XIX. *An Account of Experiments on the Change of the Elastic Force of a Constant Volume of Atmospheric Air, between* 32° F. *and* 212° F., *and also on the Temperature of the Melting-point of Mercury.* *By* Balfour Stewart, *M.A., F.R.S.*

Received June 18,—Read June 18, 1863.

It was some time since proposed by the Kew Committee of the British Association to determine the temperature of the melting-point of mercury, in order if possible to add a third to the two familiar points which have been so long exclusively used in graduating thermometers; and afterwards the sum of £150 was voted for this purpose by the Government Grant Committee of the Royal Society.

In prosecuting this research, the final arrangement of apparatus has cost much labour and time; but the results at length obtained have exhibited a precision which has induced me to present them to the Society in the following communication.

I shall in the first place endeavour to describe the apparatus used, and shall then give an account of the experiments made and deduce results.

Description of Apparatus.

The apparatus employed was very similar in principle and construction to that used by Regnault in his fourth set of experiments on the dilatation of elastic fluids,—the coefficient sought being that which denotes the increase for 1° Fahr. of the elastic force of a gas the volume of which is constant.

This apparatus was constructed by Mr. Beckley, mechanical assistant at Kew, to whose skill in device and execution I am on this occasion very much indebted; and I would likewise desire to acknowledge the promptness and skill with which the requisite glass-blowing has been executed by Mr. Casella.

The atmospheric air upon which it is desired to operate is contained in the glass bulb B (Plate XXIV. fig. 2), and this is connected by means of a capillary tube t with another tube T of larger bore, which is cemented into an iron fitting, D. This fitting is tightly screwed, by means of an india-rubber washer, upon a reservoir R filled with mercury, and there is thus a communication between the mercury of the reservoir and the bore of the tube T. Another tube, T′, similar to T, is attached in the same manner to an iron fitting D′, and by means of it to the reservoir R; but the fitting D′ is furnished with a stopcock, by shutting which the communication between the reservoir and the bore of T′ may be interrupted at pleasure. The upper extremity of T′ communicates with the atmospheric air. The reservoir R, which is made of cast iron, is fitted accurately into a strong slate slab, which is in its turn supported by a solid block of masonry,

S (figs. 1 & 2) is a screw which drives a plunger P up and down, by means of which the capacity of the reservoir R may be enlarged or contracted at pleasure. The consequence is that when the capacity of the reservoir is diminished the mercury will ascend in the tube T, and also in T′ if the stopcock be open, while if the capacity be increased it will descend in these tubes. The inside of the reservoir is so shaped as to push up any small bubble of air that might otherwise have remained in during the process of filling with mercury. There is also a fine screw, S′, with a graduated head, which drives a fine plunger P′; and the change of capacity of the reservoir due to one revolution of this screw requires to be accurately ascertained.

A little above *h*′ there are two side tubes, terminating in bulbs *b*, *b*′, which are attached at an angle to the tube T.

One of these bulbs contains a desiccating substance, such as sulphuric acid, baryta, or anhydrous phosphoric acid, while the other contains a little caustic potash, a substance which has a strong attraction for carbonic acid.

Let us begin by supposing these two bulbs to be attached to the tube T, as in fig. 1, and let us also suppose that they are open to the atmosphere at their extremities. Suppose in fact that the tube T with its appendages has just been screwed on to the reservoir R. Now by means of the screw S drive the mercury up T until it reaches the level *h*′ a little below the opening where the side tubes branch off; and when it has reached this level, seal off the extremities of the two bulbs. All communication between the air in the bulbs and the atmosphere is thus intercepted.

The bulb B must now be heated as often as possible, and each time a portion of its air will be driven into the bulbs *b*, *b*′, and there deprived of moisture and carbonic acid. The tube *t* should also be heated occasionally, and also the tube T above *h*′, including the appendage tubes, but not the bulbs, the object being to drive away any moisture which may cling to the glass; but at the same time care must be taken not to heat the mercury, in case by any possibility some of its vapour may enter into the bulb B.

