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THE ARTIFICIAL PRODUCTION OF RAIN.

THE literature upon the above subject is becoming considerable, and some of it is not characterized by judicial calmness. We desire to place both sides fairly before our readers, and as we regard the following paper by Prof. Cleveland Abbe as the best summary of one side of the question, we have for the first time broken our rule of not reprinting papers printed in English.

The copy was sent to us as it had been sent to the American journal *Agricultural Science*, and looking at its title we feel sure that the proprietors will not object to our laying before readers on this side of the Atlantic what they have spread among our cousins on the other side. Possibly some of our readers may think that if articles of this quality appear in *Agricultural Science* it may be to their interest to see it regularly.

ON THE PRODUCTION OF RAIN.

BY CLEVELAND ABBE.

THE great interest that has recently been excited throughout the world in the question as to whether or not the progress of science gives us as yet any hope that man may cause rain to fall in times of drought, or to cease falling in times of flood, renders it proper that a brief sketch should be given of some, at least, of the many methods that have been suggested as a means of accomplishing this end. Although none of these methods have any practical value, still it is important to briefly summarize the results of experience if only as a means of saving present and future generations from an unnecessary waste of money. It is, on the other hand, equally important, after divesting ourselves of erroneous views, to seek for such light on the subject as our limited knowledge affords, and to mark out such further lines of investigation as may elucidate this difficult but important problem.

Although the production of rain is undoubtedly a purely material, physical process and should be studied by the methods of modern science, yet it is impossible not to recognize that there has always been a certain supernatural aspect to the question and that probably the majority of mankind, at the present moment, take that view of it. In fact the importance of rain to human existence has, from time immemorial, led mankind to seek some method by which to secure it when needed. Divinations and incantations, prayers and sacrifices, the fetish of Africa and the gapogari of India illustrate respectively what may be called the superstitious and the theological theories on the subject of man's influence upon the weather. The recent progress of meteorological science has led us, on the one hand, to properly evaluate supernatural methods and, on the other hand, to query as to whether there really is any material physical principle that we can call to our aid in order to make it rain or cease raining. The following paragraphs may therefore illustrate such methods as have been suggested or tried :

1. Before the use of cannon the church bells were rung vigorously in order to dissipate dangerous storms. Parent states that in 1703 the inhabitants of Iliers by ringing the bells forced a hailstorm to break in two and thus saved their fields. It would appear that originally this practice was suggested by the idea that the ringing of the bell called the people to prayer and that, in fact, the bell represented the voice and prayers of the church, but eventually the theory was advanced by Le Maout (at Le Brieuc in 1854) that the sound, namely, the concussion in the air, produced by the bell, in some way caused the clouds to drop rain.

2. It is well known that it has long been the practice among sailors to discharge cannon at a water-spout, hoping that it can thus be broken up before reaching the ship. Mr. R. de C. Ward (*Am. Met. Jour.*, March, 1892) states that in the memoirs of Benvenuto Cellini there is mention of the fact that an impending rainstorm was averted in the year 1539, at Rome, by firing off artillery in the direction of the clouds which had already begun to drop their moisture. Arago says that as early as 1769 it was the practice to fire guns to break up a storm, but he shows by weather records that such firing has no such effect. The Swiss peasants discharge firearms into the clouds to draw off the rain before lightning and hail can form. The idea was that quiet air produced large hail, but that when disturbed by noise it could only produce small hail and rain—just as a crystallizing solution gives large crystals the more quiet it is. Patricius Heinrich in a prize essay published by the Bavarian Academy, in 1785, showed that cannonading does not prevent hail, and, in fact, has no appreciable influence on the clouds. Kaemtz (in 1831) quoted the case of 36,000 soldiers who fired a salute in order to break up an approaching thunderstorm during their evolutions—but failed. Denize and Parrot maintained that the vapor and smoke of gunpowder exerts a chemical influence unfavorable to the formation of thunderstorms and thus prevents them.

3. In opposition to the preceding the idea has been frequently

defended, during the past century, that the violent concussion produced by the explosion of gunpowder caused the minute particles in the clouds to jostle together and fall as rain. The earliest one to advance this idea, as far as I can find, was J. C. Lewis of Washington, in 1825, but its most prominent advocate since 1870 has been Mr. Edward Powers. On this principle, in 1854, Le Maout, from the rainfalls in western France, predicted that an important battle must be in progress in the Crimea, which, in fact, he subsequently identified as the cannonading at the battle of Inkerman an hour before his predictions. The ideas advocated in this country by Mr. Powers and in England by Mr. R. B. Belcher in 1874 received a qualified adherence from Prof. J. K. Laughton, Prof. Elias Loomis and Prof. J. D. Everett, although these distinctly disclaim their approval of the arguments used by Powers and Belcher. Mr. H. C. Russell, of Sydney, Australia, has strongly combatted both the arguments and the ideas. At present this concussion theory certainly has not the support of any prominent physicist.

