TABLE III.—$ZnCl_2$.

Temperature centigrade.	Conditions.	Time. Hours.	Volume of air under standard conditions. Liters.	Weight of water. Gram.	Volume of water vapor under standard conditions. Cc.	Pressure of water vapor. Mm.
25°	Dry	4	7.1	0.0066	8.2	0.88
	Moist	4	6.9	0.0063	7.8	0.84
	Dry	8	7.0	0.0064	8.0	0.85
	Moist	8	7.0	0.0063	7.8	0.83
					Average,	0.85
50°	Dry	4	7.05	0.0164	20.4	2.16
	Moist	4	6.90	0.0243	30.2	3.25*
	Dry	8	7.05	0.0115	14.3	1.51*
	Moist	8	6.92	0.0167	20.8	2.24
	Moist	8	6.97	0.0163	20.3	2.18
			Average, rejecting starred experiments			2.19

To summarize the results of this research, the aqueous vapor pressures of the lowest hydrates of the three salts examined are found to have the following maximum values:

	0° Mm.	25° Mm.	50° Mm.
$CaBr_2$	0.09	0.18	0.19
$ZnBr_2$	0.28	1.16	6.34
$ZnCl_2$	..	0.85	2.19

The weights of residual water in one liter of a gas dried at 25° by these salts and by calcium chloride and sulfuric acid are:

	Gram.
$CaBr_2$	0.0002
$ZnBr_2$	0.0011
$ZnCl_2$	0.0008
$CaCl_2$	0.0021
H_2SO_4	0.000003

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[CONTRIBUTIONS FROM THE HAVEMEYER LABORATORIES OF COLUMBIA UNIVERSITY, No. 184.]

A SIMPLE CONSTANT-TEMPERATURE BATH FOR USE AT TEMPERATURES BOTH ABOVE AND BELOW THAT OF THE ROOM.

BY J. LIVINGSTON R. MORGAN.

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The apparatus described in this paper is for the purpose of maintaining any desired temperature, from a little above 0° to one in the neighborhood of 90°, with an accuracy of a few hundredths of a degree. The principle of the method of regulating the temperature, in few words, is to deliver to the bath, as it is necessary, water[1] which is either higher or lower in

[1] Foote (*Z. physik. Chem.*, 33, 740 (1900)) has used this principle in a less con-

temperature, according as the fixed temperature lies above or below that of the room or of an ice or warm-water bath surrounding the lower portion of the bath. The air of the room is thus made, for medium temperatures, to act as a cooler for the higher temperatures, or a heater for the lower ones; but is aided for the extremes of each.

