VI.—On the Vapour-pressures of Mercury.

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IN a recent paper in the Transactions (1885, 640—657), we described a method by which constant known temperatures could be maintained with great exactitude. In the tables which conclude that paper, Regnault's determinations of the vapour-pressures of mercury have been accepted as correct; on revision, however, they appear to be by no means so trustworthy as most of his work. In vol. 26 of the *Mémoires de l'Académie* Regnault quotes results described in vol. 21, p. 502, and uses these results for determining the formula devised by him to express the relation between temperature and pressure at low temperatures. On reference to vol. 21, it is evident from Regnault's own remarks, that he placed little confidence in the accuracy of his results. His words are as follows:—"Ces deux séries d'expériences diffèrent notablement quand on compare les valeurs relatives qu'elles donnent pour les forces élastiques de la vapeur mercurielle; mais les différences absolues que l'on trouve entre les forces élastiques sont réellement très-petites, et de l'ordre de l'incertitude des observations. Les expériences précédentes suffisent néanmoins pour montrer que la tension de la vapeur de mercure à 100° est d'environ 0·5 mm.; et qu'à la température de 50°, elle s'élève à peine à 0·1 mm. Elle est donc à peu près négligeable au dessous de 50°." These words refer to temperatures below 100°. In a footnote he proceeds—"J'ai fait quelques déterminations de la tension de vapeur du mercure à des températures plus élevées, en chauffant le ballon dans un bain d'huile. Vers 200° les expériences sont devenues évidemment fautives, par suite de la distillation du mercure. Quoiqu'il en soit, voici les nombres que j'ai obtenu : *il convient de ne les regarder que comme des approximations.*" (The italics are ours.) His numbers then follow. They are the results of eleven readings, and these are all which he gives at temperatures below 250°. He also refers in vol. 26 to four determinations given in vol. 21, p. 230, made at the boiling point of mercury under atmospheric pressure, for the purpose of comparing his mercurial and air thermometers. His method in this instance differed essentially from the other methods employed; it consisted in heating an air reservoir terminating in a capillary tube in the vapour of mercury boiling under atmospheric pressure, sealing the tube, and when cold, breaking the point off under mercury, and measuring the contraction of the air. These four experiments gave fairly concordant results, but owing to an evident misquotation in vol. 26, it is not

quite certain to what pressures his symbols h and h_0 refer, as from h the mean of the four determinations would give the pressure 767·43, while from h_0 765·29 is the mean. But as the temperatures themselves differ by nearly 2° at the same pressure, this slip is an unimportant one. At higher pressures, Regnault employed a large iron still, containing 50 kilos. of mercury, into which dipped an iron tube containing the air thermometer. By applying pressure from an air reservoir, the boiling point of the mercury was regulated and observed. He states that the temperature was observed as soon as it had become constant, and the observations were repeated until it began to rise, by which time the greater part of the mercury had distilled over. He directs attention to the fact that, using this method, the temperatures are those of the boiling liquid, and not of the vapour. During distillation, the noise of the bumping was compared to blows of a hammer on an anvil. That these results cannot be relied on is shown by those referring to the atmospheric pressure, where a fall of 7·4 mm. in pressure corresponds to a rise of temperature of $1\cdot86^\circ$; and the mean temperature (about $355\cdot4^\circ$) by no means corresponds with that obtained by the method previously described ($358\cdot5^\circ$). It is obvious that good results cannot be anticipated under such conditions.

The importance of a correct knowledge of the vapour-pressures of mercury is evident, when it is considered that they enter into all calculations of the determinations of vapour-pressures of liquids by the usual method at high temperatures; and that they must be allowed for in determining vapour-densities by Hofmann's apparatus. Moreover, it is probable that thermometers based on a knowledge of the vapour-pressure of mercury will become available for accurate determinations of high temperatures.

Owing to the discovery of certain relations between the vapour-pressures of different substances, which are described in the *Philosophical Magazine* for December, 1885, and January, 1886, we have been able, with small expenditure of time and labour, to obtain results which we think will be generally accepted as correct. Before describing the experiments, a short description of the generalisations may render the process intelligible. Although some of these apparently have little connection with the matter in question, yet from thermodynamical considerations, they are so interlaced, that we deem it advisable to state them all. For detailed description and proof of the following statements, we would refer to the articles already mentioned.