4. The hypothesis that electrification keeps the particles of a cloud apart, and that its sudden removal by the discharge of lightning directly causes hail, and heavy rains or cloud-bursts, was promulgated soon after Franklin's experiments with his electric kite. Montbelliard, of Dijon, in 1776, held that hail would be impossible if the electricity were drawn early and quietly from the clouds, hence followed attempts to quietly discharge electrified clouds by means of lightning rods or wires carried up by kites, or even by captive balloons, in the hope that the formation of destructive hail or rain would be prevented. P. Heinrich in his prize essay above referred to, Wrede and Weiss in 1800, and many since then, have shown by statistics that fields of grain thus protected by lightning rods suffer from the hail, rain and wind quite as much as the neighbouring fields without protection. The rods do not appreciably diminish the number and intensity of destructive discharges of lightning, but when they receive the discharges they save the buildings and the harvested crops from destruction by fire; the rods have no influence on the rain and hail. According to Volta large hailstones are formed from smaller ones that are alternately attracted and repelled between two parallel layers of clouds; the surfaces of the hailstones are cooled by the electrical evaporation of the added water; Volta expressly demonstrates that the electric condition of these clouds cannot be affected by lightning rods.

5. It has been thought that, by setting fire to heaps of brushwood, a destructive storm, with its lightning and hail, can be averted; but Volta, the advocate of this method of depriving the cloud of its electricity, after a first few years of success on the Roman Campagna, found that his experience was the same as that of his neighbours and that no effect was produced. P. Heinrich, in his prize essay, also shows the uselessness of such fires. Piccard compared the data for twenty-five years as to fires and rainy days in

Switzerland, but found it demonstrable that there was no connection between them. Professor John Trowbridge, in 1872, showed how a slight possible connection might exist that is worthy of further study.

6. The electrical condition of a moist atmosphere seems likely to have some relation to the formation of raindrops, but our knowledge on this subject is very meagre. Most students agree with Kaemtz, who, in 1831, said that we know not which is cause and which is effect, but that most probably the lightning is the result of the formation of cloud and rain. Professor John Trowbridge in his experiments, above referred to, showed that flames from fires tend, like lightning-rods, to reduce the positive electrification ordinarily observed, to a neutral or even to a negative condition. Ordinary observations of atmospheric electricity show that cold, polar winds bring an increase of positive electric tension. In general a positive condition exists in the air in or around a snowstorm, but rapid changes, even from positive to negative, frequently accompany hail and rain. It is more probable that these electric changes are the result rather than that they are the cause of the precipitation or of the winds or temperature. In 1880 Mr. Ruggles advanced the idea that "by altering the electrical condition of the upper air and the electrical force that controls the atmosphere" he could govern the formation and movements of rain-clouds and thunderstorms, but no adequate means to accomplish such alteration has been devised.

7. A number of interesting laboratory experiments by Rayleigh and others (see Guthrie on "Soap Bubbles") have shown that by electrifying a fine jet of water we may prevent it from breaking up into separate drops These results are apparently produced by changes of the surface tension of the drops; the electrified drops coalesce when they strike each other, whereas drops of pure water unelectrified rebound and remain separate. Hence follows the idea that by thus electrifying a cloud we may cause the suspended small drops to unite into a steady downpour of rain; but no means has yet been found to accomplish this end. Possibly this idea is equivalent to that present in the minds of those who advocate making it rain (see J. R. Buchanan, 1891) by drawing the electricity from the clouds.

