at 62°. This time, however, six fractions of the distillate were found to contain, respectively, 30.8, 30.8, 30.9, 30.8, 30.9, and 30.9 molar per cent. of chloroform.

As already stated, changes in Brown's law itself will be proposed in communications to follow. Here we would again express our thanks to the Rumford Committee of the American Academy for a grant in aid of our researches.

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[CONTRIBUTION FROM THE LABORATORY OF PHYSICAL CHEMISTRY OF THE UNIVERSITY OF ILLINOIS. NO. 19.]

THE MEASUREMENT OF VAPOR PRESSURE LOWERING BY THE AIR SATURATION METHOD.[1]

BY EDWARD W. WASHBURN AND EDWARD O. HEUSE.

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1. Introduction.

The importance of having a reasonably accurate method for investigating the molecular character of aqueous solutions over a considerable concentration range and at a constant temperature led to an attempt to improve the vapor pressure method so that it might be employed for this purpose. The experimental work in connection with the problem was begun in 1909 by Mr. H. B. Gordon. He was able to show that the method could be made to give the desired accuracy and in addition to building and testing the apparatus he also measured the vapor pressure lowering of several aqueous solutions. The results of his work together with a comparative discussion of previous investigations in the same field were printed and distributed in 1912 in the form of a Doctor's Thesis,[2] but were not formally published. In September 1912 the experimental work was taken up by Mr. E. O. Heuse and is being carried on by him at the present time. A description of the theory of the method together with some of the results obtained was presented at the Chicago meeting of the American Physical Society, November, 1914, and published in abstract in the *Physical Review.*

The appearance of a recent paper by Frazer and Lovelace[3] on an improved *static* apparatus for measuring vapor pressure lowering seems to make it worth while to publish a description of our apparatus and method at this time, for purposes of comparison, postponing until later

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[1] This paper is an abstract of a thesis presented to the Graduate Faculty of the University of Illinois in partial fulfilment of the requirements for the degree of Doctor of Philosophy, June, 1914.

[2] H. B. Gordon, Univ. of Ill. Theses, 1912.

[3] Frazer and Lovelace, THIS JOURNAL, 26, 2439 (1914).

the presentation and theoretical interpretation of the vapor pressure data which have been collected with it.

2. Outline of the Method.

The dynamic or air-saturation method when employed for the purpose of measuring the difference between the vapor pressure (p_0) of a solvent and that (p) of a solution has usually been carried out by determining each of these quantities separately and then subtracting one from the other. This procedure gives a very low degree of accuracy on the vapor pressure lowering, the chief sources of error being (1) in the measurement of the quantity of air aspirated and (2) in maintaining the average temperature of two successive experiments sufficiently constant. The obvious modification which is necessary in order to eliminate these two sources of error is to pass the same air (whose quantity, therefore, need not be known) over the solution and the solvent in succession, each liquid being contained in a suitable "saturator" and both saturators being placed beside each other in a well stirred thermostat. Then one may either determine the losses in weight of the two saturators by weighing them before and after the experiment, as in the method of Ostwald-Walker or one may absorb the moisture in absorbers of such form and size that they can be accurately weighed. The former method has been successfully carried out by Berkeley, Hartley and Burton[1] with aqueous solutions at 0°. The latter method seemed preferable to us, however, because it involved no change in the concentration of the solution during the run and the volume of air and its rate of flow could be made as large as desired, since there was no necessity of employing a small and compact saturator as is the case when the saturator has to be weighed.

Our apparatus, therefore, has been constructed so as to embody the advantages of the differential procedure first used by Ostwald and Walker with those of the absorption method which has been employed by most investigators in this field. The type of absorber which we have employed coupled with the comparatively high rate of aspiration used necessitates the use of small differential manometers for the purpose of measuring the fall in pressure through the apparatus. With a different type of absorber cooled with liquid air, these manometers could probably be dispensed with.

3. Calculation of the Relative Vapor Pressure Lowering.

The following method of computing the results of an experiment conducted as outlined above is applicable to moderate temperatures: At high temperatures, where the deviation of saturated water vapor from Boyle's law is large, corresponding modifications must be made in the method of calculation, but these will not be entered into here.

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[1] Berkeley, Hartley and Burton, *Phil. Trans.*, (*A*) **209**, 177 (1909).