It is evident that, if this process be continued long enough, the air of the bulb B will be completely deprived of aqueous vapour and of carbonic acid; also by heating B occasionally above 300° F., any ozone which it may at first have contained will be destroyed.

When satisfied that the air of the bulb B has been thoroughly deprived of all these substances, seal off the appendage tubes, thereby detaching the bulbs *b*, *b*′; and then by means of the screw S drive up the mercury to about the level *h*. If the branch tubes are properly shaped, the mercury will now have run down and filled them. We have thus procured a quantity of unexceptionable air, which fills the bulb B and that portion of its attached tube above *h*.

It is well to remark that the tubes T and T′ are supposed to be well cleaned, and the mercury used to be quite pure.

In making an observation, the mercury is driven first by means of the screw S, and afterwards by the more delicate motion of S′ to a fixed level *h*, which is chosen near

the top of the tube T, and the reading of the cathetometer C for this point is noted. It is clear that the height of the column of mercury in the long tube T′ (the stopcock at D′ being open) will depend upon the elastic force of the air in the bulb B as compared with that of the atmosphere. If this elasticity be altered by increasing or diminishing the temperature of B, the height of the mercury in T′, as read by the cathetometer, will be altered also; and hence the difference given by the scale of the cathetometer between the fixed level *h*, at which the mercury in T is always set, and the surface of the column of mercury in T′ will afford an indication of the temperature of the bulb B*. It is on this principle that the instrument is used as a thermometer.

The mercury used in these experiments was purified in the following manner. It was first heated for some time with dilute nitric acid and then allowed to remain in contact with strong sulphuric acid, being frequently stirred in both cases. It was afterwards well washed, first with a little caustic potash and afterwards with pure water, and was finally mixed with pounded sugar, and well filtered through paper before use.

It was thought desirable to ascertain whether different specimens of mercury so treated were of precisely the same specific gravity; and with this purpose the following experiment was made. The mercury used in the construction of the Kew Standard Barometer, described by JOHN WELSH in the Philosophical Transactions, 1856, page 507, was compared with that used in the construction of another standard barometer, since erected at Kew, and also with the mercury used in the experiments now described; and the following was the result:—

Specific-gravity bottle, filled with mercury from the cistern of old Kew standard	weighed at 62° F. 13975·8 grs.
The same, filled with mercury from the cistern of the new Kew standard	weighed at 62° F. 13976·1 grs.
The same, filled with mercury used in the experiments with air-thermometer	weighed at 62° F. 13976·4 grs.

It will be seen from this how small is the observed difference in specific gravity between these various specimens of mercury, and that even if this were not due to error of observation, yet would the difference between the readings of standard barometers constructed from these different specimens scarcely exceed one thousandth of an inch.

But while these specimens of mercury are sufficiently pure, if the fluid be used in measuring pressure, it might still be doubted whether they would all have the same melting-point. The following experiment will decide this question.

An old Kew standard thermometer (No. 45) was thrust into a beaker which contained eight or ten pounds of mercury, half frozen, half melted. The mercury was not the same as that used in the experiments with the air-thermometer.

* It was ascertained that the strength of the bulb B was sufficient to prevent any sensible change of volume due to increase of pressure within the bulb.

The reading (observed by Dr. W. A. Miller and myself) was . . —37°·75

In an experiment with the mercury used in the air-thermometer in a vessel which contained fifty pounds half frozen, half melted—

The same thermometer read on one occasion . . . . —37·80

The same thermometer read on another occasion . . . . . . —37·70

The reading of this thermometer at the melting-point of ice throughout all these observations was . . . . 32·45

It may therefore be concluded that the melting-point of well-purified mercury for different specimens of the fluid, and for different masses, is practically a point of constant temperature, and that this temperature, as indicated by a Kew standard thermometer (graduated throughout according to the diameter of the bore), is 70°·2 below the freezing-point of water, or is equal to —38°·2 F.