8. Having given up the idea that rain and hail are due to he sudden removal of an intense electrification, such as precedes the discharge of lightning, some theorists reverted to the idea that it is the noise of the thunder attending the lightning that produces a concussion within the cloud and that this is nature's method of jostling the cloud particles together into larger drops of rain. This is an advance on the idea that noises made by mankind, such as bell-ringing or cannonading, can cause rain; but it is equally contradicted by ordinary observation, which shows that there is no necessary connection between thunder and rain. On this whole question of the effect of concussion, namely the rapid vibrations of sound, it may be remarked that Champion and Pellet, in 1873, succeeded in inducing

the explosion of dry iodide of nitrogen by the high-pitched notes of the violin and the Chinese tom-toms and by the explosion of a very little nitro-glycerine, but not by the noise made by the explosion of ordinary gunpowder. It has not yet been shown, however, whether the result was caused by the sympathetic vibration of the molecules of these chemicals responding to the high-pitched note, or whether it was due to the small masses of the chemicals rubbing against each other and the anvil on which they rested, both being set into sympathetic vibrations with the string of the violin. The latter is more probable, but neither case would afford ground for supposing that cloud-particles, which are relatively far apart, could be brought to coalesce by this process. The experimental firing of a pistol or a gun into a cloud of fog or steam produces no appreciable agglomerations of the globules of water.

9. The advocates of the theory that great battles are followed by rain, not content with maintaining the influence of great noise in producing rain, have also gone to the extreme of maintaining that the heat of the conflict and the moisture from the breath and the perspiration of many men has an appreciable influence in producing the subsequent rain. In general, however, it does not appear that rain is any more likely to follow a battle, great or small, than it is to occur without a battle.

10. About a hnndred years ago Hutton advocated the idea that rain is naturally formed by mixing warm, moist air with colder moist air ; this idea has long since been dispelled as it has been shown that by mixture alone we can produce only a haze or fog, but not a rain ; nevertheless it has been lately proposed to produce rain artificially by this method of mixture. Mr. G. H. Bell proposed to erect a tall tower, which might also serve for other purposes, and through which warm air is to be sent up into the upper regions and mixed with the cold, moist air above, producing a local rain in the immediate neighbourhood whenever desired. This inventor also proposed, when need be, to reverse the motion of the fan, thereby bringing the clouds down to the earth and preventing rain. A similar idea is advocated by Mr. James M. Pitkin, of Kansas City, who would have a large sheet of canvas held up by balloons, so that a horizontal wind striking against it will be deflected upwards precisely as when blowing against a mountain side. Mr. Pitkin also proposes to support large canvas tubes by means of balloons, the cold air to be drawn down a long tube and driven up through a short tube until it can be delivered at the proper elevation in the atmosphere.

These ideas of Pitkin and Bell must utterly fail of their object because of the mechanical impossibilities as well as because of the erroneous principle on which it was proposed to make rain.

11. The idea that an extensive fire may, under certain circumstances, determine the formation of cloud and rain was maintained by Espy as a necessary consequence of his theory of the cooling by expansion of rising air. In fact, numerous examples are at hand to

show that when the air is very moist a large fire may initiate a rising current of air and a cloud that shall grow into a local rainstorm; the fire is simply the initiative and determines where the cloud will start; it can hardly be said to cause the rain, nor does it decide, in any case, where the rain will fall; it simply performs the same office that the pulling of a trigger does for the discharge of a gun and the fall of a distant bird; or that an act of the will does for our physiological muscular machinery.

Prof. Espy's ideas have been widely supported, and the fact that rain cannot be started by an artificial fire when the air is very dry is really a further confirmation of the views expressed by him. Prof. J. K. Laughton, in England, and Mr. H. C. Russell, of Sydney, New South Wales, have shown how rarely the bush fires of Australia are followed by rain owing to the dryness of the climate; in general, when the winds are blowing up over a mountain range, plenty of rain falls, and usually without lightning, so that we have no reason to invoke the aid of electricity, noise, smoke or fire. The power contained in the sunshine that is received on a single acre of ground, when the sun is near the zenith, is greater than that exerted by a steam engine of 4,000 horse-power; when this power is exerted to heat the air and cause it to rise it is fully equal to the work of lifting 60 tons of moist air 1,000 ft. high per minute.

12. The experiments of many physicists have shown that certain solids have the power of attracting around themselves a condensed atmosphere of one or more gases, especially is this true of carbon, so that the fine particles that constitute smoke and soot may be conceived of as surrounded by dense atmospheres of aqueous vapour. These nuclei being good radiators of heat are supposed to become especially cooled and to condense the vapour upon themselves, so that they may become the nuclei of cloud particles. Thus these dust particles, whether they result from forest fires or the spray of the ocean, the pollen of plants, the dust of the highway, or the consumption of shooting stars, may be an essential feature in the formation of rain or snow. Therefore any process that increases the quantity of dust in the air contributes to the formation of rain, and in fact visible drops of vapour are not easily formed, even by cooling the air below its dew-point, unless dust nuclei be present; this is made the basis of Aitken's method for determining the number of particles of dust in the air. Prof. Blake, of Kansas University, proposes to make rain by distributing fine dust in the atmosphere, but human agency cannot economically increase the percentage of dust already in the cloud region.

