

In like manner it may be shown that  $z_2 = a \sin^2 2by_1 \dots (3)$

where  $y_2 = 2y_1$

Fr. m (2):  $\sin^2 by_1 = \frac{z_1}{a}$

and since  $2 \sin^2 A = 1 - \cos 2A$

we have  $\frac{2z_1}{a} = 1 - \cos 2by_1$

or  $\cos 2by_1 = \frac{a - 2z_1}{a} \dots \dots \dots (4)$

From (3):  $\sin^2 2by_1 = \frac{z_2}{a}$

(And since  $\cos^2 A = 1 - \sin^2 A$ )

we have  $\left(\frac{a - 2z_1}{a}\right)^2 = 1 - \frac{z_2}{a}$

Whence  $a = \frac{4z_1^2}{4z_1 - z_2} \dots \dots \dots (5)$

From (2):  $\cos^2 by_1 = 1 - \frac{z_1}{a}$   

$$= 1 - \frac{z_1}{4z_1^2} \frac{(4z_1 - z_2)}{4z_1} = \frac{z_2}{4z_1}$$

Whence  $b = \frac{\cos^{-1} \sqrt{\frac{z_2}{4z_1}}}{y_1} \dots \dots \dots (6)$

That these terms are not so mysterious as they appear, becomes evident after an analysis of the above proof. Thus we find that the constant,  $c$ , is dependant solely upon the initial resistance of the rubber to stretching; it will be largest for a pure gum stock and become relatively smaller and smaller as the stock is more heavily compounded. From the relationship in equation 5 we can readily see that in the case of a pure gum stock where the stretch is long and uniform,  $m_1$  and  $m_2$  having been large,  $a$  will be relatively large, in comparison with a "tread" stock which will be strong and cause the entire curve to be fairly steep, but will be small in comparison with a "whiting stock," which is characterised by an initial stiffness after which it offers comparatively little resistance to stretching. Equation 6 shows that for pure gum or tread stocks  $\cos b$  will be small and  $b$  consequently large.

The ease with which these values could be standardised in specifications for a given stock is apparent, and the value of such standards both from the point of the manufacturer and the buyer is obvious.

We have done some work in this laboratory to find how closely the curve computed from the equation agrees with the actual curve, of which the following example is typical. For our work we used the "Schwartz Rubber Testing Machine." Test specimens were cut from a "Goodyear" auto inner tube, and from curves drawn in testing these specimens we obtained constants which gave the equation:—

$$x = 1.17y + 2.06 \sin^2 34.6y.$$

Another tube made by the same formula was selected at random and a curve drawn from a sample of this tube. Assuming various values for  $y$ , the  $x$  to correspond was computed fr. m the equation and compared with the same values as measured on the curve.

The results were as follows:—

y	by	x (computed).	x (from curve).	Diff.
inches.	deg. min.	inches.	inches.	
0.2	6 55	0.26	0.26	0.00
0.5	17 18	0.77	0.78	—0.01
1.0	34 36	1.84	1.86	—0.02
1.5	51 54	3.04	3.05	—0.01
2.0	69 12	4.14	4.08	+0.06
2.5	86 30	4.78	4.70	+0.08
3.0	76 12	5.26	5.17	+0.09
3.5	58 48	5.61	5.60	+0.01
4.0	41 36	5.71	—	—

These are actual measurements from the curve representing only arbitrary values for  $x$  and  $y$ .

#### THE METHOD BY WHICH THE CORRECTED SIKES'S TABLES IN USE IN INDIA, FOR DETERMINING THE PROOF-STRENGTHS OF SPIRITS AT TEMPERATURES FROM 40° F. TO 100° F. BY SIKES'S HYDROMETER, WERE CALCULATED.

BY F. G. CARTER.

The Alcohol Tables "for the use of the Appraisers' Department, Calcutta Customs House," issued 1st September, 1889, which were taken originally from The Analyst, Vol. V. (1880, p. 42), were used by me as the basis for the specific gravities of spirits of varying degrees of proof-strengths at 60° F. compared with the sp. gr. of water at 60° F. In these tables the sp. gravity of spirit of proof strength at 60° F. as compared with the sp. gravity of water at 60° F. = 0.9198.

These sp. gravities at 60° F. compared with the sp. gravity of water at 60° F. were then converted into sp. gravities at 60° F. compared with the sp. gravity of water at 62° F. by multiplying by 1.000182 (the expansion of water from 60° F. to 62° F.).

Table B of the Spirits Act of 1880, Ch. 24, pp. 60/2, was then taken as giving the actual sp. gravities of liquids as compared with the sp. gravity of water at 62° F. which Sikes's hydrometers constructed to fit these tables, whether of glass or of brass, should give correctly at 62° F. (the corrected tables were calculated to be used with hydrometers, whether of glass or of brass, which should be constructed to indicate correctly at 62° F. the sp. gravities of Table B. as compared with the sp. gravity of water at 62° F.).