The boiling-point apparatus used in these experiments was that recommended by Regnault. It is represented in fig. 2; and I need only remark that the steam, after passing round the bulb B, flows down by the channel indicated by arrow-heads, and finally escapes into the atmosphere by an orifice near the bottom of the apparatus. The bulb is thus entirely surrounded by steam in a state of motion. This piece of apparatus was compared with two others of the same description but of very different dimensions (one being the small apparatus used by travellers); and the agreement of the three, as tested by a thermometer, was very exact. Distilled water was always used during these experiments. A box with a few small holes bored in its bottom was that used to contain the melting ice, and care was taken that the ice was really in a melting state.

The arrangement for the melting mercury is represented in figs. 3, 4, 5, 6. The vessel for holding it consists of two wooden boxes, the one within the other, with a lining of felt between. When the box was filled with mercury, the bulb, in order to counteract the upward pressure of the fluid, was bound by a string to the bottom of the box. An agitator (figs. 4, 5, 6), made of wire gauze, was made to surround the bulb when the freezing-experiment was in progress, the compartments of which were easily penetrated by fluid mercury. The solid lumps of mercury were introduced outside of the wire gauze; and the agitator served the double purpose of keeping these from contact with the bulb and of promoting currents, by means of which the whole mass was kept at a uniform temperature. For the success of these experiments I am much indebted to Mr. Robert Addams of London; indeed without his ready cooperation it would have been impossible for me to freeze mercury in sufficient quantity.

This gentleman took the trouble to bring cylinders containing liquid carbonic acid to Kew whenever the freezing-experiment was to be performed. I need not here describe how solid carbonic acid is procured from these cylinders, nor how by mixing this with ether a very intense cold is produced; it is sufficient to state that by this process a very large quantity of mercury may be kept frozen for a length of time with great facility.

Experiments and Results.

The following are the formulæ used in the reduction of these experiments:—

Let P denote the elastic force of the air in the bulb B when it is surrounded with melting ice, and let the atmosphere around, including the mercury in the two tubes T, T′, be at the temperature $32°+t$. Also let P′ denote the elastic force of the same air when the bulb is at the temperature $32°+T$, the atmosphere being supposed to remain at $32°+t$.

Further, let V denote the internal volume at 32° of the bulb B, and of that portion of the capillary tube which is subjected to the heating and cooling agents, and let v denote the internal volume at 32° of that portion of the tube T above the mercury which is not subject to the influence of these agents, but which contains air which may be supposed to retain the constant temperature $32°+t$ throughout the experiment.

Also let k denote the coefficient of expansion for 1° F. of the glass, and let α denote the corresponding coefficient of increase of elastic force of dry air the volume of which remains constant; and, finally, let us denote by unit of mass the air which occupies unit of volume under unit of pressure at the temperature of 32° F.

Then PV denotes the mass of the enclosed air which exists at the temperature of 32° F. when the bulb is surrounded by melting ice; also $Pv\frac{1+kt}{1+\alpha t}$ is that which exists, at the same time, at the temperature of the atmosphere $(32°+t)$.

Hence the whole mass of air operated upon will be denoted by

$$P\left\{V+v\frac{1+kt}{1+\alpha t}\right\}. \quad \ldots \ldots \quad (1.)$$

Now let the bulb be subjected in like manner to an agent of which the temperature is $32°+T$. Hence the mass of air existing at temperature $32°+T$ will be $P'V.\frac{1+kT}{1+\alpha T}$, while that at the temperature of the atmosphere will be $P'v.\frac{1+kt}{1+\alpha t}$, and the whole mass will be

$$P'\left\{V\frac{1+kT}{1+\alpha T}+v\frac{1+kt}{1+\alpha t}\right\}. \quad \ldots \ldots \quad (2.)$$

