SCIENCE:

A WEEKLY NEWSPAPER OF ALL THE ARTS AND SCIENCES.

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CONTENTS:

BOOK-REVIEWS.

Emigration and Immigration. By RICHMOND M. SMITH. New York. Scribner. 12°.

THE New England States were settled by a set of persons with very fixed ideas as to the proper way of conducting Church and State, and those who came later from the mother country to settle found that they must follow exactly in the footsteps of those already there, or be subject to abuse and even most cruel persecution. Those early puritans must have looked on the later comers as immigrants among themselves who had colonized the land.

We are now experiencing a somewhat similar condition of affairs. Our author, with others, extends the colonization period to the time of the Revolution, or, as few new-comers came to the country from 1776 to 1820, even to this latter date. Those who possessed the country did not by any means agree among themselves as to what sort of a country, politically and socially, it should be; but still a very successful democracy was established, with a fairly uniform conception among the people of what was best for them.

But since 1820, owing to the existence here of vast tracts of unoccupied farming-land, and to the development of methods of transportation with an accompanying enormous reduction in the cost, millions of people have left Europe to make new homes for themselves in this country. The result is, that, as Richmond Smith puts it, nearly the half of our population is made up of persons either of foreign birth or whose ancestors came to this country since 1820.

"What is to be the effect on our institutions?" is the query to which this book on emigration and immigration is written.

The need of such a book is obvious when one considers the paucity of available literature on the subject. There are, of course, numerous magazine and review articles, and numberless newspaper squibs. The last are buried hopelessly, and the former are by no means easily accessible even in the largest libraries. Every one knows what repulsive volumes are the government reports on any subject, published, as they mostly are, without any intelligent editing. So it happens that Richmond Smith has given us a most convenient and needed summary of the facts on the subject under discussion.

That the question of government regulation of immigration has been a burning one, goes without saying. The immigrants come here to earn a living, and a better living, as they believe, than they have had in their old homes. But in going to work, on arrival, Tom or Jerry appears to displace some one already in possession of a good job: so over and over again a cry has gone up from the laboring classes for a checking of this inflow of rival workers.

In the main, the immigrants come because their husbands, families, or friends are already here; and no reason appears why this process should not continue, so long as any inducement exists for them to come. This is what is happening as the result of affairs as they have come naturally to exist. Now, our author is one of that new school of economists who think that the haphazard evolution of mankind should not be allowed to go on longer unguided. This school would have all things human guided, and, as the State, whatever that may be, is the only body strong enough to enforce its guidance, guided by the State. The State is doubtless wiser than it once was, but then it has more difficult problems to deal with as it grows more developed. But how is that acme of State wisdom to come that shall make it possible for the State to deal intelligently with the immigration of a million of people to this country in a year? How is it likely that the State can wisely do more than say that paupers and members of the other defective classes shall not come, and possibly that the bringing in under contract of bands of laborers is no longer necessary?

That this influx of new population is going to have an effect in changing our institutions is doubtless true; and let us hope that the remnants of some of the institutions of our revered pilgrim fathers may be swept away, now that we no longer believe the devil is lurking beind every wood-pile, as did our ancestors.

Let us see that the immigrants coming are sound in body and mind, that they are brought here in human fashion, and that they are not fleeced after their arrival; but let us not dread the effect on the institutions of the future of sane men living in a free country.

LETTERS TO THE EDITOR.

**** Correspondents are requested to be as brief as possible. The writer's name is in all cases required as proof of good faith.*

The editor will be glad to publish any queries consonant with the character of the journal.

On request, twenty copies of the number containing his communication will be furnished free to any correspondent.

The Cause of Rain.[1]

IN a paper entitled "On the Cause of Trade-Winds," which I recently had the honor of reading before the society, I gave my reasons for assuming that the actuality which lies behind the really abstract term "a centre of high pressure" is a body of unsaturated or dry surface-air, or what may be called an air-cushion. I now propose to continue this train of thought by dealing in a similar way with low pressures, or cyclones, thereby trying, if possible, to arrive at a definite conclusion as to the actual cause of rain; rain being the most prominent feature of cyclones, or low pressures.

The difficulty in approaching this subject lies perhaps herein, that, as Mr. Scott says in his "Elementary Meteorology," 1887, "almost every one imagines himself a born meteorologist," and therefore in all likelihood almost every one of my present audience has formed for himself a more or less definite opinion of the cause of such an every-day occurrence as rain. To shake this faith a little, and to show you that we here really stand before a problem which has not as yet been solved, I may commence by quoting what a man of Mr. Scott's experience says. "We must admit," says he, "that the study of weather has made next to no progress at all in gaining an insight into the agencies which are at work in producing the various phases of weather;" and, "unless this be secured by careful and long-continued attention to a few simple and obvious principles, the labor bestowed on the most complete mathematical discussion of the results will be thrown away."

It is indeed a curious fact that the more pains meteorologists have of late years taken in trying to bring the accumulated facts of observations to agree with theory, the farther they seem to have gotten away from their goal. They may not all admit this, but it is a sign of a wise man that he admits when he knows nothing; and, as we have just seen, Mr. Scott for one is evidently fully aware of the defects of his science, which he declares can hardly be called a science as yet.

To make you a little familiar with the difficulties we have to

[1] The substance of this letter was read before the American Society of Civil Engineers, Feb. 19, 1890.

encounter, I may commence by giving an account of the rain theories which have been popularly adopted by meteorologists. These have been condensed in the following words by Mr. Scott:—

"Rain is produced by the chilling of air more or less charged with moisture. This is effected in various ways, of which the following are the principal: No. 1. The ascent of a current of damp air, which is chilled as it rises; No. 2. The contact of warm and damp air with the colder surface of the ground, as in case of our own west coasts in winter [England], where the land is colder than the sea-surface; No. 3. The mixture of masses of hot and cold air."