The mass, m, of water necessary to saturate a volume, v, of air in order to bring it into equilibrium with a liquid whose aqueous vapor pressure is p is expressed by the equation

$$m = Kpv \tag{1}$$

where K is a proportionality constant. In the method just outlined the same air is passed through both saturators and hence the volume emerging from a saturator will vary inversely as the partial pressure of the air in that saturator. Obviously, this is in each case the atmospheric pressure diminished by the vapor pressure of the liquid with which the air is in equilibrium and by the difference between the total pressure within the saturator and the atmospheric pressure. It therefore follows that

$$\frac{v_1}{v_2} = \frac{B - p_2 - \Delta P_2}{B - p_1 - \Delta P_1} \tag{2}$$

where the subscripts indicate whether the quantity is measured at the outlet of the first or the second saturator of the train. B is the barometric pressure and ΔP the difference between this pressure and that within the saturator as measured by a differential manometer.

From (1) it follows that the ratio of the masses of water absorbed by the two absorbers will be

$$\frac{m_1}{m_2} = \frac{p_1 v_1}{p_2 v_2}. \tag{3}$$

If the second saturator contains pure water ($p_2 = p_o$) and the first saturator an aqueous solution ($p_1 = p$), we have from (2) and (3)

$$p = \frac{m p_o (B - \Delta P_1)}{m_o (B - p_o - \Delta P_2) + m p_o}. \tag{4}$$

Dividing both sides of Equation 4 by p_o, subtracting each side from unity, expressing the result in the fractional form and collecting terms, we have

$$r = \frac{p_o - p}{p_o} = \frac{(m - m_o) p_o + m_o (B - \Delta P_2) - m(B - \Delta P_1)}{(m - m_o) p_o + m_o (B - \Delta P_2)}. \tag{5}$$

Putting $m_o - m = D_m$ and $\Delta P_2 - \Delta P_1 = D_p$ gives

$$r = \frac{p_o - p}{p_o} = \frac{D_m (B - \Delta P_1 - p_o) - m_o D_p}{m_o (B - \Delta P_2) - D_m p_o}. \tag{6}$$

This is the expression for $\frac{p_o - p}{p_o}$ in terms of the quantities which are directly measured in the experiment. In order to make clear the relative importance of the different terms in this expression and their influences upon the accuracy of the result, we will substitute typical values for them as obtained in an actual experiment in which the solution employed was a molal solution of cane sugar. This gives

$$r = \frac{p_0 - p}{p_0} = \frac{0.2401(749.01 - 0.24 - 23.71) - 11.7458 \times 0.050}{11.7458(749.01 - 0.29) - 0.2401 \times 23.71} =$$

$$\frac{174.1 - 0.59}{8794.2 - 5.6} = \frac{173.5}{878.9} = 0.0197. \quad (7)$$

Suppose for example that we desire an accuracy of 1% in value of r. Of the terms appearing in the denominator the last one, $D_m p_0$, is practically negligible in comparison with the first and in the first term the quantity ΔP_2 is practically negligible in comparison with B. At most an accuracy of a few tenths of a mm. in measuring ΔP_2 would be ample, and an accuracy ten times as great as this is easily attained. The degree of accuracy with which the denominator of Equation 6 is known depends, therefore, practically upon the accuracy with which m_0 and B can be measured, and it is clear that both of these quantities can be easily measured with 10 or 100 times the necessary accuracy. As far as the terms in the denominator are concerned we may, therefore, conclude that the errors involved in their measurement will not have any appreciable influence upon the accuracy of the result.

Turning to the numerator we note that the second term, $m_0 D_p$, is very small in comparison with the first, and that at most an accuracy of 0.05 mm. in the measurement of D_p would be ample. This degree of accuracy, and more, can be easily attained. In the first term of the numerator ΔP_1 is practically negligible while p_0, the vapor pressure of the pure solvent at the temperature of the experiment, needs to be known with an accuracy of 7 mm. (*i. e.*, 30%) if it is not to influence the accuracy of the result by more than 1%. In the case of water it is of course known with an accuracy 100 times greater than this and in any case its determination with the necessary degree of accuracy offers no difficulties. We may conclude, therefore, that the percentage accuracy of the result is almost entirely determined by the percentage accuracy attainable in the quantity D_m, that is, the difference in the increases in mass of the two absorbers and this difference is itself directly determined by placing the absorbers on the opposite pans of a sensitive balance and adding the necessary weights to produce equality. This difference can be determined to 0.1 or 0.2 mg. and in the example taken this would amount to less than 0.1%. Practically, however, the accuracy of the final result is not determined by the accuracy in *measuring* the actual difference D_m obtained but rather in insuring such perfect experimental conditions that the observed D_m shall correspond to the actual pressure difference within the required limits. As will be seen later the degree of concordance in duplicate experiments is more nearly 0.5% in the case of a molal solution.