Since the mass of air remains unchanged, we have (1)=(2), or

$$P\left\{V+v\frac{1+kt}{1+\alpha t}\right\}=P'\left\{V\frac{1+kT}{1+\alpha T}+v\frac{1+kt}{1+\alpha t}\right\}.$$

Hence, if we wish to determine α, we shall have

$$1+\alpha T=\frac{P'(1+kT)}{P-(P'-P)\frac{v}{V}\frac{1+kt}{1+\alpha t}}. \quad \ldots \ldots \quad (3.)$$

Here it may be remarked that $\frac{v}{V}\frac{1+kt}{1+\alpha t}$ is a small quantity; so that we may in it quite well assume as the value of α that which was previously determined by REGNAULT, even although these experiments should give a slightly different value. Now according to this observer $1+180\alpha=1{\cdot}3665$. Hence $\alpha={\cdot}002036$ nearly.

It must also be noted that in the boiling-water experiment T is determined in conformity with the report presented to the British Government by the Commissioners appointed to construct standard weights and measures, according to which 212° F. is taken to represent at London the temperature of steam at the pressure of 29·905 inches of mercury reduced to 32° F. This is also the value of 212° F., which has been adopted by the Kew Committee of the British Association*.

When it is the freezing-point of mercury which we wish to determine, the formula (3.) must be altered as follows:—

$$\frac{1+\alpha T}{1+kT}=\frac{P''}{P-(P''-P)\frac{v}{V}\cdot\frac{1+kt}{1+\alpha t}}. \qquad (4.)$$

Here it is T which we wish to determine, and which will of course appear as a negative quantity. The value of α is in this case supposed to have been previously determined.

Experiments made in order to determine α.—First Series.

In the first set of experiments made for this purpose a flint-glass bulb was used. Its volume and coefficient of expansion were determined by cleaning it, first, with nitric acid, secondly with sulphuric acid, afterwards with water, and, lastly, drying it with alcohol, after which process it admits of being well filled with mercury without any specks. It was then ascertained what weight of this fluid it held at 32°, and also at 212°.

	grs.
The weight of mercury at 32° was ascertained to be	10169·3,
That of mercury at 212° was ascertained to be . .	10011·4,

showing a loss of 157·9 grs. Had the glass not dilated, the loss of weight would have been =181·4 grs. (if we suppose the expansion of mercury between these two points to be =0·018153, which is REGNAULT'S determination). Hence the dilatation of the glass envelope of the bulb between 32° and 212° was ·00235, or the coefficient of expansion of the glass for 1° F. =·0000131=k.

Also, assuming 252·5 grs. to be the weight of 1 cubic inch of water at 62°, and having found by experiment 13·584 to be the specific gravity of the mercury used compared with water at 62°, we obtain

	cub. in.
Capacity of the bulb at 62° =	2·957
Capacity of the bulb at 32° =	2·956 nearly.

The bulb having been thus calibrated was sealed on to the capillary tube t, and, along with its appendage bulbs b, b' and tube T, was attached to the reservoir at D in the manner already described. In this experiment the bulb b contained anhydrous phosphoric acid, and b' fused caustic potash; while these tubes were attached, the bulb B was heated and cooled very many times. The potash bulb b' was detached in about a week, but the phosphoric acid bulb was kept attached for at least three weeks.

* Report of the Kew Committee of the British Association for 1853–54.

It has been already remarked that in these experiments the mercury in the tube T is always brought to a fixed point, determined by its cathetometer-reading, this being as near the top as is conveniently possible. Also, when the boiling-point apparatus is attached, it is arranged so as always to embrace, along with the bulb, the same portion of the capillary tube. If this position be marked, on one side of the mark we shall have air of the temperature of steam, and on the other side air of nearly the same temperature as the atmosphere. In order to estimate the volume of air existing in the tube at the atmospheric temperature when the mercury has been set to its fixed point by means of the cathetometer, shut the stopcock at D′, and estimate, by means of the graduated head, the number of revolutions and parts of a revolution of the fine screw S′ requisite to bring the mercury to that point in the capillary tube *t* which has been marked as that where the temperature of the boiling-water apparatus commences.

