

_____ . . .
“ _____ ” _____ 2023 .

(_____)

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“ _____ ”

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151 « , »

»

« _____ » _____ 2023 .

_____ (, ,)

1. _____

_____ 13.04.2023 . 507/ _____

2. : _____ 22.05.2023 _____ 22.06.2023 _____

3. : _____ -75 +90° ;

_____ 0 3000 . . . ; _____ 115 ,

400 ; _____ ±2% .

4. : _____ ,

_____ ,

5. : _____

_____ ,

_____ ,

_____ .

6.

-

.			
1.		28.03.2023	
2.	,	29.03.2023	
3.		08.05.2023	
4.		12.05.2023	
5.		18.05.2023	
6.	,	25.05.2023	
7.		27.05.2023	
8.		31.05.2023	

7.

: 27.03.2023 .

() (..)
.....

() (..)
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: 71 ., 46 ., 4 .

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1.	8
1.1. ()	8
1.1.2.	9
1.1.3.	11
1.2. ,	14
1.2.1.	14
1.2.2.	14
1.2.3.	15
1.2.4.	17
1.2.5.	17
1.2.6.	19
1.3.	20
1.3.1.	20
1.3.2.	21
1.3.3.	22
1.3.4.	24
1.3.6.	26
1.3.7.	28
1.4.1.	29
1.4.2.	29
1.4.3	32
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2.3.2.	39
2.4.	41
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2.6.2.	46
2.7.	49
2.7.1.	-48.....	49
3.	53
4.	59
4.1	59
4.2	62
4.3.	66
4.4.	68
	71
	72



1.1. ()

() .
100 (10⁻³ / 2) (2648-69) 1000
(10 000 / 2) (2405-72).

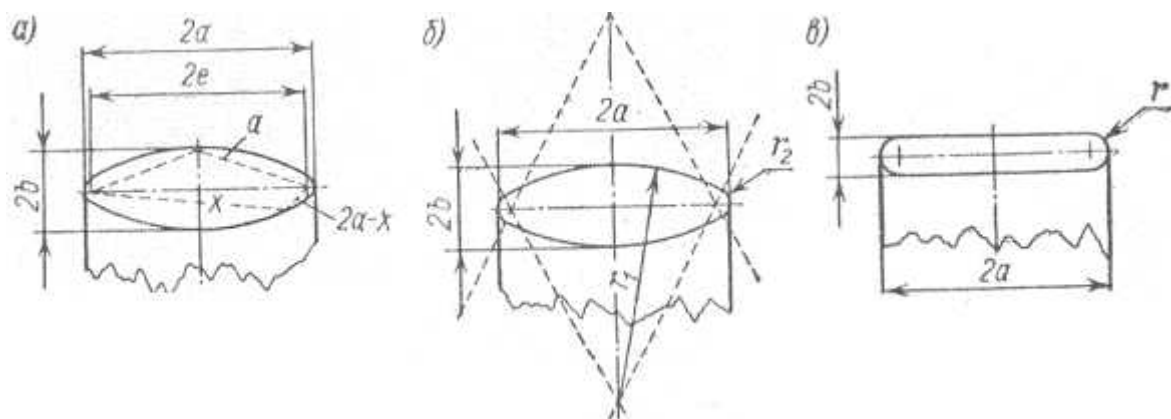
±0,16% (6521-60) ±4%, ±6% ()
).

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, ,
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Зав.каф.	Мельник Ю.В.						

1.1.1.

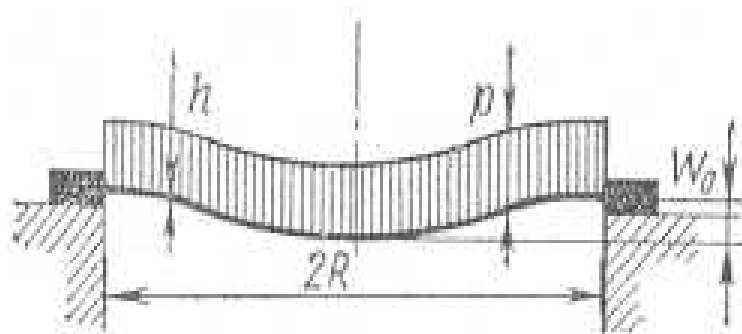
()
 (.1.1, ,),



.1.1.

: - ; - ;

1.1.2.



. 1.2 .

1.2.

1.1.3.

5,

1

2.

()

4

4

5.

3,

, 10-15 °

5

7 (

z 15)

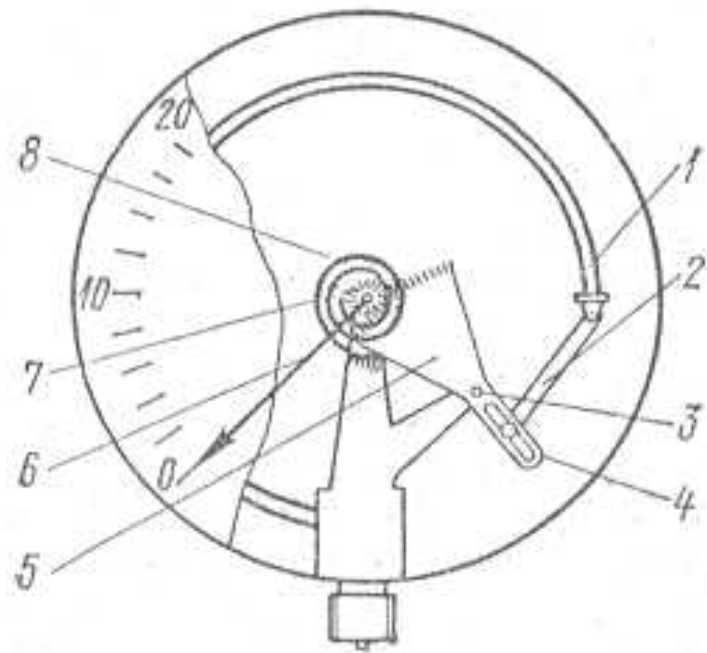
270-300 ° (± 135 - ± 150 °).

6,

7.

0,1

(. 1.3, . 8),



. 1.3 .

()

50%

(7935-74).

(1 5365-73)

1,3.

(6521-72),

1,1.

-

-'

1.2. ,

1.2.1.

1.2.2.

1.2.3.

U = / 0,

— ;

— ;

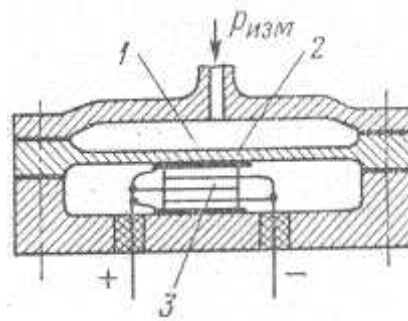
0 — ,

..

U

. 1.4
20 (5 200 / 2).

0,5



. 1.4 .

1, , ,
2 , ,
25 1 . ,
3 (5 , 1).

, , ,
-
, 50 ,
-
0 500
/ 2 .

$$U \cdot 10^{-6} = \text{const}$$

1.2.4.

$$\begin{aligned}
 & \left(\frac{1000}{30000} \right)^2 - 2 \cdot 10^{-6} / \left(\frac{1000}{30000} \right) \\
 & 0,2\% \pm 1\%
 \end{aligned}$$

1.2.5.

$$\left(\frac{100}{0,01} \right)$$

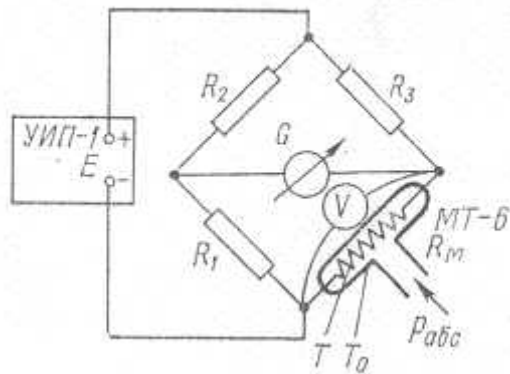
100

10

10

0,001

100



. 5 .

200° ; $\theta_0 = 20^\circ$; $R_1 = 116,5 \Omega$; $R_2 = R_3 = 100 \Omega$; $R_M = \text{const}$; $E_{\text{max}} = 12 \text{ V}$

. 1.5

200 ° ,

: t = t₀ = 20 ° .

(G) .

t = 200 ° .

V,

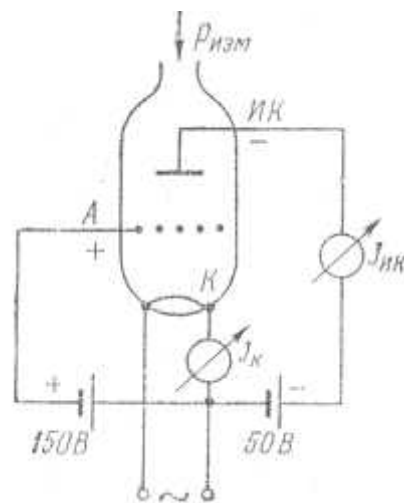
1.2.6.

-10⁻⁶)

10⁻³ -10⁻⁷ . .

(10⁻¹

(. 1.6).



. 6.

() .

()

100 200,

20- 100 .

I ,

1.3.

1.3.1.

1.3.2.

, (\quad)
 (\quad)
).

, , .
 , , .
 , , , , .
 , , , , .
 , , , , .
 , , , , .
 , , , , .

to t

$$\frac{\Delta p}{\Delta t} = \frac{(\gamma - \alpha)V_F}{XV + C} \quad (1.1)$$

— ; — ' ;
 — ; V_F — ' ;
 ; V — ; — ,
 ; X — .

