

wave-lengths of the first sets of the S.D. series for each element, with their corresponding  $\nu$  and  $\sigma$  separations. For fuller conviction the more complete data (*l.c.*) should be consulted. It is much to be desired that the spectra for Gd (between In and Tl) and for Sa (between Ag and Au) should be discussed for series data in order to make the general evidence more complete.

CdS''2.		NEUTRAL ATOM. EuS''2.		HgS''2.	
5085.8		5377.0		5460.7	
4799.9	1170.88	4709.8	2633.71	4358.3	4630.62
4678.2	541.89	4495.1	1013.96	4046.5	1767.35
D'''2.		D''2.		D'''2.	
3614.4	11.10	3638.1	62.63	3662.8	60.10
3612.9	18.23	3629.8	103.85	3654.8	35.14
3610.5		3616.2		3650.1	
	1171.10		2633.39		4630.56
3467.6	11.87	3320.0	59.77	3131.5	60.73
3466.2		3313.4		3125.5	
	542.19		1004.16		1767.41
3403.6		3312.8		2967.2	
S''1.		IONISED ATOM. S''1.		S''1.	
-2144.4		-2375.5		?	$\nu=9831$
-2265.0	2482.01	-2720.6	5338.68		
D''2.		D''2.		D''2.	
2321.2		2688.5			
2312.8	155.74	2666.9	301.52		
	2482.79		5345.25		
2194.6		2350.6			

W. M. HICKS.

**The Critical Velocity in Pipes.**

In the course of a recent conversation, Major A. R. Low pointed out to me that one state of steady fluid flow will not change to another unless there is a difference in the energies corresponding to the two types, or, as I prefer to put it, no change from one state to the other will occur spontaneously unless the change involves a dissipation of energy. If we call  $p/\rho$  the head in C.G.S. units, then in viscous flow the head lost in a length  $\Delta x$  of a pipe can be written in the form

$$\frac{1}{\rho} \cdot \frac{\partial p}{\partial x} \Delta x = \frac{32\rho v^3}{\mu} \cdot \left(\frac{\mu}{\rho v d}\right)^2 \Delta x.$$

In turbulent flow the head similarly lost can be expressed as

$$\frac{4\rho v^3}{\mu} \cdot \left(\frac{\mu}{\rho v d}\right) L \cdot \Delta x,$$

where  $L$  is defined by the relation

$$F = \rho v^2 \cdot L,$$

and  $F$  is the wall friction in dynes per sq. cm.

Hence it follows that viscous flow cannot change to turbulent flow unless  $L \geq \frac{8\mu}{\rho v d}$ .

In the foregoing,  $\mu$  is the viscosity,  $\rho$  the density, and  $v$  the velocity of the fluid, all in C.G.S. units, whilst  $d$  is the pipe diameter in cm.

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**Densities of Photographic Plates.**

IN NATURE of April 5, p. 494, Mr. G. M. B. Dobson suggests that it should be possible for photographic plate manufacturers to produce plates which would yield uniform density after uniform exposure and development.

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It has been pointed out (*Photographic Journal*, vol. 61, p. 425) that, even if the emulsion is uniformly coated upon optically worked glass, and dried under such conditions that no irregularities from this cause can arise in the portion of the plate to be used, normal methods of development lead to the production of non-uniform density. One of the causes is the local concentration of the products of reaction due to development.

In the paper referred to, a means of minimising this is described. The evidence shows that variations due to development are greater than those due to irregularities in the processes of coating and drying the emulsion when these operations are carried out for experimental work of this character.

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April 5.

**Refractive Index of Gums.**

IN the letter on the Refractive Indices of Gums published in NATURE, February 2, p. 159, the formula used in computing the indices was wrong, and should have been  $\mu = 1 + pc$ , where  $c$  is the difference between the refractive index of the standard material and unity. The order in which the gums are placed in the table is correct, but the values given to  $\mu$  are too large.

A corrected table, with some additions, is given below.

**CORRECTED TABLE OF REFRACTIVE INDICES.**

	$\mu$ .		$\mu$ .
Water . . . . .	1.333	†Kauri . . . . .	1.48
Ether . . . . .	1.358	†Copal . . . . .	1.49
Acetone . . . . .	1.360	†Storax . . . . .	1.50
Alcohol . . . . .	1.355	†Benzoin . . . . .	1.51
Amyl acetate . . . . .	1.395	†Shellac . . . . .	1.51
Chloroform . . . . .	1.460	†Mastic . . . . .	1.52
Benzole . . . . .	1.49	†Damar . . . . .	1.52
Xylol . . . . .	1.49	†Gutta-percha . . . . .	1.52
Cedar oil . . . . .	1.51	†Resin . . . . .	1.53
Oil of Cassia . . . . .	1.64	†Sandarac . . . . .	1.53
Albumen . . . . .	1.35	†Guaiacum . . . . .	1.53
Treacle . . . . .	1.495	§Styrax (a) . . . . .	1.54
†Cane Sugar . . . . .	1.54	§ „ (b) . . . . .	1.57
†Artist's copal varnish . . . . .	1.48	§ „ (c) . . . . .	1.59
*Gum of Cherry, Thick Sol. . . . .	1.34	† „ (d) . . . . .	1.64
Gum of Cherry, Solid . . . . .	1.45	Mixed Iodides of Mercury and Potassium . . . . .	1.73
*Gum Acacia, Thick Sol. . . . .	1.37	†Sulphur . . . . .	2.03
Gum Acacia, Solid . . . . .	1.47	†Phosphorus . . . . .	2.12
*Gum Arabic, Thick Sol. . . . .	1.37	†Realgar (Red Light) . . . . .	2.55
Gum Arabic, Solid . . . . .	1.45	„ (Green Light) . . . . .	2.61

The simplest way of dealing with the observations is by a diagram. If  $n_x$  and  $n_a$  are the micrometer readings for the displacements caused by substances the refractive indices of which are respectively  $\mu_x$  and  $\mu_a$ ;

$$p_x = n_x/n_a = \mu_x - 1/\mu_a - 1.$$

Taking  $p$  as the abscissa and  $\mu$  for the ordinates, draw a straight line through the origin and the point  $p = 1, \mu = \mu_a$ , then for any value  $p_x$  of  $p$  the ordinate is  $\mu_x$ .

A. MALLOCK.

9 Baring Crescent,  
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\* Thick solution in water. † Melted in prism.  
‡ As sold. § Evaporated alcoholic extract.  
(a) Gum imported in small dry black pellets.  
(b) and (c) Imported in a semi-fluid state.  
(d) Prepared by Grüber of Leipzig.