Philosophical Magazine Series 4

ISSN: 1941-5982 (Print) 1941-5990 (Online) Journal homepage: http://www.tandfonline.com/loi/tphm15

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To cite this article: Charles Tomlinson (1862) XLVII. On the motion of camphor towards the light , Philosophical Magazine Series 4, 24:162, 358-371

To link to this article: http://dx.doi.org/10.1080/14786446208643371

Published online: 26 May 2009.

saturation of the space at a temperature of 0°, although the aperture of the tube had a diameter of 1·1 Paris lines.

We are incontestably entitled to conclude from these experiments that Dalton's theory, in so far as it assumes that the air and the vapour existing in the same space are independent of each other, is totally unfounded; the true view rather is that *the air exerts a pressure upon the vapour and the vapour upon the air*. I make use here of this mode of expression merely in order to represent the effect. I hope at a future opportunity to be able to show that the humidity must be regarded as adhering to the molecules of air, and that the phenomena admit of a simple explanation by means of a natural hypothesis concerning the expansion of dry and wet molecules of air.

If it be desired to apply the theory developed in the foregoing to the circumstances of the aqueous vapour in the atmosphere, it is in the first place to be inferred from it that (since the diffusion of the vapour in the air takes place but very slowly, and since in different places, according to the temperature and the magnitude of the surface of the water exposed to the air, very different quantities of vapour pass into it) in regard to the humidity of the air, strictly speaking, no relations subsist conformable to any law. Of course the continually existing currents of air occasion a complete mingling of the more and less dry masses of air; but this takes place in no uniform manner, and therefore no exact relation of dependence exists between the degrees of humidity in different points of any space. But particularly the idea of an atmosphere of vapour subsisting independently by itself appears to be inadmissible, and the data furnished by the psychrometer can no longer be regarded in any other light than as the expression of *local humidity*.

XLVII. *On the Motion of Camphor towards the Light.* By Charles Tomlinson, *Lecturer on Physical Science, King's College School, London**.

IN Chaptal's *Elémens de Chimie* (vol. i. p. 36), published in 1790, a property is claimed for light which has been recognized by later philosophers. For example, in Professor Daniell's 'Introduction to the Study of Chemical Philosophy' (2nd ed., 1843, p. 452), we read, "Light is capable of acting upon and directing homogeneous attraction, and of influencing the crystallization of certain substances. Evidence of this may very commonly be found in druggists' shops, where, in the glass jars which contain camphor and are placed in the windows, beautiful crystals

* Communicated by the Author, having been read at the British Association at Cambridge, October 1862.

may generally be seen attached to the sides the nearest to the light. Many other substances which are capable of the same kind of sublimation exhibit the same phenomena in their solidification.

"M. Chaptal first made the observation that when a number of capillary crystals shoot up the sides of a glass vessel containing a saline solution, they attach themselves only to that side of the vessel which is most strongly illuminated. He was thus able to cause crystals to form on any selected side; and by placing a screen before the vessel, he found that the line between light and darkness was distinctly marked by the limit of crystallization. This result is most readily obtained with the metallic salts."

Professor Brande, in his 'Manual of Chemistry' (1848, p. 11), has a similar statement, and our latest printed authority, Professor Miller's 'Elements of Chemistry' (vol. iii. 2nd edit., 1862), states (p. 540) that camphor "becomes slowly volatilized at common temperatures; and if kept in glass bottles, is gradually sublimed and condensed in octahedral crystals on the side of the vessel which is exposed to the light."

The motion of camphor towards the light was investigated by Dr. Draper, Professor of Chemistry in New York, who, in the Appendix to a work published in 1844, entitled "Treatise on the Forces which produce the organization of Plants," brings together the results of his experiments on the camphor-motions which had been previously published in scientific journals.

It did not escape the notice of the early observers that other substances besides camphor moved towards the light in the glass vessels that contained them. Thus M. Dorthes, one of Chaptal's laboratory pupils, states that spirits of wine, water, &c., "always condense on the most illuminated sides of the vessels." Dr. Draper found that if iodine be heated in a glass vessel and be placed in the sun, the vapour would in like manner condense on the most illuminated side. His method of operating with camphor was to place it in a vessel, which was then exhausted of air, and so moved into the sun. A crystalline deposit would be made on the sunny side in about five minutes, and this would increase during the next two hours, and sometimes cover the whole side of the glass. If a ring of tinfoil $1\frac{1}{2}$ inch internal diameter and $\frac{1}{2}$ an inch wide were attached to the glass, it prevented the deposit in and about it, and would even remove a deposit already formed. A similar effect was produced if the ring were placed near the glass instead of being in contact with it.

