

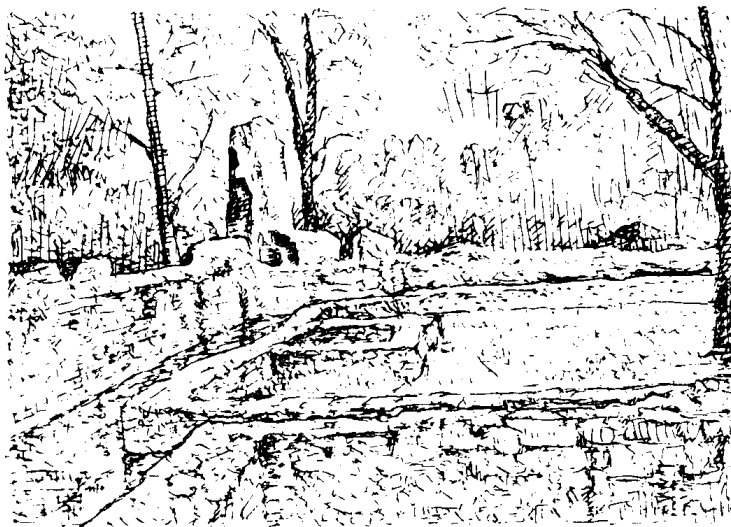
1

1.1 가

가 , 가 가 .
((流體, fluid)) [(流體力學, fluid mechanics)]
()] , [(流動學)]
[(水路) , 가 ,
(用水路) , ,
가 .
가 ,
가 ,
가 []

1.2

가 , 가
(水路) (船)



1.1 (가)



1.2



1.3

4000

가

(水道)가

가

가

(1.1).

가

180

가

1

240

2000

가

(送水壓)

가



(Leonardo da Vinci 1452-1519)

1.2 (浮彫細工)

2700

가

가

1.3

(造船)

[, [가 (抵抗)] 3 (,)

(浮力), (流出), (水車) (水力機械) (渦), (波), (落水),

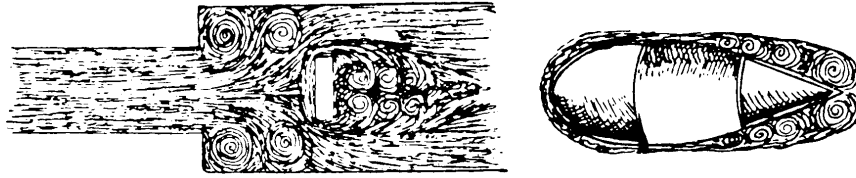
1.4

1.5

(流線形)



1.4



1.5 가

가

(噴流),

가

(浮遊物)

(黎明期)

가

17

20

1.3

(1)

2가

(粘性)

(壓縮性)

가

가

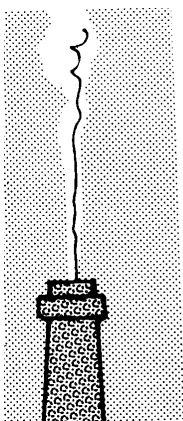
가

(粘度, viscosity) m

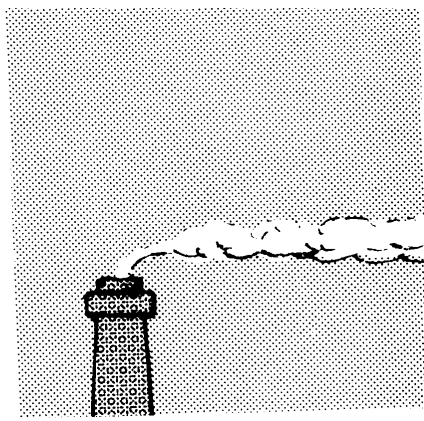
r

(動粘度) n

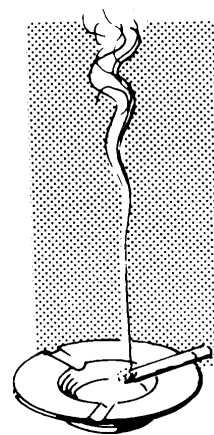
55



(a)



