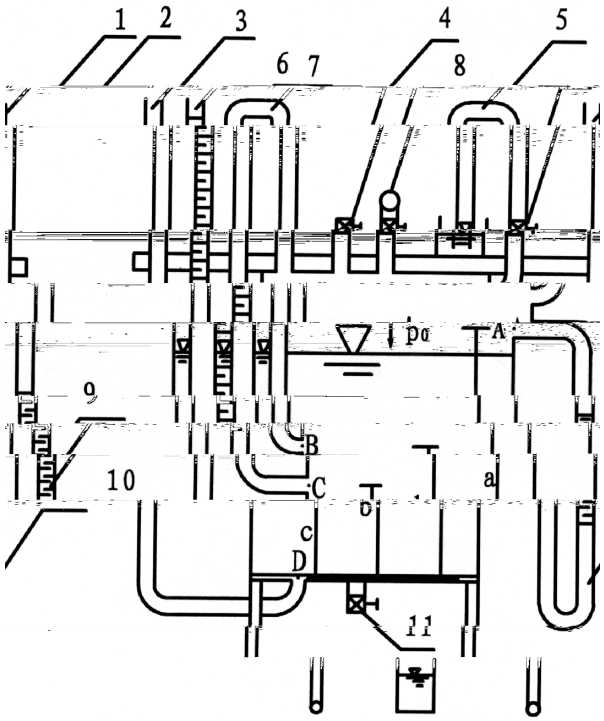
2023 6

1.



1. 2. 3. 4.
5. U 6. 7. 8.
9. 10. 11.

:

(1) (2)

(2) ∇_B ∇_C ∇_D B C D

, ∇_B ∇_C ∇_D Z_B Z_C Z_D

(3)

2.

(1)

(2)

(3)

3.

(1)

U

(2) , 0.1cm

(3)

(4)

(5) =150cm 55cm

1.

800ml

2.

A B $5^{\#}$U

20cm

1~2cm

3. 1 2 5

4.

5.

(a)

(b)

(c)

(d)

6.

5(a) (c)

1.

——

(1)

(2)

(1)

(2)

(1) C D

(2) p_0 4

2 3

(3)

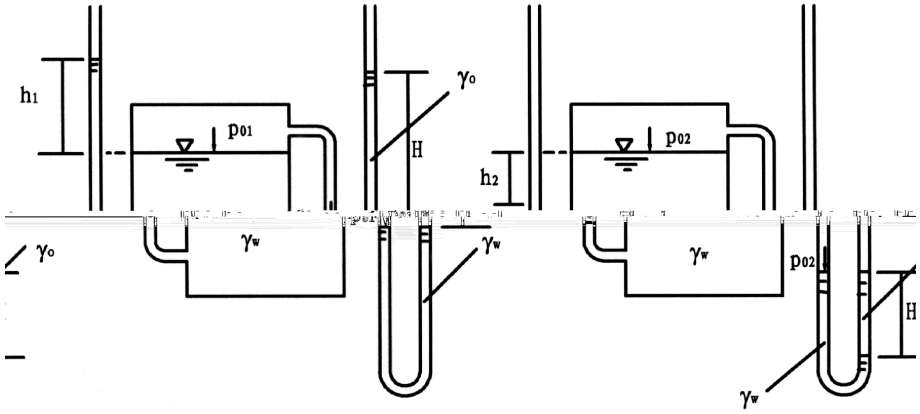
(4)

6 11

4 2

U

2.



(1)

(2)

Z ——
p —— (,)
p_0 ——
γ ——
h ——

( )U S_0

(3)

( ) S_0

3.

(1)

, 1 2 4 5

3

(2)

C D 2

C C C (p_C/γ) C

D C (Z_C) C

(Z_C+p_C/γ)

(3)

1 2 3

(4)

4

$p_0>0$

$p_0<0$ 4

(5)

C D

C D

(6)

C C C

C

(7)

2cm

a. C 1 2 5

b. 5 U

c. 4 4

4 b

c a 1 2

(8)

∇_h,

∇_h h $=\nabla_0-\nabla_h$

(9)

U

(10)

p_0=0

γ

γ

(11)

C

1 C

C

(12)

4

4 4

(13)

80 1-12

4 2

h ( )

h 4

4.

