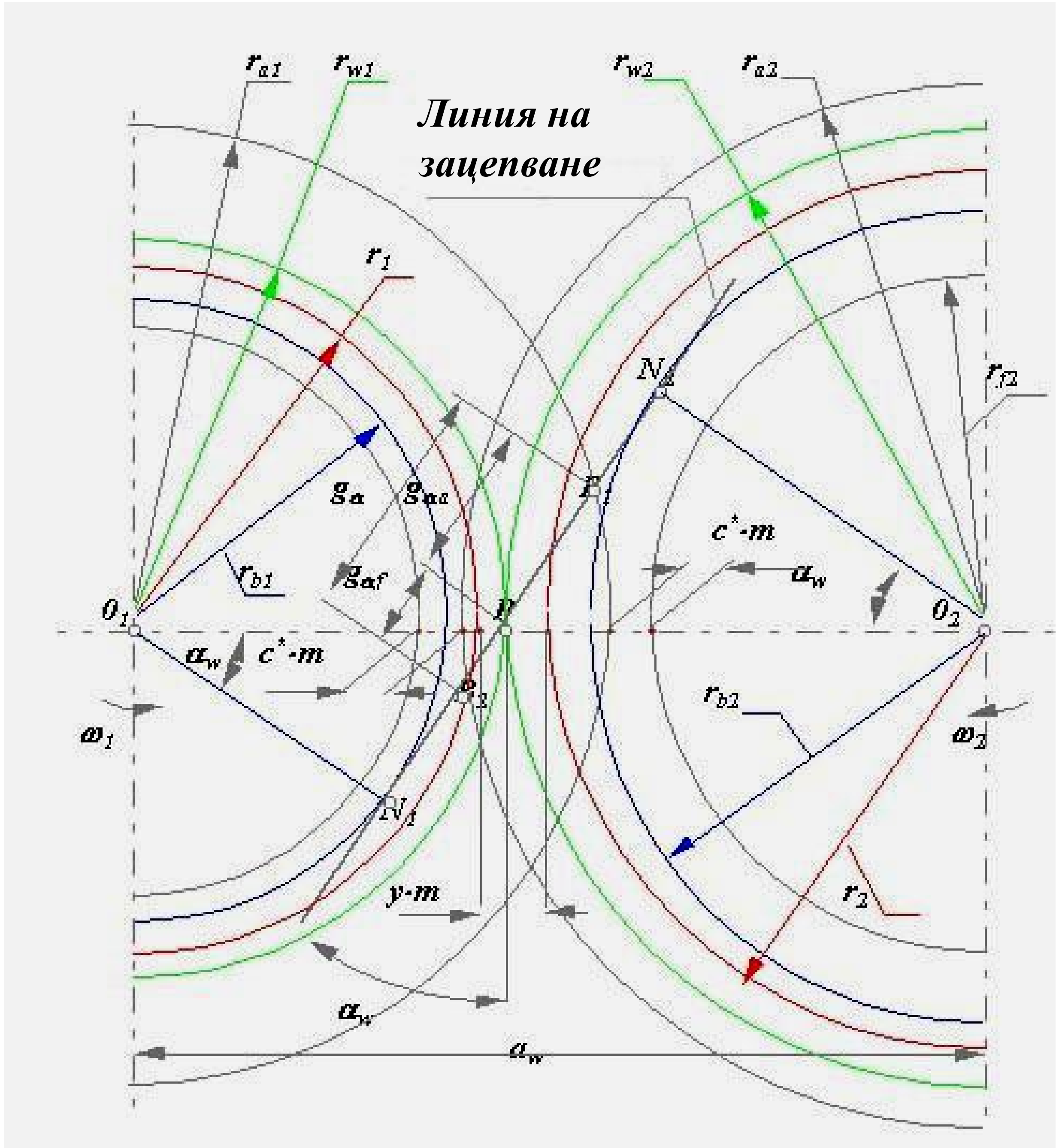
$$p_w = s_{w_1} + e_{w_1} = s_{w_2} + e_{w_2} = s_{w_1} + s_{w_2}$$

$$p_w = \frac{pd_{w_1}}{z_1} = \frac{pd_{w_2}}{z_2}$$

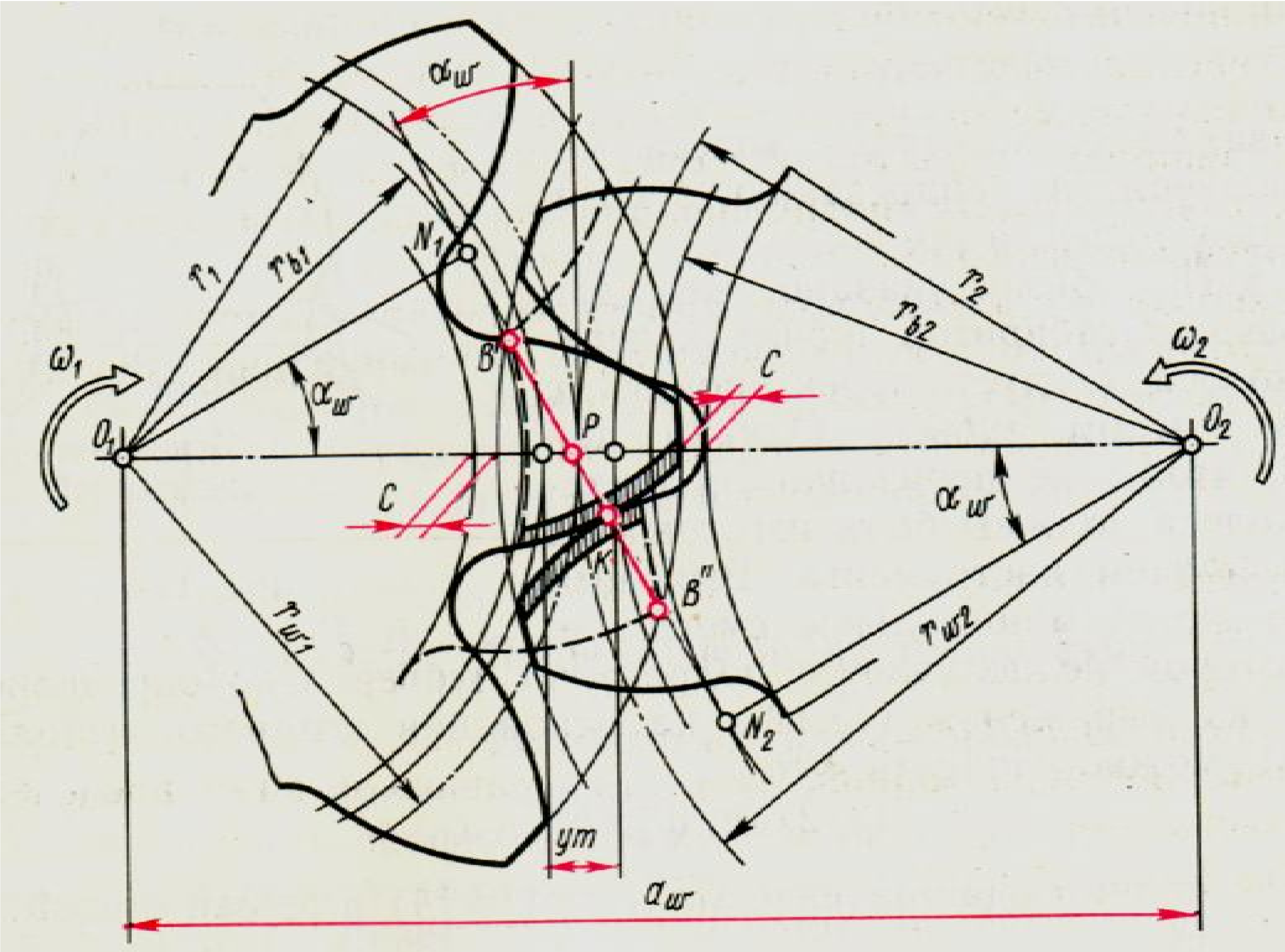
$$s_{w_1} = d_{w_1}\left(\frac{p}{2z_1} + \frac{2x_1 \tan a_0}{z_1} + inv(a) - inv(a_{w_1})\right)$$

