A NEW FORM OF AIR-BATH.

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(*Read at Meeting, November*, 1889.)

Bearing in mind the universal and indispensable utility of the air-bath to the chemical analyst, one might expect to find much variety and perfection in the design and construction of such an important piece of apparatus. Strange to say, this is not so. I very much doubt if there is to be found any piece of chemical apparatus in the chemist's laboratory that has received less attention, or stands more in need of it.

This fact was forced upon my attention by the great difficulty found in bringing certain hygroscopic substances to a constant weight, and I soon discovered that the attempt was hopeless with the ordinary instrument, the reasons for which were not far to seek. In the first place, in the ordinary bath it is impossible to maintain a uniform temperature throughout the whole of the drying chamber, for, even with the help of a thermostat, though it may be regulated with accuracy for some one special portion, other parts will in all probability be found to be several, indeed many, degrees hotter or colder according to the circumstance, so that to dry a substance, say at 100° C., the bath, though regulated to stand at this point for the spot where the thermometer is placed, is no assurance that the thing to be dried is exposed to the temperature desired, and if the object is of any considerable bulk, the probability is that one portion of it may extend into a region that is much below a hundred, and another into a place that is much above a hundred. Naturally the greatest heat is found near the floor, where the thermometer is never placed, and the least heat at the sides and in the corners, where radiation and stagnation mostly takes place; but more especially it is cold in the line of draughts that proceed from the chinks of the door and through the primitive contrivance that is usually provided for ventilation. In these parts the temperature may be very little above that of the external atmosphere. No wonder then that the complete drying of delicate hygroscopic organic substances is found to be so difficult, for before the colder part can be made to give up the last trace of moisture that clings so tenaciously to it, the hotter is over dried and stands the risk of being charred.

In a case like this there is nothing to be got by turning and twisting the thing round so as to expose alternately its various parts to the greater heat. In imagination one can see what occurs; by a process of distillation and condensation the same kind of transference of moisture from the hotter to the colder parts takes place as is seen to occur, for instance, when the attempt is made to dry a damp flask under similar circumstances.

But even this picture by no means exhibits the whole of the perplexing difficulties of tracing and controlling the air currents in an ordinary air-bath. They are so erratic, so fortuitous, so delusive, and subject to such uncontrollable shiftings, that, practically speaking, it is a question whether thorough drying in such a case is possible without destruction of the substance. At all events the chances in favour of it are so slender as not to be relied upon.

Reflecting upon these difficulties, the theory of a perfect method for air-drying suggested two things as indispensable.

1. A constant current of pure dry air brought to the desired degree of temperature before admission into the drying chamber.