1. The amount of heat required to produce unit increase of volume in the passage from the liquid to the gaseous state at the boiling point under normal pressure, is approximately constant for all substances.

2. If the amounts of heat required to produce unit increase of volume in the passage from the liquid to the gaseous state be compared at different pressures for any two bodies, then the ratio of this amount at the boiling point under a pressure p_1 to the amount at another pressure, p_2 , is approximately constant.

3. It appears probable, from the few data at present available, that if a diagram be constructed in which the ratios at the same pressure between the heats of vaporisation of two liquids, at various pressures, the same for both, form the abscissæ, and the absolute temperatures of one of the two liquids, corresponding to those vapour-pressures, form the ordinates, then the points representing the relations between these ratios and the absolute temperatures will lie in a straight line.

4. The products of the numbers representing the absolute temperature into the increase of pressure per unit rise of temperature at those temperatures, are approximately the same for all substances at the same vapour-pressure; but the differences are real and are not due to error of experiment or calculation.

5. The rate of increase of this product with rise of pressure is very nearly constant for all bodies.

6. The deviation from constancy presents the following relations:— If a diagram be constructed in which the ratios at definite pressures of the product referred to in (4) for any two substances be made the abscissæ, and the absolute temperatures of one of the bodies at corresponding vapour-pressures be made the ordinates, then the points representing the relations of these two quantities will fall in a straight line.

7. A relation exists between the ratios of the absolute temperatures of all bodies, whether solid or liquid, whether stable or dissociable, which may be expressed in the case of any two bodies by the equation $R' = R + c(t' - t)$; where R is the ratio of the absolute temperatures of the two bodies, corresponding to any vapour-pressure, the same for both; R' , the ratio at any other pressure, again the same for both; c , a constant, which may equal 0 or a small plus or minus number; and t' and t the temperatures (absolute or centigrade) of one of the bodies corresponding to the two vapour-pressures.

When $c = 0$, $R' = R$, or the ratio of the absolute temperatures is a constant at all pressures; and when $c > 0$, or $c < 0$, its value may readily be determined either by calculation, or graphically by representing the (absolute) temperatures of one of the two bodies as ordinates, and the ratio of the absolute temperatures at pressures corresponding to the (absolute) temperatures of that body as abscissæ. It is found in all cases that points representing the relation of the ratio of the absolute temperatures of the two bodies to the (absolute) temperature of one of them fall in a straight line.

On comparing such relations for different substances of which the vapour-pressures had been accurately determined, in twenty-three cases, this relation was found to hold absolutely; for on calculating by means of this ratio the absolute temperatures of these substances corresponding to given pressures, the differences observed between calculated and experimental results fall well within the limits of experimental error. On using Regnault's determinations of the vapour-pressures of mercury, the case was different. Here a curve, instead of a straight line, was obtained. Now it is evident that if satisfactory proof can be given that certain temperatures, sufficiently far removed from each other, when compared with the ratios between these absolute temperatures of mercury and some other liquid of known vapour-pressure, *e.g.*, water, give points which fall in a straight line, the value of *c* is calculable, and as a consequence, the whole vapour-pressure curve of mercury. Mercury also formed the only exception to statements (5) and (6).

The temperatures chosen were—(1) the boiling point of methyl salicylate under atmospheric pressure; (2) the boiling point of bromonaphthalene under a pressure of 612.8 mm.; (3) the same under a pressure of 756.2 mm.; (4) more reliance is to be placed on the boiling point of mercury under atmospheric pressure, determined by Regnault, described in vol. 21 of the *Mémoires*, as the method he adopted seems to deserve greater confidence than his later method; and the mean of his four results may be taken as fairly correct; (5) the boiling point of sulphur under atmospheric pressure, determined by Regnault. For the accuracy of our knowledge of the first three of these temperatures reference must be made to the *Transactions* (1885, p. 640 *et seq.*).