$$s_{w_2} = d_{w_2}\left(\frac{p}{2z_2} + \frac{2x_2 \tan a_0}{z_2} + inv(a) - inv(a_{w_2})\right)$$

$$inv(a_{w_1}) = inv(a_{w_2}) = inv(a_w)$$



Линия на зацепване
r_{a1}
r_{w1}
r_{w2}
r_{a2}
r_1
r_{f2}
N_2
g_α
$g_{\alpha a}$
E_1
$c^*\cdot m$
r_{b1}
$g_{\alpha f}$
α_w
0_1
P
0_2
α_w
$c^*\cdot m$
E_2
r_{b2}
ω_1
ω_2
N_1
r_2
$y\cdot m$
α_w
a_w



α_w
r_1
r_{b1}
N_1
r_2
r_{b2}
ω_1
ω_2
O_1
O_2
B'
P
C
C
K
B''
r_{w1}
r_{w2}
N_2
ym
a_w

$$\frac{pd_w}{z_1} = d_{w_1}\left(\frac{p}{2z_1} + \frac{2x_1 \tan a_0}{z_1} + inv(a) - inv(a_w)\right) +$$

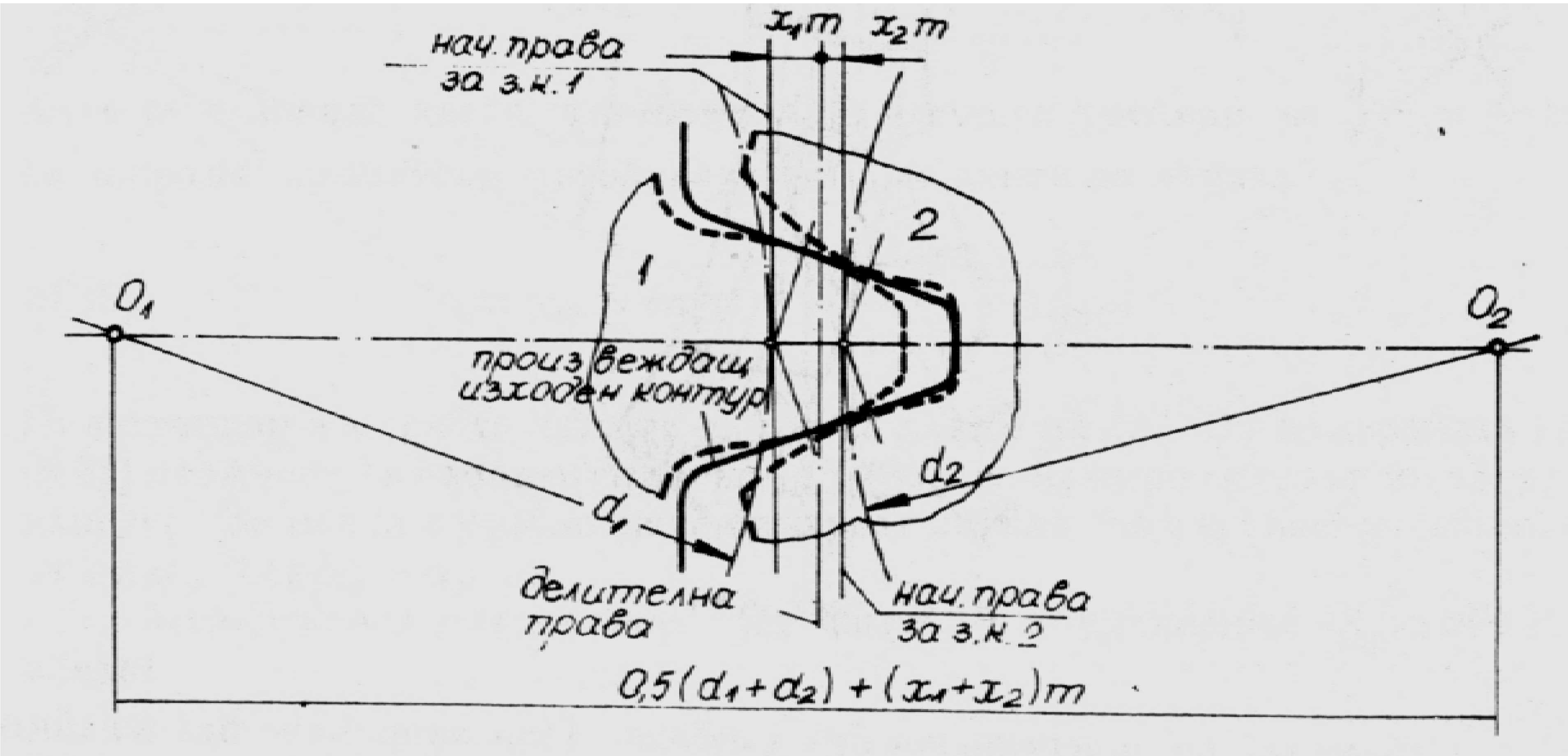
$$+ d_{w_2}\left(\frac{p}{2z_2} + \frac{2x_2 \tan a_0}{z_2} + inv(a) - inv(a_w)\right)$$

$$inv(a_w) = inv(a) + \frac{2(x_1 + x_2)}{z_1 + z_2}\tan a_0$$

$$a_0 = a = 20^0 \Rightarrow a_w = ?$$

$$a_w = \frac{d_{w_1} + d_{w_2}}{2} = \frac{m(z_1 + z_2)}{2}\frac{\cos a}{\cos a_w} = a\frac{\cos a}{\cos a_w}$$