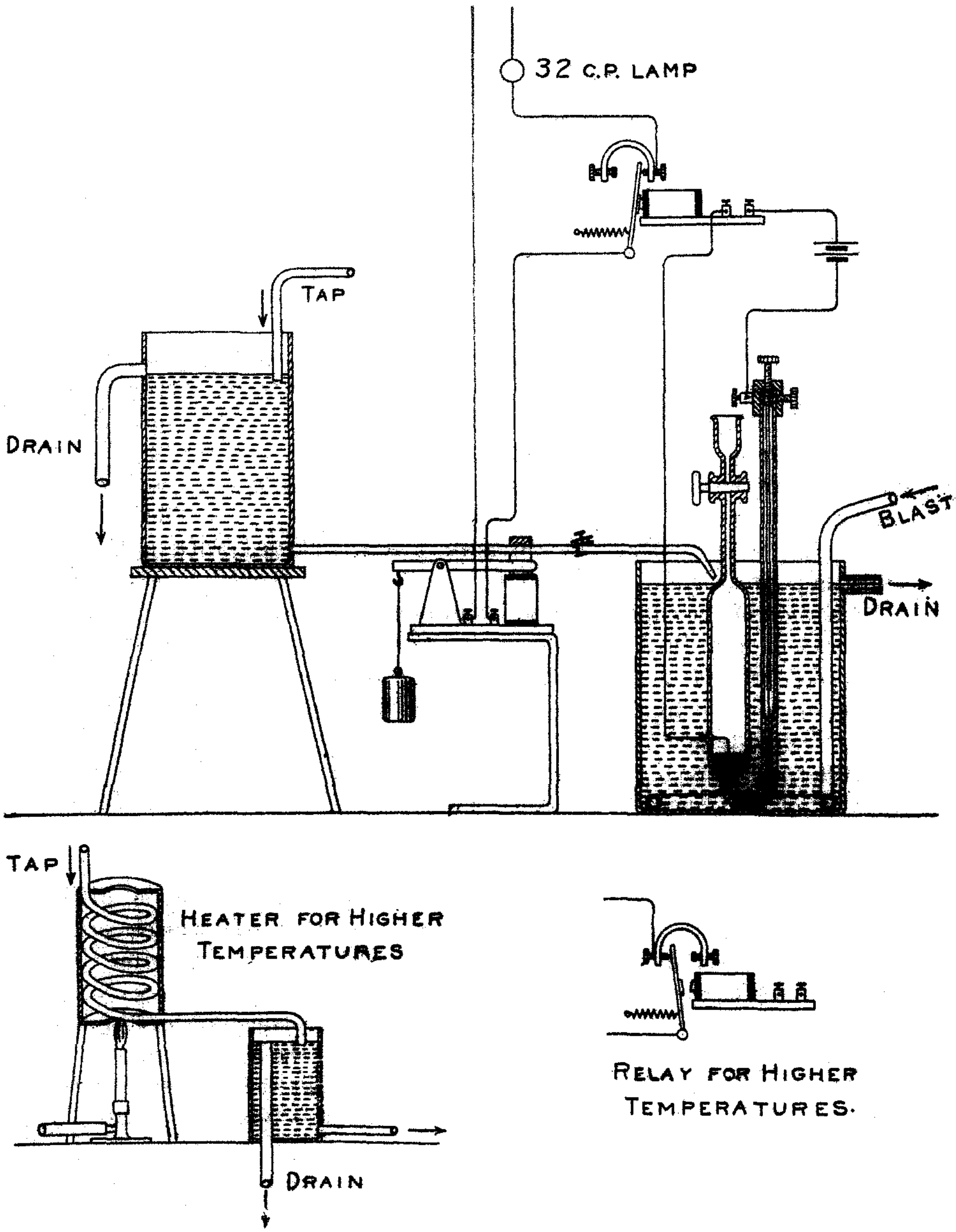
The general plan of the apparatus, for the convenience of those who wish to make up one with the least trouble, is shown in some detail in the figure. The regulator is of the kind which allows the mercury meniscus to attain approximately the same position at all the temperatures—the turning of a stopcock, after the desired temperature is reached, causing the subsequent expansion or contraction of the liquid to affect the meniscus and to maintain that temperature. The usual and most convenient form of this is of a U-shape, one side of which is a tube 3 cm. in diameter and about 15 cm. long, to which is attached a small funnel provided with a stopcock; at the bottom of this tube a platinum wire is fused into the glass. The lower part of the other side of the U is capillary (6 mm. in diameter, the bore being 0.75 mm.). This tube extends upwards for about 6 cm., the continuation being of tubing with a bore of 4 mm. After enough mercury has been added to the bulb side to bring the smaller meniscus, in the capillary, to a point about 3 cm. below the top of the capillary, the rest of the bulb, including the funnel tube, is filled in the usual way with toluene. A threaded collar, fastened with a thumb screw and provided with a binding post, is now attached to the wider continuation of the capillary tube. Through this collar passes a threaded brass rod (2 mm. in diameter), to the lower end of which is soldered a short piece of platinum wire, 0.5 mm. in diameter. By screwing this rod up or down, contact with the meniscus in the capillary can be made at any desired temperature around that at which the stopcock was turned; the stiffer rod, carrying the short piece of platinum wire, allowing greater delicacy of movement than would be possible with a piece of slender wire of the same length, such as would be necessary were the whole tube capillary, instead of being widened at its upper end.

