! " # " $ % & ' $ % ( )   (* $ + & ,)   " $ ' & - # & ,)

$. & / " 0 1 2 #) ,)) 3 ' 0 4) (0 # " 5 ') $ $ " 6 $ 7) 6

8 & - & ' 0 / " "

% 0 , 0 # ') , $ 7 " 6 ,) $ 9 - 0 ' $ % (& # # * 6

' 0 - ") % & : # " ; & $ 7 " 6 9 # " (& ' $ " % & %

7<=>?@< ABCDE@FG@BH<C**G I** @<?GBJK>AE@BCCBL <MM<@<EF@**N**

' 9 7) ( ) - $ % ( )

A HNMBKC>CGO @<PBEN @<DQ>ECB-R@<=GQ>DABRB M@<AEGAFS<

7) # $ % ' 9 " ') (0 # " & , " 3 ' " - # * :

" # % & , ' 0 1 2 # * :   ! " 7 ') $: & !

MB AF@DF

7) # $ % ' 9 " ') (0 # " & " ' 0 $; & % ! " 7 ') $: & !

" ! " 7 ') T 1 & ! & # %) (T (0

- KI DEF?>CEBH DM>UG<KVCBDEG **0648**

! " # 621.382.81

$%&' (')*+(' & (, -'. /0/12 345'+, 34*60+/'-7348160*&' 7' -34&+1&%94 «#'/*+3%13'(4/10 71531)/, : 1/+0734. ;/, : 91&3'*:09» -' &%3*% «#'/*+3%&<11 1 34*60+ 91&3'*:09 1 91&3' =. 090/+' (>?@». ". A *+%)0/+' (*-0<14. ;/'*+1 0648. B') 30). C. D. B'/'9430(4.

#'/'-. 0(E. F.

G474/3' 7, G$GH, 1981.

C0+')160*&10 %&4I4/1A *')03J4+ 3%&' (')*+('). A (, -'. /0/1A 34*60+/'-7348160*&' K 345'+, «#'/*+3%13'(4/10 71531)/, : 1/+0734. ;/, : 91&3'*:09» 1 (&. 2642+ '-1*4/10 '*'50//'*+0K &'/*+3%&<11 91&3'*:09, 90+')1&1 -3'0&+13'(4/1A, -34(1. 4 '8'39. 0/1A &'/*+3%&+'3*&'K)'&%90/+4<11. ? -31.'J0/1A: -31(0)0/, '*/'(/, 0*-34('6/, 0)4//, 01 34**9'+30/ -31903 34I345'+&1 71531)/'K 1/+0734.;/'K *:09, (FHL).

$%&' (')*+(' 9'J0+ +4&J0 1*-'.;I'(4+;*A *+%)0/491 *-0<14.;/'*+1 0705 -31 (, -'. /0/11 &%3*'('('7' -3'0&+4 -'&%3*% «#'/*+3%&<11 1 +0: /'.'71A 91&3'*:09».

G45. . 8, 1. . 18, 515. 1'73. 10.

L'*+4(1. E. F. #'/'-. 0(

$0<0/I0/+ M. D. E. 1/'(, &4/). +0:/. /4%&,)'<0/+ &480)3, G$>@ G$GH.

1. .) ' 5 -) 7 (* .) 1 # & # " 5 ' 0 $; & % #) -
, ' 0 8 " ; & $ 7 " : ' 0 3) % " $) - & ' W 0 # " &) % ; & %) (

N0. ; 2 . 45' 34+' 3 /' 7' 34*60+/' -7348160*&' 7' -34&+1&%94 A(. A0+*A 1I%60/10 &' /*+3%&<1K 1 : 434&+031*+1& 1/+0734. ; /, : 91&3' *: 09 1 34I(1+10 % *+%)0/+' (/4(, &' (&' /*+3%13' (4/1A 1 34*60+4 71531)/, : -. 0 /' 6 /, : (FHL) 1 -' . %- 3' (') /1&' (, : (HBL) 91&3' *: 09 [1 - 5].

O45' 34+' 3 /, K -34&+1&%9 (&. 2640+ (, -' . /0/10) (%: 345'+. B31 (, -' . /0/11 -03(' K 345'+, -3' (') A+*A 34*60+ 1 &' /*+3%13' (4/10 FHL, (&' +' 3' K 1*-' . ; I%0+*A (&460*+(0 &' 9-' /0/+4 50*&' 3-%*/4A HBL, 34I3454+, (4094A -31 (, -' . /0/11 (+' 3' K 345'+, .

L+%)0/+49 (,)42+*я +0: /160*&10 I4)4/1A /4 -3' 0&+13%09, 0 91&3' *: 09, 94. ' 7' %3' (/A *. ' J/' *+1 1 *: 094 =. 0&+3160*&4A -31/<1-14. ; /4A 304. 1I%09' 7' %*+3' K*+(4. P4 =. 0&+3160*&' K *: 090 (,) 0. 0 /4 64*+; %*+3' K*+(4, &' +' 3%2 /4) . 0J1+ 304. 1I' (4+; ((1) 0 HBL.

$45' +% /461/42+ * 4/4. 1I4 +0: /160*&' 7' I4) 4/1A 1 =. 0&+3160*&' K *: 09, . ? 30I%. ; +4+0 4/4. 1I4 8' 3913%2+*A +305' (4/1A & &' /*+3%&<11 =. 090 /+' (1 91&3' *: 09, (<0. ' 9. " 4. 00 -3' (') 1+*A (, 5' 3 1 ' 5' */' (4/10 &' /*+3%&+1 (/' -+0: /' . ' 7160*&' 7' (4314/+4 91&3' *: 09, , (, 5' 3 94+0314. ' (, 34*60+ =. 090 /+' (, 34I345' +&4 +' -' . ' 711 91&3' *: 09, . B31 34I345' +&0 FHL /4 ' */' (4/11 30I%. ; +4+' (4/4. 1I4 +0: /160*&' 7' I4) 4/1A (, 51340+*A &' 3-%* 1 -3' (') 1+*A ' <0/&4 +0-. ' (' 7' 30J194 91&3' *: 09, . E0*&' 3-%*/4A HBL (, -' . /A0+*A ((1) 0 &31+*+4. . 4 I4)4//, : 34I903' (, I4Q1Q0//' /' 7' *. ' 09 . 4&4 1. 1 &' 9- 4%*/) 4.

R+60+ -' 34*60+/' -7348160*&' K 345'+0)' . J0/ *') 03J4+; 30I%. ; +4+, 34*60+' (91&3' *: 09 1 &' /*+3%&+' 3*&%2)' &%90/+4<12.

P4 FHL (, -%*&40+*A &' 9-. 0&+ &' /*+3%&&' (' 3*&' K)' &%90/+4<11, (&. 2642Q1K *-0<181&4<12, *5' 3' 6 /, K 603+0J, 603+0J -. 4+, (+' -' . ' 7160*&1K 603+0J), *: 09% =. 0&+3160*&%2 -31/<1-14. ; /%2 . ? ' +60+ -' (+' 3' K 345'+0 -' 90Q40+*A +' . ; &' =*&1I +' -' . ' 7160*&' 7' 603+0J4 &31+*+4. . 4 HBL.

2. 0 # 0 1 " 4 % & : # " ; & $ 7) ,) 40 - 0 # " 5

N0. ; 2 4/4. 1I4 +0: /160*&' 7' I4)4/1A 91&3' *: 09 A(. A0+*A %+' 6/0/10 +0: /160*&1: +305' (4/1K, -30) SA(. A09, : & =. 0&+3160*&19 : 434&+031*+1&49, &' /*+3%&<11 1 +0: /' . ' 711 1I7' +' (. 0/1A 91&3' *: 09.

R5Q10 +305' (4/1A & =. 0&+3160*&19 1 &' /*+3%&+1 (/, 9 : 434&+031*+1&49 /4-34(. 0/, /4 -' (, T0/10 /4) 0J/' *+1 1 %/181&4<12 91&3' *: 09. B31 -3' 0&+13' (4/11 *. 0)%0+ %61+, (4+; *. 0)%2Q10 ' */' (/, 0 +305' (4/1A:

- 91&3' *: 09, ')/' 7' +1-4) ' . J/, 5, +; (I419' I490/A09, 91;

- (03' A+/' *+; 50I' +&4I/' K 345'+, 91&3' *: 09, (0*. 1 =+' /0 ' 7' (' 3' /0 ' *' 5' (+0: /160*&' 9 I4)4/11) (+060/10 1000 6)' . J/4 5, +; /0 90/00 0,95;

- '50*-060/10 ('I9' J/' *+1 &' /+3' . A -43490+3' (=. 090/+' (-030) *5' 3&' K 91&3' *: 09;

- 91&3' *: 094)' . J/4 190+; 943813' (&% * ' 5' I/460/109 +' (43' (1/4&4 -30) -31A+1A-1I7' +' (1+0. A, 90*A<4 1 7') 4 1I7' +' (. 0/1A, &. 0K9' ' +) 0-. 4 +0: /160*&' 7' &' /+3' . A (RG#) 1 &. 26 - %&4I4+0. ; 90*+4 34*-' . ' J0/1A -03(' K (, ((') 4.

U4*+/, 0 +0: /160*&10 +305' (4/1A ' - 30) 0. A2+*A +0: /160*&19 I4) 4/109 1 /4 '*/' (0 4/4. 1I4 =.0&+3160*&' K *: 09, . # 61*.% '*/' (/, : 64*+/, : +0: /160*&1: +305' (4/1K '+/' *A+*A:

 - +305' (4/1A & =.0&+3160*&19 -43490+349 91&3' *: 09, , 1: *+451. ; /' *+1 1)' -%*+19, 9 - '730T/' *+A9;

 - +305' (4/1A - ' %*+' K61(' *+1 & 90: 4/160*&19, &. 194+160*&19 1) 3%719 (/0T/19 (' I) 0K*+(1A9 [5] ;

 - 30&' 90/) %094A <' &' . 0(&4 91&3' *: 09, .

V*. 1 +305' (4/1A & <' &' . 0(&0 /0 '7' (' 30/, , +' 30&' 90/) %0+*A *. 0) %2Q4A: 1-K (, (') &' 3-%*4 - '5Q1K, &34K/10 (, ('), - -1+42Q10 /4- 3AJ0/1A.

3. 7) # $ % ' 9 " ') (0 # " & , " 3 ' " - # * : " # % & , ' 0 1 2 # * : ! " 7 ') $: & ! (, " $)

3.1. TK>S>CEN G ABSMBC>CEN , " $

3.1.1. . B?KBXAG

B03060/; '*/' (/, : 94+0314. ' (, -3190/A09, :). A 1I7' +' (. 0/1A -'). '-J0& FHL, 1 1: *(' K*+(4 - 31(0) 0/, (- 31. . I.

B03*-0&+1(/, 91 1 T13'&' 34*-3'*+34/0//, 91 94+0314. 491 A(. A2+*A *1+4.., , &'+'3, 0 (2-3 34I4 -3'6/00 *+0&'.. ".A 9'Q/, : FHL -30)-'6+1+0. ;/00 1*-'. ;I' (4+; &0349160*&10 94+0314., , 1902Q10 5'.00 (, *'&%2 +0-.'-3' (')/' *+; 1 90: 4/160*&%2 -3'6/'*+;. "3%719 (4J/, 9 &460*+(' 9 &0349160*&1: -'). 'J0& A(. A0+*A (, *'&4A +09-034+%34 34I9A760/1A &03491&1, 6+' -'I('. A0+ -3190/A+; 1: (-3'1I(')*+(0 +'. *+'-. 0/' 6/, : 91&3' *: 09, -. 4+, &'+'3, : -31 1I7' +' (. 0/11 '53454+, (42+*A -31 (, *'&1: +09-034+%34:.

R5345'+&4 345'61: -' (03: /' *+0K -'). 'J0& +'/&' -. 0/' 6/, : FHL)'. J/4 *''+(0+*+(' (4+; 13-14 &. 4**% 61*+'+, , +'.Q1/4 0,6⁻⁰·¹ 99. ".A 1I7' +' (. 0/1A +'. *+'-. 0/' 6/, : FHL)'-%*+19' -3190/A+; -'). 'J&1, '5345'+4//, 0 -' 8-10 &. 4**% 61*+'+, , +'. Q1/4 1,6⁻⁰·³ 99. U1*+' +'+4 '5345'+&1 +'3<' (1 /0345' 60K -' (03: /' *+1 -'). 'J&1)'. J/4 5, +; /0 :%J0 6 &. 4**4.

3.1.2. . @BHB?CGAG G ABCE<AECN> MKBY<?AG

L -'9'Q;2 -. 0/' 6/, : -3' (')1&' ('*%Q0*+(. A0+*A =.0&+3160*&' 0 *''0)1/0/10 =. 090/+' (1 &'9-' /0/+' (FHL. ".A -31*'0)1/0/1A (/0T/1: (, (')' (/4(0*/, : &'9-' /0/+' (, 4 +4&J0). A &'/+3'. A =. 0&+3160*&1: :434&+031*+1& 91&3' *: 09, *.%J4+ &'/+4&+, 0 -. 'Q4)&1. ?/0T/10 &'/+4&+, 0 -. 'Q4)&1 +'/&' -. 0/' 6/, : FHL *'0)1/A2+*A * (, (')491 &'3-%*4 -3' (')1&491). 1/' K)' 5 99 1I I'. '+' K (3 . 999,9 FRLG 7222-74) 1. 1 90)/' K (90); C?, G! II W 0 0,021.040-72, - '&3, +10 - - 31- 'K B L3 RL3-38, G! X 48-07-247-70) -3' ('. '&1) 1490+3'9 40-90 9&9. ? +'. *+'- . 0/' 6/, : FHL, (, -%*&409, : (90+4.. '-'. 1903/, : &'3-%*4:, (, ('), 91&3' *: 09,) 1490+3'9 0,3-1,1 99 '5, 6/' -31-41(42+*A /0- '*30)*+(0//' & (/0T/19 &'/+4&+, 9 -. 'Q4)&49 -.4+, .

Y434&+031*+1&1 94+0314. ' (-. 0/' 6/, : -3' (')1&' (-31(0)0/, (-31. . II. ? +'. *+'- . 0/' 6/, : FHL 1*-'. ;I%2+*A, &4& -34(1. , 9/' 7' *. 'K/, 0 *1*+09, , *'*+'+'Q10 1I *. 'A 94+0314. 4 * :'3' T0K 4)70I10K & -'). 'J&0 (-'). *. 'K), *. 'A (, *'&' -3' (')AQ07' 94+0314. 4 1 I4Q1+/' 7' -'&3, +1A.

". A 1I7' +' (. 0/1A -3' (')1&' (1 &' /+4&+/, : -. 'Q4)'& +'. *+'- . 0/' 6-/, : FHL -3190/A2+*A -4*+, , (&. 2642Q10 -4. . 4) 1K (G! 6-09-2025-72),

*03053' (FRLG 1277-63), *+0&.' 943&1 660^4 (G! 10-3) 1 '&1*; (1*9%+4 (FRLG 10216-62). ? I4(1*19'*+1 '+ 30<0-+%3, -'.%642+ -4*+, BB-1, BB-2, BB-3 1 BB-4. B4*+4 BB-1 -3190/A0+*A).A 1I7'+'(.0/1A -3'(')/1&'(, &'/+4&+/, : -.'Q4)'&1 /1J/1: '5&.4)'&-.0/'6/, : &'/)0/*4+'3'(; -4*+4 BB-2 -).A 1I7'+'(.0/1A (03:/1: '5&.4)'&&'/)0/*4+'3'(; -4*+4 BB-3 -).A 1I7'+'(.0/1A -3'(')/1&'(, /1J/1: '5&.4)'&&'/)0/*4+'3'(1 &'/+4&+/, : -.'Q4)'&).A 9'/+4J4 &'9-'/0/+'(* J0*+&191 (, (')491; -4*+4 BB-4 -).A 1I7'+'(.0/1A -3'(')/1&'(, /4/'*19, : /4 *.'K)1=.0&+31&4. ".A -'(, T0/1A /4)0J/'*+1 -4A/, : *'0)1/0/1K 1 %90/;T0/1A *'-3'+1(.0/1A -3'(')AQ10 =.090/+, /4 '*/'(0 -4*+ BB-1, BB-3 1 BB-4 30&'90/)%0+*A -'&3, (4+; -31-'09 B L3 RLZ-58.

3.1.3. .K>CBQCN> @>ZGDEB@N

G1-'(4A &'/+3%%&<1A -.0/'6/'7' 30I1*+'34 -3A9'%7'.;/'K 8'39, -'&4I4/4 /4 31*.3.1 $0I1*+'3 *'*+'1+ 1I -'.'*&1 30I1*+'+1(/'K -.0/&1 1 &'/+4&+/, : -.'Q4)'& Y434&+031*+1&1 /0&'+'3, : 94+0314. '(30I1*+'+'3'(-31(0)0/, (-31.. III. ".A 1I7'+'(.0/1A +'/&'-.0/'6/, : FHL * /1I&''9/, 91 30I1*+'+3491 1*-'.;I%0+*A +4/+4., T13'&' -3190/A0+*A /1:3'9, 4 (*.%640 -'(, T0//, : +305'(4/1K & *+451.;/'*+1 -43490+3'(30I1*+'+3'(- -*-.4(X 3. ".A 1I7'+'(.0/1A FHL * (, *'&''9/, 91 30I1*+'+3491 1*-'.;I%0+*A *-.4(&0390+. B31 -3'1I(')*+(0 +'.*+'-.0/'6/, : FHL -3190/A2+*A 30I1*+'+1(/, 0 -4*+, B$, (&.2642Q10 -4..4)1K (G! -6-09-2025-72) , *03053' (FRLG 1277-63), *+0&.' 943&1 660^4 (G! 10-3).