Обратно изместване



Обратно изместване

$$a_w = \frac{1}{2}\left(d_1 + d_2\right) + ym = a + ym$$

$$a_w = \frac{d_{w_1} + d_{w_2}}{2} = \frac{m\left(z_1 + z_2\right)}{2}\frac{\cos a}{\cos a_w} = a\frac{\cos a}{\cos a_w}$$

$$y = \frac{a_w - a}{m} = \frac{z_1 + z_2}{2}\left(\frac{\cos a}{\cos a_w} - 1\right)$$

$$\Delta y = x_\Sigma - y$$

8. Класификации на предавките

- Без изместване

$$x_1 = x_2 = 0$$

$$inv(a_w) = inv(a) \Rightarrow a_w = a; y = 0; \Delta y = 0$$

- С изместване

$$x_\Sigma = x_1 + x_2$$

$$x_\Sigma = 0 \Rightarrow x_1 = -x_2 \Rightarrow$$

$$inv(a_w) = inv(a) \Rightarrow a_w = a; y = 0; \Delta y = 0$$

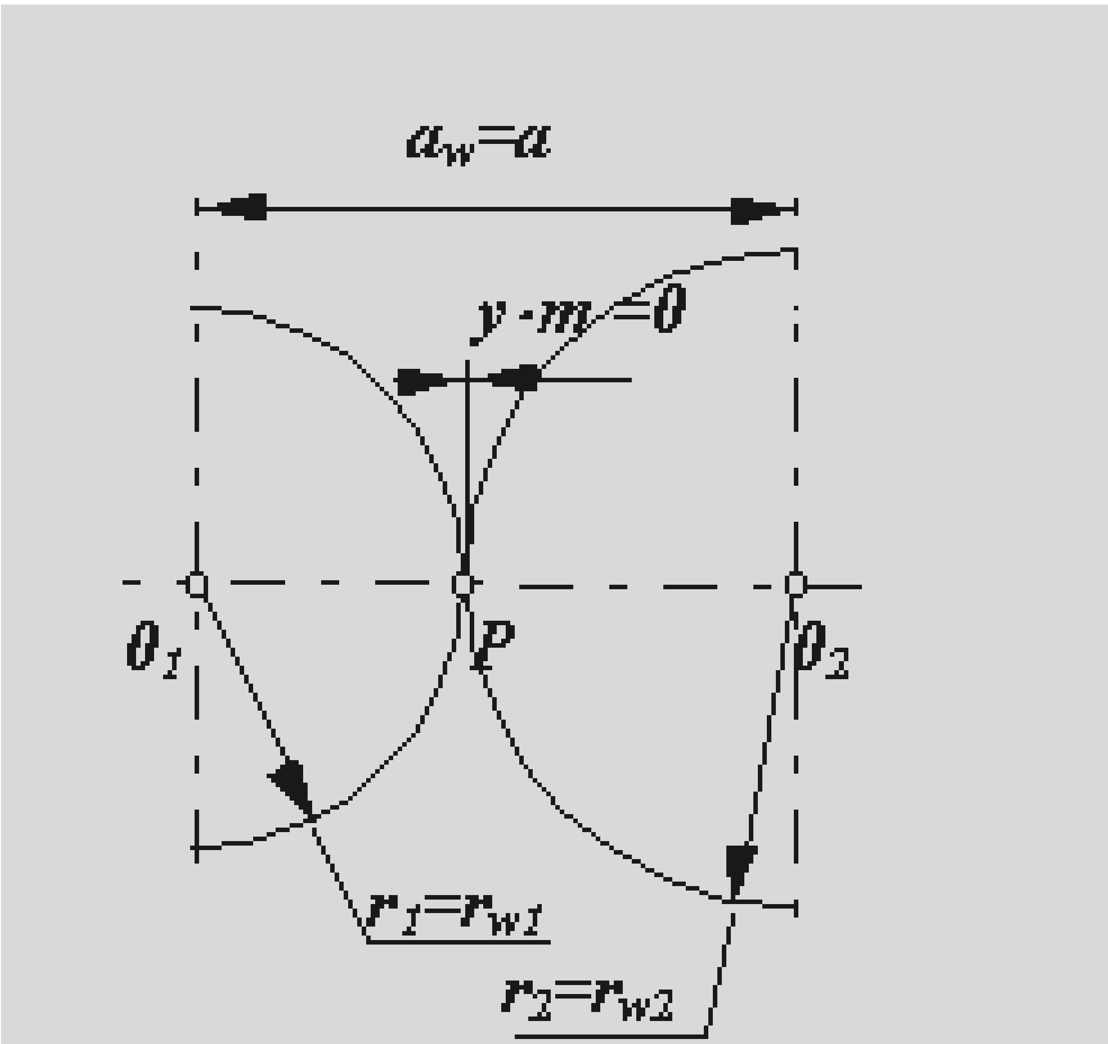
$$x_\Sigma > 0 \Rightarrow$$

$$a_w > a;\ a_w > a;\ y > 0; \Delta y > 0$$

$$x_\Sigma < 0$$

