Citation:

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leum ether and ordinary ether. The substance was dissolved in a little ether and the solution poured into a glass basin when the acid was obtained in beautiful crystals.

After exposure to full sunlight for seventeen mornings an examination was made to see what change had taken place.

It was very plain that the substance was no longer the same, as it consisted of a quite opaque mass whereas the original crystals were beautifully transparent.

It exhibited no definite melting point; at 95° it became somewhat soft to finally melt completely at 165°. Only a portion dissolved in ether. The undissolved mass melted just above 200° (β-truxillic acid melts at 206°). In ammoniacal solution it gave a heavy precipitate with barium chloride and the acid isolated therefrom melted at 206°; when mixed with β-truxillic acid, isolated from the coca-acids, the melting point remained unchanged.

From the ethereal solution a further quantity of β-truxillic acid was obtained and also α-truxillic acid, ordinary cinnamic acid and a trace of oil.

In all, 0.64 gram of β-truxillic acid, 0,1 gram of α-truxillic acid and 0.2 gram of cinnamic acid were obtained. The α-truxillic acid has been formed in all probability, from the ordinary cinnamic acid. Whether β-truxillic acid is formed from two mols. of *allo*cinnamic acid or from one mol. of *allo-* and one mol. of ordinary cinnamic acid (generated from *allo*cinnamic acid) will be further investigated.

Physics. — *"Isotherms of diatomic gases and of their binary mixtures.* VIII. *Control measurements with the volumenometer".* By W. J. DE HAAS. Communication N°. 121*a* from the Physical Laboratory at Leiden. (Communicated by Prof. KAMERLINGH ONNES).

(Communicated in the meeting of April 28, 1911).

§ 1. *Introduction.* With a view to the determination of the compressibility of hydrogen vapour, Prof. KAMERLINGH ONNES invited me to make a special study of the volumenometer (see Comm. N°. 84) with which these measurements were to be made; the results of this particular investigation are given in the present paper, and, at the same time I have described the improvements mentioned in Comm. N°. 117 which were specially introduced for the measurement of the compressibility of hydrogen vapour, and to which reference was then made as to be described later in another paper dealing with that investigation.

The measurements intended necessitated great accuracy in determinations with the volumenometer. While in the researches described in Comm. N°. 117 the volume of the gases which were admitted from the dilatometer to the volumenometer could be measured under pretty high pressures (1—½ atm.), and consequently those pressures had to be known with certainty only to 0.05 mm., it is desirable in a determination of the compressibility of hydrogen at very low temperatures (—259 to —252°C.), to measure pressures which may be as low as 10 cm. to one five-thousandth of their value, so that in this case an accuracy of 0.02 mm. is essential. The lowness of the pressures to be measured necessitates a very high degree of accuracy in the pressure measurements. My object in the present investigation was to see in what way these high demands could be satisfied, [1] and to make sure that such was actually the case in the results obtained.

§ 2. *Constants. I. Determinations of the Volumes.*

As has already been mentioned in Comm. N°. 117 § 3, the accurate volumenometer in use in the cryogenic laboratory [2] described in Comm. N°. 84 was re-calibrated, from which at the same time comparisons might be made with the data of Comms. N°. 88 and N°. 92 and an idea of the accuracy to be reached could be obtained. For this purpose a capillary tap with a fine drawn out nozzle was fused to the lower end of the air-trap at Eb_0 (Pl. I. Comm. No. 84). The calibrations were made with mercury with which the apparatus was filled under high vacuum. During the progress of the calibrations the temperature of the volumenometer was kept constant to within $^1/_{40}$th of a degree by means of the thermostat described in § 5) [3].

1) A discussion of the degree of accuracy which was then reached was given by KEESOM in Comm. N°. 88 (1903).

2) The volumenometer with its auxiliary apparatus is shown on the left hand side of Pl. I Comm. N°. 117 to which belongs fig. 1 Pl. I of Comm. N°. 84, along with the modifying diagram shown on fig. 2 Pl. I of this Communication. In connection with fig. 2 Pl. I. see also § 4 of this paper. For the arrangement of the volumenometer, scale, cathetometer, etc., see Comm. N°. 117. For description of the thermostat see § 5 of this Communication

3) Before proceeding to calibrate the apparatus it was thoroughly cleaned both inside and out. In this process the screen Eg_1 (Pl. I, Comm. N°. 84) was replaced by a new one, and the optical properties of the glass windows in the jacket were investigated before the latter were replaced.