(1)

σ γ *d* *h*

(t=20) σ=7.28dyn/mm γ=0.98dyn/mm^3 θ
cosθ=1.0

(h d mm)

10mm

σ

θ *h*

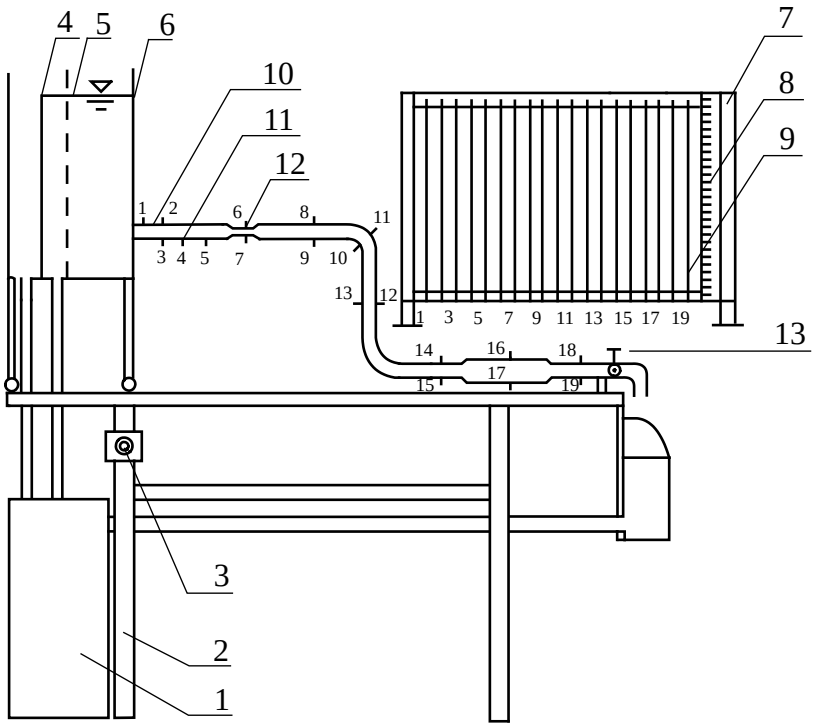
(2) *δ* *H*
p_0=0 (H+δ)
H 0.8cm 20cm
, *δ* 1 2
H

d 0.8cm D 20cm
δ / H 0.0032
ε

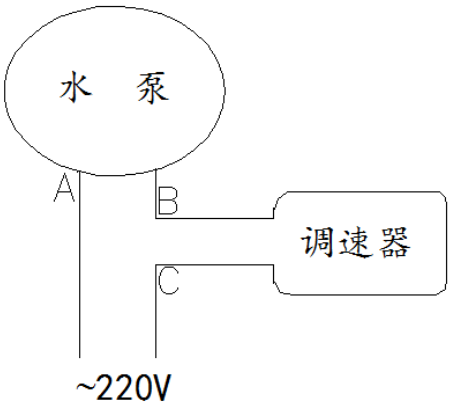
D/d≤10 D/d≤7
ε≤0.01

:

CAI


4
5
6
10
11
12
7
8
9
13
3
2
1

[ ]