In the first place, it seems strange that rain should be caused by the chilling of the atmosphere, as rain is almost invariably accompanied by milder weather. A certain type of mild weather is nearly always the forerunner of rain. During the rain the temperature hardly sinks, although the sun is prevented from shining on the ground; and we generally expect warmer weather to follow after the rain. These remarks may serve to rouse suspicion against the theory of rain being caused by chilling, for we may feel perfectly sure that any theory which goes straight against the general weather indication must be wrong from the outset. However, let us now examine the theory in detail.

Of these three causes, No. 3 is by the author himself placed *hors de combat*, when he states that Dr. Haun of Vienna has calculated, "that even by assuming a very extreme case, which could hardly occur in nature, there could not be produced as much as the twentieth part of an inch of rain."

Cause No. 2 is by the author partly included in cause No. 1, as the sloping land-surface causes the air moving against it to ascend. As to the other part of it, I fail to see how contact between a cold surface and warm air can produce rain. It can produce deposit of dew, as, for instance, when we bring a glass of cold water into a heated room; but rain always falls from a considerable distance from the ground, and is therefore not created at the place of contact of the air with the land-surface.

We are therefore now reduced to cause No. 1 as the only possible cause of rain. This is, however, worse than any cause at all, as may be seen from the following simple and well-known experiment. If, under the piston of a strong glass cylinder, we have air saturated with moisture, and press the piston down, a portion of the moisture is condensed into water, as is seen by the mist formed, and the trickling of dew down the inner surface of the glass vessel. The temperature is raised by the compression, but not sufficiently to prevent condensation from taking place. If we now draw the piston back to its first position, we find the air under the piston in the same condition as when we started the experiment. But this means, that, by expanding the air, the moisture which was condensed into water by the compression has again evaporated. The air, therefore, gets chilled by the expansion, but not sufficiently to prevent this evaporation from taking place.

The consequence is, that the chilling produced by expansion during the ascent of a current of damp air can under no circumstances cause condensation of its moisture into rain. The experiment, however, shows that condensation or rain can be produced by a body of saturated air being brought under greater pressure; and of this we will just make a passing note.

The modus or the ascent of a current of damp air is by most meteorologists considered to be the chief cause of rain, and is supposed to take place at the centre of a cyclone. It is thus maintained that there is a certain inward movement of the circulating surface-air in a cyclone, and that for the air (this is supposed to be always damp air) which is carried by it towards the centre there is no other means of escape but to rise at the centre. How absurd this whole explanation must appear to anybody who has been living in deserts or arid districts, will be observed when I mention, that, while I was in Australia during a period of very severe drought, a break in the drought was caused by a series of cyclones crossing the country,[1] entering in the northern part of New South Wales, and passing out again through Victoria, thereby drenching a narrow strip of land about 50 miles wide and 400 or 500 miles long with rain, while on both sides the drought continued uninterruptedly. It seems difficult to explain how this cyclone should have gathered its supply of moisture from moisture rising from the dry surface-air over a perfectly dried-up country.

What we want is evidently a rain theory which is capable of accounting for rain, whether the surface over which a cyclone passes is wet or dry, or whether it is giving off vapors or not; and I have taken pains to show how utterly incapable the existing theories are in this respect, so as to clear the atmosphere from old cobwebs which might stand in the way of an entirely different view of the whole question, being well aware of the opposition with which new theories are generally met at the beginning.

In my pamphlet on drought I called attention to the aqueous vapor as the element of the atmosphere to which some unknown quality was likely to adhere, and by knowing which we should be able to explain the whole atmospheric puzzle. With the object in view of finding this secret, I undertook in April, 1888, a series of observations from the tower of the Rouen Cathedral in France.

The object of these observations was to ascertain the difference in barometrical pressure existing between the two ends of a vertical air-column, and to observe how far and in what manner this difference, or the weight of the air-column, changes when the state of humidity of the air varies. At the base and top of the steeple of the cathedral, which is upwards of 500 feet high, was established a station containing quicksilver barometers (and aneroid barometers to check the readings of these) and dry and wet bulb hygrometers. At convenient places between the two stations, thermometers were hung out with the object of attaining a fair average of the temperature of the air-column.

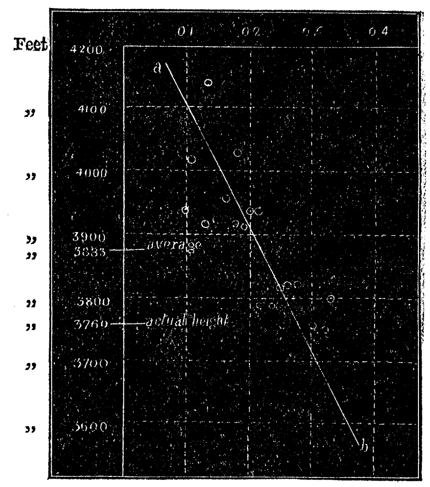


FIG. 1.

The two stations were connected with a telephone; and at convenient hours, at any time during the day or night, for a period of about fourteen days, synchronous readings of all instruments were taken at both stations.

The instruments were the best and newest made by Messrs. Negretti and Zambra of London, and were all adjusted at the Kew Observatory. It is my pleasant duty to mention here that this well-known firm of instrument-makers wrote me a polite letter, in which they offered the loan of their instruments free of charge, considering the interest involved in my researches. To assist me in making these observations, I secured the services of Mr. McClellan of the Greenwich Observatory, who has had many years' experience in handling the most delicate meteorological instruments.

Thus every thing possible was done to obtain reliable observations, and the result was as stated below. Instead of reproducing here the figures of my own personal observations, I think it will be more to the purpose to point out how the same result can be

[1] See H. C. Russel, Report on Rainfall of New South Wales.

distinctly traced in the observations made by others, who at the time were not aware that these results could be deduced from their observations.

As such, I have selected Professor S. P. Langley's "Professional Papers, Signal Service, No. XV., War Department, U.S." On p. 191 is a table showing the results obtained by measuring the altitude between sea-level and Lone Pine, Mount Whitney. Of these forty measurements, I have in the following table given the ten highest (upper half of table) and the ten lowest (lower half), arranged according to the height.