Dr. Draper states, further, that the camphor-vessel may be kept in the dark for any length of time without producing a deposit; that artificial light has no effect in producing a deposit; that the deposits are sometimes furthest from the sun, and at other times nearest: these are termed *aphelion* and *perihelion* movements. Dr. Draper says, "The sun's rays have the power of causing vapours to pass to the perihelion side of vessels in which they are confined; but, as it would appear, not at all seasons of the year. For example, I have a certain glass fitted up for making these observations; and in this vessel, during December, January, and part of February 1836–37, a deposit was uniformly made towards the sun; during March, April, and May next following, although every part of the arrangement remained to all appearance the same, yet the camphor was deposited on the side furthest from the sun. It does not appear that any immediate cause can be assigned for this waywardness."

It was further found that when the sun's light was passed through water and solutions of ammonio-sulphate of copper and of bichromate of potash, the crystallization was on the aphelion side.

The following statement is also made:—"Light which has suffered reflexion at certain angles seems to have undergone a remarkable modification, being no longer able to put the glass into such a condition that it can cause motion towards the sun. Under such circumstances crystallization proceeds with rapidity, not on the perihelion side of the vessel, but on the opposite side. This result is not supposed to be due to polarization, as it takes place at all angles."

A very few words will explain Dr. Draper's theoretical views. From the results of an experiment made with a differential thermometer, he "cannot admit that the rays of heat have any active part in bringing about the phenomena." He was strongly inclined to the opinion, from the action of the tinfoil rings, that the motion of camphor to the light was an electrical phenomenon; but he failed to detect electricity, though sought for by means of a delicate electrometer. His ultimate conclusion seems to have been that these deposits are due to a mechanical action of light. In short, the result of Dr. Draper's elaborate inquiry was to multiply phenomena and to leave the theory as it was.

I am not aware that this subject has been investigated by any one since the publication of Dr. Draper's volume. In repeating his experiments, I found it necessary to get rid of the air-pump and of exhausted vessels altogether, in order to be at liberty to multiply experiments to any extent. In some comparative trials it was found that raw camphor was more sensitive than refined, and it was accordingly adopted. Common corked and stoppled bottles of white and coloured glass were used, varying in capacity from a few ounces to a quart and more. These were charged with various quantities of crude camphor, from 2 or 3 grains to 100, and were placed in the window on flat supports at the junction of the sash-bars, and also in various other positions with respect to the light as occasion required. An arrow pointing to the light was marked on every bottle, and in many cases the date when the bottle was first exposed.

It may here be stated once for all, that the substances which produce good deposits are ordinary refined camphor, Borneo camphor, oil of camphor, artificial turpentine camphor, chloral, naphthaline, iodine, mercury, sesquichloride of carbon, water, alcohol, &c.

I must confess that in the early part of the inquiry the whole subject of these camphor motions seemed to be beset with difficulties. I not only obtained Dr. Draper's results, but others equally surprising and contradictory so long as the action of light was looked for. I did not presume to suppose that Chaptal's statement, indorsed as it was by the honoured name of the late Professor Daniell, and by the names of all chemists of repute, was altogether a mistake; but when I considered somewhat the history of science, and remembered that Chaptal wrote at a time when men had no correct views on many parts of the science to which I was led to refer these phenomena—when, for example, the present theories of radiant heat and of dew, of evaporation and condensation did not exist,—I was led to think that my presumption might be pardoned if I ventured to propound an entirely new theory as to the motions of camphor, &c. towards the light.