From this discussion of the theory of the differential method the following facts are brought out, which distinguish it from most of the previous attempts to determine the vapor pressure lowering of aqueous solutions by means of the dynamic or air-saturation method:

(1) It is not necessary to measure or to know even approximately how much air is passed through the system during the experiment, and its amount may, therefore, be made as large as desired.

(2) In order to measure the relative lowering of the vapor pressure the individual vapor pressures themselves are not required, except a very rough value of p_0, the vapor pressure of the pure solvent, an accuracy of a few mm. in the value of p_0 being amply sufficient.

(3) Temperature variations[1] as great as 1° during the course of an experiment would not appreciably influence the result for solutions of moderate concentrations provided the thermostat is kept thoroughly stirred.

4. Description of the Apparatus.

General Arrangement.—In the apparatus now in use *three* saturators are employed in each experiment, the first and third containing pure water and the second the solution under investigation. The general plan of the apparatus is shown diagrammatically in Fig. 1.

Air, drawn by the constant level aspirator B passes first through the soda lime tube, T, and then into the presaturator, PS_1, where it is *saturated* with water vapor at about 50°. The air then passes down into the flask F which is immersed in the thermostat and here it deposits most of its excess of moisture and enters the first saturator S_1 of the train slightly supersaturated. On emerging from this saturator it is in equilibrium with water at 25°. It then passes out of the thermostat through the tube C_1, which is surrounded by a heating coil and is heated to a temperature of about 30° before it emerges from the thermostat. The warm air then passes at once through the absorber A_1 where all of the moisture is removed. The perfectly dry air then goes through a second presaturator, PS_2, containing water at 25° where it takes up the bulk of the moisture necessary to bring it into equilibrium with the solution in saturator S_2. After passing through this saturator and its absorber, A_2, the perfectly dry air then passes directly into the third saturator, S_3, which contains pure water. In the first and third saturators equilibrium is always approached from *opposite directions* and a valuable check upon experimental conditions is thus obtained.

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[1] The temperature coefficient of $r = \frac{p_0 - p}{p_0}$ is $\frac{100\,\mathrm{d}r/\mathrm{d}t}{r} = 100\,(1 + 1/r)\frac{L_D}{RT^2}$ % per degree where L_D is the differential heat of dilution (heat absorbed) per mole of solvent. At 25° this becomes $\frac{100\,\mathrm{d}r/\mathrm{d}t}{r} = 5.66.10^{-4}\,(1 + 1/r)\,L_D$. Thus for a molal cane sugar solution L_D is about 2 cal. and $r = 0.02$. Hence the temperature coefficient of r for this solution is only 0.06% per degree.

The small differential manometers, M_1, M_2, M_3, connected (through stopcocks) as shown, serve to measure from time to time the pressure differences ΔP_1, ΔP_2 and ΔP_3, respectively. All connections under the water of the thermostat are sealed glass joints, the whole apparatus being supported on a frame as shown in Fig. 2. The details of construction of the different parts follow.

ARRANGEMENT OF VAPOR PRESSURE APPARATUS.