(\quad)

$t - t_0$.

V_F .

$(V - V_F)$

600° .

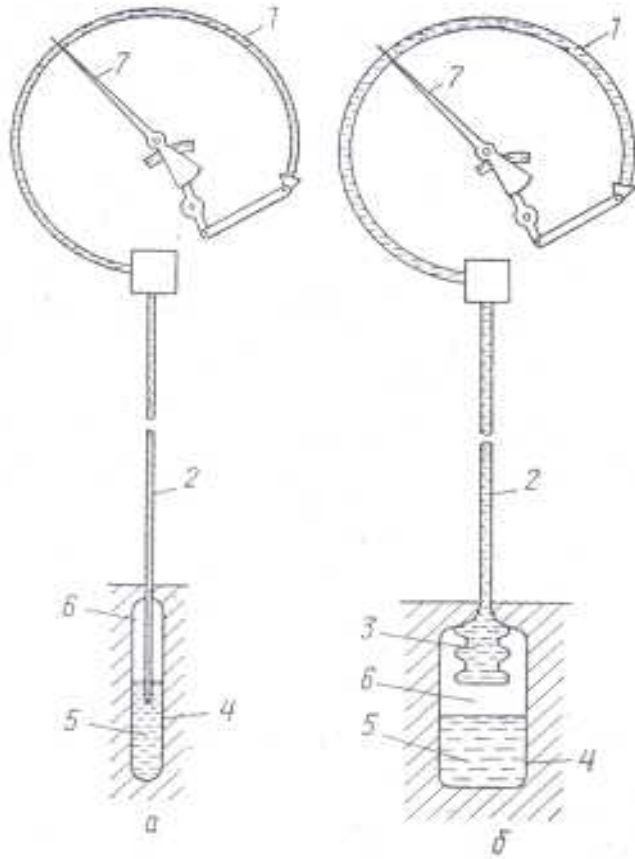
1.3.3.

(.1.7,).

1.8).

$-35 \quad 500^\circ$, t

(.



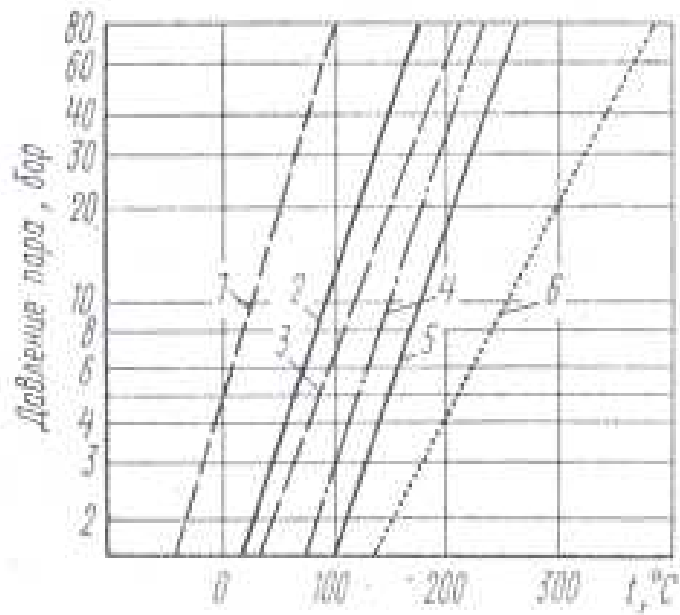
.1.7

- ; - ; 1 -
 ; 2 - ; 3 - ; 4 - ; 5 - ; 6 - ; 7

-40 4-40 °
 40 195 ° , .0 160 ° ,
 85 245 ° 150 360° .

15 60 .

60%.



. 1.8.

:

1 - ; 2 - ; 3 - ; 4 - ; 5 -
; 6 -

1.3.4.

5 , 15 - 20 .

-268 °) .

550 ° ,

-125 ° ,

-147 °

80 .

30 - .

250

40

1.3.5.

()

.

1.3.6.

,

.

,

.

.

300° ,

600°

1000° (. 1.9).

(300).

,

,

.

2%

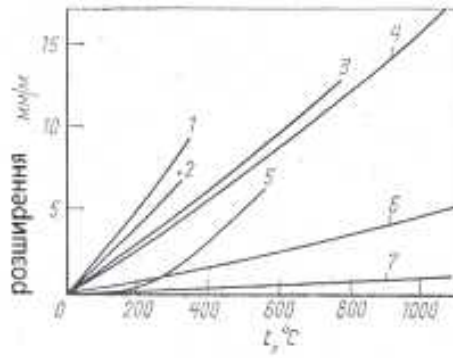
.

,

.

(. 1.10);

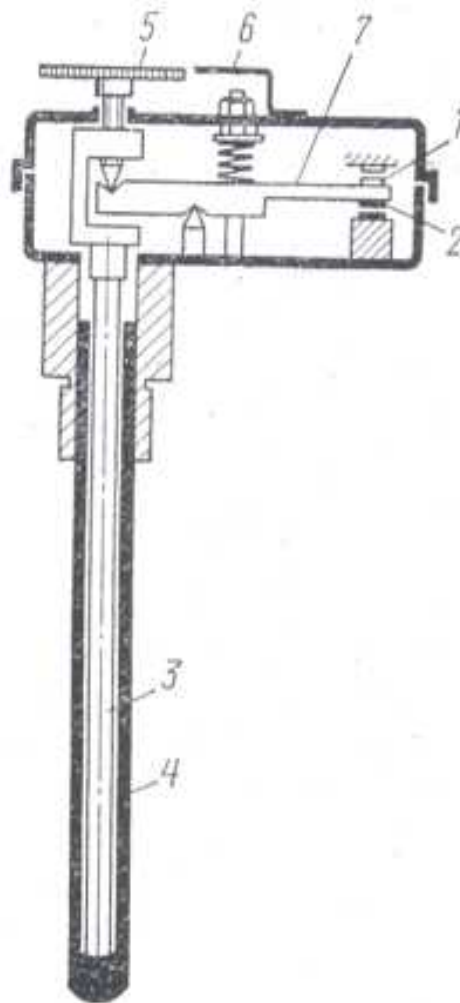
.



. 1.9.

:

1 - ; 2 - ; 3 - ; 4 - ; 5 - ; 6 - ; 7 -



. 1.10.

; 1 -

; 2 -

; 3 -

; 4 -

; 5 -

; 6 -

; 7 -

(, 100).

1.3.7.



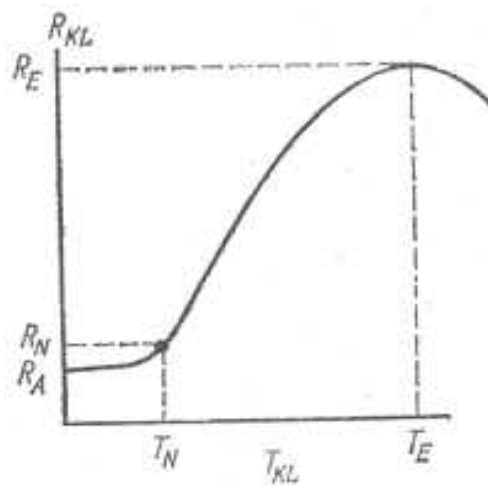
. 1.11.

R_t/R_{20}

20 $20 \cdot 10^{-3}$

$60 \cdot 10^{-3}$ (20

)



. 1.12.

R_{KL}

T_{KL} :

R_A —

; R_N R_E —

;

T_N T_E —

?

() .

) ,

(

(. 1.11 1.12) .

$0;100,$

$0-100^\circ$,

R_{100}/R_0 100° .

$$a_{0;100} = \frac{R_{100} - R_0}{\Delta t R_0} \quad \frac{R_{100}}{R_0} = 1 + r_{0100} \Delta t \quad (1.2.)$$

$R_{100} - R_0$ 100° ; $t = 100$,
 0 100° .

1.4.3

Stanley STHT80874-0

PSI / Bar / kPa / / 2.
0,5 PSI. 0,01PSI.



. 1.13

Stanley STHT80874-0

WT3652,

:
 - : 32 °C 43 °C.
 - : 0 °C 100,0 °C.
 - : 1 10 .
 -
 - : 0,99 ()
 - , 32 .
 - .
 - .
 - :
 - .
 - .



. 1.14

WT3652

2.1. ()

:

)

±3%,

±4%;

)

;

)

2.2.

,

(. 2.1).

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Зав.каф.	Мельник Ю.В.						

. 2.1

12,

13.

9.

6,

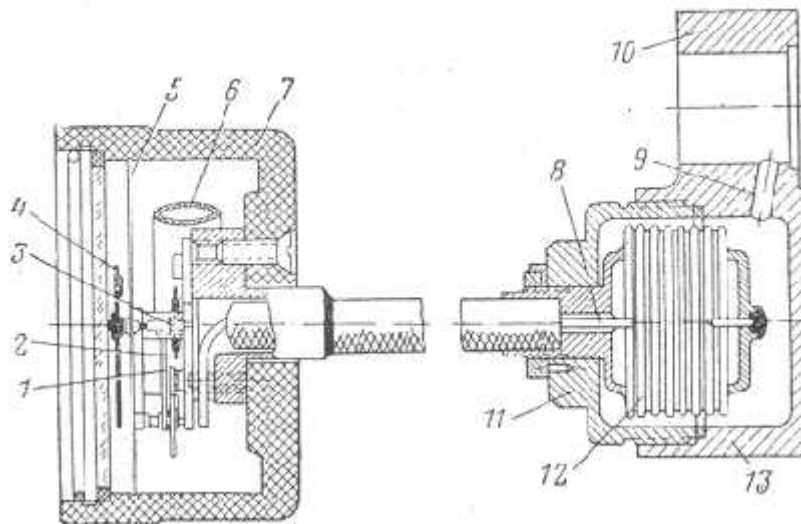
6

4

1

3.