Regnault determined the vapour-pressures of sulphur, using an apparatus similar to that with which he determined the vapour-pressures of mercury. He did not find it necessary to fill the still with liquid sulphur, and the boiling took place quietly, without bumping. He appears to place more reliance on his determinations of the vapour-pressures of sulphur than on those of mercury; and this conclusion is borne out by our experience; for on comparing the vapour-pressures of sulphur with those of carbon disulphide, the ratios of the absolute temperatures form with the absolute temperatures of carbon disulphide, or sulphur, a straight line, when considered as described in statement (7), and the results agree remarkably well with statements (4), (5), and (6). It is obvious that the temperature of the boiling point of sulphur under atmospheric pressure really amounts to an indirect reading of Regnault's air thermometer; and for the above-mentioned reasons we believe that the temperature in this case is correct.

For the determinations of the vapour-pressure of mercury, the process adopted in our late experiments was employed; and the apparatus is represented in a woodcut on p. 643 of the Transactions for 1885, modified as described on p. 651. A description is therefore unnecessary here.

(1.) The detailed results are as follows :—

Closed limb of apparatus.	Open limb of apparatus.	Δ .	Δ at 0°.	Pressure A at 0°.	Pressure B at 0°.	Vapour pressure of mercury.	Mean.
703·8	704·5	- 0·7	- 0·7	34·9	35·1	34·3	} 34·4
704·2	705·0	- 0·8	- 0·8	35·2	35·2	34·4	
701·1	708·0	- 6·9	- 6·65	—	41·05	34·4	
704·3	704·1	+ 0·2	+ 0·2	34·1	34·2	34·45	

NOTE.—Two gauges and barometers were used, lettered A and B respectively. The mean reading of the two was taken.

The pressure under which the methyl salicylate boiled was 746·95 mm. (reduced to 0°), and the corresponding temperature 222·15°. The mean observed vapour-pressure of mercury at this temperature is accordingly 34·4 mm.

(2) and (3.) The detailed results of our observations with bromonaphthalene are given in our previous paper (*loc. cit.*). The numbers are as follows :—

Pressure of bromonaphthalene vapour.	Pressure of mercury vapour.	Temperature from Regnault's data.
756·2 mm.	157·15 mm.	280·6°
612·8 „	124·35 „	270·35°.

These temperatures are calculated from Regnault's formula for the vapour-pressures of mercury, and were made use of in determining the position of the curve representing the relations of temperature to pressure for bromonaphthalene. It was noticed at the time that this curve would not pass through both points representing the temperatures of the bromonaphthalene; and as other readings had been taken with a mercury thermometer previously compared with an air thermometer, confirming the lower temperature, it was judged right to construct the curve on this basis. Reading then from the curve we adopted, the higher temperature becomes 280·2°, instead of 280·6°. The justice of this correction has since been confirmed by a study of the relations between the absolute temperatures of bromonaphthalene and water.

(4.) The relations obtained for mercury at the atmospheric pres-

sure by Regnault have already been considered. They are as follows:—

Temperature.	H_1 .	H_0 .
358·46°	769·59 mm.	770·27 mm.
357·48	768·40 „	766·76 „
359·27	768·08 „	766·11 „
358·68	763·65 „	758·02 „

H_1 and H_0 are the barometric heights at the moment of closing the air thermometer, and of breaking the point off under mercury; but it is uncertain from the text which symbol is to be used for the one and which for the other. The mean temperature is 358·47°; the mean of h_1 is 767·43 mm.; and the mean of h_0 , 765·29 mm.

(5.) In order to determine the vapour-pressure of mercury at the boiling point of sulphur, a new form of apparatus was employed, which is shown in the accompanying figure.

The apparatus AA' is constructed of barometer tubing of small bore. At the end A is blown a bulb so adjusted as regards size that the volume of the bulb is approximately equal to that of the horizontal portion of the stem, and when cold, containing mercury to the mark *a*. B is a vessel containing sulphur; in one experiment this was a flask, as shown; in the other, a wide test-tube. On applying heat, the sulphur vapour could be caused to completely surround the bulb A. The mouth of the flask was loosely closed with cotton-wool, to prevent escape of sulphur vapour, or the formation of air currents. C is a jacketing tube in the form of a Liebig's condenser, whereby the horizontal portion of AA' could be maintained at a constant known temperature, shown by the thermometer D.

