XXI. *On Evaporation.* *By* John Andrew de Luc, *Esq. F.R.S.*

Read June 28, 1792.

In my last papers on hygrometry, I have considered moisture in the air as a modification of a particular fluid, produced by the evaporation of water, composed of water and fire, mixed with the air, but independent of it. However there was a more common theory of that phænomenon, in which evaporation was attributed to a dissolution of water by air: but as an inquiry into the cause of evaporation belongs more to hygrology than to hygrometry, I made then no remark on that subject; having in view some experiments which were to ascertain a particular point fundamental to it. Since that time I have made those experiments, which are the object of this paper; but before I relate them, it is necessary to explain how they connect hygrometry with hygrology; which will be by stating the principles of those two branches of experimental philosophy according to my system.

From the time I fixed my attention on evaporation, and its various consequences, I was led to think, that the kind of dissolution of water, observed in those phænomena, was operated by fire, without any interference of air: and among other reasons for that opinion, the most decisive for me was, that every liquid cools when it evaporates; for I considered that circumstance as a proof, that the portion of the liquid which then disappears, is carried away by a quantity of fire proceeding from the liquid itself.

The general phænomena of evaporation and moisture had been my only guides, when I first published my opinion in that respect in my work *Rech. sur les Mod. de l'Atmosphère:* but it was then in a very imperfect state, and I owe much to Mr. WATT, the inventor of the new steam engine, for the degree of precision which that theory has acquired in my last work, *Idées sur la Meteorologie.* In particular, I am indebted to that truly ingenious and learned experimental philosopher, for an immediate proof of my fundamental opinion, resulting from an experiment, that he was so good as to repeat in my presence, and which demonstrates, that in the common evaporation of water in open air, the quantity of heat lost by the mass, bears to the quantity of water carried away, a proportion still greater than that which is found in the steam produced by boiling water. Therefore there is no reason to doubt, that steam is formed in the first, as in the last of those cases.

It is true, that in some other respects, appearances are very different in those two classes of phænomena; but those differences proceed from well determined causes, as will appear by the following abstract of my theory.

On the Laws of Hygrology.

1. Whenever water is in a state of evaporation, an expansible fluid, composed of water and fire, is produced. To that

fluid, the object of hygrology and hygrometry, I shall give the name of steam, in every case.

2. As long as steam exists, it has a power of pressure, as air itself; but it does not belong to the class of permanent fluids, for it may be decomposed by a certain degree of pressure, or cooling, according to determined laws.

3. The characteristic property of steam, from which proceeds its decomposition by those causes, is, the having a fixed maximum of density by a given temperature, which increases with the temperature. Thus, when that fluid is arrived at the maximum correspondent to a certain temperature, it must undergo a decomposition, either by cooling, because its actual maximum is too great for the new temperature; or by an increase of pressure (the temperature remaining the same), because its density becomes too great for that temperature.

4. The degree of pressure exercised by steam, or which it can support without decomposition, being, *cæteris paribus*, proportional to its density, depends, in the same manner, on temperature.

5. Steam is formed by every temperature, when a previous space permits its expansion; but, according to the above law, no steam can be formed when, for its formation, it ought to repel an obstacle superior, in the smallest degree, to the maximum of its power by the actual temperature; and if it has been formed under a pressure not exceeding its power, if that pressure increases, or the temperature lowers, ever so little, it is totally decomposed.

6. This is what determines both the degree of heat by which water can begin to boil, and the variations of that degree, by those of pressure. For ebullition is that state of

a liquid in which steam is continually formed within itself, notwithstanding the external pressure; and as such an expansive power in steam depends on a certain degree of density, its production requires, in the liquid, a certain degree of heat, which thus is determined by the degree of pressure. As for the fixity of the degree of heat in water boiling under a constant pressure, it proceeds from an equilibrium constantly produced between the quantity of fire which continues to penetrate the water, and that which goes off in the steam; the differences which happen in the first of those quantities, having no other sensible effect, than to produce a more or less rapid formation of steam.

7. Now from the same law derives also the difference between the phænomena of common evaporation and ebullition. If the latter requires a determined degree of heat, it is only because the steam cannot be formed within the water, without having at once a sufficient degree of density for overcoming alone the actual pressure exercised over that water by the atmosphere. But in common evaporation the steam is formed at the surface of the water by every temperature, because there it meets with no resistance but what it can always overcome: for it only mixes with the air, and expands it in proportion to its quantity, as would a new quantity of air.

