I have endeavoured to prove in the foregoing pages the following main facts :—

1. That the iodide of silver exists in three allotropic forms, viz. (α), at temperatures between 116° C. and its fusing-point, as a plastic, tenacious, amorphous substance possessing a reddish colour and transparent to light ; (β), at temperatures below 116° C., as a brittle, opaque, greenish-grey, crystalline mass ; and (γ), if fused and poured into cold water, as an amorphous, very brittle, yellow, opaque substance.

2. That the iodide possesses a point of maximum density at or about 116° C. at the moment before passing from the amorphous into the crystalline condition.

3. That if we allow a mass of molten iodide to cool, the following effects may be observed :—(α) at the moment of solidification a very considerable contraction takes place ; (β) the solid, on further cooling, undergoes slight and regular contraction after the manner of solid bodies in general, until (γ) at or about 116° C. it undergoes sudden and violent expansion, passing from the amorphous into the crystalline condition ; (δ) after undergoing this expansion the mass on further cooling undergoes slight expansion, and (ϵ) the coefficient of contraction diminishes as the temperature decreases (or otherwise expressed, the coefficient of contraction augments with the temperature).

I must, in conclusion, express my great indebtedness to Dr. Guthrie for allowing me to carry out many of the foregoing experiments in the Physical Laboratory at South Kensington.

IV. "On the Coefficient of Expansion of a Paraffine of high boiling-point." By G. F. Rodwell, F.R.A.S., F.C.S., Science Master in Marlborough College. Communicated by Prof. Stokes, Sec. R.S. Received November 17, 1874.

In the search for a liquid of high boiling-point which could be used for the exact determination of the coefficient of expansion of iodide of silver, and which at the same time should be free from certain objections which apply to the employment of mercury for this purpose, a paraffine of high boiling-point naturally suggested itself. Mr. W. H. Hatcher, to whom I express my acknowledgments, procured for me a specimen of paraffine which was taken from one of the stills at Messrs. Price's works at a high temperature. With it the following experiments were made.

The paraffine in question is perfectly white and pearly, and in thin layers translucent ; it fuses to a colourless liquid, which slightly darkens when heated for some time to a temperature exceeding 600° F. (315°·55 C.). Its specific gravity at 32° F. (0° C.) is ·921. It is hard and somewhat granular when broken, and at a low temperature may be crudely pulverized by a blow. At temperatures exceeding 100° F.

(37°·75 C.) it begins to soften slightly, and gradually becomes softer as the temperature rises, until just before reaching the fusing-point, 142° F. (61°·11 C.), it is quite plastic, and may be moulded by pressure, or spread out into thin coherent sheets. It thus resembles some metals which are brittle at the ordinary temperature, but become more and more malleable as the temperature rises. As the temperature rises, the paraffine becomes more and more translucent; and, like sealing-wax and some other bodies, it becomes what we may call either semifluid or semisolid before it finally fuses to a colourless perfectly transparent fluid. As the temperature approaches 400° F. (205°·5 C.), the liquid begins to give off fumes; it "flashes" (that is to say, the vapour ignites on the application of flame, but does not continue to burn) at 458° F. (236°·65 C.); and the vapour ignites spontaneously without the presence of flame and continues to burn at 576° F. (302°·75 C.). Finally the boiling-point is above the melting-point of lead and the boiling-point of mercury, but below the melting-point of zinc (apparently not much below it), presumably about 750° F. (398°·8 C.). Air-thermometer determinations of the boiling-point were not satisfactory. As the liquid cools from the boiling-point the contraction is seen to be enormous. The comparatively small quantity of liquid paraffine (about 15 grammes) capable of being contained in a tube 15 centimetres (nearly 6 inches) long by 15 millimetres (nearly $\frac{5}{8}$ inch) diameter can be *seen* to sink two or three centimetres in less than 10 minutes. The subsidence continues until the point of solidification is attained, when the mass commences to solidify at the bottom, and proceeds gradually up the sides of the tube, leaving a central core of perfectly fluid matter which does not solidify for some length of time. The mass parts with its heat very slowly. When perfectly and uniformly cooled down to the ordinary temperature, a hollow central core is found in the mass of paraffine, extending nearly to the bottom, and gradually narrowing as it descends. The contraction which takes place in passing from the liquid to the solid condition is very considerable.

