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2	.	01.09.2020 – 15.09.2020	
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4		17.10.2020 – 17.11.2020	
5		18.11.2020 – 30.11.2020	
6		01.12.2020 – 03.12.2020	
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, 2020.

## ABSTRACT

Bezugly P.A. Improving the maintainability of the drive mechanisms of the coke pusher coke battery.

Qualification final work for obtaining a higher education degree of a master's degree in specialty 133 - Industrial engineering, scientific adviser Yo.K. Oginsky. Zaporozhye National University, Engineering Educational and Scientific Institute, Department of Metallurgical Equipment, 2020.

The analysis of the existing designs of the coke pusher is carried out, the advantages and disadvantages of the existing technical solutions are analyzed. A variant of the modernization of the drive of the door-lifting rod is proposed. The analysis of the layouts of hydraulic circuits is carried out. The dependence of the

minimum diameter of the hydraulic cylinder of the door-removing mechanism drive on the pressure of the hydraulic pump and the proportionality coefficient has been established. Recommendations are given on the use of safety devices to protect the operator of the coke pusher from excessive noise.

Key words: DRIVE, COKE, COKE EJECTOR, DOOR DEVICE, PROPORTIONALITY RATIO.

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2.1		38
2.2		
		43
2.3		47
2.4		
		55
2.5	,	57
3	-	59
3.1		59