As my object is to make a short statement, I omit a number of details which led me to adopt a new theory. I also omit many subsidiary facts observed during the inquiry. What led me to suspect that light had nothing to do with the camphor deposits, was the fact that during about a week of fine weather early in May the bottles in the east windows showed deposits *furthest* from the light, while those in the west windows were *nearest* to the light. In order to test this result more closely, four quart stoppled bottles, A, B, C, D, were supplied each with 100 grains of crude camphor in coarse powder and placed as follows:—A in the west window, B outside the west window on the balcony, C in the east window, and D outside the east window. The outside bottles were tied over with india-rubber cloth. In the course of the day deposits were obtained in all four bottles, varying in position and character, clearly establishing the fact that, while one of the indoor bottles was forming a deposit furthest from the light, the corresponding outside bottle had its deposit nearest to the light. The two bottles, within a few feet of each other, gave contradictory evidence. They were both placed under the same circumstances as to light, but with this important difference as to weather—that one was protected from it, and the other exposed to it. In fact there was no escaping from the conclusion, notwithstanding Dr. Draper's protest, that heat is largely concerned in the production of the phenomena. It appeared in these early trials to be clearly made out that the vapour of camphor which filled the bottle was disposed of on the coldest surface of the glass, which might or might not be furthest from the source which supplied both the light and the heat, where it condensed after the manner of dew.

To test this idea, all that seemed necessary was to expose the vessel containing the camphor to the heating action of the sun apart from its light. Accordingly two cylindrical glass jars, A and B, 7 inches high and $2\frac{1}{2}$ inches in diameter, were charged with about 100 grains of crude camphor: their mouths were closed with bungs covered with tinfoil, and so enclosed in well-fitting canisters of tinned iron. A was placed in the west, and B in the east window, on the morning of the 8th of May. They were examined at 3 P.M., the temperature in the west window being 70°. A exhibited a faint deposit of crystals on the side of the glass furthest from the light, that is, on the coldest part of the jar. B gave no result, the sun having left the window before this canister was placed. The next morning B was again examined, and a faint deposit was found furthest from the light.

A result being thus obtained by heat alone, the experiment was varied in the following manner. Four 8-ounce phials, A, B, C, D, were charged, A with refined, and the others with crude camphor. A was covered with tinfoil, B was enclosed in a tin canister, C was covered with brown paper, and D was left naked. They were all arranged around a heated cannon-ball in a darkened room, at such distances as to be exposed to an initial temperature of nearly 90°. In less than half an hour C and D exhibited copious deposits of small crystals furthest from the source of heat. In an hour and a half A had a very faint furthest deposit, B no deposit.

I could now understand why the glasses in the tin canisters exposed to the sun exhibited only faint deposits. The canisters being good conductors of heat, made the glass of nearly the same temperature all round, and my theory required that one part should be colder than the other, and hence the faint deposit on the furthest side where it was only slightly colder; whereas brown paper being a bad conductor, would keep the glass warm on the side nearest the source of heat, and much colder on the furthest or opposite side, as was proved by the copiousness of the deposit.

But how did these results agree with Dr. Draper's assertion, that reflected light produces furthest deposits? Does it? To test this, a camphor-bottle was furnished with a brown paper hood so as completely to cover it. A slit was then cut out $3\frac{1}{2}$ inches in length and $\frac{3}{4}$ inch in width, extending from near the top to the bottom of the bottle. A looking-glass was placed near to and facing an east window, and, a few inches off, the covered bottle with the slit opposite the looking-glass. The morning was wet and cloudy with occasional bursts of sunshine; but in the course of two hours a deposit was formed nearest the slit, and consequently nearest the reflected light. The experiment was repeated over and over again with the same result—modified in this way, that, if the morning sun were unusually hot, the deposit was scattered over a considerable portion of the interior of the bottle, but in such case the largest crystals were opposite the slit, where in fact the bottle was coldest.. A bottle was wrapped up in tinfoil, and a slit only $\frac{1}{10}$th of an inch wide cut out. The deposit was in this case confined to the slit and its vicinity. The results of these and many experiments satisfied me that the "remarkable modification" which Dr. Draper supposes reflected light to have undergone, whereby it produces only aphelion deposits, is really an effect of heat, capable of easy explanation.

The experiments on the protecting action of tinfoil rings, though not very original in their conception, produce admirable results. Had Dr. Draper been acquainted with Prevost's experiments on dew*, and those of Carena on hoar frost†, he would have seen how tinfoil favours or prevents the deposition of moisture on glass according as its position favours or obstructs the radiation of heat. He would, moreover, have seen that his electrical theory is of no value in explaining phenomena which fall under the operation of those great laws which regulate the formation of dew.