The expansion which paraffine undergoes when heated appeared to be so unusually great, that the following experiments were made in order to determine its amount. They may be divided into three parts, viz. experiments to determine:—(α) the coefficient of expansion of the solid for temperatures between 32° F. (0° C.) and the point of fusion, 142° F. (61°·11 C.); (β) the precise change of volume which ensues when the solid at 142° F. passes into the liquid at 142° F.; and (γ) the coefficient of expansion of the liquid between its point of maximum density (142° F.) and its boiling-point (presumably about 750° F., 398°·8 C.).

In these determinations the greatest obstacle to be contended against was the slight conductivity of the paraffine, which made it very difficult to evenly heat either a solid or liquid mass. The only way of doing this was to keep the mass for a length of time at the precise temperature required; and this it is almost impossible to do when the temperature of

the liquid mass is above the point at which the vapour ignites spontaneously. It is also difficult to manipulate with a liquid which is above the boiling-point of mercury, and is at the same time giving off clouds of spontaneously inflammable vapour. The slight conductivity of the solid is shown by the following results. The bulb of a thermometer was imbedded in a mass of paraffine in such a manner that the distance between the outer surface of the paraffine and the surface of the bulb was 8 millims. (about $\frac{5}{16}$ inch). It was immersed in water, and kept in a fixed position about 3 centimetres above the bottom of the beaker, and on a level with a thermometer-bulb in direct contact with the water. The beaker was gently heated on a sand-bath, and the thermometers were observed for nearly an hour at intervals of two minutes. At starting, 11.20 A.M., the temperature of the water was 52° F. (11°·11 C.). The gas was turned

Time.	Temperature shown by the thermometer immersed in water.	Temperature shown by the thermometer imbedded in paraffine.	Difference.
h m			
11 20 A.M.	52° F.	52° F.	0° F.
11 22	68	54	−14
11 24	85	58	−27
11 26	105	67	−38
11 28	124	79	−45
11 30	141	92	−69
11 32	148	100	−48
11 34	148	107·5	−40·5
11 36	146	112	−34
11 38	144	116·5	−27·5
11 40	141·5	120·5	−21
11 42	139	124	−15
11 44	137	127	−10
11 46	134	129	− 5
11 48	131	130	− 1
11 50	129·5	130	+ 0·5
11 52	128	130	+ 2
11 54	126	129	+ 3
11 56	124	128	+ 4
11 58	122	126	+ 4
12 00	120	124·5	+ 4·5
12 2 P.M.	118	122	+ 4
12 4	116·5	120·5	+ 4
12 6	115·5	119·5	+ 4
12 8	114	118·25	+ 4·25
12 10	112·5	117·25	+ 4·75
12 22	105	111·25	
12 47	90·5	90·5	
1 6	82·5	82·5	
2 14	66·5	66·5	

out when the thermometer immersed in the water read 141° F., but it rose to 148° F. (six degrees above the point of fusion of the paraffine), and a very small amount of paraffine at the surface melted; hence, with the exterior surface actually fusing at 148° F., it will be seen that the imbedded thermometer, separated from the fused surface by only 8 millims. of paraffine, read 48° F. lower. Further, it will be noticed that the temperature of the water rose steadily to 148° F. and then sank at the rate of about one degree in a minute, while the paraffine acquired heat increasingly till the water ceased to be heated, then less quickly, until when the paraffine had acquired a temperature of 130° F. the temperatures coincide, half an hour after the commencement of heating. Then the temperature of the paraffine begins to fall gradually, and less quickly than that of the water, until at 90°·5 F. there is once again coincidence, one hour and twenty-seven minutes from the commencement of heating. After this the temperatures read alike, and the thermometers continue to fall *pari passu*. In the column of differences, *minus* differences signify that the temperatures of the paraffine-thermometer were *below* those of the water-thermometer, *plus* differences that the former were *above* those of the latter.

It will be noticed that the two-minute observations cease at 12.10 P.M., and that the last four are made at intervals of 12, 25, 19, and 68 minutes.