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3.2	
	70
3.3	75
4	82
4.1	
	82
4.2	83
4.3	86
4.3.1	86
4.3.2	87
4.3.3	87
4.4	89
4.4.1	89
4.4.2	91
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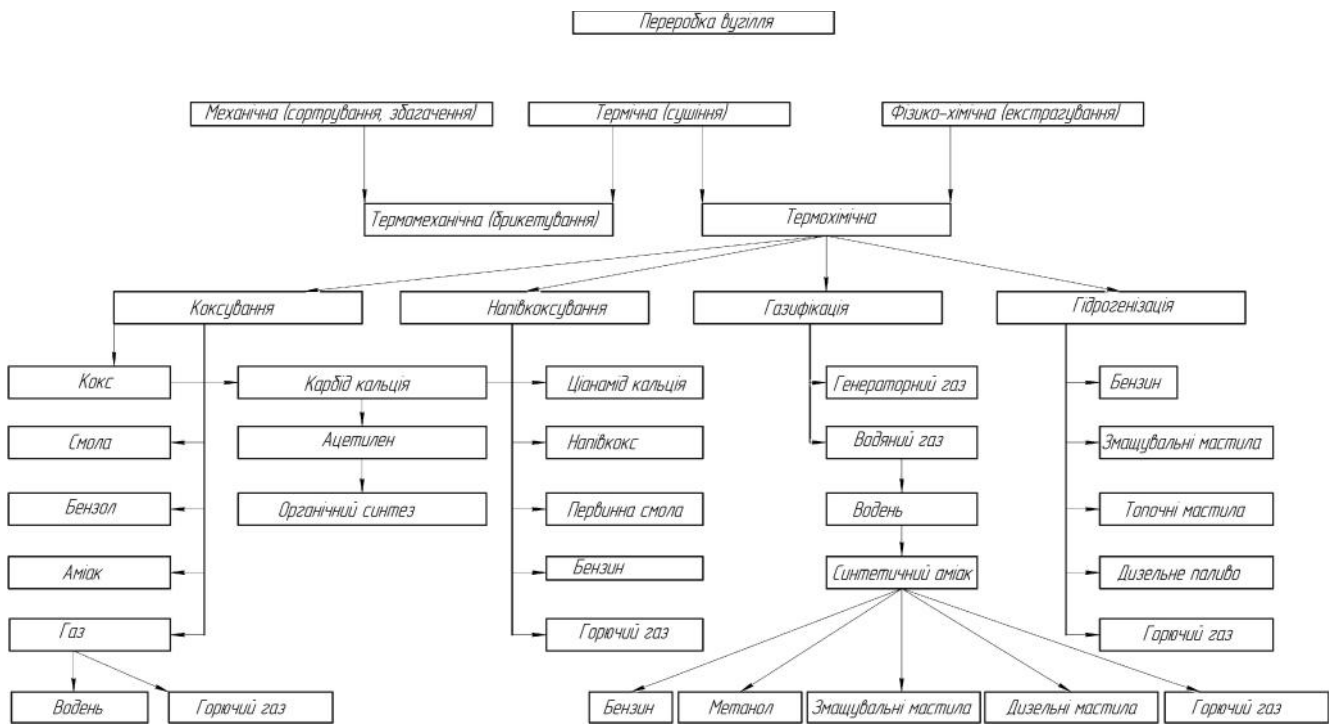
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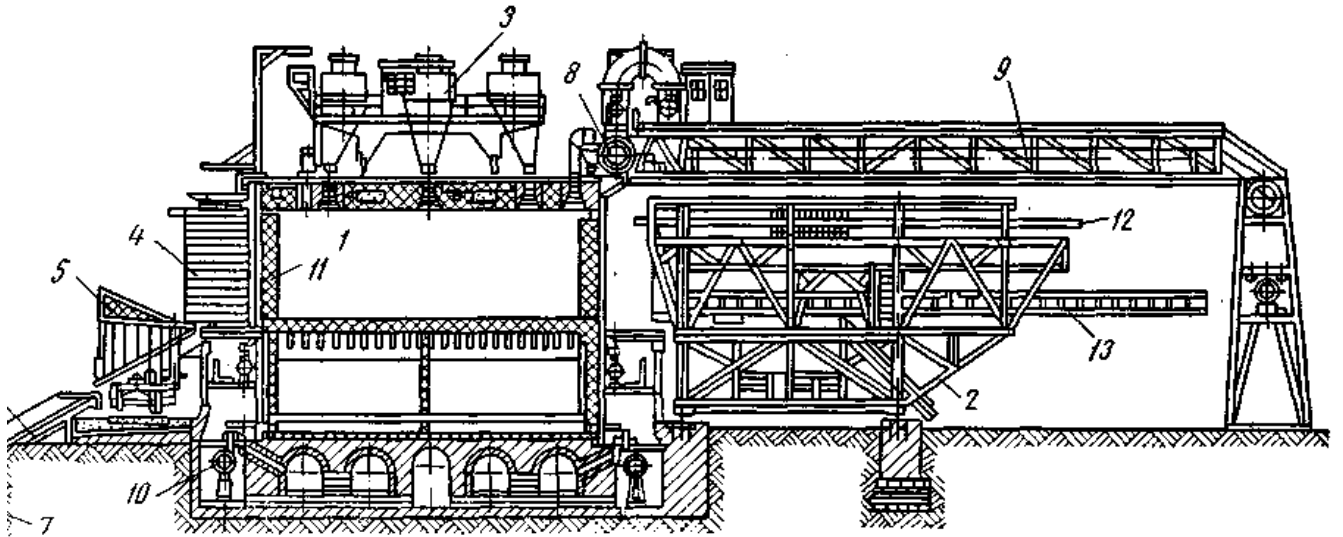
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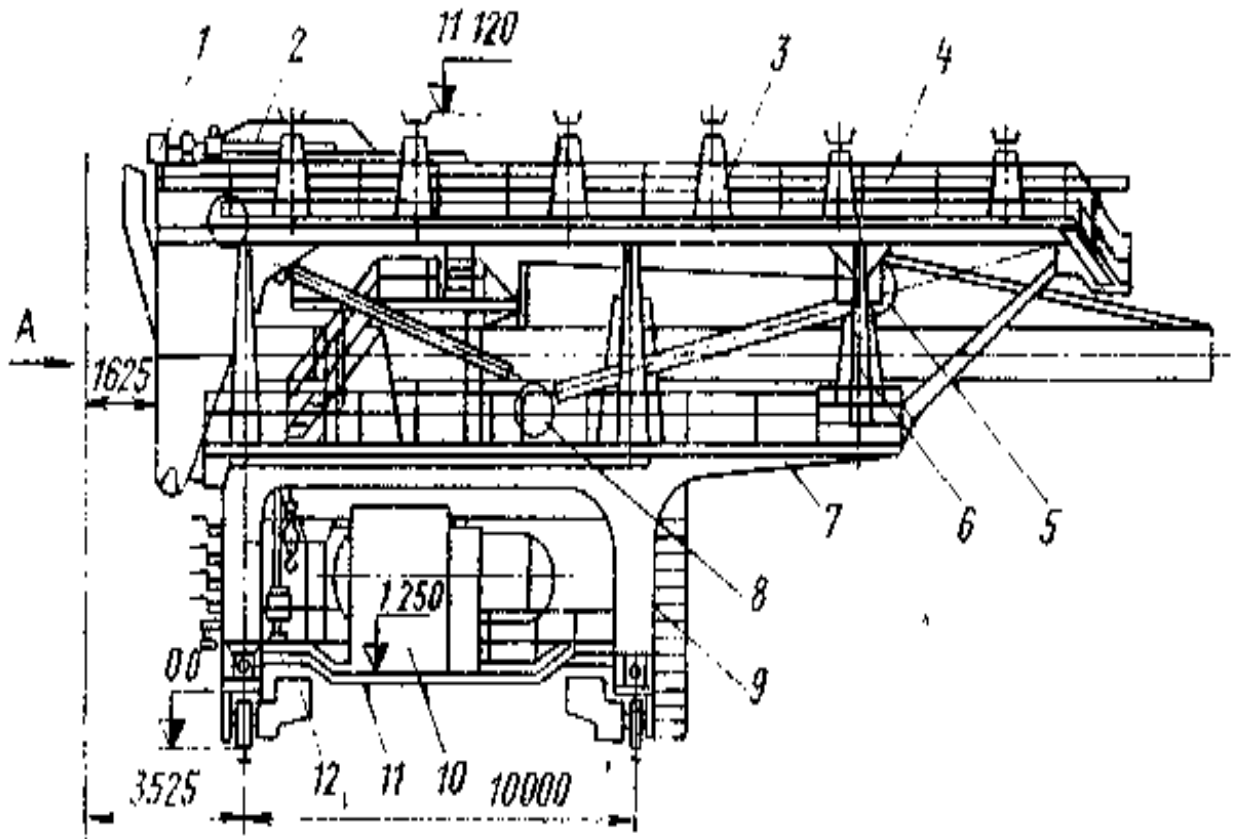
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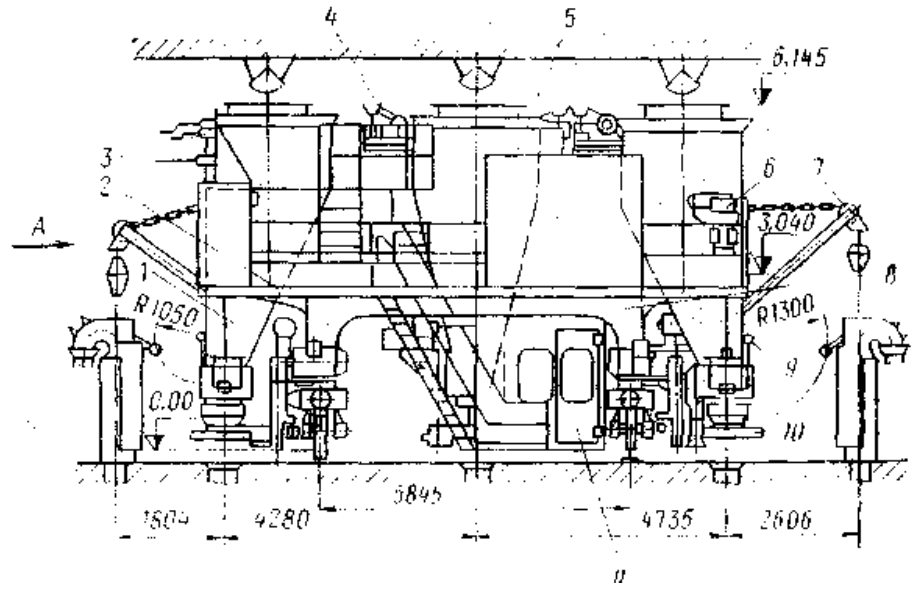
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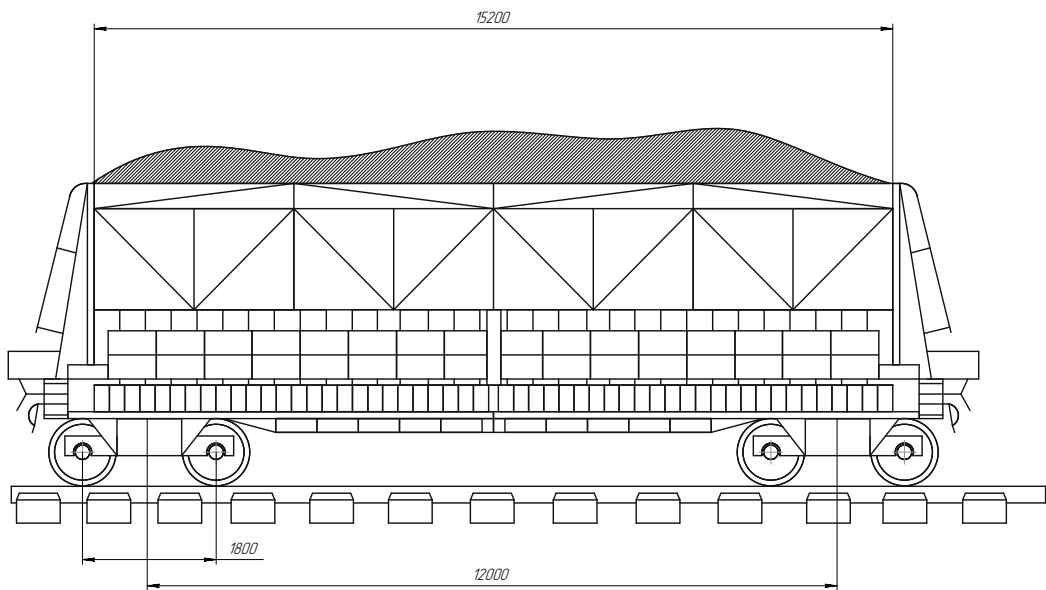
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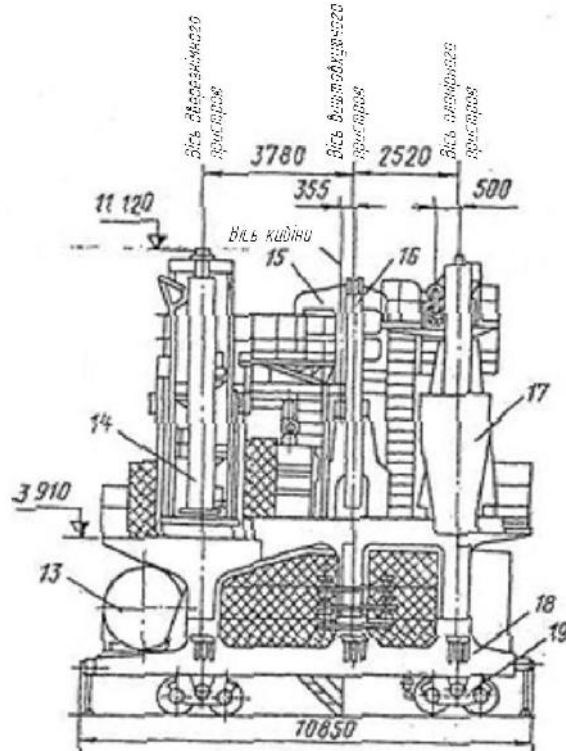
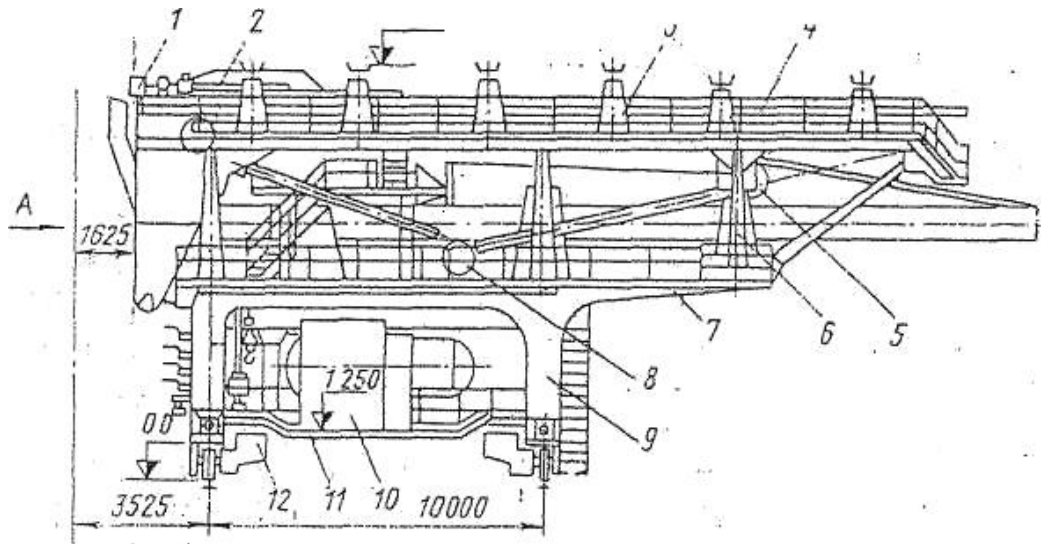
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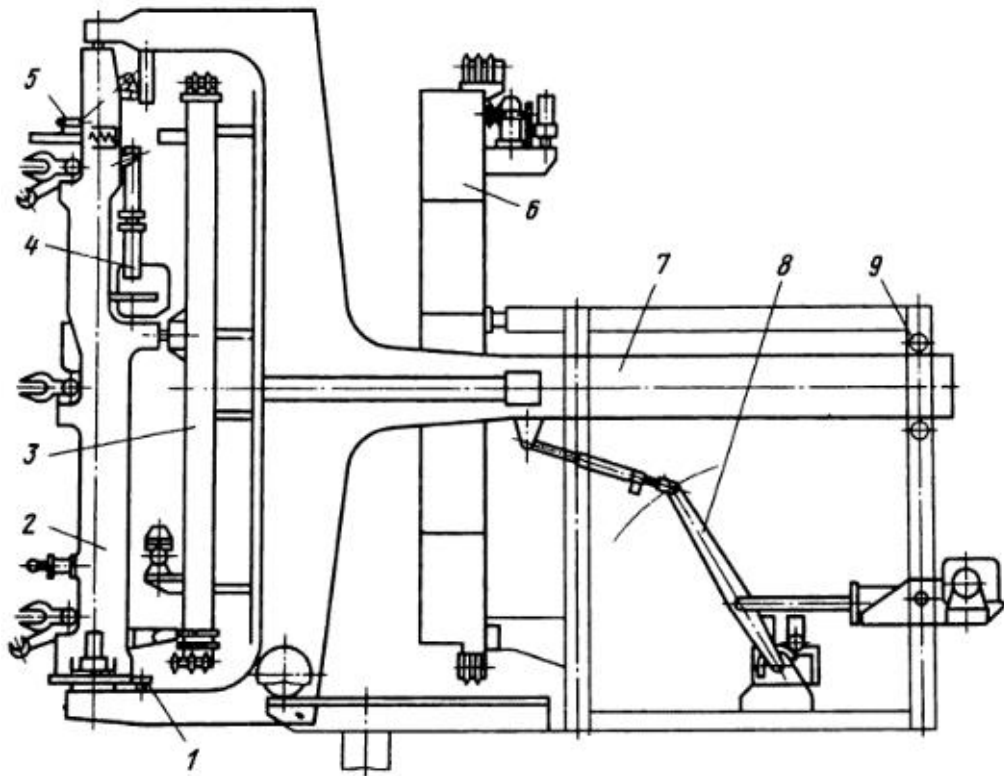
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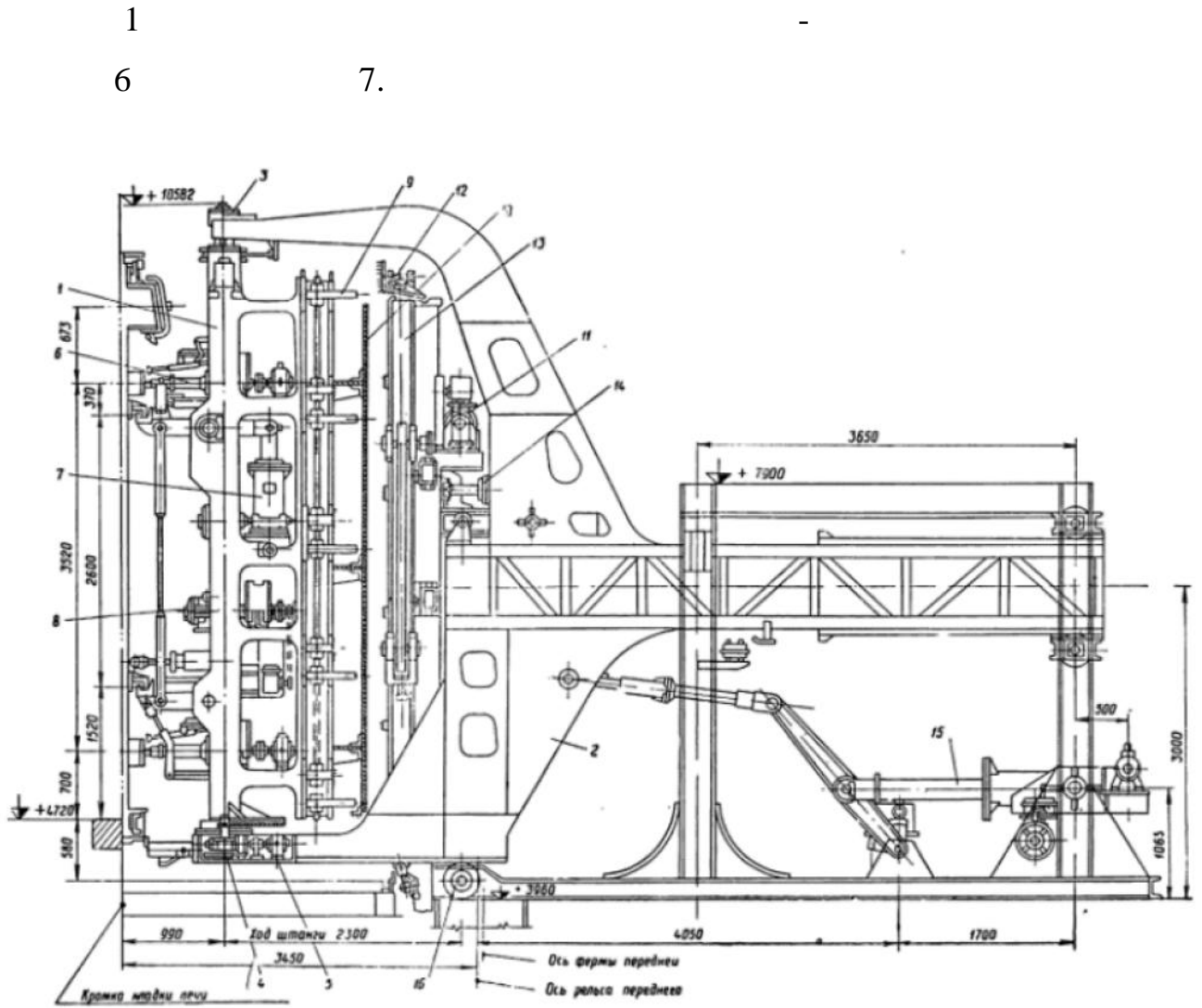