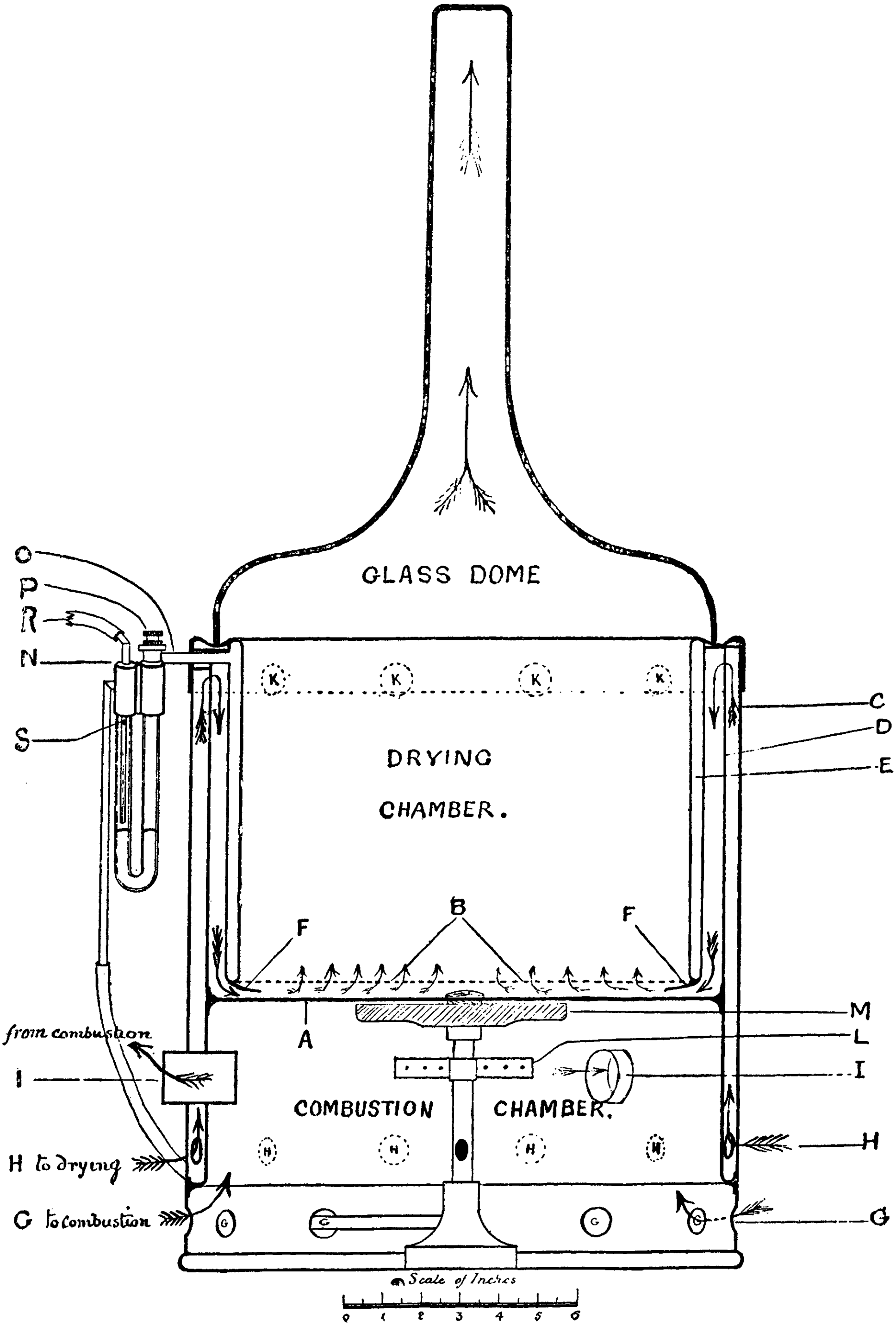
2. A regulated source of heat.

Both these conditions to be under perfect control.

I place current first as being the more important item, and the one to which hitherto very little attention appears to have been paid so far, at all events, as regards the temperature of the current when admitted into the drying chamber. As for the source of heat, this has been brought fairly under control by previous experimenters by the use of one or other of the several thermostats, though I was unable to discover one quite suited to the purpose.

To meet these requirements I have designed the instrument which I now have the honour of bringing under your notice, and which with the assistance of the diagram will be easily understood.

You will observe it consists essentially of a double jacketted cylinder with air passages, so contrived as to compel the air used for the drying to circulate between the jackets before its final admission into the drying chamber, in such a manner as to ensure that its temperature shall be raised to the required degree before it is allowed to come in contact with the thing to be dried. Moreover, as a secondary, but still very important consideration, the inlet of the air-supply is so placed that the air used for drying is kept as distinct as possible from all contact or admixture with the products of combustion, such products naturally being loaded with watery vapour and CO_2. The pure air thus heated before entering the drying chamber is evenly diffused over the whole area of the bottom of the bath, between it and the perforated false bottom which forms the floor of the drying chamber, the air then ascends bodily as a solid cylinder, and escapes by the tall chimney of the domed glass cover. In this way vigorous circulation of dry hot air is constantly maintained, which effects a rapid and uniform drying, such as no ordinary air-bath can accomplish. We will now turn to a consideration of the source of heat and its regulation. This consists of a Bunsen air-burner placed in the cavity under the bottom, but the heat is first received upon a solid disc of metal, separated by a sufficient space from the bottom to prevent the heat of the flame being transmitted direct to the bottom of the bath, the object being to avoid any localisation of the heat. Moreover, the mass of the metal disc, besides acting as a distributor, also serves as a reservoir of heat and assists in maintaining the equality of temperature, but this equality is chiefly provided for by an entirely new form of thermostat. It is to be observed that within the two jackets already spoken of is placed an annular copper vessel, which forms the boundary wall of the drying chamber. This is a cylinder composed of two thicknesses of thin sheet copper, enclosing an air space of 5 m.m. wide, 98 c.m. circuit, and 22·75 c.m. in height. It is securely closed top and bottom, and has a capacity of 1100 c.c. This constitutes the heat regulating chamber or thermostat, the cavity of which is connected up to a U tube, having mercury in the bend. Gas is admitted on the other side of the U, and by means of an arrangement, such as is usual in a gas thermostat, depression of the mercury in one limb cuts off the main gas supply, which can then reach the burner by a small bye pass only. By means of a screw at the top of the other limb of the U, air can be admitted into or allowed to escape from the regulator. With the rise or fall of the temperature, and the consequent expansion or contraction of the air contained in the regulator, pressure is exerted or withdrawn from the surface of the mercury, which is thereby forced down the one limb and up the other.