The tube AA' was first graduated in millimetres from about *a* to the end; it was then exhausted, filled with mercury, and repeatedly

boiled out under atmospheric pressure, until air bubbles ceased to come off from the glass. The end A' was next drawn out to a capillary tube, and was exhausted repeatedly with a Sprengel's pump, dry air, which had stood in contact with phosphorus pentoxide for some time, being admitted after each exhaustion. While the capillary tube was still connected with a small drying tube of pentoxide, the tube AA' was placed in a vertical position in a wide tube through which a current of water of constant known temperature ran; the capillary end of AA' projected just above the surface of the water. The temperature of the water and the atmospheric pressure were then read, and the capillary was sealed, the position of the mercury in the tube being noted at the same moment. From these data, the volume of the air at known temperature and pressure was subsequently ascertained. The apparatus was then arranged as shown in the figure, and the sulphur made to boil. The ebullition took place quietly and easily, and thin deposit of liquid sulphur on the sides of the flask made it certain that the vapour was not superheated. Had this not been the case, the bulb would have been surrounded with asbestos. When the mercury in the bulb had become hot, it was driven by the pressure of its vapour nearly out of the bulb, and was forced along the horizontal portion of the tube, as far as *b*, compressing the air. The position of *b* was then read, and the temperature of the water in the jacket C was noted. The barometric pressure was also read, so as to determine the temperature of the sulphur vapour. When cold, the tube was broken close to the bend, and calibrated by weighing with mercury. The pressure of the mercury vapour in the bulb is equal to that of the air in the gauge, plus the pressure of a column of mercury equal to the vertical distance between the level of the mercury in the bulb and that in the horizontal portion of the tube, this column being corrected for temperature.

The detailed results are as follows:—

I. (1.) Air at atmospheric pressure:—

Temperature.	Pressure (reduced to 0°).	Volume.
16·20°	743·7 mm.	0·91690 c.c.

(2.) Air at high pressure:—

Temperature.	Volume.
16·60°	0·24440 c.c.

Pressure calculated from above data, 2794·0 mm.

(3.) Column of mercury heated to 450°, 57 mm.

“ “ “ about 100°, 51 mm.

These reduced to 0° become 52·8 mm. and 50·1 mm. respectively.

The total pressure of the mercury vapour is therefore $2794 + 52.8 + 50.1 = 2896.9$ mm.

(4.) The barometric pressure when the sulphur was boiling was 742.6 mm. (reduced to 0°), and the corresponding temperature was 447.0° .

II. (1.) Air at atmospheric pressure :—

Temperature.	Pressure.	Volume.
16.24°	752.3 mm.	0.53546 c.c.

(2.) Air at high pressure :—

Temperature.	Volume.
15.40°	0.14385 c.c.

Pressure calculated from above data, 2791.0 mm.

(3.) Column of mercury heated to 450° , 52.5 mm.

„ „ „ about 100° , 66.0 mm.

These reduced to 0° become 48.6 mm. and 64.9 mm. respectively. The total pressure of the mercury vapour is therefore $2791 + 48.6 + 64.9 = 2904.5$ mm.

(4.) The barometric pressure when the sulphur was boiling was 754.4 mm. (reduced to 0°), and the corresponding temperature was 448.0° .

The whole of these results are shown in the following table :—

Temperature (centigrade).	Temperature (absolute).	Pressure.	Absolute temperature of water at pressure p .	Ratio of absolute temperature.
222.15°	495.15°	34.40 mm.	304.5°	1.6262
270.30	543.30	124.35 „	329.2	1.6504
280.20	553.20	157.15 „	334.2	1.6553
358.46	631.46	$\left\{ \begin{array}{l} h_1 \text{ 769.59} \\ h_0 \text{ 770.27} \end{array} \right.$ „	$\left\{ \begin{array}{l} 373.35 \\ 373.37 \end{array} \right.$	$\left. \begin{array}{l} \\ \end{array} \right\} 1.6913$
357.48	630.48	$\left\{ \begin{array}{l} h_1 \text{ 768.40} \\ h_0 \text{ 766.76} \end{array} \right.$ „	$\left\{ \begin{array}{l} 373.30 \\ 373.25 \end{array} \right.$	$\left. \begin{array}{l} 1.6889 \\ 1.6892 \end{array} \right.$
359.27	632.27	$\left\{ \begin{array}{l} h_1 \text{ 768.08} \\ h_0 \text{ 766.11} \end{array} \right.$ „	$\left\{ \begin{array}{l} 373.29 \\ 373.22 \end{array} \right.$	$\left. \begin{array}{l} 1.6938 \\ 1.6941 \end{array} \right.$
358.68	631.68	$\left\{ \begin{array}{l} h_1 \text{ 763.65} \\ h_0 \text{ 758.02} \end{array} \right.$ „	$\left\{ \begin{array}{l} 373.13 \\ 372.93 \end{array} \right.$	$\left. \begin{array}{l} 1.6930 \\ 1.6938 \end{array} \right.$
447.0	720.0	2896.9 „	415.26	1.7338
448.0	721.0	2904.5 „	415.36	1.7359