13. The idea has been promulgated that possibly there exists some gas or vapour or other substance that, like smoke, can be injected into the air and that will initiate the condensation of the aqueous vapour. This is the method claimed by Mr. Frank Melbourne, but the chemicals used by him are kept a secret, and other parties having adopted the same idea appear to be using

chemicals different from Melbourne's. The general method of procedure seems to be that the operator, within a building, makes the gas in secret, and it is seen escaping from a chimney, while an assistant circulates among the spectators outside and takes their bets as to the success of the operation. There is no principle known to chemists that would justify us in expecting this method to succeed in producing rain, and actual experience shows that the failures have been quite as numerous as the successes, just as would be the case if the chemicals had nothing to do with the rain.

14. The explosion of balloons, filled with a mixture of oxygen and hydrogen, produces a small quantity of aqueous vapour which is at first hot and expanded, but in a few moments becomes cool and condensed. Dysenforth advances the theory that these few particles of nascent water serve as natural nuclei, attracting to themselves the aqueous vapour already in the atmosphere resulting in the formation of mist, cloud and rain. No successful experiment of this kind has ever yet demonstrated the truth of this ingenious theory. Evidently the great heat produced by the chemical combination of oxygen and hydrogen must, in some way, be got rid of before the surrounding aqueous vapour can condense into drops.

15. Man may not hope to assist nature in the formation or prevention of rain until he better understands the details of nature's own methods. The ideas most widely accepted, at present, as to the natural process of the formation of rain, go only so far as to say that the moisture present in the atmosphere is extracted from the air by three different steps, namely, *first*, the saturation with aqueous vapour that is produced by cooling the air; *second*, the condensation of the vapour into small visible particles of cloud and fog; *third*, the agglomeration of these droplets of water into drops large enough to be precipitated as falling rain, hail or snow.

I. The ordinary natural methods of accomplishing the cooling required in the first of these steps are: (*a*) the mixing of cold and warm air, by which, however, only a very slight amount of precipitation can be formed; (*b*) the radiation of heat to the colder earth and air and space by which at first thin layers of fog or stratus clouds are formed which then slowly thicken with time; (*c*) the rise and expansion of large masses of air; the mechanical work done by the expansion simultaneously of the whole mass may cool it to any extent whatever. This last is the important process on which all our rain depends.

II. The second step, namely, condensation, is a molecular process that has been likened to the crystallization of solid salts from liquid solutions, although there is too little known about either process to warrant the belief that they are really similar. Aitken and others maintain that the condensation of vapour, like the crystallization of salts, demands some nucleus as a starting-point, and that every minute droplet of fog or cloud must have a particle of atmospheric dust as its initiative.

III. The third step in the above process of rain formation is the agglomeration of fog or cloud-particles into larger drops. About this there is very little known from actual observation, and the hypotheses are quite various. The hypothesis that among these particles some are larger than others, and, by their more rapid descent, overtake the smaller ones and thus grow larger as they descend, seems at first quite natural, and is sufficient to explain the fact that the quantity of rainfall is an exceedingly small percentage of the water that is visible as a cloud and, of course, a still smaller percentage of the water that is present as vapour in the air. On the other hand, microscopic observations of the sizes of the particles of fogs do not show a variation in the diameters sufficient to allow of one particle falling much faster than its neighbour; therefore, as the air always has a motion sufficient to carry these minute particles along with it, it would seem that if they are to come in contact and form larger particles, it must be through a process of jostling together rather than through a process of falling by gravity.

But the contact of two particles, whether by gravitational fall or by the jostling of wind-currents, will not necessarily cause their union; it is essential that the surface tensions of the two particles be properly adjusted to each other, and this latter point seems to demand further study. It is true that by proper electrification we are able, in the laboratory, to alter the surface tensions and to cause small fog particles to coalesce, but it is not so evident that this is the ordinary process of nature. We are also able in a laboratory to alter surface tensions by surrounding the particles with a different gaseous or vaporous atmosphere, or even by changing the temperature of the particles; but neither of these processes is likely to be the process that takes place in the clouds. Rayleigh's experiments on jets of soapy water make it plausible that a slight impurity in the rain water, such as ammonia or nitric acid, may make it possible for certain cloud-particles to agglomerate, while the neighbouring droplets of pure water would not do so. Again, a thin film of foreign substance, such as oil on the water, lowers the surface tension and allows two such oily drops to combine into one, when the film is broken at any point, by pressing the drops close together. But none of these laboratory experiments seem applicable to the formation of the natural cloud and rain.