It is true also that vapour of water and of iodine move towards the light, but only under certain circumstances. Dr. Draper's method of performing the iodine experiment is, I think, characteristic of his general mode of inquiry. He raises the iodine in vapour, and then places the vessel containing it in the sunshine; that is, he hastens the result, and is satisfied when it is obtained. Had the iodine been exposed to the varying influences of heat and cold, sunshine and shade, it would have been found that the deposit, like that of camphor, and also of water, &c., is sometimes made towards the light, and at other times away from it. An experiment should speak with many tongues; and in order to enable it to do so, it must be repeated many times, under circum-

* *Annales de Chimie*, an xi. 1802-3.

† *Mémoires de l'Académie Royale des Sciences de Turin*, 1813-14.

stances sufficiently varied to detect the regulating law, and to eliminate disturbing causes.

In this examination of Dr. Draper's results, the inquiry became divested of some of its marvellous features, and pointed out the line of inquiry to be followed, and the theory to be established. Let it be granted that camphor, and other substances capable of being raised in vapour at ordinary temperatures, become, on the reduction of temperature, condensed on the coldest side of the vessel after the manner of dew, and all these varied phenomena range themselves in the most orderly manner under two well-known laws, namely, *radiation of heat*, whereby a surface, or a portion of a surface, becomes colder than the vapour in contact with it, and, secondly, *condensation of vapour* by the contact of the colder body. That is the theory which I have now to support.

In proceeding to apply this theory to Chaptal's experiments, I adopted certain variations in the mode of performing them; and naturally so, because, as the form of an experiment is but the expression of the thought that produces it, the one will vary with the other, as vessels cast in moulds of different patterns will vary. Chaptal exposed his solutions to the light in glass vessels, one-half of each vessel being covered with black taffeta, for the purpose, as he thought, of shutting out the light, when in fact he was merely preventing cooling by radiation. I obtain results identical with his in transparent vessels in the full sunshine by preventing radiation and evaporation in one-half of each vessel by covering it with a thin plate of glass or of mica. In such cases the exposed half of the vessel had a crystalline capillary deposit running round it, and increasing from day to day, and even passing over the edge of the glass and covering the outside, while on the covered portion there was no deposit whatever, or only a faint one after some days' exposure. Indeed it is not necessary that the covering glass plate should be in contact with the glass: if it only overshadow it, or be suspended over it, the preventive action is equally produced. I have had a solution of bichromate of potash in one vessel and a solution of sulphate of iron in a similar vessel at a lower level. The glass, which partly covered the first, projected over the second vessel without touching it; and in both cases, that is, in the covered half of one, and the overshadowed half of the other, there were no deposits, although there were abundant ones in the uncovered sides of both glasses.

Chaptal recognized the fact that when a large number of evaporating dishes were arranged according to his method in a small close room, no results were produced. He would have succeeded had he contrived some method of keeping the air dry. I put a solution of sulphate of copper, partly covered with a glass plate, upon a shelf in a dark cupboard. No crystals were formed after many days, on account of the enclosed space becoming saturated with moisture, and thus preventing evaporation. To prove that the absence of light had nothing to do with the result, a capsule containing a few lumps of caustic potash was placed by the side of the solution, and the whole was covered with a bell-glass. In the course of a few hours the creeping crystals began to form on the side of the vessel not covered with the glass plate, just as in the case of similar solutions exposed to the light. Identical results were obtained when solutions of sulphate of zinc and of sulphate of copper were placed in the dark enclosed space without being covered with the bell-glass, provided the air were kept dry by means of caustic potash.

These experiments also serve to explain some facts which puzzled Dr. Draper. A bottle of camphor in the dark produces no deposit, even though left for months, but when put in the window, it forms a deposit immediately. One bottle put within another forms no deposit, even though exposed to the diffused light of day. Exactly so. A bottle shut up in the dark is protected from radiation: it is equally warm all round, and, though filled with vapour, there is no sufficient reason why a deposit should be made at one part of the bottle more than another. Put that bottle in the window, and it becomes cooled on the side nearest the window-pane, and a deposit is made. Light has nothing to do with this result. The experiment can be made in the dark as well as in the light; indeed much better, for by night there is a greater difference between the inner and the outer temperatures than by day. I have taken a bottle of camphor out of a dark cupboard, and placed it in the window on which the moon was shining. A deposit was made within three minutes on the side nearest the moon. Anyone satisfied with the result of one experiment, would say that the light of the moon produced the deposit. I have tried the same experiment when there was no moon, and obtained the same result. So also if a tube containing a little crude camphor be passed through a cork into the centre of an empty bottle, there will be no deposit on the tube on exposure to the light, because the tube is equally warmed all round. So also if a camphor bottle be surrounded with water at 100° or 110° and left to cool, there will be no deposit. In an experiment of this kind, a quart glass jar was three parts filled with water at about 110°, and an eight-ounce phial, containing crude camphor that had been kept in the dark some months without showing any signs of deposit, was plunged into it. The temperature was now 100°; the jar was covered with a large air-pump receiver and left facing the light. Next morning the bottle was taken out and carefully examined; there was no deposit whatever. The bottle was now wiped dry and put in the angle of the window on which the sun was shining. A thermometer placed near it marked 70° and rose to 78°. In less than 25 minutes there was a copious deposit of small crystals on the side nearest the sun. The warm woodwork prevented a deposit on the furthest side: in fact the deposit was formed on the side of the bottle where radiation was most free, even though that side was most exposed to the sun.