$1*.3.1. #'/*+3%%&<1A -.0/'6/'7' 30I1*+'+34 -3A9'-%7'.;/'K 8'39, .1 -30I1*+'+1(/, K *.'K, 2 -&'/+4&+/, 0 -.'Q4)&1, 3 --')'.'J&4.
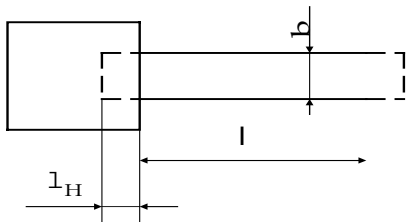
?0. 161/4　*' - 3' +1(. 0/1A　　- . 0/' 6/' 7'　30I1*+' 34　' - 30)0. A0+*A (, 34J0/109:

$$R = \frac{\#_v l}{db} \; ! \; 2R_k = \#_0 K_\phi \; ! \; 2R_k , \qquad (3.1)$$

7)0　$\#_v$ – %)0. ; /' 0 ' 5S[9/' 0 *' - 3' +1(. 0/10;

$\#_0$ - %)0. ; /' 0 - ' (03: /' *+/' 0 *' - 3' +1(. 0/10　30I1*+1(/' K - . 0/&1, 61*. 0//' 34(/' 0 *' - 3' +1(. 0/12　30I1*+' 34 &(4)34+/' K 8' 39, ;

$$\#_8 = \frac{l}{b} - \&' = 881<10/+ 8' 39, \quad 30I1*+' 34;$$

R_k - - 030: ')/' 0 *' - 3' +1(. 0/10 ' 5. 4*+0K &' /+4&+' (30I1*+1(/' K 1 - 3' (')/1&' (' K - . 0/' &.

$R5, 6/' (-31 R>10 R9) *' - 3' +1(. 0/10 ' 5. 4*+0K &' /+4&+' (I/461+0. ; /' 90/; T0 *' - 3' +1(. 0/1A 30I1*+1(/' K - . 0/&1, - ' =+' 9% 1I 8' 39%. , (3.1):

$$R \approx \#_0 K_\phi . \qquad (3.2)$$

H*: ')/, 91)4//, 91). A 34*60+4 30I1*+' 3' (A(. A2+*A:

-　/' 91/4. ; /4A (0. 161/4 *' - 3' +1(. 0/1A R, R9;

-　)' - %*+19' 0 ' +&. ' /0/10 84&+160*&' K (0. 161/, *' - 3' +1(. 0/1A ' + /' 91/4. 4

$$\& \delta(\frac{\%R}{R})) ' - . \%;$$

-　9' Q/' *+; , 34**01 (4094A 30I1*+' 3' 9, P, ?+;

-　&' =881<10/+ /473%I&1 $K_/$ (($K_н \approx 0.5$ (1.0; - 31 - ' (, T0//, : +305' (4/1A: & /4)0J/' *+1 *. 0)%0+ (, 5134+; 90/; T10 I/460/1A $K_/$ 1I 30&' 90/)' (4//' 7')14-4I' /4);

-　%*. ' (1A =&*-. %4+4<11 1 : 34/0/1A: 91/194. ; /4A $G_{91/}$ 1 94&*194. ; /4A $G_{94\&*}$ +09-034+%3, ' &3%J42Q0K *30), , #; - 3') ' . J1+0. ; /' *+; =&*-. %4+4<11 t $_{345}$ 1. 1 : 34/0/1A t $_{: 34/}$ 6;

-　&' /+3%&+1(/' +0: /' . ' 7160*&10 ' 734/160/1A: 91/194. ; /')' - %*+194A T131/4 - . 0/' 6/' 7' 30I1*+' 34 $b_{91/}$ (). A +' /&' - . 0/' 6/, : 91&3' *: 09 $b_{91/}$=1009&9,). A +' . *+' - . 0/' 6/, : - $b_{91/}$=8009&9), 45*' . 2+/, 0 - ' 730T/' *+1 34I903' (&' /+%34 - . 0/' 6/' 7' =. 090/+4 $\& \delta(\%b)$ 1 $\& \delta(\%l)$ (). A +' /&' - . 0/' 6/' K +0: /' . ' 711 $\delta(\%b) \approx \delta(\%l) \approx 5$ (10мкм ,). A +' . *+' - . 0/' 6/' K – 50 -1009&9).

B31 (, 5' 30 94+0314. 4 30I1*+1(/' K - . 0/&1 30&' 90/)%0+*A *+3091+; *A & +' 9% 6+' 5, (*0 30I1*+' 3, , 34*-' . ' . J0//, 0 /4 ')/' K - . 0/' *+1 ')1/4&' (' K - ' -. ' Q4)1, 190. 1 ')1/4&' (' -' - (03: /' *+1. C4+0314. (, 51342+ (*9. - 31. . III) * +4&19 ' 30) /19 I/460/109 $\#_0$, 6+' 5, (0. 161/, $\#_8$, ' - 30)0. A09, 0). A (*0: 30I1*+' 3' (91&3' *: 09, 1I 8' 39%. , (3.2), . 0J4+ 1 (- 30)0. 4: 0.1<$\#_8$<10). A 94*' 6/, : 90+'')' ((1I7' +' (. 0/1A FHL 1 (- 30)0. 4: 0.1<$\#_8$<50). A 8' +' . 1+' 7348160*&1: 90+')' (). (. ?, *' &' ' '9/, 0 30I1*+' 3, , 91&3' *: 09, ,). A &' +' 3, : - ' . %640+*A $\#_8$>10(50) *. 0)%0+ - 3' 0&+13' (4+; (4+; ((1)0 30I1*+' 3' (*. ' J/' K 8' 39, , &' /+3%&&<1A &' +' 3, : - ' - &4I4/4 /4 31*. 3.2 (+' . *+' - . 0/' 6/, 0 30I1*+' 3, , &4& - 34(1. ', (, - ' . /A2+*A +' . ; &' - 3A9' %7' . ; /' K 8' 39,).

". A (, 534//' 7' 94+0314. 4 1I - 31. . III ' - 30)0. A2+*A :434&+031*+1&1: *30) /00 I/460/10 $\#_0$ 1)' - %*& $\& \delta(\frac{\%\#_0}{\#_0})$;)' - %*+194A %)0. ; /4A 9' Q/' *+;

34**01(4/1A p_0; *30)/00 I/460/10 $\mathcal{T}_{\#_0}$ 1)'-%*& & $\delta(\%\,)\#_0$) +09-034+%3/'7' &'=881<10/+4 *'-3'+1(.0/1A (G#L); *30)/00 I/460/10 $\overline{K}_{LG}$ $\#_0$ 1)'-%*& & $\delta(\%K_{CT}\#_0)$ &'=881<10/+4 *+430/1A.

$4*60+ 30I1*+'34 /461/42+ * '-30)0.0/1A &'=881<10/+4 8'39, -'8'39%.0 (3.2).
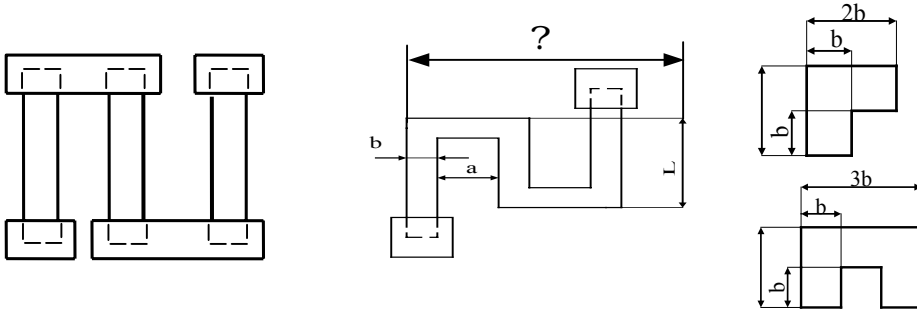
5   (

$1*.3.2. #' /*+3%&<1A 30I1*+'3' (*.' J/'K 8'39, : «I90K&4» (4), «904/)3» (5), =.090/+, *'-3AJ0/1A (() - #$_{8*}$=2,55). A F-'534I/'7' 1 #$_{8*}$=4). A B-'534I/'7' =.090/+4.

Z4+09 '-30)0.A2+)'-%*+19%2 (0.161/% *.%64K/'K *'*+4(.A2Q0K -'.A)'-%*&4 $\delta(\frac{\%R}{R})_{\Sigma_{don}}$:

$$\delta(\frac{\%R}{R})_{+_{don}} = \frac{|\delta(\frac{\%R}{R})_{don}|}{,} \left(M(\frac{\%R}{R})_{+!} \right. ; \qquad (3.3)$$

$$\delta(\frac{\%R}{R})_{+_{don}} = \frac{|\delta(\frac{\%R}{R})_{don}|}{,} \left(|M(\frac{\%R}{R})_{+(}| \right. ; \qquad (3.4)$$

7)0 , - &'=881<10/+ I4-4*4 /4 %:') -43490+3' (-'))0K*+(109 /0%6+0//, :)0*+451.1I13%2Q1: 84&+'3' (: 34)14<1A, 4+9'*803/'0)4(.0/10 1)3.; ,≈1,1~1,2;

$M(\frac{\%R}{R})_{+!}$ 1 $M(\frac{\%R}{R})_{+(}$ - 4.70534160*&10 *%99, -'.'J1+0.;/, : 1 '+31<4+0.;/, : *30)/1: I/460/1K -'730T/'*+0K *'-3'+1(.0/1A 30I1*+'34, (, I(4//, : 1I90/0/109 +09-034+%3, '&3%J42Q0K *30), 1 *+430/109 94+0314.4.

L30)/10 I/460/1A -'730T/'*+0K *'-3'+1(.0/1A '-30)0.A2+*A (, 34J0/1A91

$$M(\frac{\%R}{R})_{T_{max}} \equiv \mathcal{T}\#_0(T_{max} (T_H)100\% ; \qquad (3.5)$$

$$M(\frac{\%R}{R})_{T_{min}} \equiv \mathcal{T}\#_0(T_{min} (T_H)100\% ; \qquad (3.6)$$

$$M(\frac{\%R}{R})_{CT} = \overline{K}_{CT} \#_0 t_{rab}100\% ; \qquad (3.7)$$

7)0 G_P - +09-034+%34 /'394.;/, : &.194+160*&1: %*.'(1K (293 #).

? &460*+(0)'-%*+19'K (0.161/, $\delta(\frac{\%R}{R})_{\Sigma_{don}}$ (, 51342+ 91/194.;/'0 I/460/10 1I '-30)0.0//, : -' 8'39%.49 (3.3) 1 (3.4). V*.1 34*60+ -' =+19 8'39%.49)40+ '+31<4+0.;/'0 I/460/10 $\delta(\frac{\%R}{R})_{\Sigma_{don}}$, +' =+' 'I/4640+, 6+').A 304.1I4<11 I4)4//'K +'6/'*+1 /0'5:')19' (, 534+; 94+0314. 30I1*+1(/'K -.0/&1 * 90/;T191 G#L 1 $K_{CT\#_0}$.

"4.00'-30)0.A2+)'-%*+19%2 -'730T/'*+; &'=881<10/+4 8'39, :

$$\delta(\frac{\%K_\phi}{K_\phi})_{don} = \{[\delta(\frac{\%R}{R})_{+don}]^2 \ ([\delta(\frac{\%\#_0}{\#_0})]^2 \ ([\delta(\%K_{CT\#_0})t_{pa6}100\%]^2 \ ([\delta(\%)\#_0)\%T100\%]^2_{max}\}^{0,5},$$

7)0 $[\delta(\%)_{\#_0})\%T100\%]_{max}$ - 94&*194.;/'0 I/460/10 *.%64K/'K *'*+4(.A2Q0K '+&.'/0/1A *'-3'+1(.0/1A -31 1I90/0/11 +09-034+%3, '&3%J42Q0K *30), ; (, 51340+*A 5'.;T00 I/460/10 1I) (%: :

$| \delta(\%)_{\#_0})(T_{max} \ (\ T_H)100\% | \ 1.1 | \delta(\%)_{\#_0})(T_{min} \ (\ T_H)100\% |$

B31 $\#_8$.1 34*60+/'0 I/460/10 T131/, 30I1*+'34 b_{34*6} '-30)0.A0+*A 1I *.0)%2Q07' %3' (/A: b_{34*6})'.J/' 5, +; 5'.;T0 /415'.;T0K 1I +30: (0.161/ b_{min}, b_p, b_δ, 7)0 b_p- 91/194.;/')'-%*+19'0 I/460/10 T131/, , '-30)0.A09'0 +305' (4/109 &+'6/'*+1 &'=881<10/+4 8'39,

$$b_\delta = \frac{| \delta(\%b)|[1 \ ! \ (K_\phi)^{(2}]^{0,5}100\%}{\delta(\frac{\%K_\phi}{K_\phi})_{don}} \qquad (3.9)$$

$$b_p = (\frac{p}{p_0 K_H K_\phi})^{0,5}. \qquad (3.10)$$

R&' /64+0.;/' T131/4 30I1*+'34 (, 51340+*A 34(/'K 5.1J4KT09% & b_{34*6} 5'.;T09% <0.'9% I/460/12, &34+/'9% T47% &''3)1/4+/'K *0+&1 +'-'.'7160*&' 7' 603+0J4.

$4*60+/'0 I/460/10).1/, 30I1*+'34 -3A9'%7'.;/'K 8'39, (, 51340+*A 1I *''+/'T0/1A:

$$l_{34*6}=bK_8 \qquad (3.11)$$

".1/4 -31/1940+*A 34(/'K 5.1J4KT09% & l_{34*6} <0.'9% I/460/12, &34+/'9% T47% &''3)1/4+/'K *0+&1. ? *.%640, 0*.1 603+0J (, -'./A0+*A 50I 1*-'.;I'(4/1A &''3)1/4+/'K *0+&1, (0.161/, l_{34*6}, b_{34*6} 30I1*+'34 '&3%7.A2+*A)' I/460/1K, &34+/, : 109&9.

B'*.0 '-30)0.0/1A 34I903'(30I1*+'34 /0'5:')19' '<0/1+; -'730T/'*+;, (, I(4//%2 '&3%7.0/109 (0.161/, l_{34*6}, '-30)0.1((0.161/% $\delta(\frac{\%K_\phi}{K_\phi})$ 1I 8'39%., (3.9), -')*+4(1('&3%7.0//, 0 I/460/1A l, b. V*.1

$\delta(\frac{\%K_\phi}{K_\phi}) > \delta(\frac{\%K_\phi}{K_\phi}))'-$, +' /0'5:')19' %(0.161+; T131/% 30I1*+'34. B31 $\#_8$<1 l_{34*6} (, 51340+*A 5'.;T0 /415'.;T0K 1I +3[: (0.161/: l_{min}, l_δ, 1 l_p.

?0.161/4 l_δ '-30)0.A0+*A -' 8'39%.0

$$l_\delta = \frac{| \delta(\%l)|(1 \ ! \ K^2_\phi)^{0,5}100\%}{\delta(\%K_\phi / K_\phi)_{don}} .$$

?0. 161/4 $l_р$ ' - 30). A0+*A - ' 8' 39%. 0 $l_p = (\dfrac{pK_\phi}{\#_0 K_H})^{0,5}$.

C1/194. ;/4A). 1/4 $l_{91/}$ 30I1*+' 34 +' /&' -. 0/' 6/' K FHL)' . J/4 5, +; /0 90/00 1009&9, 91/194. ;/4A). 1/4 +' . *+' -. 0/' 6/' 7' 30I1*+' 34 − 800 9&9. \ 131/4 30I1*+' 34 - 31 1I(0*+/' K). 1/0 l_{34*6} ' - 30)0. A0+*A 1I 8' 39%. , (3.11).

C0+') 1&4 34*60+4 (, *' &' ' 9/, : 30I1*+' 3' (+1-4 «I90K&4» (*9. 31*. 3.2.,4) /0 ' +. 1640+*A ' + - 31(0)0//' K (, T0. B' *. 0 34*60+4 ' 5Q0K). 1/, l_{34*6} 30I1*+' 3)0. A+ /4 3A) *0&<1K - 3A9' %7' . ;/' K 8' 39, , 1*:') A 1I %)' 5*+(4 34I90Q0/1A 30I1*+' 34 /4 -. 4+0.

L' - 3' +1(. 0/10 30I1*+' 34 +1-4 «904/)3» (*9. 31*. 3.2.,5) ' - 30)0. A0+*A (, 34J0/109

$$R = \#_0 K_{\phi cp} = \#_0 \frac{l_{cp}}{b},$$

7)0 $\#_{8*3}$, l_{*3} − *30)/1K &' =881<10/+ 8' 39, 1 *30) /AA). 1/4 30I1*+' 34.