2



. 2.1.

:

1- ; 2- ; 3- ; 4- ; 5- ; 6 - ; 7-

; 8- , ' ; 9 - ;

10 ; 11- ; 12 - ; 13

/ ² 0 15 / ².

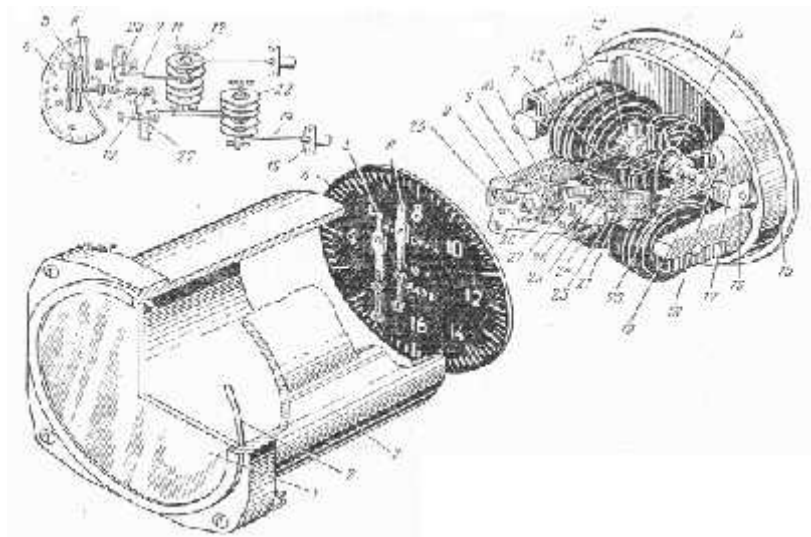
±3%.

2.2.1.

2.2

22

12



2.2.

:

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

; 12 - ; 13 ; 14- ;
 15 - ; 16 - ; 17, 19- ; 18 - ; 20
 ; 21 - ; 22 ; 23- ; 24 -
 ; 25 - ; 26 - ; 27 - ; 28 - ; 29-
 300 2000 . .
 20 . .

±1%.

7

23

2.3.

, .
 0— 250 / ². 3 / ² 2 0—1
 , 100 / ² — - 250 / ² —

:

2.3.1.

0—1 0—150 / ².

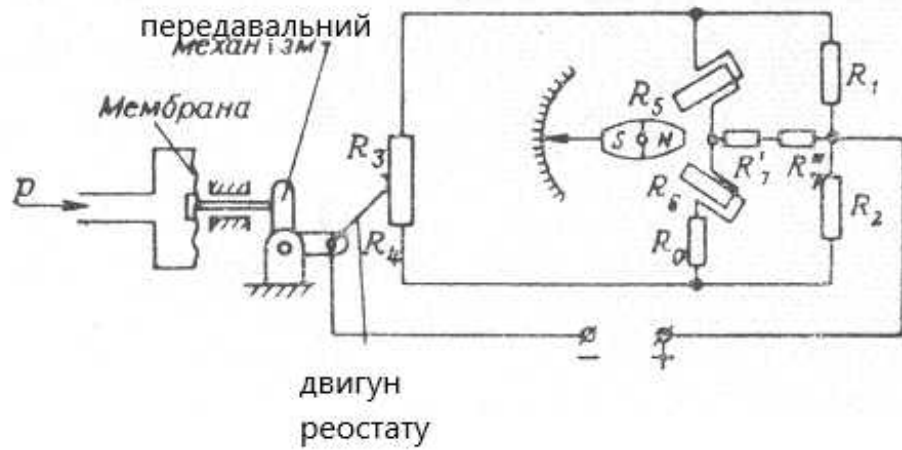
(, ,)

(. 2.3)

R_3 R_4 , R_3 R_4

R_2 , R_1

R_5 R_6 , R_7' R_8'' .



. 2.3.

.2.1.

.2.1.

	R3 + R4	R1	R2	R5	R6	R7'	R7''	R0
	255	1200	1200	280	220	2120	330	60

120 °;

$R_0 = 60$

R_7' R_7'' ,

R_7'

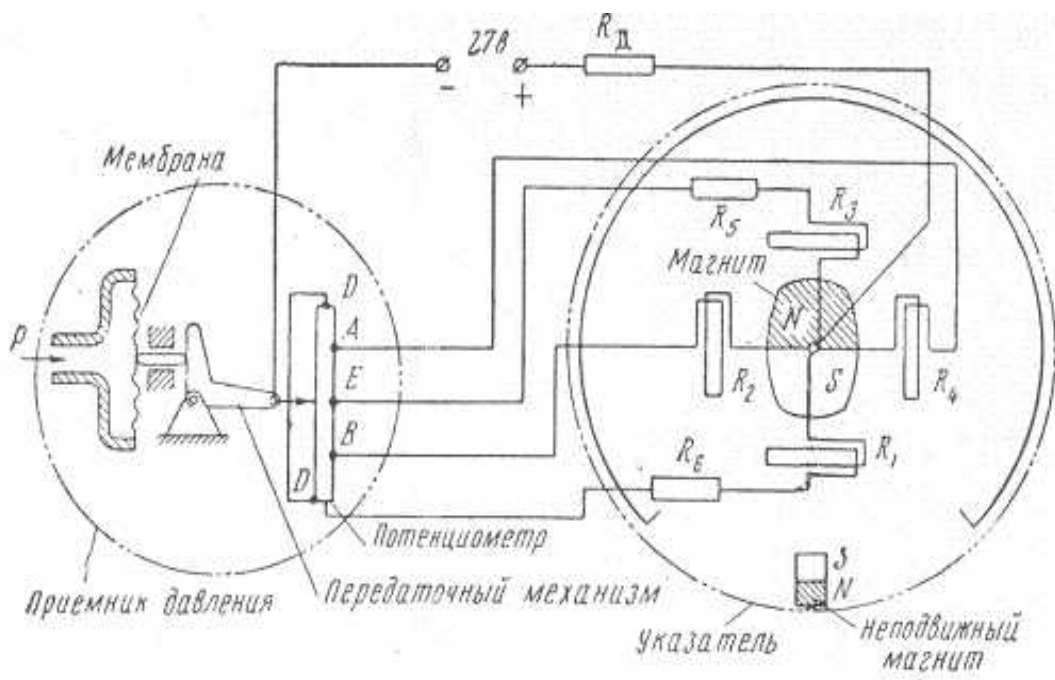
R_3 R_4 .

2.3.2.

(-100)

(-10)

270°.



. 2.4.

. 2.4

90°.

270°.

2.4).

2.4.

()

700 .

0—3 / ² 0—300 / ².

. 2.5.

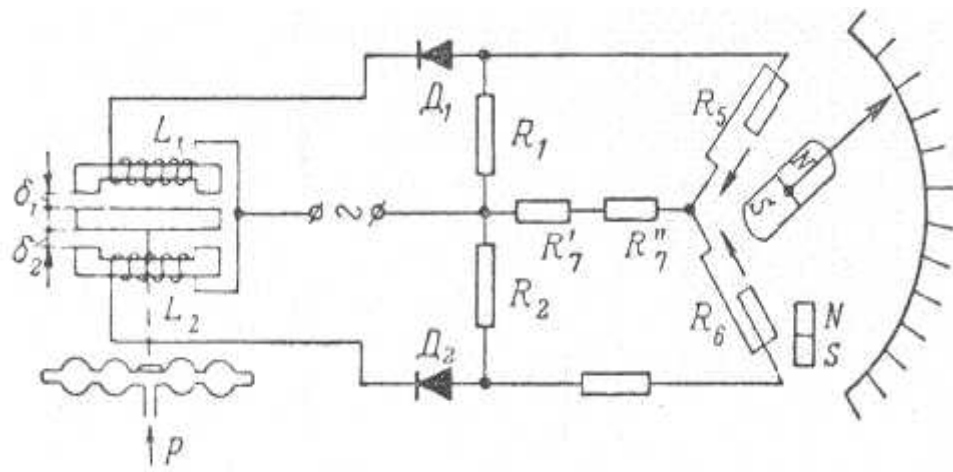
100 / ²

300 / ² —

1 2 .

L₁ L₂ .

R₁ R₂ .



. 2.5.

2.5. ()

(),

300 1200 ° , 1400 ° .

3000 ° .

50-140 °

0-300 °

0,5-1%.

1—2%.

·
·
(,) ,

2.6.

1)

;

2)

;

3)

;

4)

;

5)

)

(

;

6)

;

7)

2.6.1.

-13

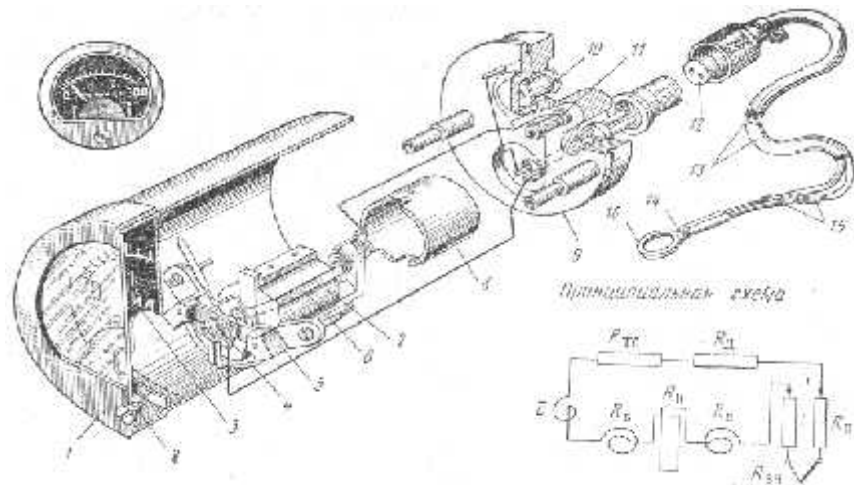
-13 (. 2.6)

- 14 () 16.
,

13

() 85 , -130

; 1,5 .