$$a_w < a;\ a_w < a;\ y < 0; \Delta y < 0$$

Без изместване



$$x_\Sigma = x_1 + x_2$$

$$x_\Sigma = 0 \Rightarrow x_1 = -x_2 \Rightarrow$$

$$inv(a_w) = inv(a) \Rightarrow a_w = a;$$

$$y = 0; \Delta y = 0$$

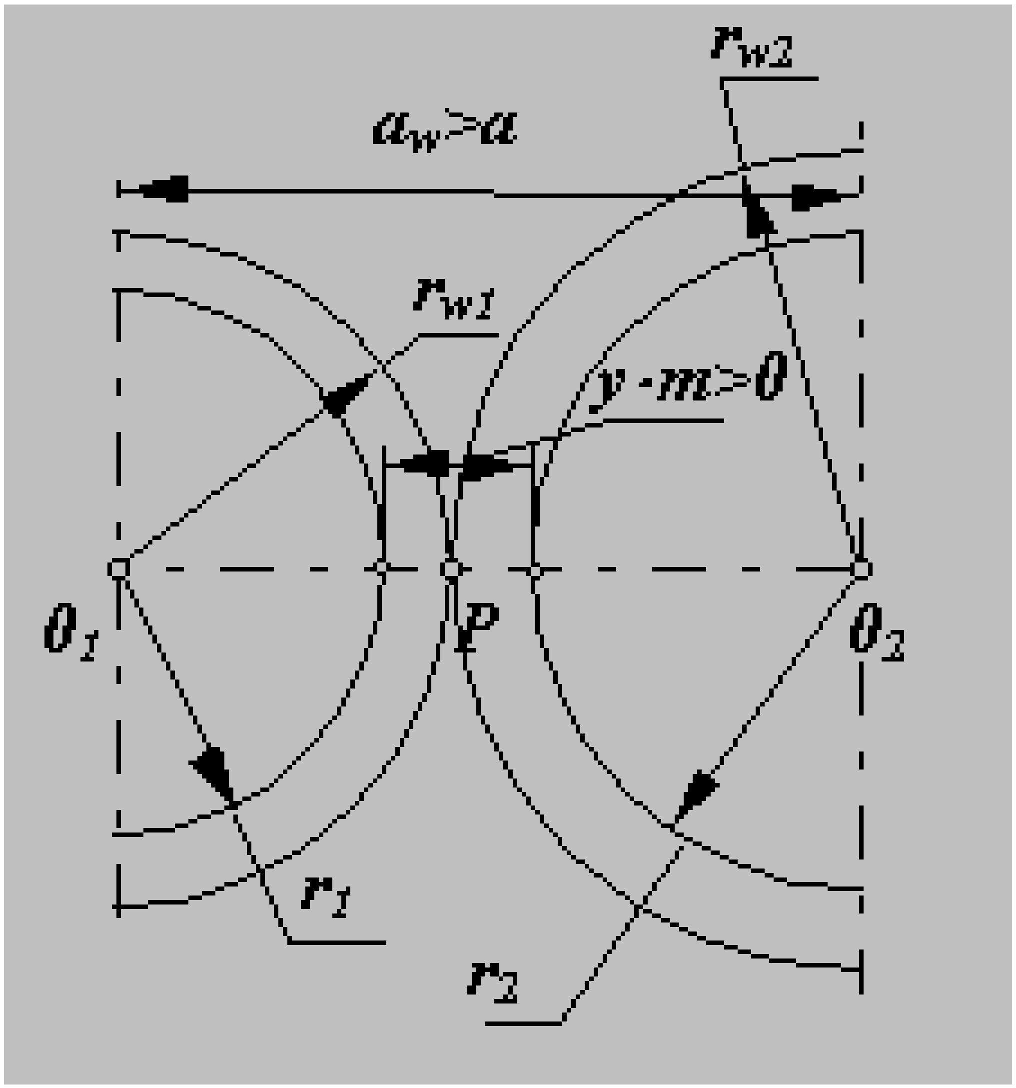
$$x_\Sigma > 0 \Rightarrow$$

$$a_w > a;\ a_w > a;\ y > 0; \Delta y > 0$$

$$x_\Sigma < 0$$

$$a_w < a;\ a_w < a;\ y < 0; \Delta y < 0$$

С изместване >0



$$x_\Sigma = x_1 + x_2$$

$$x_\Sigma = 0 \Rightarrow x_1 = -x_2 \Rightarrow$$

$$inv(a_w) = inv(a) \Rightarrow a_w = a;$$

$$y = 0; \Delta y = 0$$

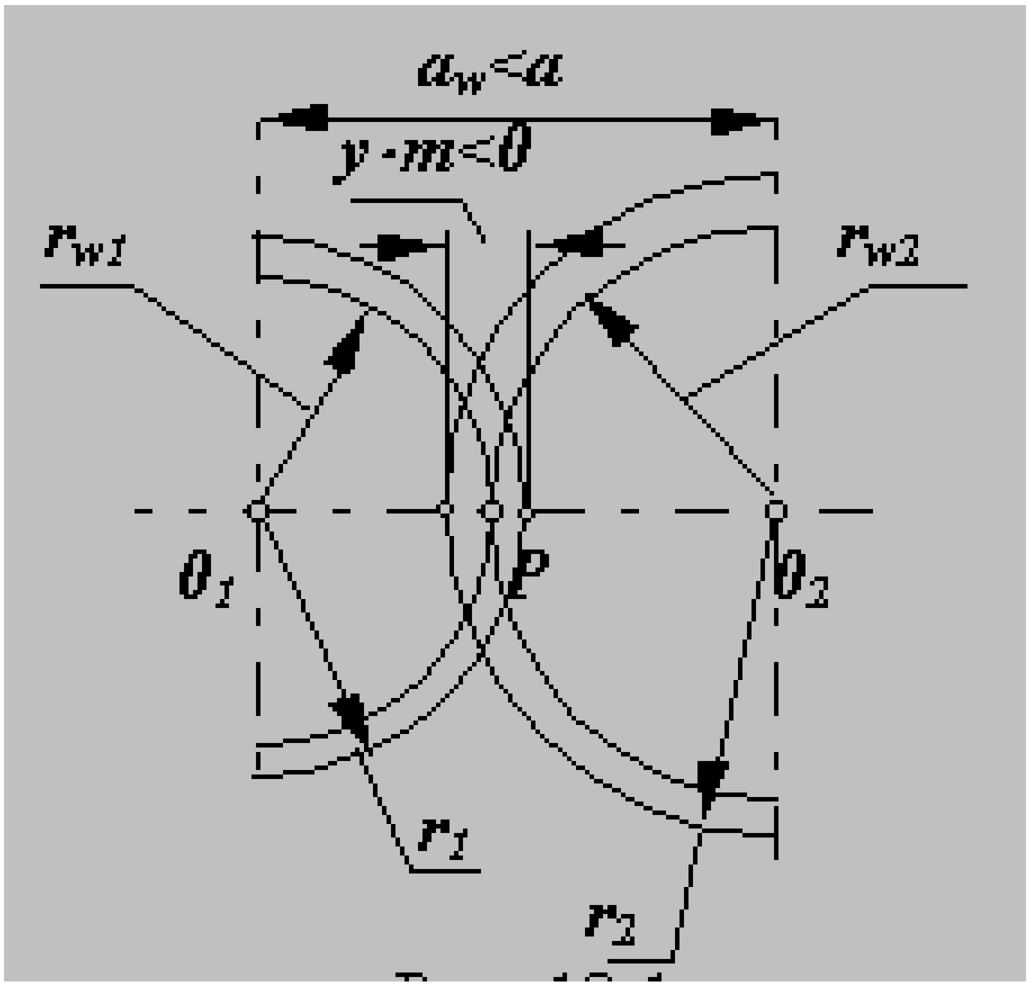
$$x_\Sigma > 0 \Rightarrow$$

$$a_w > a;\ a_w > a;\ y > 0; \Delta y > 0$$

$$x_\Sigma < 0$$

$$a_w < a;\ a_w < a;\ y < 0; \Delta y < 0$$

С изместване <0



$$x_\Sigma = x_1 + x_2$$