In regard to the fluid paraffine, a mass of from 20 to 30 grammes takes two or three hours to cool down from just below its fusing-point to the temperature of the air—that is, to cool through about 80° F. The bulb of a thermometer was surrounded by 8 millimetres of liquid paraffine at 150° F., and was plunged in a bath kept at 245° F.; at the end of half an hour the mass of about 30 grammes had barely acquired the temperature of the bath. In heating a vessel of paraffine there is always a marked difference between the temperatures of the upper and lower levels. The convection-currents part with their heat so slowly that a uniform temperature throughout the mass seems to be altogether unattainable without constant and complete agitation. During the heating of about half a litre of the liquid paraffine in a cylindrical copper vessel 75 millimetres (about 3 inches) diameter by 150 millimetres high, the following results were obtained:—The upper thermometer was placed with its bulb a centimetre from the surface, the lower thermometer with its bulb a centimetre from the bottom. The fluid mass was directly heated by a Bunsen burner from below. In the column of differences, *minus* differences signify that the temperature of the lower thermometer is *below* that of the upper thermometer, and *plus* differences that the temperatures of the former are *above* those of the latter. The gas was turned out at 6 P.M., the highest temperature being attained by the lower thermometer (361° F.) at 6.1 P.M., while the highest temperature attained by the upper thermometer was 354° F. at the same time.

Time.	Upper thermometer.	Lower thermometer.	Differences.
h m			
5 55 P.M.	270° F.	282° F.	+12° F.
	280	291	+11
	290	298	+ 8
	300	310	+10
	320	331	+11
	330	340	+10
	340	350	+10
6 00	350	359	+ 9
	354	361	+ 7
	354	356	+ 2
	352	348	− 4
	348	337	−11
6 5	336	317	−19
	330	310	−20
	320	298	−22
	310	286	−24
6 10	300	274	−26
	290	264	−26
	280	254	−26
	270	244	−26
6 15	260	235	−25
	250	226	−24
6 20	245	221	−24
	240	217	−23
6 30	198	182	−16
7 20	144	144	0

It will be observed that while observations were made at intervals of 5 minutes (and at first at each of the intervening minutes), the interval between the last two is 50 minutes, and the mass partly solidified had fallen to 144° F. The greatest difference between the upper and lower thermometers during the cooling through a range of 200° F. is no less than 26° F., and only for an instant, at a temperature of about 355° F., have the two thermometers coincided.

Determination of the coefficient of expansion of solid paraffine between 32° F. (0° C.) and the fusing-point, 142° F. (61·11 C.).

The above examples show us the extreme difficulty of obtaining uniformity of temperature in either a solid or liquid mass of paraffine, and help to explain various incongruities which presented themselves in the course of the following determinations. The coefficient of expansion of the solid was determined by weighing a piece of compact paraffine in water at different temperatures, the expansion of water (as determined by M. Despretz to seven places of decimals) being of course well known.

Owing to the great contraction which takes place when a mass of liquid paraffine solidifies, it was found to be somewhat difficult to obtain a solid mass free from minute cavities and of uniform texture. The plan eventually adopted was to take a long column of melted paraffine and to cool the lower extremity of it. The supernatant fluid forced its way into the central cavity produced by the contraction of the solidifying mass, and the result was a mass of paraffine apparently quite compact and free from cavities. It was suspended from the balance by horsehair, and weighted by a piece of brass, the weight of which in air and water at different temperatures was known; and the whole was finally weighed in distilled water which had been well boiled and cooled in a good vacuum. After the immersion of the paraffine the whole was again placed in a good vacuum. The mass was heated and weighed in water at various temperatures, between 32° F. (0° C.) and 142° F. (61°·11 C.); the melting-point and the cubical expansion was found to be as follows, for one degree Fahrenheit:—

Between	32° F.	and	60° F. (15°·55 C.)	·00031985
,,	60° F.	,,	100° F. (37°·6 C.)	·00039090
,,	100° F.	,,	120° F. (48°·85 C.)	·00143118
,,	120° F.	,,	142° F. (61°·11 C.)	·00244358

The considerable increase of the coefficient as the point of fusion is approached is explained by the fact, already adverted to, that the solid paraffine becomes soft and semisolid like sealing-wax and gutta-percha before actually becoming liquid. From the above coefficients we deduce the fact that

100 volumes of paraffine at 32° F. become	100·8955	at	60° F.
,, ,, ,, ,, ,,	102·4591	,,	100°
,, ,, ,, ,, ,,	105·3215	,,	120°
,, ,, ,, ,, ,,	110·6974	,,	142°

As the latter temperature is approached the mass may be moulded by the hand like a mass of dough or putty; and on continuing the heat at the same temperature, it fuses to a limpid liquid.