TABLE I.

Volumes between the marks.

	Individual measure-ments.	Mean.	Deviations from mean.	Former (1902) calibration.	Differences between the two calibrations.
Bulb Eb_2 [2])	microliters				
1st calib.	25220	25229	1/5000		
2nd „	25233				
3rd „	25226				
4th „	25236				
Bulb I.					
1st calib.	252584	252589	1/50000	252555	1/8000
2nd „	252594				
Bulb II.					
1st calib.	253565	253550	1/17000	253572	1/12000
2nd „	253537				
Bulb III and IV.					
1st calib.	505640 ⁰	505640 ³	1/2000000	505650	1/50000
2nd „	505640 ⁶				
Bulb V.					
1st calib.	252854	252845	1/25000	1) No compari-son possible.	
2nd „	252837				

Each of the bulbs Eb_1 (I, II, III, IV and V of fig. 1 Pl. I Comm. N°. 117) was calibrated twice, the auxiliary bulb Eb_2 (cf. Pl. I Comm. N°. 84) and the connecting neck Eb_3 were each calibrated four times. The foregoing table contains the old and the new calibrations all of which are reduced to 20° C. From the excellent correspondence obtained, it appears that the screen-method is quite reliable, for the positions of the screens on the connecting necks have not altered in any way since Comm. N°. 84 (1902). At the same time it is evident that the volumenometer is capable of determining volumes accurately

[2]) This was not calibrated in 1902.

to $^1/_{10000}$ as long as the volumes of the mercury menisci are known with sufficient accuracy.

§ 3. *II. Determinations of the optical constants.*

1st. Owing to the prismatical shape of the windows in the jacket through which the volumenometer was observed, and 2nd to the circumstance that their surfaces were not accurately vertical, an optical correction had to be applied to the height readings in the volumenometer. The latter correction may be regarded as composed of two distinct parts, 1st. a correction in consequence of the deviation from 90° of the inclination to the horizon of the long axis of the apparatus in the plane of incidence, and 2nd. a correction in consequence of the angle α_i made at any point i by the outer surface with the long axis of the apparatus.

Of these the first was determined every time from the deviations of a plumb line arranged so that when pointing at the corresponding mark it is parallel to the long axis of the apparatus, or from the deviations of a spirit level laid on a plane perpendicular to the long axis. Both this perpendicular plane and the plumb line mark were firmly attached to the apparatus. With a sufficiently careful observation with the plumb line an accuracy of 0.01 mm in the height readings can be attained. By reading the spirit level during this operation one can substitute the simpler level reading for the plumb line. When it is not desired to read to more than 0.05 mm. a simple reading with the plumb line is sufficient.

The angles between the front surfaces of the windows at any point i and the long axis of the apparatus are constants of the apparatus, and need to be re-determined only in the event of the windows being removed. The correction resulting from this angle may be evaluated in either of two ways.

1st *Method.* If the long axis of the apparatus is perfectly vertical the correction to be applied to a reading for a perfectly horizontal beam of light is, for small angles of incidence,

$$A\left(\theta - \frac{\theta}{n_{1.2}}\right)$$

in which A is the length of the path traversed by the light in water from the point on which the telescope is focussed to the front of the windows (in the apparatus used this distance was 8 cm.), θ is the angle [1]) between the normal to the windows and the horizontal

[1]) One can easily see that a difference of 1′ in the horizontal position of the telescope (when the distance between the objective and the focussed mark is ± 45 cm.) can have no effect upon an accuracy of 0,01 mm. nor can the deviation of light caused by the glass of the connecting necks when these are carefully constructed.

plane, and $n_{1.2}$ is the refractive index for air-water. The angle θ was measured by means of a combination level. For this purpose was used a level from a cathetometer by the Société Genevoise (1 scale division $= 0,'06$) placed upon an auxiliary apparatus (Pl. II fig. 1). This arrangement consisted of an arm R turned accurately cylindrical and attached perpendicularly to a heavy copper plate P. By means of the three adjusting screws a, b and c this plate R can so be placed against a glass comparison surface, which has been made accurately vertical that the level placed on the arm R indicates a perfectly horizontal position. The square end of the level is then pressed against the windows of the volumenometer jacket and the level is again brought to the horizontal. From the number of turns of the divided screw head of the screw c necessary to accomplish this, from the pitch of the screw c which has been determined beforehand, and from the known distance of the point of the screw c to the line ab the angle θ may be calculated. From this the error in the reading follows at once when the angle of refraction of the window is allowed for. (The application of the combination level assumes that the curvature is negligible, which will probably always be the case with plate glass for degrees of accuracy up to 0,05 mm.).