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DRYING
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B
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from combustion
I
COMBUSTION
CHAMBER.
H
H to drying
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Scale of Inches
0 1 2 3 4 5 6

A. Diaphragm completely separating the drying from the combustion chamber. B. Perforated false bottom. C. Outer jacket. D. Inner jacket. E. Copper regulating chamber or thermostat. F. Baffle plate. G. Apertures in jacket C giving admission to air for combustion. H. Apertures for the passage of air between the jackets for drying. I. One of three apertures for escape of products of combustion. K. Apertures in inner jacket D for passage of drying air. L. Burner. M. Thick metal plate for receiving heat of the flame. N. Mercury U tube. O. And its connection with copper regulator. P. Screw whereby the degree of heat is regulated. R. Gas supply. S. Tube with bye-pass.

I have already mentioned the capacity of this copper regulator is 1100 c.c., the coefficient of expansion for one degree Centigrade being ·00367, the alteration of volume for a single degree of temperature at boiling point will be about three cubic centimeters (2·95). It is therefore plain we have here a means of regulation of the temperature of extraordinary sensitiveness, and accordingly we find we can command what practically amounts to a fixed temperature at any desired degree, and seeing that the copper regulator entirely surrounds the drying chamber and that the whole of the air employed in the drying process must of necessity sweep both its surfaces, exterior and interior, amounting to nearly half a (·4459) square metre in extent, it follows that no local currents can interfere with the accuracy of its working. You will agree, I am sure, that this a grand point.

A Page's regulator, or any similar instrument, may be all very well in a still atmosphere, but where a current is concerned it is not unlikely to be at fault and thrown out of working from one cause or another, purely local, such for instance as being shadowed by an object in process of drying, or being placed where there is either an undue amount of current, or too little, or in an eddy. Our arrangement has a further advantage of occupying no space within the drying chamber. Having said this much respecting the principles involved in the design and the mode of construction, let us now pass to a consideration of its performances; but before doing this it will be as well to relate some particulars concerning difficulties encountered in connection with the regulator. When first set in action there was no getting a fixed degree of heat; the thermometer kept steadily mounting, degree by degree, without apparent cause. Naturally we looked for some escape of air from the chamber of the regulator, but the closest inspection failed to reveal any point at which escape could take place, and it was only by immersing the copper regulator in water and blowing through the tube attached that enabled us to discover several tiny leaks in the solder. After these were made good and the test repeated, the thermometer still recorded a constantly increasing temperature. Again and again we went through the process of searching for leaks, but all in vain. Fixity of temperature seemed impossible, when at last I observed some condensation of moisture within the U tube on the regulator side of the mercury, This at once gave the clue to the cause of the rise of temperature. Each time of immersing the regulator in the water, when search was being made for leaks, a small amount of moisture must have gained access into the interior, and this, as the temperature of the bath was raised to boiling point, became converted into steam and mingled with the contained air. So long as this moisture remained at the high temperature of the interior of the regulator, it exerted the vapour tension due to that temperature, but little by little a certain portion found its way into the U tube out of reach of the heat, and thereupon deposited its moisture by condensation on the sides of the tube, producing of course a partial vacuum in the tube and thereby drawing in a fresh supply of hot moist air and steam, so that at last quite a considerable amount collected in the U tube.