Tables of the expansion of mixtures of water and alcohol in proportions ranging from water to absolute alcohol from 60° F. to 100° F. and contractions from 60° F. to 40° F. were then prepared for calculating variations of temperature for the above (para. 2) sp. gravities, as follows:—

Separate co-ordinate curves were made for 70° F., 85° F., 100° F., 50° F., and 40° F. for expansion throughout the whole range of proof-strengths at these temperatures from the formulae of Baumhauer,\* Recknagel, Kopp and others (Castell-Evans's Physico-Chemical Tables, Vol. 1) and data derived from these curves were tested against hydrometer determinations of various strengths and at different temperatures compared with pyknometer weighings of the same samples at 60° F. I then completed expansion tables, from which tables of variations of sp. gravities were obtained which agreed generally more nearly, perhaps, with Tralles' Tables, III. and IV.† (p. 492 of Bayley's Chemists' Pocket Book) than with the tables by Gilpin and Blagden, by Mendeléeff and others.

After calculating the various sp. gravities as above, for the final step of fitting them at all temperatures from 40° F. to 100° F. to indications, through Table B, of hydrometers (whether of glass or of brass) it was necessary to consider the volume-expansion and volume-contraction of glass and brass from 62° F. to 100° F., and from 62° F.

\* In Baumhauer's coefficients (p. 162 of Castell-Evans, Vol. 1.) there is a misprint in the first coefficient of .033981 for .031981.  
 † Tralles' Table IV. should read "to be added" where "to be subtracted" is printed and "to be subtracted" where "to be added" is printed.

to 40° F. For this, coefficients of linear expansion for 1° C. were taken from p. 284 of Deschanel, Part II., Heat, namely, for glass for 1° C. 0.00008116, for brass 0.00001878. These were multiplied by 3 for cubical expansion and by  $\frac{1}{2}$  to apply them to degrees Fahrenheit.

A table of differences of sp. gravities for each degree of temperature from 40° F. to 100° F. (excepting 62° F.), of which the following is a short summary, was then made, and from this table the necessary adjustments were made before the specific gravities were finally fitted to hydrometer-indications, through Table B.

Having prepared all the preliminary data, on the above lines, the work was then taken in hand systematically.

For 50° F.

Contraction of Proof-spirit from 60° F. to 50° F. = 0.99536 approx.

$$\text{sp. gr. of Proof-spirit at } 50^\circ \text{ F.} = \frac{0.919967}{\text{Aq. } 62^\circ \text{ F.}} = 0.924255$$

For contraction of the hydrometer from 62° F. to 50° F.,

if for glass instruments subtract 0.00016

if for brass instruments subtract 0.000375

The hydrometer-indication required, therefore, is that hydrometer-indication in Table B which corresponds,

if for glass instruments, to a sp. gr. of 0.924255—0.00016 = 0.9241 approx.

if for brass instruments, to a sp. gr. of 0.924255—0.000375 = 0.92387 that is, for glass hydrometers, an hydrometer-indication 61.2 and for brass hydrometers, an hydrometer-indication 61.1

	To be subtracted.					To be added.						
	40° F.	45° F.	50° F.	55° F.	62° F.	70° F.	75° F.	80° F.	85° F.	90° F.	95° F.	100° F.
For glass instruments	-0003	-00023	-00016	-0001		-0001	-000176	-00024	-0003	-00038	-00045	-00051
For brass do.	-00069	-00053	-000375	-00022		-00025	-0004	-00056	-00072	-00088	-00104	-0012

The following example will perhaps best make clear the above notes and demonstrate the essential system upon which the whole was elaborated.

Proof-spirit at 85° F. and at 50° F.

Data. Sp. gr.  $\frac{60^\circ \text{ F.}}{\text{Aq. } 62^\circ \text{ F.}} = 0.9108$  ("The Analyst," loc. cit.).

$\therefore$  Sp. gr.  $\frac{60^\circ \text{ F.}}{\text{Aq. } 62^\circ \text{ F.}} = 0.9108 \times 1.000182 = 0.919967$

As it had been decided for the future to use glass hydrometers only in India, tables for glass instruments were alone elaborated, but I made a table of proof-degree differences for using or adapting these tables to brass instruments, of which the following is a summary.

NOTE.—Where the + sign is shown these differences are to be added to, and where a — sign to be subtracted from,\* net proof-strength found in the tables for glass hydrometers.