The result of this experiment was quite satisfactory to my mind; but as it is my duty to try and convince the minds of other men, I may be allowed to pile up a few of these proofs.

When the surface of the earth and the air resting upon it are of the same temperature, no dew is formed. If the earth be cooled ever so little, there is condensation: so also if the camphor bottle be surrounded by a medium of the same temperature, there is no deposit. Let that medium be of unequal temperature, and a deposit is immediately formed on the colder side. For example: a bottle containing crude camphor, which had been kept in a cupboard during some months without showing any sign of deposit (even when examined by that most delicate of all tests, a lighted candle), was taken out, and a circular piece of filtering paper of about the size of a florin was wetted with sulphuric ether, and so stuck on the outside of the bottle. In a few seconds an abundant deposit was made on the inside, exactly corresponding with the external plaister. The experiment was repeated with paper dipped in alcohol, bisulphide of carbon, &c., with the same result. I could now explain a result which had puzzled me not a little. Bottles containing crude camphor were from time to time placed on a shelf in a glazed bookcase close to the door and opposite a window, and were occasionally changed during several months. They were exposed to the diffused light of the room, and formed furthest deposits during March, April, and May, and no deposits at all during June, July, and August. Now, during the first three months the room had a fire in it; the wall formed the back of the bookcase, and glass doors its front; consequently the back part of the bottles would feel the stream of cold air from the door which passed along the wall to the fire, while the front of the bottles, protected by the glass and looking into the warm room, would preserve a higher temperature than the back; and hence deposits were formed at the back, and none in the front. When, however, fires were left off, the stream of cold air from the door would cease to flow, the inside of the bookcase would not vary in temperature, and the bottles, being protected from radiation, would not be in a condition to form deposits.

Whatever, then, protects the bottles from radiation, either wholly or in part, prevents the formation of deposits. The wooden scale of a thermometer hanging in a window a few inches from a bottle opposite the light, prevents a deposit in a broad line exactly corresponding with the form of the scale. A bottle placed near a bar of the window-frame will mark out the form of the bar by the camphor crystals coming up to within a certain distance of the bar, leaving that portion of the bottle naked which coincides with the form of the bar. In such a case as this, not only does the bar of wood prevent radiation from a portion of the bottle, but, by absorbing heat from the sun, it acts as a source of heat for hours afterwards. So also if a glass containing camphor stand on wood, the lower part is permanently warmer than the upper, as is shown by the repulsion of the deposit from the lower part, and that chiefly at the back—the front, where it is exposed to the light, being kept colder from being nearer the window. When bottles are tied over with flannel or india-rubber cloth, there is no deposit under these flaps. When glasses are closed with bungs, these retain the heat and keep the upper parts of vessels warmer than the middle parts, so that no deposit is made within half an inch or an inch of the bung. Coloured glass bottles produce furthest deposits, when exposed to the sun, more readily than white ones, because they sooner become heated on the exposed side.

The tinfoil rings of Dr. Draper act as screens in preventing radiation. The glass under and for a short space around the metal is kept warmer than the uncovered portion nearest the window, and hence no deposit in and about the protected portion. To prove that this is the correct explanation, it seemed to me that black absorbent substances would act more efficiently as protectors than bright reflecting ones. Accordingly I arranged a number of bottles containing crude camphor, and attached to them disks and rings of tinfoil, and of black, red, yellow, and white paper. The space kept clear by the black paper was many times larger than that cleared by the tinfoil and the lighter papers, and these all varied in extent of clearance with their colour. To show the protecting influence of white paper on a large scale, one half of a large cylindrical jar containing crude camphor was loosely covered with white paper in the direction of its length, and so placed in the window, the paper side nearest the light. There was an abundant deposit on the exposed half of the glass, which has remained some months, but no trace of a deposit has been found on the covered side.