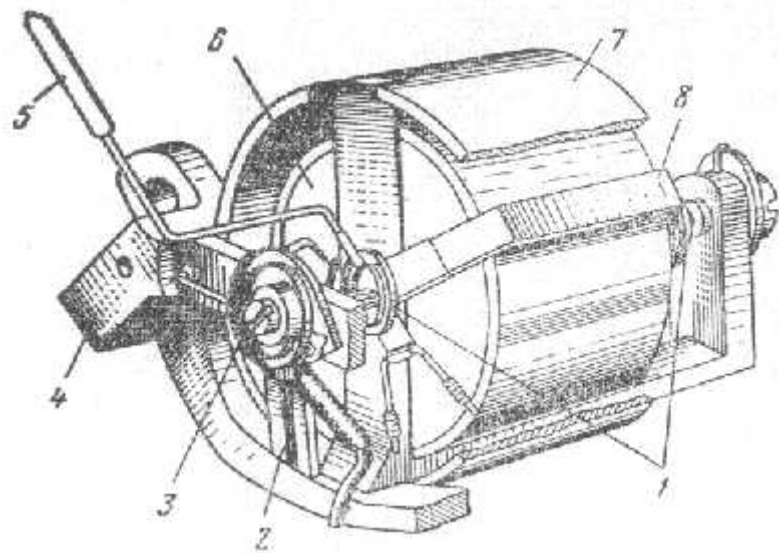
.2.6.

-13:

1- ; 2- ; 3 - ; 4- ; 5
 - ; 6 - ; 7 - ; 8 - ; 9-
 ; 10 - ; 11- ;
 12 - ' ; 13 - ' ; 14- () ; 15
 - ' ; 16 - ; R -
 ; R ; - ; R TC - ;
 R - ; R - ; R H -

7,15 (),
JRU.

2 3.



.2.7.

-13:

1- ; 2- ; 3- ; 4-

; 5- ; 6- ; 7- ; 8

(2.7)

6,
 7 ,
 ,
 (. 2.6).

8.

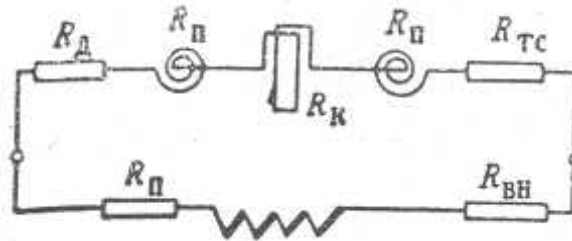
1,

(.2.6)

0 300 ° 20 °
± 8 °

2.6.2.

(.2.8),



.2.8.

- ()

().

300° ,

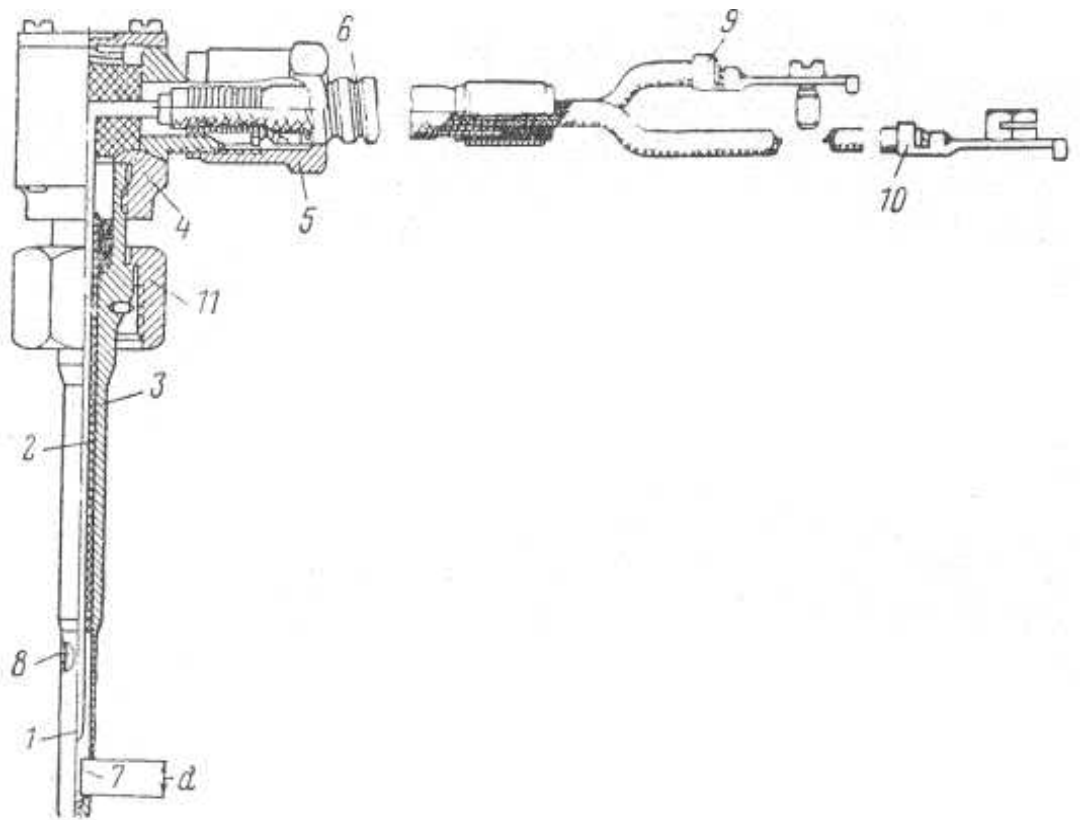
. 2.10.

4

3 -

2 18 9.

3 1 ,
 2.
 7 3
 ,
 ,
 . 8
 11 .
 2 -411.
 ,
 80 ,

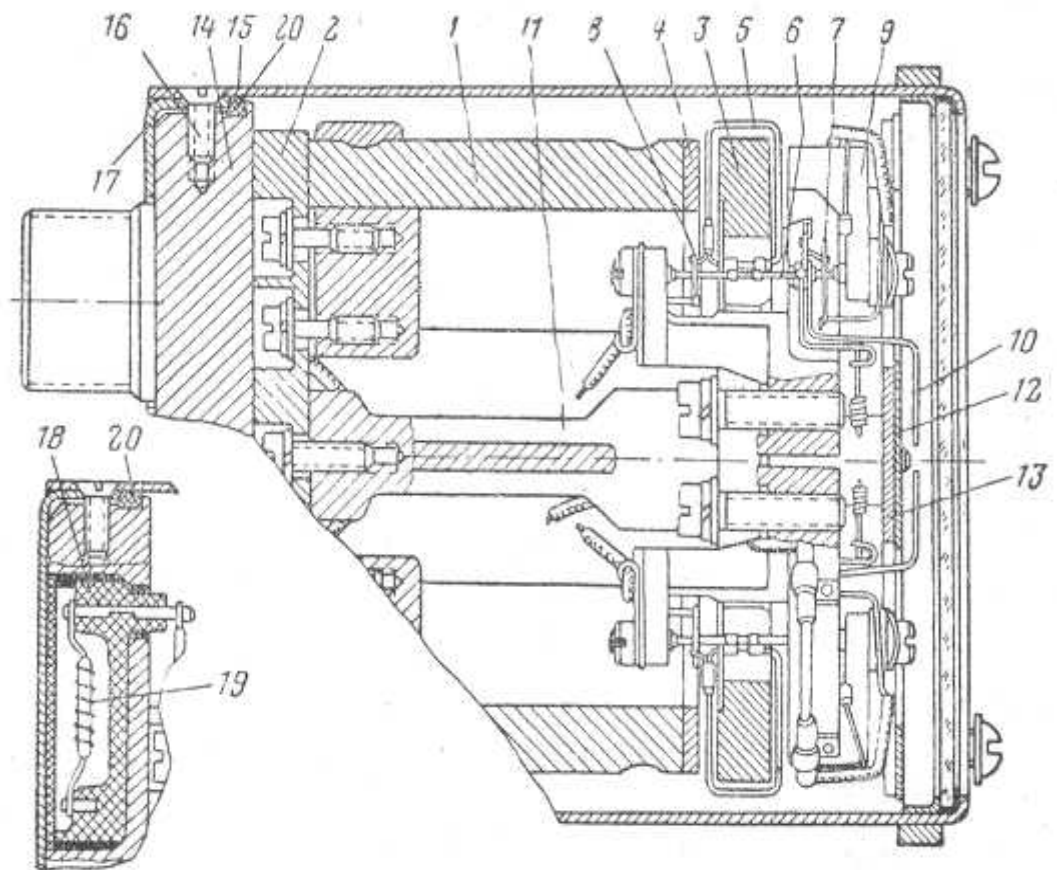


. 2.9. : 1 - ; 2 -
 ; 3 - ; 4 - ; 5 - ; 6 - ; 7 -
 (d=3) ; 8 - (d=0.8) ; 9, 10 - ; 11 - .
 (. 2.10)

1 2 3
 4.

5, 6,
 7 8, 10.
 6,
 13, 15 17.
 20.
 (. 8. 7) 19
 18.