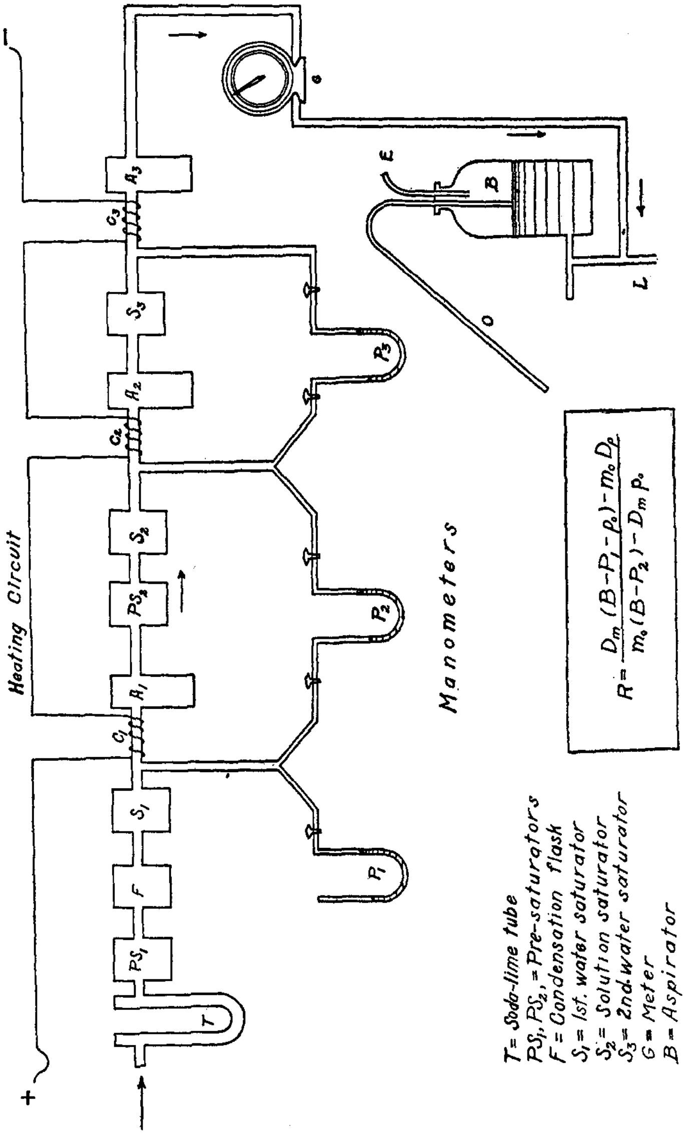

Fig. 1.

The Saturators.—These are of the type devised by Berkeley and Hartley,[1] modified by the addition of the small bulbs at the ends as shown in Fig. 3 and Fig. 2. The horizontal tubes are filled about half full of liquid and then, as the platform on which the saturators are placed rocks slowly back and forth, the liquid flows from one end of the horizontal tubes to the other. The air which enters at the center of each horizontal tube passes around through