8. Steam formed by common evaporation is absolutely of the same nature with that of boiling water; and in respect of the pressure that it undergoes, it is in the same state as when produced by evaporation under an exhausted receiver. In this case, where the pressure of the atmosphere is suppressed, the resistance which steam meets with in the space is its

own, and consequently it is proportional to its own power; and in open air, the part of the whole pressure incumbent on steam is, to that whole, as its power is to that of the whole mass, the rest of the pressure being supported by the air with which it is mixed: which proportion in the pressure that steam undergoes, in this case, comes exactly to that of the first. This is agreeable to the laws of expansible fluids, and the following example, taken at a determined temperature, will prove it from experience.

9. The thermometer being at about 65° of FAHRENHEIT, the maximum of evaporation, in an exhausted receiver, keeps a column of quicksilver of 0,5 inch suspended in the short manometer (I have quoted the experiments which give that middle result). That phænomenon has been considered by some natural philosophers as distinct from common evaporation, and depending on a disposition of the particles of liquids of repelling each other; which disposition, supposed to be counteracted by the pressure of the atmosphere, must appear when that pressure is removed. But, besides the known loss of heat by the liquid, in this case as well as in open air, which points out the same cause of evaporation, an equal pressure is also produced, and added to that of air, when the receiver is filled with the latter; which again indicates the same effect, as will appear in the following example.

10. If, by the above temperature, the receiver is filled with air of the same density as the air of the place; in which case a barometer inclosed in that receiver will stand at the same height as in the open air; and that in the receiver, being then very dry, water be introduced in a quantity sufficient

for producing in it the maximum of evaporation, the inclosed barometer, considered here as a manometer, will rise 0,5 inch; as Mr. DE SAUSSURE has found it by experiments.

11. If now we consider that the instrument called barometer, is in every case a manometer, we shall find, that those phænomena observed in close vessels, give us a true idea of what happens to steam in the atmosphere. When that instrument is observed in open air, it is with reason called barometer; since the expansive power exercised on its mercurial column is determined by the weight of the incumbent column of air; therefore it is the true measure of the weight of that column. But at the same time, and more immediately, it is a real manometer, since the immediate action exercised on its column, and to which this is also proportional, is, *cæteris paribus*, exercised by the density of the fluid, or fluids, which surround it, whose action is exactly the same as if any part of the mass of those fluids were suddenly secluded from the rest in a close vessel. Therefore, when steam is mixed with air, be the mass shut up in a vessel, or be it a certain part of the atmosphere distinct by its place, both fluids will act on the column of the manometer or barometer, or on every obstacle, and thus against each other, according to their respective power; for this fundamental reason, proceeding from the nature of steam as now explained, "That no mechanical cause can produce the decomposition of that fluid, "but by forcing its particles to come nearer each other than "the actual temperature can permit:" which case cannot happen in the atmosphere, except by the accumulation of steam itself in some part of it; since, elsewhere, it only remains mixed

with the air according to its own laws, as if there were no air.

The whole theory of hygrology, as far as I have been able to collect the phænomena of that class, appears to me comprehended in the foregoing propositions, founded on facts. The objects of that science are in general the cause of evaporation, and the modifications of the evaporated water. The common source of the water thus disseminated in the atmosphere, is the surface of the earth; whence, in spontaneous evaporation, both in air and *in vacuo*, as well as in ebullition, we see that water fly off with latent fire. If we collect that product in a close space, it acts in the same manner as a new quantity of expansive fluid. We know from experience, that an expansive fluid is really produced by ebullition, and by evaporation in an exhausted vessel: there is no reason why the cause of evaporation, and its product, should change in any case, only by the presence of air; and in examining what may happen in open air, we find no particular cause of the destruction of that expansible fluid, nor any difficulty in conceiving its dissemination in every part of the atmosphere.

But here we lose sight of steam, for it is as transparent as air itself: here also its mechanical action is as little perceivable as that of any set of scattered particles of air; and though its specific gravity is much less than that of air, its quantity existing in the atmosphere is most times so inconsiderable, that it can hardly be discovered by that means, on account of other causes which also affect the specific gravity of a given mass of free air. Therefore, notwithstanding our experiments on the formation of steam and its effects in our vessels, we should be ignorant of its functions in the atmosphere, if it were not for its property of producing moisture, by which we may trace it wherever it is, and determine its quantity. Here then a new field is open for experiments and observations; since by connecting hygrometry with hygrology, the hygrometer is for us in the atmosphere, what the manometer is in close vessels.