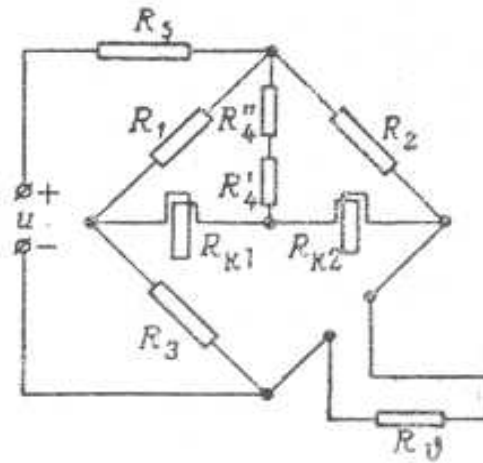
300-900 ° 20 ° .
 ±20 ° .



. 2.10. : 1- ; 2 - ; 3- ; 4
 ; 5- ; 6- ; 7 8 - (; 9 ; 10- ; 11- ; 12 - ; 13- ; 14 - ; 15 ;
 16 ; 17 - ; 18 ; 19 - ; 20-

2.7.

. 2.11 2.12



. 2.11.

2.7.1.

-48

-48

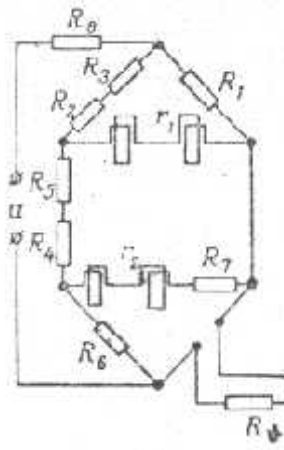
. 2.13

. 2.2.

$d=0,05$.

. 2.3.

-48 (. 2.13)



. 2.12.

-48

3,

4

7,

5

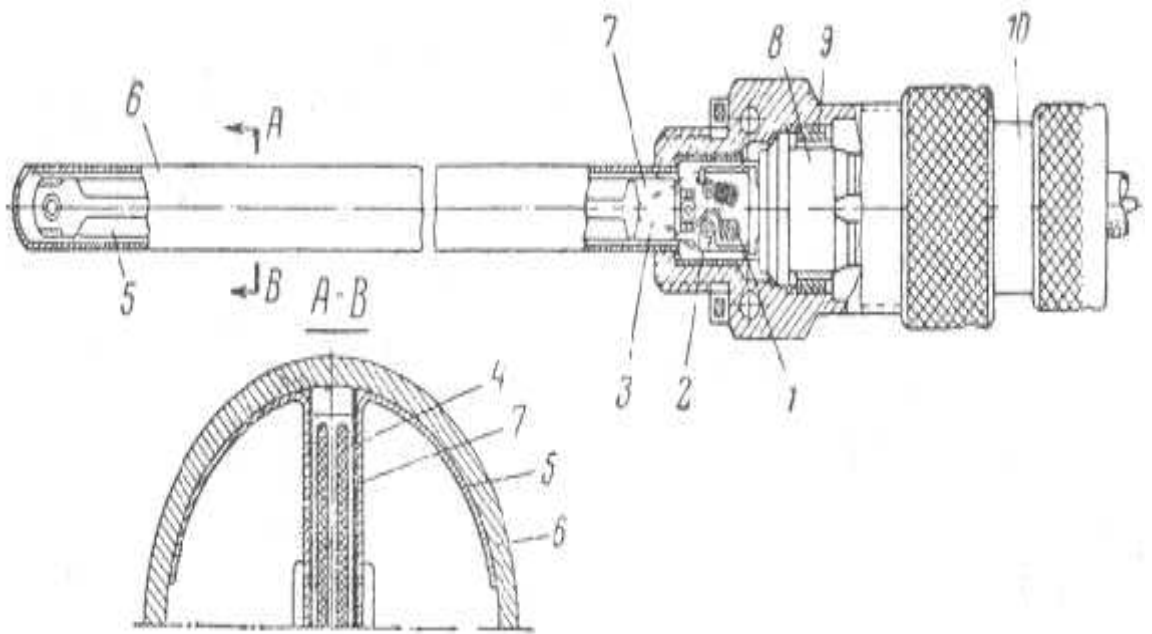
6..

2.2.

R1	700		R6	82	
R2	665	“	R7	60	
R3	80		R8	100	
R4	25	“	r1	280 ±10	
R5	13		r2	220 ±10	“

°		°	
-70	68,2	40	104,70
-60	70,90	50	108,65
-50	73,70	60	112,62
-40	76,70	70	116,80
-30	79,80	80	121,06
-20	83,00	90	125,40
-10	86,40	100	129,80
0	90,10	110	134,25
10	93,60	120	143,40
20	97,20	130	148,20
30	100,90	150	153,10

9 5
11 -
6
1



. 2.13.

-48:

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

: 3 10

120°.

4.

8

,
 R_3, R_4, R_5 (. 2.13)

3

3.1.

2, ’

1.

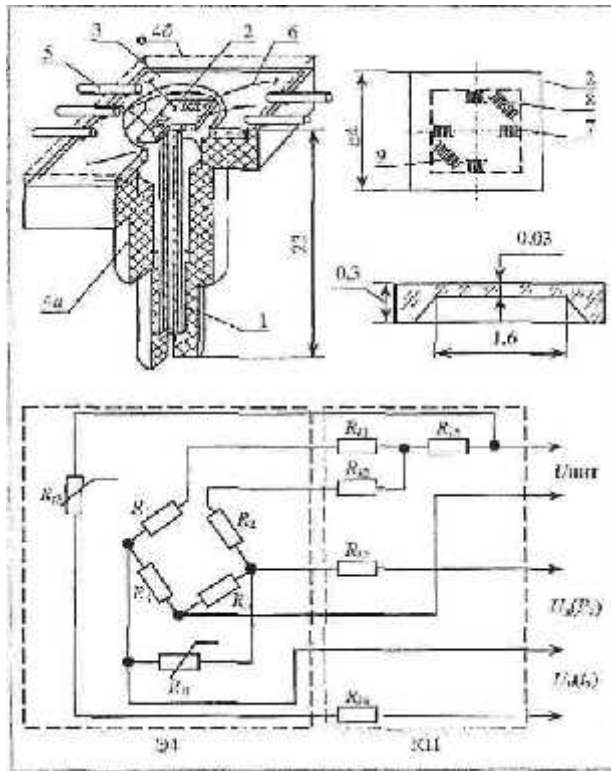
6 ’

5.

9.

5.

	...						
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. 3.1.

4 , 4 () .

, , ,

8, 9

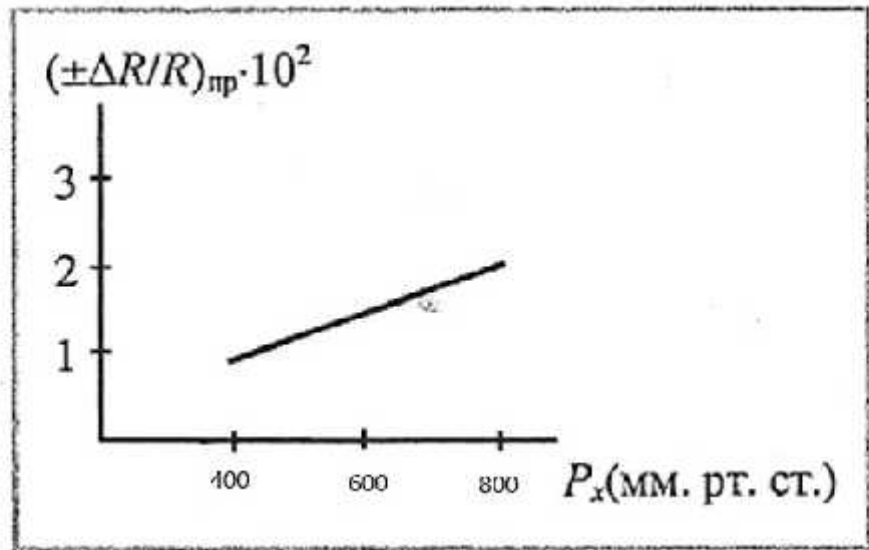
, ,

7

8 9 Rx Rtx
 tx, Rx Rtx
 Ux, Ut ,

5.

Rt1 Rt2 30



. 3.2.

:

—

RK

3.3,

—

:

—

(-75...+90)°

()

;

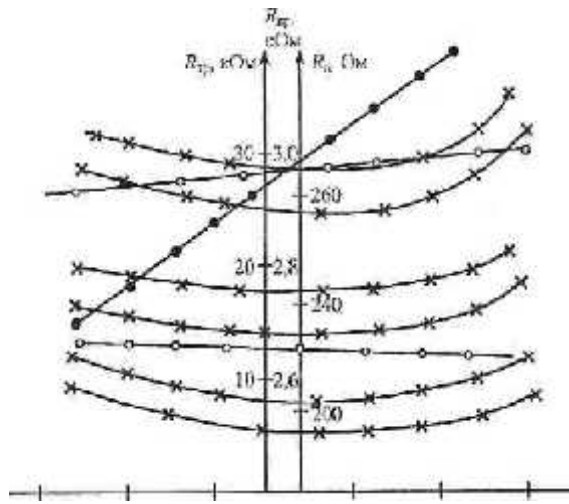
—

+3-10-2 % / ° ,

—

6*10-5%/° ;

0,02...0,04



3.3.

: •-R_p; ×-R ; °-RK

0,5%.

: = (0,2.. 0,6)%; = (0,025 0,1)%.