16. As to these various hypotheses that have been suggested concerning the method by which the agglomeration of droplets into large drops is actually affected by nature in her regular process of making rain, I must remark that it is not yet clear to me that anyone has demonstrated that small drops actually do agglomerate into larger ones to any considerable extent. I think it quite possible that the union of small cloud-particles into larger ones is only effective in driving fogs or clouds whose upper surfaces cool by radiation but is, after all, not an important feature in the natural production of generous rains and summer thunder showers. It is a reasonable

"working hypothesis" that the particles which were originally too small to fall from the clouds with any rapidity actually remain there entangled in the currents of air that characterize clouds, and that they are subsequently evaporated, while, on the other hand, only those fall as rain which, originally, had a size vastly larger than the average size of the smaller particles that constitute the major portion of a cloud. There may be some reason why the condensation of the superabundant molecules of a saturated vapour should form not merely cloud-particles whose diameter is ordinarily less than one one-hundredth of an inch, but also, here and there, large drops which fall to the ground as rain with very much the same size as when originally formed a few moments before in the clouds. The sudden pour of heavy rain from a limited region within a thunder cloud cannot be due to a general slow progressive agglomeration of droplets into drops.

On this point I submit the following modification of ideas suggested by reading von Bezold's fourth paper on the "Thermodynamics of the Atmosphere," Berlin, 1892; it suggests a new point of view, and one that demands further experimental elucidation.

(To be continued.)

THE RAINFALL OF JAMAICA.

FEW things are more striking than the rapidity with which a network of stations for the measurement of the fall of rain has spread over the globe. It has been accepted as so essential that the development has hardly excited any comment, and few, if any, persons have realized the magnitude of the movement—except the opticians, some of whom must have found it very profitable.

This development can be illustrated from nearly all parts of the world, but the present notice of it has been suggested by Mr. Maxwell Hall's excellent book,* though we must go behind it to the monthly *Weather Reports* issued under his supervision (and upon which the present beautiful maps are based), to realise fully the progress that has been made. We give merely two facts. In 1877 by far the best paper upon the rainfall of Jamaica which had appeared, was sent to the Meteorological Society. It embraced the seven years 1870–76, and contained perfect records for the seven years from only 3 stations, and fragmentary records from 22 others, the largest number perfect in any one year being 17. In 1892 the number of stations is 149, or nearly ten times what it was 15 years previously.

* Special Publications of the Institute of Jamaica: No. 1. The Rainfall of Jamaica; thirteen maps, showing the average rainfall in each month and during the year, with explanatory text, by Maxwell Hall, M.A., F.R.A.S., Barrister-at-Law, Jamaica Government Meteorologist, &c. London: Stanford, 1891. Fcap. folio, 8 pp., and 13 coloured plates.

The present work is based upon observations at no fewer than 153 stations, all of which had been established long before 1889. The numerical values have been given in the Government publication; the present work is essentially an atlas of rainfall maps, one for each month and one for the year, giving the relative rainfall all over the island.

But we must, *en passant*, mention that there is one respect in which we think that Mr. Maxwell Hall's work could be improved. His report, No. 33 of October 18th, 1883, and his yearly summaries are equally excellent, but he has never given a table like Table II., p. 16, of the *Quar. Jour. Met. Soc.*, vol. iv. He has the yearly total from one or more stations for every year from 1858 onwards, and if he would give us the entire series grouped in his own divisions, it would be easy to determine many questions as to the fluctuation of the yearly fall, and as to the true averages, which at present it would be impossible for any non-resident to work up correctly.

As a rough type of what we suggest, we give as much of the first 15 years of the table as our page will take in, but doubtless have made some errors in it, especially in grouping the stations:

Total Rainfall at Stations in Jamaica.