The accompanying diagram, in which the ratios are represented as abscissæ, and the absolute temperatures of mercury in one case and of water in the other are the ordinates, represents the results obtained.

The ratios calculated from Regnault's determinations give the dotted curve with absolute temperatures of water as ordinates.

It will be noticed that in each case a straight line can be drawn through all the points. The value of c , if the temperatures of mercury are chosen as ordinates, is 0.0004788; if those of water are chosen, it is 0.0009792.

The calculations of the vapour-pressures of mercury from these two constants give slightly different results; but the difference within the limits of temperature given in the ensuing tables is unimportant, although at higher temperatures it might become considerable. It was more convenient to employ the constant derived from the abso-

late temperatures of mercury; and we now proceed to show the method of calculation.

A point was read from the straight line, giving the ratio at any one temperature. The absolute temperature of water was calculated from the ratio. The vapour-pressure of water corresponding to this temperature is the same as that of the mercury, inasmuch as the ratios refer to equal pressures. Thus, at an absolute temperature of mercury of 508° , the ratio as read from the line was 1.6331. The absolute temperature of water was therefore $\frac{508}{1.6331} = 311.06^{\circ}$. The vapour-pressure of water at 311.06° , ascertained from Regnault's tables is 49.466 mm., and this is therefore the vapour-pressure of mercury at an absolute temperature of 508° . The ratios corresponding to other absolute temperatures of mercury were calculated from the equation $R' = R \pm c(t' - t)$, the value of R being 1.6331, as given above. Of course other ratios might have been read from the straight line; but it seemed better to employ the factor 0.0004788 in the calculation.

The data employed and the results of this calculation are as follows:—

Temperature (centigrade).	Absolute temperature of mercury.	Ratio.	Absolute temperature of water.	Vapour- pressure.
135°	408°	1.585220	257.38°	1.409 mm.
140	413	1.587614	260.14	1.754 "
145	418	1.590008	262.89	2.172 "
150	423	1.592402	265.64	2.680 "
155	428	1.594796	268.37	3.287 "
160	433	1.597190	271.10	4.013 "
165	438	1.599584	273.82	4.879 "
170	443	1.601978	276.53	5.904 "
175	448	1.604372	279.24	7.116 "
180	453	1.606766	281.93	8.535 "
185	458	1.609160	284.62	10.204 "
190	463	1.611554	287.29	12.137 "
195	468	1.613948	289.98	14.403 "
200	473	1.616342	292.64	17.015 "
205	478	1.618736	295.30	20.028 "
210	483	1.621130	297.95	23.482 "
215	488	1.623524	300.59	27.447 "
220	493	1.625918	303.22	31.957 "
225	498	1.628312	305.84	37.083 "
230	503	1.630706	308.46	42.919 "
235	508	1.633100	311.06	49.466 "
240	513	1.635494	313.67	56.919 "
245	518	1.637888	316.26	65.241 "
250	523	1.640282	318.85	74.592 "
255	528	1.642676	321.42	85.010 "
260	533	1.645070	324.00	96.661 "

VAPOUR-PRESSURES OF MERCURY.