It may perhaps be objected to this method of measuring $\frac{v}{V}$, that should there be a small bubble of air lurking in the reservoir R, or at the points of the appendage tubes, after the bulbs *b*, *b′* have been detached, this air will contract under the additional pressure caused by raising the mercury in T, and will consequently make *v* appear to be greater than it really is. It has, however, been ascertained, by means of pushing the mercury to a fixed point of the capillary tube *t*, with the stopcock at D′ shut, and then increasing the pressure by heating the bulb, that the error arising from this source is inappreciable.

It has also been ascertained, by means of inserting a small thermometer, that the temperature of the air in the tube immediately above the mercury at *h* remains nearly the same as that of the atmosphere without, even when the boiling-water apparatus is in operation.

It requires two observers to work the instrument. When the ice or boiling-water apparatus has been sufficiently long attached to make the observations constant, one observer is stationed at the cathetometer, which is set to the fixed point *h*, while another, by means of the fine screw S′, pushes the mercury (always a very little up) to the proper height for the cathetometer-setting. By making the mercury always rise, a uniform capillary action is secured. The cathetometer-observer then records the height of the mercury in T′. Suppose this to be higher than *h*, the difference between the level of the mercury in the two tubes, added to the barometric pressure, will give us the pressure of the air in the bulb B.

Mr. George Whipple, meteorological assistant at Kew, an exceedingly accurate and delicate observer, took most of the cathetometer- and barometer-readings in these experiments. It has been found that for a length of 30 inches the cathetometer-measurement requires a correction of +·003 inch, or for a difference of 11 inches +·001 nearly. This has been attended to in reducing the experiments. The bore of the tube T′ is about ·25 inch, that of the tube T at *h* is generally smaller; the capillary correction is ascertained after the bulb is detached, and the same atmospheric pressure acts on the

surface of mercury in both tubes, by setting the mercury in T to the height h, and then reading by means of the cathetometer the height of the fluid in T'. In the first set of experiments the capillary correction has been found to be insensible. The following Table exhibits the results of this series of experiments.

TABLE I.—Results from first Bulb.

Date.	Number of readings taken		Elasticity of air in inches of mercury, having			Values of				Resulting value of $1+180\alpha$.
1862.	At 32°.	At 212°.	P.	P'.	the temp.	k.	T.	$\frac{v}{V}(1+kt)$.	$1+\alpha t$.	
Sept. 9.	8	4	30·811	41·965	65°	·0000131	180·25	·00555	1·0672	1·36729
Oct. 22.	6	6	30·791	41·868	56	·0000131	179·10	·005646	1·0489	1·36741
29.	7	6	30·777	41·903	52	·0000131	180·04	·005646	1·0407	1·36731
Mean value of $1+180\alpha$.........										1·36733

After the experiments recorded in Table I. were made, the bulb was again carefully examined, and found to be free from mercury, and then a very small portion of this fluid was pushed into the bulb, and the experiments recorded in Table II. were made in order to ascertain the influence of mercurial vapour upon the result obtained.

TABLE II.—Results from first Bulb with a little mercury in it.

Date.	Number of readings taken		Elasticity of air in inches of mercury, having			Values of				Resulting value of $1+180\alpha$.
1862.	At 32°.	At 212°.	P.	P'.	the temp.	k.	T.	$\frac{v}{V}(1+kt)$.	$1+\alpha t$.	
Nov. 21.	6	6	30·757	41·914	44·0°	·0000131	180·45	·00555	1·0244	1·36774
Dec. 2.	6	6	30·768	41·857	45·0	·0000131	179·39	·00555	1·0265	1·36749
8.	8	6	30·769	41·923	50·0	·0000131	180·25	·00575	1·0366	1·36786
13.	6	6	30·768	41·901	47·0	·0000131	180·10	·00565	1·0305	1·36755
Mean value of $1+180\alpha$.........										1·36766

Hence we see that, by forcing a little mercury into the bulb, the value of $1+180\alpha$ is apparently increased by the amount ·00033.