Рис. 140. Дверьёмное устройство коковьталкивателя с поворотом головкки на 180°

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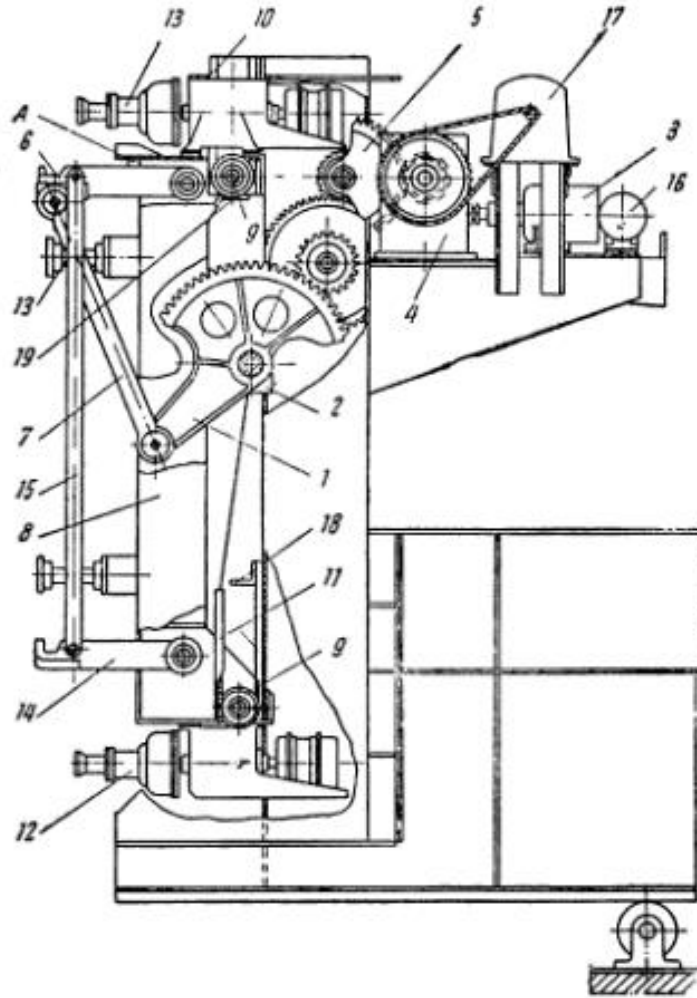
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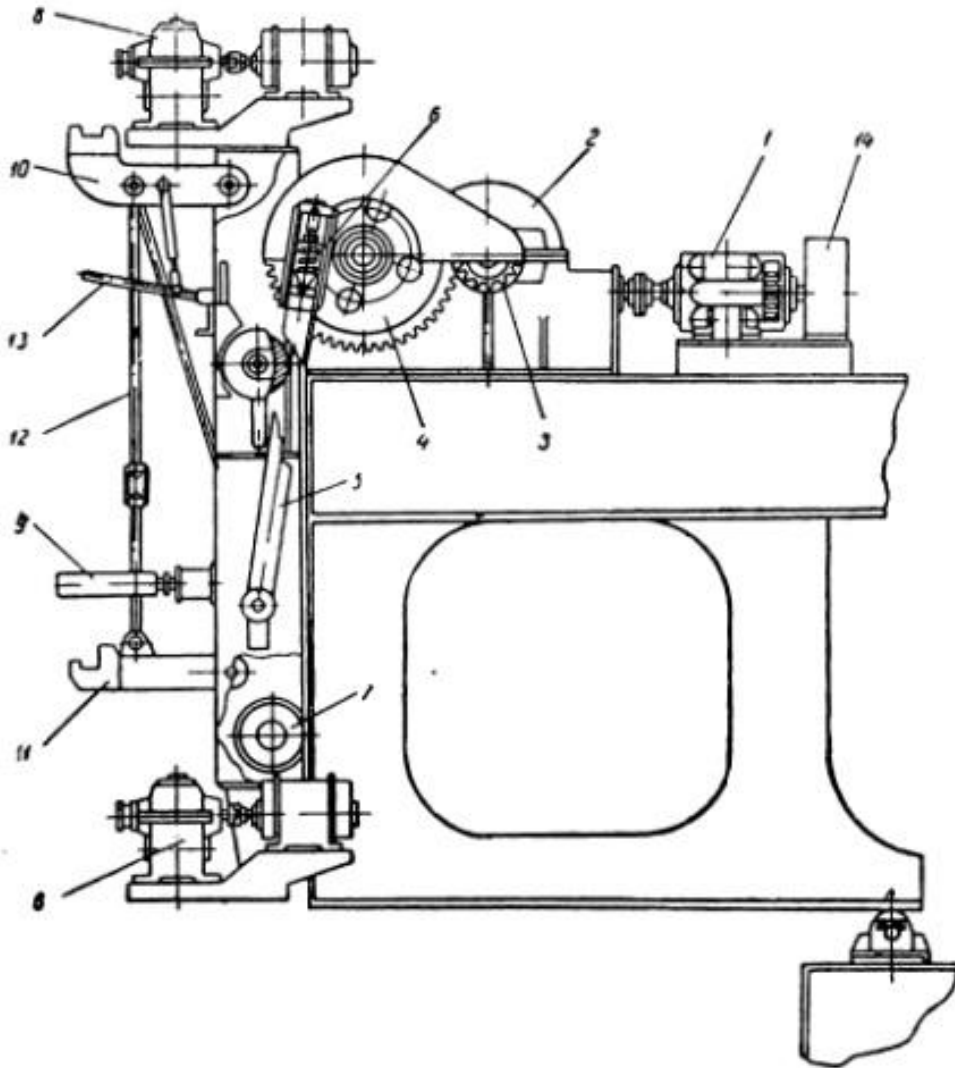
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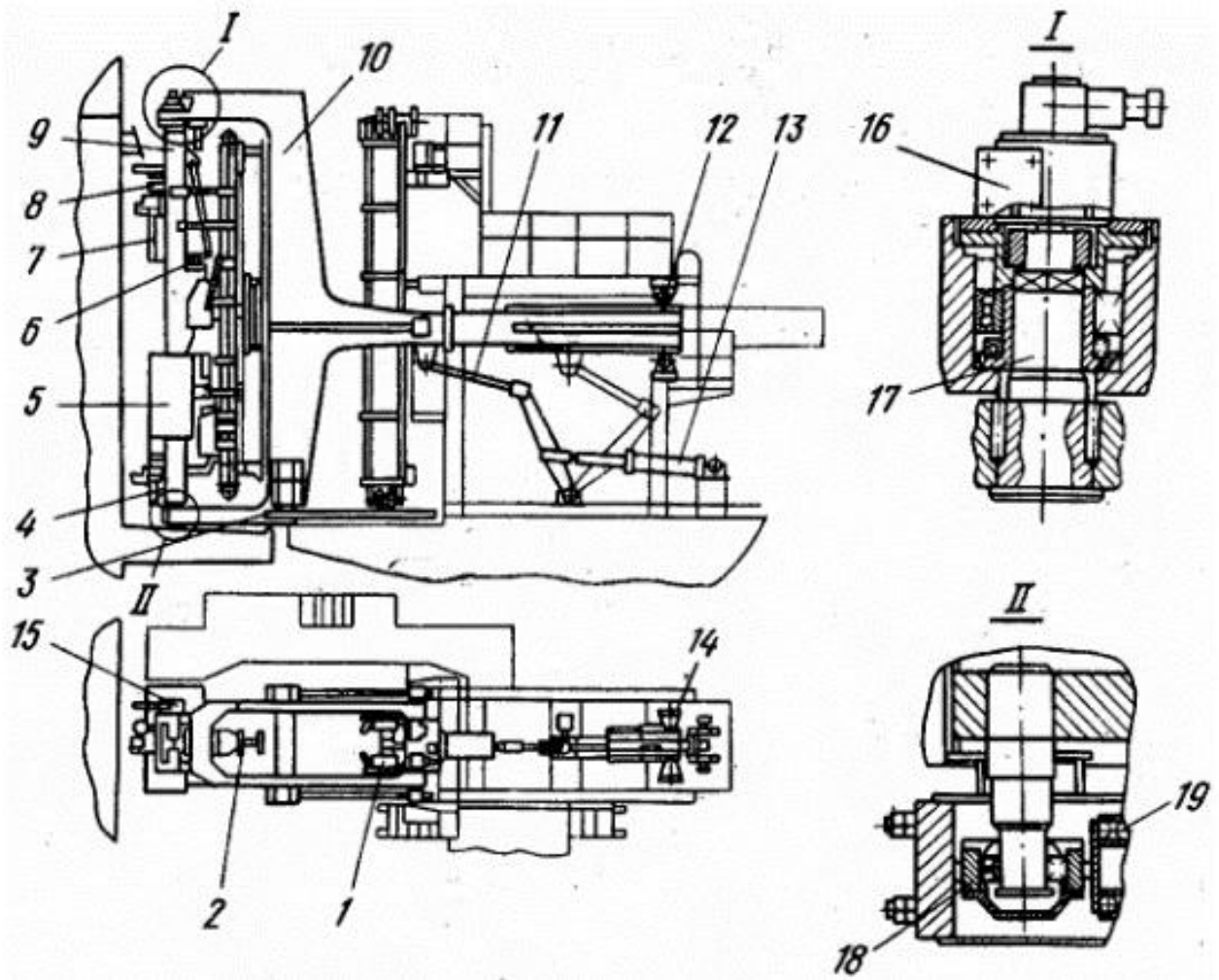
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:  
 ,  $L = 2400$ ;  
 ,  $G_0 = 3000$ ;  
 , (  $G_1 = 1400$ ;  
 , ),  $G_2 = 3000$ ;  
 , /  $V = 7$ ;  
 ,  $= 16,62$ .