Table of Barometric Measurements of Altitude between Sea-Level and Lone Pine, Mount Whitney.

Time of Observation. 1881.	Results in Feet.	Weight of Vapor in Inches of Mercury.	At Lone Pine.	
			Relative Humidity.	Temperature, Fahrenheit.[1]
Aug. 26, noon	4,140	0.1354	10.3	87.8°
Aug. 26, 9 P.M.	4,030	0.1823	28.8	65.7°
Sept. 3, noon	4,020	0.1060	8.7	85.4°
Aug. 29, noon	3,960	0 1627	15.6	80.6°
Aug. 25, noon	3,940	0.2081	18.1	83.6°
Sept. 3, 9 P.M.	3,940	0.0960	13.5	69.1°
Aug. 24, noon	3,940	0.2158	16.0	88.6°
Aug. 17, noon	3,920	0.1782	14.9	84.6°
Sept. 2, noon.	3,920	0.1302	9.9	87.8°
Aug. 24, 9 P.M.	3,915	0.1931	29.0	67.2°
Aug. 20, 9 P.M.	3,820	0.2787	35.5	72.0°
Aug. 19, noon	3,820	0.2615	17.8	91.3°
Aug. 23, 9 P.M.	3,815	0.2508	38.3	66.7°
Aug. 18, 9 P.M	3,800	0.3314	78.0	54.7°
Aug. 31, 9 P.M.	3,790	0.2190	45 7	57.6°
Aug. 30, 9 P.M	3,790	0.2352	53.1	55.6°
Aug. 27, 9 P.M.	3,760	0.2543	68.0	51.0°
Aug. 21, 9 P.M.	3,760	0.3034	38.4	72.2°
Aug. 22, 9 P.M.	3,750	0.3232	70.1	56.7°
Aug. 19, 9 P.M	3,710	0.3405	71.5	57.6°
Sept. 7, 9 P.M.	3,625	no record		
Sept. 6, 9 P.M	3,620			

[1] The ten highest give an average of 80° F.; the ten lowest, 63° F.

Alongside of each of these figures will be found a number representing the weight of vapor per unit of volume contained in the atmosphere at the time of observation. These latter numbers are obtained by multiplying the relative humidity at Lone Pine (see table in Langley, p. 177) by the elastic force of vapor (Glaisher's tables).

The difference between the maximum and minimum result is 520 feet, or 14 per cent of the trigonometrically surveyed height, 3,760 feet. This latter number was obtained by the engineers who built the railroad passing Lone Pine. Langley's party wrote to the engineers for this information, and awaited their reply with considerable anxiety.

From the table it will be noticed that the amount of vapor in the atmosphere was considerably less when the ten highest results were obtained than when the ten lowest were obtained; and, as perhaps may be better illustrated by the accompanying diagram (Fig. 1), there appears to be an unmistakable relation between the measured heights and the humidity of the atmosphere. The heights are here placed at distances from the vertical line to the left proportional to the amount of vapor in the air, and the line $a\ b$ shows the general tendency of the figures. That these do not follow the line $a\ b$ more closely, may be accounted for by the humidity of the air having been measured only at one end of the air-column; namely, at Lone Pine. This seems to prove the greater buoyancy of cold vapors compared with warm.

We may, however, trace another coincidence in our table. It will be noticed that the ten highest results are generally from observations taken at noon, when the thermometers showed a relatively high temperature, while the ten lowest results are all (except one) from observations taken at 9 P.M., when the temperature was considerably less This is only what we might have expected, and shows that the buoyancy or tending upwards of the vapors in the atmosphere is considerably greater at a lower temperature than at a higher, as explained elsewhere.

Professor Langley's observations give results corresponding to those I obtained at Rouen, and the relations here pointed out may be traced in numerous works from ancient and modern times, though perhaps not in all. However, it should be remembered that it is not so much my present purpose to show how the measurement of altitudes by means of barometers may be carried out with greater accuracy than hitherto (this method being highly unsatisfactory for obvious reasons) as to show that the hidden agencies which are at work in the atmosphere, and without assuming which the whole atmospheric problem remains unsolved, may be distinctly traced in the observations carried out by others. Surely we must expect to find the secrets well concealed, or they would have been demonstrated ages ago; but here, as elsewhere, it is the instances when "the sky is unobscured by clouds," to use a figure of speech, which we must select to make our observations, and Langley's table is such an instance

The results of my experiments above referred to showed that an air-column 150 metres high, between the top and base of this tower, became 1.3 per cent lighter by an increase of atmospheric humidity, indicated by an increase of elastic force of vapor of from .2 to .3 of an inch pressure. The temperature was reduced to 40° F., and the atmospheric pressure to 30 inches.

According to Glaisher's "Hygrometrical Tables," one cubic foot of dry air at 40° F. at a pressure of 30 inches, weighs 557.8 grains, while one cubic foot of saturated air weighs 556 grains. The difference, 1.8 grains, is about .0033 per cent of the whole weight. The dry air, by becoming saturated, has therefore suffered a loss in specific gravity of .0033 per cent, or, what is pretty nearly the same, it has been expanded .0033 per cent.

According to my observations at Rouen, the loss in weight would, under similar conditions, have been 3.2 per cent, or ten times greater than shown by the tables.

How are these seemingly contradictory results to agree? The method of taking the weight of a certain volume of air confined in a vessel, by which the tables have been computed, is eminently adapted to give us the exact specific gravity; and the experiments have been repeated so often by excellent observers that we have no reason to doubt their correctness. If, therefore, we take it for granted that only one-tenth of the loss in weight sustained by the open column of air was due to expansion, the rest, or nine-tenths, must have been due to the buoyancy[1] of the aqueous vapors, which would carry a part of the weight of the air-column; and this force could under no circumstances have shown itself under the experiments with air in confined vessels, whose absolute weight is taken in a vacuum.