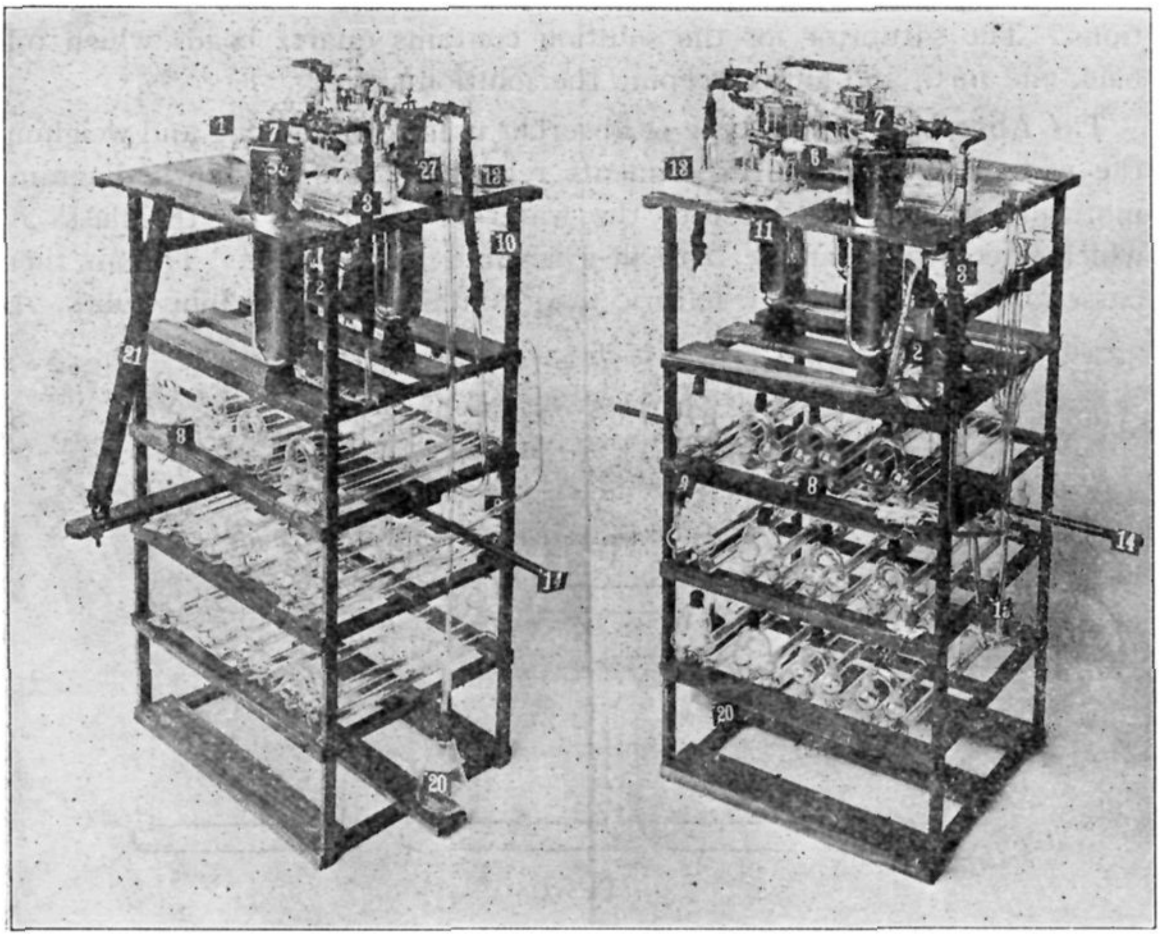

Fig. 2.

(Letters in parentheses refer to Fig. 1.) (1) Tubes leading to manometers. (2) Presaturator (PS_2) for solution. (3) Tube and heating coil (C_2). (6) P_2O_5 safety tube. (8) Saturator (S_3). (9) Point where the air enters the system. (13) Absorber (A_1). (14) Axle on which frame rocks. (20) Condensation flask (F).

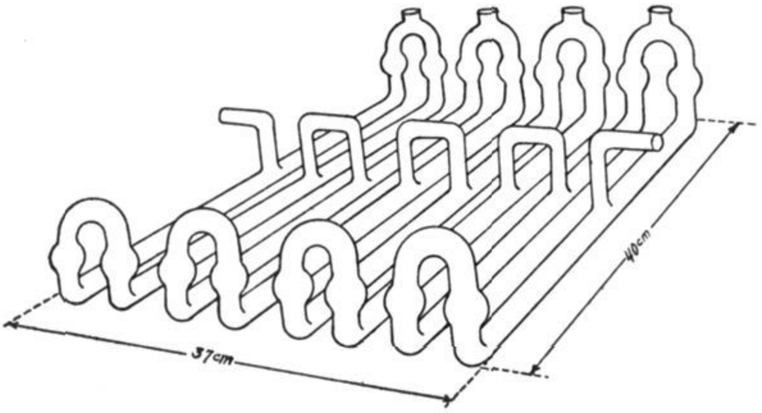

Fig. 3.

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[1] Berkeley and Hartley, *Proc. Roy. Soc.*, (*A*) **77**, 156 (1906).

first one vertical connecting tube and then the other as the saturator tips back and forth. The air never bubbles through the liquid at any point. The small bulbs in the vertical connecting tubes are for the purpose of breaking liquid films which sometimes form in the case of certain solutions. The saturator for the solution contains quartz beads which roll back and forth and aid in keeping the solution stirred.

The Absorbers.—The type of absorber used for removing and weighing the water vapor in the experiments recorded below is shown diagrammatically in Fig. 4. Most of the water is condensed in the flask, *F*, which is cooled by an ice bath in a silvered Dewar tube. The air then passes over concentrated sulfuric acid contained in the four tubes, *A*. These tubes have a series of depressions or pockets (not shown in the figure) along the bottom for increasing the amount of sulfuric acid which they will contain. The two tubes, *P*, are about two-thirds filled with glass beads and phosphorus pentoxide and a removable pentoxide safety tube (not shown) completes the absorber and serves to prevent the diffusion of any moisture backward against the air current. The absorber is compactly built so that it will fit the pan of a sensitive balance. It is shown in position on the upper shelf of the support, at 13 in Fig. 2. About 25 g. of water can be condensed and absorbed in one absorber. The different absorbers are as nearly identical as possible in construction and when charged ready for use weigh about 300 g. each.