Second Series of Experiments.

On December 22, 1862, the bulb used in the first series of experiments was detached, and another, containing a little anhydrous barytes, was put in its place. In a couple of days the air in this bulb seemed to have become sufficiently dried; while there could be no suspicion of vapour of mercury having in this time distilled over into the bulb through a capillary tube of the length of 9 inches, and while the bulb remained at the same temperature as the other parts of the apparatus.

The bulb also was not calibrated before use, nor did any mercury come in contact

with it until after the experiments about to be described. It was finally calibrated in the usual way. The tubes T, T′ were the same as those used in the last experiment, and the capillary correction was inappreciable. The result obtained by this bulb is recorded in the following Table:—

TABLE III.—Results from second Bulb.

Date.	Number of readings taken		Elasticity of air in inches of mercury, having			Values of				Resulting value of $1+180\alpha$.
1862.	At 32°.	At 212°.	P.	P′.	the temp.	k.	T.	$\frac{v}{V}(1+kt)$.	$1+\alpha t$.	
Dec. 24.	6	4	28·454	38·747	44°	·0000130	180·60	·00753	1·0244	1·36730
27.	4	4	28·457	38·766	46	·0000130	180·84	·00753	1·0285	1·36737
29.	4	4	28·460	38·684	48	·0000130	179·28	·00753	1·0326	1·36745
									Mean value of $1+180\alpha$	1·36737

After the experiments recorded in Table III. a little mercury was pushed into the bulb; and the results obtained are recorded in the following Table:—

TABLE IV.—Results obtained from second Bulb with a little mercury in it.

Date.	Number of readings taken		Elasticity of air in inches of mercury, having			Values of				Resulting value of $1+180\alpha$.
1863.	At 32°.	At 212°.	P.	P′.	the temp.	k.	T.	$\frac{v}{V}(1+kt)$.	$1+\alpha t$.	
Jan. 12.	6	6	28·444	38·729	41°	·0000130	180·40	·00753	1·0183	1·36762
14.	4	4	28·450	38·749	44	·0000130	180·60	·00753	1·0244	1·36762
									Mean value of $1+180\alpha$	1·36762

It appears from a comparison of Tables III. and IV., that the value of $1+180\alpha$ is apparently increased ·00025 by forcing in the mercury. For the first bulb this increase was ·00033; and the difference between these numbers is probably owing to errors of observation: but the agreement is sufficiently close to show that the first bulb cannot have at first contained any vapour of mercury; for, if it had, the difference caused by forcing in mercury, instead of being greater than that for the second bulb, should have been much less.

Third Series of Experiments.

The barytes bulb was now removed, and another bulb of flint glass, along with its own drying-arrangement and tube T, was attached to the apparatus. The bulb was only calibrated after use, and had not come in contact with mercury until the experiments were finished.

Sulphuric acid was used instead of anhydrous phosphoric acid in the bulb b, and potash, as before, in b'.

Unfortunately the capillary correction due to the setting at h was not determined in

an unexceptionable manner; but as the third series of experiments is precisely similar (as regards the value of $\frac{v}{V}$) to the fourth, to be hereafter described, we shall apply to the former the capillary correction for the fourth series as probably near the truth. Accordingly, for equal pressures on both tubes, we shall suppose that T would have read ·018 in. lower than T′.

TABLE V.—Results from third Bulb.

Date.	Number of readings taken		Elasticity of air in inches of mercury, having			Values of				Resulting value of $1+180\alpha$.
1863.	At 32°.	At 212°.	P.	P′.	the temp.	k.	T.	$\frac{v}{V}(1+kt)$.	$1+\alpha t$.	
March 3.	6	6	31·887	43·424	56°	·0000141	179·75	·00323	1·0489	1·36729
16.	8	6	31·866	43·413	47	·0000141	180·09	·00323	1·0305	1·36719
31.	14	6	31·879	43·465	54	·0000141	180·55	·00323	1·0448	1·36732
Mean value of $1+180\alpha$.........										1·36727

Fourth Series of Experiments.