?0. 161/, $\#_{8*3}$, l_{*3} 1 b_{34*6} ' - 30)0. A2+*A - ' - 31(0)0//' K (, T0 90+') 1&0. Z4+09 ' - 30)0. A0+*A %9943/4A). 1/4 I(0/; 0(- 3A9' %7' . ;/' K 8' 39, , I4&. 260//, : 90J)% =. 090/+491 *' - 3AJ0/1A (*9. 31*. 3.2.,()

$$l_E = l_{cp} （ b_{расч} n K_{\phi c},$$
(3.12)

7)0 n − 61*. ' =. 090/+' (*' - 3AJ0/1A;

$\#_{8*3}$ − &' =881<10/+ 8' 39, =. 090/+4 *' - 3AJ0/1A (*9. 31*. 3.2.,();

". A 30I1*+' 34 * F-' 534I/, 91 =. 090/+491 *' - 3AJ0/1A (*9. 31*. 3.2.,() /0' 5:') 19' 0 &' . 160*+(' =. 090/+' (9' J/' ' <0/1+;). A 34I. 16/, : ' +/' T0/1K L/B 1 m = a/b

$$n = \sqrt{\frac{K_{\phi c}/}{1！m}\frac{L}{B}}.$$
(3.13)

" 3' 5/' 0 n ' &3%7. A0+*A)' 5. 1J4KT07' 61*. 4. #' 9-4&+/%2 8' 39% 1902+ 30I1*+' 3, * L/B = 0,5 − 2.

". A 30I1*+' 34 * B-' 534I/, 91 =. 090/+491 *' - 3AJ0/1A /0' 5:') 19' 0 &' . 160*+(' =. 090/+' (/4 ') 1/ 90/; T0, 609 ' - 30)0. A0+*A - ' 8' 39%. 0 (3.13).

L <0. ; 2 %*+34/0/1A (. 1A/1A -' 730T/' *+1 *' (90Q0/1A 94*' & 30I1*+' +1(/' 7' *. ' A 1 &' /+4&+' (/4 -' 730T/' *+; *' - 3' +1(. 0/1A -. 0/' 6/' 7' 30I1*+' 34 *. ' J/' K 8' 39, /0' 5:') 19', 6+5, +' &1 (:') 4 1 (, :') 4 5, . 1 /4- 34(. 0/, (') /% *+' 3' /%.

L' - 3' +1(. 0/10 30I1*+' 3' (- ' (, T0//' K +' 6/' *+1 - 31 - ') 7' /&0 1I90/A0+*A (*+' 3' /% %(0. 160/1A I4 *60+ %90/; T0/1A T131/, (*9. 31*. 3.3.,4) 1. 1 %(0. 160/1A). 1/, (*9. 31*. 3.3.,5) 30I1*+' +1(/' K -. 0/&1. L+%- 0/64+4A -') 7' /&4 ' 50*+-061(40+ '6/' *+;)' 1%, -. 4(/4−)' 0,1%.

B31 *+%- 0/64+' K -' 730T/0). 1/4 '*/' (/' 7' (/' K 64&+1 l_0 1)' -' . /1+0. ; /, : *0&<1K l_c 1 &' . 160*+(' *0&<1K n_c (, 51340+*A * 1*-' . ; I' (4/109 8' 39%.

$$l_0 = \frac{R_{\max} b}{\overline{\#_0}[1！\delta_{\frac{5}{4}}^{\frac{3}{?}}\frac{\%\#_0}{\#_0}{_0^2}/100\%]};$$
(3.14)

$$l_c = \frac{b（R_{\max}（R_{\min}）}{\overline{\#_0}[1！\delta_{\frac{5}{4}}^{\frac{3}{?}}\frac{\%\#_0}{\#_0}{_0^2}/100\%]}$$
(3.15)

$$n_c = \frac{R\min\,(\,R^*\min}{R\max\,(\,R\min}\;\frac{100\%\;!\;\delta_{\frac{3}{4}}^{\frac{5}{5}}\frac{\%\#_0}{\#_0}\frac{2}{0}}{100\%\;(\;\delta_{\frac{3}{4}}^{\frac{5}{5}}\frac{\%\#_0}{\#_0}\frac{2}{0}},\qquad (3.16)$$

7) 0

$$R\max = R_{\frac{3}{4}}^{5}1\;!\;\frac{\delta_R}{100\%}\frac{2}{0}\;;$$

$$R\min = R_{\frac{3}{4}}^{5}1\;(\;\frac{\delta_R}{100\%}\frac{2}{0}\;;$$

$$R^*\min = \frac{R\max_{\frac{3}{4}}^{5}1\;(\;\frac{\delta_{TEX}}{100\%}\frac{2}{0}}{{\frac{3}{4}}^{5}1\;!\;\frac{\delta_{TEX}}{100\%}\frac{2}{0}}\;;$$

$$\delta_R = \{[\delta_{\frac{3}{4}}^{5}\frac{\%R}{R}\frac{2}{0}]^2_{+\partial \pi}\;(\;[\delta(\%K_{cm\#0}7t_{pa\delta}100\%]^2\;(\;[\delta(\%)_{\#_0}7\%T100\%]^2\;\max\}^{0,5}\;;$$

$$\delta_{TEX} = \{[\delta_{\frac{3}{4}}^{5}\frac{\%\#_0}{\#_0}\frac{2}{0}]^2\;(\;[\delta_{\frac{3}{4}}^{5}\frac{\%K_\Phi}{K_\Phi}\frac{2}{0}]^2\}^{0,5}\;;$$

$$\delta_{\frac{3}{4}}^{5}\frac{\%K_\phi}{K_\phi}\frac{2}{0} = \frac{|\delta(\%b7|[1\;!\;(K_\phi7^{(2}]^{0,5}100\%}{b}\;,$$

b – (, 51340+*A 5' . ; T0 /415' . ; T07' 1I) (%: (0. 161/ b_{min} 1 b_p.
" 3' 5/' 0 I/460/10 n_c ' &3%7. A0+*A)' 5' . ; T07' <0. ' 7' 61*. 4. V*. 1 34*60+/' 0 I/460/10 l_c 90/; T0 l_{min}, +'). 1/4)' -'. /1+0. ; /' K *0&<11 -31/1940+*A 34(/' K l_{min}. ? =+' 9 *. %640 &' 330&+13%0+*A T131/4 30I1*+' 34 1). 1/4 ' */' (/' K *0&<11

$$b^{'} = \frac{b\,l_{min}}{l_c}\qquad (3.17)$$

$$l^{'}_{0} = \frac{l_0\,b^{'}}{b}\;.\qquad (3.18)$$

4   5
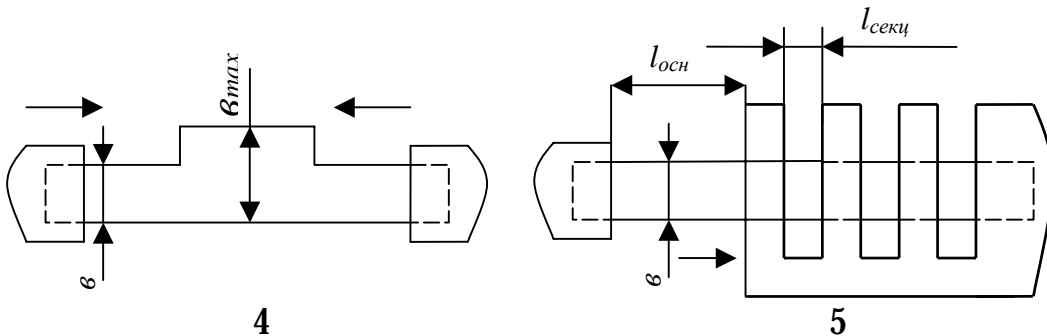
$1* . 3.3. #' /*+3%&<1A 30I1*+' 3' (-' (, T0//' K +' 6/' *+1; * -. 4(/' K (4) 1 *+%- 0/64+' K (5) -') 7' /&' K *' - 3' +1(. 0/1A. L+30. &491 -' &4I4/, 90*+4 1 /4- 34(. 0/1A - 03030I4/1A - . 0/' & - 31 -') 7' /&0.

3.1.4. . K>CBQCN> ABC?>CD<EB@N

G1-' (4A &' /*+3%&<1A -. 0/' 6/' 7' &' /)0*4+' 34 -' &4I4/4 /4 31*. 3.4. Y434&+031*+1&1 /0&' +' 3, : 94+0314. ' (-. 0/' 6/, : &' /)0*4+' 3' (-31(0)0/, (-31. .IV. " . A 1I7' +' (. 0/1A +' /&' -. 0/' 6/, : &' /)0*4+' 3' (*

09&' *+;2 10-1000 - D T13' &' 1*-'.;I%2+ 9' /' ' &1*; &309/1A; -3190/0/10
9' /' ' &1*1 70394/1A 1. 1 =.0&+3' (4&%%9/' 7' *+0&. 4 L44-I -' I('. A0+
1I7' +' (1+; &' /) 0/*4+' 3, * 09&' *+;2)' 10.000 -D. ? 91&3' *:094:,
1I7' +4(. 1(409, : -' +4/+4. ' ('K +0:/'. '711 [4] (&460*+(0) 1=. 0&+31&4
1*-'.;I%0+*A -A+1' &1*; +4/+4. 4, -'. %60//4A =.0&+3' :19160*&19
4/')13' (4/109 /1J/0K '5&. 4) &1 &' /) 0/*4+' 34; -31 =+' 9 %) 40+*A -'. %61+;
09&' *+;)' 0,1 9&D. ". A 1I7' +' (. 0/1A) 1=. 0&+3160*&1: -4*+ &' /) 0/*4+' 3' (
+'. *+' -. 0/' 6/, : FHL 1*-'.;I%2+ &0349160*&1K 94+0314. Va-2 (FRLG
5458-64) 1 8. 2* Х6 (G! 17 LDL 4275-70). ? I4(1*19' *+1 ' + 30<0-+%3,
-'. %642+ -4*+% B# 1000-30, -3190/A09%2). A 1I7' +' (. 0/1A &' /) 0/*4+' 3' (
* 09&' *+;2)' 500 -D, 4 +4&J0 -4*+% B#-12, '50*-061(42Q%2 -'. %60/10
&' /) 0/*4+' 3' (* 09&' *+;2)' 5000 -D.

V9&' *+; -. 0/' 6/' 7' &' /) 0/*4+' 34 (-1&' 8434) 4: ' -30) 0. A0+*A -'
8' 39%. 0

$$C = 0{,}0885 \frac{,S_0}{d} = C_0 S_0 \qquad (3.19)$$

7) 0 , -' +/' *1+0. ;/4A) 1=. 0&+3160*&4A -3' /1<409' *+;) 1=. 0&+31&4;
$S_0 = LB$ – – .' Q4); (I419/' 7' -030&3, +1A '5&. 4) &, *9^2;
d – +'. Q1/4) 1=. 0&+31&4, *9;
L_0 – %) 0. ;/4A 09&' *+;, -D/*9^2.

". A %90/;T0/1A -' 730T/' *+1 09&' *+1 30&' 90/) %0+*A -3' 0&+13' (4+;
&' /) 0/*4+' 3, &(4) 34+/' K 8' 39, , S_0 . 5 99^2.

H*: ') /, 91) 4//, 91). A 34*60+4 &' /) 0/*4+' 34 A(. A2+*A:
- /' 91/4. ;/4A (0. 161/4 [9&' *+1 L, - D;
-)' -%*+19' 0 ' +&. ' /0/10 84&+160*&' K (0. 161/, 09&' *+1 ' + /' 91/4. 4
&δ(%L/L),% ;
- 345' 600 /4- 3AJ0/10 U_p, ?;
- &' =881<10/+ I4-4*4 =. 0&+3160*&' K -3' 6/' *+1 #$_I$ (#$_I$ ≈ 2-10, -31
-' (, T0//, : +305' (4/1A: & /4) 0J/' *+1 *. 0) %0+ (, 5134+; 5'. ;T10
I/460/1A #$_I$ 1I 30&' 90/) ' (4//' 7') 14-4I' /4);
- %*. ' (1A =&*-. %4+4<11 1 : 34/0/1A: G_{min}, G_{max}, К, t_{345}, 1. 1 $t_{:3}$, 6;
- &' /*+3%&+1 (/' -+0: /'. '7160*&10 '734/160/1A: 30&' 90/) %09, 0
+'. Q1/,) 1=. 0&+31&4 d_{min} 1 d_{max}, 9&9 (*9. -31. . IV);
- -' 730T/' *+; (' *-3' 1I(0) 0/1A I4) 4//' K +'. Q1/,

$$\& \delta \frac{5}{4} \frac{\%d}{d} \frac{2}{1} = \&65\ (10^7\% ;$$

*%9943/4A -.' Q4); (I419/' 7' -030&3, +1A '5&. 4) ' &
&' /) 0/*4+' 3' (/4 -. 4+0 /0)' . J/4 -30(, T4+; 2 *9^2, 91/194. ;/4A -. ' Q4);
'5&. 4) ' & – 1 99^2; /1J/AA '5&. 4) &4)' . J/4 (, *+%-4+; I4 &34K (03: /0K /0
90/00 609 /4 200 9&9). A +' /' &' -. 0/' 6/, : FHL 1 /4 300 9&9). A
+'. *+' -. 0/' 6/, :,) 1=. 0&+31&)'. J0/ (, *+%-4+; I4 &34K /1J/0K '5&. 4) &1
/0 90/00 609 /4 100 9&9). A +' /' &' -. 0/' 6/, : 1 /4 200 9&9). A
+'. *+' -. 0/' 6/, : FHL.
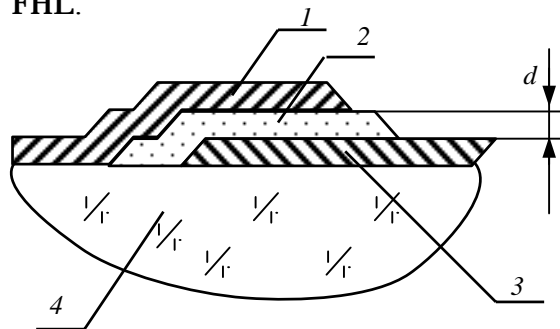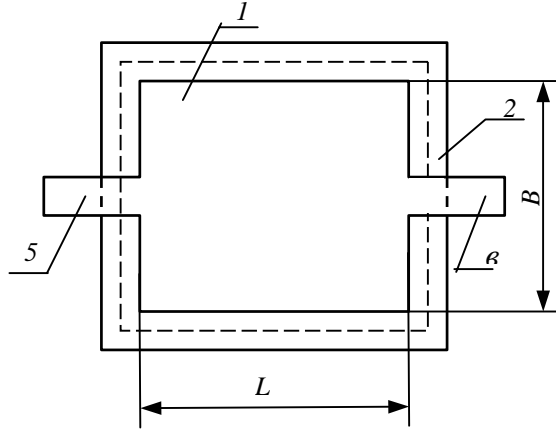
$1* 3.4. #' /*+3%&<1A -. 0/' 6/' 7' &' /) 0/*4+' 34. 1 − (03: /AA ' 5&. 4) &4,
2 −) 1=. 0&+3160*&1K *. ' K, 3 − /1J /AA ' 5&. 4) &4, 4 − -') . ' J&4,
5 1 6 − (, (') , .

". A (, 534//' 7' 94+0314. 4) 1=. 0&+31&4 -' -31.. IV ' -30) 0. A2+*A
: 434&+031*+1&1: *30) /00 I/460/10 $\overline{}$, 1) ' -%*& & $\delta\frac{\%, }{, }$; =. 0&+3160*&4A
-3' 6/' *+; V -3; +09-034+%3/, K &' =881<10/+ 09&' *+1 (G#V); *30) /00
I/460/10 $\overline{}$, 1) ' -%*& & $\delta 6\%$, 7; 1 *30) /00 I/460/10 $\overline{K}_{CT}$, 1) ' -%*&
& $\delta 6\%$, 7 &' =881<10/+4 *+430/1A.

$4*60+ &') 0/*4+' 34 /461/42+ * ' -30) 0. 0/1A) ' -%*+19' K
70' 90+3160*&' K *' *+4(. A2Q0K -' 730T/' *+1 09&' *+1 (-31 L = B)

$$\delta_{S\partial\partial o} = \delta\frac{3}{4}\frac{\%L}{L}\frac{2}{1_{\partial on}} = \delta\frac{3}{4}\frac{\%B}{B}\frac{2}{1_{\partial on}} = \{[\delta\frac{3}{4}\frac{\%C}{C}\frac{2}{1_{+\partial on}}]^8 ([\delta\frac{3}{4}\frac{\%,}{,}\frac{2}{1}]^2 ([\delta\frac{3}{4}\frac{\%d}{d}\frac{2}{1}]^2 (([\delta 6\%K_{CT,} 7 t_{pa\delta}100\%]^2 ([\delta 6\%)_, 7\%T100\%]^2_{max}\}^{0,5}, \quad (3.20)$$

7) 0 $[\delta(\%)_,)\%T9100\%]_{max}$ − 94&*194. ;/' 0 I/460/10 *.%64K/' K
*' *+4(. A2Q0K -' 730T/' *+1 -31 1I90/0/11 +09-034+%3; ; (, 51340+*A
5' . ; T00 I/460/10 1I) (%: : $|\delta(\%)_,)(T_{max} − T_/)100\%|$ 1. 1 $|\delta(\%)_,)(T_{min} −
T_/)100\%|$;

$\delta\left(\%C\middle/C\right]_{+\partial on}$ -) ' -%*+194A (0. 161/4 *.%64K/' K *' *+4(. A2Q0K -'. A
) ' -%*&4 ' -30) 0. A0+*A 4/4. ' 716/' $\delta\left(\%R\middle/R\right]_{+\partial on}$ -' 8' 39%. 49 (3.3) 1 (3.4); -31
=+' 9 /0' 5: ') 19' R I490/1+; /4 L, $\overline{)}_{\#_0}$ /4 $\overline{)}_{,}$, $\overline{K}_{CT\#_0}$ /4 $\overline{K}_{CT}$, .