(b)

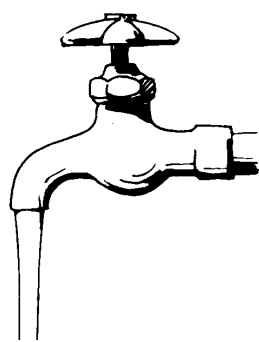


1.7

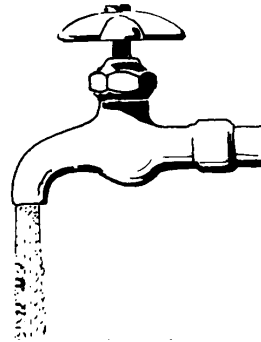
1.6

15

1



(a)



(b)

1.8

, 1000 가 5% .

1.6(a)

가

가

1.6(b)

,

, 1.7 가

가 ,

.

가

2 가

[(層流, laminar flow)], [(亂流, turbulent flow)] .

가 1.8

(水流)



(Osborne Reynolds 1842-1912)

,

,

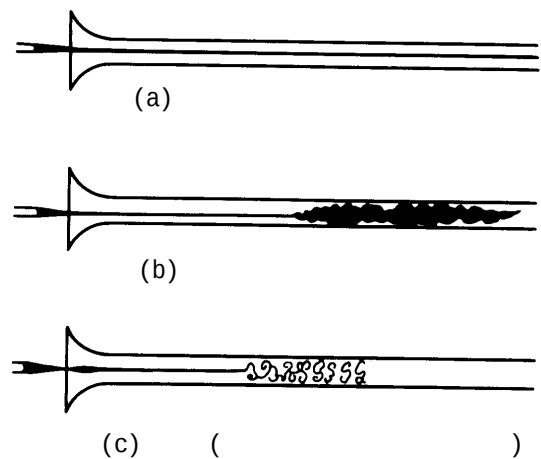
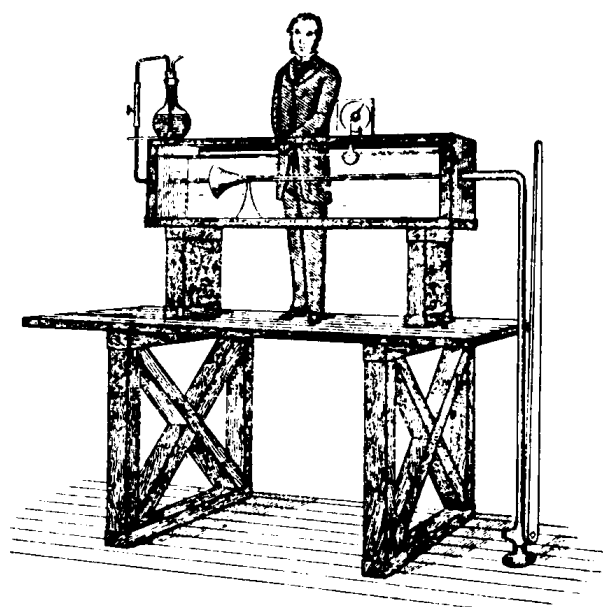
가

가

,

(2) 가 ()
100 가
1.9 가 1.10(a)
가 , 1.10(b)
[가 (可視化)]
가
 n Ud/n 2320 가 , Ud/n
[] (模型)
[Re]

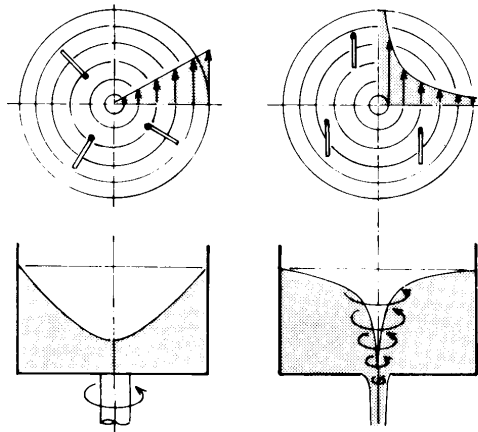
(3) (下流) TV
가
1.11(a)