Years.	Hampstead.	Albion.	Bradfield.	Salter's Hill.	Drax Hall.	Georgia.	Green Park.	Braco.	Denbigh.	Chapelton.	Windsor.	Black River.
1858	47·33	...	...	...	...	...	..	...	...	..	...	...
9	45·02	...	...	...	...	...	...	...	...	..	...	...
1860	63·39	..	...	...	...	...	...	...	...	...	...	...
1	64·83	...	...	...	...	...	...	...	...	...	...	...
2	73·35	...	...	...	...	...	...	...	71·65	...	...	...
3	...	...	...	...	...	...	...	..	56·88	...	...	...
4	...	...	...	...	...	...	...	...	53·53	...	...	...
5	...	...	...	...	..	...	...	...	44·81	...	...	...
6	..	74·17	70·89	...	...	...	...	...	36·57	..	51·86	...
7	...	63·47	66·82	...	...	..	...	..	62·83	...	65·44	...
8	...	70·13	77·16	...	...	...	...	...	55·79	...	73·80	
9	..	63·81	74·91	78·86	...	...	...	...	26·75	...	61·15	...
1870	...	84·60	103·74	114·34	96·56	85·48	79·78	75·10	78 16	61·78	92·36	71·11
1	.	64·91	74·16	70·46	64·29	44·03	35·54	33·26	37·95	43 67	70·78	48·17
2	...	61·06	61·50	62·53	51·34	33·93	31·51	30·44	40·69	48·35	69·04	55·75

Reverting, however, to the maps, they are tinted in blue of five shades, representing—

	I.	II.	III.	IV.	V.
Monthly maps...	1 to 3,	3 to 5,	6 to 9,	10 to 14,	over 15 inches.
Yearly map......	30 ,, 35,	40 ,, 50,	55 ,, 70,	75 ,, 95,	,, 100 ,,

Jamaica, we may add, is about 140 miles long from W. to E., and on the average about 25 miles broad—rather more than half the area of Yorkshire.

The total yearly rainfall varies in Jamaica much as it does in Yorkshire; the wettest part of Jamaica has about 100 inches and the driest about 30 inches—while for Yorkshire we suppose that the corresponding values would be about 80 inches and 25 respectively. Subject to correction for the altitude of the stations, the fall seems to us tolerably uniform, except in the N.E. of Jamaica, where it is much heavier than in other parts—just as, to continue our parallel, the fall in the N.W. of Yorkshire far exceeds that in other parts of the county.

As regards the beautiful monthly maps, we cannot do justice to them, as all our readers have not them to refer to. Perhaps the best commentary is to reprint the concluding paragraph of Mr. Maxwell Hall's introduction:—

"The utility of these maps is sufficiently obvious; if the agriculturist wants constant and heavy rains, he will find them as a rule in the parishes of Portland and St. Mary; if he wants heavy summer rains, he will find them in the west central parts of the island; if he wants a moderate rainfall all the year round, he will find it in the area between Chapelton and Linstead, Albion and Cave valley. Not that he will, perhaps, secure such rainfall in any one year, but that, taking one year with another for a series of years, he may count upon the rainfall laid down in these maps."

RAIN ON OCTOBER 4TH.

IT was stated recently by a correspondent of the *Morning Post* that the fall of rain (2·65 inches) on the 4th instant at Cross-in-Hand, Sussex, was such that "the oldest inhabitants of this district cannot remember anything like this rainfall." We think that the memory of these good persons must be failing rapidly, for as recently as July 31st, 1888, over an area of quite 100 square miles, and within about ten miles of Cross-in-hand, if indeed it did not reach there, the fall was between three inches and three inches and a half. (*British Rainfall*, 1888, p. [102].

However, the fall was undoubtedly an important one, affecting chiefly the South-east of England. Arranged according to largeness of totals, the following are the values already reported :—

Sussex	Cross-in-Hand	2·65 in.
,,	Winchelsea	2·50 ,,
,,	Bryckden, Waldon	2·19 ,,
,,	Lower Cousley Wood, Wadhurst	2·17 ,,
Kent	Benenden	1·97 ,,
,,	Leysdown, Isle of Sheppey	1·93 ,,
Norfolk	Yarmouth	1·86 ,,
Kent	Tenterden	1·66 ,,

CLIMATOLOGICAL TABLE FOR THE BRITISH EMPIRE, MARCH, 1892.