Temperature (centigrade).	Absolute temperature of mercury.	Ratio.	Absolute temperature of water.	Vapour- pressure.
265°	538°	1·647464	326·55°	109·556 mm.
270	543	1·649858	329·11	123·905 "
275	548	1·652252	331·66	139·802 "
280	553	1·654646	334·21	157·378 "
285	558	1·657040	336·75	176·733 "
290	563	1·659434	339·28	197·982 "
295	568	1·661828	341·80	221·251 "
300	573	1·664222	344·31	246·704 "
305	578	1·666616	346·81	274·443 "
310	583	1·669010	349·31	304·794 "
315	588	1·671404	351·80	337·753 "
320	593	1·673798	354·28	373·528 "
325	598	1·676192	356·75	412·249 "
330	603	1·678586	359·22	454·277 "
335	608	1·680980	361·68	499·656 "
340	613	1·683374	364·14	548·715 "
345	618	1·685768	366·59	601·583 "
350	623	1·688162	369·04	658·515 "
355	628	1·690556	371·48	719·772 "
360	633	1·692950	373·91	785·107 "
365	638	1·695344	376·33	855·223 "
370	643	1·697738	378·75	930·335 "
375	648	1·700132	381·16	1010·47 "
380	653	1·702526	383·56	1096·22 "
385	658	1·704920	385·95	1186·67 "
390	663	1·707314	388·34	1283·71 "
395	668	1·709708	390·72	1386·60 "
400	673	1·712102	393·09	1495·60 "
405	678	1·714496	395·45	1611·19 "
410	683	1·716890	397·81	1733·79 "
415	688	1·719284	400·16	1863·36 "
420	693	1·721678	402·50	2000·21 "
425	698	1·724072	404·85	2145·57 "
430	703	1·726466	407·19	2298·80 "
435	708	1·728860	409·51	2459·41 "
440	713	1·731254	411·83	2628·79 "
445	718	1·733648	414·15	2807·53 "
450	723	1·736042	416·47	2996·06 "
455	728	1·738436	418·77	3192·69 "
460	733	1·740830	421·07	3399·50 "
465	738	1·743224	423·36	3616·22 "
470	743	1·745618	425·65	3843·68 "
475	748	1·748012	427·92	4080·10 "
480	753	1·750406	430·18	4327·14 "
485	758	1·752800	432·44	4585·95 "
490	763	1·755194	434·70	4856·74 "
495	768	1·757588	436·96	5139·89 "
500	773	1·759982	439·21	5434·99 "
505	778	1·762376	441·45	5741·86 "
510	783	1·764770	443·67	6059·16 "
515	788	1·767164	445·90	6391·49 "
520	793	1·769558	448·12	6736·60 "

In calculating pressures below 4·6 mm., Regnault's formula

expressing the relation between temperature and pressure of water between 0° and 100° has been employed.

As it was impossible to calculate the vapour-pressure of mercury below 135° , owing to our ignorance of the vapour-pressure of water at low temperatures; and as a knowledge of the lower vapour-pressures of mercury is necessary, the constants of a formula of the form employed by Regnault in calculating the vapour-pressures of water below 0° were calculated. The formula is—

$$\log p = a + bx^t.$$

In calculating this formula, the temperatures and pressures made use of in determining the value of the constants were as follows:—

Temperatures.	Pressures.
160°	4.013 mm.
220	31.957 „
280	157.378 „

The constants are therefore—

$$\begin{aligned} a &= 4.493745 & \log b &= 0.5899797 \\ b &= -3.890276. \\ t &= t^{\circ} \text{C.} - 160 & \log \alpha &= 1.9980929. \end{aligned}$$

The table which follows shows the vapour-pressures of mercury at temperatures below 160° , calculated as above described.

Temp.	Pressure.	Temp.	Pressure.	Temp.	Pressure.
40°	0.008 mm.	100°	0.270 mm.	140°	1.763 mm.
50	0.015 „	110	0.445 „	145	2.181 „
60	0.029 „	120	0.719 „	150	2.684 „
70	0.052 „	130	1.137 „	155	3.289 „
80	0.092 „	135	1.419 „	160	4.013 „
90	0.160 „				

As these numbers are extrapolated from 220° , it appeared necessary to control them by a determination at a lower temperature. The vapour-pressure of mercury was therefore directly determined at the boiling point of chlorobenzene under a pressure of 754.2 mm., corresponding to a temperature of 131.8° , by the method employed for its determination at the boiling point of methyl salicylate. Twenty-three readings were taken, the level of the mercury in the vapour-pressure tube being altered from time to time. The mean result was 1.58 mm.; the mean probable error was 0.14 mm. The calculated pressure is 1.24 mm.; but we think that the experimental result is as

close as can be expected from the very small amount to be measured, and we regard it as a sufficient confirmation of the accuracy of the table given above. At 132° Regnault's pressure is 2·30 mm., and this is manifestly too high.