We have hereby been able to demonstrate the buoyancy of aqueous vapor in the atmosphere as a force that must influence the readings of the barometer very considerably, and we now understand fully why the readings of the barometer are lower when the atmosphere is moist than when it is dry, as in an anticyclone or air-cushion, simply because the greater amount of vapors in the moist air carries a greater portion of the weight of the air-column overhead than when the air is in a dryer state.

The atmosphere being a perfect mechanical mixture of air ($O+N+CO_2$) and aqueous vapor (H_2O), the buoyancy of the latter must mainly depend upon the difference in specific gravity between the vapor and the air by which it is surrounded; and

[1] See my paper, "On the Cause of the Diurnal Oscillation of the Barometer," in Engineering, London, Jan. 11, 1889.

we will now examine how this changes for different temperatures and at different levels. The following table is gathered from Glaisher's "Hygrometrical Tables" (IV. and VI.) :—

Weights in Grains of One Cubic Foot, at 30 Inches Pressure.

Temperature, Fahrenheit.	Dry Air. (a)	Vapor. (v)	Ratio. $\frac{a}{v}$
0°	606.4	0 55	1,000
10°	593.4	0.84	700
20°	581.1	1.30	447
30°	569 2	1 97	300
40°	557.8	2.86	200
50°	546.8	4.10	133
60°	536.3	5.77	91
70°	526.2	8 01	66
80°	516.4	10 98	47
90°	507.0	14.85	35
100°	497 9	19 84	20

It will be seen from this table how much lighter vapor is than air, and that the difference in specific gravity is highly increased as the temperature sinks. While air follows Gay Lussac's law by expanding by heat and contracting by cold, the vapor follows a law the reverse of Gay Lussac's by contracting by heat and expanding by cold, but at a much greater rate for equal temperatures: $\frac{v}{a}$ gives us the specific gravity of vapor, that of the surrounding air being 1; it shows how the buoyancy of vapor $\left(\frac{a}{v}\right)$ is strongly increased as the temperature sinks. At 100° the specific gravity of vapor is one-twentieth of that of the surrounding air, and at 0° it is only a thousandth part of it. The weights are measured under a pressure of 30 inches, the pressure at the earth's surface. To find the weights at higher levels, where the pressure is less, we have only to multiply the numbers of columns (a) and (v) with the same factor according to Marriott's law. As $\frac{v}{a}$ hereby remains unchanged, it appears that the buoyancy of vapor in the atmosphere depends entirely upon the existing temperatures, and is independent of the pressure, or the level at which the vapors are found. As the temperature constantly sinks as we rise in the atmosphere, the buoyancy of vapor, or the force with which vapors tend upwards as they rise to higher levels, is constantly increased, and at an astonishingly high rate. While, therefore, the speed with which vapors rise in the atmosphere may be more or less imperceptible at the ordinary temperatures at the earth's surface, it is rapidly increased as the vapors rise, and may attain an almost inconceivable magnitude in the extreme cold which exists at a great distance from the earth's surface.

With the results deduced from the table fresh in our mind, we may now draw a picture from nature while trying to follow the vapors on their upward passage through the atmosphere, and we shall see how far our calculations agree with the natural phenomena. To take a distinct case before us, let us suppose that on a fine day, with high barometer, we are in a dry locality in which is found an isolated swampy place or lake (Fig. 2). While the surface-air is dry generally, we find it moister over the swampy place, as the sun and the warm and dry air which passes over it cause a strong evaporation to take place. The warm surface-air, though expanded by heat, moves over the ground without rising. It is first caused to ascend by being intermixed with the vapor-particles. According to their buoyancy, the vapor-particles tend upwards through the atmosphere, thereby carrying the air with which they are intermixed upwards also, and the ascent of a current of damp air is established. The vapors are the real cause or life in this motion, each and all of its particles acting as so many minute balloons. Some eight or ten thousand feet overhead, perhaps at a little distance laterally from the moist ground, according to the direction in which the air moves over the ground, we notice an enormous cumulus-cloud being formed, and we have no doubt whatever that it is caused by the current of damp air ascending from the moist piece of ground. The ascending current, after having passed through the heated surface-air, gets suddenly into a much colder stratum, and condensation takes place by mixture of the rising damp air with the cold air it is passing through. As a rule, the chilling caused by the expansion of the ascending current gives it a temperature pretty nearly the same as that of the air through which it passes. It is only when it is met by a sudden change in the temperature of the surrounding air that condensation takes place by mixture, which we may express by saying that the ascending current has "caught a cold." Instead, therefore, of it being the chilling by expansion which causes condensation into clouds and thereby rain, we see that it is a fact that the chilling was not sufficient when the ascending current was taken by surprise by the sudden change in temperature If the colder stratum of air be moving along, we may notice a row of detached cumulus-clouds at some distance from the one nearest to the moist piece

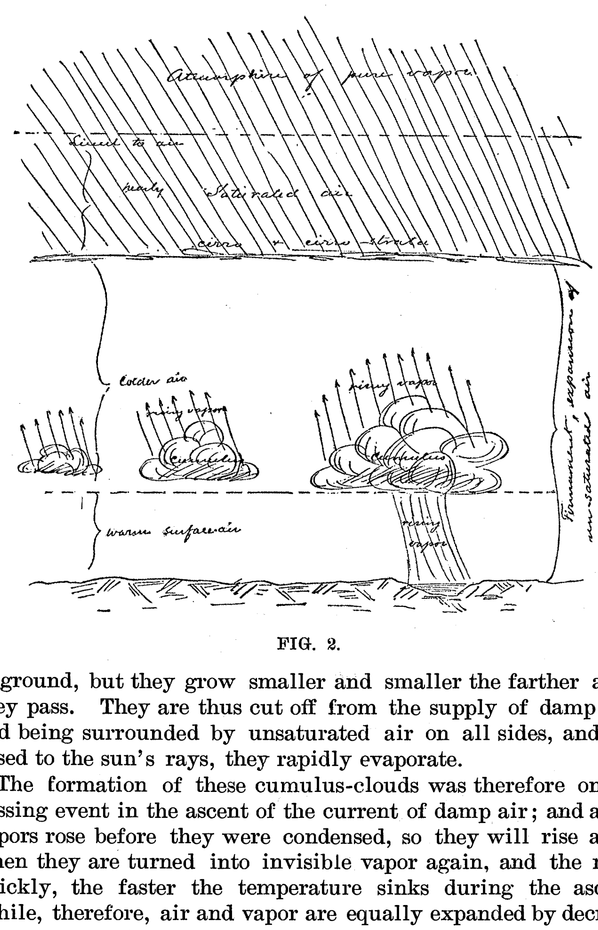


FIG. 2.