- 1) ( ) ;
- 2) ;
- 3) ;
- 4) , ;
- 5) .

$R_A$   $R$

.2.1 [7].

1.  
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$$R = \frac{G_0 \cdot x_0 + G_1 \cdot x_1 + G_2 \cdot x_2}{x}, \tag{2.1}$$

$G_0, G_1, G_2 -$  ;

, 0, 1, 2 -

$$R_A = \frac{3000 \cdot 766 + 1400 \cdot 611 + 3000 \cdot 511}{421} = 11100$$

$$R = \frac{3000 \cdot 345 + 1400 \cdot 190 + 3000 \cdot 90}{421} = 3700 \text{ .}$$

2.

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:

$$R'_A = \frac{3000 \cdot 526 + 1400 \cdot 381 + 3000 \cdot 281}{421} = 7000 \text{ ;}$$

$$R' = \frac{3000 \cdot 105 + 1400 \cdot 40 + 3000 \cdot 140}{421} = 380 \text{ .}$$

$R_A$   $R_B$

,

:

$$W_1 = C \cdot (R_A \frac{2 \cdot f_K + f \cdot d_1}{D_1} + R \frac{2 \cdot f_K + f \cdot d_2}{D_2}), \quad (2.2)$$

-

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( , . ), =3;

f - , f=0,08;

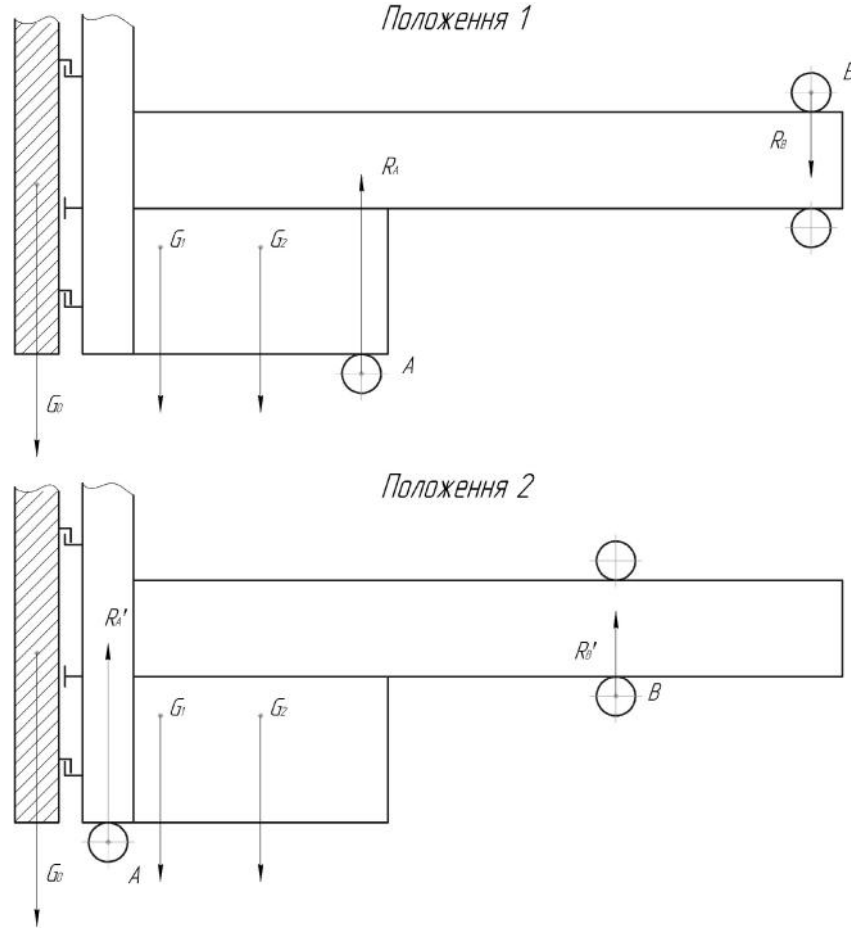
f - ,

, f= 0,015;

$d_1$  -

,  $d_1=0,11$  ;

$d_2 -$  ,  $d_2 = 0,1$  ;  
 $D_1 -$  ,  $D_1 = 0,35$  ;  
 $D_2 -$  ,  $D_2 = 0,25$  .



2.1 –

:

$$W_1 = 3 \cdot \left( 11100 \cdot \frac{2 \cdot 0,08 + 0,015 \cdot 0,11}{0,35} + 3700 \cdot \frac{2 \cdot 0,08 + 0,015f \cdot 0,1}{0,25} \right) = 450 \quad 4,5$$

:

$$W_2 = p \cdot F, \quad (2.3)$$



$F = 25 \text{ H/}^2$  ;  
 $F = 6 \text{ }^2$  ;  
 $1 \text{ }^2$  ;  
 $25 \text{ / }^2 = 250 \text{ H/ }^2$  .  
 :

$$W_2 = 25 \cdot 6 = 150 \text{ .}$$

( )  $W_3$ .

:

$$W_3 = \frac{G \cdot V}{g \cdot t}, \quad (2.4)$$

$G = 7400$  ;  
 $V = 0,12 \text{ /}$  ;  
 $t = 2$  ;  
 $g = 9,81 \text{ / }^2$  .  
 :

$$W_3 = \frac{7400 \cdot 0,12}{9,81 \cdot 2} = 44 \text{ .}$$

:

$$W_3 = W_1 + W_2 + W_3, \quad (2.5)$$

$$W_3 = 450 + 150 + 44 = 644$$

$W = 664$

$= 2000$  :

$S = W + P,$  (2.6)

$S = 644 + 2000 = 2644$

$664 \quad 1400$  .

. 2.2.

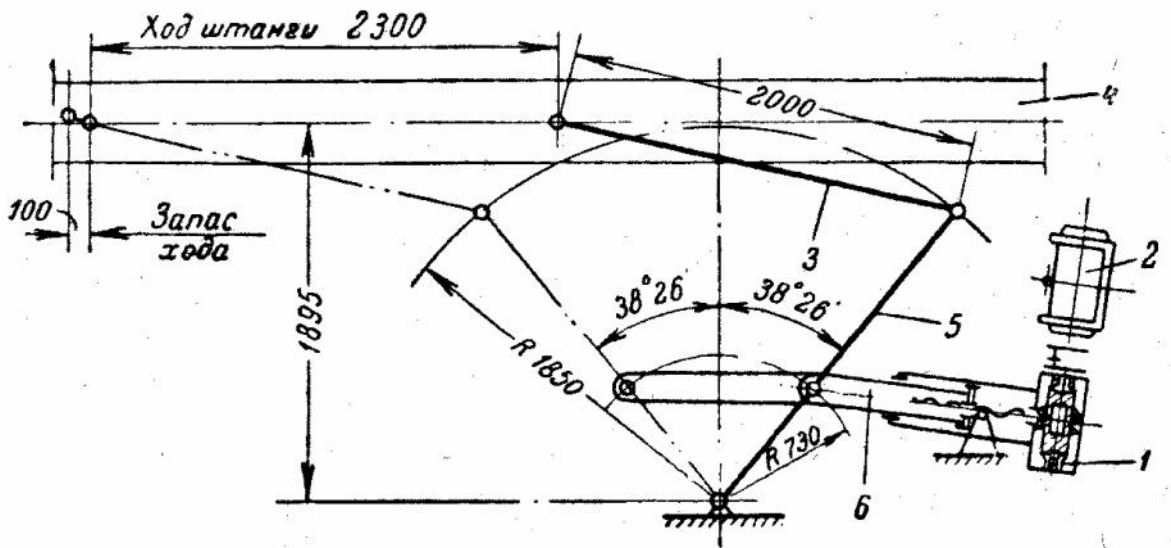
2300

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1000

2300

$38^{\circ}26' \cdot 2 = 76^{\circ}52'$



1 - , 2 - , 3 - ; 4 -

, 5 - ; 6 -

2.2 -

S = 2644 ,

Q = 5500 .

16700 ,

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10000 ,

( 2400 ),

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, F=10000 =100 .

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, :

F =  $F_0 \cdot k$ , (2.7)

$F_0 =$

$F_0 = 10 = 100$  ;

k -

, k=1,1...1,2;

k=1,2.

F = 100 · 1,2 = 120 .

:

$$D = \sqrt{\frac{4 \cdot F}{3,14 \cdot P}}, \quad (2.8)$$

F – , .  
– , =5,5

$$D = \sqrt{\frac{4 \cdot 120 \cdot 10^3}{3,14 \cdot 5,5}} = 166$$

[14]

D = 160

:

$$d = 0,60 \cdot D, \quad (2.9)$$

$$d = 0,6 \cdot 160 = 96 \text{ .}$$

[14] d = 100 .

[13] :

$$D = \sqrt{\frac{4 \cdot F}{f \cdot P_p \cdot y}}, \quad (2.10)$$

– , =5,5 ;  
y – , y =0,85.

$$D = \sqrt{\frac{4 \cdot 120}{3,14 \cdot 5,5 \cdot 0,85}} = 182$$

[14]

$$D = 200 \quad .$$

:

$$Q = V \cdot S, \quad ^3/ \quad (2.11)$$

$$V - \quad , V = 0,005 \quad / ;$$

$$S - \quad :$$

$$S = \frac{f \cdot D^2}{4}, \quad ^2 \quad (2.12)$$

$$Q = \frac{3,14 \cdot 0,2^2}{4} = 0,0314 \quad ^2$$

:

$$Q = 0,05 \cdot 0,0314 = 0,00157 \quad ^3/ \quad .$$

$$Q = 0,00157 \cdot \frac{1000}{1/60} = 94 \quad / \quad .$$

:

$$R_k = R_0 \sqrt{\frac{\sigma_p + 0,4P_y}{\sigma_p - 1,3P_y}}, \quad (2.13)$$

$R_0$  – ;  
 $\sigma_p$  – ,  $\tau_p = 70$  ;  
 $P_y$  – :

$$P_y = 1,4P , \quad (2.14)$$

$$P_y = 1,4 \cdot 5,5 = 7,7$$

$$R_k = 100 \cdot \sqrt{\frac{70 + 0,4 \cdot 7,7}{70 - 1,3 \cdot 7,7}} = 110 .$$

$$R_k = 110 , D = 220 .$$

:

$$t_c = R_k - R_0 , \quad (2.15)$$

$$t_c = 110 - 100 = 10$$

:

$$t = 0,405 \cdot d \sqrt{\frac{P}{\tau}} , \quad (2.16)$$

$$t = 0,405 \cdot 200 \cdot \sqrt{\frac{7,7}{70}} = 26,6 .$$

$$t = 28 .$$

2.3

:Q=94 / .

$$Q=94 / \quad =5,5$$

.1.13.

20-25

=6,3 , Q =1,667·10<sup>-3</sup> <sup>3</sup>/ (100 / .), η=0,85,

:

- 7 ( 3,33·10<sup>-3</sup> <sup>3</sup>/ , 0,2 ,

D =32 );

- 20-32 ( 2,67·10<sup>-3</sup> <sup>3</sup>/ ,

D =32 );

- 202 ( 2,67·10<sup>-3</sup> <sup>3</sup>/ ,

D =20 );

- 55-35 ( 2,67·10<sup>-3</sup> <sup>3</sup>/ ,

D =32 , 0,2 ).

$$Q =1,667 \cdot 10^{-3}$$

<sup>3</sup>/ .