The particular experiments which I have to relate, have that connection in view; as they will shew, that in a close vessel, either filled with air, or free from it, the product of evaporation affects, at the same time, the hygrometer and the manometer; the former by moisture, the latter by pression. But I must here take this as a fact, in order not to interrupt the course of the theory, which, from hygrology, leads to hygrometry, by certain laws demonstrated in the fluid which is the cause of moisture.

Of the Laws of Hygrometry.

1. The science of hygrometry derives its origin from the cause whence proceeds, that the density of steam has different maxima, according to the temperature. I have shewn, in my last work on meteorology, that in the particular association of water and fire which produces steam, both of those ingredients retain the faculty of producing their respective equilibrium between the medium and bodies; that also the particles of water retain a tendency of uniting together, which begins to be effectual at a certain distance: and that their union takes place when they come to a degree of proximity, by which

they can surmount the cause which keeps them disseminated in the space, namely, fire. The less the quantity of free fire (or of the cause of heat) in a space, the greater is the distance at which the particles of water have the faculty of uniting together, and also of following other tendencies, by abandoning their latent fire; and *vice versa.* A final union of a sensible quantity of particles of water in the medium (or, what comes to the same, that precipitation of water which first appears in it as a mist) takes place, when the density of steam is arrived beyond its limits; and those limits depend on temperature, because, the greater the quantity of free fire in the space, the nearer the particles of steam may come to one another, without a final union of their water. The whole *in vacuo*, as in air. Such is the physical principle common to hygrology and hygrometry.

2. Hygroscopic substances are of three distinct classes. Some seize on the water of steam, by a chemical affinity with that liquid; among these are acids, salts, and calces. Some only imbibe it by its tendency to propagate itself in capillary pores; but, from their nature they receive no sensible increase in their bulk by its introduction; in the number of these are porous stones. Lastly, some substances, which also only imbibe a certain quantity of water, are thereby expanded; and these are most of the solids belonging to the vegetable and animal kingdoms. Various hygroscopic phænomena, which only depend on the different properties of the substances themselves, being thus foreign to the fundamental laws of hygrometry, I shall here confine myself to the last class, which appears the only proper one for that general purpose; and, among the hygroscopes of that class, I shall only consider

those which cease to lengthen, only when they cannot be penetrated with more water; as, by the use of these, there cannot be any fallacy in respect of the most important phænomena to be determined, namely, the more or less intensity, according to certain circumstances, in the cause which affects the hygroscope placed in a medium.

3. The word moisture, like some others which also have been applied to certain phænomena the causes of which were not determined, is ambiguous in common language, implying sometimes the idea of a cause, and at other times that of an effect, without a proper determination; that defect might be corrected by means of different words for the cause and for the effect: but neologisms are often so troublesome, and sometimes so arbitrarily introduced into languages, that I shall only endeavour to determine the sense of the word moisture, according to cases, so as to avoid ambiguity.

4. Moisture, taken in a general sense, may be considered simply as invisible water, producing observable phænomena. Thus, in hygroscopic bodies, the quantity of water which expands them, and increases their weight, is concealed within their pores; and in the ambient medium, that water which affects hygroscopic bodies, being there under the form of steam, is as invisible as air itself.

5. But in respect of hygrometry, where moisture is considered as having correspondent degrees in the medium, and in hygroscopic substances, that word requires a more particular determination, on account of those two different situations of invisible water. Moisture may be either totally absent, or absolutely extreme, both in hygroscopic bodies, and in the ambient medium; which circumstance, on both sides, affords

a fixed module for determining correspondent degrees; but these modules are not of the same nature; and thence, in their relation to one another, both in the whole and in correspondent parts, moisture assumes in the medium, the character of a cause, and in hygroscopic bodies, that of an effect, as will appear by the following determination of both cases.