水　泵
A
B
C
调速器
~220V

α α α α

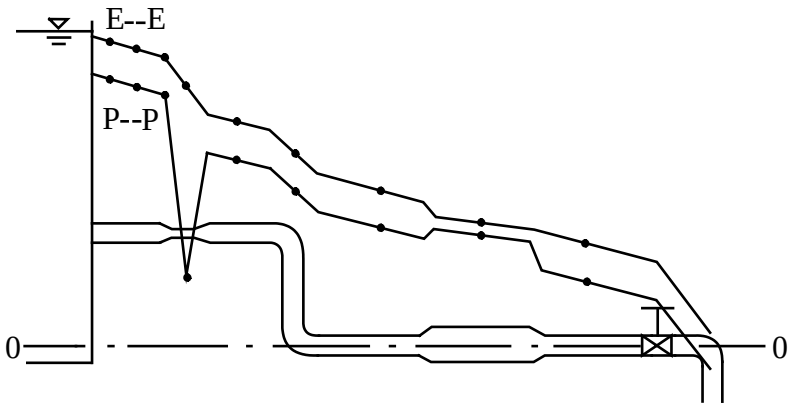
υ

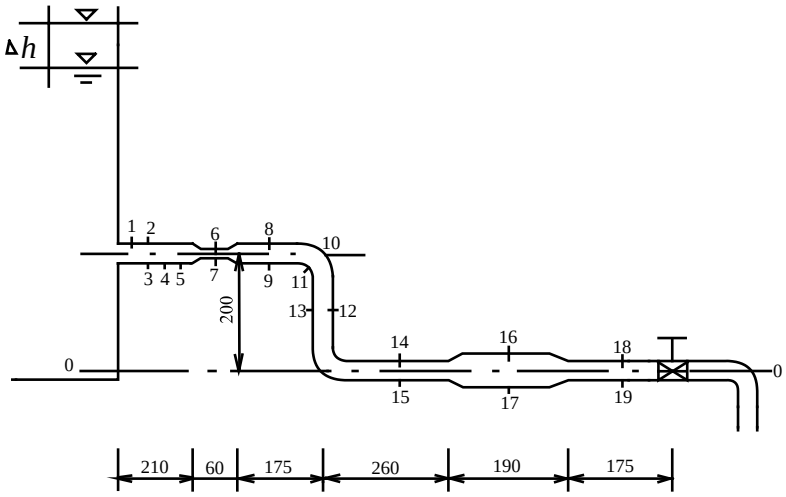
h_9

$h_9 = Z_9 + \frac{p_9}{\gamma}$ h_8 $h = Z_8 + \frac{p_8}{\gamma} + \frac{\upsilon^2}{g}$

h h Δh

h Δh





Δh

Δh Δh Δh

Δh Δh

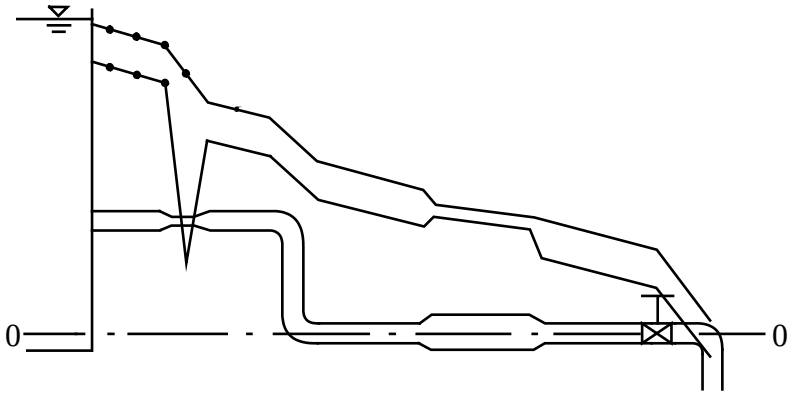
J_p

J J

J_p J_P

h h h

J



$$Z_1 + \frac{p_1}{\gamma} + \frac{\upsilon_1^2}{2g} \quad \frac{\omega_1^2 r_1^2}{2g} = Z_2 + \frac{p_2}{\gamma} + \frac{\upsilon_2^2}{2g} \quad \frac{\omega_2^2 r_2^2}{2g} + h_w$$

#

°

γ

Δh

$\alpha \quad \alpha$

Δh

h

$$h_{w1-2} = (\lambda \frac{l_{1.2}}{d_2} + \zeta_e + \zeta_s) \frac{\upsilon_3^2}{2g} = \zeta_{c1.2} \frac{\upsilon_3^2}{2g}$$