Determination of the amount of expansion which paraffine undergoes when it passes from the solid condition at 142° F. *to the liquid condition at the same temperature.*

Tubes of known weight and capacity were exactly filled with melted paraffine at 142°. They were then allowed to cool; the cavity produced by contraction was accurately filled with mercury, which was weighed and the capacity of the cavity deduced therefrom. The results were concordant and satisfactory. Thus it was found that volume=100 at 60° F. becomes, in the fluid condition, at 142° F.:—

I.	115·0565
II.	114·7232
III.	114·9458
IV.	114·7318
Mean=	114·8643

From this we deduce that a volume of paraffine=100 at 32° F. will equal 113·8447 at 142° F. in the fluid state; and if we subtract the expansion between 32° and 142° F. of the solid, we find that the actual expansion of the semisolid paraffine in passing into the perfect liquid will be 3·1473 on the volume 100 at 32° taken as the starting-point.

Determination of the coefficient of expansion of liquid paraffine between 142° F. *and its boiling-point* (*presumably about* 750° F.).

The paraffine was heated in tubes of known weight and capacity in a bath of paraffine, and the weight of paraffine which exuded between any observed range of temperature was determined. Specific-gravity flasks with capillary stoppers were found to be unsuitable for the determinations, on account of the difficulty of uniformly heating the mass of liquid within them. Many attempts were made to determine the increase of the coefficient with the temperature, but the results were not satisfactory; hence I can only give the mean coefficient of expansion between the melting-point and the boiling-point.

The result of many experiments gave

·000593

as the mean coefficient of expansion of the liquid. The following are records of some of the determinations:—

A volume of liquid paraffine at 142° F. being taken at 100,

	Found.	Calculated.
Volume at 200° F.	=103·4951	103·4394
,, ,, 250°	=106·4766	106·4044
,, ,, 300°	=108·9820	109·3694
,, ,, 350°	=112·6365	112·3344
,, ,, 400°	=116·4143	115·2994
,, ,, 500°	=122·3814	121·2294
,, ,, 600°	=127·2905	127·1594
,, boiling-point	=135·3344	136·0544

The volume at the boiling-point is calculated on the supposition that it is 750° F., near to which it certainly must be; the volume found corresponds, if we employ the above coefficient of expansion, to 744° F. (395°·5 C.).

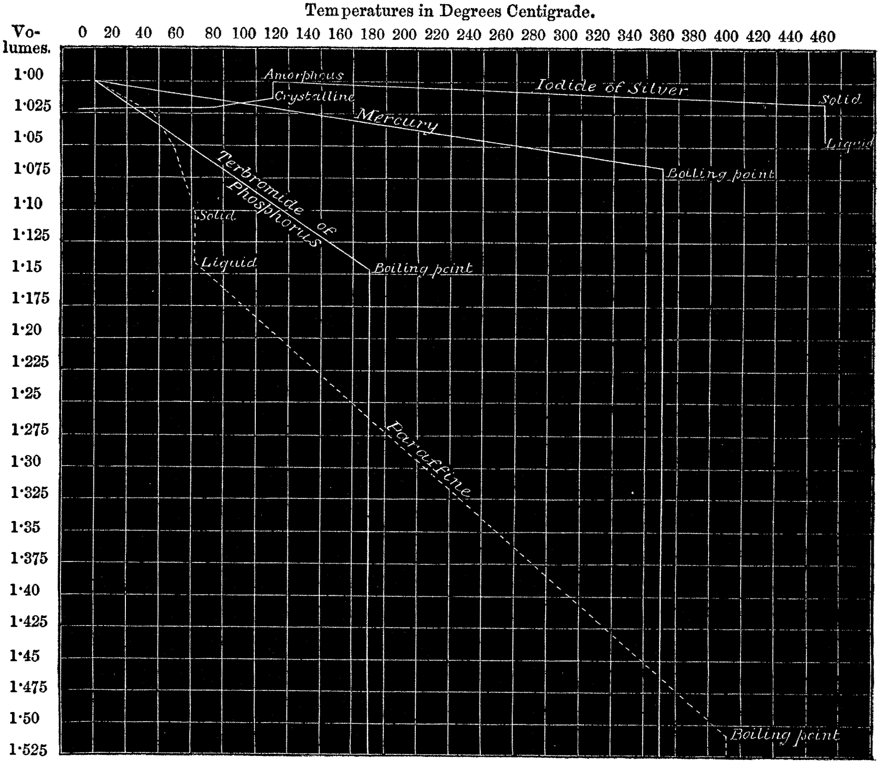
Summarizing the above results we obtain the following Table, which represents the volumes of a mass of paraffine (taken at 100 at 32° F.,