6. Moisture is totally absent, first in the medium, when it contains no steam; then (as a consequence) in hygroscopic bodies, because they contain no more water than can evaporate, without a decomposition of their component parts. The case supposed in that definition, is when, by some adequate cause, no sensible quantity of steam is permitted to remain in the medium; as in my lime-vessel. Moisture is extreme, first in the medium, either air or a space free from air, when no more steam could be introduced into it, without a part of it being decomposed; and then (also as a consequence to be explained) it is extreme in hygroscopic bodies, because no more water can be admitted into their pores. Now, from the nature of the last of those maxima, the quantity of water which produces it in a given body is fixed, since it is determined by the actual capacity of its pores; whereas the quantity of water which produces extreme moisture, in a medium of a given extent, is as variable as the temperature: therefore, the hygroscopic equilibrium between the medium and hygroscopic bodies in different stages of moisture, which equilibrium is the object of hygrometry as a science, does not depend on certain quantities of water contained in the first, of which the last may receive their share; it depends on different aptitudes of the steam contained in the medium to communicate water to those bodies; which aptitudes vary, not

only by the different densities of that fluid, but in steam of the same density according to the temperature.

7. In order to assign the cause of that equilibrium, we have previously to determine, 1. Whence proceeds a maximum of length in the hygroscopic bodies here referred to; 2. How that maximum is produced by steam; 3. Why it takes place by different densities of that fluid, when the temperature is different.

8. Water introduces itself into the above bodies by its property of adhering and propagating itself on their surface, and thereby of entering their capillary channels; and those bodies resist its introduction, which expands them, by the tendency of their particles to remain united. This last tendency, from its own law, being less and less in proportion as the particles of the body are already less in contact with each other, it should appear, that water ought at last to divide them entirely: but, according also to the law of that propagation of water, the greater is its quantity already induced on the internal channels of the body, the less is the tendency of new particles to enter them; and this last diminution being more rapid than the former, there comes a point in which the two forces are in equilibrium; which circumstance determines the maximum of the introduction of water, and consequently that of the lengthening of the body.

9. The maximum of length of those hygroscopic bodies is thus produced, whenever a sufficient quantity of water stands or floats round them, without having a stronger tendency elsewhere. Therefore that maximum is produced when such a body is immersed into water; and it is also produced when the same substance stands in a space where

steam is arrived at its maximum; for that fluid is then so ready to abandon its water, if this has a tendency elsewhere, that a small quantity of new steam introduced in the space, would occasion the decomposition of part of it, followed by a spontaneous precipitation of water.

10. But we have seen above, that steam arrives to its maximum with different degrees of density, according to the temperature; consequently, whatever be the actual density of steam, if that density is its maximum conformable to the temperature, the hygroscopic body will receive water to the maximum; and thereby it will attain its maximum of length.

11. Now, as according to the premises, the density of steam is not the only circumstance by which, at the last period, the hygroscopic body retains in a medium the maximum of water that it can receive, that effect depending also on the temperature; by the same cause, the density of steam is not at the former periods, the only circumstance which determines the quantity of water that the hygroscopic body can retain in the medium; that quantity depends also on the temperature. The following is the theory of that phænomenon, or of the hygroscopic equilibrium between the medium and bodies.

12. In consequence of the above determined composition of steam, whatever be its quantity in a given space, either filled with air or free from it, its aptitude of communicating water to hygroscopic substances, is always proportional to the actual ratio between that quantity and the maximum correspondent to the temperature; which ratio, and not an absolute quantity of steam, is a certain degree of moisture considered in the medium; whereas moisture considered in a

certain hygroscopic body, is the determined quantity of water which it can retain in the medium, according to the actual *ratio* in the steam. Moisture in the medium is greater, and an hygroscope retains in it a greater quantity of water, when the actual quantity of steam bears a greater proportion with its maximum correspondent to the temperature; and *vice versa*. Therefore the divisions of the instrument are meant to indicate, by every temperature, the actual distance of moisture in the medium, either from its zero, or from its maximum; and that distance is the degree of moisture. But this is yet without any reference to the density of steam; the determination of this having the temperature for one of its indispensable elements.

13. From that derives the remarkable phænomenon of the effects produced on moisture in the medium, by the variations of temperature, though the quantity of steam, or evaporated water, remains the same in the same space; effects of which we are informed by the variations of the hygroscope, and which are the same by the absence or presence of air. Every change in the temperature, operates a correspondent change in the module of moisture; or in a variable *totum*, of which, according to its magnitude, the actual quantity of steam is a greater or a smaller aliquot part; that module being always the quantity of steam that could not be exceeded in the space, by the actual temperature, without the decomposition of part of it; which is always extreme moisture in the medium.