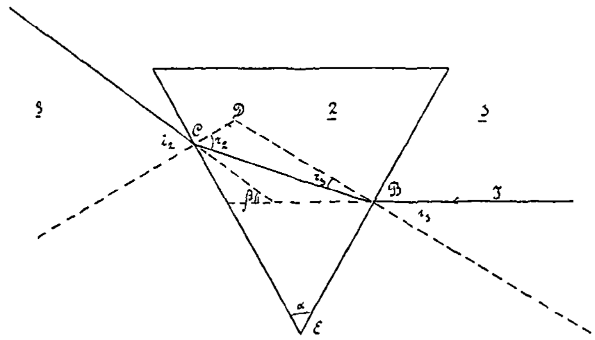
The results are given in Table III, column II (p. 111).

In our present experiments the auxiliary apparatus employed for the spirit level has not yet allowed us to attain with sufficient certainty an accuracy greater than that corresponding to an error of about 0′,3 (that is to say a correction of 0,01 mm.).

The 2nd *method* of determining the errors in the readings consists of obtaining readings of the heights of the middle mark on the screens when no water is in the jacket and also when the jacket is full. For simplicity this measurement is reduced to a determination of the change in height of one of the marks and the change in distance of the other mark from this one. For during the measurement of the differences in height for one mark a layer of water 8 cm. thick is alternately interposed and removed, and therefore the cathetometer must be moved as a whole so as to allow its being focussed upon the standard metre with which every care is taken to ensure its fixed position and to protect it against any temperature change. Absolute height measurements were rendered very tedious on account of this repeated moving of the cathetometer, while the determination of the alteration in the distances between two central lines was comparatively simple. The determinations of the changes in the distances of each line from the fundamental one were, in order to ensure the invariability of the lengths measured, reduced in every case to the determination of the changes in the distances between two successive central lines.

In the sequel the glass windows, even when they exhibit some curvature, are regarded as prisms, and it is assumed that each of the portions through which the screens are seen — even in the same piece of glass — has an individual angle of refraction. These angles of refraction α_1, α_2 etc., (projected upon the plane which during the height measurements coincides with the vertical plane through the axis of the telescope) were all measured beforehand.

The next figure (in which the ray is projected upon the vertical plane through the axis of the telescope) shows a window in which



the prismatic character is strongly accentuated so as to add to the clearness of the drawing. Let I be the incident ray which traverses the axis of the cathetometer telescope supposed horizontal. The media are represented by the indices 1, 2, and 3. Let β_0 represent the total deviation which the ray undergoes at the mark m_0 owing to refraction at the surfaces 1.2 and 2.3; for the sake of simplicity this total deviation will, in the sequel, be referred to as β as long as there is only a single mark involved.

Since

$$\beta = i_1 + i_2 - \alpha$$

we get

$$\beta = (n_{1.2} - 1)\, \alpha + r_2\, (n_{3.2} - n_{1.2}).$$

When there is no water in the volumenometer jacket it follows that

$$\beta = (n_{12} - 1)\, \alpha.$$

Hence, calling the distance of the front surface of the windows from the screens A, we get for the optical correction to be applied to the reading for a line on the screens

$$A\, r_2 (n_{3.2} - n_{1.2}).$$

This difference was repeatedly determined for one of the central lines, the one chosen being the central line of the middle screen, so as to make the deviation errors for the other lines as small as possible. In these measurements allowance is made for the sinking of the volumenometer as a whole when water is admitted; the distances through which it sank were measured each time by focussing a second telescope of the cathetometer upon a mark on the volumenometer.