I think enough has been stated to prove that the motion of camphor, &c. towards the light is really an effect of heat. The laws which regulate the deposit of dew and hoar frost apply here.

The bottles exposed in or near a window will always have one side colder than the other, and this colder surface will determine the deposit. Generally the side nearest the window is the coldest (seeing how little sun we have, and how long our nights are), and here the deposit is most copious; but when the sun shines on the window, and the side nearest the light is the hottest, a deposit is naturally made on the furthest side. This furthest deposit, however, is but transient. It disappears when the sun goes off the window, because the furthest side ceases to be the coldest. It goes, in fact, to augment the increasing deposit on the coldest side, or that nearest the light. I could always tell whether there had been any morning sun, by inspecting the east-staircase bottles on descending to breakfast. During the last spring and summer there would sometimes be sunshine and furthest deposits at 5 or 6 o'clock A.M., while clouds or rain would come on about 8, and the furthest deposits would disappear during the day.

It is scarcely necessary to prove that a large bottle placed in the window will be hottest on the side next the light when the sun is shining on the window, and coldest at other times, except perhaps during some of the warmest days of our short summer, when the external temperature is equal to, or even higher than the internal; but as I am supporting a new theory against the united testimony of many illustrious philosophers during three quarters of a century, it is scarcely possible for me to overstate my case. I will therefore give a few more details.

A glass shade with its mouth upwards was placed on a small table about 2 feet from a west window. Two thermometers which marked the same temperature were hung within it, one at the front or nearest the light, and the other at the back or furthest from it. The open mouth was then covered with a flat book. This was on the afternoon of the 7th of July, the weather being cloudy, with occasional bursts of sun. In half an hour the front thermometer read 82°, the back 78°. In another thirty minutes the weather was cloudy, windy, and threatening for rain; front 76°, back 74°. In another thirty minutes, during which heavy rain fell, the temperatures became inverted; the front was now 68°, and the back 74°. The colder temperature was on the side nearest the window during the night, and not until the sun had come round next day did the nearer side become the warmer.

Now if fresh bottles of camphor be placed near the window at intervals during all these mutations of temperature, it will be found that the deposits go to or from the light according as the front or the back of the bottle is the colder. There is no evidence of this fact more satisfactory than actual measurement; and to be quite sure of my instruments, I asked Messrs. Negretti and Zambra to prepare two thermometers that should range together with considerable accuracy. These instruments were received during the very warm weather towards the end of July, and the results obtained by them struck me as remarkable. A cylindrical glass 10½ inches high, and nearly 3 inches in diameter, was washed with sulphuric acid and an abundance of water, dried, and charged with crude camphor. The thermometers were suspended in the glass, front and back. The readings were taken at first every five minutes.

July 26, 1862. Sun on west window.

Remarks.	Furthest.	Time.	Nearest light.	Remarks.
	74° F.	5.40 P.M.	74° F.	
	83	5.45	83	Slight misty appearance in the glass.
	83½	5.50	83¾	
	81	5.55	81½	
	79	6.00	79½	
	78	6.5	78½	Clouds coming over the sun.
Faint camphor deposit. Moisture condensed high up on one side near the back.	77	6.10	77½	
	72	6.15	72	Slightly clouded.
	72	6.20	72	
	76	6.25	76½	
	77	6.30	76	Faint deposit.
	76¼	6.35	75¾	Do. increasing.
	76	6.40	75	Ditto.
	75½	6.45	75	
	75	6.50	74½	Deposit much more marked than on the other side, but still faint.
	75	6.55	74	
	74½	7.00	73½	
	73½	7.10	72½	
	73	7.20	72	
	72½	7.30	71½	
	72½	7.40	71½	
	72	7.50	71	
	71	8.00	70	
	70¼	8.30	69½	
Candles introduced.	71	9.00	70	
	69	10.00	69	
Deposit all gone.	66	11.00	66	Deposit all gone.

The above results are remarkable. The camphor vapour, as also the small amount of moisture left in the glass, are condensed on the side furthest from the light where the temperature is a little lower than in front; but the most remarkable feature is the scantiness of the camphor deposits, although there was an abundance of light and heat. The deposits were almost nothing, and at length they disappeared. The reason for this is that the front and back temperatures are about equal.