The water, at a higher or lower temperature, which is to be added automatically to the bath is contained in a constant-level vessel, so arranged that the water pressure cannot exceed 40–50 cm. of water. So long as this pressure is not exceeded, the height of the level may vary.

In the case of water for cooling purposes, this constant-level vessel is preferably a large fiber pail, with a hole near the top, fitted with a rubber stopper and tube, to carry off to the drain the excess of water which is running slowly and continuously into it. Near the bottom is

venient and delicate way for the maintaining of any one, low, temperature; but with his regulator, changes in the fixed temperature, *i. e.*, the partial emptying or further filling, are not readily accomplished.

another, similar, hole, fitted also with a rubber stopper, containing a 5 cm. glass tube. It is through this that the water to supply the bath flows. When lower temperatures are desired, this pail is filled partially with cracked ice or snow; for continuous running in this way, the pail



of course should be large enough to contain a supply of ice sufficient for twenty-four hours, or should be wrapped with felt, or placed in a refrigerator.

For a warm water supply the constant-level vessel is simply a metal can of about 500 cc. capacity, fitted with an overflow leading to the drain, and an outlet at the bottom. The tap water which runs slowly and continuously into this is first heated by passage through a copper coil placed over a burner, or through any one of the quick water heaters to be found on the market. The speed of flow of the tap water here regulates approximately the temperature of the supply water, and should be such that that of the constant-level vessel is at least 5° or 10° above that to be maintained in the bath.

For temperatures up to 10° the bath itself would best be placed in another and lower vessel filled with ice, or snow, and salt, which will give the bath a temperature that is too low. The water flowing in in this case is tap water, which *raises* the temperature of the bath as it is necessary.

For temperatures above 50°, it is best to place the bath in a lower vessel, into which the water from the coil flows directly and continuously at a temperature about 5° above that desired. Tap water is run in here by the regulator to *cool* the bath, as that is necessary.

The bath itself may be a battery jar of 2 or 3 liters capacity, or even a large beaker. 3 cm. from its top should be a hole, provided with a rubber stopper, through which runs a glass tube to carry off to the drain the excess of water. Stirring is most simply obtained by blowing air through a single coil of tin pipe placed at the bottom and bored with four small holes. A pump for this purpose can be very simply made from a filter pump and a tin tank with an overflow, if no continuous blast is available.

The two platinum wires of the regulator are connected with the binding posts of a dry cell or a storage cell, in series with a small relay, which must be used to prevent sparking in the regulator. This relay is so arranged that the house circuit, in series with a 16 or 32 candle power lamp, can be either made or broken in a large telegraph sounder connected to the other two terminals of the relay. This sounder has attached to it a bar of brass, about 5 mm. above the lowest position of the arm, when it is attracted by the magnet. The other end of the sounder arm has attached to it by wire a weight of several pounds, so that when no current is passing through the sounder, the arm presses tightly against the brass bar.

The thin rubber tube of 4 mm. bore, connected to the outlet of the constant-level vessel, is now run over the sounder arm and under the bar above it. Water is thus allowed to flow from the supply vessel into the bath when the sounder arm is drawn down by the current; at all other times the rubber tube is pinched tightly together by the weight, and the flow of water is prevented.[1] The bath should be placed as close as possible to both the sounder and the supply vessel to prevent any too excessive radiation. The water flowing into the bath should fall upon the regulator, so that the effect of the change in temperature is most marked at that point. To secure this result the inflow tube is attached directly to the regulator by the clamp holding that in position.