[13]

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$$V =2 / .$$

:

$$S_T = \frac{Q}{V}, \quad (2.17)$$

$$S_T = \frac{1,667 \cdot 10^{-3}}{2} = 8,335 \cdot 10^{-4} \quad 2$$

$$d_T = \sqrt{\frac{4 \cdot S}{f}}, \quad (2.18)$$

$$d_T = \sqrt{\frac{4 \cdot 8,335 \cdot 10^{-4}}{3,14}} = 3,258 \cdot 10^{-2}$$

$$d = 32 \quad . \quad 40 \quad .$$

( .1.13),

$$Q = 1,667 \cdot 10^{-3} \quad 3/ .$$

:

$$Q = 1,667 \cdot 10^{-3} \quad 3/ ,$$

:

$$Q = Q \cdot \frac{S}{S}, \quad 3/ . \quad (2.19)$$

$$Q = 1,667 \cdot 10^{-3} \cdot \frac{0,00785}{0,02794} = 0,56 \cdot 10^{-3} \quad 3/$$

:

$$R_e = \frac{Q}{(0,785 \cdot d \cdot v)}, \quad (2.20)$$

$$v = \quad , \quad 2/ , \quad -30 \quad v = 3 \cdot 10^{-5} \quad 2/ ;$$

$$d = \quad , \quad d = 20 \quad ;$$



Q – , <sup>3/</sup> .

$$R_e = \frac{0,56 \cdot 10^{-3}}{0,785 \cdot 3,2 \cdot 10^{-2} \cdot 3 \cdot 10^{-5}} = 743 .$$

. .  $R_e = 743 < R = 2500$  –

1

$$R_e = \frac{0,56 \cdot 10^{-3}}{0,785 \cdot 3,2 \cdot 10^{-2} \cdot 3 \cdot 10^{-5}} = 743 .$$

$R_e < R$  –

2

$$R_e = \frac{1,667 \cdot 10^{-3}}{0,785 \cdot 3,2 \cdot 10^{-2} \cdot 3 \cdot 10^{-5}} = 2212 .$$

$R_e > R$  –

$$R_e = \frac{1,667 \cdot 10^{-3}}{0,785 \cdot 3,2 \cdot 10^{-2} \cdot 3 \cdot 10^{-5}} = 2212 .$$

$R_e > R$  –

$\lambda$

:

$$\lambda = \frac{75}{R_e} , \tag{2.21}$$

:

$$\lambda = (100 \cdot R_e)^{-0,25} \quad (2.22)$$

$$\lambda = \frac{75}{743} = 0,1,$$

$$1 \quad \lambda = \frac{75}{743} = 0,1,$$

$$2 \quad \lambda = (100 \cdot 2212)^{-0,25} = 4,61 \cdot 10^{-2},$$

$$\lambda = (100 \cdot 2212)^{-0,25} = 4,61 \cdot 10^{-2}.$$

:

$$\Delta p = \frac{\lambda \cdot 8 \cdot Q^2 \cdot p \cdot l}{\pi^2 \cdot d^5}, \quad (2.23)$$

$\lambda -$  ;

$l -$  .

( $l=12$  )

$$\Delta p = \frac{0,1 \cdot 8 \cdot (0,56 \cdot 10^{-3})^2 \cdot 900 \cdot 12}{3,14^2 \cdot (3,2 \cdot 10^{-2})^5} = 8190 \quad ,$$

$1$  ( $l=3$  )

$$\Delta p = \frac{0,1 \cdot 10^{-2} \cdot 8 \cdot (0,56 \cdot 10^{-3})^2 \cdot 900 \cdot 3}{3,14^2 \cdot (3,2 \cdot 10^{-2})^5} = 2050 \quad ,$$

$2 \quad 2 (l=3 \quad )$

$$\Delta p = \frac{4,61 \cdot 10^{-2} \cdot 8 \cdot (8,335 \cdot 10^{-4})^2 \cdot 900 \cdot 3}{3,14^2 \cdot (3,2 \cdot 10^{-2})^5} = 2090 \quad ,$$

$(l=10 \quad )$

$$\Delta p = \frac{4,61 \cdot 10^{-2} \cdot 8 \cdot (1,667 \cdot 10^{-3})^2 \cdot 900 \cdot 10}{3,14^2 \cdot (3,2 \cdot 10^{-2})^5} = 27880 \quad .$$

:

:

$$\Delta p_{TH} = 8190 + 2050 = 10240 \quad ,$$

$$\Delta p_{T3} = 27880 + 2090 = 29970 \quad .$$

( .1.13)

[13]

$\xi$ :

$\xi_3=2,5; \quad \xi_4=2,5; \quad \xi_{11} =2; \quad \xi_{11} =1; \quad \xi_{12}=0,12; \quad \xi_{13}=1,25; \quad \xi'_{13}=1,75; \quad \xi_{14}=0,2; \quad \xi_{15}=1,4;$   
 $\xi_{16}=1,4.$

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$$\Delta p_M = \frac{8 \cdot Q_{BA}^2 \cdot \dots}{f^2 \cdot d_T^2} \cdot (\langle_4 + 5 \cdot \langle_{12} + \langle_{13} + 6 \cdot \langle_{14} + \langle_{15} + \langle_{16}) + \Delta p_5 + \frac{8 \cdot Q_{BA}^2}{f^2 \cdot d_p^4} \cdot \langle, \quad (2.24)$$

$d_p-$

$$\begin{aligned} \Delta p_M &= \frac{8 \cdot (0,56)^2 \cdot 900}{3,14^2 \cdot (3,2 \cdot 10^{-2})^4} \cdot (2,5 + 5 \cdot 0,12 + 1,25 + 6 \cdot 0,2 + 1,4 + 1,4) + \\ &+ 2 \cdot 10^5 + \frac{8 \cdot (0,56)^2 \cdot 900}{3,14^2 \cdot (2 \cdot 10^{-2})^4} \cdot 2,5 = 226864 \end{aligned}$$

1 1 :

$$\Delta p_M = 2 \cdot \frac{8 \cdot Q_{D1D1}^2 \cdot \dots}{f^2 \cdot d_T^4} \cdot (\langle_{11} + \langle_{12}), \quad (2.25)$$

$$\Delta p_M = 2 \cdot \frac{8 \cdot (0,56) \cdot 900}{3,14^2 \cdot (3,2 \cdot 10^{-2})^4} \cdot (2 + 0,12) = 1153$$

2 2 :

$$\Delta p_M = 2 \cdot \frac{8 \cdot Q_{D2D2}^2 \cdot \dots}{f^2 \cdot d_T^4} \cdot (\langle_{11} + \langle_{12}), \quad (2.26)$$

$$\Delta p_M = 2 \cdot \frac{8 \cdot (8,335 \cdot 10^{-4})^2 \cdot 900}{3,14^2 \cdot (3,2 \cdot 10^{-2})^4} \cdot (2 + 0,12) = 2050$$

- :

$$\Delta p_M = \frac{8 \cdot Q^2 \cdot \dots}{f^2 \cdot d_T^4} \cdot (\langle_4 + 6 \cdot \langle_{12} + \langle_{13} + 8 \cdot \langle_{14}) + \frac{8 \cdot Q^2 \cdot \dots}{f^2 \cdot d_T^4} \cdot \langle_3 + \Delta p_7, \quad (2.27)$$

$$\Delta p_M = \frac{8 \cdot (1,667 \cdot 10^{-3})^2 \cdot 900}{3,14^2 \cdot (3,2 \cdot 10^{-2})^4} \cdot (2,5 + 6 \cdot 0,12 + 1,75 + 8 \cdot 0,2) +$$

$$+ \frac{8 \cdot (1,667 \cdot 10^{-3})^2 \cdot 900}{3,14^2 \cdot (2 \cdot 10^{-2})^4} \cdot 2,5 + 2 \cdot 10^5 = 244441 \quad .$$

:

$$\Delta \quad = 226864 + 1153 = 228017 \quad ,$$

$$\Delta \quad = 244441 + 2050 = 246491 \quad .$$

:

$$\Delta p = \Delta \quad + \Delta \quad + \Delta \quad + \Delta \quad , \quad (2.28)$$

$$\Delta p = 10240 + 228017 + 29970 + 246491 = 514718 \quad .$$

$$\Delta = 0,5 \quad .$$

:

$$= 5,5 - 0,5 = 5 \quad .$$

$$(\quad = 5,5 \quad ) .$$

:

$$N = \frac{p \cdot Q}{1000 \cdot \eta_0}, \quad (2.29)$$

$\eta_0 =$  ,  $\eta_0 = 0,85$ .

$$N = \frac{6,3 \cdot 10^6 \cdot 1,667 \cdot 10^{-3}}{1000 \cdot 0,85} = 15 \quad .$$

$n = 15$  ,  $n = 970$   $^{-1}$  .

$$S_p = \frac{3,6 \cdot \Delta p \cdot Q}{(T - t_0) \cdot K} \leq S, \quad (2.30)$$

$\Delta$  – ,  $\Delta = 0,6$  ;

$Q$  – ;

$t_0 = 20^\circ$  ;

$\delta = 63$  .

$$S_p = \frac{3,6 \cdot 0,6 \cdot 10^5 \cdot 1,667 \cdot 10^{-3}}{(60 - 20) \cdot 63} = 1,9 \text{ }^2 < S = 2,35 \text{ }^2 .$$

$$u = \frac{p \cdot D \cdot \{ \dots \}}{2,3 \cdot [t] - p} + , \quad (2.31)$$

– ,  $\nu = 1,3$ ;

– ,  $\nu = 6$  .

$$u = \frac{7,68 \cdot 0,32 \cdot 1,3}{2,3 \cdot 80 - 7,68} + 0,006 = 0,01845 = 18,5 \text{ .}$$

$$\delta = 20 \text{ .}$$

2.4

( 2.3)

:

$$\tau = 10^{-2} \cdot \frac{0,4 \cdot r^2 + 1,3 \cdot R^2}{R^2 - r^2} \leq [\tau] , \quad (2.32)$$

R – ,  $R = 110$  ;

r – ,  $r = 100$  ;

– ,  $\nu = 7,7$  ;

$\sigma$  –

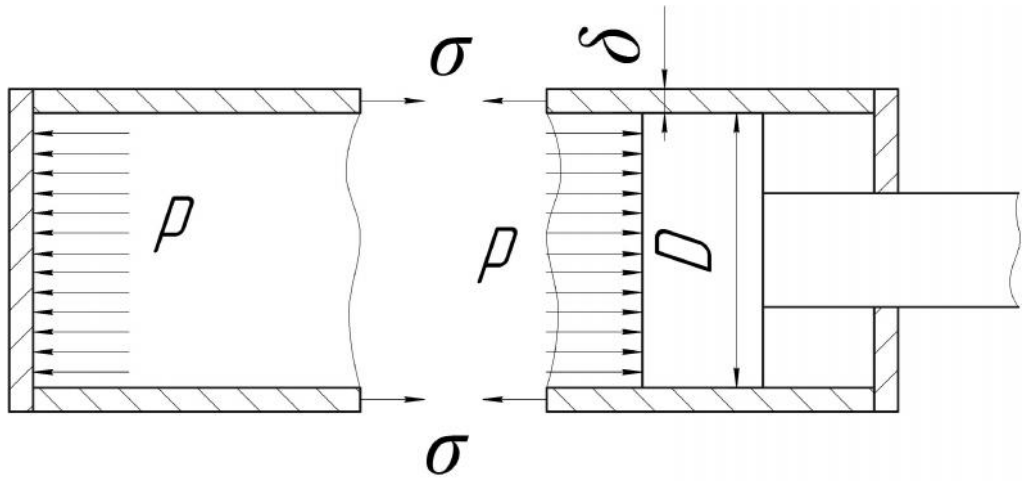
;

$[\sigma]$  – ,  $[\sigma] = 120$  .

$$\tau = 10^{-2} \cdot \frac{0,4 \cdot 0,100^2 + 1,3 \cdot 0,110^2}{0,110^2 - 0,100^2} \cdot 7,56 = 0,7 < 120 \text{ .}$$

,

.