$4*60+/' 0 I/460/10 +'. Q1/,) 1=. 0&+3160*&' 7' *. ' A d_{34*6} ' -30) 0. A0+*A
1I *. 0)%2Q07' %*. ' (1A: d_{34*6})'. J/' 5, +; 5'. ; T0 /415'. ; T0K 1I +30:
(0. 161/ d_{min}, d_U, d_\delta, 7) 0 d_U − 91/194. ;/') ' -%*+19' 0 I/460/10 +'. Q1/, ,
' -30) 0. A09' 0 345' 619 /4-3AJ0/109; d_\delta - 91/194. ;/') ' -%*+19' 0 I/460/10
+'. Q1/, , ' -30) 0. A09' 0) ' -%*+19' K 70' 90+3160*&' K *' *+4(. A2Q0K
-' 730T/' *+1. L) 3%7' K *+' 3' /, , d_{34*6} /0) '. J/' -30() (, T4+; d_{max}.

$$d_U = \frac{U_p K_з}{E_{np}};\qquad (3.21)$$

1-338-74). C0: 4/160*&' 0 I4&30-. 0/10 &' 9-'/0/+' ('*%Q0*+(. A0+*A -%+09
-31&. 01 (4/1A 1: & -. 4+0 1. 1 '*/' (4/12 &' 3-%*4 &. 009 /4 '*/' (0
=-'&*1)/'K *9'., >"5 (FRLG 10587-63). #'9-'/0/+, , %*+4/' ('6/4A
-' (03:/'*+; &'+'3, : 90+4.. 1I13' (4/4, 9'7‰+ -31-41 (4+;*A &
90+4.. 1I13' (4//, 9 %64*+&49 -. 4+, 1. 1 '*/' (4/12 &' 3-%*4. B31 =+'9
%Q0+(0//' %. %6T40+*A +0-.' ('K 30J19 &'9-'/0/+' (. C'/+4J
&'9-'/0/+' (-%+09 -31-4K&1 J0*+&1: (, (')'(& *''+(0+*+(%2Q19
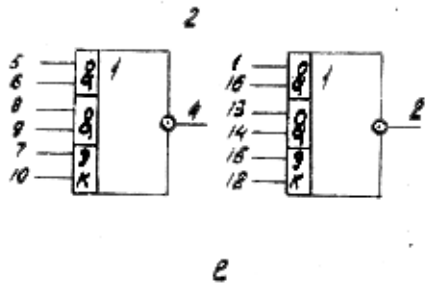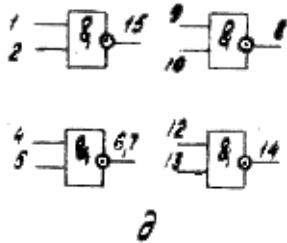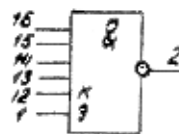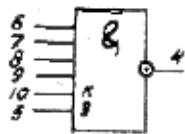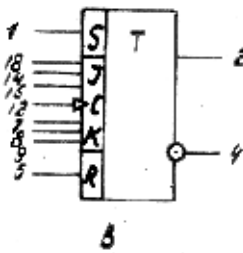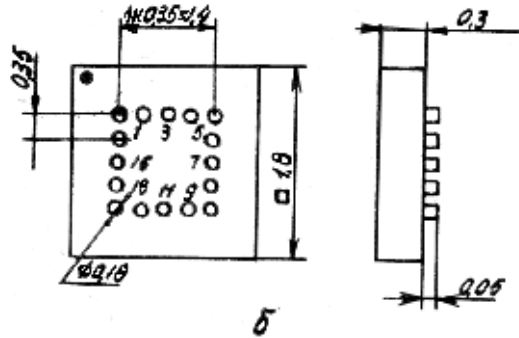-. 'Q4)&49 -. 4+, -'I('. A0+ 4(+'94+1I13' (4+; *5'3&% FHL.

3.2. 4<YGE< , " $ BE HC> [CG\ HBZ?>LDEHGL

Z4Q1+4 FHL '+ (/0T/1: ('I)0K*+(1K '*%Q0*+(. A0+*A -%+09 -'90Q0/1A
-. 4+ * =. 090/+491 1 &'9-'/0/+491 (90+4.. '*+0&. A//, 0,
90+4.. '&0349160*&10, 90+4.. '-'. 1903/, 0 1. 1 -. 4*+94**' (, 0 &' 3-%*4.

? -31.. VI -31 (0)0/, 34I903, 1 :434&+031*+1&1 90+4.. '*+0&. A//, :
&'3-%*' (FHL. B. 4+4 I4&30-. A0+*A /4 '*/' (4/11 &' 3-%*4 * -' 9'Q;2 &. 0A
/4 '*/' (0 =-'&*1)/'K *9'., >"5 1. 1 =-'&*1)/' -&30I'. ;/' 7' . 4&4 >B-91
(C$G! 6-10-530-67). B'*. 0 9' /+4J4 -. 4+, 1 &'9-'/0/+' (&3, T&4
-31 (431 (40+*A &'*/' (4/12 &' 3-%*4.
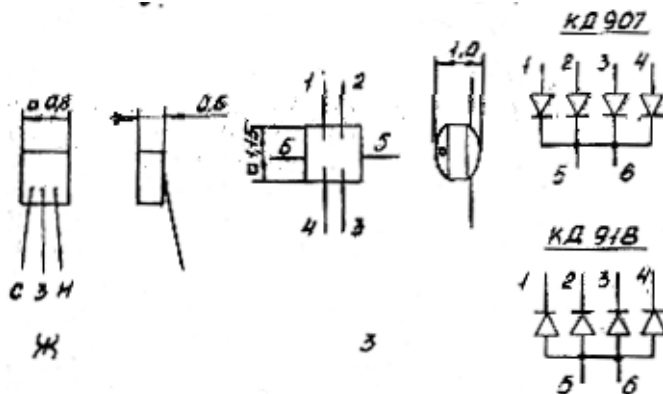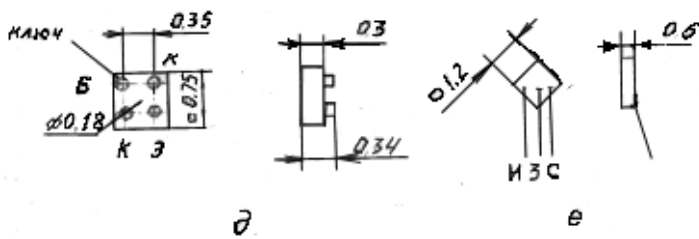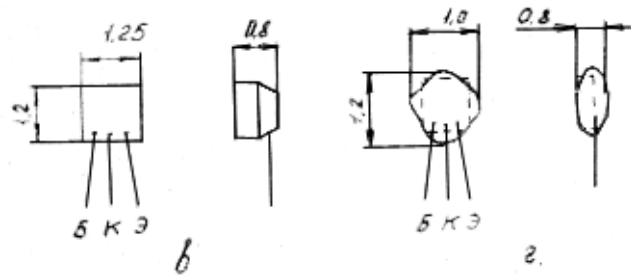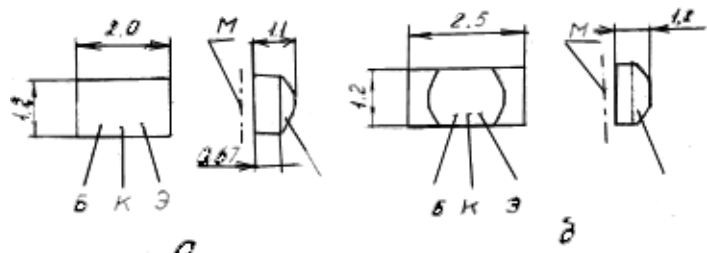
КД 907

КД 918

а

б

в

г

д

е
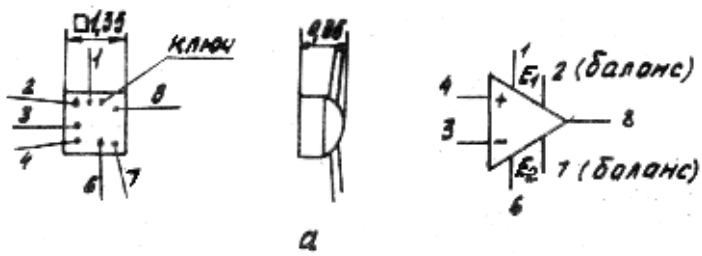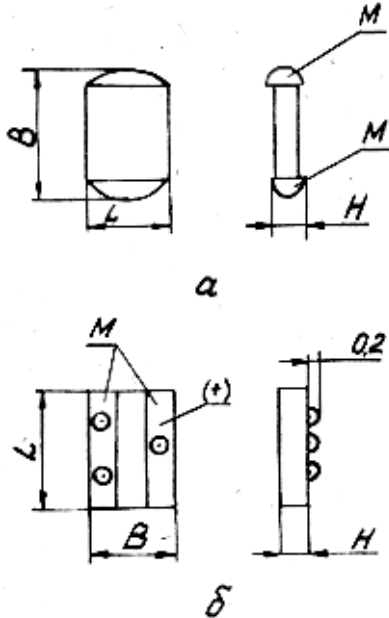
$1*. 3.6. F45431+∕, 0 603+0J1 HBL: **4** – 740! " 4 – I; **5** – HBL *0311 703
(3 – ' **5Q1K**, II – V = +5E;) . **A** HL 7G#R31 10 **1** 11 – V = +5?); (– 7G#R31;
7 – 7OER31;) – 7OER33; **0** – 7O$R31.

3.3. '<Z@<PBEA< EBMBKBRGG , " $.

3.3.1. ? - 3' <0**0 34I345' +&1 +' - '. ' 7160*&' 7' 603+0J4 (603+0J4 - . 4+,)
' - 30) 0. A0+*A (I419/' 0 34*- '. ' J0/10 1 8' 394 - . 0/' 6/, : =. 090/+' (,
34**61+, (42+*A 1: 70' 90+3160*&10 34I903, , (, 51342+*A 90*+4
34*- '. ' J0/1A /4(0*/, : - . ' Q4)' &.

$1*.3.7. F45431+/, 0 603+0J1 &' /)0/*4+' 3' (: 4 - #10-9; 5 - #53-15
(C - ' 5. %J0//, 0 &' /+4&+/, 0 - ' (03: /' *+1).

H*: ') /, 91) 4//, 91). A 34I345' +&1 A(. A2+*A +0: /160*&10 +305' (4/1A 1
&' /*+3%&+1 (/' -+0: /'. ' 7160*&10) 4//, 0 1 ' 734/160/1A. P1J0 - 31 (0) 0/4
+1-' (4A - ' *. 0) ' (4+0. ; /' *+; *. ' 0(, /4/' *19, : /4 - . 4+% :

1-K *. ' K – 30I1*+1 (/, K;

2-K *. ' K – (, (') , 30I1*+' 3' (, &' /+4&+/, 0 - . ' Q4)&1, 64*+;
- 3' (') /1&' (;

3-K *. ' K –) 1=. 0&+31& (90*+4: - 030*060/1A - 3' (') /1&' (;

4-K *. ' K – 64*+; - 3' (') /1&' (;

5-K *. ' K – /1J/10 ' 5&. 4)&1 &' /)0/*4+' 3' (1 64*+; - 3' (') /1&' (;

6-K *. ' K –) 1=. 0&+31&& &' /)0/*4+' 3' (;

7-K *. ' K – (03: /10 ' 5&. 4)&1 &' /)0/*4+' 3' (1 64*+; - 3' (') /1&' (;

8-K *. ' K – I4Q1+/, K) 1=. 0&+31&.

B31 - 3' 0&+13' (4/11 +' /&' - . 0/' 6/, : FHL %61+, (42+ ' */' (/, 0
' 734/160/1A: - 030&3, +10). A *' (90Q0/1A =. 090/+' (, 34*- '. ' J0//, : (
34I/, : *. ' A:, /0 90/00 200 9&9 - 31 94*' 6/' 9 1 /0 90/00 100 9&9 - 31
8' +'. 1+' 734811; 91/194. ; /') ' ' -%*+19, 0 34I903, &' /+4&+/, : - . ' Q4)' &
). A - 31-4K&1 400: 400 9&9,). A &' /+3' . A - 43490+3' (=. 090/+' ((200: 200
9&9 (). A 9' /+4J4 &' 9-' /0/+' ((* J0*+&191 (, (')491)' -%*&42+*A
34I903, - . ' Q4)' & 250: 250 9&9 - 31 I4I' 30 90J)% /191 100 9&9); /4(0*/, 0
&' 9-' /0/+, %*+4/4(. 1(42+ /4 34**+'A/11 /0 90/00 0.5 99 ' + - . 0/' 6/, :
&' /)0/*4+' 3' ((1)3%71: - . 0/' 6/, : =. 090/+' (, /0 I4Q1Q0//, :
) 1=. 0&+31&' 9, 1 90/00 0,6 99 ' + &' /+4&+/, : - . ' Q4)' & - 31 91/194. ; /' 9
34**+'A/11 90J)% &' 9-' /0/+491 0,3 99 ()' -%*&40+*A %*+4/4(. 1 (4+; &' 9-' /0/+, * 715&191 (, (')491 /4 - 3' (') /1&4: 1 94. ' 9' Q/, :

30I1*+'34: , I4Q1Q0//, :) 1=. 0&+31&' 9);). 1/4 -3' ('. '6/, : (, (') ' (
/4(0*/, : &' 9-'/0/+' ( )'. J/4 /4: ') 1+;*A (-30) 0. 4: 0,5-5 99,
&' 9-'/0/+, 1 -. 0/'6/, 0 =. 090/+, , & +'6/'*+1 &'+'3, : -30) SA(. AA
J0*+&10 +305' (4/1A, 34*-'. 4742+*A /4 34**+'A/11 /0 90/00 0,7 99 '+ &34A
-'). 'J&1, '*+4. ;/, 0 =. 090/+, - /4 34**+'A/11 /0 90/00 0,5 99;
91/194. ;/')'-%*+19'0 34**+'A/10 90J)% -. 0/'6/, 91 =. 090/+491, ((+'9
61*. 0 &'/+4&+/, 91 -. 'Q4)&491) – 0,299; 91/194. ;/4A T131/4 -. 0/'6/, :
-3' (') /1&' (*'*+4(. A0+ 100 9&9 -31 94*'6/'9 1 50 9&9 –
8'+'. 1+'7348160*&' 9 90+')4: ; 34**+'A/10 '+ 734/1<,) 1=. 0&+31&4)'
&'/+4&+/'K -. 'Q4)&1 – /0 90/00 0,5 99.

B31 -3'0&+13'(4/11 +'. *+'-. 0/'6/, : FHL %61+, (42+ *. 0)%2Q10
'734/160/1A: 91/194. ;/'0 34**+'A/10 '+ &34A -. 4+,)' -. 0/'6/'7'
=. 090/+4 – 0,1 99, '+ &34A -. 4+,)' '+(03*+1K -') (/0T/10 (, ('), – 0,5
99, 90J)% -. 0/'6/, 91 =. 090/+491 – 0,2 99; 91/194. ;/4A T131/4
-. 0/'6/, : -3' (') /1&' (– 0,2 99 -31 /4/0*0/11 -4*+, /4 -'). 'J&% 1 0,3
99 -31 /4/0*0/11 -4*+, /4) 1=. 0&+3160*&1K *. 'K; 91/194. ;/, 0 34I903,
&'/+4&+/, : -. 'Q4)'& – 0,3:0,4 99; 34I903, &'/+4&+/, : -. 'Q4)'&). A
9'/+4J4 &'/)0/*4+'3' (* J0*+&191 (, (')491)'. J/, /4 0,2 99
-30(, T4+; 34I903, &'/+4&+' (&'/)0/*4+'3' (; 91/194. ;/'0 -030&3, +10
=. 090/+' ((34I/, : *. 'A: – 0,1 99; 91/194. ;/, K 34I903 '+(03*+1A (
90J*. 'K/'K 1I'. A<11). A *'0) 1/0/1A) (%: %3' (/0K 90+4. . 1I4<11 – 0,6 99;
'*+4. ;/, 0 '734/160/1A 4/4. '716/, +09, 6+' -31(0) 0/,). A
+'/&' -. 0/'6/'K +0: /'. '711.

?,) 0. 0//4A /4 =. 0&+3160*&' K *: 090 64*+; %*+3' K*+(4 304. 1I%0+*A ((1) 0
50*&' 3-%*/' K HBL (34I903 &31*+4. . 4 1:1 99), &'/*+3%&<1A &'+'3' K
4/4. '716/4 &'/*+3%&<11 -'. %-3' (') /1&' (, : -315'3' (1 HBL, '-1*4//, :
(3.1.6.

3.3.2. $4I345'+&4 +'-'. '711 (, -'. /A0+*A (/0*&' . ;&' =+4-' (. P4 -03(' 9
=+4-0 -3' (') 1+*A -30' 534I' (4/10 =. 0&+3160*&' K *: 09, , 1I &'/*+3%&<1K
1*&. 2642+*A &' 9-'/0/+, : (, ('), -'*. 0) /1: I490/A2+*A &'/+4&+/, 91
-. 'Q4)&491. L: 094 -03060361(40+*A +4&19 '534I' 9, 6+' 5, %90/; T1+;
61*. ' -030*060/1K -3' (') /1&' (1 *'&34+1+; 1:). 1/%. B030345'+4//4A
-31/<1-14. ;/4A *: 094 -30)*+4 (. 0/4 /4 31*%/&0 &' 99%+4<1' //' K *: 09, .