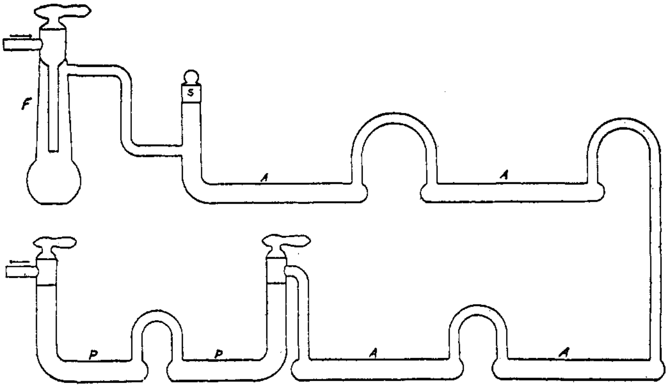

Fig. 4.

The Differential Manometers.—The small differential manometers, M_1, M_2, M_3, shown in Fig. 1 are water manometers inclined at such an angle that 1 mm. of mercury is equivalent to 200 mm. of water. The angle of inclination was determined accurately by means of a cathetometer. The stopcocks which separate these manometers from the train are opened at intervals during the run and the readings of the manometers recorded.

When the experiment is proceeding properly these readings are practically constant throughout the run.

The Thermostat.—The apparatus and support as shown in Fig. 2 are immersed in a large water bath at such a depth that the three lower platforms and their saturators are completely covered. The whole support is then rocked back and forth on the axle (14, in Fig. 2) at the rate of four complete oscillations per minute. In addition to the stirring produced by this motion two powerful turbine stirrers and one propeller blade stirrer insure a uniform temperature throughout all parts of the thermostat. Three heaters symmetrically distributed and controlled by a hydrogen regulator served to keep the temperature constant.

With this arrangement the apparatus can be kept in continuous operation and as many runs as desired made with a given solution, the air current being interrupted only long enough to replace one set of absorbers by another. When a new solution is to be employed the apparatus is lifted out of the thermostat, the old solution removed with a pipet and the new one introduced. It is not necessary to take the apparatus apart for this operation. Previous to the first insertion of a weighed pair of absorbers in the train the air current is allowed to pass through the system for half an hour to insure equilibrium and proper working conditions. The barometer is read from time to time during the run. In one or two cases the occurrence of thunder storms during the run necessitated the use of a barograph record in finding the weighted time average of the barometric pressure during the run.

5. Testing the Apparatus.

One of the most satisfactory methods of testing the apparatus is to make a run with pure water in all three saturators and then compute the value of $r = \frac{p_0 - p}{p_0}$ by means of Equation 6. The result should of course be zero. In seven successive experiments of this kind in which only two saturators were employed Gordon found an average value[1] of 0.026 for 100 r. With the apparatus now in use this has been considerably reduced indicating a more perfect attainment of equilibrium between the liquid and gaseous phases during the passage of the air current. Some typical data of this kind are shown in Table I. When one recalls that the value of 100 r for a molal aqueous solution of a nonelectrolyte is about 2 it is evident that the residual errors indicated by the figures in the last column of Table I would tend to show that the error in measuring the vapor pressure lowering of a molal solution should not exceed one-fourth of 1% on the average.

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[1] Gordon, *Loc. cit.*, p. 22, Table III.

TABLE I.—RESULTS WITH WATER IN ALL THREE SATURATORS.

Duration of run.	Saturators used in calculation.	m_o.	D_m.	Volume of air aspirated. Liters.	ΔP_1.[1]	ΔP_2.[1]	ΔP_3.[1]	100 r.[2]
45 hrs......	1 and 2	18.2417	0.0033	789.0	0.18	0.33	0.50	—0.0027
	2 and 3	18.2435	0.0051					0.0041
24 hrs......	1 and 2	14.9149	0.0031	645.0	0.10	0.21	0.33	0.0051
	2 and 3	14.9147	0.0029					0.0025
							Mean value,	0.0036

6. The Vapor Pressures and Osmotic Pressures of Cane Sugar Solutions.

The Experimental Data.—In order that a check upon the reliability of the results obtained with our apparatus might be secured, some measurements were carried out with solutions of cane sugar for the purpose of securing a comparison with the accurate osmotic pressure data obtained by Morse. The sugar employed had been carefully purified and the measurements were made on a weight molal solution to which 0.1 of 1% of $HgCl_2$ was added. The results obtained are shown in Table II. The average percentage deviation of the individual results from the mean is 0.4% showing that reasonably *concordant* results can be obtained at this concentration. Their *accuracy* can be tested by calculating the corresponding values of the osmotic pressure and comparing with Morse's directly measured values for the same solution.