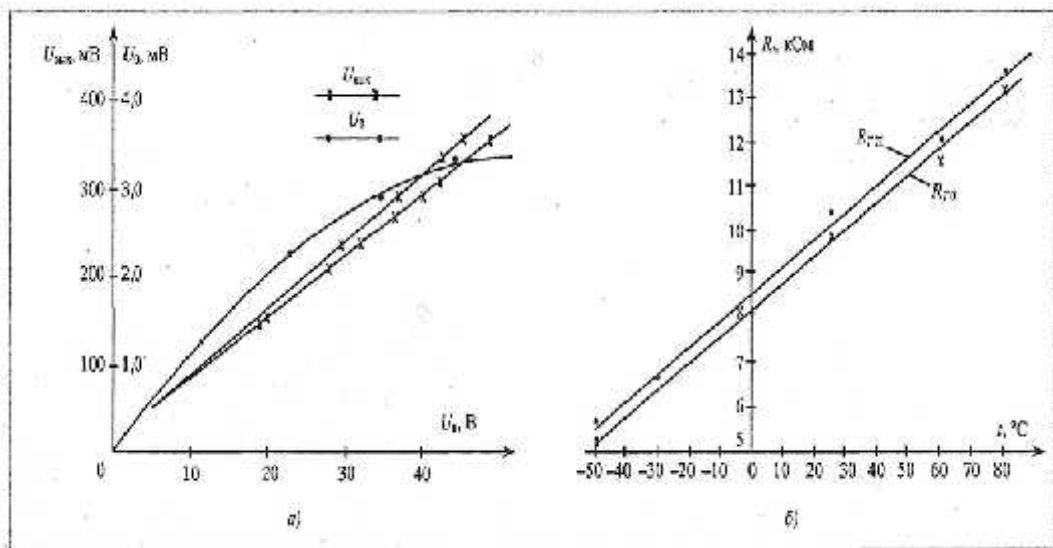
3.4.

350

U_0

U

$$R_t = f(t^\circ)$$



3.4.

: -

; -

3.1

		, °					
		-50	-30	25	40	60	80
15	R _{0t}	5,2	6,1	9,0	9,9	11,5	13,1
	R _{st}	5,8	6,8	9,6	10,5	12,2	13,3
9	R _{0t}	5,2	6,0	9,0	9,8	11,5	13,1
	R _{st}	5,7	6,7	9,5	10,4	12,0	13,6

$$\eta_3 = W_{\text{кор}} / W_{\text{спсж}} \tag{3.1}$$

W - ,
 W - ,
 - ,
 :

$$W_{\text{кор}} = \frac{U_{\text{ВЛХ}}^2}{R_{\text{ВХ}}} t_1 + \alpha_t R_t \Delta t^\circ J_{\text{ДИМ}} t_2, \tag{3.2}$$

$$W_{\text{СПСЖ}} = \left(\frac{U_{\text{ЖКВ}}^2}{R_{\text{М}}} + \frac{U_{\text{ЖКВ}}^2}{R_t} \right) t_{\text{max}}, \tag{3.3}$$

U = 50 - ; R = 1 -
 ; t = 0,5% C⁻¹ -
 ; J — ,
 ; t° -
 (t° = 1 °); t₁ t₂ - , ,

$t_1 = 0,1$; $t_2 = 0,15$) ; $R = 5$ - ; $R_t = 5$ - ; t_{max} - ,
 10 .

(3.2) (3.3) , :

$$W_{\text{max}} = 4 \cdot 10^{-1} ; W_{\text{act}} = 7,5 \cdot 10^{-5} ,$$

$$, = 2 \cdot 10^{-5}$$

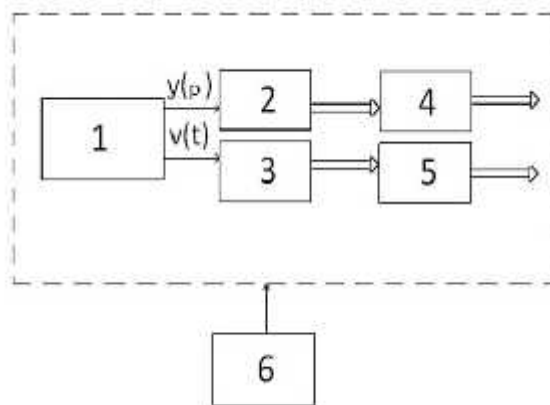
:

$$\eta_{\text{н}} = \frac{9,3 + \frac{1}{2} \lg W + \frac{1}{2} \lg \eta_3}{9,3 + \frac{1}{2} \lg W} = 1 + \frac{\frac{1}{2} \lg \eta_3}{9,3 + \frac{1}{2} \lg W} \quad (3.4)$$

$W = W$.

(3.4) W , $= 0,7$.

. 3.5.



. 3.5

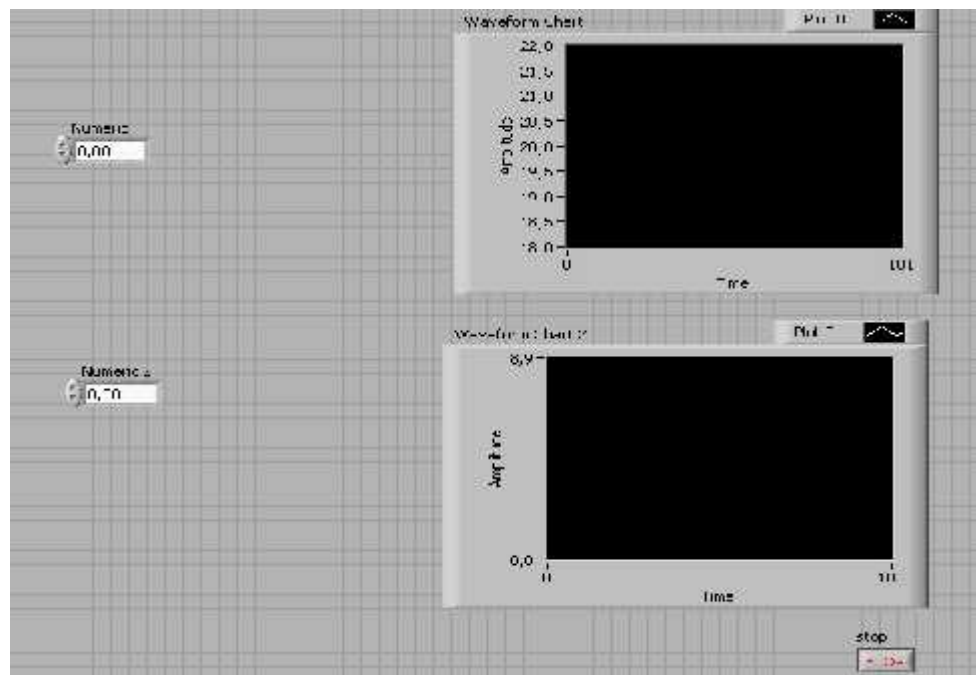
:

1- ; 2,3 - ;

4,5 - ; 6 - .

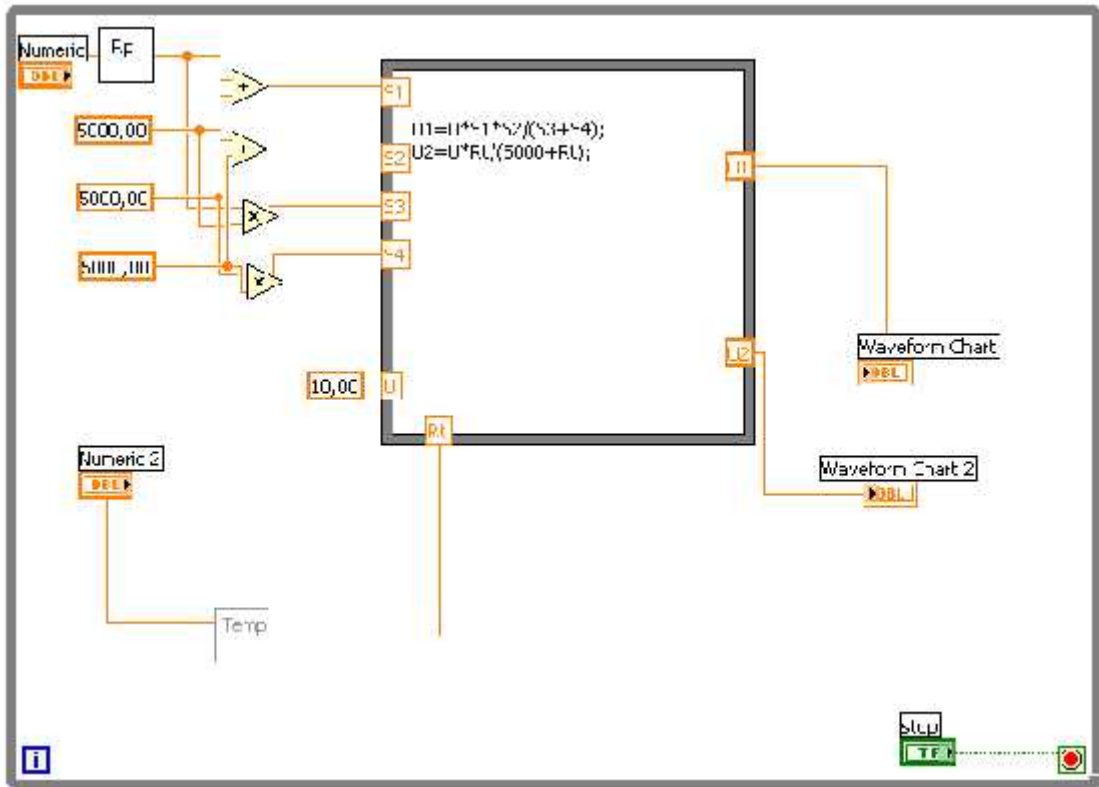
4.1

– LabVIEW (Laboratory Virtual Instrument Engineering Workbench). LabVIEW –



. 4.1.