$$x_\Sigma = 0 \Rightarrow x_1 = -x_2 \Rightarrow$$

$$inv(a_w) = inv(a) \Rightarrow a_w = a;$$

$$y = 0; \Delta y = 0$$

$$x_\Sigma > 0 \Rightarrow$$

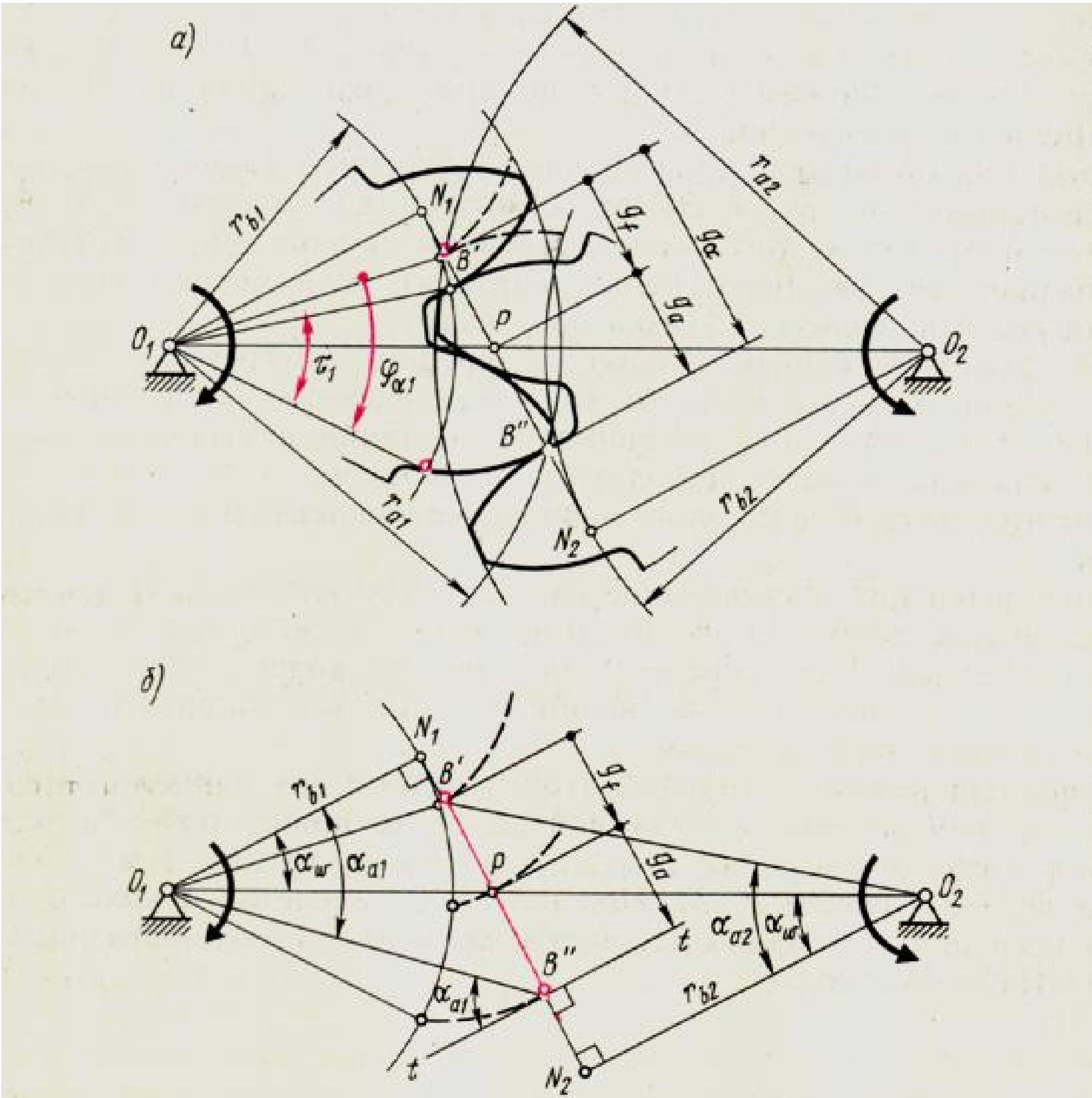
$$a_w > a; \; a_w > a; \; y > 0; \Delta y > 0$$

$$x_\Sigma < 0$$

$$a_w < a; \; a_w < a; \; y < 0; \Delta y < 0$$

9. Качествени показатели на зъбните предавки

Коефициент на челно покриване



$$e_a = \frac{j_{a1}}{t_1} = \frac{j_{a2}}{t_2}$$

$$j_a = \frac{\overline{A_b A_{b'}}}{0.5 d_b} = \frac{B'B''}{0.5 d_b}$$

$$t = \frac{2p}{z} = \frac{p_b}{0.5 d_b}$$

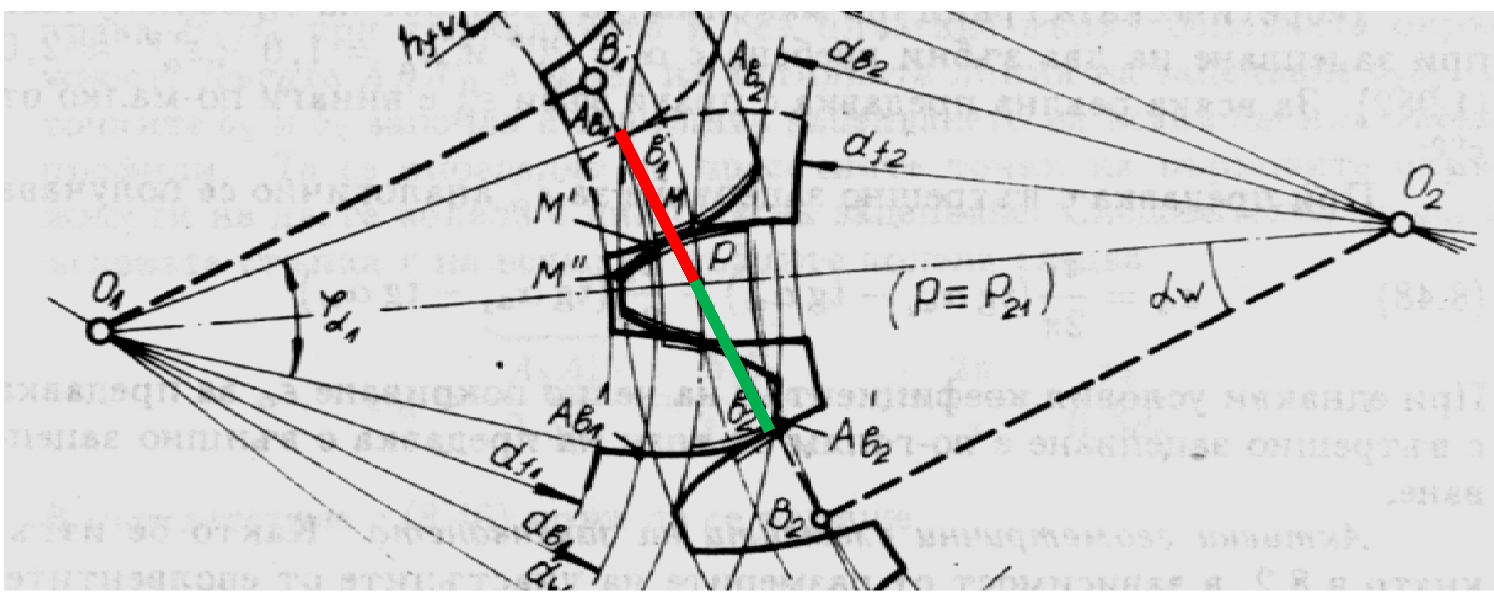
$$e_a = \frac{j_a}{t} = \frac{B'B''}{p_b}$$

$$e_a = \frac{\overline{b_1P} + \overline{Pb_2}}{p_b} = \frac{\left(\overline{B_2b_1} - \overline{B_2P}\right) + \left(\overline{B_1b_2} - \overline{B_1P}\right)}{p_b}$$