TABLE II.—VAPOR PRESSURE MEASUREMENTS OF WEIGHT-MOLAL SOLUTIONS OF CANE SUGAR.

Duration. of run.	Saturators used in calculation.	m_o.	D_m.	Volume of air aspirated. Liters.	ΔP_1.	ΔP_2.	ΔP_3	100 r.	Deviations.
24 hrs......	1 and 2	11.7458	0.2401	509	0.24	0.29	0.31	1.974	+0.004
	2 and 3	11.7432	0.2375					1.957	—0.013
24 hrs......	1 and 2	11.6451	0.2376	504	0.39	0.48	0.57	1.965	—0.005
	2 and 3	11.6464	0.2389					1.975	+0.005
23 hrs......	1 and 2	4.8408	0.0996	209	0.09	0.13		1.987[1]	+0.017[3]
							Mean,	1.970	+0.008 =0.4%

POLARISCOPE READINGS FOR THE ABOVE SOLUTIONS.

For the solution used in the	Before the run.	After the run.
1st run........................	356.25°	356.00°
2nd run........................	355.61°	355.58°

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[1] The pressures here given are mean values (weighted-time-averages) and are expressed in millimeters of mercury.

[2] $r = (p_o - p)/p_o$.

[3] Because of the small value of m_o in this run, this value was given only half-weight in the calculation of the mean.

Osmotic Pressure and Vapor Pressure Lowering.—The osmotic pressure of a solution as directly measured in such experiments as those of Morse is defined by the equation

$$\pi' = P - 1 \tag{8}$$

where P is the pressure (in atmospheres) upon the solution when osmotic equilibrium is attained. The osmotic pressure thus defined is connected with the partial vapor pressure of the solvent by the purely thermodynamic relation,[1]

$$\left(\frac{\partial p}{\partial \pi'}\right)_T = -\frac{\overline{V}}{v}, \tag{9}$$

where v is the specific volume of the saturated vapor at the temperature T, and $\overline{V}$, the "specific solution volume" of the solvent, is the increase in volume which occurs when 1 g. of the solvent is added to an infinite amount of the solution, under the pressure P.

For saturated water vapor at 25°, we may without appreciable error assume Boyle's law for the small pressure interval here involved and write

$$v = \frac{k}{p}. \tag{10}$$

The constant k is most accurately obtained from the thermodynamic relation

$$k = \frac{L_v p}{T(\partial p/\partial T)_P} \tag{11}$$

where L_v is the latent heat of vaporization. The best available data for water when substituted in this equation give a value of k which is not appreciably different from $RT/18$ which value we shall, therefore, employ.

$\overline{V}$, the specific solution volume of the solvent, will in general be a function of π'. It may be calculated for any solution which contains s per cent. of solute and has the density D_P, by means of the relation

$$\overline{V} = \frac{1}{D_P} + \frac{s}{D_P^2}\left(\frac{dD_P}{ds}\right) \tag{12}$$

For cane sugar solutions the evaluation of $\overline{V}$ at 25° in terms of π would strictly require a knowledge of the proper compressibility coefficients of the solutions at this temperature. No such data seem to be available but by employing those of Tait[2] for 12.4° an approximate calculation of $\overline{V}$ as a function of π' may be made. In this way we find the following values:

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[1] This rigorously exact relation can be written down immediately with the aid of the perfect thermodynamic engine described in a previous paper (THIS JOURNAL, **32,** 467 (1910)) giving a much shorter and more direct derivation than that given by Porter for the relation between these two quantities.

[2] Landolt-Börnstein tables.

π	0	8.44	16.93	22.16	26.52	atmospheres
$\overline{V}$	1.0029	1.0056	1.0034	1.0008	0.999	cc.