of ground, but they grow smaller and smaller the farther away they pass. They are thus cut off from the supply of damp air, and being surrounded by unsaturated air on all sides, and exposed to the sun's rays, they rapidly evaporate.

The formation of these cumulus-clouds was therefore only a passing event in the ascent of the current of damp air; and as the vapors rose before they were condensed, so they will rise again when they are turned into invisible vapor again, and the more quickly, the faster the temperature sinks during the ascent. While, therefore, air and vapor are equally expanded by decrease of pressure during ascent, the decrease of temperature acts differently upon them, having the effect of contracting the air, while the vapors are very much expanded. For both these reasons the buoyancy of the vapor is increased during the ascent. The vapors must therefore necessarily rise as long as there is any air to pass through, unless they meet with a layer of saturated moisture, or air saturated with moisture.

The clouds produced by the ascent of a current of damp air are cumulus-clouds, and they resemble in their shape very much the mist caused by steam escaping from a chimney. The phenomena are, in fact, precisely similar; and the cumulus-clouds are in their nature as unstable a product as the mist from a chimney, only the first phenomenon is on a much larger scale, and consequently it takes a much longer time for the cumulus-clouds to evaporate.

The formation of this class of clouds has, however, had a very disturbing effect upon the conclusions arrived at as to the cause of rain, particularly as they are not absolutely rainless, but occasionally give a shower of rain. A shower, however, is a distinct case, which has nothing in common with the great rain, day's rain, or cyclone-rain, capable of yielding eight to ten inches of rain *per diem.*

To continue our sketch from nature, at a considerable distance overhead we will generally on such a fine day, notice some extremely thin and airy clouds,—the so-called mare's-tails, cirrus, or cirro-stratus. The sky is often suddenly changed from a perfectly cloudless one to one completely covered by a thin layer ("pallium," or cloak, as it has been called) of clouds; and records show that not only has it been the case with the small part of the sky we can observe from one place, but that the sky has been suddenly covered by these clouds far and wide for thousands and thousands of square miles.

As to the height at which these clouds are found, I have particularly asked Mr. Glaisher, who is famous for his wonderful balloon-ascents. He told me that he had gone up five and six miles, and passed through other clouds, but he never seemed to get any nearer to the cirrus-clouds. He even went up seven miles; but then he became senseless, and unable to observe any thing. To estimate their height at thirty or forty miles seems, therefore, hardly to be an exaggeration.

What is the cause of these clouds, and where do they get their supply of vapor to keep them permanent often during the whole long day in the face of the shining sun? As they are strata-like, and entirely different in their shape from cumulus-clouds, we may feel certain that they are not, like the cumulus-clouds, caused by the ascent of damp air. But if their supply of vapor

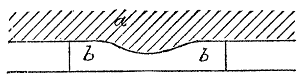


FIG. 3.
a, moist air; *b*, rotating body of surface-air.

is not to be found below them, it must be on the other side of the strata, or above them. The occurrence of cirrus-clouds is therefore an unquestionable proof of the existence of a uniform layer of saturated air at an exceedingly high level.

Our table has shown us clearly where the invisible vapors must go to, and the cirrus-clouds now show us where they are stored up at a great distance from the earth. Our only difficulty now is to explain how the vapors are brought down from this high level, or how they become condensed into clouds and rain. For all we know, a cyclone is a body of surface-air brought into rotary motion, and the effect of this rotation is that rain occurs, if anywhere, at or towards the centre of the rotating body of surface-air; and this takes place whether the cyclone passes over the sea, over moist ground, or over dry land. The centrifugal force sweeps the surface-air from the centre of the cyclone. The partial vacuum which is thereby produced can only be filled up by the descent of the air or vapor above the rotating body of surface-air. This is thereby brought under greater pressure; and, as the experiment referred to above shows that condensation or rain can be produced by compression, we have hereby arrived at a possible explanation of cyclone-rain. This theory agrees with such a general observation as that the clouds are at their lowest level when rain comes from them.

In agreement with this compression theory, we may explain the prevalence of rain on the rising slope of coast mountains, or mountain-ridges in general. While rain falls at the centre of a cyclone, the sky at some distance from where the rain falls is in a condition not far from giving off rain, and so the extra pressure brought to bear upon this saturated air by meeting an obstacle, such as a mountain-ridge, causes rain to set in.

The sketch may represent in section a mountainous coast, against which the moisture-laden clouds are driving from out at sea. The current of air, by meeting this obstacle, is caused to rise, following something like the course shown in Fig. 4. At *a* there is always shelter during such a gale, as shown by the sheep and cattle which gather there. In other words, the current rises to its maximum height at *b* above the inland slope of the mountain. Consequently that is where, according to the theory I am opposing, we should expect the greatest downpour; but there is generally next to none, while the rain nearly all falls on the front side of the mountain. At *c* the current is forced out of its horizontal direction, but a force can only be communicated to an elastic body like air by compressing it. The rain has therefore been caused by compression of saturated air.