1.9

1.10

가



1.12

1.11(b)

2가 가

2가

[(强制渦, forced vortex)],

[(自由渦, natural vortex)]

(潮水)

1.4

가

(1) ()

가

가

()

1.12

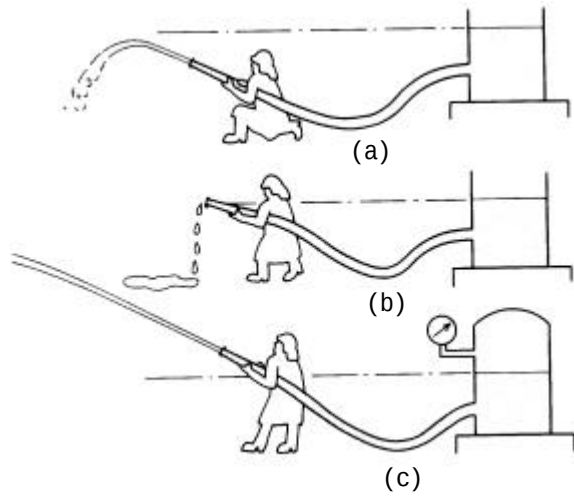
가

■



•

•



1.14

1981 4 12 7

(1.15).

가? 가

m 가 가 u

(運動量) mu

가

가

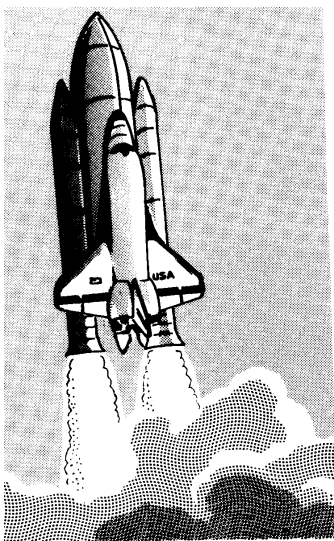
(墳流)

(反力)

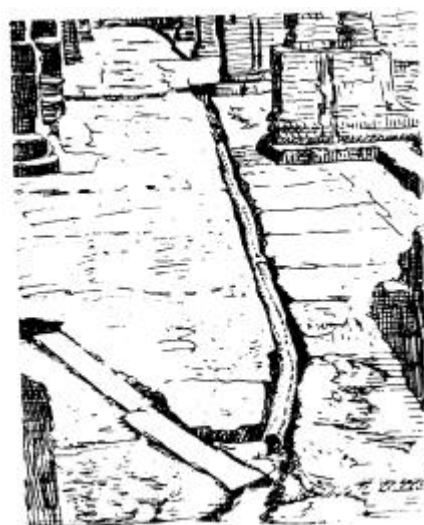
가

1.5

, (1)



1.15



1.16 (鉛製) ()

管) (1.16), (鉛
管) (粘土管), (磁器

A B
가가 (壓力損失, pressure loss) h

$$h = l \frac{\ell}{d} \frac{u^2}{2g} \quad (\text{Darcy-Weisbach})$$

ℓ , d , u , g 가, l (管
摩擦係數)

l 가, 1944 Moody가 Re l
(線圖) [Moody]