By integration between 0 and 27 atmospheres the average value of $\overline{V}$ between these limits is found to be 1.003.

Equation 9, therefore, becomes

$$1.003\ d\pi' = -\frac{RT}{18}\frac{dp}{p} \qquad (13)$$

and on integration gives

$$\pi' = \frac{RT}{18.054}\left[\left(\frac{p_0 - p}{p_0}\right) + {}^1/_2\left(\frac{p_0 - p}{p_0}\right)^2 + \ldots\right] \qquad (14)$$

In Table III the values of π' calculated with this equation from the vapor pressure data of Table II are compared with the directly measured values of Morse. The agreement between the two is well within the experimental errors of the vapor pressure data and justifies the conclusion that the values obtained with our apparatus are correct within their own degree of precision.

TABLE III.—COMPARISON OF OSMOTIC PRESSURES CALCULATED FROM VAPOR PRESSURE MEASUREMENTS WITH OSMOTIC PRESSURES OBSERVED.

100 *r*.	Osmotic pressure calculated.	Osmotic pressure observed (Morse).
1.974	27.01	27.030
1.957	26.77	..
1.965	26.88	..
1.975	27.02	27.076
1.987	27.19	..
Mean,	27.0	27.05
Average deviation,	0.11	
% deviation,	0.4	

7. Discussion of the Method.

The results obtained with our apparatus indicate that values of $\frac{p_0 - p}{p_0}$ of the order of magnitude of 0.02 can be measured with an accuracy of better than 0.5% in a 24-hour run. This seems to be about ten times better than the best values recorded for the dynamic method as usually carried out.[1]

The experiments of Berkeley, Hartley and Burton,[2] however, who employed the differential method of Ostwald-Walker also gave closely concordant results. They worked with calcium ferrocyanide solutions in small saturators of the same general form as that shown in Fig. 3 and their method differed from ours only in the fact that the air entered the system perfectly dry and the losses in weight of the two saturators were determined by weighing them directly. It is difficult to directly compare the degree of accuracy which they obtained with that given by our ap-

[1] Cf. Gordon's discussion, *Loc. cit.*, p. 23.

[2] *Loc. cit.*

paratus because they worked entirely with stronger solutions and only two measurements are recorded for any one concentration. Their most dilute solution gave $\frac{p_0 - p}{p_0} = 0.032$, the two determinations differing by only 0.2%. Similarly for stronger solutions, the differences between the two determinations were for $\frac{p_0 - p}{p_0} = 0.054$, d = 0.1%; for $\frac{p_0 - p}{p_0} = 0.065$, d = 0.03%; for $\frac{p_0 - p}{p_0} = 0.084$, d = 1.0%. The *percentage* accuracy should, of course, increase rapidly with increase in the relative lowering measured and although we have as yet made no careful measurements with solutions in which $\frac{p_0 - p}{p_0}$ exceeded 0.02, the results obtained by Berkeley, Hartley and Burton as far as a comparison is justified seem to show in general a degree of concordance of the same order as that given by our apparatus. Their experiments were made at 0°, and the duration of a run was about *three days.*

In the static method for measuring vapor pressure lowering as perfected by Frazer and Lovelace an accuracy of 0.001 mm. is claimed. This would correspond to an accuracy of 0.2% on the value of $\frac{p_0 - p}{p_0}$ for a weight molal solution at 25° and is, therefore greater than that obtained in our experiments with the cane sugar solutions, but of the same order of accuracy as that indicated by the data recorded in Table I. By extending the time of run over several days instead of one, more complete equilibrium could perhaps be obtained with our apparatus but the possible increase in accuracy which might thus be secured has not in most cases seemed worth the additional expenditure of time.

In Frazer and Lovelace's apparatus a minimum of about eight days seems to be required for the attainment of equilibrium and its final measurement, but their results at the end of that period appear to be very accurate, which is more than can be said of any previous attempts to use the static method, and they are to be congratulated upon their success where so many others have failed. We are at present engaged in measuring solutions of mannite at 25° and 35° and as these authors appear to be working with the same solutions we may hope to obtain a direct comparison of results by the two methods for the same solutions.

URBANA, ILLINOIS.

NOTE.

Nichrome Gauze.—Many questions have been asked concerning this gauze, designed in 1911 at Amherst College and since distributed to many of the New England laboratories. It had been the custom to supply