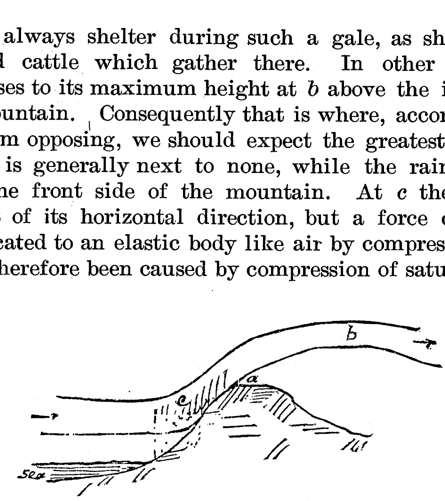


FIG. 4.

Fig. 5 represents a section of the atmosphere of the southern hemisphere for the month of July, the section being made through the Tropic of Capricorn (see map in my paper, "On the Cause of Trade-Winds"). The intersected parts of the three southern continents are at that time of the year in a dried-up state, and the air-cushions which consequently develop over their surfaces are thrown westwards over the oceans. The height of the vapor atmosphere over the surface of the earth is varying and at its maximum in the anti-cyclones. If we should imagine for a moment that there is no surface-evaporation, or that the earth is

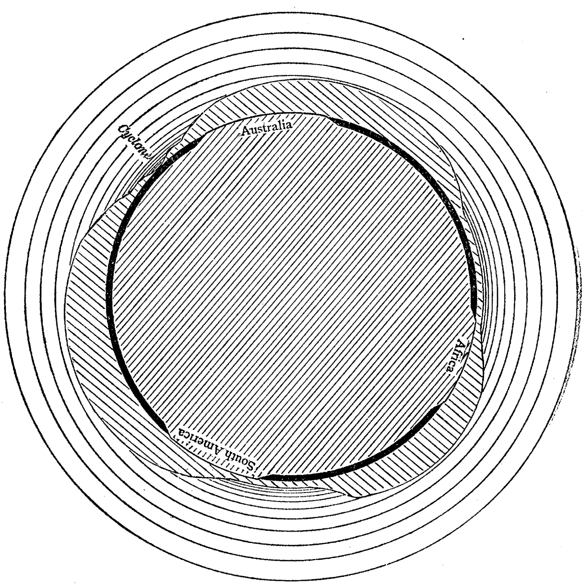


FIG 5.—IDEAL SECTION OF ATMOSPHERE AT THE TROPIC OF CAPRICORN.

(The circles indicate the outer atmosphere of invisible vapor.)

perfectly dried up, the dry air would arrange itself in a uniform layer between the earth and the vapor atmosphere as a continuous air-cushion of uniform thickness, and there could be no possibility of rainfall. The tendency of the vapor atmosphere is towards such a regular shape, but this tendency is counteracted by the varying degree of evaporation at different parts of the earth's surface. A strong surface-evaporation has the effect of decreasing the height of the vapor atmosphere over the surface of the earth, while little or no surface-evaporation has the opposite effect. In the space between the anti-cyclones the height of the vapor atmosphere over the ground is comparatively small, and it reaches a minimum when (say, for instance, in the V-depression between two anti-cyclones) the surface-air is, by the currents of opposite directions along the borders of the anti-cyclones, brought into rotary motion, which drives the surface-air away from a centre. The vapor atmosphere is thereby caused to approach the earth's surface, and by thus descending is brought under greater pressure, so as to give off rain at the centre of the cyclone, as explained above.

Having, by a simple way of reasoning, arrived at the conclusion that an atmosphere of pure aqueous vapor must exist outside the atmosphere proper, we should not feel justified in stopping without carrying our idea out in at least some of its consequences, although the following remarks do not concern our immediate subject, the cause of rain. Supposing there was an outer limit to this aqueous atmosphere, the difficulty which would present itself is, that we should find aqueous vapor alongside of the vacuum of space. It is well known that when moisture is brought into an artificially produced vacuum, the latter gets instantaneously filled with aqueous vapor. How is this experiment to agree with the popular notion that vapor, as well as the other constituents of the atmosphere, is kept within limits round the earth by means of gravitation? If the vapors of the supposed outer border of the atmosphere were prevented from entering space owing to gravitation, how much more would the vapors at the bottom of an artificial vacuum be prevented from filling this space, as the force of gravity is much the greater at the earth's surface than at a supposed outer border of the atmosphere?

Surely, we must conclude that it is impossible to imagine how moisture could remain in the air or on the earth's surface, unless space were filled with aqueous vapor. The earth's surface being practically that of a huge drop of water, and this drop moving round the sun in a supposed vacuum, how could this moisture be prevented from escaping into space unless space was filled with aqueous vapor? The only thing to prevent such an emergency is the thin veil of an atmosphere; but this, being itself all permeable and permeated with aqueous vapor, seems indeed a very poor protection.

Laplace's nebular theory of the evolution of the solar system points towards the same fact; for, if aqueous vapor has once been uniformly dispersed throughout the solar space, it follows of necessity that this space could not afterwards have become perfectly exhausted of aqueous vapor: gravitation towards the sun and the planets could not establish such a vacuum.

If it should be used as an argument against my theory, that we might with just as much right expect to find the other constituents of the atmosphere dispersed through space in a rarefied state, then I would say, as has been pointed out above, that these follow the reverse law of aqueous vapor by being contracted by cold, and that makes all the difference.

The general conclusion I arrive at is, therefore, that the interplanetary space is filled with vapor in an extremely rarefied state. The sun and each of the planets is surrounded by a vapor atmosphere of a denser state, the quantity of vapor surrounding each of these bodies depending upon its size and its surface-temperature. The sun will for both reasons have by far the lion's share of such a vapor envelope. This theory seems to agree perfectly well with the following observed facts:—

1. The retardation suffered by the comet Encke indicates that this comet, when nearest to the sun (that is, at a distance from the sun about that of Mercury), passes through a medium of a certain resistance.