STATIONS. (*Those in italics are South of the Equator.*)	Absolute. Maximum. Temp.	Absolute. Maximum. Date.	Absolute. Minimum. Temp.	Absolute. Minimum. Date.	Average. Max.	Average. Min.	Average. Dew Point.	Average. Humidity.	Absolute. Max. in Sun.	Absolute. Min. on Grass.	Total Rain. Depth.	Total Rain. Days.	Aver. Cloud.
	°		°		°	°	°	0-100	°	°	inches		
England, London	59·8	18	22·3	9	44·9	31·0	32·3	83	96·7	20·3	1·04	9	5·6
Malta	70·8	14	44·9	20	63·9	51·8	49·6	81	129·4	38·0	·81	5	4·4
Cape of Good Hope	90·1	4	52·2	22	76·0	58·5	...	...	...	...	1·75	7	4·5
Mauritius	84·7	8	69·6	31	82·6	73·6	71·8	83	137·5	64·0	9·57	24	6·7
Calcutta	100·8	21	53·8	1	93·9	68·4	64·6	61	155·1	43·0	·00	0	1·2
Bombay	91·8	26	66·0	5	85·4	74·1	70·8	74	135·8	49·7	·00	0	7·0
Ceylon, Colombo	91·0	29	69·8	8	85·1	75·7	71·4	64	159·0	65·0	1·52	5	4·5
Melbourne	104·0	8	43·2	31	76·3	56·3	55·8	72	153·2	33·8	1·56	6	5·2
Adelaide	104·5	7	47·3	29	81·8	60·5	52·7	53	163·2	39·2	·76	3	4·4
Tasmania, Hobart	...	...	...	...	...	...	...	...	...	...	...	..	...
Wellington	75·0	2*a*	44·0	27	68·6	54·0	53·5	77	128·0	38·0	6·36	11	4·3
Auckland	79·0	17	51·0	23	73·9	60·9	61·2	80	136·0	47·0	1·53	7	5·0
Jamaica, Kingston	88·3	20	64·0	1	85·8	69·8	68·4	73	...	...	·19	3	...
Trinidad	91·0	7*b*	66·0	25	88·7	69·0	69·2	74	158·0	56·0	1·85	14	...
Toronto	43·6	29	5·3	14	34·2	21·7	21·6	73	...	2·0	·77	16	5·1
New Brunswick, Fredericton	48·0	10	— 3·3	15	33·5	16·6	19·0	68	...	...	3·15	12	4·9
Manitoba, Winnipeg	46·9	30	—23·5	15	26·6	6·1	...	...	...	...	1·60	8	4·9
British Columbia, Esquimalt	61·9	15	31·5	2	51·6	40·3	44·1	94	...	...	3·05	19	7·2

a And 9, 15. *b* And 8, 28, 29.

REMARKS.

MALTA.—Mean temp. 56°·5. Mean hourly velocity of wind 10·9 miles. The sea temp. fell from 61°·0 to 59°·8. L on 30th. J. SCOLES.

Mauritius.—Mean temp. of air 0°·2, dew point 1°·9, and rainfall 1·28 in. above their respective averages. Mean hourly velocity of wind 7·4 miles, or 2·5 miles below the average; extremes, 20·3 on 25th and 0·0 on 2nd; prevailing direction E.S.E. T and L on 7 days, T on 2 days, and L on 1 day.

C. MELDRUM, F.R.S.

Melbourne.—Mean temp. of air 1°·9, of dew point 3°·7, and humidity 4, above; mean amount of cloud ·4 and total rain ·48 in. below, their respective averages. Prevailing winds S. and S.E., strong on 5 days. Heavy dew on 11 days. Fog on the 31st. L on the 14th. Dust storm on the evening of the 25th.

R. L. J. ELLERY, F.R.S.

Adelaide.—Mean pressure ·073 in. below the average of 35 years, the absolute max. (30·253 in.) being the lowest max. on record for March. Mean temp. 0°·8 above the average, the max being over 90°·0 on 5 days, and on 2 days over 100°. The absolute max. (104°·5) is the highest in March since 1872. Rainfall ·30 in. below the average. The month was very dry over the whole colony, particularly the inland regions.

C. TODD, F.R.S.

Wellington.—Fine in the early part, with moderate northerly winds, except on 11th and 12th, when it was strong. Heavy rains fell in the middle of the month, especially on 18th and 20th, when 2·14 in. and 2·10 in. were recorded. The last few days were fine, with N. wind. Mean temp. 0°·7 below the average. Rainfall 3·54 in. above the average. R. B. GORE.

Auckland.—An unusually fine and dry month, the only rain experienced being in the period from the 17th to the 23rd. Mean temp. 2° above, and rainfall nearly an inch below, the average. T. F. CHEESEMAN.

SUPPLEMENTARY TABLE OF RAINFALL, SEPTEMBER, 1892.

[For the Counties, Latitudes, and Longitudes of most of these Stations, see *Met. Mag.*, Vol. XIV., pp. 10 & 11.]