Further, let the indices e and f of $\beta_0, \beta_1, \beta_2$ etc., indicate whether they represent the corresponding angles when the volumenometer jacket is empty or when it is full of water, and just as with β, let us write r_{01}, r_{11}, etc., and r_{02}, r_{12}, etc., for the various values of r_1 and r_2; we then get for the distance measured with the jacket empty e. g.

$$A (\beta_{1e} - \beta_{2e}) = A\, n_{1.2} \{ (r_{11} - r_{21}) + (r_{12} - r_{22}) \} - A (\alpha_1 - \alpha_2)$$

and when it is full

$$A (\beta_{1f} - \beta_{2f}) = A\, n_{1.2} (r_{11} - r_{21}) + A\, n_{32} (r_{12} - r_{22}) - A (\alpha_1 - \alpha_2).$$

Taking the measured distances $A(\beta_{1e} - \beta_{2e})$ and $A(\beta_{1f} - \beta_{2f})$ in pairs and subtracting the one from the other we obtain the following equations in which V is the difference thus obtained.

$$r_{02} = \frac{V_{01}}{A} \frac{1}{n_{3.2} - n_{1.2}} + r_{12}$$

$$r_{12} = \frac{V_{12}}{A} \frac{1}{n_{3.2} - n_{1.2}} + r_{22}$$

$$r_{22} = \frac{V_{23}}{A} \frac{1}{n_{3.2} - n_{1.2}} + r_{32}$$

$$r_{32} = \frac{V_{34}}{A} \frac{1}{n_{3.2} - n_{1.2}} + r_{42}\,.$$

Substituting in these equations the value of r_{32} which is directly measured at m_3, we obtain in succession values for r_{22}, etc., and from these the optical deviations are calculated. For example for m_1 from

$$A (n_{1.2} - 1)\, \alpha_1 + A\, r_{12} (n_{3.2} - n_{1.2}).$$

The numbers thus obtained are given in Tab. III, col. III (p. 111).

§ 4. *Control measurements.*

Partly to verify the results obtained and partly to control the proper temperature equilibrium between the various mercury filled parts of the apparatus, control measurements were carried out as indicated in § 3 of Comm. N°. 117 (June 1910) with the mercury at the same pressure in the two communicating vessels, the manometer and the volumenometer. For this purpose the upper portions of the volumenometer and the manometer were brought into communication with each other and the mercury was then driven up until the meniscus stood in one of the connecting necks of the volumenometer; the clamp l_9 (Pl. I fig. 1, cf. Pl. I, Comm. N°. 117) was then closed so as to avoid the effects of vibrations in the mercury in the bulb Q_1 (cf. Pl. I Comm. N°. 117) caused by gusts of wind or by vibration of the building. Care was always taken to ensure a good vacuum above the two corresponding mercury levels, so as to prevent troublesome expansions and too slow equilibration between the gas in the volumenometer and the manometer. Since in the case of the uppermost necks mercury columns about 1 metre in height had to be kept in hydrostatical equilibrium, the greatest care had to be taken to ensure the temperature equilibrium of the mercury column. For this purpose a water jacket was put around the manometer tube being firmly attached to it by means of two rubber stoppers. In order to reduce to a minimum the optical corrections necessarily introduced by the use of this jacket, the holes in the rubber stoppers were bored to one side of the centre so that the water jacket was thinnest just at the side through which the readings were made. In order to determine the optical corrections fifteen fine lines were etched on the other side of the manometer tube. The heights of these lines were also read on the cathetometer with the volumenometer jacket both empty and full of water. Each of these measurements was repeated sixteen times. Since both the water layer and the air layer through which readings were made were only 4 mm. thick the cathetometer telescope could be kept immovable and the difference could be determined directly each time with the micrometer eyepiece. Parallax errors were avoided by covering one half of the telescope objective with a plate of glass whose optical thickness was the same as that of the water layer in the volumenometer jacket. When the jacket was full, readings were taken through the uncovered half of the objective, and when it was empty readings were made through the covered half. The optical error due to the glass plate was determined independently. In this way the optical errors due to the manometer jacket were easily determined with accuracy to within 0.005 mm. From the results it is evident that the use of such a jacket has much to recommend it, while the optical correction appears to be only about 0,03 mm. a value that may in the majority of cases be regarded as negligible.

The manometer jacket was supplied from underneath with water from the thermostat. (see § 5). From above the water flowed out through a connecting tube which was well protected from heat exchange with the surroundings to the lower portion of the volumenometer jacket. Hence variations in the temperature of the jacket water occasion errors which neutralise each other at least in part, a result which one cannot be sure of obtaining when the water supplies are independent or form branches of one circuit.