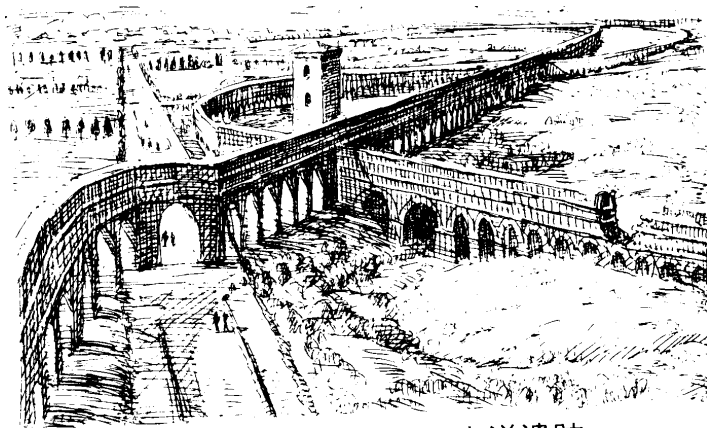
1.6

[(水路)]
312
16.5 km 305 14 가 가
578 km 가 (1.17).
가
(粗度)

가 Chezy u 가가

$$u = c\sqrt{mi}$$

m [
] , i c (流速係數) , [Chezy
]



1.17

1.7

(1)

(内部流動, internal flow) , (外部流動, external flow)

1.18

(速度勾配)가

[(境界層, boundary layer)]

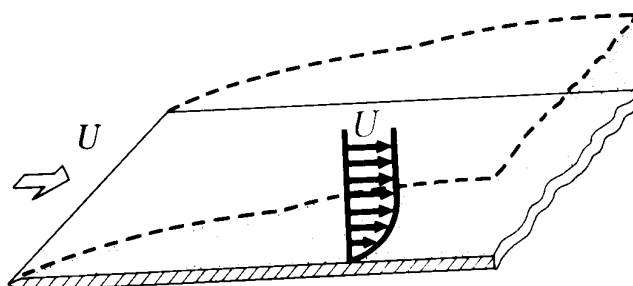
Prandtl 가 1904
8 , 12

(摩擦抗力, friction

drag) , Prandtl

50

가 Kline . Kline



1.18



(Ludwig Prandtl 1875-1953)

(Blasius), (Karman)

(外層)

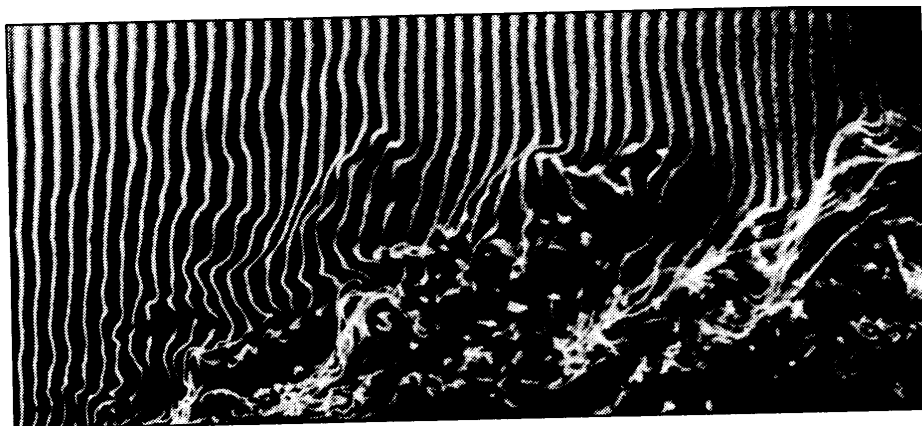
가 , (減速)

[(bursting)] , 가
(1.19).



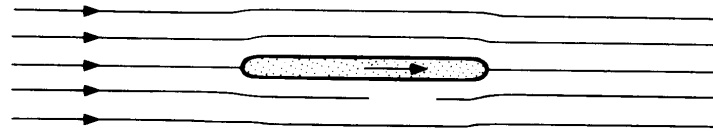
(Stephen Jay Kline 1922 ~)

가

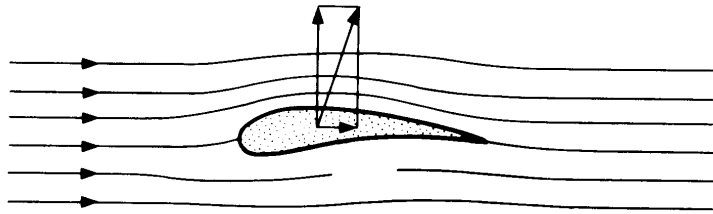


1.19

(2) 가 가 ?