July 27.

Furthest.	Time.	Nearest.	
68½°	8 A.M.	67½°	Three or four lines of scattered deposit nearest the light.
69	9	68	
69	10	68	

Here again is the fact that on this warm and bright morning, when the heat and the light were abundant, the deposits were insignificant. This is easily explained when it is considered that, in consequence of open doors and windows, the temperatures indoors and out are nearly the same. The conditions required for the production of fine deposits are warmth to raise the vapour, and cold on one side to condense it. A room warmed by a fire, and cold air outside, are favourable to the result, so that the camphor-bottles in the window in cold weather are in a better position than in this warm equable temperature.

It may be supposed that the position of the charge in the bottle may have something to do with the motion of the deposit. To settle this point, I prepared four 8-ounce phials of white glass, and put 10 grains of crude camphor into each. In bottle A the charge was in a heap at the back of the bottle, in B in the front, in C at the left-hand side, and in D on the right. The bottles were placed in the window, and fine deposits were formed in all four cases on the side nearest the light; only, in B, C, and D, the deposit was connected with the charge in the same way as smoke may be said to be connected with the fire that produces it. In bottle A there was no such connexion, the deposit being exactly in front, while the charge that supplied it was behind, and no visible connexion between the two.

There is another point which may require notice in these days, when men's minds are so strongly impressed with the actinic action of light. Dr. Draper says that light passed through a solution of bichromate of potash so as not to blacken nitrate of silver, produces an aphelion deposit in a bottle containing camphor. This is a mere effect of the absorption of heat. I arranged a number of flat-sided bottles in pairs, the bottle nearest the light containing a coloured solution, and the bottle in contact with it containing camphor. The narrow sides of the camphor-bottles were made opake, so that the light which passed into them came through the coloured solutions only. These observations were extended over several months, and in every case the camphor produced furthest deposits; and when the bottle was turned round so as to make the furthest deposit a nearest one, it invariably went over to the furthest side. I also enclosed a white glass bottle containing camphor in a wooden box furnished with a sliding vertical door containing a hole about $2\frac{1}{2}$ inches in diameter, which was accurately closed with a disk of coloured glass. In all cases the deposits were furthest from the light—and naturally so, seeing that a coloured object absorbs the heat more readily than a white one, and keeps the side of the bottle nearest to it of a higher temperature than the other parts.

One more point remains to be noticed. When mercury was exposed to the light in a tall narrow glass, no reliable results were obtained, that is, no deposit was formed that appeared to arise from the condensation of vapour. On two or three occasions metallic tears were seen in the vessel, but it was never clear to me that they did not arise from some shaking or disturbanee of the vessel. I could not reproduce even this unsatisfactory result in a narrow vessel, though I carefully tried for it by furnishing the vessel with a cap and stopcock and exhausting it with a syringe. I was also further surprised to find that a barometer-tube of thick glass charged with camphor and exhausted, produced little or no deposit even on the warmest days, and by exposure to direct sunshine. No sooner, however, had I dismissed the action of light from this subject, than the whole matter became clear. A thick glass tube by exposure to the light does not cool unequally, but slowly varies in temperature throughout its mass, so that no deposit either of mercury or of camphor is possible. If, however, the tube be thin, of large diameter and mounted, so that while one part is exposed to radiation the other part is protected, partial cooling is possible, and a deposit is produced. This, too, furnishes an explanation of a fact that had often surprised me. In barometers of large bore there is a deposit of mercury in the Torricellian vacuum on the side nearest the light. I had never seen this in a tube of small bore, though I had frequently looked for it in my own instrument. Some of the barometers of large bore in the International Exhibition have very fine deposits of mercury vapour in the Torricellian vacuum, but in such cases they are mounted so that the tube is more or less exposed. Where the tube is boxed in and protected from radiation there is little or no deposit.

King's College, London,
Long Vacation, 1862.

XLVIII. *Remarks on the Forces of Inorganic Nature.* *By* J. R. Mayer*.

THE following pages are designed as an attempt to answer the questions, What are we to understand by "Forces"?

* Translated from the *Annalen der Chemie und Pharmacie*, vol. xlii. p. 233 (May 1842), by G. C. Foster, B.A., Lecturer on Natural Philosophy