2. The present condition of the surfaces of the four inner planets varies according to their distances from the sun, or, what is likely to be in proportion thereto, their surface-temperatures. On Mars we find more land than water surface, and a clear sky. The conditions on the earth in this respect need not be repeated here. As to Venus and Mercury, they possess an atmosphere of great density; and, as they are constantly covered by clouds, we have no means of ascertaining the proportion between land and sea surface, but their clouded state seems to indicate that they must be entirely or almost entirely covered by water. These varying conditions seem to indicate that the planets are gradually approaching a state of being dried up, or that their waters and vapor envelope are gradually leaving them; and the conditions on the moon indicate that this state will have been reached when they have become extinct planets.

3. The moon being an integral portion of the earth, there can be no doubt but it must once have possessed surface waters and a vapor envelope in proportion to its size. It is now an extinct planet, and its surface is void of waters. What has become of this water, unless it has passed into space?

We have hereby gained a fresh point of view, from which it may be worth our while to reconsider the former, present, and future conditions on the earth. Geologists have come to the conclusion that at the time of the coal period there must have been much less land surface than now, and that the atmosphere must then have been much warmer and moister than it is now. The land may, of course, gradually have emerged from out the seas since then, the quantity of water on the earth remaining constant; but it seems exceedingly more natural to suppose that the earth contained much more water during the coal period than it now contains. When, therefore, we nowadays find ancient sea-beds in the highest of mountain-ridges, we need not feel so sure that these have risen to their present elevated position from under the present level of the sea, as probably the sea-level was formerly quite different from what it is now.

Mathematicians have at various times attempted to determine the outer limit of the atmosphere by calculating at what distance from the earth there would be equilibrium between the centripetal and the centrifugal forces acting upon the smallest particle of air, thereby arriving at results varying from fifty to two hundred miles, the difficult point being how to determine the actual mass and density of the particle of air. Other philosophers have seen the absurdity of imagining the situation of an air-particle in a state of uncertainty as to whether to remain with the earth or go off at a tangent, and therefore have concluded that the atmosphere is practically unlimited.

Another series of considerations has led to the conclusion that outside the atmosphere of air, which may be estimated at forty or fifty miles, must exist an atmosphere exceedingly thinner than air. These various theories are brought into perfect agreement, and the absurdities are avoided, by assuming my theory of an outer atmosphere of vapor, which is unlimited.

It is truly said that there is nothing new under the sun, and we might therefore expect to find that my definition of the atmosphere is merely a repetition of what has been said at former times. In his excellently written book, Mr. Scott points out that the old biblical scriptures, particularly the Book of Job, contain many a sound reasoning on the atmosphere which holds good to this very day. Not having found the information I wanted in modern works on this subject, I took the hint, and looked up these ancient sayings, until I came to a passage by Moses which made me pause. Perhaps Col. Ingersoll may some day point out some serious mistakes in my argument or in the figures I have produced to support it, but at present it seems rather as if Moses managed to give us a pretty clear definition of the atmosphere when he wrote, "And God said, Let there be a firmament [Hebrew, "expansion"] in the midst of the waters: and let it divide the waters from the waters. And God made the firmament, and divided the waters which were under the firmament from the waters which were above the firmament: and it was so."

The coincidence between this observation of Moses and the result I have arrived at may perhaps, in our advanced age, be considered merely as a curiosity; but, considered as a purely objective and perfectly unbiased view of the matter, it seems to me to afford some further interest. Moses could not argue much on atmospheric subjects, as he had no natural sciences to guide him, but neither could they lead him astray. His knowledge of air was very limited. He did not know that it exerts a pressure of fourteeen pounds per square inch, and that this pressure grew much less when he went on to Mount Sinai to write the Commandments; and neither could he have any knowledge of the existence of invisible vapor. But when he walked about in the desert for forty years under a generally serene blue sky, and on rare occasions saw a cyclone set in, then he would observe this phenomenon exactly as Mr. Scott describes it nowadays: "He saw the thin cirro-clouds overhead gradually change into stratus, and these gradually growing further condensed and sink to a lower level, until rain ultimately set in." He saw the clouds and rain being formed on the spot, and could have no suspicion of their being caused by vapors rising out of the dry sand of the desert, and so he wrote faithfully according to what he saw. Although, therefore, no doubt, there are more things between heaven and earth than was dreamt of in the philosophy of Moses, when he tells us that there is a firmament between heaven and earth, dividing the waters from the waters, the time may perhaps not be far distant when we shall all agree with him on that particular point.

The nomenclature of clouds being a question which of late years has provoked considerable dispute, it seems to me, that, according to my explanation of the general atmospheric arrangements, clouds might more properly be grouped according to their cause or origin, rather than entirely according to their appearance, which is so varying and deceptive. We find, thus, two distinct groups of clouds; namely, what we may call "evaporation clouds" and "condensation clouds."

Evaporation clouds are cumulus-clouds in shape. They are formed by mixture at the summit of a current of damp air rising from the ground. They are unstable and merely indicate a stage in the upward passage of vapors. They are essentially rainless clouds, and found in the expansion or cushion of unsaturated air. They have their supply of vapor from below.

Condensation clouds are stratified clouds, cirrus, and stratus. They are formed by condensation by compression at the lower limit of the outer atmosphere of vapor. They are essentially rain-clouds, or those from which the great rain ultimately comes. They have their supply of vapor above them.

FRANK A. VELSCHOW, C.E.

A New Meteorite.

AT a meeting of the Rochester Academy of Science held Feb. 17, Mr. E. E. Howell gave an account of a new iron meteorite recently added to the Ward and Howell collection.

This meteorite was found April 30, 1888, about one and a half miles north of Welland, Ontario, Canada. It was ploughed up by Walter Caughell, and attracted attention by its specific gravity. Before throwing the mass aside as worhthless, a small piece was with much difficulty broken off. This piece, weighing five ounces, was kept by a Mr. Holland until September last, when he gave it to a friend, who, being convinced it was meteoric, forwarded it to Mr. Howell.