2.3 –

:

$$F_k = k \cdot \frac{f^2 \cdot E \cdot I}{L^2} \geq F, \quad (2.33)$$

F –

;

F –

;

k –

,

, k=1 –

;

–

, = 2 · 10<sup>5</sup> ;

I –

;

L –

,

, L=1 .

$$F_{kp} = 1 \cdot \frac{3,14^2 \cdot 2 \cdot 10^5 \cdot 0,05 \cdot 0,140^4}{1^2} = 1,13 .$$

$$F = 1,13 > F = 0,1 .$$



2.5

$$\tau = \frac{4Q}{fd^2z}, \quad (2.34)$$

Q –

:

$$Q = \cdot k, \quad (2.35)$$

– ;

– 1,25 ÷ 1,5 ;

$$Q = 1,5 \cdot 11560 = 18496 \quad ;$$

D –

, ;

z –

, z = 6.

–

$$\tau = \frac{4 \cdot 18,496 \cdot 10^3}{3,14 \cdot 2^2 \cdot 12} = 491 \quad .$$

:

$$\tau = \frac{T \cdot d \cdot k_1}{0,2 \cdot d^3 \cdot z}, \quad (2.36)$$

$$k_1 = 0,12 -$$

$$\ddagger = \frac{18,496 \cdot 10^3 \cdot 2 \cdot 0,12}{0,2 \cdot 2^3 \cdot 12} = 231 \quad .$$

:

$$\dagger = \sqrt{\dagger^2 + \ddagger^2}, \quad (2.37)$$

$$\dagger = \sqrt{491^2 + 231^2} = 542 \quad .$$

,

:

$$n = \frac{\dagger}{\ddagger} \geq 1,2 \div 2,5$$

$$\dagger - , \quad 40 \quad \sigma_T = 840 \quad .$$

$$n = \frac{840}{542} = 1,557 > 1,2 .$$

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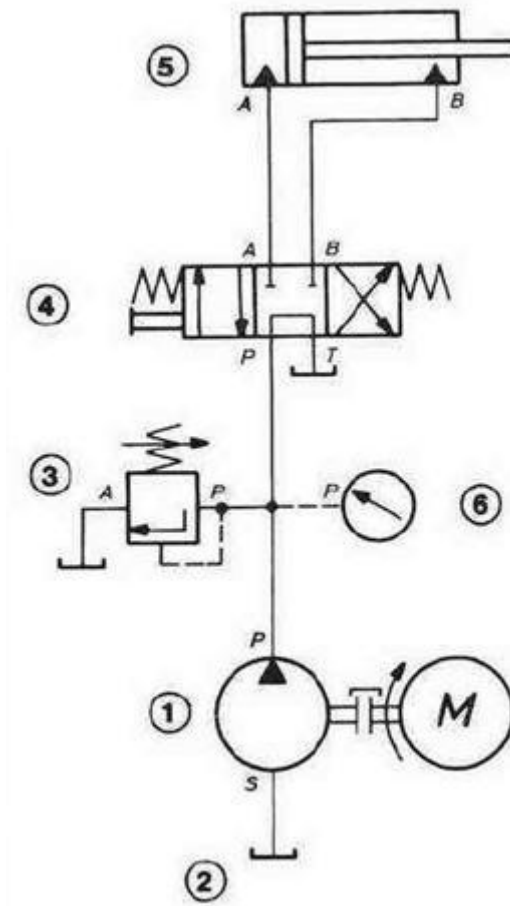
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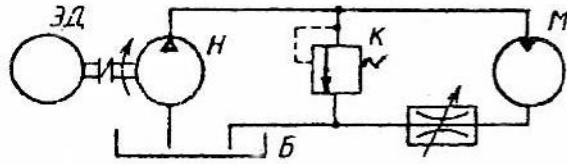
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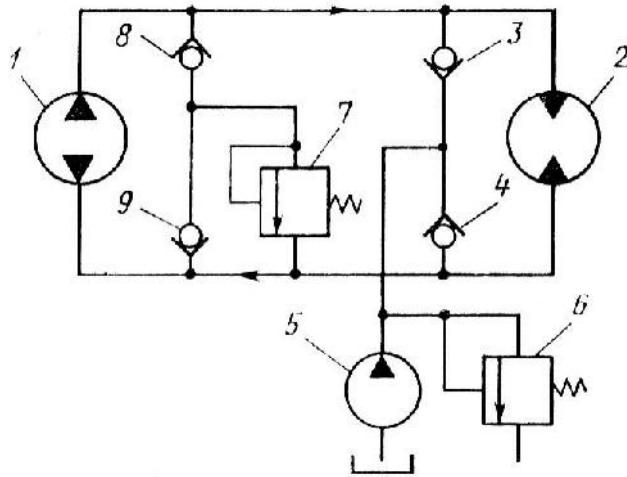
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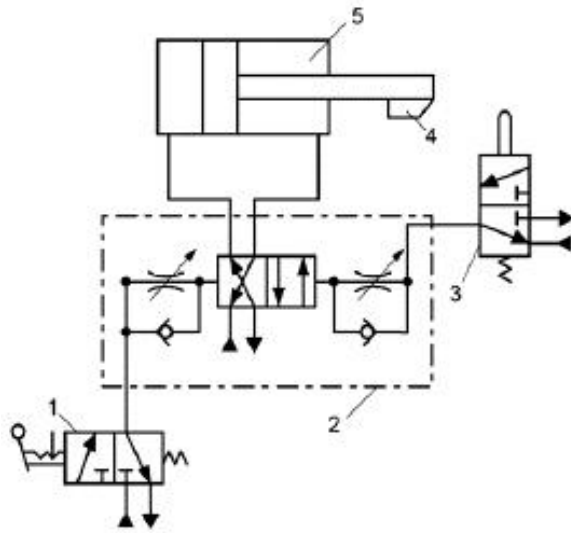
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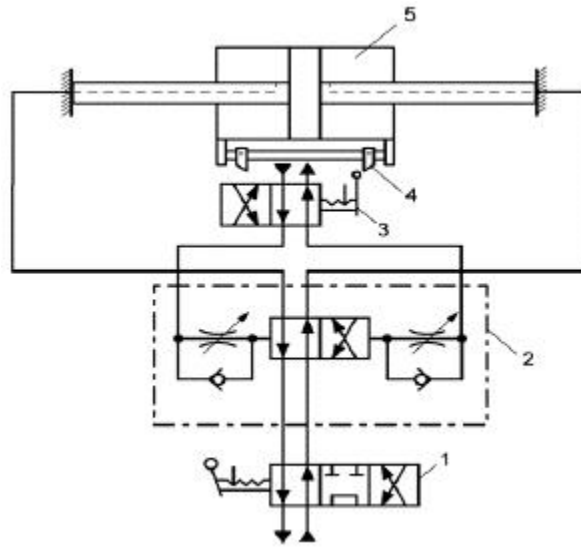
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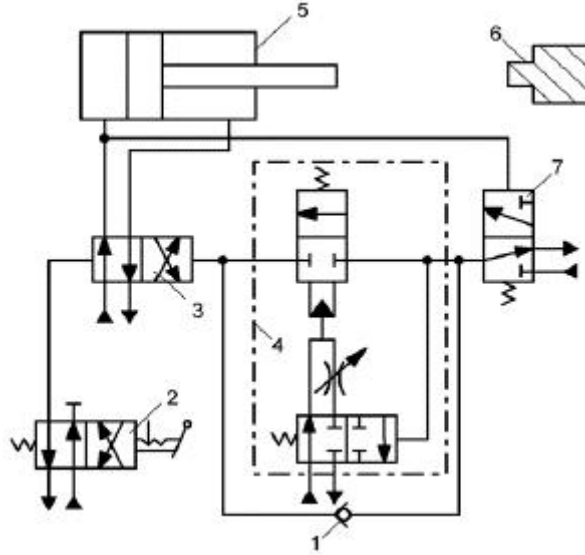
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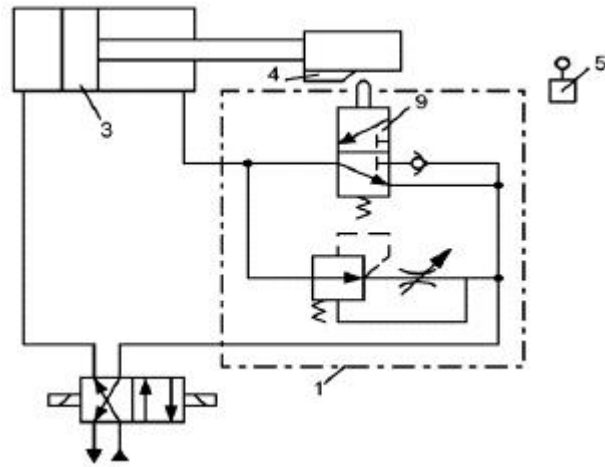
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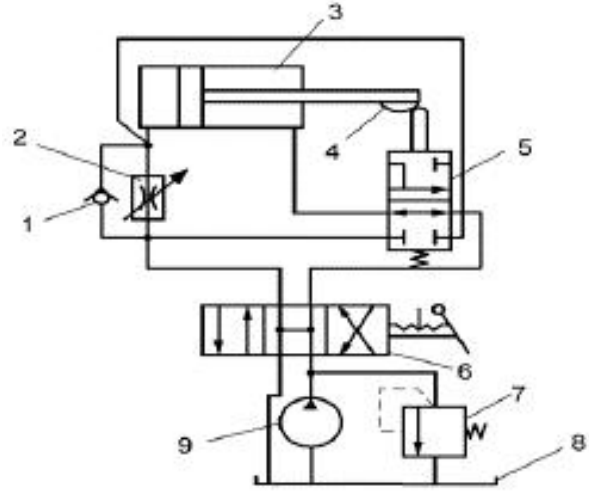
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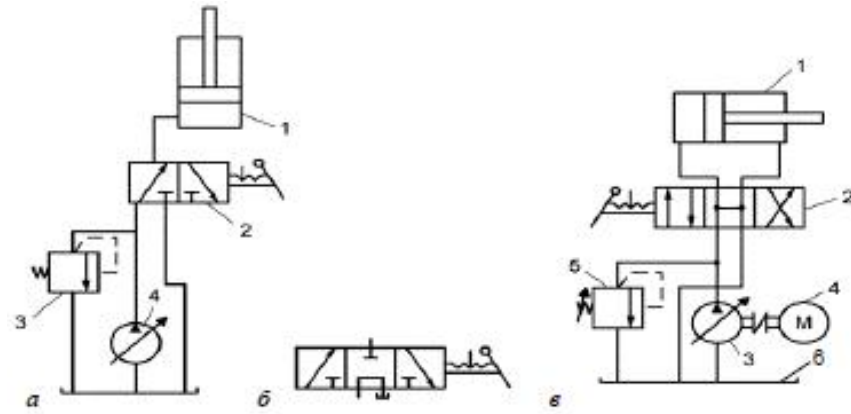