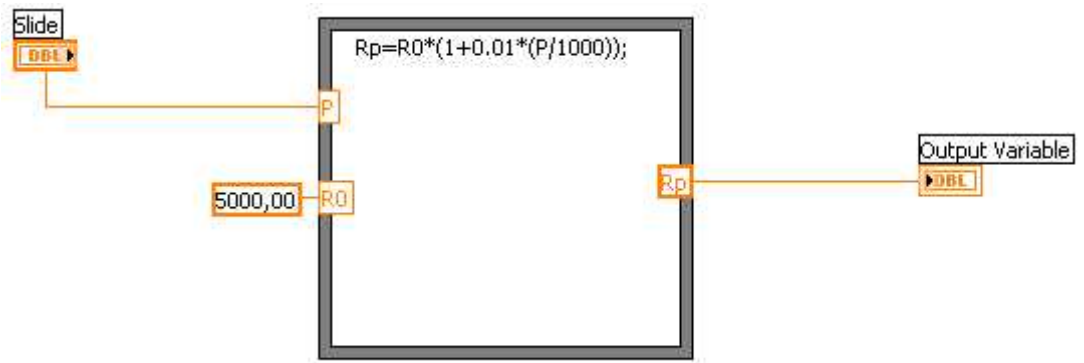
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Н-контр.	Дивнич М.П.			151-301-С			
Зав.каф.	Мельник Ю.В.						



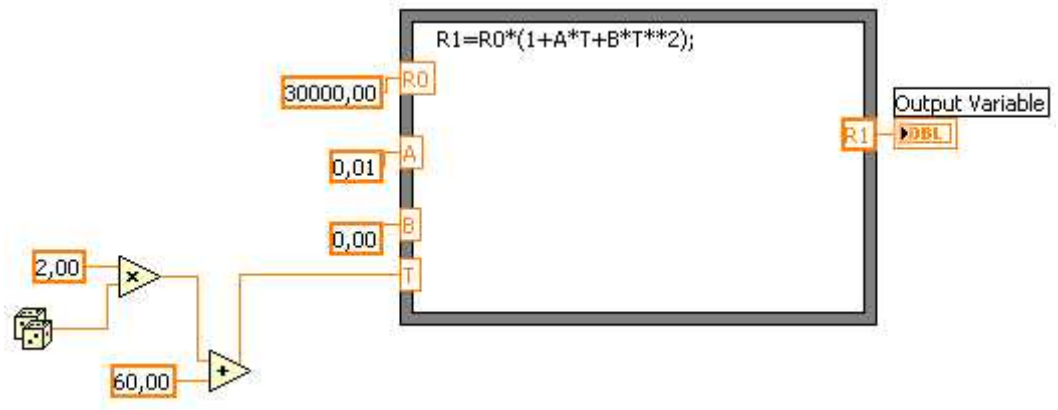
. 4.2.

, (. 4.3.)

(. 4.4.).

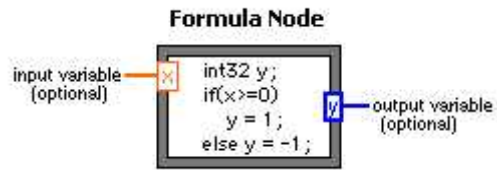


. 4.3.



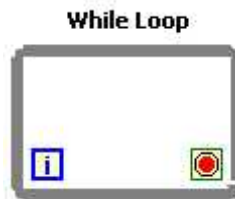
. 4.4.

" (4.5).



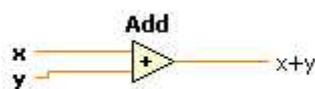
. 4.5.

(. 4.6).



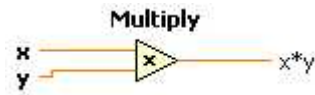
. 4.6.

(4.7).



4.7.

(. 4.8.).



. 4.8.

(. 4.9).

LabVIEW,

. Y -

X, X0 -

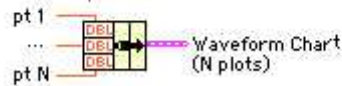
Waveform Charts:

Wire data directly to chart:

Data	Resulting Chart
Scalar	Single plot - 1pt
1D	Single Plot - 1 or more pts
WDT	Single Plot - 1 or more pts
2D	Multiplot - 1 or more pts

WDT (Waveform Data Type) includes timing info.

Or combine points with a bundle node:



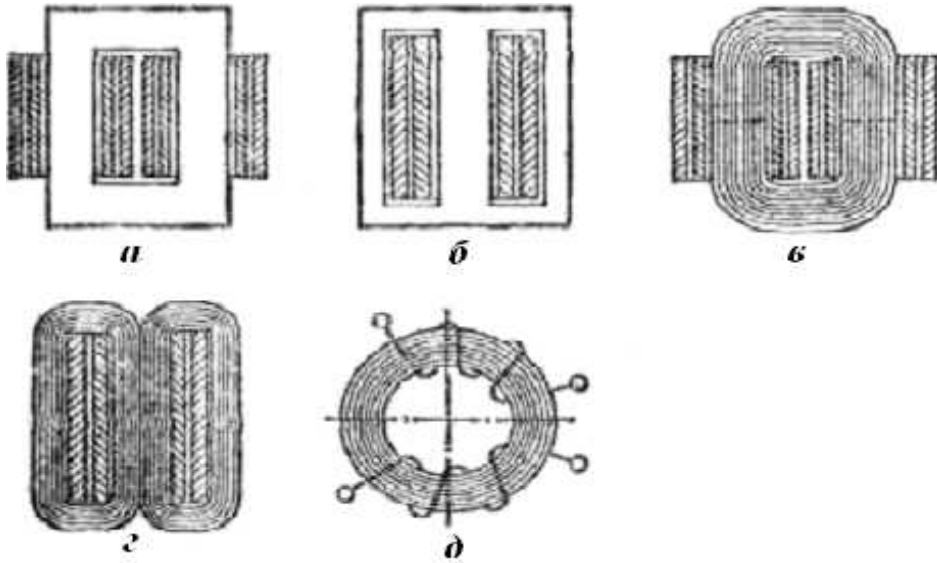
Or use timing information in WDT.

. 4.9.

4.2

48, 340 70 50 44, 45, 46, S47, 0,2; 0,15; 0,1; 0,08 0,05 .

. 4.10.



.4.10.

; , -

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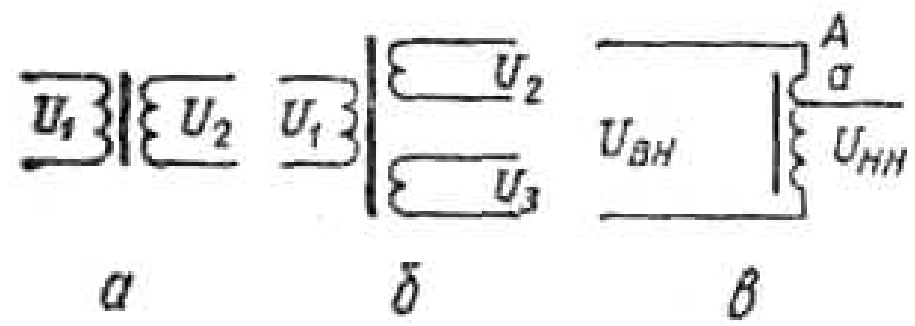
(

,

);

(

)



.4.11 —

: -

; -

; -

$$\begin{aligned} & (U_{II}), & (U_I) \\ & (I_H). \end{aligned}$$

$$I_{II} = 1,5 * I_H = 1,5 () \quad (4.1)$$

$$P_{II} = U_{II} * I_{II} = 24,04 () \quad (4.2)$$

$$P_{TP} = 1,25 * P_{II} = 30,05 (Вт) \quad (4.3)$$

$$I_I = \frac{P_{TP}}{U_I} = 0,26 (А) \quad (4.4)$$

$$S_H = 1,3 * \sqrt{P_{TP}} = 7,1 (см^2) \quad (4.5)$$

$$N_I = 50 * \frac{I_I}{S} = 845 (виток/в) \quad (4.6)$$

$$N_{II} = 50 * U_{II}/S = 121 (виток) \quad (4.7)$$

$$: d = 0,2 * \sqrt{I} ()$$

$$d_I = 0,2 * \sqrt{0,26} = 0,1 (мм)$$

$$d_{II} = 0,2 * \sqrt{1,5} = 0,25 (мм)$$

I – 2 (0,1);

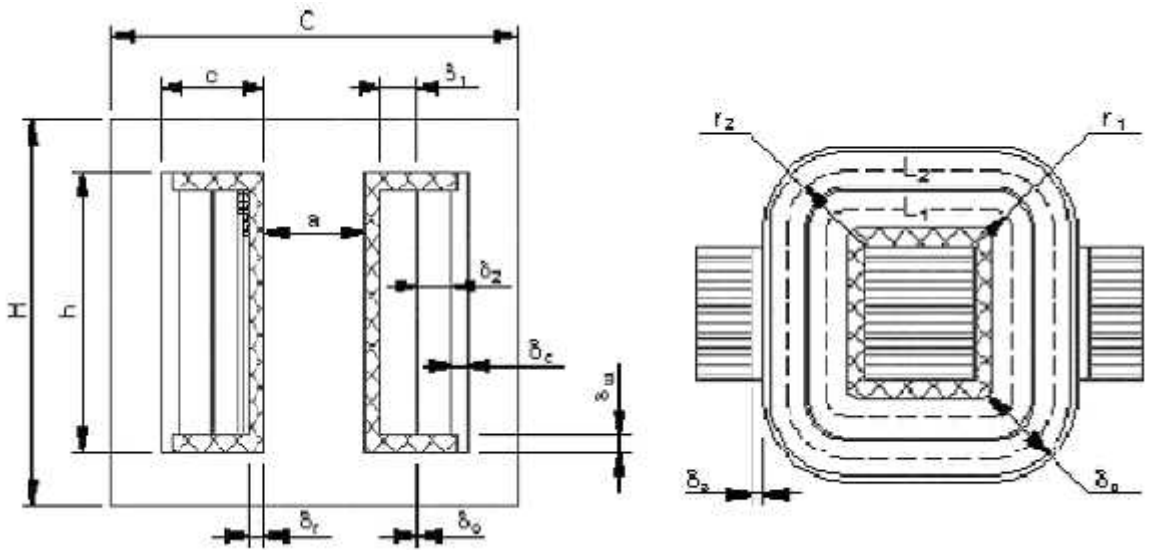
II – 1 (0,25).