In the room in which readings are taken it is difficult to keep the temperature gradient below $^1/_2{}^\circ$ per metre; it often assumes greater values and, in consequence, it is easy for the mercury in the bulb and in the rubber tubes to assume a temperature different from that obtaining in the mercury columns within the jackets; on this account the water which flows out from the upper end of the volumenometer jacket is utilised to warm or cool as the case may be the mercury which flows from the mercury bulb to the manometer or to the volumenometer. For this purpose the short rubber tubes are joined to the large glass T-piece. The vertical arm of this T-piece is widened so as to obtain a greater surface for heat exchange, and this vertical arm is surrounded by the two copper tubes shown in Pl. I, fig. 1. The water which is flowing off from the volumenometer is then divided into two circuits which traverse these copper tubes and then leave the apparatus at f_1 and f_2. By this arrangement are eliminated all undesirable convection currents and conduction phenomena in the masses of mercury.

In conclusion we may mention that all parts of the apparatus were carefully wrapped up so as to be protected from heat exchange with the outside.

After these precautions had been taken, a great number of measurements were made of the heights of the menisci in the communicating vessels. The capillary depressions were obtained from KELVIN's graphical constructions in which a mean capillary constant was assumed. After a proper application of the temperature and capillary corrections the optical corrections were calculated as the remaining difference in height. In Table II are collected the mean data obtained from the various measurements which with the help of the method of communicating vessels have led to one of the determinations of the optical constant for the mark m_0. The means of all the measurements are given in Table III, col. IV.

Since there can be no doubt about the pressure equilibrium a comparison of the optical corrections thus determined with those obtained by the method of the combination level with the removal

TABLE II.

Control measurement at mark m_0 (Pl. I. Comm. N°. 117).

Neck mark m_0	level	Cath. meter scale.	Eye-piece head	Men. height		
					Temp. of volum.m. jacket at 1 h. 45 m.	below 16.05[5] above 16.07
Volumenom.men.top.	10	79.024 cm.	21.25	0.181 cm.	Temp. of manom.	below 16.02
„ „ base	10	78.843	21.25		jacket at 1 h. 45 m.	above 16.10
Manometer men. top.	10		21.20	0.188		
„ „ base	10		26.37			
Volumenom.men.top. (mean of 7 readings)	10		21.25			
Manometer men. top. (mean of 7 readings)	10		21.21			
Manometer men. top.	10		21.20	0.182	Temp. of volum.m.	below 16.13
„ „ base	10		26.29		jacket at 2 h. 15 m.	above 16.13
Volumenom.men.top.	10	79.024	21.27	0.184	Temp. of manom.	below 16.13
„ „ base	10	78.840			jacket at 2 h. 15 m.	above 16.11

		Capillary depr. Volumenom.	Manom.
	1h.45m	0.144 mm.	0.045 mm.
	2h.15m	0.148	0.043
	mean	0.146	0.044
Correction for capillary depression			—0.102
Correction for temperature difference between the comm. vessels			
	1h.45m	none	
	2h.15m	0.014	
	mean		+0.007
Optical correction for manom. jacket (see p. 108)			—0.040
Actual height difference observed (4/273 mm.)			0.014
Hence optical corr. for volumenometer			− 0.121

of the water from the jacket (Table III, cols. I and III) gives an immediate opportunity of judging the degree of accuracy of the pressure measurements. When everything mentioned in the foregoing has been taken into consideration it appears that the pressure is certain to within 0.02 mm. and, in favourable circumstances, to

W. J. DE HAAS. "Isotherms of diatomic gases and of their binary mixtures. VIII. Controlmeasurements with the volumenometer".

Pl. I.

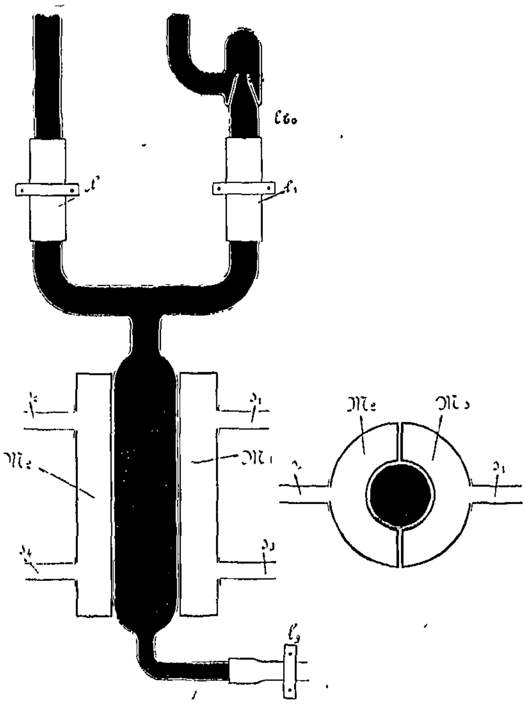


Fig. 1.