(a)



(b)

1.20

1.20(a) 가 ,
 (翼) 1.20(b) 가 ,
 (上面) 가 , (下面) 가 ,
 (揚力, lift) .

(3) 가

U 가 (抗力, drag) D

,

$$D = C_D A \frac{\rho U^2}{2}$$

A , C_D [, drag coefficient] (定數) .

C_D , C_D .
 C_D 0.3 0.5 .
 (剝離, separation) ,

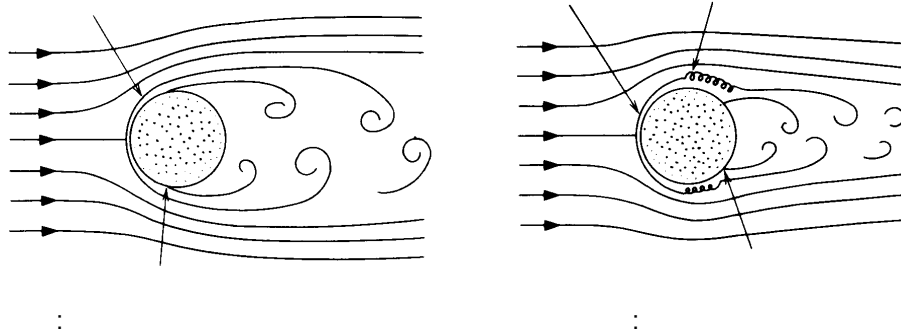
가

(圓柱) 1.21

(背後)

,

.



1.21

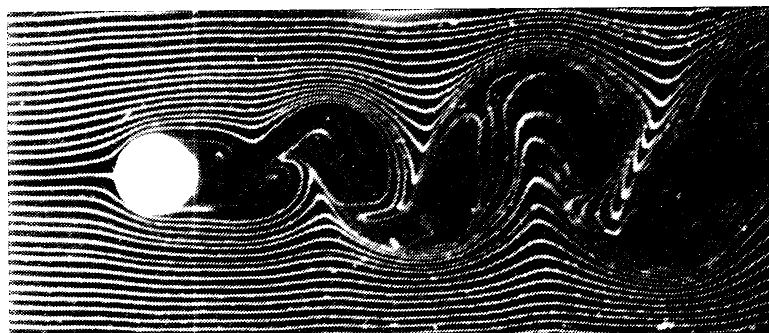
(剥離点, separation point)
 가
 C_D 3 1
 가
 (誘起) C_D 가 ()
 가

Karman (渦列)

가 1.22
 [Karman]
 f , 1

$$f = 0.2 \frac{U}{d}$$

U , d . Karman f 가



1.22 Karman



(Theodor von Karman 1881-1963)

가 Karman

Karman

(音)

가

Karman

가

가

(流線形)

(4)

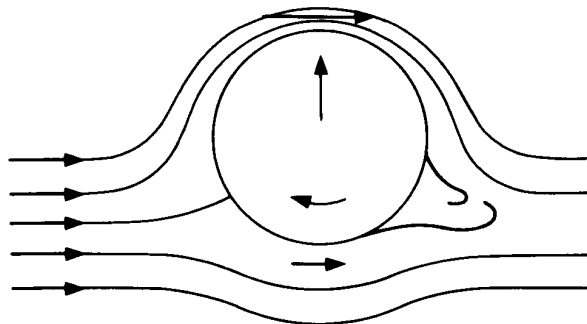
(浮上)

1.23

Magnus가 1852

Magnus

가



1.23