The third bulb was removed, and another bulb of crown glass put in its place. This bulb had not come in contact with mercury before the experiments were made; it was afterwards calibrated in the usual manner. The capillary correction has been already given. The results with this bulb are embodied in the following Table:—

TABLE VI.—Results from fourth Bulb.

Date.	Number of readings taken		Elasticity of air in inches of mercury, having			Values of				Resulting value of $1+180\alpha$.
1863.	At 32°.	At 212°.	P.	P′.	the temp.	k.	T.	$\frac{v}{V}(1+kt)$.	$1+\alpha t$.	
June 1.	6	6	30·681	41·817	62°	·0000141	180·42	·00335	1·0611	1·36713
2.	8	8	30·687	41·804	66	·0000141	180·18	·00335	1·0692	1·36691
5.	8	6	30·681	41·792	64	·0000141	180·01	·00335	1·0651	1·36715
6.	8	6	30·685	41·744	64	·0000141	179·18	·00335	1·0651	1·36705
8.	20 (double set.)	12 (double set.)	30·679	41·757	63	·0000141	179·37	·00335	1·0631	1·36736
Mean value of $1+180\alpha$										1·36716

We have thus, by means of these four series of experiments, four mean values of $1+180\alpha$, as under:—

First bulb, flint glass, dried by anhydrous phosphoric acid, gives .	1·36733
Second bulb, flint glass, dried by anhydrous barytes in bulb, gives	1·36737
Third bulb, flint glass, dried by sulphuric acid, gives	1·36727
Fourth bulb, crown glass, dried by sulphuric acid, gives	1·36716
Mean value of $1+180\alpha$ . .	1·36728

This, therefore, is to be regarded as the coefficient obtained by these experiments. It differs slightly from that found by REGNAULT, who makes it to be 1·3665; and although the difference is not great, I should have preferred to have agreed still more closely with this eminent authority, but I am unable to think of any source of error in these experiments.

Two sets of experiments were made in order to determine the freezing-point of mercury. In these, in order to ensure the greatest possible amount of precision, it was estimated that the air in a portion of the capillary tube near the mercury had a temperature lower than that of the atmosphere. The first set of experiments were made with the first bulb, and the second set with the third bulb.

Here the formula to be employed is

$$\frac{1+\alpha\mathrm{T}}{1+k\mathrm{T}}=\frac{\mathrm{P}''}{\mathrm{P}-(\mathrm{P}''-\mathrm{P})\frac{v}{\mathrm{V}}\frac{1+kt}{1+\alpha t}},$$