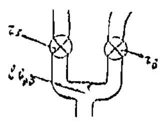


Fig. 2.

W. J. DE HAAS. "Isotherms of diatomic gases and of their binary mixtures. VIII. Controlmeasurements with the volumenometer".

Pl. II.

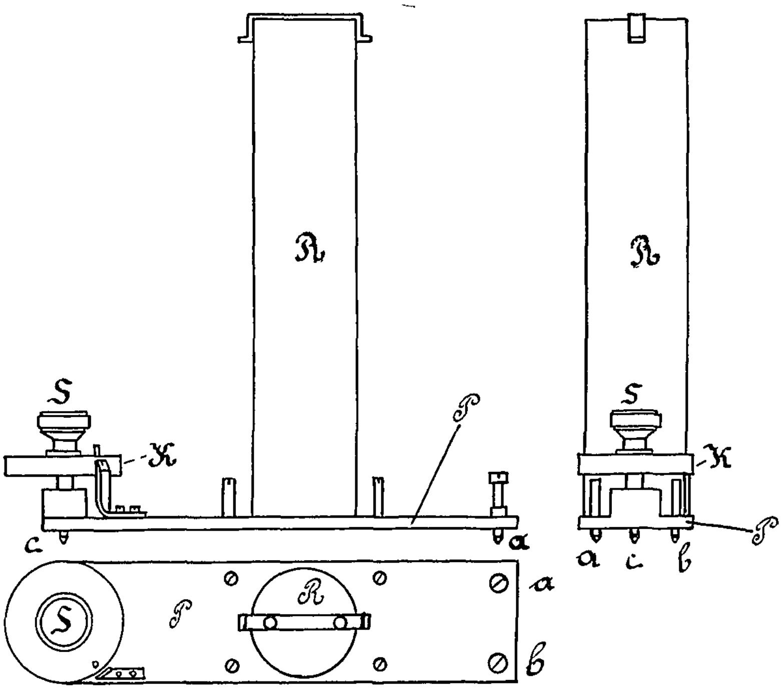


Fig. 1.