ζ ζ ζ

$$\frac{\upsilon_2^2}{g} = \frac{d_3}{d_2}^4 \frac{\upsilon_3^2}{g}$$

$$Z_1 + \Delta h = Z_3 + \frac{\upsilon_3^2}{2g} + \zeta_{c1.3}$$

ζ

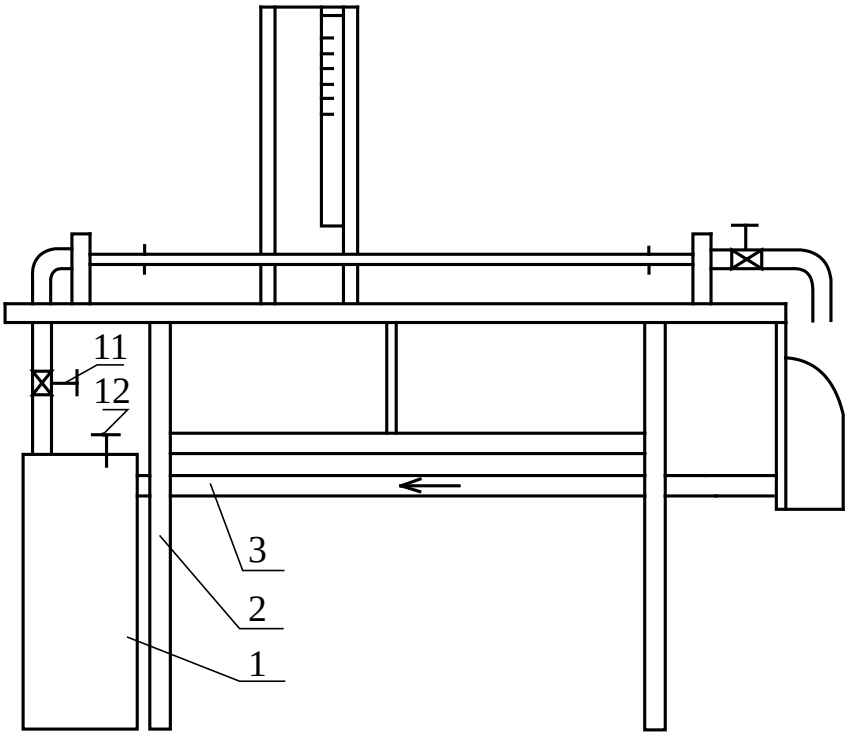
Δh ζ

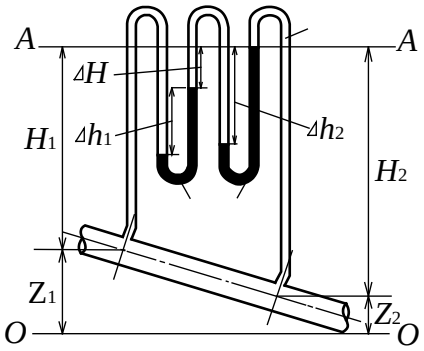
γ Δh ∂ γ ∂ Δh

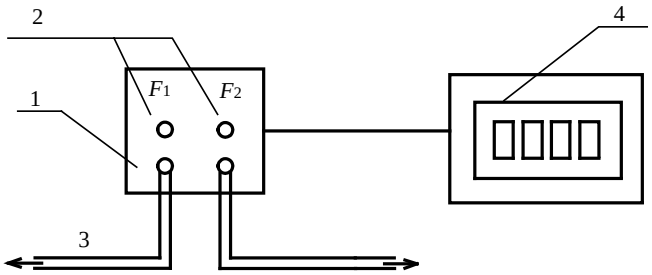
ζ ζ γ Δh

Δh γ

1.







1. 2.

3. 4.

2.

(1)

;

(2) ;

(3)

3.

(1) , 11 ,

;

(2) ,

± 1mm;

(3) ,

, , ;

(4) U ,

;

(5) 6 8 , ;

(6) : 220V, 50HZ; 450W;

(7) 250ml/s, 11 ;

(8) : 0.8kg/cm^2, 1.4kg/cm^2;

(9) : =150cm 55cm

1. , ,
, ;
, ;

2. , 220V , ,
, , ,
, , ;

3. , ,
, ,
;

4.

(1) ,
,

, 3/5, ,
, , ,

(2) F_1
F_1

5. ,

6.

(1)

a. , , ;

b. ;

c. , , ;

d. , , ;

e. , , ;

f. , ,
, ; ,
, ;

g. , ,

(2)

a. , ;

b. ,

, 5 10 ;

c. ,

, , 502 ,

;

d. , , ,

;

e. ,

1.

,

,

,

,

;

;

, , ;

, , , ,

, , , ,

,

,

,

, ,

±1 mm , 150cm

55cm , ,

,

,

, ,

, ,

,

2.

, ,

, ,

,

$$\upsilon = C\sqrt{RJ} \qquad (1)$$

(Chezy) , , : υ ;

R , R $\frac{A}{P}$, J , J $\frac{h_f}{L}$; C ,

a.

$$\frac{1}{\sqrt{\lambda}} = -2lg\ \frac{k_s}{3.7d} + \frac{2.51}{Re\sqrt{\lambda}}$$

b. *S J*

$$\lambda = \frac{1.325}{ln\ k_s / 3.7d + 5.74 / Re^{0.9\quad 2}}$$

c. *Barr*

$$\frac{1}{\sqrt{\lambda}} = -2l\ g\ \frac{k_s}{3.7d} + \frac{5.1286}{Re^{0.89}}$$

c $\frac{k_s}{d}$, *b* λ *Re*

k_s / d, k_s

(2)