For temperatures requiring that the bath be cooled by the inflowing liquid, the water, either at tap temperature or in contact with ice, is allowed to flow through the rubber tube leading over the sounder to the bath, the stopcock of the regulator being open and the platinum wire in contact with the mercury meniscus, until the bath is filled with water at the desired temperature. The addition of warmer water may also be desirable if time is an object. When the desired temperature is obtained in the bath, the stopcock of the regulator is turned off, and the threaded rod moved sufficiently to raise the platinum wire, which has been in contact with the mercury, to a point just above it, thus breaking the current and shutting off the supply of cold water. The relay in this case must close the circuit in the sounder when the bath becomes too warm, *i. e.*, when the mercury is in contact with the platinum point. So soon as the air of the room, or its aids, causes this to take place, then, the circuit is again closed, in both relay and sounder and the weight is lifted, allowing cold water to flow in until the mercury falls away from the platinum point, when once again the weight drops and shuts off the water. If the volume of water flowing in is too great, it will be noticed that the temperature continues to fall, even after the water is shut off. This can be avoided by regulating the speed of flow in the beginning with a screw pinchcock placed on the rubber tube, between the sounder and the bath. The cock should be so fixed that the effect of the supply water added ceases as soon as it is shut off.

When the bath is to be heated by the flow of supply water, just as before, as soon as the desired temperature is reached the stopcock of the regulator is turned off.[3] Here, however, contrary to the lower temperature case, the supply water must be turned on when the bath is too cool, hence the sounder arm must be drawn down by the current when the mercury and platinum are *not* in contact, *i. e.*, when no current is passing through the relay. In order to bring this about the positions on the relay of the insulated screw and the platinum pointed one are exchanged, so that the current will flow through the sounder when it is *not* passing

[1] This principle, without the weight, has already been used in a similar way to regulate the flow of gas.

[2] It is well to fix the desired temperature in the bath as exactly as possible (by working the sounder by hand) *before* turning the stopcock, and regulating the platinum wire; for otherwise mercury may be driven beyond the platinum, forming small globules which destroy the regulation.

through the relay. In the original filling of the bath in this case, then, the mercury and platinum must not be in contact until after the stopcock is closed, when the wire is screwed down so that it just makes contact. As this contact is broken, owing to the cooling of the bath, the relay current is also broken, which causes current to flow through the sounder, drawing down its arm and allowing warmer water to flow in until contact is again made, when the weight carries down the unattracted arm and pinches the rubber tube.

The advantages of this apparatus are as follows:

Any temperature, between 0.1° and 90°, can be maintained, with an accuracy of a few hundredths of a degree, in one form of bath, which is simple, easy to adjust and inexpensive.

A small and transparent bath can be employed without sacrifice of delicacy.

A series of determinations, such as specific gravities, each at a different temperature, can be made in a day, for but a short time is required to change from one constant temperature to another.

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[CONTRIBUTIONS FROM THE HAVEMEYER LABORATORIES OF COLUMBIA UNIVERSITY No. 185.]

THE WEIGHT OF A FALLING DROP AND THE LAWS OF TATE. III. AN APPARATUS FOR RAPID AND ACCURATE DETERMINATION OF THE WEIGHT OF A FALLING DROP OF LIQUID.

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Introduction.

The results obtained in the previous researches of this series,[1] employing the cumbersome and elaborate apparatus necessary for the calculation of the weight of a falling drop from the very accurately determined volume of a single falling drop of the liquid, and its density, have shown that for all the (6) liquids studied[2] the weight of the drop is strictly proportional to the surface tension of the liquid at that temperature; and can be substituted very satisfactorily for the latter in the relationship of Eötvös, as modified by Ramsay and Shields.

Since, contrary to the conclusions of all the other investigators in this field, the weight of a falling drop of liquid from any one tip is thus found to

[1] Morgan and Stevenson, THIS JOURNAL, 30, 360–76; *Z. physik. Chem.*, 63, 151–70 (1908). Morgan and Higgins, *Ibid.*, 30, 1055–68; *Ibid.*, 64, 170–86 (1908).

[2] Work with the new apparatus on about 50 new liquids, in place of contradicting this, confirms absolutely all the conclusions, with regard to this relationship, reached in the two previous papers.