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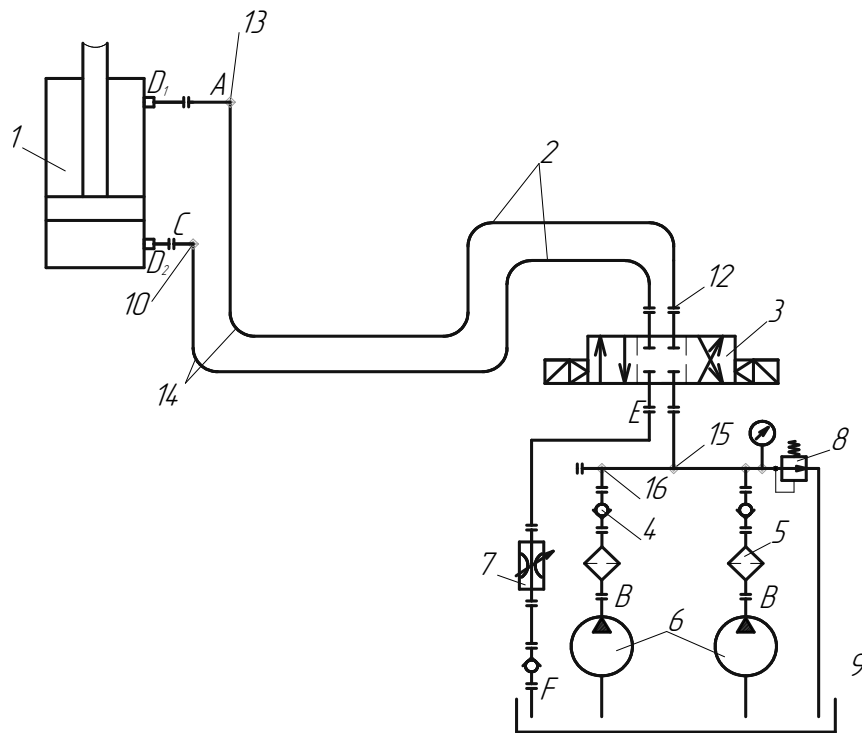
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( 3.10)

( 3.10)



- 1 - ; 2 - ; 3 - ; 4 - ; 5 -  
 ; 6 - ; 7 - ; 8 - ; 9 - ; 10 - ; 11-16

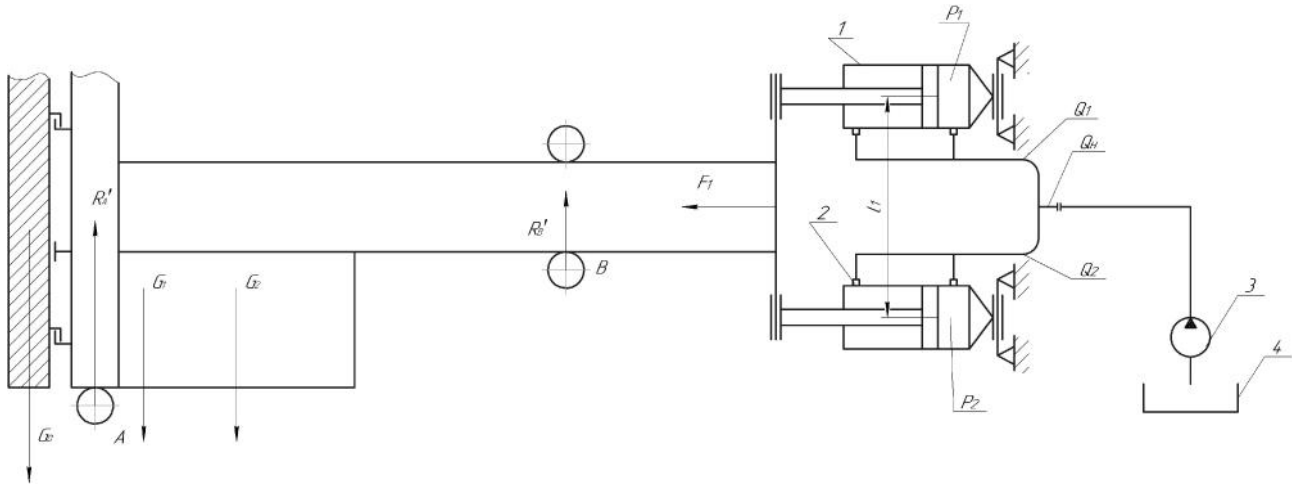
3.10 -

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« » , ( .3.11).



1,2 – , 3 – , 4 –

3.11 –

3.10 3.11

$$\begin{cases} Q_1 \cdot K_t = \frac{\pi \cdot d^2}{4} \cdot \frac{dl}{dt} + a_{y1} \cdot P_1 + k_{p1} \cdot \frac{dP_1}{dt} \\ Q_2 \cdot K_t = \frac{\pi \cdot d^2}{4} \cdot \frac{dl}{dt} + a_{y2} \cdot P_2 + k_{p2} \cdot \frac{dP_2}{dt} \\ \frac{m \cdot d^2 l}{dt^2} = mg + F \end{cases} \quad (3.3)$$

$Q_1$   $Q_2$  – , 1 2

( .3.11), <sup>3/</sup>

$t$  – , ;



d – , ;  
 V – ;  
 m – , ;  
 l – , ;  
 g – , / 2;  
 F – , ( .3.11);

t –

$$K_t = \frac{t}{t_H} \quad t \leq t_H; \quad K_t = 1 \quad t > t_H.$$

t<sub>H</sub> –

0

Q<sub>H</sub>.

K –

,  
 , K = 1 ;

1 1 –

;

1 2 –

, ;

1 2 –

;

:

$$K_{P_1} = \frac{10^{-5}}{7,28P_1 + 106}; \quad K_{P_2} = \frac{10^{-5}}{7,28P_2 + 106}. \quad (3.4)$$

,

,

$$K_{P_1} = \frac{10^{-5}}{2 \cdot (7,28P_1 + 106)}; \quad K_{P_2} = \frac{10^{-5}}{2 \cdot (7,28P_2 + 106)}. \quad (3.5)$$

:

$$\begin{cases} Q_1 = \frac{\pi \cdot d^2}{4} \cdot \frac{dl}{dt} + a_{y1} \cdot P_1 + k_{p1} \cdot \frac{dP_1}{dt} \\ Q_2 = \frac{\pi \cdot d^2}{4} \cdot \frac{dl}{dt} + a_{y2} \cdot P_2 + k_{p2} \cdot \frac{dP_2}{dt} \\ m \cdot \frac{dl}{dt} = (m \cdot g + F) \cdot t \end{cases} \quad (3.6)$$

(3.6)

:

$$\begin{cases} Q_1 = \frac{\pi \cdot d^2}{4} \cdot \frac{dl}{dt} + a_{y1} \cdot P_1 + k_{p1} \cdot \frac{dP_1}{dt} \\ Q_2 = \frac{\pi \cdot d^2}{4} \cdot \frac{dl}{dt} + a_{y2} \cdot P_2 + k_{p2} \cdot \frac{dP_2}{dt} \\ \frac{dl}{dt} = \frac{(m \cdot g + F) \cdot t}{m} \end{cases} \quad (3.7)$$

$$-\frac{\pi \cdot d^2}{4} = S$$

:

$$\begin{cases} Q_1 = S \cdot \frac{(m \cdot g + F) \cdot t}{m} + a_{y1} \cdot P_1 + k_{p1} \cdot \frac{dP_1}{dt} \\ Q_2 = S \cdot \frac{(m \cdot g + F) \cdot t}{m} + a_{y2} \cdot P_2 + k_{p2} \cdot \frac{dP_2}{dt} \end{cases} \quad (3.8)$$

(3.8)

$$\begin{cases} \frac{dP_1}{dt} = \left( 2 \cdot (7,28P_1 + 106) \cdot \left( Q_1 - S \cdot \frac{(m \cdot g + F) \cdot t}{m} + a_{y1} \cdot P_1 \right) \right) \cdot 10^5 \\ \frac{dP_2}{dt} = \left( 2 \cdot (7,28P_2 + 106) \cdot \left( Q_2 - \frac{(m \cdot g + F) \cdot t}{m} + a_{y2} \cdot P_2 \right) \right) \cdot 10^5 \end{cases} \quad (3.9)$$

(3.9)

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=0,5-1,5 -

$\sigma_0=6,3$

[21]:

$$m = \frac{\sqrt{3,6\kappa^2 + 2,225\kappa - 1,625\kappa}}{0,975\kappa + 2,225}, \tag{3.10}$$

=0,5-1,5

[21]:

$$\sigma = \frac{P}{m}, \tag{3.11}$$

) [21]:

$$D = \sqrt{\frac{Q}{0,785} \left( \frac{1}{p} + \frac{1}{\kappa \cdot \sigma} \right) \cdot \left( \frac{\sigma + 0,5p}{\sigma - 1,625p} \right)}, \tag{3.12}$$

(3.10)-(3.12)

3.1,

=0,1

$\sigma_0=6,3$

3.1 –

=const

	Q, kHz		m		D,
6,3	100	0,5	0,223457	28,19339	452
		0,6	0,230262	27,36016	401
		0,7	0,235597	26,74058	363
		0,8	0,239897	26,26126	333
		0,9	0,243439	25,87918	310
		1	0,246407	25,56741	291
		1,1	0,248932	25,30816	274
		1,2	0,251104	25,08918	261
		1,3	0,252994	24,9018	249
		1,4	0,254652	24,73965	238
		1,5	0,256119	24,59798	229
		1,6	0,257425	24,47316	220
		1,7	0,258596	24,36237	213
		1,8	0,25965	24,26339	206
		1,9	0,260606	24,17444	200
		2	0,261475	24,09407	194
		2,1	0,262269	24,02112	189
2,2	0,262997	23,9546	184		

[21]