Now, seeing that 1 c.c., of water at 15·5 C. will produce 1696 c.c. of steam at 100° at ordinary barometric pressure, there is no need to dwell further upon the cause of our difficulty, or the necessity for keeping the interior of the copper regulator quite dry. I hope to be pardoned this digression. My excuse is that addressing practical men like yourselves one is bound to put those who may desire to follow in a similar investigation on their guard against needless loss of time, trouble, and temper.

Now, with respect to the performance of this instrument as an air-drying bath, I have directed my experiments to the demonstration of three things:—

I. To show the existence of, and determine the amount of, current passing through the bath.

The passage of the current is roughly but abundantly demonstrated by holding a flame opposite any one of the twelve air inlets; you will observe how the air rushes in. Again, at the outlet the current is manifested by this mica whirlygig arrangement, which you observe sails round famously by the impact of the current.

I have attempted to measure the amount of air that passes through the instrument by means of an anemometer, and find that it travels along a chimney whose sectional area = 5·4119 inches at the rate of 204 feet per minute, from which I calculate that no less than 7·6875 cubic feet of air pass through the apparatus per minute.

II. The next point of importance was to ascertain that this current was evenly distributed throughout the whole sectional area of the drying chamber.

This equal distribution you will observe was contrived at by making the instrument circular and admitting the air at points placed at equal intervals all round, and by surrounding the lower part of the inner jacket with a curved flange projecting inwards, the object of which is to direct the current horizontally between the true and the false bottom, and so prevent its premature passage through the perforations of the false bottom before having had time to take up heat from the bottom plate, and by thorough mingling and mixing, preventing local inequalities of temperature.

That these designs work well can be demonstrated by the smoke of smouldering brown paper, which shows that the current spreads itself over the whole area; there is no creeping up the sides or centre, it seems to pervade equally the whole space.

III. The final point that we have thought it important to enquire into relates to the vertical distribution of the heat.

At one time I was strongly tempted to head this communication with the title of "A Perfect Air-bath," and should have ventured to do so but for the practical impossibility of obtaining a perfectly equal temperature from top to bottom. For a certain very considerable range it is sufficiently so for all practical purposes, and far more so than it is, or can be, in any ordinary bath. For the convenience, if not the necessity, of the case, the source of heat is applied to the bottom, and you will remember we have interposed a large mass of metal between the flame and the bottom for the purpose of moderating, storing, and distributing the heat; but, nevertheless, all parts in metallic connection therewith get hot by conduction more in proportion as they are near to the source of heat. They in turn become radiators, and any object placed within near range of their radiation before the air current has had time to take up and distribute the same, gets more than its share of heat. Our experiments show that the useful range is anywhere above 3 ins. of the bottom. Below this undoubtedly the temperature increases rapidly, and more so the closer the bottom is approached. Above 3 ins., and for the whole of the rest of the drying-chamber the extent of the variation between any two parts does not amount to more than from 1° Centigrade.

In these several ways we have endeavoured to meet the requirements of a theoretically perfect bath.

We have contrived an instrument that provides a vigorous current of heated air of definite temperature under perfect control of a self-acting source of heat, and out of reach of contamination by the results of combustion.

Taken together, these results are, I submit, satisfactory, and show the instrument to be a substantial improvement on the ordinary air-bath, of sufficient value, I trust, to deserve your attention.

The following table exhibits the temperature as shown by two thermometers, one being fixed at 8 ins. from the bottom, which uniformly registered 100 degs. Cent., and the other at various distances as follows:—

Distance in inches.	Temperature degs. Cent.	Distance in inches.	Temperature degs. Cent.
10½	100	5½	100
10	100	4½	100
9½	100	4	100¼
9	100	3½	101
8½	100	3	102
8	100	2½	104
7½	100	2	106
7	100	1½	110
6½	100	1	115
6	100	½	124
5	100		

The metal portion of the apparatus was made by James Clinch, of 30, King Street, Maidstone, and the glass dome by Messrs. Powell, Whitefriars Glass Works, E.C.