14. From that results lastly; that if, besides being acquainted, by the hygroscope, of the degree of moisture in the medium, or of the *ratio* between the density of steam and its actual module, it is required to know the density of that

steam, or its quantity in a given space; the observation of the temperature is required: as this, by previous experiments in order to determine the quantities of steam correspondent to its different maxima according to the temperature, will afford a co-efficient for the *ratio* observed.

15. But are we permitted to consider the variations of the hygroscope as proportional to those of moisture in the medium? This, according to the above determinations, would be the case, if the hygroscopic substance of the instrument lengthened in proportion to the quantity of water that it may retain in the medium. But the cause of the expansion of those substances by water, and the capacity of their pores at different periods of moisture, are too complicated for answering that question *à priori*; and by experience, the great differences observed in the marches of many of those instruments made of different substances, prevents us from assigning that property to any of them, till some particular experiment comes to help us in that respect. However, that circumstance affects only the practical part of hygrometry, and is foreign to the fundamental principles of that science, which I have now exposed as they appear to me from its general phænomena.

I have indicated, in my last paper, two means which I had formerly imagined for obtaining that desirable and still wanting correspondence between the march of a determined hygroscope, and that of moisture in the medium. One of those means was, to observe, at the same time, the variations in weight and length of the same substance, in order to compare the quantities of water which it retains, with their effects on its length. I have executed that experiment; but its results, which I gave in my last paper, have confirmed my doubts, on even the acquisitions of weight being proportional to the increase of moisture in the medium ; since they do not keep the same pace in different substances.

The other means was, to introduce in a dry vessel successive equal quantities of water without opening the vessel, and to observe their effect on the hygroscope. I made, last year, a first attempt of that experiment, which succeeded in respect of the introduction of water in a space of a known small degree of moisture; but the event confirmed also the uncertainty that I suspected in that method, because of a variable share of water retained by the vessel itself. However, as some parts of my apparatus might contribute to that uncertainty, I intend to correct it, and repeat the experiment; which, if I obtain regular results, I shall have the honour to communicate to the Royal Society.

I have now summed up the series of propositions which connect together in one system the whole of the fundamental phænomena of hygrology and hygrometry; and the only part of that system which remained to be proved by immediate experiments is, that *link* mentioned above between the two classes of phænomena, namely ; " That *in vacuo*, as in air, " the product of evaporation affects the hygroscope as it " does the manometer." I had ascertained that fact since the year 1776, by immediate experiments; which was the reason why, in my last work, I considered that circumstance as a principle, which, at least, could not be denied by any thing known to the contrary. But, for an immediate demonstration of it, many conditions were wanting in my first experiment, which could not be obtained but by the whole of my subsequent labour. That experiment is now made with a sufficient degree of regularity; and the more so, as it has been executed by Mr. Haas, in one of his air-pumps, with some of my whale-bone hygrometers, made by himself: and I shall now give its result.

Experiments on Evaporation, in Air and in Vacuo.

The purpose of these experiments being to shew, that the effects produced by evaporation on the hygrometer and the manometer, are the same in the absence of air, as when they take place in air; I shall begin here by referring to Mr. Nairne's paper, in the Philosophical Transactions for 1777, in which it is proved by experiments, that Mr. Smeaton's pear-gage is not a true manometer, since it does not indicate the presence of steam, when some remains in an exhausted receiver; but that it is the only true measure of the quantity of air itself remaining in that space.

That property of the pear-gage, proceeds from the fifth law of the above theory of hygrology. When, in the common temperature of the atmosphere, steam is unprotected by a sufficient mixture of air, it is totally decomposed by the pressure of the atmosphere, when this acts by the interposition of some sort of piston, as is the column of quicksilver in the pear-gage: therefore no fluid can remain at the top of that instrument when filled with quicksilver, except the quantity of air which was contained in its capacity before the introduction of the quicksilver.

When some lasting cause of formation of steam happens to be within the air-pump, and that the pump is long worked, the air is at last almost completely exhausted, and the remaining pressure acting on the manometer is that of steam. Mr. NAIRNE has shewn me an instance of that effect, in which the quantity of air indicated by the pear-gage, was not above $\frac{1}{10000}$ part of the whole. That remarkable fact will prove, that in the following experiments, air itself was exhausted to the utmost degree, and thus reduced to nought in respect of any influence on the main phænomena.