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– 25 ,

– 40 ,

– 80-100 ,

– 150-180 ,

– 100-120

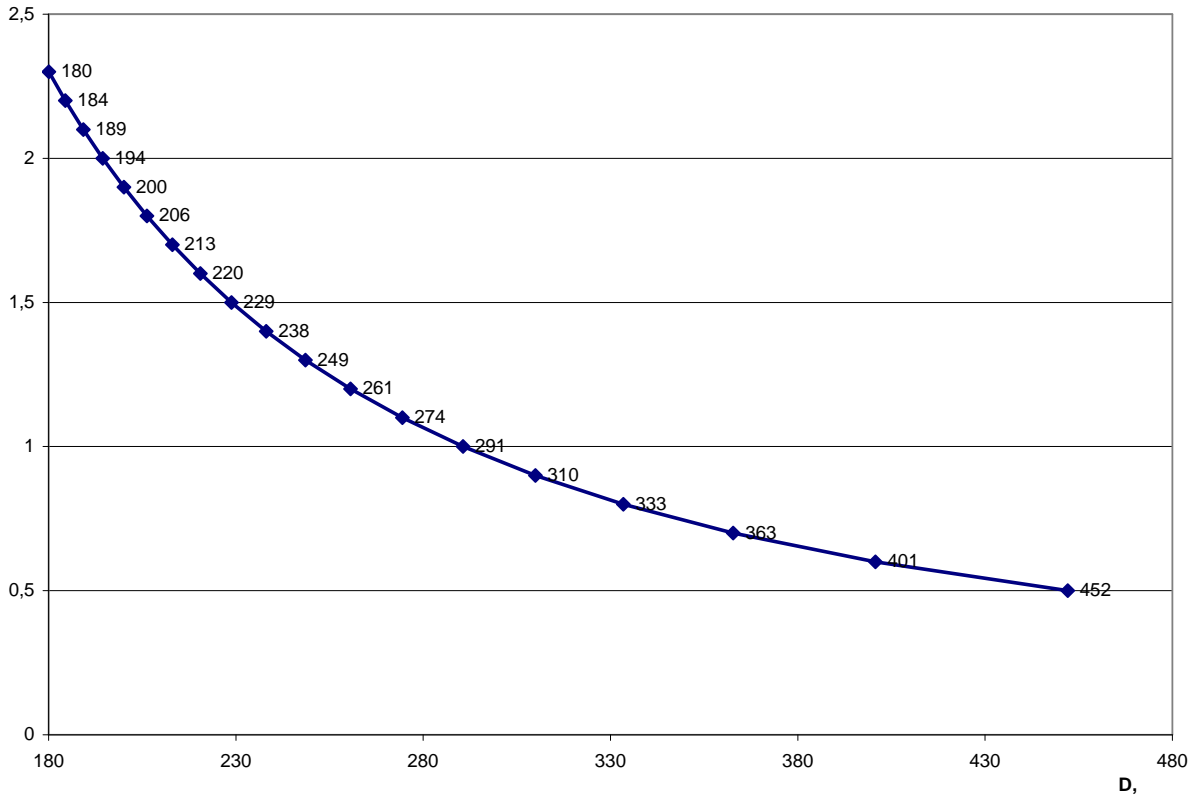
3.1

1,9 2,2

3.1

D=f(k),

3.12



3.12 –

P=const

3.12

0,5 1,3,

2

D=200 ,

=1,9.

(3.10)-(3.12)

2,2,

3.2,

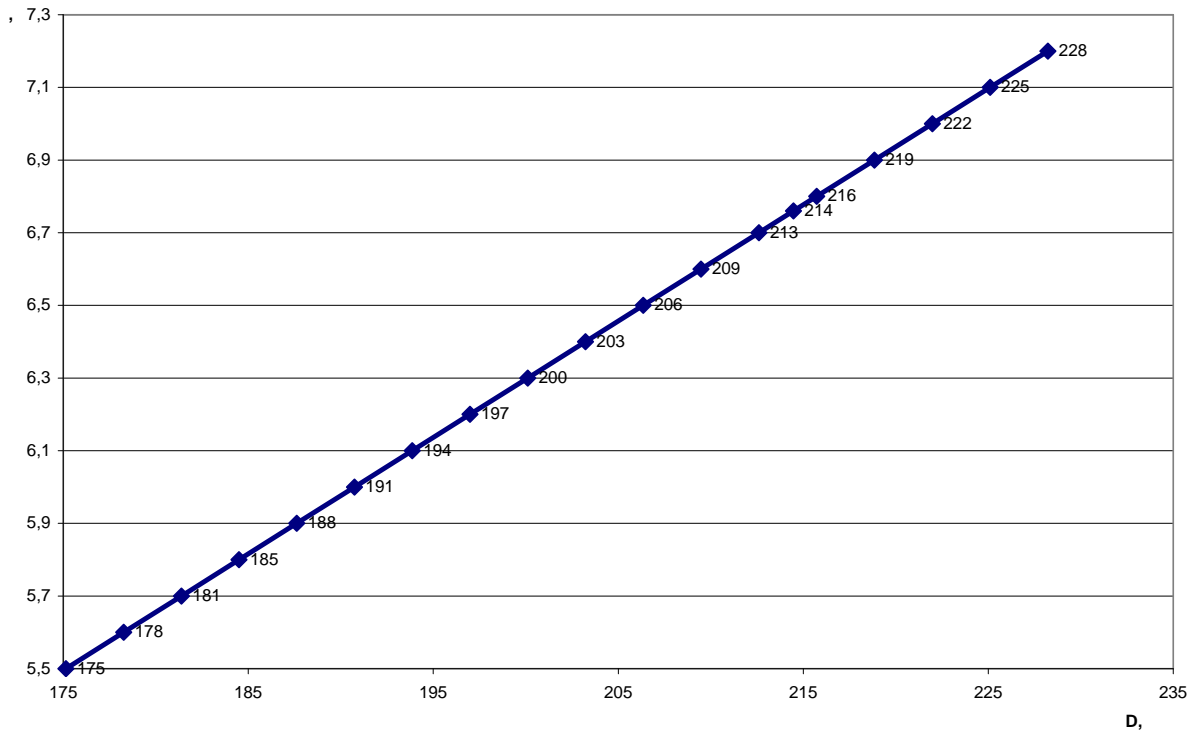
min=5,5

15 %

=0,1

D=f(P),

3.13



3.13 -

=const=2

3.2 –  
=const

	Q, kHz	.	m	D,	
5,5	100	2,2	0,262997	20,91275	162
5,6			0,262997	21,29298	164
5,7			0,262997	21,67321	167
5,8			0,262997	22,05345	170
5,9			0,262997	22,43368	173
6			0,262997	22,81391	176
6,1			0,262997	23,19414	179
6,2			0,262997	23,57437	182
6,3			0,262997	23,9546	184
6,4			0,262997	24,33484	187
6,5			0,262997	24,71507	190
6,6			0,262997	25,0953	193
6,7			0,262997	25,47553	196
6,76			0,262997	25,70367	198
6,8			0,262997	25,85576	199
6,9			0,262997	26,236	202
7			0,262997	26,61623	205
7,1			0,262997	26,99646	207
7,2			0,262997	27,37669	210



6,9

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$$B = \frac{M}{M+R} \cdot 100\%, \tag{4.1}$$

– ;  
 – – ;  
 R – – .  
 =1:

$$= \frac{1}{1+7} \cdot 100 = 12,5\%$$

4.1.

4.1 –

/			–			%
1		2	7·2=14	1·2=2	16	12,5
2		6	6·6=36	2·6=12	48	25
3		3	0·3=0	8·3=24	24	100
4		3	3·3=9	5·3=15	24	62,5

, 4.1 ,  
 – 2, – 1, – 1.

4.2

: – , , :  
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4.2 –

			III			, %
			1 –	2 –	3 –	
I.	, / 3					
1						
	0,02	0,02	2			85
2						
	5,0	6,5	1,3			85
	2,0	4,0	2			85
II.	, / 3					
– 2,5%	4,0	26,4			6,6	83,1
, 3-4	0,3	0,56	1,87			85
III.	80	93		13		100
IV.	( )					
– o	27	40,5			13,5	83,1
– , /	0,2–0,5	0,27				83,1
– , / 2	140	794		654		80
V.						
,	28,1%	30%	6,7			
, II :						
			4	2	2	

1.

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III 3 .

2. :  
:2 3 ,2 2 ,4

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10 « » , 7 ,  
24 %.

4.3

4.3 –

/					
1			3	7800 <sup>3/</sup>	
2			« »	30 / <sup>3</sup>	
3		,		110	
4		,	20	t -20°C	
		/	15	t 15°C	
5		, + / ,		30 / <sup>3</sup>	

[23].

### 4.3

#### 4.3.1

[24]

### 7.4.

#### 4.4 –

		°	, %	/	
	II	15	75	0,2	13
	III	13	75	0,3	12
	II	16	70	0,4	15
	III	15	75	0,5	13

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IV = III = 1,5 % -





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4.5 –

	63	125	250	500	1000	2000	4000	8000
1	25	30	35	40	45	50	50	55
2	15–24	20–29	25–34	30–39	35–44	40–49	40–49	35–44
3	5–14	10–19	15–24	20–29	25–34	30–39	30–39	25–34
4	0–4	0–9	5–14	10–19	15–24	20–29	20–29	15–24

:

$$R = L - L ; \tag{4.5}$$

L -

( ),

:

$$L = L - 20 \cdot \text{Lg}\left(\frac{R}{R_1}\right); \tag{4.6}$$

L - (R) , R = 3 ;

L - ,

L = 80 ; R<sub>1</sub> = 1 ;

:

$$80 = L - 20 \cdot \text{Lg}\left(\frac{3}{1}\right) \Rightarrow L = 80 + 9,5 = 89,5 .$$

(4.5) :

$$R = 89,5 - 80 = 9,5 .$$

4.6

:

$$R_{Hi} = R + 10Lg \frac{S_i}{S} + 10Lg \cdot n \quad (4.7)$$

$S$  – ,  $^2$ ;  
 $S_i$  – ,  $^2$  ( .7.6)  
 $n$  – ;

7.6 –

	-			( )
	( / $^2$ )			1000
,	220	140	-	48
	-	5	-	28
	-	40	-	26
	320	20		48

:  
 -  $-S = 2,1 \text{ } ^2$  ;  
 -  $-S = 4,14 \text{ } ^2$  -  
 -  $-S = 12 \text{ } ^2$  ,  
 - ,  $S = 35,76 \text{ } ^2$  .  
 .. ( , , , , )  
 )  
 $n=1$ . (4.7)

:  
 - , :

$$R = 17,5 + 10 \text{Lg} \frac{35,76}{34} + 0 = 15,7 \quad .$$

– :

$$R = 25,198 + 10 \text{Lg} \frac{4,14}{34} + 0 = 14,04 \quad .$$

– :

$$R = 25,198 + 10 \text{Lg} \frac{2,1}{34} + 0 = 9,1065 \quad .$$

– :

$$R = 25,198 + 10 \text{Lg} \frac{12}{34} + 0 = 13,665 \quad .$$

( )

:

$$R = 10 \cdot \text{Lg} \left( \frac{S}{\sum_{i=1}^n S_i \cdot 10^{-0,1R_i}} \right), \quad (4.8)$$

$R_i$  – , ( .4.6);

(7.8) :

$$R = 10 \cdot \text{Lg} \left( \frac{34}{2,1^{0,126} + 4,14^{-0,128} + 35,76^{-0,148} + 12^{-0,148}} \right) = 17,5 \quad .$$

( $R < R$ )

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