In order to afford data whereby the temperatures of mercury vapour used as a jacket may be easily ascertained from the read pressure, we append a table of the vapour-pressures for each degree centigrade. This table is to be substituted for the one published in the *Trans.*, 1885, p. 656.

The results given were smoothed by the method of differences, and each degree was calculated by differences.

Temp.	Pressure.	Temp.	Pressure.	Temp.	Pressure.
270°	123·92 mm.	301°	252·18 mm.	332°	472·12 mm.
271	126·97 "	302	257·65 "	333	481·19 "
272	130·08 "	303	263·21 "	334	490·40 "
273	133·26 "	304	268·87 "	335	499·74 "
274	136·50 "	305	274·63 "	336	509·22 "
275	139·81 "	306	280·48 "	337	518·85 "
276	143·18 "	307	286·43 "	338	528·63 "
277	146·61 "	308	292·49 "	339	538·56 "
278	150·12 "	309	298·66 "	340	548·64 "
279	153·70 "	310	304·93 "	341	558·87 "
280	157·35 "	311	311·30 "	342	569·25 "
281	161·07 "	312	317·78 "	343	579·78 "
282	164·86 "	313	324·37 "	344	590·48 "
283	168·73 "	314	331·08 "	345	601·33 "
284	172·67 "	315	337·89 "	346	612·34 "
285	176·79 "	316	344·81 "	347	623·51 "
286	180·88 "	317	351·85 "	348	634·85 "
287	185·05 "	318	359·00 "	349	646·36 "
288	189·30 "	319	366·28 "	350	658·03 "
289	193·63 "	320	373·67 "	351	669·86 "
290	198·04 "	321	381·18 "	352	681·86 "
291	202·53 "	322	388·81 "	353	694·04 "
292	207·10 "	323	396·56 "	354	706·40 "
293	211·76 "	324	404·43 "	355	718·94 "
294	216·50 "	325	412·44 "	356	731·65 "
295	221·33 "	326	420·58 "	357	744·54 "
296	226·25 "	327	428·83 "	358	757·61 "
297	231·25 "	328	437·22 "	359	770·87 "
298	236·34 "	329	445·75 "	360	784·31 "
299	241·53 "	330	454·41 "		
300	246·81 "	331	463·20 "		

The result of this investigation, we venture to think, furnishes a most convincing proof of the justice of the generalisations on which it is based.

ADDENDUM.

Since reading the above paper, Professor Herbert McLeod has kindly directed our attention to two memoirs on the same subject, one by Hagen (*Ann. Phys. Chem.*, N.F., **16**, 610), and one by Hertz (*ibid.*, N.F., **17**, 193). The methods employed by both these experimenters in measuring temperature are open to criticism. Hagen's experiments appear to have been conducted with very great care; but the results are abnormal, for he finds a pressure which must be greatly in excess of the truth at low temperatures. Hertz employed a method analogous to ours, and the closeness of the coincidence between his results and ours is remarkable, when it is remembered that ours are extrapolated from measurements at much higher temperatures, the correctness of which was confirmed by their agreement with the relations mentioned in our paper. We think it advisable to reproduce their numbers at low temperatures, comparing them with those of Regnault and ourselves.

Temperature.	Regnault.	Hagen.	Hertz.	Ramsay and Young.
0°	0·02 mm.	0·015	0·00019	—
10	0·0268 "	0·018	0·00050	—
20	0·0372 "	0·021	0·0013	—
30	0·0530 "	0·026	0·0029	—
40	0·0767 "	0·033	0·0063	0·008
50	0·1120 "	0·042	0·013	0·015
60	0·1643 "	0·055	0·026	0·029
70	0·2410 "	0·074	0·050	0·052
80	0·3528 "	0·102	0·093	0·092
90	0·5142 "	0·144	0·165	0·160
100	0·7455 "	0·210	0·285	0·270
120	1·5341 "	—	0·779	0·719
140	3·0592 "	—	1·93	1·763
160	5·9002 "	—	4·38	4·013
180	11·000 "	—	9·23	8·535
200	19·90 "	—	18·25	17·015
220	34·70 "	—	34·90	31·957