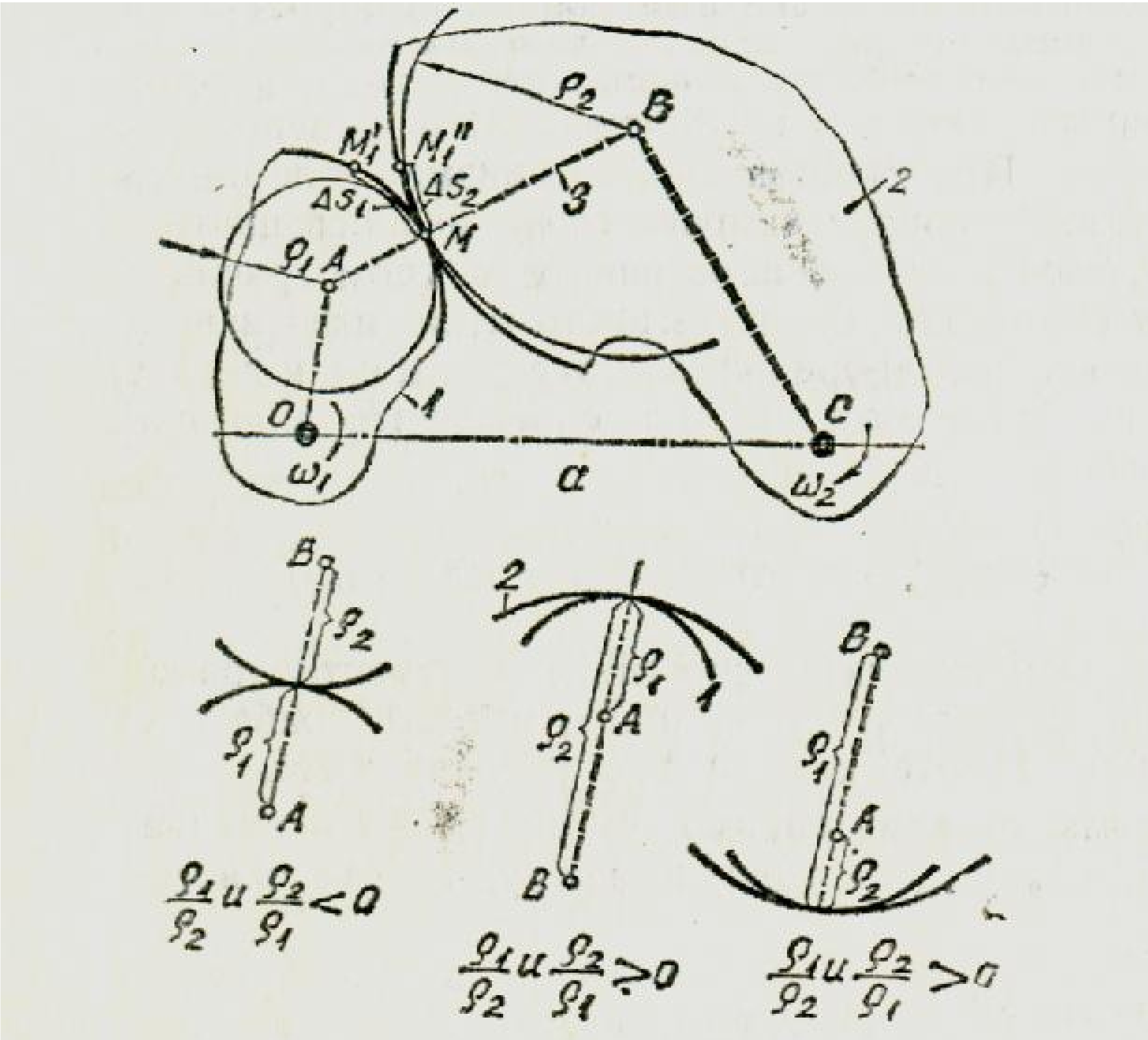
$$\left(\overline{B_2b_1} - \overline{B_2P}\right) + \left(\overline{B_1b_2} - \overline{B_1P}\right) = \frac{d_{b_2}}{2}\left(\tan a_{a_2} - \tan a_w\right) + \frac{d_{b_2}}{2}\left(\tan a_{a_1} - \tan a_w\right)$$

$$p_b = \frac{pd_{b_1}}{z_1} = \frac{pd_{b_2}}{z_2}$$

$$e_a = \frac{z_1}{2p}\left(\tan a_{a_1} - \tan a_w\right) + \frac{z_2}{2p}\left(\tan a_{a_2} - \tan a_w\right)$$



Коефициент на относително плъзгане



$$l_1 = \frac{\Delta S_1 - \Delta S_2}{\Delta S_1} = 1 - \frac{\Delta S_2}{\Delta S_1};$$

$$l_2 = \frac{\Delta S_2 - \Delta S_1}{\Delta S_2} = 1 - \frac{\Delta S_1}{\Delta S_2}$$

$$\Delta \varphi_i = \omega_i \Delta t,$$

може да се напише

$$\Delta \varphi_2 = \omega_2 \Delta t = \omega_2 \frac{\Delta \varphi_1}{\omega_1} = i_{21} \Delta \varphi_1; \quad \Delta \varphi_3 = \frac{\omega_3}{\omega_1} \Delta \varphi_1 = i_{31} \Delta \varphi_1.$$