DISCUSSION.

Mr. ALLEN (who had temporarily taken the chair) said they would be very glad to inspect more closely this very ingenious and next door to perfect air-bath which Mr. Adams had described. They were indebted to Mr. Adams for several ingenious and practical devices. They would always associate his name with the paper-coil method of determining fat in milk, and they knew how thoroughly satisfied they were with it.

He would like to know how long it took before the desired temperature was obtained, because it was so extremely sensitive that the regulation of it might, he thought, prove troublesome in practice. He thought Mr. Adams might make the temperature more equable than it was by having an asbestos card-board diaphragm between the source of heat and the copper cylinder.

The contrivance by which Mr. Adams got rid of the heat afterwards was very interesting, because he got a good flow of heat over the bottom. He should have thought it was not necessary to have so large a copper cylinder to go over the interior of the bath, as it had a tremendous surface.

They were also indebted to Mr. Stansell for rigging up the apparatus there, and he should like to know where to get such glass hoods ready made, and he asked if it would not be convenient to have a regulator of the current, by means of a kind of damper at the top.

Dr. MUTER said he thought this would turn out a very useful improvement in laboratory apparatus. It was practically an ingenious circular modification of the principle of Griffin's air-bath, which he had used for many years, and which was doubtless at present the best bath in the market; the air being taken in at the top, entering the inner chamber through holes at the bottom, and finally escaping by the chimney. He had much improved the working of his bath by placing a sheet of asbestos millboard over the bottom plate against which the burner impinged, and he thought, if the President would try such an addition, he would find that the unduly high temperature on the gauge bottom would no longer exist. If to this were added a second internal gauge, say two inches above the bottom one, for articles to rest upon, he should fancy that in the President's bath chemists would find the nearest approach to perfection yet met with in such apparatus.

Dr. VIETH said that Griffin's bath, so far as he knew, was at the present time the best in the market. He had used it for nine years with very little trouble and good results. He would like to ask Mr. Adams whether it would not be advantageous to place the false bottom three inches above the present one; that is to say, at a height where the temperature, according to Mr. Adams' observations, was, so to speak, normal.

Mr. ADAMS, in reply, said that it was by no means an expensive or complicated affair, and they must remember that it was not only a bath, but a thermostat as well, and perhaps it was the copper chamber which constituted the thermostat that made it appear somewhat complicated. All the rest was plain enough. In every instrument that he had seen, the means for escape of the products of combustion of the gas used for heating, was placed below the inlet for the air used for drying. This was a very serious fault. They could see (as he showed) what an enormous amount of watery vapour came out by the outlets provided for the escape of these products, and in the ordinary bath this went straightway into the drying-chamber, to say nothing of carbonic acid. Replying to Mr. Dyer as to whether there was any reason for having the dome made of glass, Mr. Adams said it was really a mournful thing to him that through the model having been broken by the railway company he was unable to show it in its entirety; the glass not only looked well, but everything that was going on could be seen, and the drying process watched without disturbance; but, of course, the glass dome could be replaced by a metal one.

As regarded regulation of temperature, this was as simple as possible. It could be set at any temperature wished for, from that of the room up to any degree that could be required, in the course of a few minutes. He had only to undo the screw (P) and allow a little of the air contained in the copper chamber to escape, and when the desired temperature was reached, screw it down again, and this, by preventing further escape, fixed the temperature at that point. On the other hand, if he wanted to lower the temperature, he would turn the gas out and allow air to enter the copper chamber until the temperature stood at the desired point. A thermometer hung from the chimney, and the temperature could be seen at any moment. The regulation could be accomplished not only exactly but immediately, and, moreover, the temperature was absolutely fixed. It might be set going on January 1st and go on to December 31st, and it would not vary. It might do some good to put some asbestos on the upper surface of the diaphragm that divides the drying and combustion chambers.

(Conclusion of the Society's Proceedings)