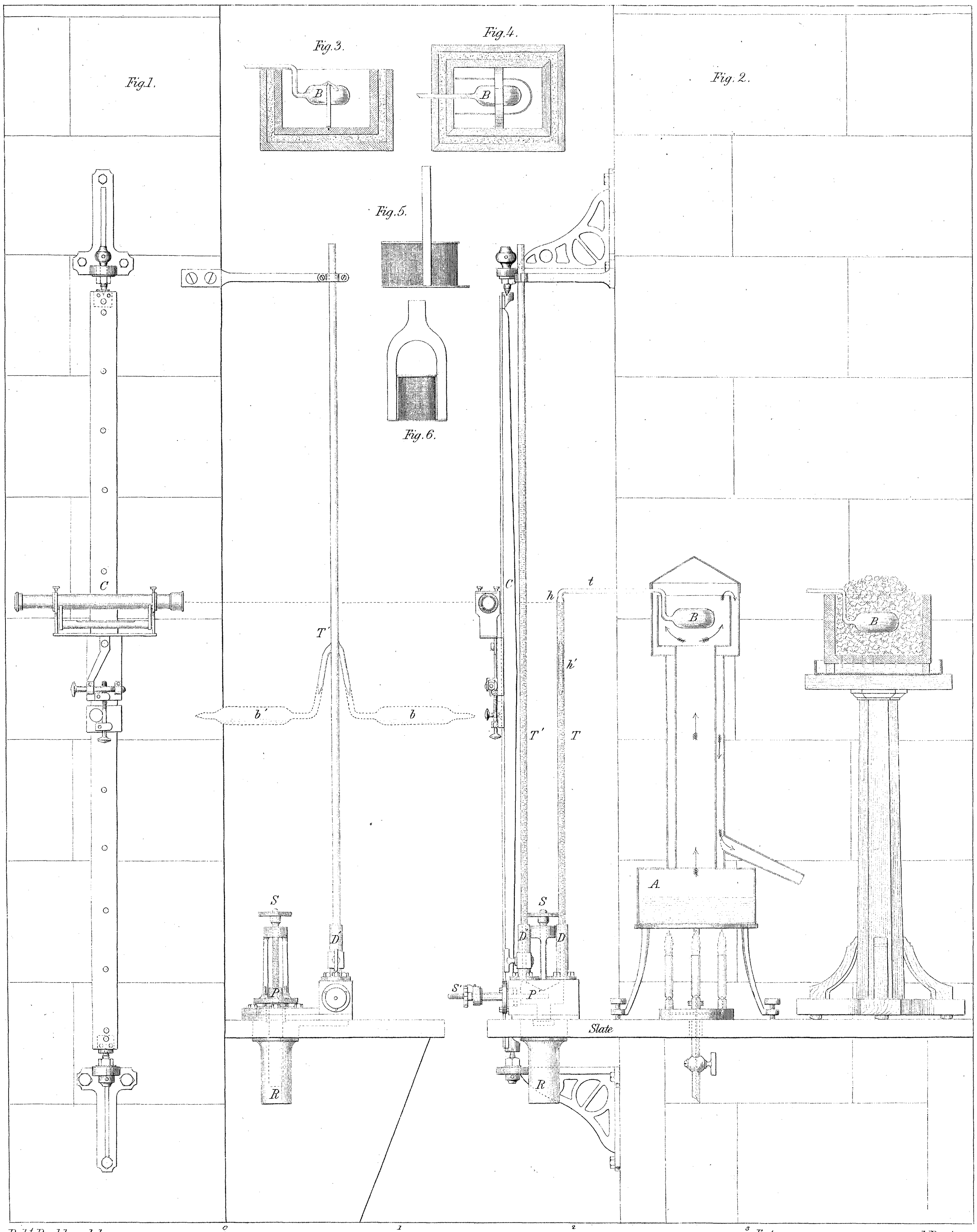
and the freezing-point of water now becomes the higher temperature. The result of these experiments is embodied in the following Table:—

TABLE VII.—Experiments made in order to determine the Temperature of Melting Mercury.

Date.	Number of readings taken		Elasticity of air in inches of mercury, having			Values of				Resulting value of T.
	At 32°.	At melting-point of mercury.	P.	P″.	the temp.	α*.	k.	$\frac{v}{\mathrm{V}}(1+kt)$.	$(1+\alpha t)$.	
1862. Oct. 22.	6	12	30·791	26·446	56	·0020404	·0000131	·00652	1·0489	−69·91
1863. Mar. 13.	14	15	31·879	27·368	54	·0020404	·0000141	·00329	1·0448	−69·95
							Mean value of T.........			−69·93

Hence the value on FAHRENHEIT'S scale of the melting-point of mercury, as determined by these experiments, is −37°·93 F., while on a standard Kew mercurial thermometer the reading was −38°·2 F. It may perhaps be gathered from this that mercury, before beginning to freeze, slightly increases the rate at which it contracts; but further experiments must be made with other mercurial thermometers before this can be accurately determined.

* As determined by the foregoing experiments.



Robt. Beckley del.

J. Basire sc.