Re λ , ,

, *Re* λ

,

λ π *g* ^{5} $_{f}$ 8 *Q*

d *Q* , *Q* 2% , λ 4% , *d* 2% , λ 10% *Q* , *d* , , $\varepsilon < 1\%$, ,

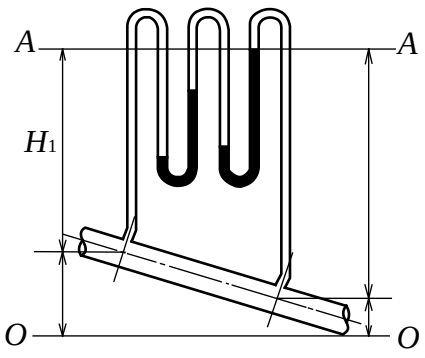
, ,

,

(3) *m*

(lgh_f $lg\upsilon$) *m* 1.0 1.8, h_f $\upsilon^{1.0\ 1.8}$,

m 1.0



(4) ? ,

?

A *A*

:

0 0 , 1 1 2 2 , ,

υ_1 υ_2, $\sum h_j$ 0,

$$h_{f1-2} = Z_1 + \frac{p_1}{\gamma} - Z_2 + \frac{p_2}{\gamma}$$

$$\frac{p_1}{\gamma} = \frac{p_2}{\gamma} - H_2 + 13.6\Delta h_2 - \Delta h_2 + \Delta H + 13.6\Delta h_1 - \Delta h_1 - \Delta H + H_1$$

$$= \frac{p_2}{\gamma} - H_2 + 12.6\Delta h_2 + 12.6\Delta h_1 + H_1$$

$$h_{f1-2} = Z_1 + H_1 - Z_2 + H_2 + 12.6\Delta h_2 + 12.6\Delta h_1$$

=12.6 Δh_1 Δh_2

,

(5) , ,

, , ?

0.2mm, (20) 0.01cm^2/s,

300cm/s, *D* (20 100)cm, *Re* 6 10^5 3 10^6, $\frac{k_s}{d}$

0.0002 0.001, ,

, *Re* 10^6 9 10^6, (5 9)m/s

(1 9)mm, (2 3)m,

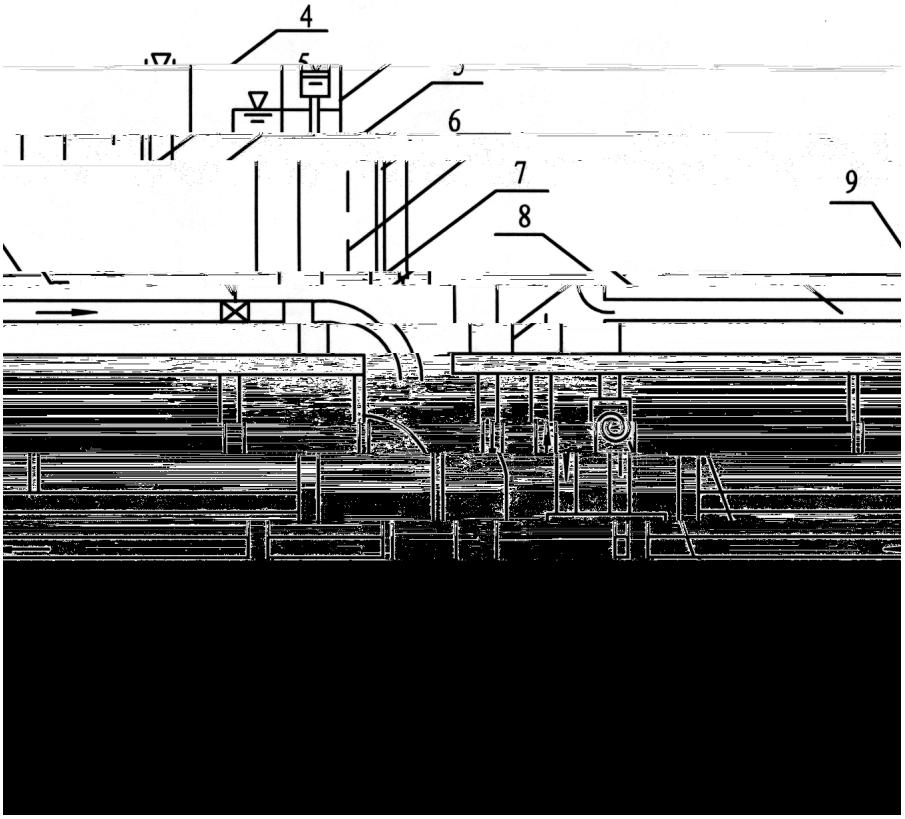
(5 10)m/s , *Re* 10^7,

:

, , CAI

, ,

1.