0° C.) at various temperatures, and the specific gravities corresponding thereto (sp. gr. at 32° F.=·921).

100 volumes at 32° F. become

100·8955	at	60° F. (15°·55 C.).	Sp. gr.	·913	
102·4591	,,	100° F. (37°·6 C.).	,,	·899	
105·3215	,,	120° F. (48°·85 C.).	,,	·874	
110·6974	,,	142° F. (61°·11 C.).	,,	·884	solid.
113·8447	,,	142° F. ,,	,,	·799	liquid.
117·8135	,,	200° F. (93°·3 C.).	,,	·766	
123·9717	,,	300° F. (148°·8 C.).	,,	·739	
130·1297	,,	400° F. (205°·5 C.).	,,	·706	
136·2879	,,	500° F. (260° C.).	,,	·675	
142·4461	,,	600° F. (315°·5 C.).	,,	·647	
150 9853	,,	744° F. ? (395°·5).	,,	·610	

Temperatures in Degrees Centigrade.



It is thus seen that paraffine is a body which undergoes a most unusual expansion in passing from its ordinary solid condition to the high boiling-

point which it possesses. I do not remember any other substance of a high boiling-point which occupies at the boiling-point a volume which is one half as large again as the volume at the ordinary temperature. In the accompanying figure (p. 115) I have introduced, side by side with the paraffine curve, the expansion curves of mercury, iodide of silver, and terbromide of phosphorus, one of the most expansible liquids known, if we except such bodies as ether, bromide of ethyl, acetate of methyl, &c., the boiling-point of which is below 100° C., and which, therefore, could not easily be introduced into the figure for comparison with a body which boils at nearly 400° C.

V. "Experiments showing the Paramagnetic condition of Arterial Blood, as compared with the Diamagnetic condition of Venous Blood." By Richard C. Shettle, M.D. Communicated by Dr. Lockhart Clarke, F.R.S. Received October 20, 1874.