Temperatures F.° .. ..	40° to 45°	45° to 50°	50° to 55°	55° to 62°	62° to 70°	70° to 75°	75° to 80°	80° to 85°	85° to 90°	90° to 95°	95° to 100°
Differences in sp. gr. between glass and brass ..	-00034	-00025	-00016	-0007	-00008	-00017	-00026	-00035	-00044	-00053	-00062
Hydrometer Indications.	pf. degrees.	pf. degrees.	pf. degrees.	pf. degrees.	pf. degrees.	pf. degrees.	pf. degrees.	pf. degrees.	pf. degrees.	pf. degrees.	pf. degrees.
A 0 .. A 10 .. ..	-0.15	-0.1	-0.05	nil	nil	+0.05	+0.1	+0.15	+0.2	+0.25	+0.3
A 10 .. A 20 .. ..	-0.15	-0.1	-0.05	-0.05	+0.05	+0.05	+0.1	+0.15	+0.2	+0.25	+0.3
0 .. 5 .. ..	-0.15	-0.1	-0.05	-0.05	+0.05	+0.1	+0.15	+0.2	+0.25	+0.3	+0.35
5 .. 10 .. ..	-0.15	-0.1	-0.1	-0.05	+0.05	+0.1	+0.15	+0.2	+0.25	+0.3	+0.35
10 .. 15 .. ..	-0.2	-0.15	-0.1	-0.05	+0.05	+0.1	+0.15	+0.2	+0.25	+0.3	+0.4
15 .. 20 .. ..	-0.2	-0.15	-0.1	-0.05	+0.05	+0.1	+0.15	+0.2	+0.3	+0.35	+0.4
20 .. 25 .. ..	-0.2	-0.15	-0.1	-0.05	+0.05	+0.1	+0.15	+0.2	+0.3	+0.35	+0.4
25 .. 30 .. ..	-0.2	-0.15	-0.1	-0.05	+0.05	+0.1	+0.15	+0.25	+0.3	+0.35	+0.4
30 .. 35 .. ..	-0.2	-0.15	-0.1	-0.05	+0.05	+0.1	+0.15	+0.25	+0.3	+0.35	+0.45
35 .. 40 .. ..	-0.2	-0.15	-0.1	-0.05	+0.05	+0.1	+0.2	+0.25	+0.3	+0.35	+0.45
40 .. 45 .. ..	-0.25	-0.15	-0.1	-0.05	+0.05	+0.1	+0.2	+0.25	+0.35	+0.4	+0.5
45 .. 50 .. ..	-0.25	-0.2	-0.1	-0.05	+0.05	+0.15	+0.2	+0.25	+0.35	+0.4	+0.5
50 .. 55 .. ..	-0.25	-0.2	-0.1	-0.05	+0.05	+0.15	+0.2	+0.25	+0.35	+0.4	+0.5
55 .. 60 .. ..	-0.25	-0.2	-0.15	-0.05	+0.05	+0.15	+0.2	+0.3	+0.35	+0.45	+0.55
60 .. 65 .. ..	-0.3	-0.2	-0.15	-0.05	+0.05	+0.15	+0.25	+0.35	+0.4	+0.5	+0.6
65 .. 70 .. ..	-0.3	-0.2	-0.15	-0.05	+0.1	+0.15	+0.25	+0.35	+0.4	+0.5	+0.6
70 .. 75 .. ..	-0.35	-0.25	-0.15	-0.05	+0.1	+0.15	+0.3	+0.4	+0.5	+0.6	+0.7
75 .. 80 .. ..	-0.4	-0.3	-0.2	-0.1	+0.1	+0.2	+0.3	+0.45	+0.55	+0.6	+0.7
80 .. 85 .. ..	-0.5	-0.4	-0.25	-0.1	+0.1	+0.25	+0.35	+0.5	+0.6	+0.7	+0.8
85 .. 90 .. ..	-0.7	-0.5	-0.3	-0.1	+0.1	+0.3	+0.4	+0.55	+0.6	+0.7	+0.8
90 .. 95 .. ..	-0.6	-0.45	-0.25	-0.1	+0.1	+0.25	+0.35	+0.45	+0.6	+0.7	+0.85
95 .. 100 .. ..	-0.45	-0.35	-0.2	-0.1	+0.1	+0.2	+0.35	+0.45	+0.55	+0.7	+0.85

For 85° F.

Expansion of Proof-spirit from 60° F. to 85° F. = 1.0125 approx.

$\therefore$  sp. gr. of  $\frac{\text{Proof-spirit}}{\text{Aq. } 62^\circ \text{ F.}}$  at 85° F. =  $\frac{0.919967}{1.0125} = 0.9086$  nearly.

For expansion of the hydrometer from 62° F. to 85° F.

if for glass instruments add 0.0003 to the above,

if for brass instruments add 0.0007 to the above.

The hydrometer-indication required, therefore, is that hydrometer-indication in Table B which corresponds,

if for glass instruments, to a sp. gr. of 0.9086 + 0.0003 = 0.9089,

if for brass instruments, to a sp. gr. of 0.9086 + 0.0007 = 0.9093, that is, for glass hydrometers, an hydrometer-indication = 53.1

and for brass hydrometers, an hydrometer-indication = 53.3

## A RAPID AND ACCURATE METHOD FOR THE DETERMINATION OF CARBON IN IRON AND ITS ALLOYS.

BY DR. ERNST SZASZ, DÍEGYÖR, HUNGARY.

Recently I described in a German journal (Z. angew. Chem., 1913, I., 281) a method for the gas-volumetric determination of carbon in iron by dry combustion, which

\* By "net proof-strengths" is meant that e.g. 60° u.p. is 40° "net proof strength," 25° u.p. is 75° "net proof strength," and 40° u.p. is 140° "net proof strength."