1. 2. 3. 4.

5. 6. 7. 8.

9.

[ ]

, 4 ,

, 3~5

5 8, ,

2.

,

3.

(1) ;

(2) , ,
3 5 ;

(3) , ,
;

(4) : 220V 50HZ; : 100W;

(5) 2000 2300, 3000 5000;

(6) : 0 300ml/s, 0 200ml/s;

(7) : =150cm 55cm

1. , , ;
;
, ;

2. 220V , ,
, , , ,
;

3. , , ,
, ;

4. ( ) , 700ml ,
, , , 10 20ml ,
, ;

5. , , , ,
, ;

6.

(1)

a. , ;

b. ;

c. , , ;

d. ;

e. , ,

(2)

a. , , ,
5 10 ;

b. , , ,

; , , ,

;

c. , ;

d. , , :

220V , B C , , A B (220V),

, ; , , ;

, , (6A,) :

, ,

1.

, , ,

, , ,

,

; , ,

, , ; ,

, , ,

,

2.

$$Re = \frac{\upsilon d}{\nu} = \frac{4Q}{\pi d \nu} = KQ$$

$$K = \frac{4}{\pi d \nu} \qquad (1)$$

:

υ —— ;

ν —— ;

d —— ;

Q ——

, d

ν , $\frac{\upsilon_c d}{\nu}$, Re_c ,

$$Re_c = \frac{\upsilon_c d}{\nu} \qquad (2)$$

, , ,

$\mathrm{Re}_c, \mathrm{Re}_c = \frac{\upsilon_c d}{\nu}$; , $Re_c, Re_c = \frac{\upsilon_c d}{\nu}$

, ,

Re_c , ,

Re_c 2320 $Re<Re_c=2320$,

; $Re>Re_c=2320$,

3.

(1)

, , , ,

, , ,

, ,

, ,

(2) ,

a.

, , , ,

, ( ) , ,

, , 2000 2300

2320,

, ,

,

, 2000 2300 , ,

2000 ,

b.

, , , , , ,

, , ,

, 3000 5000 , , ,

, 12000, 20000,

40000 , , ,

4.

(1) ,

1883 , —— ,

$\upsilon_c^{'}$,$\upsilon_c^{'}$ ν d ,

$$\upsilon_c^{'} = f(\nu, d) \qquad (3)$$

, $\upsilon_c^{'}$

, ,

$(\upsilon d / \nu)$,

(3)

$$\upsilon^{'} = K\nu^{\alpha_1} d^{\alpha_2} \qquad (4)$$

K

(4)

$$[LT^{-1}] = [L^2T^{-1}]^{\alpha_1}[L]^{\alpha_2} \qquad (5)$$

,

L: $2\alpha_1+\alpha_2=1$

T: $-\alpha_1= -1$

$\alpha_1 = 1$, $\alpha_2 = -1$

, (4),

, ( ) ,

, , , ,

, ,

, ,

, , ,

, , , ,

→ → → ,

(4)

$= ma = \rho W \frac{d\upsilon}{dt}$, W L

, $[W]=[L]^3$; $\frac{d\upsilon}{dt}$, $[\frac{d\upsilon}{dt}] = \frac{[\upsilon]}{[t]}$

$$[\rho][W][\frac{d\upsilon}{dt}] = [\rho][L]^3 \frac{[\upsilon]}{[t]}$$

$T = \mu\omega \frac{du}{dn}$, ω L , $[\omega]=[L]^2$, $\frac{du}{dn}$

L , $[\frac{du}{dn}] = \frac{[\upsilon]}{[L]}$

$$[\mu][L]^2 \frac{[\upsilon]}{[L]} = [\mu][L][\upsilon]$$

$$\frac{[\qquad]}{[\qquad]} = \frac{[\rho][L]^3 \frac{[\upsilon]}{[t]}}{[\mu][L][\upsilon]} = \frac{[\rho][L]^2}{[\mu][t]}$$

$$= \frac{[\rho][L][L]}{[\mu][t]} = \frac{[\upsilon][L]}{[\nu]}$$

, L d ,

R

,

(5)

a. , Re_c=1.0, $Re=DU/\nu$<1.0 , , , U

, D , ν

b. ( ), $Re=\upsilon R/\nu$ $R=$ $/P$, P ,

$R=d/4$, Re_c=800

:

, , CAI

, ,