Елементарните относителни ъглови премествания се определя

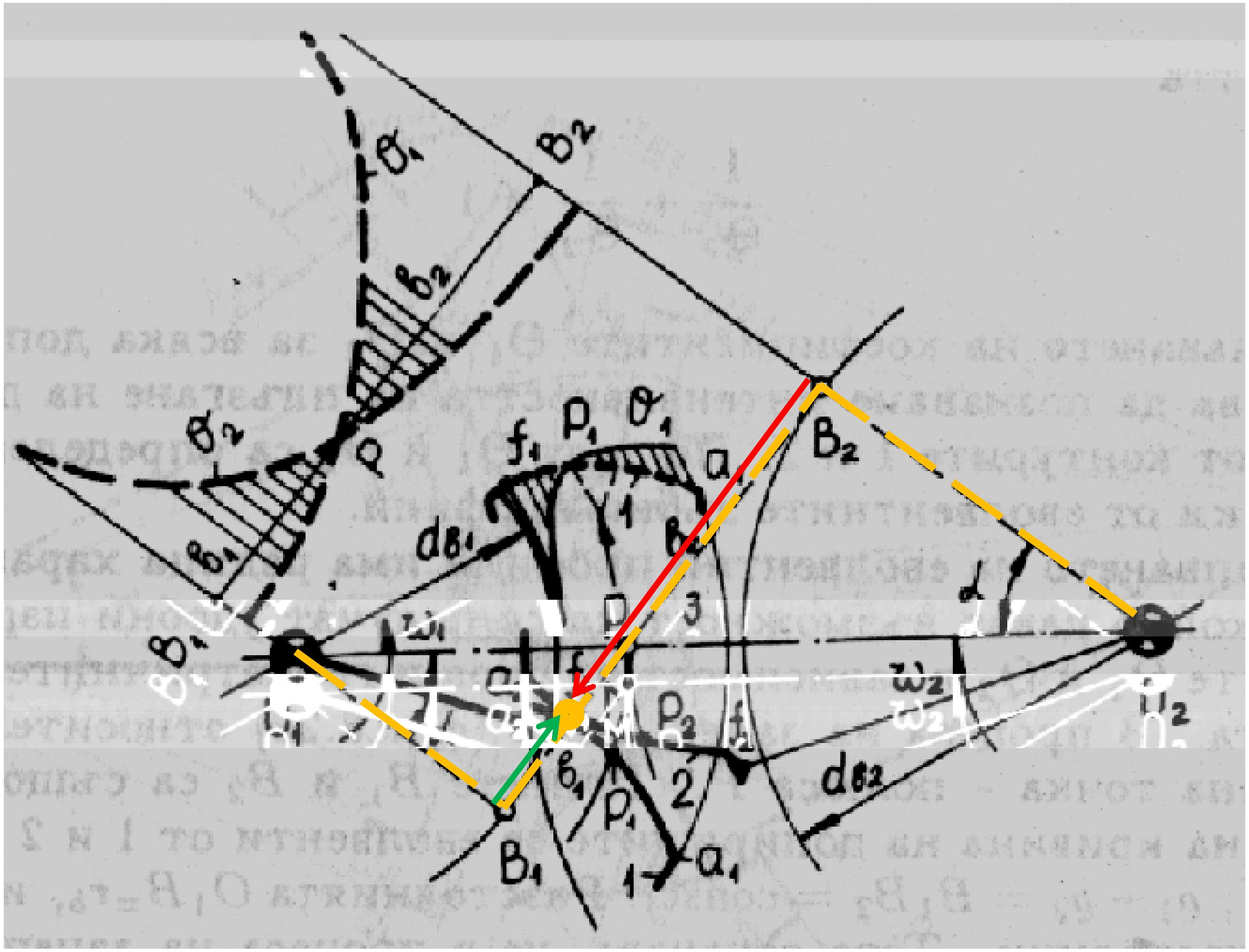
$$\Delta \varphi_{31} = \Delta \varphi_3 - \Delta \varphi_1 = (i_{31} - 1) \Delta \varphi_1;$$

$$\Delta \varphi_{32} = \Delta \varphi_3 - \Delta \varphi_2 = (i_{31} - i_{21}) \Delta \varphi_1,$$

след което дъгите Δs_1 и Δs_2 могат да се изразят от

$$(4.17) \quad \begin{vmatrix} \Delta s_1 = \rho_1 \Delta \varphi_{31} = \rho_1 (i_{31} - 1) \Delta \varphi_1; \\ \Delta s_2 = \rho_2 \Delta \varphi_{32} = \rho_2 (i_{31} - i_{21}) \Delta \varphi_1. \end{vmatrix}$$

$$l_1 = 1 - \left(\pm \frac{r_2}{r_1} \right) \frac{i_{31} - i_{21}}{i_{31} - 1}; \quad l_2 = 1 - \left(\pm \frac{r_1}{r_2} \right) \frac{i_{31} - 1}{i_{31} - i_{21}}$$



$$i_{31} = \frac{w_3}{w_1} = 0$$

$$l_1 = 1 - \left(\frac{r_2}{r_1}\right) i_{21}$$

$$l_2 = 1 - \left(\frac{r_1}{r_2}\right) \frac{1}{i_{21}}$$

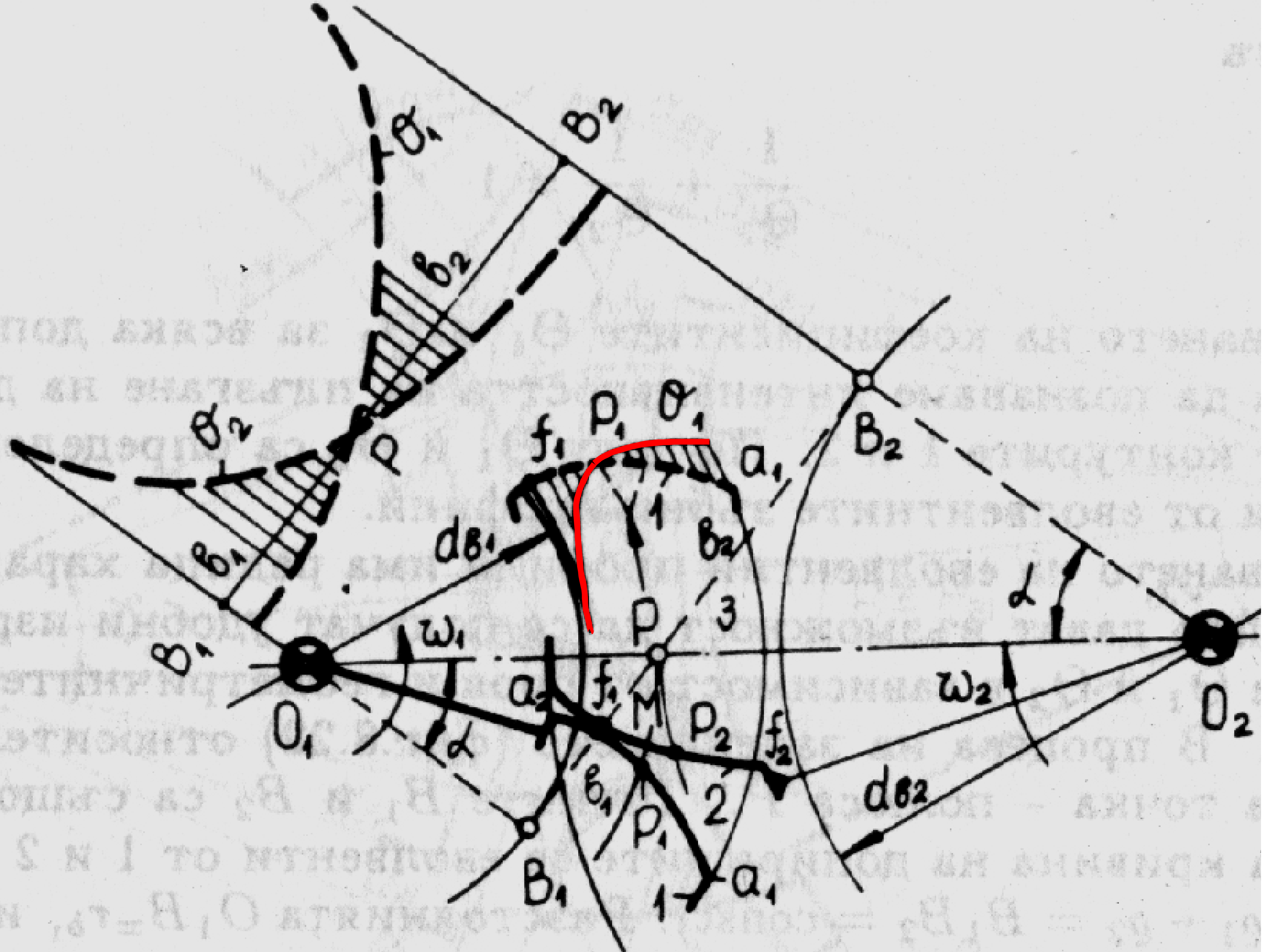
$$r_1 = \overline{B_1 M};\ r_1 = \overline{B_2 M}$$