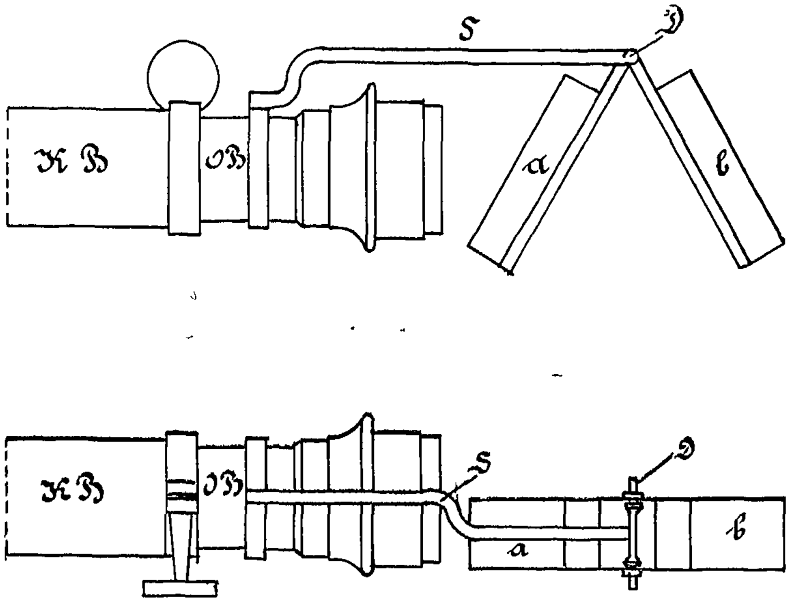
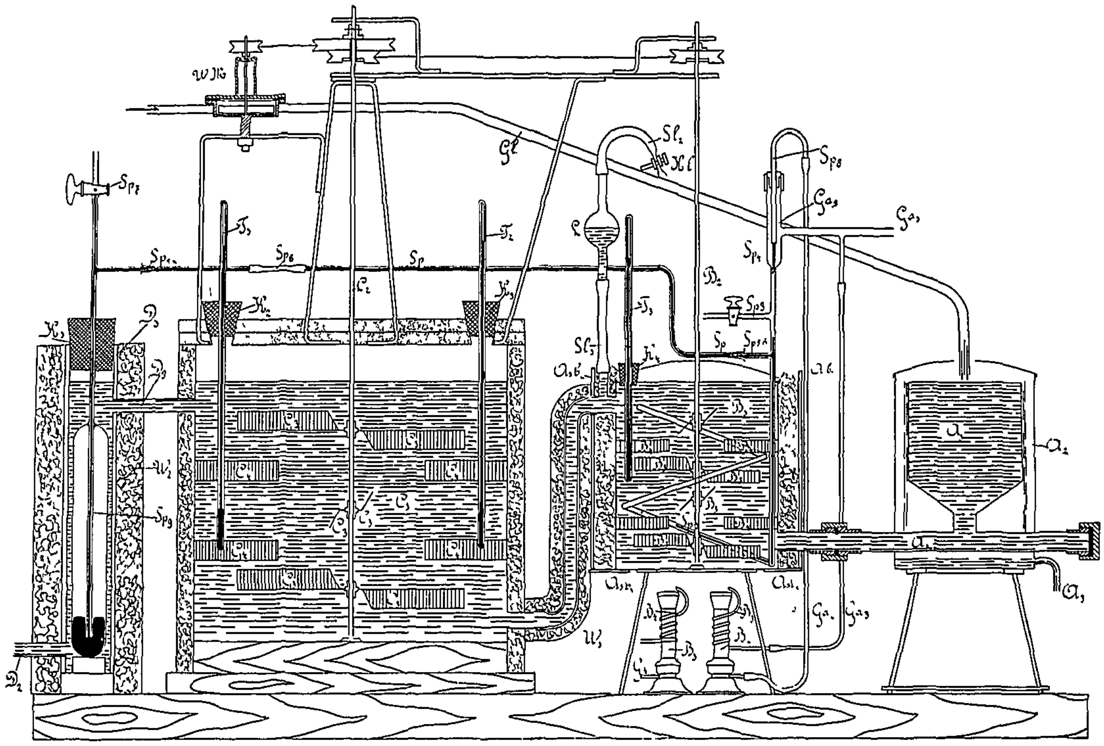


Fig. 2.

W. J. DE HAAS. „Isotherms of diatomic gases and of their binary mixtures. VIII. Controlmeasurements with the volumenometer". Pl. III



within 0.01 mm.; it is therefore possible to measure mercury pressures of 10 cm. with certainty to 1 in 10000.

In conclusion it may be mentioned that the heights of the edges of the menisci were read at the near side. As comparatively little light could be introduced into the interior of the volumenometer jacket, readings at the sides of the volumenometer tube were matters of considerable difficulty, but by making them in front sharp readings could be obtained, for, with suitable illumination from an electric hand lamp the meniscus edge could always be seen as a sharp line at which a number of images came to an end. As the near edge of the meniscus was about 8 mm. nearer the objective of the telescope than the top the same artifice was employed to eliminate parallax errors in this method of reading as was indicated above in the determination of the corrections for the manometer. Glasses were placed in front of the telescope objective and were firmly attached to the telescope tube as is shown in Pl. II. fig. 2. The optical shortening of the path of the light rays was about 8 mm. By turning the glasses round their axis and thus causing them to approach or recede from each other the adjustments could be made perfectly free from parallax. The top of the meniscus was read through the glasses and the edge through the uncovered portion of the objective. Optical errors arising from the glasses used in this apparatus and also from those already mentioned as used for the manometer tube were accurately determined beforehand.

TABLE III.

Comparison of the different measurements.

Neck	Method I	Method II	Control measurem.
Eb_{82}	-0.13^{2} mm.	-0.13^{3} mm.	-0.12^{1} mm.
Eb_{81}	-0.13^{2}	-0.13^{3}	-0.12^{2}
Eb_{7}	-0.13^{2}	-0.13^{8}	-0.15^{3}
Eb_{6}	-0.15^{9}	-0.14^{6}	-0.15^{5}
Eb_{4}	$+0.03^{5}$	$+0.05^{1}$	$+0.04^{1}$
Eb_{3}	$+0.03^{5}$	1)	$+0.05^{0}$

1) Method II could not be applied to this screen. For this method to be applied, the screens must be very clean and quite dry. In this instance it was impossible to fulfill the latter condition, for when the water was being drawn off from the jacket this lowest screen was kept moist by the water that remained behind since the level of the tap was but very little below the mark on the screen.