I must also premise, whence proceed some anomalies which will be observed in those experiments. It is in general from the nature of steam, from which, in our experiments, it is submitted to certain modifications, depending on its laws, but which cannot be always referred to them by immediate explanation, because of undetermined effects of the sides of the vessels, and of irregularities in the temperature.

The law of steam, which is the most subject to anomalies by those causes, is that of two distinct maxima, one of production, the other of preservation. Those two maxima coincide, when the temperature is near the freezing point; as in that case, the whole quantity of steam that can exist at one time in a space, is also produced when there is a sufficient quantity of water in any part of it; whereby the hygrometer stands at 100, which is its point of extreme moisture. But in proportion as the whole apparatus grows warmer, the maximum of production falls short of that of preservation; the quantity of steam does not increase, though it might be more dense without undergoing a decomposition; and thereby the hygrometer recedes from extreme moisture.

Such is the general law of steam, as it results clearly from the whole of my experiments; but in particular cases, it is subject to anomalies from various causes, among which are the following. If the water that evaporates is warmer than the space which receives the steam, more moisture is produced in that space, or the quantity of steam is greater in it than by an equal temperature in both; and *vice versa*. More or less distance of the part of the space where the hygrometer stands from the sides of the vessel, produces also anomalies; as according to their own state of moisture, if near enough, they have an influence on moisture in that space, as I have explained in my former paper; and this is often the case in some measure when the vessels are too small. Lastly, differences in the temperature of the whole or of some part of the vessel, comparatively with that of the space, are the most common causes of anomalies; for steam is alternately decomposed and reproduced by those differences, and when they have once begun in a vessel, there is no certain means to bring it to a regular course of phænomena, except by beginning again, or by a long equal temperature.

I come now to the experiments, in which I shall indicate some effects of those causes.

FIRST EXPERIMENT.

The receiver used was about eight inches in diameter, and twelve in height. One of my hygrometers was suspended in it, with a thermometer, the degrees of which were actually divided in ten parts. In the evening, a very large wet cloth was placed in loose folds on its bottom, and the first observation was made the next morning as follows.

Time.	Long Gage.	Short Gage.	Hygrom.	Therm.
$7^h\ 5'$ A.M.	0.0	———	96,5	47,75

The maximum of evaporation was then surely produced; but it remained short 3,5 degrees from extreme moisture: this was in air.

I could not have any indication of the quantity of pressure produced by the steam, mixed then with the air; for a receiver, equally pressed in and out, is not air tight. An experiment for determining that increase of pressure, must be made in a sealed vessel, as in Mr. DE SAUSSURE's experiment, by which he found that important phænomenon: but from that experiment we are sure, that if a barometer had been inclosed in the above receiver, being then sealed, the steam produced would have made it rise, at the same time that it affected the hygrometer.

The pump was then worked; after which the instruments were found as follows.

7,15	26,0	———	97,0	44,75

I shall make here a remark on the known phænomenon of the diminution of heat, when a space filled with air is suddenly exhausted; as in this case we have an analogy that will enhance the most natural explanation of that phænomenon. Free fire, the cause of heat, being an expansible fluid, as air and steam, is then carried away with them, notwithstanding its tenuity, and heat is diminished in the space till new fire is come through the vessel. Now, the same is observed in respect of moisture with a quick hygrometer, for it goes for an instant to dryness, while the quantity of steam carried away is repairing by a new evaporation.

In the above case, moisture was lastly increased 0,5 degree; yet the quantity of steam was less than before, and the cause of that increase of moisture was, the diminution of its module by that of heat.

In respect of air, its quantity was so diminished, as to permit a column of quicksilver of 26 inches to rise in the long gage.

The pump was again worked, and time given for the instruments to settle.

7,25′	28,7	———	96,5	47,75

The original temperature was now restored; and as air had been much diminished by the first operation, fire, thus much more free in this, escaped the action of the pump. Moisture also was restored nearly to its original degree, though very little air remained in the receiver.

The pump was worked by intervals.

10,5′	28,5	0,70	95,66	47,75

The quantity of air was now so little, that it cannot be supposed to have had any share in the effect of the steam; however moisture remained sensibly the same by the same temperature.

Worked again the pump to the best vacuum.