$$l_1 = 1 - \frac{\overline{B_2 M}}{\overline{B_1 M}} \frac{z_1}{z_2};$$

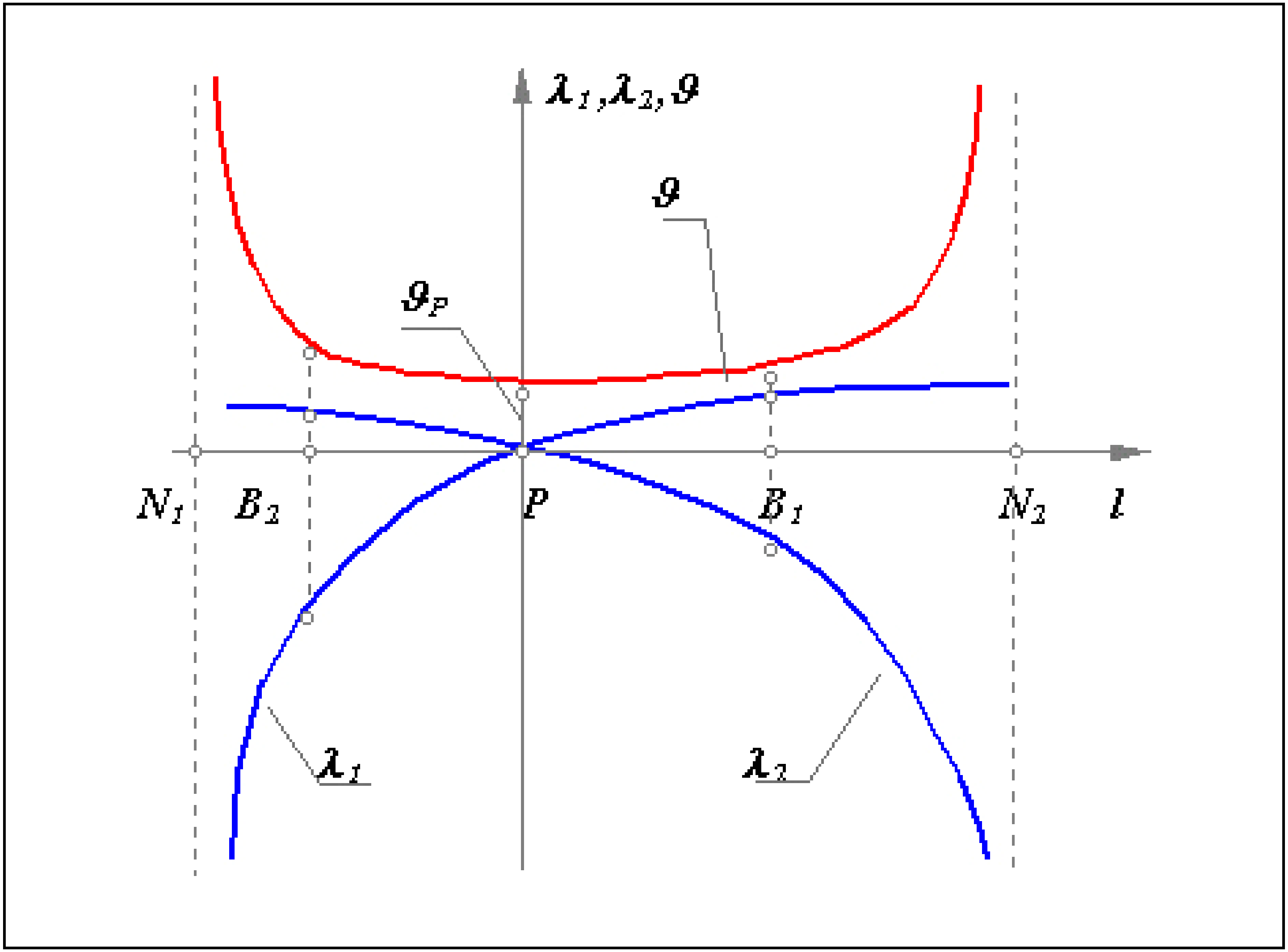
$$l_2 = 1 - \frac{\overline{B_1 M}}{\overline{B_2 M}} \frac{z_2}{z_1}$$

$$l_1^r = 1 - \frac{\overline{B_2 M}}{\overline{B_1 M}} \frac{z_1}{z_2};$$

$$l_2^r = \frac{z_1}{z_2} - \frac{\overline{B_1 M}}{\overline{B_2 M}}$$



σ_1
B_2
b_2
σ_2
P
b_1
B_1
f_1
ρ_1
σ_1
a_1
b_2
d_{B1}
1
P
3
B_2
α
ω_1
O_1
α
a_2
f_1
M
ρ_2
f_2
ω_2
O_2
b_1
ρ_1
2
d_{B2}
B_1
1
a_1


λ1,λ2,ϑ
ϑ
ϑP
N1
B2
P
B1
N2
l
λ1
λ2

Блокиращи контури