§ 5. *The Thermostat.* The thermostat which was used in these control measurements and also in experiments upon the compressibility of hydrogen at ordinary temperature which have already been made but are not yet published was essentially the same as that described in Comm. N°. 70. For a description of the apparatus reference must be made in the first place to that paper. Certain modifications have been introduced with a view to

1. better constancy of the temperature during a great time interval and consequently less necessity for constant supervision ; and
2. easier adjustment to the desired temperature.

The water vessels have remained the same. A small cylindrical vessel has been introduced immediately after the large one (see Pl. III). The copper spiral with the xylol regulator of the vessel B has been removed and in its place has been put (temporarily) a glass spiral of three turns going from the bottom of the vessel B upwards. This spiral is bent upwards from below and ends in the gas regulator. A side tube with ground joints connects the spiral with a large thermometric vessel. A rubber connecting piece allows the system to vibrate without damage. The thermometric vessel and the spiral are filled with chloroform and mercury, the mercury being shown black in the figure. The use of chloroform as thermometric liquid offers the advantages of small specific heat, and small compressibility, compared with a pretty large expansibility (cf. Comm. N° 70 III § 3). The spiral contains about 100 cc. and the thermometric vessel about 600 cc. of chloroform. By means of a tap Sp_3 the total mass of mercury present in the apparatus may be altered.

The action of the apparatus is briefly this: The glass spiral regulates the temperature of the bath B just as the copper spiral did in the Plate of Comm. N°. 70 III, while the large vessel C considerably diminishes small temperature variations. The thermometric vessel, which presents a relatively small surface compared with its large volume, is not sensitive to these variations. The same applies equally well to integral temperature variations. Should, for instance, a continuous rise in the temperature of the room cause the temperature of the vessel C to rise a little, then mercury will flow from the thermometer vessel through Sp_n to the spiral, the regulating flame will become smaller, and water will enter the large vessel at a temperature that is lower but is still kept constant by the spiral, so that the absorption of heat by the walls of the large vessel is thereby to a great extent neutralised.

The second purpose for which the modifications were introduced is, as can easily be seen, also served. For, when once the burners have been lighted, the thermostat adjusts itself to a temperature that is practically determined by the quantity of mercury present in the apparatus. The utility of the apparatus is therefore greatly increased. To give an idea of the capabilities of the apparatus temperatures taken on some of the measuring days are given below. The temperature was taken immediately before the water was allowed to flow into the manometer jacket.

	12 h. 15 m.	12 h. 45 m.	2 h. 15 m.	3 h. 5 m.	4 h. 55 m.
March 22nd '11	16.04	16.07	16.07	16.07	16.07

	3 h. 40 m.	3 h. 55 m	4 h. 20 m.	4 h. 45 m.	5 h. 25 m.	6 h.
March 30th '11	19.00	19.00	19.00	19.00	19.00	19.05

So that the temperature as can be seen remains for hours at a time constant to less than 0.01°.

How far this constancy of the temperature can be utilised to keep the temperature of the volumenometer constant depends upon the constancy of the room temperature; its heat insulation however can still be improved. If sufficient care is taken to keep the room temperature constant, one is usually successful in keeping the gradual change of the temperature of the volumenometer to within 0°.03 per hour [1]), and any single temperature measurement remains certain to 0°.02.

Physics. — "*Further Experiments with Liquid Helium.* D. *On the Change of the Electrical Resistance of Pure Metals at very low Temperatures, etc.* V. *The Disappearance of the resistance of mercury.*" By Prof. H. KAMERLINGH ONNES. (Communication N°. 122*b* from the Physical Laboratory at Leiden).

As was mentioned in a former Communication (April 1911) I have made a more accurate examination of the resistance of pure mercury at helium temperatures, in which I have once more had the assistance of Messrs. DORSMAN and HOLST. The resistance was now measured with the differential galvanometer by the method of the overlapping shunts (KOHLRAUSCH) and also by the method of the measurement of current strength and of potential difference. By this it was confirmed that at 3° K. the value of the resistance sinks to below 0.0001 times the value of the resistance of solid mercury at 0° C. extrapolated from the melting point. But from the present measurements it has also been ascertained that the actual value of the resistance is very much smaller than this upper limit which I was able to ascribe to it from my former measurements.

1) For the comparison of mercury columns as in Table II constancy to within 10 times this value will be sufficient.