P4 (+'3' 9 =+4-0 (, 51342+*A 94+0314. , , 8'394 -. 0/'6/, : =. 090/+' (1
34**61+, (42+*A 1: 34I903, -' 90+') 1&49 3.1.

P4 *. 0) %2Q09 =+4-0 -30) 0. A0+*A '310/+13' (' 6/4A -. 'Q4); -. 4+,

$$S_n = K_{H\Pi}\left(\sum_{i=1}^{n_R} S_{Ri} + \sum_{i=1}^{n_c} S_{Ci} + \sum_{i=1}^{n_k} S_{Ki} + \sum_{i=1}^{n_H} S_{Hi}\right),$$

7) 0 K_1 = 2-3 - &' =881<10/+ 1*-'. ;I' (4/1A -. 'Q4) 1 -. 4+, ;
S_{Ri}, n_R -. 'Q4); i-7' 30I1*+'34 1 &'. 160*+(' 30I1*+'3' (;
S_{Ci}, n_C -. 'Q4); i-7' &'/)0/*4+'34 1 &'. 160*+(' &'/)0/*4+'3' (;
S_{Ki}, $n_#$ -. 'Q4); i-K &'/+4&+/'K -. 'Q4)&1 1 1: &'. 160*+(';
S_{Hi}, n_H - %*+4/' (' 6/4A -. 'Q4); i-7' /4(0*/'7' &'/*+3%&+4,
%*+4/4(. 1(409' 7' /4 *('5')/'K '*/' (4/11 1 =. 090/+' ((-' (03: /'*+1 -. 4+, , 1 1:
&'. 160*+(' .

H*-'. ;I%A 30I%. ;+4+ '<0/&1 /0' 5:') 19' K -. 'Q4) 1 -. 4+, , (, 51342+
34I903, -. 4+, 1 &'3-%* FHL (-31. . VI).

L. 0) %2Q19 =+4-' 9 34I345'+&1 +'-'. '711 A (. A0+*A 34I90Q0/10
-. 0/'6/, : =. 090/+' ((/4 -. 4+0 1 -3' & . 4)&4)&4 *'0) 1/0/1K; /, : -3' (') /1&' (.

L. 0)%0+ - 3' 0&+13' (4+; =. 090/+, /415'. 00 - 3' *+' K 8' 39, ; - 31) 4/10 =. 090/+49 8' 39, *' *+' AQ1: 1I '+30I&' (- 3A9, :, /0 - 434.. 0. ; /, : '*A9 &' ' 3) 1/4+ (%7'. /4&. ' /4)'. J0/ 5, +; &34+/, 9 15^0),)' -%*+19' . 1T; (+0: *. %64A:, &' 7) 4 =+' - 31 (') 1+ & I/461+0. ; /' 9% %- 3' Q0/12 +' - '. '711 1 %90/; T0/12 34I903' (- . 4+, .

?, 60361 (4/10 =*&1I4 - . 4+, 30&' 90/) %0+*A - 3' (') 1+; /4 91.. 190+3' ('K 5%9470 (94*T+454: %(0. 160/1A, &34+/, :. 10 (10:1, 20:1 1 +.).).

3.3.3. P4 - '*. 0) /09 =+4- 0 &' /*+3%13' (4/1A FHL 34I3454+, (40+*A =*&1I &' /*+3%&<11 91&3' *: 09, , '+34J42Q1K 34*- '. ' J0/10 - . 4+, 1 /4(0*/, : &' 9- ' /0/+' ((&' 3-%*0, 4 +4&J0 - 3' (') 1+*A ' <0/&4 - 434I1+/, : *(AI0K [1,7] +0- . ' (, : 30J19' (=. 090/+' (1 &' 9- ' /0/+' (1 34*60+ - 3' 0&+/' K /4) 0J /' *+1 [I].

3.4. %>MKBHBL @>XGS , " $

3.4.1. B31 34I345'+&0 &' /*+3%&<11 FHL 5'. ; T' 0 (/194/10 %) 0. A0+*A '50*- 060/12 /' 394. ; /' 7' +0- . ' (' 7' 30J194 =. 090/+' (1 &' 9- ' /0/+' (, +4& &4& ' + 1: +09- 034+%3, *%Q0*+(0// I4(1*1+ /4) 0J /' *+; 91&3' *: 09. ". A %90/; T0/1A +09- 034+%3, =. 090/+' (1 &' 9- ' /0/+' (30&' 90/) %0+*A: (, 5134+; /0(, *' &10 I/460/1A (10-20 &?+/99^2) %) 0. ; /' K 34**01 (409' K 9' Q/' *+1 P_0; - 3190/A+; - ') . ' J&1 * (, *' &' K +0- . ' - 3' (') /' *+; 2; '*%Q0*+(. A+; : '3' T1K +0- . ' ('K &' /+4&+ &' 9- ' /0/+' ((* - '). ' J&' K (%90/; T0/10 +'. Q1/, *. 'A &. 0A, - 31- 4K&4 &' 9- ' /0/+' (& 90+4.. 1I13' (4//, 9 %64*+&49 - . 4+, 1. 1 & '*/' (4/12 &' 3-%*4); 34(/' 903/' 34*- 30) 0. A+; - ' - '). ' J&0 1*+' 6/1&1 +0- . 4; 6%(*+(1+0. ; /, 0 & +09- 034+%30 =. 090/+, 1 &' 9- ' /0/+, 34*- '. 474+; I4 - 30) 0. 491 I' / +0- . ' (' 7' (. 1A/1A 1*+' 6/1&' (* - ' (, T0//, 9 +0- . ' (,) 0. 0/109.

3.4.2. R<0/&% +0- . ' (' 7' 30J194 FHL (90+4.. '*+0&. A//' 9 &' 3-%*0 9' J/' '*%Q0*+(1+;, 1*- '. ; I%A 90+') 1&% [I].

G09- 034+%34 i-7' =. 090/+4 (&' 9- ' /0/+4) ' - 30) 0. A0+*A (, 34J0/109

$$T_i = T_c \ ! \ \because_k \ ! \ \sum_{j=1}^{n} \because_{ji},$$ (3.24)

7) 0 G* - +09- 034+%34 ' &3%J42Q0K *30) , ;

:& - - 030730(&' 3-%*4 ' +/' *1+0. ; /' G* (I4(1*1+ '+ *- '*' *54 9' /+4J4 FHL (4- - 434+%3% 1 *' '+(4 (. A0+ ' 5, 6/' 5-10 #);

:ji - *' '+(4 (. A2Q4A - 030730(i-7' =. 090/+4 (- 03(, K 1/) 0&* - /' 903 1*+' 6/1&4 +0- . 4, (+' 3' K - - 3109/1&4 +0- . 4; - 030730(:ii, '5%*. ' (. 0//, K 9' Q/' *+; 2, 34**01 (409' K i-9 =. 090/+' 9, /4I, (42+ *' 5*+(0//, 9).

". A - '. %-3' (') /1&' (, : - 315'3' (1 HBL ' - 30) 0. A0+*A +4&J0 +09- 034+%34 3-n- - 030: ')' (

$$T_{BHi} = T_i \ ! \ \because_{BHi},$$ (3.25)

7) 0 $\because_{BHi} = P_i R_T b_{Hi}$ - (/%+30//1K - 030730(i-7' &' 9- ' /0/+4, 34**01 (42Q07' 9' Q/' *+; P_i;

$R_T b_{Hi}$ - (/%+30//00 +0- . ' ('0 *' - 3' +1(. 0/10 &' 9- ' /0/+4

(- 31.. V), %61+, (42Q00 *- '*' 5 07' I4&30- . 0/1A () . A &31*+4.. 4 34I3454+, (409' K 50*&' 3-%*/' K HBL R_{TBH}= 1#/9?+, 94&*194. ; /4A +09- 034+%34 3- - - - 030: ')' (- 418#).

L' 5*+(0//, K - 030730(=. 090/+4 (&' 9- ' /0/+4) ' - 30) 0. A0+*A (, 34J0/109

$$\therefore_{ii} = P_i R_{Ti\max} <(r,q) = \frac{P_i l <(r,q)}{;S_i}, \qquad (3.26)$$

7) 0 R_{Timax} – 94&*194. ; / ' 0 +0-. ' (' 0 *' - 3' +1 (. 0/10 *i*–7' =. 090/+4;
; - +0-. ' - 3' (') / ' *+; - ') . ' J&1;
S_i – - . ' Q4) ; *i*–7' =. 090/+4;

$l = h_n \ ! \ \dfrac{\dot{;}_{hk}}{\dot{;}_k}$ - =&(1 (4. 0/+/4A +'. Q1/4 - ') . ' J&1 (- 31 $\dfrac{\dot{;}_k}{;}$ =0.1-1.0 1

$\dfrac{h_k}{h_n}$ =0.1-0.3);

;& – +0-. ' - 3' (') / ' *+; &. 0A, I4&30-. A2Q07' - . 4+% (&' 3-%*0
(; &≈0.3?+/9.#);
h_n, h_k – +'. Q1/4 - . 4+, 1 *. ' A &. 0A, *' ' +(0+*+(0//' (h_k≈0,1 99);
<(r,q) – 8%/&<1A, I4(1*AQ4A '+ +/' *1+0. ; /, : 34I903' (=. 090/+4

$$< = \frac{\%_1}{2l}; q = \frac{\%_2}{2l};$$

$\%_1$, $\%_2$ – 34I903, *i*–7' =. 090/+4;
F3481& 8%/&<11 <(r,q) -'&4I4/ /4 31*. 3.8. (8%/&<1A *1990+316/4
'+/' *1+0. ; /' < 1 q).
D' / ' (, K -030730(, '5%*. ' (. 0//, K +0-. ' (, 91 - '+'&491 *' *0) /1:
=. 090/+' ((&' 9- ' /0/+' (), ' - 30) 0. A0+*A (, 34J0/109

$$\therefore_{ji} = \frac{P_i l}{4 ;S_i}[<(r_1,q_1) \ ! \ sign(q_2)sign(<_2)<(|\,r_2\,|,|\,q_2\,|) \ ! \ sign(q_2)<(r_1,|\,q_2\,|) \ !$$

$$+ sign(r_2)<(q_1,|\,r_2\,|)]; \qquad (3.27)$$

7) 0 $q_1 = \dfrac{\%_1}{2l} \ ! \ |\,\dfrac{x_0}{l}\,|, \qquad q_2 = \dfrac{\%_1}{2l} \ (\ |\,\dfrac{x_0}{l}\,|;$

$r_1 = \dfrac{\%_2}{2l} \ ! \ |\,\dfrac{y_0}{l}\,|, \qquad r_2 = \dfrac{\%_2}{2l} \ (\ |\,\dfrac{y_0}{l}\,|;$

$\%_1$, $\%_2$ – 34I903, *j*–7' =. 090/+4 (1*+' 6/1&4 +0-. 4);
x_0, y_0 – &' ' 3) 1/4+, *i*–7' =. 090/+4 (-3109/1&4 +0-. 4) '+/' *1+0. ; /'
<0/+34 *j*–7' =. 090/+4 (&' ' 3) 1/4+, ' - 30) 0. A2+*A)' 5. 1J4KT0K & <0/+3% *j*-
7' =. 090/+4 +' 6&1 *i*–7' =. 090/+4);
sign a= +1   - 31 4>0;
sign a= -1   - 31 4<0;
sign a= 0   - 31 a = 0.
Z/460/1A 8%/&<1K (8' 39%. 0 (3.27) ' - 30) 0. A2+*A 1I 31*. 3.8.
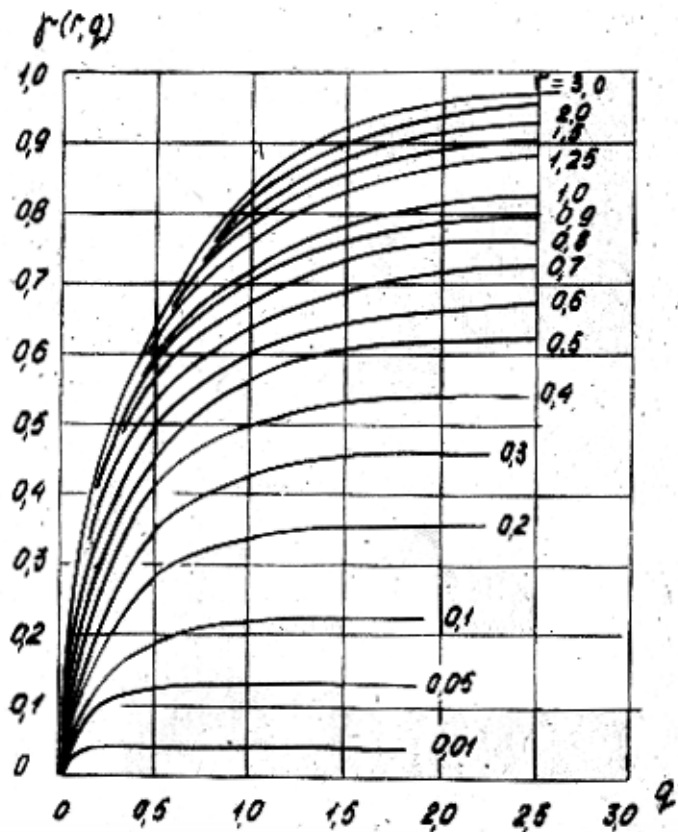
$1*. 3.8. F3481& 8%/&<11 = (r,q).

B31 -3' (0) 0/11 '<0/&1 +0-.' ('7' 30J194 =.090/+' (1 &' 9-'/0/+' (
FHL 9' J/' /0 %61+, (4+; -030730(&' 3-%*4 '+/' *1+0. ;/' '&3%J42Q0K
*30), :&; -31 /0' 5:') 19' *+1 9' J/' 34**61+4+;, 1*-'.;I%A 90+') 1&% [8].

$4**61+4//, 0 (0.161/, +09-034+%3, =.090/+' (1 &' 9-'/0/+' (
*34(/1(42+*A *)'-%*+19, 91. "'-%*+19, 0 345'610 +09-034+%3,).A
&' 9-'/0/+' (-31(0)0/, (-31.. V,).A -.0/'6/, : &' /)0/*4+'3' ((-31..
IV. ".A -.0/'6/, : 30I1*+'3' (94&*194.;/4A)'-%*+194A +09-034+%34
*' *+4(.A0+ 423#. V*.1 34*60+/4A +09-034+%34 -30(, T40+)'-%*+19%2,
/0' 5:') 19' -030345'+4+; &' /*+3%&<12 FHL * %60+' 9 30&' 90/)4<1K 3.4.1.

".A 34*60+4 +0-.' ('7' 30J194 FHL 9' J/' 1*-'.;I' (4+; *+4/)43+/%2
-3' 73499% @G$HL-1 [9].

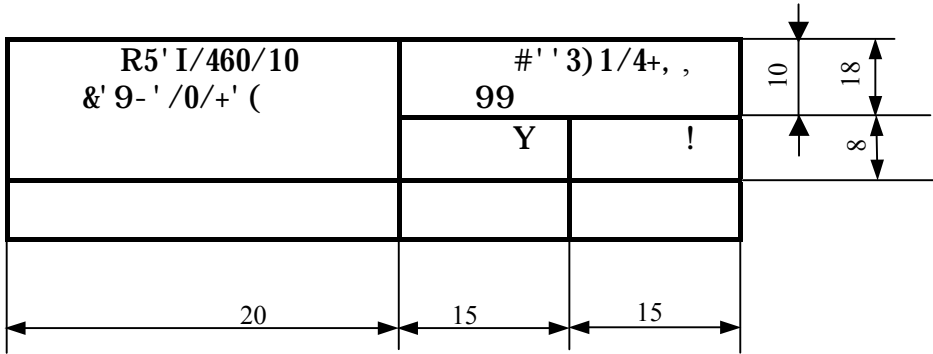### 3.5. . @<HGK< B=B@SK>CGI ABCDE@FAEB@DABL ?BAFS>CE<UGG C< ‚ " $.

? '*/' (/'K &' 9-.0&+ &' /*+3%&+' 3*&' K)' &%90/+4<11 /4 FHL (:') A+:
*-0<181&4<1A, *5'3'6/, K 603+0J FHL, *:094 =.0&3160*&4A
-31/<1-14. ;/4A, +0: /160*&10 %*.' (1A (1.1 -'A*/1+0.;/4A I4-1*&4),
+'-'.'7160*&1K 603+0J -.4+, .

L-0<181&4<1A *'*+4(.A0+*A (*''+(0+*+(11 * FRLG 2.108-68 .

L5'3'6/, K 603+0J FHL '8'39.A0+*A -' '5Q19 -34(1.49,
%*+4/'(.0//, 9 FRLG 2.109-69, 1)'.J0/ *')03J4+;)'-+4+'6/'0 61*.'
(1)' (, -3'0&<1K, *060/1K 1 34I30I' ( ).A +'7, 6+'5, -'&4I4+; (I419/'0
34*-'.'J0/10 (*0: *'*+4(/(/, : 64*+0K FHL 1 *-'*'5, 1: I4&30-.0/1A. ?
+'0 /160*&1 +305' (4/1A:, -31(')19, : /4 603+0J0,)'.J/, *'')03J4+;*A
*(0)0/1A ' *5'3&0, '34*&0, 943&13' (&0 1I)0.1A 1 **, .&1 /4)' &%90/+, ,
307.490/+13%2Q10 :434&+031*+1&1 FHL 1 *-'-'*, 1: 1I9030/1A. P4 -'.0

21

603+0J4 -'90Q42+ +45.1<% * %&4I4/109 &''3)1/4+ 90*+ %*+4/' (&1
&'9-'/0/+' ((.0(, K /1J/1K %7' . &'9-'/0/+4), 8'394 &'+'3'K -'&4I4/4 /4
31*. 3.9 ()' -%*&40+*A -'730T/'*+; %*+4/' (&1 0,1 − 0,5 99).