10,10	28,7	0,53	94,5	48,8

The pressure on the short gage was now, according to Mr. NAIRNE's experiments, almost wholly produced by steam; yet moisture preserved its own distinct modifications: here it is diminished, notwithstanding the maximum of evaporation, because of the increase of heat.

The pump was worked at different times, for extracting some air that was disengaging itself from the large wet cloth.

11,35′	28,7	0,53	91,0	51
2,50 P.M.	28,72	0,60	86,75	54,15

Here again, notwithstanding a constant maximum of evaporation, moisture continued to diminish by the increase of heat, as it does in air.

The apparatus was left in that situation about four hours; and the observers having left the room, this, and the approaching evening, occasioned a sensible diminution in the heat; whereby, as the sides of the vessel cooled before the inclosed space, the steam began to be decomposed against them, and they were found covered with dew and streaming water, by a real continuing distillation. The last cause of anomaly above mentioned is here conspicuous by its great effect; for, during that distillation, and consequently though new quantities of steam ascended continually through the space, moisture was in it much less than in the former observations, as will be seen by the following, made before and after working the pump. The thermometer could not be observed, on account of the thickness of the dew on its side of the vessel.

4,20′	27,35	———	76,0	———

Worked the pump.

4,35′	27,75	0,62	76,0	———

The steam continued some time to decompose itself against the sides of the vessel, and moisture to remain in that state of diminution, till the heat communicated by the observers to the apparatus made the internal dew evaporate; and when thereby the thermometer could be observed, the instruments were as follows,

6,47′	28,18	0,6	96,0	52,75

Here also is an instance of what I have mentioned above, of the irregularities attending all the phænomena, after some water has been once deposited on the sides of the vessel: moisture was too great for the temperature, and it remained in that state the whole evening.

7,55′	28,82	0,6	96,5	52,75
8,4	28,82	0,6	96,5	52,—

But the next morning, after the dissipation of some dew that was on the inside of the vessel, and after having worked the pump, the instruments were found as follows.

7,35′ A. M.	29,12	0,6	97,66	44,75

Now this, in respect of moisture, and its correspondence with the temperature by the maximum of evaporation, is sensibly the same, as when the receiver was filled with air at the beginning of the experiment, though at this time no sensible quantity of air remained in it.

SECOND EXPERIMENT.

Every part of the apparatus was the same in this experiment as in the former, except the receiver, which was only about six inches in diameter, and eight in height; to which circumstance may be assigned, that moisture was generally greater comparatively with the temperature; but in respect of the indifference of air to the phænomena of moisture, the results were the same.

A wet cloth, only sufficient to keep up the maximum of evaporation throughout the whole experiment, was used this time; by which means no air appeared in the receiver after the disengagement of the little quantity contained in the small cloth. This was put under the receiver, filled with air, at about four o'clock in the afternoon: and the first observation, made in that state, was thus:

8,— P. M.	0,0	———	95,0	65,75

The pump was then worked, for extracting a part of the air, and time given for the instruments to settle, and they were found,

8,15′	6,5	———	94,0	65,75

After this observation, and after each of the following, the pump was worked, and time also given for the instruments to settle.

8,30′	13,0	———	91,0	66,75
8,45	19,0	———	86,5	67
9,15	25,0	———	86,0	67,75
9,30	29,3	0,65	85,0	67

After this, the pump was no more worked the same day, but the two following observations were still made.

10,0′	29,23	0,65	89,0	66,5
11,0	29,23	0,65	95,0	64,5

The apparatus was left in that situation till the next morning, when the following observation was made before working the pump.

6,20′ A. M.	29,35	0,55	97,5	63,15

The pump was then worked, and the best possible vacuum was produced, in which, according to Mr. Nairne's experiments, there could not be any sensible quantity of air.

6,40′	29,40	0,50	96,5	63,15

In comparing the results of this experiment with those of the first, moisture, as I have said, is generally greater in proportion to the temperature. But, setting this aside, and comparing the motions of the hygrometer and the thermometer, it is evident, that they are independent of the modifications of air; and that it may safely be concluded: "That "the product of evaporation is always of the same nature, "namely, an expansible fluid, which, either alone or mixed "with air, affects the manometer by pressure and the hy- "grometer by moisture, without any difference arising from "the presence or absence of air; at least without any per- "ceived hitherto."