After careful search, the original mass was at last rediscovered in a pile of old iron. It is impossible to determine the original size of the mass, as it has been so long exposed that none of the outer crust nor characteristic pittings are preserved, but only the general form, which is a kidney-shaped mass, with the inner edge and smaller end drawn out thin. At two or three points the octahedral structure is well exposed. After being freed from all loose scales, the total weight, including the piece first broken off, is seventeen pounds and three-quarters. Mr. Howell proposed to call it the "Welland meteorite," from the locality where it was found. Mr. Howell stated that this was the second meteorite they had received from Ontario.

The first one fell about 2 P.M., Jan. 21, 1887, in the village of De Cewsville. It struck in the ditch by the side of the street, about fifteen feet from a lady who was passing along the middle of the street at the time.

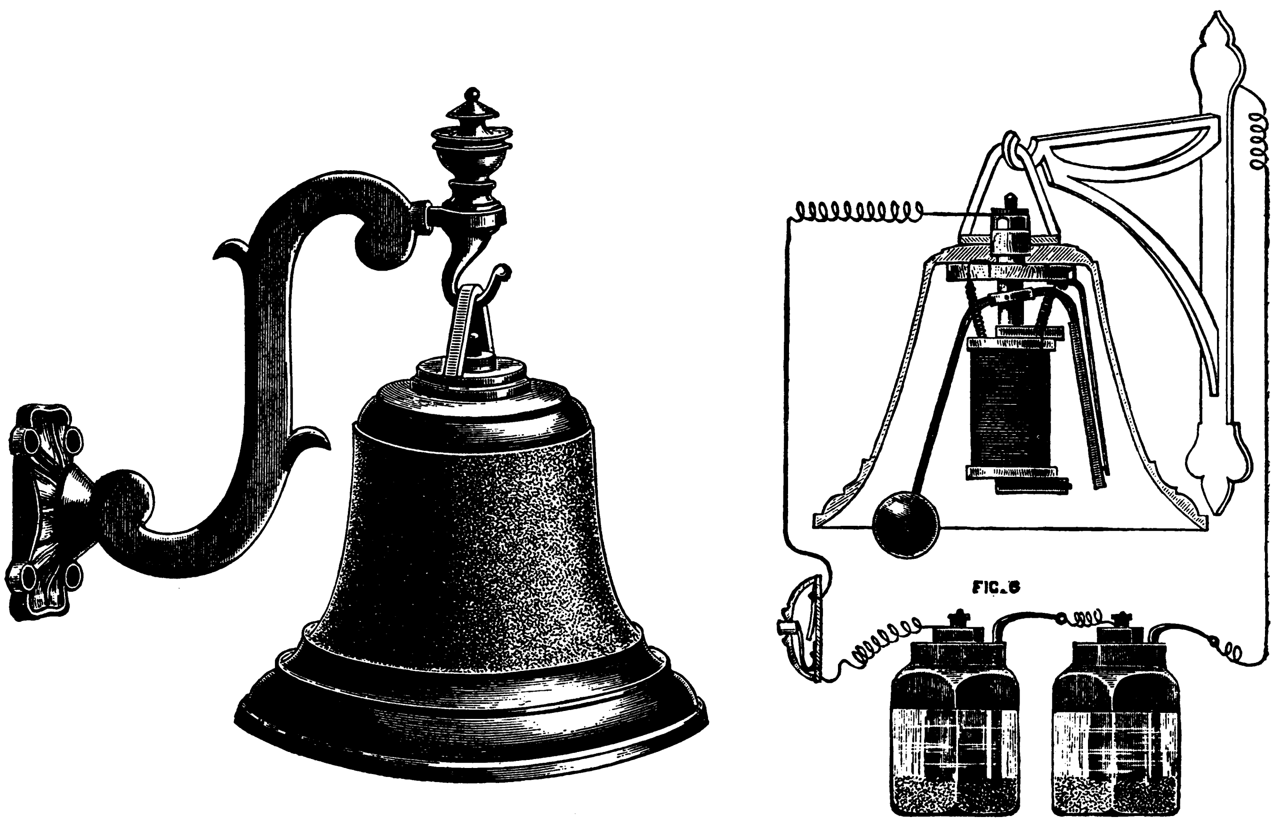
It broke through a thin sheet of ice, and was not found until the 16th of the following month, about four feet to the east of where it fell. It is an aerolite weighing twelve ounces, with specific gravity roughly calculated at 3.43. H. L. PRESTON.

Rochester, N.Y., Feb. 28.

INDUSTRIAL NOTES.

A Novel Electric Bell.

THE Jensen electric bell shown in perspective in Fig. 1, and in section in Fig. 2, possesses some novel features worthy of notice. It will be seen, by examination of Fig. 2, that the operating mechanism and the method of making the electrical connections differ materially form those in ordinary use. Only one magnet is employed instead of two, and by the use of extension pole-pieces at each end of the core the attractive force of the magnet is exerted on a line parallel to its axis. In the ordinary form, the armature acts at right angles with the axis of the magnet. This new device, owing to its compactness, is peculiarly adapted to this form of bell; and this style of magnet gives a powerful magnetic field, insuring quick and vigorov action.



FIGS. 1 AND 2.—THE JENSEN ELECTRIC BELL.

By reference to the sectional illustration, it will be noticed that the method of hanging the clapper is novel and very ingenious. Advantage is taken of gravitation, to an excellent purpose. This form of bell admits of its being used in many places where it would be impracticable to put bells of the ordinary kind. For instance, it can be hung to a clock, and with the use of proper appliances made to strike the hour, or oftener if desired. It is also adapted to church chimes, which can be rung on this principle as easily as playing on the keyboard of a pianoforte.

One great advantage of this invention in its application to locomotive bells is quite obvious. Instead of the fireman spending half his time pulling the bell-cord, the bell by this new method would be placed at the command of the engineer, the same as the whistle or brake, and would be instantly sounded and the alarm made continuous by simply turning the switch. This adaptation alone makes the invention valuable, to say nothing