L:094 =.0&+3160*&4A -31/<1-14. ;/4A (, -'./A0+*A (*''+(0+*+(11 *
FRLG 2.701-76, 2.702-75, 2.708-72. P4 *:090 1I'534J42+*A ((1)0 %*.' (/, :
7348160*&1: '5'I/460/1K =.090/+, , &'9-'/0/+, , -3'(')/1&1 1
&'/+4&+/, 0 -.'Q4)&1. P%9034<1A &'/+4&+/, : -.'Q4)'&)'.J/4
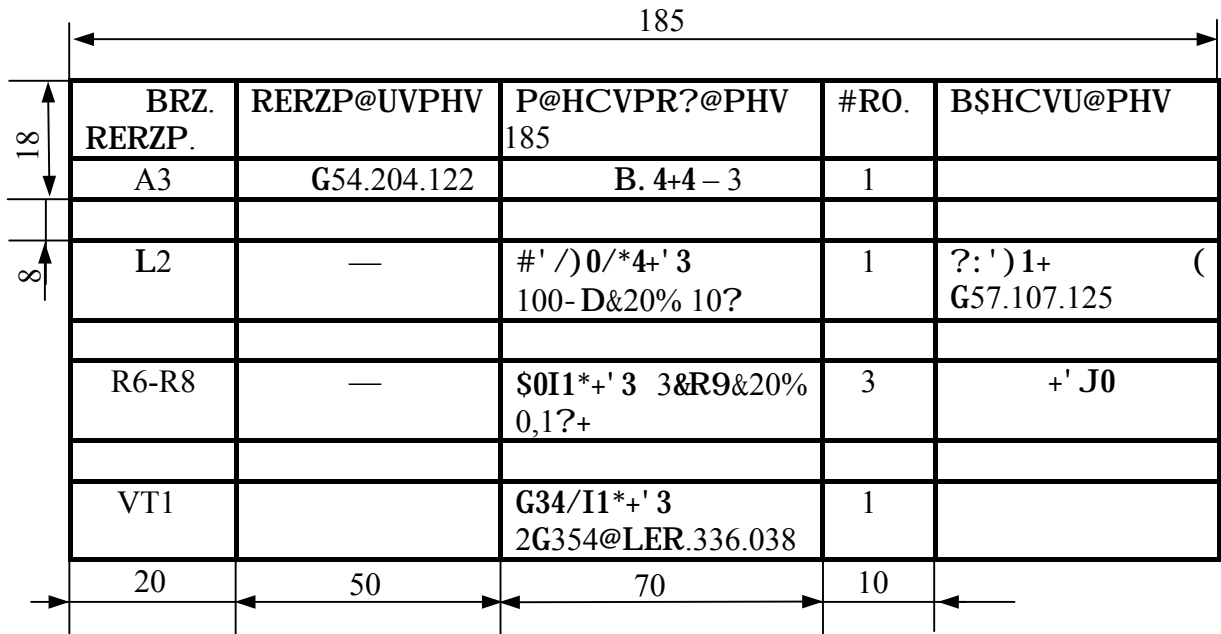*''+(0+*+(' (4+; -31/A+'K /4 +'-'.'7160*&'9 603+0J0.

#4J)'9% =.090/+% *:09, -31*(41(40+*A 5%&(0//'-<183'('0
-'I1<1'//'0 '5'I/460/10. B'*.0)'(4+0. ;/'*+; -31*('0/1A -'3A)&'(, :
/'903'(-'I1<1'//, 9 '5'I/460/1A9)'.J/4 *''+(0+*+(' (4+;
-'*.0)'(4+0. ;/'*+1 34*-'.'J0/1A %*.' (/, : 7348160*&1: '5'I/460/1K
=.090/+'(/4 *:090, *61+4A *(03:% (/1I (/4-34(.0/11 *.0(4 /4-34((' . ?*0
=.090/+, 1 &'9-'/0/+, (/'*A+*A (-03060/; =.090/+'(, 34*-'.'.47409, K /4
-'.0 *:09, 1 (, -'./A09, K -' 8'390, -31(0)0//'K /4 31*. 3.10.
B'*.0)'(4+0. ;/'*+; I4-1*1 (-03060/; '-30)0.A0+*A FRLG 2.702-72. ".A
=.090/+'(73484 "R5'I/460/10" -3'603&1(40+*A, (7348% "P4190/'(4/10"
(-1*, (42+ /4190/'(4/10 =.090/+4, /'91/4. '*/'(/'7' -43490+34 1
)'-%*&, 94&*194. ;/%2 9'Q/'*+; 34**0A/1A ().A 30I1*+'+'()' 1.1
94&*194. ;/'0 345'600 /4-3AJ0/10 ().A &'/)0/*4+'3'((). ? 7348%
"B319064/10" *.0)%0+ (-1*, (4+; '5'I/460/10 603+0J4 -.4+, , (&'+'3%2
(:')1+)4//, K =.090/+. ".A &'9-'/0/+' ((7348% "P4190/'(4/10"
(-1*, (42+ /4190/'(4/10 &'9-'/0/+4 1 '5'I/460/10 *+4/)43+4 1.1
+0:/160*&1: %*.' (1K /4)4//, K &'9-'/0/+. V*.1 &'9-'/0/+ -3190/A0+*A
-' *-0<181&4<11 1.1 603+0J% (/4-31903, *%5-.4+4 * &'9-.0&+'9
')/'+1-/, : -.0.'/6/, : : =.090/+'((), +' (73480 "R5'I/460/10" I4-1*, (42+
'5'I/460/10 '*/'(/'7' &'/*+3%&+1(/'7')'&%90/+4 /4)4//, K &'9-'/0/+.

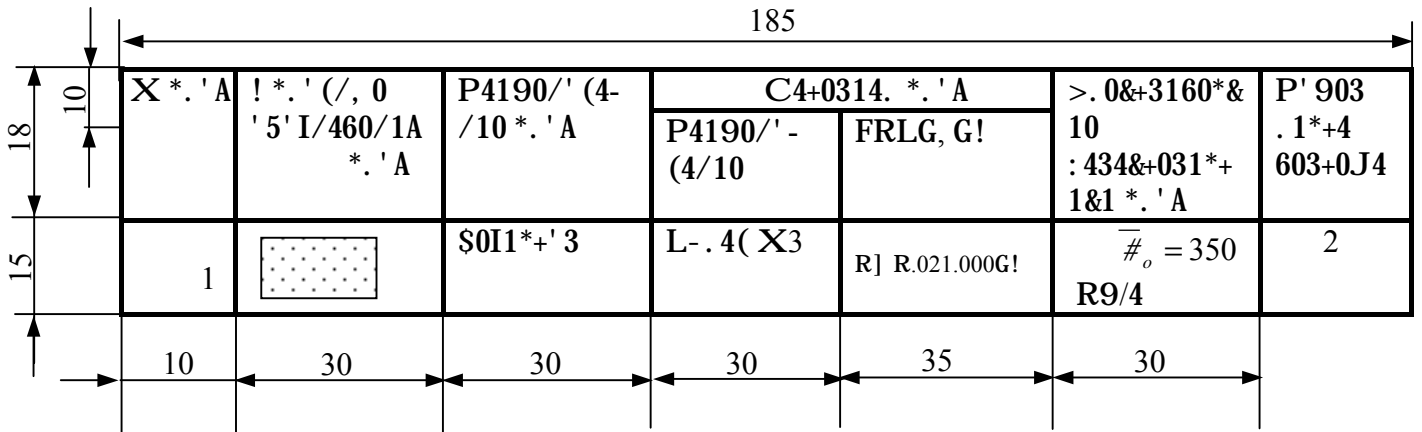| R5'I/460/10 &'9-'/0/+'(	#''3)1/4+, , 99		10	18
	Y	!		8

20 | 15 | 15

$1*. 3.9. D'394 +45.1<, &''3)1/4+ %*+4/' (&1 &'9-'/0/+'(.

G'-'.'7160*&1K 603+0J -.4+, , (, -'./A0+*A (*''+(0+*+(11 * FRLG
2.417-68 (94*T+454:, &34+/, :)0*A+1, +.0. 10:1, 20:1 1 +.). U03+0J%
-31*(41(40+*A /4190/'(4/10 "B.4+4" 1 '5'I/460/10 *)0*A+16/'K
:434&+031*+1&'K 7.100 1.1 7.107 (*''+(0+*+(11 * [10]. ? 73480 3 '*/'(/'K
/4)-1*1 %&4I, (40+*A 94+0314. -').'.J&1 1.1 '5'I/460/10 603+0J4
I47'.'(&1 (&1 ()0*A+16/4A :434&+031*+1&4 7.810). G'-'.'7160*&1K 603+0J
.0)%0+, &4& -34(1.', (, -'./A+; /4 /0&'. ;&1: .1*+4:. P4 -03('9 .1*+0
1I'534J40+*A -.4+4 *' (*091 /4/0*0//, 91 /4 /00 *.'A91 1 '5'I/460/10
-'I1<1'//, :, : '5'I/460/1K =.090/+'((, /4 -'*.0)%2Q1: .1*+4: -'90Q40+*A
1I'534J0/10 &4J)'7' *.'A. P4 &4J)'), K *. ;K /4 -03('9 603+0J4
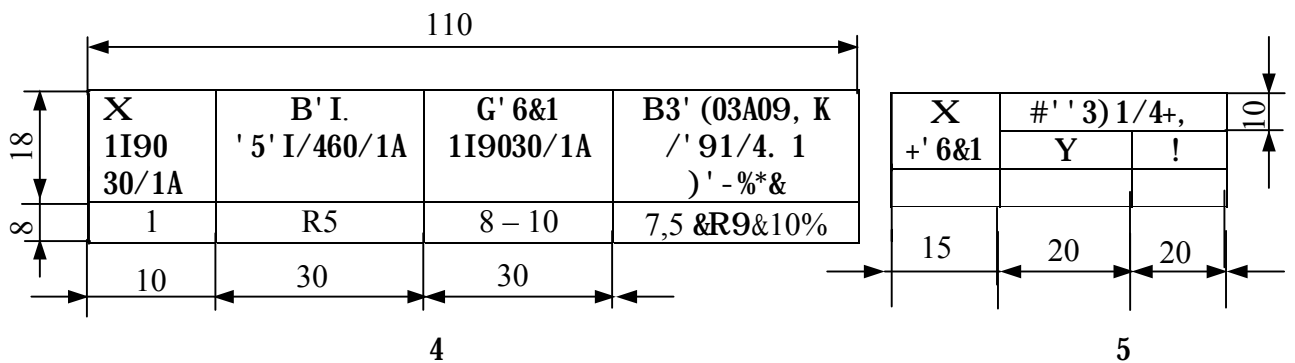/4/4/'*A+ T+31:' (&% (%*.' (/'0 '5'I/460/10 *. ;A). ?1) T+31:' (&1

34*T183'(, (40+*A (+45. 1<0, 8'394 &'+'3'K -'&4I4/4 /4 31*. 3.11. P4
1I'534J0/11 &'/+4&+/, : -.'Q4)'& /4 -03('9 .1*+0)'.J/, 5, +;
-3'*+4(.0/, 1: /'9034. P%9034<1A (/0T/1: &'/+4&+/, : -.'Q4)'&)'.J/4
''+(0++(' (4+; /%9034<11 (, (')'(&'3-%*4. L''+(0+*+(10)'.J/'
*':34/A+*A 1 (+'9 *.%640, &'7)4 1*-'.;I%2+*A /0 (*0 (, ('), &'3-%*4.
P%9034<1A (/%+30//1: &'/+4&+/, : -.'Q4)'& *.%J4Q1:).A -')&260/1A
(, (')'(&'9-'/0+'(1).A &'/+3'.A =.090/+'(,)'.J/4 A(.A+;*A
-3')'.J0/109 /%9034<11 (/0T/1: -.'Q4)'&; -'3A)'& /%9034<11 − */1I%
((03: (/4-34(.0/11 *.0(4 /4-34('), 0*.1 -03(4A -.'Q4)&4 34*-'.'J0/4 (
.0('9 /1J/09 %7.%-.4+,.

BRZ. RERZP.	RERZP@UVPHV	P@HCVPR?@PHV 185	#RO.	B$HCVU@PHV
A3	G54.204.122	B. 4+4 – 3	1	
L2	—	#' /) 0/*4+' 3 100- D&20% 10?	1	?: ') 1+ (G57.107.125
R6-R8	—	$0I1*+' 3 3&R9&20% 0,1?+	3	+' J0
VT1		G34/I1*+' 3 2G354@LER.336.038	1	
20	50	70	10	

$1*. 3.10 D' 394 - 0306/A =. 090/+' (.

185

X *. ' A	! *. ' (/, 0 ' 5' I/460/1A *. ' A	P4190/' (4- /10 *. ' A	C4+0314. *. ' A		>. 0&+3160*& 10 : 434&+031*+ 1&1 *. ' A	P' 903 . 1*+4 603+0J4
			P4190/' - (4/10	FRLG, G!		
1		$0I1*+' 3	L- . 4(X3	R] R.021.000G!	$\overline{\#}_o = 350$ R9/4	2
10	30	30	30	35	30	

$1*. 3.11 D' 394 +45. 1<,   : 434&+031*+1& *. ' 0(.

110

X 1I90 30/1A	B' I. ' 5' I/460/1A	G' 6&1 1I9030/1A	B3' (03A09, K /' 91/4. 1)' - %*&
1	R5	8 – 10	7,5 &R9&10%
10	30	30	

4

X +' 6&1	#' ' 3) 1/4+,	
	Y	!
15	20	20

5

$1*. 3.12 D' 394 +45. 1<: 4 – =. 0&+3160*&10 - 43490+3, =. 090/+' (,
5 – &' ' 3) 1/4+,   (03T1/ =. 090/+' (.

1 "%&' 0%9' 0

1. V39'.40(M.B., B'/'943[(C.D., #32&'(M.F. #'/*+3%&<11 1 +0:/'.'71A 91&3'*:09. – C.: L'(. $4)1', 1980. – 256 *.

2. V819'(H.V., F'35%/'(M.H., #'I, 3; H.W. C1&3'=.0&+3'/1&4. D1I160*&10 1 +0:/'.'7160*&10 '*/'(, , /4)0J/'*+;. – C.: ?, *T. T&'.4, 1977. – 416 *.

3. V819'(H.V., F'35%/'(M.H., #'I, 3; H.W. C1&3'=.0&+3'/1&4. B3'0&+13'(4/10, (1), 91&3'*:09, /'(, 0 /4-34(.0/1A. – C.: ?, *T. T&'.4, 1978. – 312 *.

4. U03/A0(?.P. G0:/'.'71A -3'1I(')*+(4 1/+0734.;/, : 91&3'*:09. – C.: >/0371A, 1977. – 376 *.

5. B'-'(?.B. C0+')160*&10 %&4I4/1A & 34*60+/'-7348160*&19 345'+49 -'&'/*+3%13'(4/12 91&3'*:09. – G474/3'7: G$GH, 1973. – 77 *.

6. LGB–500! –74. L+4/)43+ -30)-31A+1A. R5Q10 +0:/160*&10 1 &'/*+3%&+1(/, 0 +305'(4/1A & 5.'&49 34)1'=.0&+3'//'K 4--434+%3, . – G474/3'7: G$GH, 1974. – 11 *.

7. C0:4/<0(V.E. $4*60+74.;(4/160*&1: 1 09&'*+/, : *(AI0K (*1*+094: *-.'*&191 =.0&+3')491. ! 605/'0 -'*'510. – G474/3'7: G$GH, 1977. – 40 *.

8. C0:4/<0(V.E. R*/'(, 4/4.1I4 +0-.'(, : 30J19'($>@. O0&<11 -' &%3*% "G0'30+160*&10 '*/'(, &'/*+3%13'(4/1A 1 /4)0J/'*+1 $>@". – G474/3'7: G$GH, 1976. – 54 *.

9. B3'734994 4/4.1I4 +0-.'('7 30J194 1/+0734.;/, : *:09 /4 >?C C6000 – "@G$HL - 1". H/*+3%&<1A -'-'.;I'(4/12. - G474/3'7: G$GH, 1981. – 6 *.

10. C0J)%(0)'9*+(0//4A /'394.;. L1*+094 603+0J/'7' :'IAK*+(4, 64*+;; 4. R5'I/460/10 &'/*+3%&+'3*&1:)'&%90/+'(. P0.000.005.