(. 4.12).

(u_1),

(u_2).

0,01
 0,1 , 0,05 (0,1...0,5)
 0,12 0,5 .



. 4.12.

:

$$h = H - 2u - 2u \quad (4.8)$$

, H — , ;

u — ;

u — ,

$$h = 32 - 2 \cdot 2.2 - 2 \cdot 0.5 = 28.6$$

N_i :

$$N_i = \left(\frac{h}{k_y d_i} \right) - 1 \quad (4.9)$$

$$N_1 = 35 \quad N_2 = 36$$

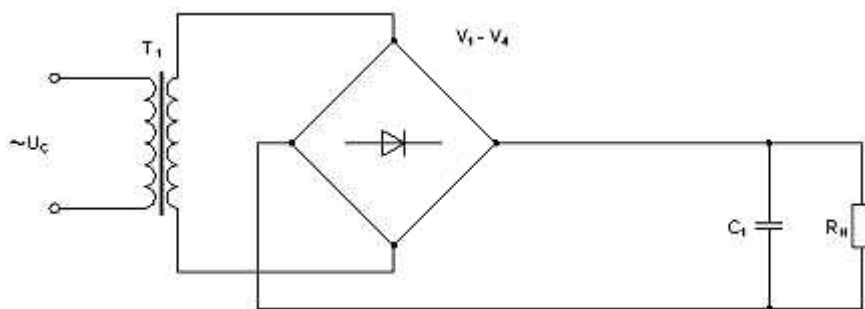
d_i — , ;

k_y — , (

$k_y = 1, 1 \dots 1, 15$).

4.3.

. 4.13 .



. 4.13.

$$U_0 = 115 ;$$

$$I_{max} = 1 ; I_{min} = 0,03 ;$$

$$U_I = 1 , \quad f = 400 .$$

$$U_{op}; I_{np.}; I ,$$

S .

$$D = 2,1..2.2.$$

$$D. \quad B = 0,95...1,1;$$

$$a_{max} = 0,08$$

$$U_{o_{max}} = U_o(1 + a_{max}) \quad (4.10)$$

$$U_{max} = 115(1 + 0.08) = 124,2$$

$$C = 100H / rK \quad (4.11)$$

$$C \approx 1000$$

$$H — ; r - , ;$$

$$- , \% ; - , .$$

$$y = P_0 / (P_0 + P_{TP} + P_B) \quad (4.12)$$

$$y \approx 0.7$$

$$P_{TP} = S_{TP}(1 - y_{TP}) \quad (4.13)$$

$$P = 0.3$$

203

10

800

1,0

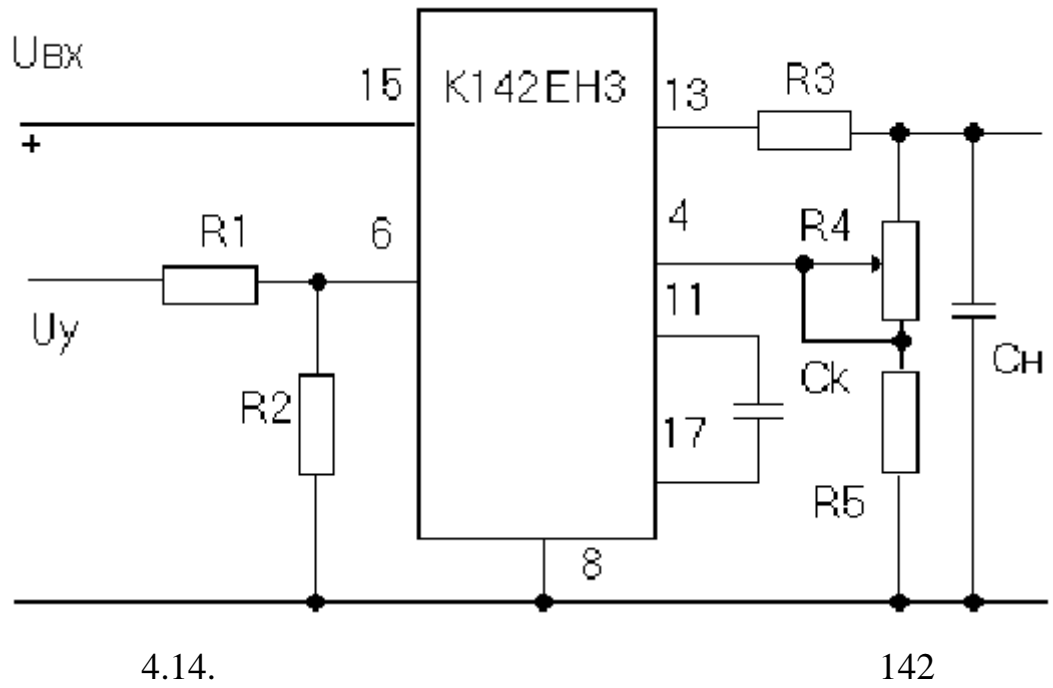
-60 +130

4.4.

142 3

2,2 2,2 .

1 .



$\varphi = +65^\circ$; $\varphi = +145^\circ$; R_3 -
 $\varphi = -$; $\varphi =$;
 $\varphi = 0,01$
 $\varphi = 2,2$).

R_2 , , :

$$R_2 \cong \frac{U_{OS}/T_k - 6,65}{1 - 0,01557k} \cong 3,06 \text{ (кОм)} \text{ (при } T_k=115^\circ \text{)} \quad (4.14)$$

$R_1 \cong \frac{U_y R_2 (1 + 0,4R_2) - R_2 (1,8 + 0,5R_2)}{1,8 + R_2 (1,2 + 0,2R_2)} \cong 7,5 \text{ (кОм)} \quad (4.15)$

U_y -

$R_3 = \frac{1,25 - 0,5I_{nop} - 0,023(U_{ax} - U_H)}{I_{nop}} \approx 110 \text{ (Ом)} \quad (4.16)$

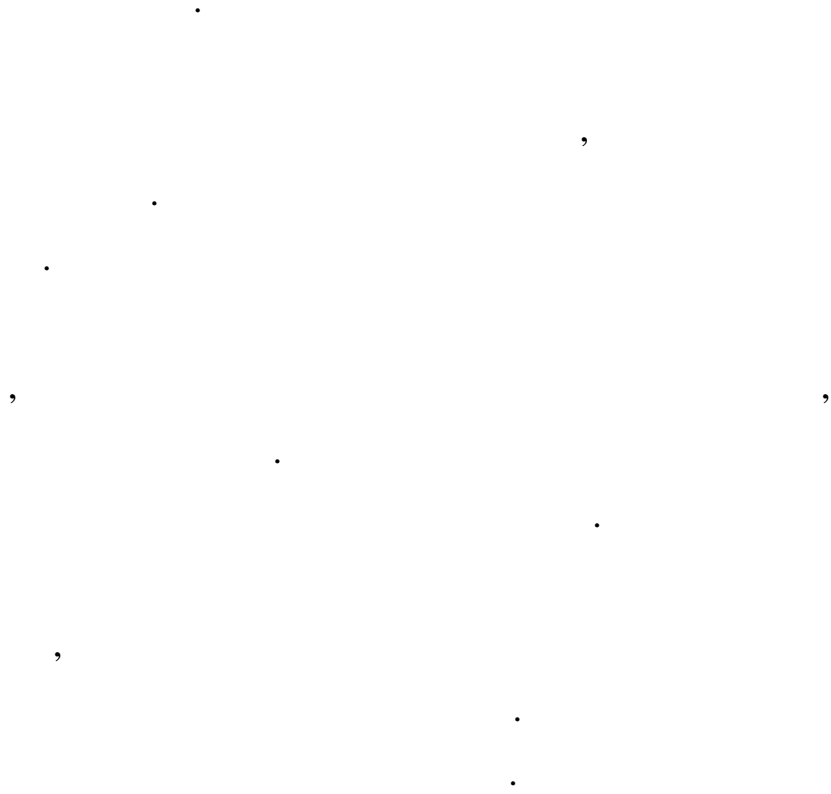
$R_4, R_5 \text{ I} > 1,5$.

$$R_{4,5} = \frac{U_H}{I_H} = 4,8 \text{ (кОм)} \quad (4.17)$$

$$R_5 \quad :$$

$$U_{\text{обп}} = 2,5\text{В} + 10\%. \text{ Тогда } R_5 = \frac{U_{\text{обп}}}{I_H} = \frac{2,75}{0,002} = 1,4 \text{ (кОм)} \quad (4.18)$$

$$R_4 = R_{4,5} - R_5 = 4,8 - 1,4 = 3,4 \text{ (кОм)} \quad (4.19)$$



1. :
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2.
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7. :
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« » , 2016. – 123
10. : , 1979 .
11. : .
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12. : , 1989 -
702 .
13. :
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14. , 1969.
15. 2003 . 11
16. 2003 . 12