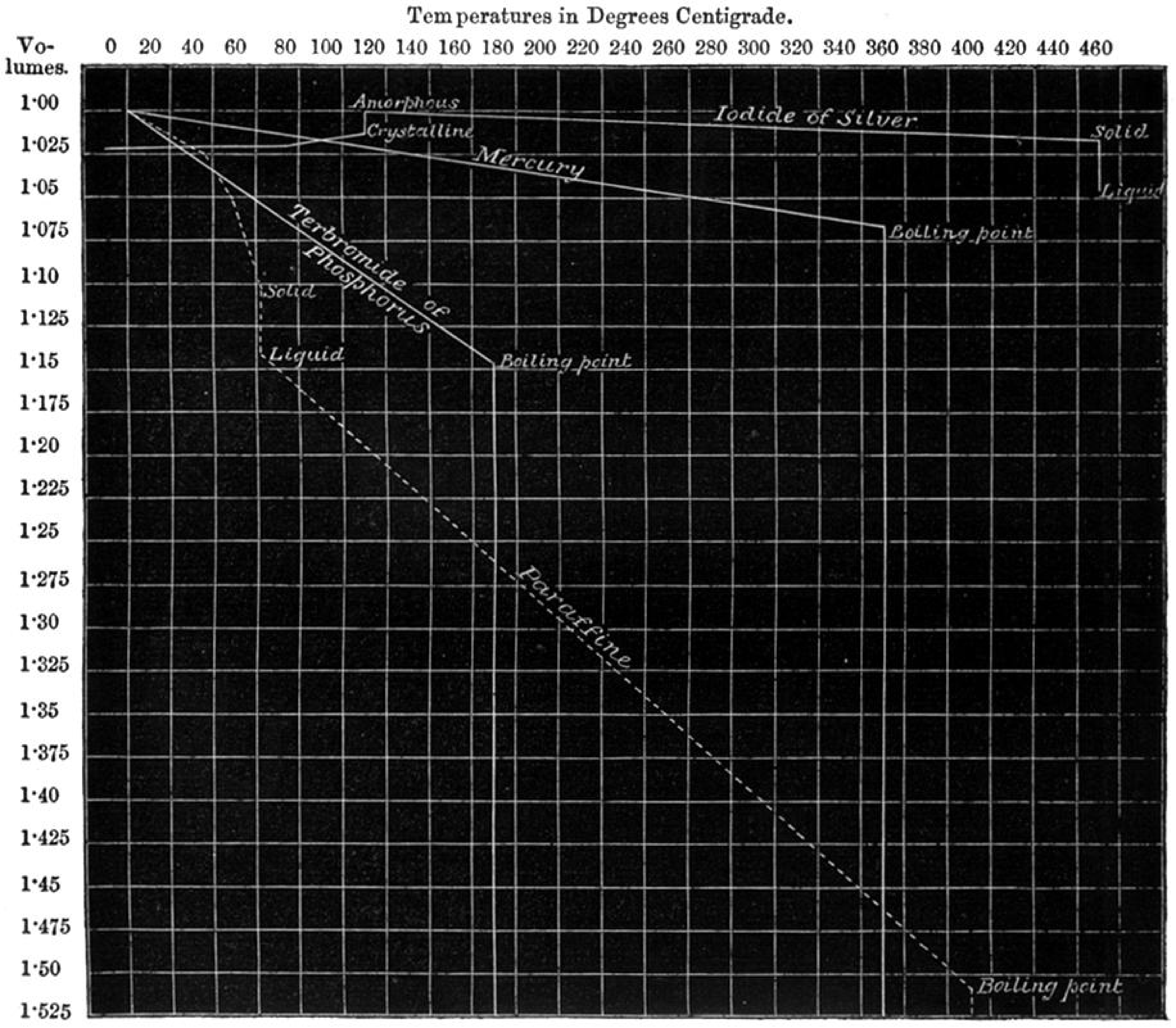
The magnetic condition of all matter has been well ascertained, and the fact that the same matter may exhibit different magnetic phenomena according to the medium in which it is placed is a point of considerable importance when testing for such results.

It is therefore absolutely essential that any experiments which have for their object the demonstration of paramagnetic force of low power should be tested in media of known strength. In the experiments I have now the honour of laying before the Royal Society, the relative condition which bodies bear to each other as regards their magnetic properties has been strictly observed.

The experiments consist in suspending between the poles of a powerful electromagnet arterial blood hermetically sealed in a glass tube in a medium of venous blood, and venous blood in the same tube, previously well emptied of its contents, in a medium of arterial blood, care being taken to avoid as far as possible any exposure of the blood to the atmosphere, thus preventing any alteration in its physical characteristics as regards the gases which it contains.

The necessary apparatus consists of some German glass tubes in which the fluid to be tested is hermetically sealed, a thin glass vessel for holding the medium in which the testing-tube is suspended, two glass bottles for defibrinating the blood, two store glass bottles for receiving the blood after it has been defibrinated, oxygen gas, carbonic acid gas, very thin india rubber, and an electromagnet and battery of 15 Grove's cells.

The testing-tube (fig. 1) was made of very thin German glass, and the one used for these experiments was of the size and shape shown. It was filled by means of the two short tubes on the upper surface, and when filled was carefully tied over with very thin india rubber; it was suspended by silk in the ordinary way.


Temperatures in Degrees Centigrade.
Volumes.
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460
1·00 1·025 1·05 1·075 1·10 1·125 1·15 1·175 1·20 1·225 1·25 1·275 1·30 1·325 1·35 1·375 1·40 1·425 1·45 1·475 1·50 1·525
Amorphous
Crystalline
Iodide of Silver
Solid
Liquid
Mercury
Boiling point
Terbromide of Phosphorus
Solid
Liquid
Boiling point
Paraffine
Boiling point