Y4348&+031*+1&4 94+0314.4	L+0&' L48-3, PBR.027.600	L1+4.. LG50-1, RLGIIBR. 094.022-72	C4+0314.		
			#03491&4 22YL, 4WR.027. 002G!	#03491&4 7. 4I%3' (4//4A ⟍ HR.781 001G!	#03491&4 /4 '*/'(0 '&1*1 5031.1A «E3' &031+-3» PGYR.027. 023
#.4**61*+', -'(03:/'*+1	14	13 – 14	12	14	12
G09-034+%3/, K &'=881<10/+ .1/0K/'7'34*T130/1A)910, I/#	4,8	5,0	6,0	7,6	6,1
G0-.'-3'(')/'*+; .;?+(9.#)	0,84 – 1,34	1,43	8,40	1,05 – 1,47	210,00
R+/'*1+0.;/4A)1=.0&+3160*&4A -3'/1<409'*+; /464*+'+01CF<	3,7 – 8,0	8,5	10,3	13,0 – 16,0	6,3
G4/70/* %7.4)1=.0&+3160*&1: -'+03; /4 64*+'+0 1 CF< $tg\,\delta^9 10^4$	15	20	6	20	3 – 6
>.0&+3160*&4A 9'Q/'*+;, &?/99	40	40	50	50	50
!)0.;/'0*'-3'+1(.0/10,R9.*9	10^{17}	10^{15}	10^{14}	10^{14}	10^{15}
G09-034+%34 34I9A760/1A, #	1020	990	1870	1870	1870

C4+0314. ,	G' . Q1/4 *. 'A, /9	!) 0. ; / ' 0 - ' (03: / ' *+/ ' 0 *' - 3' +1 (. 0/10, RC/4	L- ' *' 5 &' /+4&+13' (4/1A * - 3' (' . ' 6/, 91 - 3' (') /1&491
B') *. ' K – /1:3' 9 Y20P80, FRLG 12766-67 L. ' K – 4. 291/1K @99, FRLG 11069-74	10 – 30 300 – 600	0,08 – 0,16	B4K&4, *(43&4
B') *. ' K – /1:3' 9 Y20P80, FRLG 12766-67 L. ' K – 4. 291/1K @99, FRLG 11069-74 B' &3, +10 – /1&0. ; , C$G! 14-14-46-65	40 – 50 250 – 370 50	0,1 – 0,2	B4K&4, *(43&4
B') *. ' K - /1:3' 9 Y20P80, FRLG 12766-67 L. ' K – 90) ; C?, G! 11W0 0.21.040-72 B' &3, +10 – /1&0. ; , C$G! 14-14-46-65	10 – 30 600 – 800 80 – 120	0,02 – 0,04	L(43&4
B') *. ' K - /1:3' 9 Y20P80, FRLG 12766-67 L. ' K – 90) ; C?, G! 11W0 0.21.040-72 B' &3, +10 –I' . ' +' Z. 999,9, FRLG 6835-72	10 – 30 600 – 800 50 – 60	0,02 – 0,04	B4K&4, *(43&4
B') *. ' K – /1:3' 9 Y20P80, FRLG 12766-67 L. ' K – I' . ' +' Z. 999,9, FRLG 6835-72	10 – 30 600 – 800	0,03 – 0,04	B4K&4, *(43&4
B4*+4 BB-1	(10 – 20) 10^3	0,02 – 0,05	B4K&4
B4*+4 BB-2	(15 – 20) 10^3	2,00 – 5,00	B4K&4
B4*+4 BB-3	(15 – 25) 10^3	0,02 – 0,05	B4K&4
B4*+4 BB-4	(15 – 25) 10^3	0,02 – 0,05	B4K&4

C4+0314. 30- I1*+1(/'7 *.'A	C4+0314., &'/+4&+/,: -.'Q4)'&	B'(03:/'*+/'0 *'-3'+1(.0/10 L30)/00 I/460-/10 #_0, R9/4	"'-%*& $\&\delta\left\{\dfrac{5\%\#_0}{4}\right\}^2$ $_{,\%}$	C48*194.;/')'-%*+194A %)0.;/4A 9'Q/'*+; 34**0A/1A $_0, C?+/99^2	G#L (1/+03(4.0 +09-034+%3 213-398 # L30)/00 I/460/10 $\top_{\#_0}$ ^{9}10^{(4}, 1/#	"'-%*& 10^{-4} 1/#, $\&\delta\left(\dot{0\%}\right)_{\#_0}$ ⌐	#'=881<10/+ *+430/1A L30)/00 I/460/10 $\overline{K}_{CT\#_0}$ ^{9}10^{-5}, 1/6	"'-%*& $\&\delta(\%K_{CT\#_0})^9$ 10^{-5}, 1/6
G4/+4. G?U, $>G! 1244-67	P1:3'9- 4.291/1K, /1:3'9- 4.291/1K- /1&0.;	1-100	&3	30	-1,0	&0,5	1,0	&0,1
P1:3'9 Y20P80 FRLG 12766-67	P1:3'9- 90);-/1&0.;, /1:3'9-90);- I'.'+'	300	&5	20	0	&1,0	1,2	&0,1
L-.4(X3, R] R.021. 000G!	P1:3'9- I'.'+'	350	&5	10	+0,4	&0,2	0	&0,5
#0390+ #-50L, VGR.021. 033G!	P1:3'9- 90);-I'.'+', /1:3'9- I'.'+', /1:3'9-90);- /1&0.;	3000 5000 10000	&7	20	+3,0 -4,0 -5,0	&1	0	&1,0
B4*+4 B$	B4*+, BB-1, BB-3	5,100,500, 1000, 3000, 6000, 20000, 50000	&10	30	+8	&2,0	0	&3,0

!0%&''01*.1&#);#*:7)#-&#$0%)')(,"$

C4+0314.)1=.0&+31-60*&'7'A *.'A	C4+031-4.'5&.4-)'&	§0&'90/-)%09,0+'.Q1/,)1=.0&+-31&49&9 d,	R+/'*1+0.;/4A)1=.0&160*&4A-3'/1<409'*+; L30)/00I/460/10 "'-%*& &$\delta_3\frac{5\%}{4},\frac{0}{1}$ %	>.0&31 60*&4A-3'6-/1*+; $E_{np},910^6,$ В/см	C4&-*1-94.;-/4A 64*-+'+4 $f_{max},$ CF<	G4/70/*%7.4)1-=.0&+31:60*&1-'+03; tg δ	G#V (4.0+09-034+%3) L30)/00I/4-60/10 $),\frac{9}{10^{-4}},1/#$	1/+03-034+%3 "'-%*& $\delta(\%),\frac{9}{10^{-4}},1/#$	#'=881<10/+*+430/1A L30)-/00I/460-/10 $K_{Ct},\frac{9}{10^5},1/6$	"'-%*& $\delta(\%K_{CT},)\frac{9}{10^5},1/6$	"14-4-I'/345'-61:+09--034+%3,#
C'/''&1*; &309/1A, FRLG 5634-70	@.291-/1K		5,5	&3	2,0	500	0,01-0,02	2,0	&0,5	0	&4	213-398
C''/''&1*; 70394/1A, FRLG 19602-74		0,3 – 4	11	&4	1,0	300	0,005 – 0,007	3,0	&0,5	-1	+0,1	213-358
L+0&.' =.0&+3'- (48%%9/'0 L44-1, RLG 11 BR.094. 022-73		0,1 – 0,5	5,1	&1	3,0		0,002 – 0,003	1,2	&0,6	0	&3	213-398
BA+1'&1*; +4/+4.4	G4/+4.-/1J/AA, 4.291-/1K-	0,1-0,4	22	&4	2,0	0,1	0,02	3	&1	0	&5	213-398

30

.'"1) W & # " & 5

3 & $ 7) ' . 9 $ # * & 7) ! .) # & # % * , " $

%<PKGU< 5.1

.BKFM@BHB?CGABHN> M@GPB@N G SGA@BD\>SN

P4190/' (4/10	R5'I/460/10	C4**4, 97, /0 5'.00	C4&*194.;/4A 34**01 (4094A 9'Q/'*+; 9?+,-31 +09-034+%30 293#	?/%+30//00 +0-.'('0 *'-3'+1(.0/10, #/9?+	C4&*194.;/4A +09-034+%34 p-n--030:')'(, #	"14-4I'/ 345'61: +09-034+%3, #	F45431+/, K 603+0J (31*).
E1-'.A3/, K +34/I1*+'3, n-p-n	2G 625-2, W53.365.022-G!	15	1000	0,05*	408	213 – 358	3.5, 4
G' J0	#GL 395, 4@R.336.067-G!	50	300	0,10*	423	213 – 358	3.5, 5
E1-'.A3/, K +34/I1*+'3, p-n-p	#GL 394, @@R.336.067-G!	50	300	0,10*	423	213 – 358	3.5, 5
G' J0	2G 360, ^ GR.335.059-G!	3	10	7,00	393	233 – 358	3.5, (
E1-'.A3/, K +34/I1*+'3, n-p-n	2G 354, LER.336.038-G!	3	30	1,70	423	213 – 398	3.5, 7
G' J0	#G 379, 4@R.036.030-G!	10	25	1,50	373	233 - 358	3.5,)

	(03: /AA '5& . 4) &4	20 – 80	0,6	200 450	+4 &6	300 10	0,035	0	&10	&0	&5	213–358
B#1000-30	BB-1,											
B#-12	BB-3- /1J /AA, BB-2- (03: /AA '5& . 4) &4											

.@B?BKX>CG> E<PKGUN 5.1

P4190/'(4/10	R5'I/460/10	C4**4, 97, /05'.00	C4&*194.;/4A 34**01(4094A 9'Q/'*+; 9?+, -31 +09- -034+%30 293#	?/%+30//00 +0-.'('0 *'-3'+1(.0/10, #/9?+	C4&*194.;/4A +09-034+%34 p-n--030:')'(, #	"14-4I'/ 345'61: +09-034+%3, #	F45431+/, K 603+0J (31*)
E1-'.A3/, K +34/I1*+'3, p-n-p	#G 380, 4@R.036.028G!	10	25	1,50	373	233 - 358	3.5,)
B'.0('K +34/I1*+'3 n-&4/4.	2B201 GDZ.365.006G!	5	60	1,75	408	213 - 358	3.5, 0
B'.0('K +34/I1*+'3 p-&4/4.	2BL202 GDR.336.010G!	2	30	3,00	418	213 − 398	3.5, J
"1')/4A 94+31<4 * '5Q19 &4+')'9	#"907@-F, SZ.362.036G!	10	30	2,00	378	213 − 358	3.5, I
G'J0*'5Q19 4/')'9	#"918@-F, SZ.362.022G!	10	30	2,00	378	213 − 358	3.5, I
HBL, '-034<1'//, K %*1.1+0.;	740!"4-1, 5#R.347.021G!	10	85	0,40	408	213 − 373	3.6, 4
HBL, JK- +317703	7G#R31, ^ HZ.410.017G!	5	90	0,25	423	213 − 398	3.6, (
HBL, 2=.090/+4 «H-PV»	7OER31, ^ BZ.402.036G!	5	30	0,25	423	213 - 398	3.6, 7

) ABCQ<CG> E<PKGUN 5.1

P4190/'(4/10	R5'I/460/10	C4**4,97, /05'.00	C4&*194.;/4A 34**01(4094A 9'Q/'*+; 97+,-31 +09- -034+%30 293#	?/%+30//00 +0-.'('0 *'-3'+1(.0/10, #/9?+	C4&*194.;/4A +09-034+%34 p-n-030:')'(, #	"14-4I'/ 345'61: +09-034+%3, #	F45431+/,K 603+0J (31*)
HBL, =.090/+4 «2H-PV»	7OE.033, ^ HZ.402.047G!	5	60	0,25	423	213 – 398	3.6, 0
HBL, =.090/+ «2-2H-2HOH-PV»	7OS031, ^ HZ.402.046G!	5	40	0,25	423	213 – 398	3.6, 0

* --31 - 4K80 &31*+4..4 &90+4..1I13'(4//'K -'(03:/'*+1

33

%<PKGU< 5.2
7BC?>CD<EB@N
(?G<M<ZBC @<PBQG\ E>SM>@<EF@ BE 213 ?B 350 7)

P4190/' (4/10, '5'I/460/10	" 14- 4I' / 09&' *+0K, 9&D	$4I903, , 99			C4**4, 7, /0 5'. 00	F45431+/, K 603+0J (31*.)
		L	B	H		
#' /)0/*4+' 3 &0349160*&1K	0,00003-0,001			1,2	0,1	
#10-9,	0,00022-0,1	4,4	5		0,5	3.7, **4**
R] R.460.068G! (U_p = 15 ?)	0,00091-0,47	8,5	10	3,0	1,5	
#' /)0/*4+' 3 '&*1) /' - '. %-	1,5; 2,2	5,5	4,5		0,25	
-3' (') /1&' (, K #53-15,	3,3; 4,7			2,3	0,65	3.7, **5**
R] R.464.121G! (U_p = 16 ?)	6,8; 10,0	10,5			1,5	

. @GKBX>CG> 6
7) ' . 9 $ 0 " ' 0 4 ! & ' * . 1 0 % , " $
: 0 ' 0 7 % & ' " $ % " 7 " 7) ' . 9 $) (

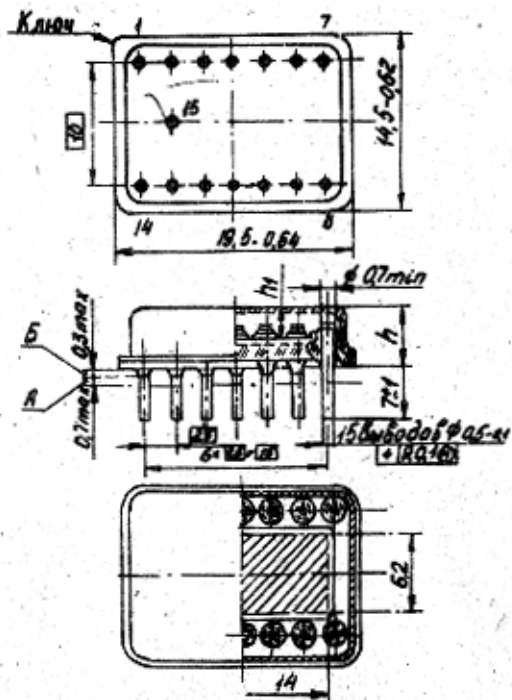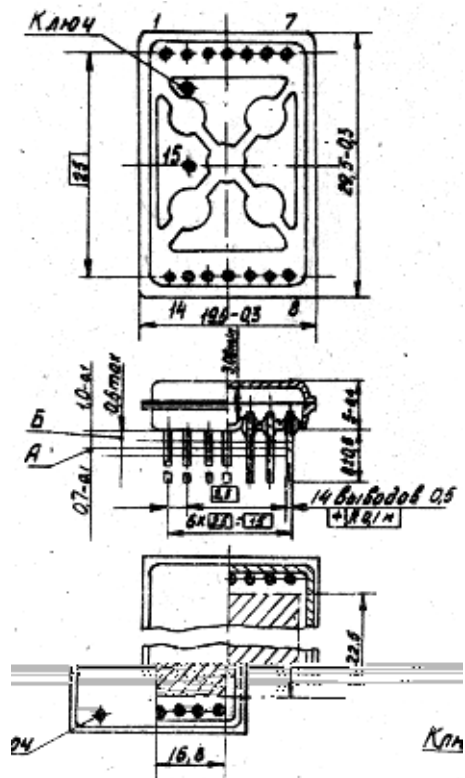| R5'I/460/10	#'. 1- 60*+(' (, ('-)' (	$4I903, -. 4+, 99		$4I903, &' 3- %*4, 99		C4**4, 7, /0 5' - . 00	C4&*1- 94. ; /4A 34**01- (4094A 9' Q/' *+;, ?+
		4	b, /0 5'. 00	h $_{94\&*}$	h$_1$ $_{91/}$		
151.15-4, ^ HR.487.008G!	15	6&0,1	14&0,1	5,0	3,0	2,43	3,3
151.15-6, ^ HR.487.008G!	15	6&0,1	14&0,1	3,2	1,3	2,43	3,1
155.15-1, FFR.487.003G!	15	22&0,2	16&0,3		3,08	6,5	2

Рис. VI.1. Корпус 151.15—4 (151.15—6)

Рис. VI.2. Корпус 155.15—1

35

. ' " ! & ' ' 0 4 ' 0 3) % 7 " 7) # $ % ' 9 7 / " " , " $
$4**9'+319 &34+&' '*/'(/, 0 ('-3' *, 34*60+4 1 34I345'+&1
+' - ' . ' 711 FHL /4 - 319030 - 3' 0&+13' (4/1A &' 9-434+' 34, *: 094 &' +' 3' 7'
- ' &4I4/4 /4 31*. 7.1. ($T_{макс} = 358К, T_{мин} = 233К, t_{раб.} = 1000$ ч). >. 090/+, ,
(,) 0. 0// , 0 -%/&+13/' K . 1/10K, 304. 1I%2+*A ((1) 0 50*&' 3-%*/' K HBL,
'5' I/46409' K &4&@1. ? +45. . c(0)0/, -43490+3, 30I1*+' 3' (&' 9-434+' 34.

<div align="center">В43490+3, 30I1*+' 3' (</div>

В43490+3	R1	R2	R3	R4	R5	R6	R7	R8	R9
R, &R9	10	2,7	2	2,7	3,6	10	0,6	0,4	2,4
$\delta\left(\dfrac{\%R}{R}\right)_{доп}$,%	10	30	30	30	20	10	2,3	10	20
$, 9?+	3,77	3,33	7,41	0,83	0,003	0,06	15	10	6,67

" . A &' /) 0/*4+' 34 L = 100 - D &20%; U_p = 0,1 ?. " . A +34/I1*+' 3' (VT1;
VT2; 9' Q/' *+; 34**01(4/1A 34(/4 1,13 1 1,28 9?+ *' ' +(0+*+(0//' ;) . A VT3
(2G354@) − 2,37 9?+.

? &460*+(0 94+0314. 4 30I1*+' 3' (FHL (, 513409 *-. 4(X3 (-31. .3), -31
=+' 9 (0. 161/, $K_ф$, ' -30) 0. 0//, 0 1I 8' 39%. , (3.2), . 0J4+ (-30) 0. 4: 1,143
− 28,571. В3' (0)09 34*60+) . A 30I1*+' 34 R9 -31 $в_{мин}$ = 100 9&9, $\delta\%б7$ = 10
9&9. В' 8' 39%. 0 (3.2) ' -30) 0. 19 $K_ф = \dfrac{2,4}{0,35} = 6,857$.

HI 8' 39%. (3.5) - (3.7)

$$M\left(\frac{\%R}{R}\right)_{Тммак} = 0,4·10^{(4}(358 (293)·100\% = 0,26\%;$$

$$M\left(\frac{\%R}{R}\right)_{Тмми} = 0,4·10^{(4}(233 (293)·100\% = (0,24\%;$$

$$M\left(\frac{\%R}{R}\right)_{СТ} = 0·1000·100\% = 0;$$

$$M\left(\frac{\%R}{R}\right)_{+'} = 0,26\%; \quad M\left(\frac{\%R}{R}\right)_{+(} = (0,24\%$$

В' 8' 39%. 0 (3.3) -31 >= 1,15 ' -30) 0. 19

$$\delta\left(\frac{\%R}{R}\right)_{+доп} = \frac{20}{1,15} (0,26 = 17,13\% .$$

В' 8' 39%. 0 (3.8) ' -30) 0. 19

$$\delta\left(\frac{\%K_ф}{K_ф}\right)_{доп} = \left\{ ?17,13]^2 ([5]^2 ([0,5·10^{(5}·10^3·100]^2 ([0,2·10^{(4}(358 (293)·100]^2 \right\}^{0,5} = 16,38\%$$

$1*. 7.1. L: 094 =. 0&+3160*&4A - 31/<1- 14. ; /4A &' 9- 434+' 34

H*- ' . ; I%A 8' 39%. , (3.9) 1 (3.10), - ' . %619 ($К_н = 0,8$)

$$в_\delta = \frac{10\left[1 ! \dfrac{5}{4}\dfrac{1}{6,857}\dfrac{2}{1}0\right]^{0,5} ?100}{16,38} = 62 мкм .$$

$$в_р = \dfrac{5}{4}\dfrac{6,67}{10?0,8?6,857}\dfrac{2}{1}0^{0,5} = 0,112 мм = 122 мкм .$$

?, 513409 $в_{расч} = 130 мкм$.

В' 8' 39%. 0 (3.11) - ' . %619

$$l_{расч} = 130?6,857 = 891 мкм \approx 890 мкм .$$

@/4. ' 716/' 34**61+, (42+*А 30I1*+' 3, R5 1 R8.

$4**61+409 (, *' &' ' 9/, К 30I1*+' 3 R1, *- 3' 0&+13' (4(07' (8' 390 «904/) 34» (*9. 31*. 3.2, 5). R- 30)0. 19 - ' 8' 39%. 49 (3.2) 1 (3.11) $в_{расч} = 150$ 9&9, $l_{ср} = 150?28,571 = 4285,65 мкм$.

В' 8' 39%. 0 (3.13) 34**61+409 61*. ' =. 090/+' (*' - 3АJ0/1А

$$n = \sqrt{\frac{28,571}{1 ! 1}}0,5 = 2,7 \approx 3 .$$

" . А В-' 534I/, : =. 090/+' ($n = 3$ (1= 2 .

В' 8' 39%. 0 (3.12)

$$l_+ = 4285,65 (150?2?4 = 3085,65 мкм .$$

G' 7)4). 1/4 &4J)' 7' 1I +30: - 3А9' . 1/0К/, : %64*+&' (30I1*+' 34 34(/4 3085,65 : 3 = 1028,55 \approx 1030 9&9.

@/4. ' 716/' 34**61+, (40+*А 30I1*+' 3 R6.

$4**61+409 30I1*+' 3 -' (, Т0//' К +' 6/' *+1 R7 * %60+' 9 *+%- 0/64+' К -')7' /&1 (*9. 31*. 3.3, 5).

В' 8' 39%. 0 (3.2) ' - 30)0. 19

$$К_ф = \frac{600}{350} = 1,714 .$$

R- 30)0. А09 - ' 8' 39%. 0 (3.3)

$$\delta\frac{5}{4}\frac{\%R}{R}\frac{2}{1_{+доп}}0 = \frac{2,3}{1,15} (0,26 = 1,74\% .$$

В' 8' 39%. 0 (3.9) - ' . %619

$$\delta\!\left(\frac{\% K_\phi}{K_\phi}\right)_{\!\!don} = \left\{ [1,74]^2 \cdot [5]^2 \cdot [0,5 \cdot 10^{(5} \cdot 10^3 \cdot 100]^2 \cdot [0,2 \cdot 10^{(4}(358 \cdot 293) \cdot 100]^2 \right\}^{0,5} = \sqrt{(22,24.}$$

Для того чтобы определить номинальное сопротивление термометра, воспользуемся выражением.

Выражение (3.10)

$$\varepsilon_p = \left(\frac{15}{10 \cdot 0,8 \cdot 1,714}\right)^{0,5} = 1,046 \, мм = 1046 \, мкм .$$

Принимаем $\varepsilon = 1050$ мкм.

Выражения (3.14) и (3.15) определим

$$\delta\!\left(\frac{\% K_\phi}{K_\phi}\right) = \frac{10\left[1 + \left(\frac{1}{1,714}\right)^2\right]^{0,5} \cdot 100}{1050} = 1,10\%;$$

$$\delta_{mex} = [(5)^2 + (1,10)^2]^{0,5} = 5,12\%;$$

$$\delta_R = \left\{ [1,74]^2 \cdot [0,5 \cdot 10^{(5} \cdot 1000 \cdot 100]^2 \cdot [0,2 \cdot 10^{(4}(358 \cdot 293) \cdot 100]^2 \right\}^{0,5} = 1,66\%;$$

$$R_{макс} = 600\left(1 + \frac{1,66}{100}\right) = 609,96 \; Ом;$$

$$R_{мин} = 600\left(1 - \frac{1,66}{100}\right) = 509,04 \; Ом;$$

$$R^*_{мин} = \frac{609,96\left(1 - \frac{5,12}{100}\right)}{\left(1 + \frac{5,12}{100}\right)} = 550,54 \; Ом;$$

$$l_C = \frac{(609,96 - 590,04) \cdot 1050}{350\left(1 + \frac{5}{100}\right)} = 56,9 \; мкм;$$

$$l_O = \frac{609,96 \cdot 1050}{350\left(1 + \frac{5}{100}\right)} = 1742,7 \; мкм.$$

Для того чтобы выполнялось условие $l_C < l_{мин}$, принимаем значение

$l_C = l_{мин} = 100$ мкм.

Число витков обмотки и ее длину определим по выражениям

(3.17) и (3.18)

$$\varepsilon' = \frac{100 \cdot 1050}{56.9} = 1845 \approx 1850 \; мкм;$$

$$l'_O = \frac{1742,7 \cdot 1850}{1050} = 3070,4 \approx 3070 \; мкм.$$

Проверим условие $П_L$ (3.16)

$$П_C = \frac{590,04 - 550,54}{609,96 - 590,04} \cdot \frac{100 + 5}{100 - 5} = 2,19 .$$

?, 513409 $\Pi_C = 3$.

$4**61+409 \&' /) 0/*4+'3 C1. ? \&460*+(0) 1=. 0\&+31\&4 (, 513409

9' /' ' \&1*; \&309/1A (*9. -31. . 4). B31/19409 $K_3 = 8$, $\delta\left(\dfrac{\%d}{d}\right) = 10\%$.

B' 8' 39%. 49 (3.3) – (3.7)

$$M\left(\frac{\%C}{C}\right)_{T_{макс}} = 2 \vartheta 10^{(4}(358 (293) \vartheta 100 = 1{,}3\%;$$

$$M\left(\frac{\%C}{C}\right)_{T_{мин}} = 2 \vartheta 10^{(4}(358 (293) \vartheta 100 = 1{,}2\%;$$

$$M\left(\frac{\%C}{C}\right)_{CT} = 0;$$

$$\delta\left(\frac{\%C}{C}\right)_{+\partial on} = \frac{20}{1{,}15} (1{,}3 = 16{,}09\%.$$

B' 8' 39%. 0 (3.20) ' - 30) 0. 19

$$\delta_{s\partial\partial o} = \left\{ [16{,}09]^2 ([3]^2 ([10]^2 ([4 \vartheta 10^{(5} \vartheta 1000 \vartheta 100]^2 ([0{,}5 \vartheta 10^{(4} \vartheta (358 (293) \vartheta 100]^2 \right\}^{0{,}5} = 11{,}57\%.$$

H*-' . ; I%A 8' 39%. , (3.21) 1 (3.22), -' .%619

$$d_U = \frac{0{,}1 \vartheta 8}{2 \vartheta 10^6} = 4 \vartheta 10^{(7} \text{ см} = 0{,}004 \text{ 9\&9};$$

$$d_\delta = \frac{0{,}354 \vartheta 5{,}5 \vartheta (10 \vartheta 10^{(4})^2}{100 \left(\dfrac{11{,}57}{100}\right)^2} \vartheta 3 1 \left! \dfrac{3}{100}\right) = 1{,}5 \vartheta 10^6 \text{ см} = 0{,}015 \text{ 9\&9}.$$

! 61+, (4A, 6+' $d_{мин} = 0{,}3$ 9\&9, (, 513409 $d_{расч} = 0{,}5$ 9\&9.

B' 8' 39%. 0 (3.23)

$$S_O = \frac{100 \vartheta 0{,}5 \vartheta 10^{(4}}{0{,}0885 \vartheta 5{,}5} = 1{,}027 \vartheta 10^{(2} \text{ см} = 1{,}027 \text{ 99}^2;$$

$$L = B = \sqrt{1{,}027} = 1{,}01 \text{мм} = 1010 \text{ 9\&9}.$$

>*\&1I +' -' . '711 FHL \&' 9-434+'34 -' \&4I4/ /4 31*. 7.2.

R<0/19 +0-. ' ('K 30J19 HBL, 34*-' .' J0//'K /4 -. 4+0 FHL (5. 1I1 30I1*+'34 R7, (,)0.A2Q07' /415'.; T%2 9'Q/'*+; (+0-. ' (, 91 -'. A91 '*+4. ;/, : =.090/+'(1 \&'9-'/0/+'( ).A -3'*+'+, (=+'9 -319030 -30/05307409).

". A -') .'J\&1 1I *1+4. . 4 (*9. -31. . 1) ' -30) 0. 19 -' =\&*-. 1\&4<11 \&
8' 39%. 0 (3.26) =\&(1(4. 0/+%2 +'. Q1/%

$$l = 0{,}6 \left! \frac{1{,}43 \vartheta 0{,}1}{0{,}3}\right. = 1{,}08 \text{ 99}.$$

L' 5*+(0// , K -030730(HBL ' -30) 0. 19 -' 8' 39%. 0 (3.26). B. 'Q4);

HBL $S_{A1} = 1{,}0 \vartheta 1{,}0 = 1{,}0$ 99^2; 00 '+/' *1+0. ;/, 0 34I903, $q = r = \dfrac{1{,}0}{2 \vartheta 1{,}08} = 0{,}46$.

B' 73481\&49 (*9. 31*. 3.6) ' - 30) 0. 19 $<(r, q) = 0{,}43$.

G' 7) 4 -31 9' Q/' *+1, 34**01 (409' K HBL $P_{A1} = 14$ 9?+, -' .%619

$$\Theta_{iA1} = \frac{14 \cdot 10^{(3} \cdot 1{,}08 \cdot 10^{(3} \cdot 0{,}43}{1{,}43 \cdot 19 \cdot 10^{(6}} = 4{,}6 \ \#.$$

D' /' (, K - 030730(, ' 5%*. ' (. 0//, K +0- . ' (, 9 - ' +' &' 9 1I 30I1*+' 34 R7, **34**61+409 - ' 8' 39%. 0** (3.27)

-31 $\%_1 = 1{,}85 \ 99$; $\%_2 = 3{,}07 \ 99$; $X_O = 0{,}5 \ 99$; $Y_O = 0$;

$$S_{R7} = 1{,}85 \cdot 3{,}07 = 5{,}68 \ 99^2;$$

$$q_1 = \frac{1{,}85}{2 \cdot 1{,}08} \ ! \ \frac{0{,}5}{1{,}08} = 1{,}32;$$

$$q_2 = \frac{1{,}85}{2 \cdot 1{,}08} \ (\ \frac{0{,}5}{1{,}08} = 0{,}39;$$

$$r_1 = r_2 = \frac{3{,}07}{2 \cdot 1{,}08} \ \& \ \frac{0}{1{,}08} = 1{,}42 \ ;$$

$$<(r_1, q_1) = <(q_1, |r_1|) = 0{,}85;$$

$$<(|r_2|, |q_2|) = <(r_1, |q_2|) = 0{,}52;$$

$$\Theta_{R7A1} = \frac{15 \cdot 10^{(3} \cdot 1{,}08 \cdot 10^{(3}}{4 \cdot 1{,}43 \cdot 5{,}68 \cdot 10^{(6}} [0{,}85 \ ! \ 0{,}52 \ ! \ 0{,}52 \ ! \ 0{,}85] = 1{,}4 \ \#.$$
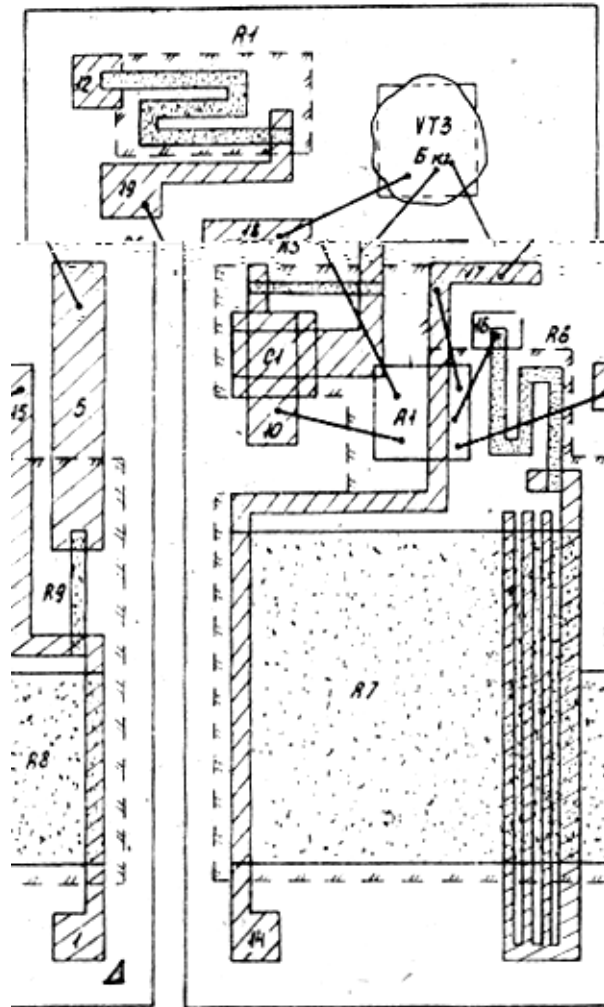
$1*. 7.2. >*&1I +' - ' . ' 711 FHL

?/%+30//1K - 030730(&31*+4. . 4 HBL ' <0/19 - ' 8' 39%. 0 (3.25)

$$\Theta_{вHA1} = 14\vartheta1 = 14 \, \#.$$

L%9943/4A +09- 034+%34 HBL ' - 30)0. A0+*A - ' 8' 39%. 0 (3.24)
(- 31 94&*194. ; /' K 345' 60K +09- 034+%30)

$$T_{A1} = 385 \,! \, 4,6 \,! \, 1,4 \,! \, 14 = 378 \, \#.$$

$4**61+4//4A (0. 161/4 +09- 034+%3,   /0 - 30(, T40+ - 30)0. ; /'
)' - %*+19%2 (418 #)). A &31*+4. . 4 HBL.

41

3B@GD ‚>B@RG>HGQ 7BCBMK>H

$%&' (') *+(' & (‚ -' . /0/12 345' +‚
34*60+/' -7348160*&' 7' -34&+1&%94

#' /*+3%13' (4/10 71531) /‚ : 1/+0734. ; /‚ : 91&3' *: 09
-' &%3*%
«#' /*+3%&<11 1 34*60+ 91&3' *: 09 1 91&3' =. 090/+' (>?@»
). A *+%) 0/+' (*-0<14. ; /' *+1 0648

B') - 1*4/' & - 064+1 28. V. 1981
D' 394+ 60×84 $\frac{1}{16}$ E%9474 ' 503+' 6/4A

R8*0+/4A - 064+; . ! *. . - . . . - 3,1. ! 6.-1I) . . . - 2,6.
Z4&4I X 602   G134J 300 =&I.

HI) 4+0. ; *+(' G474/3' 7*&' 7' 7' *%) 43*+(0//' 7'
34) 1' +0: /160*&' 7' %/1 (03*1+0+4
FLB 17 @, G474/3' 7, 28, P0&34*' (*&1K, 44
G1-' 73481A G474/3' 7*&' 7' 34) 1' +0: /160*&' 7'
%/1 (03*1+0+4
FLB 17 @, G474/3' 7, 28, >/70. ; *4 1.