Div.	STATION.	Total Rain.	Div.	STATION.	Total Rain.
		in.			in.
II.	Dorking, Abinger Hall.	2·87	XI.	Rhayader, Nantgwillt..	4·88
,,	Birchington, Thor	1·75	,,	Corwen, Rhug	3·79
,,	Brighton PrestonvilleRd	2·69	,,	Carnarvon, Cocksidia ...	5·86
,,	Hailsham	2·86	,,	I. of Man, Douglas	4·05
,,	Ryde, Thornbrough	3·16	XII.	Stoneykirk, ArdwellHo.	3·15
,,	Alton, Ashdell...........	3·31	,,	New Galloway, Glenlee	5·39
III.	Oxford, Magdalen Col...	2·19	,,	Melrose, Abbey Gate ..	1·56
,,	Banbury, Bloxham	2·97	XIII.	N. Esk Res. [Penicuick]	2·80
,,	Northampton, Sedgebrook	2·67	,,	Edinburgh, Blacket Pl..	1·20
,,	Cambridge, Fulbourne..	...	XIV.	Glasgow, Queen's Park.	4·12
,,	Wisbech, Bank House..	3·39	XV.	Islay, Gruinart School..	6·57
IV	Southend	1·21	XVI.	Dollar......................	3·06
,,	Harlow, Sheering	2·22	,,	Balquhidder, Stronvar..	10·01
,,	Rendlesham Hall	1·89	,,	Coupar Angus Station..	1·95
,,	Diss	3·33	,,	Dunkeld, Inver Braan..	2·29
,,	Swaffham	2·17	,,	Dalnaspidal H.R.S. ...	8·37
V.	Salisbury, Alderbury...	2·36	XVII.	Keith H.R.S.	2·37
,,	Bishop's Cannings	2·75	,,	Forres H.R.S.	2·10
,,	Blandford, Whatcombe.	2·78	XVIII.	Fearn, Lower Pitkerrie.	2·79
,,	Ashburton, Holne Vic....	4·14	,,	Loch Shiel, Glenaladale	16·69
,,	Okehampton, Oaklands.	4·59	,,	N. Uist. Loch Maddy ...	5·58
,,	Hartland Abbey	4·14	,,	Invergarry	10·28
,,	Lynmouth, Glenthorne.	4·14	,,	Aviemore H.R.S.	3·79
,,	Probus, Lamellyn	2·52	,,	Loch Ness, Drumnadrochit	4·08
,,	Wincanton, StowellRec.	2·70	XIX.	Lairg H.R.S.	..
,,	Weston-super-Mare	3·19	,,	Scourie	5·84
VI.	Clifton, Pembroke Road	3·40	,,	Watten H.R.S.	2·16
,,	Ross. The Graig	2·36	XX.	Dunmanway, Coolkelure	6·57
,,	Wem, Clive Vicarage ...	2·38	,,	Fermoy, Gas Works ...	3·55
,,	Cheadle, The Heath Ho.	3·35	,,	Killarney, Woodlawn ...	5·24
,,	Worcester, Diglis Lock	2·27	,,	Tipperary, Henry Street	3·69
,,	Coventry, Coundon	2·12	,,	Limerick, Kilcornan ...	4·09
VII.	Ketton Hall [Stamford]	2·39	,,	Ennis	5·49
,,	Grantham, Stainby	2·21	,,	Miltown Malbay.........	6·60
,,	Horncastle, Bucknall ...	1·90	XXI.	Gorey, Courtown House	3·47
,,	Worksop, Hodsck Priory	1·74	,,	Mullingar, Belvedere...	3·74
VIII.	Neston, Hinderton	2·95	,,	Athlone, Twyford	4·48
,,	Knutsford, Heathside...	2·81	,,	Longford, Currygrane...	4·56
,,	Lancaster	...	XXII.	Galway, Queen's Coll...	5·72
,,	Broughton-in-Furness..	8·40	,,	Crossmolina, Enniscoe..	6·03
IX.	Ripon, Mickley	1·29	,,	Collooney, Markree Obs.	4·93
,,	Scarborough, WestBank	1·21	,,	Ballinamore, Lawderdale	4·83
,,	EastLayton[Darlington]	2·76	XXIII.	Lough Sheelin, Arley ..	4·59
,,	Middleton, Mickleton..	5·39	,,	Warrenpoint	4·04
X.	Haltwhistle, Unthank..	5·20	,,	Seaforde	2·94
,,	Bamburgh................	1·70	,,	Belfast, Springfield	2·91
,,	Newton Reigny	5·33	,,	Bushmills, Dundarave...	3·49
XI.	Llanfrechfa Grange	2·76	,,	Stewartstown	3·52
,,	Llandovery	5·08	,,	Buncrana	3·80
,,	Castle Malgwyn	2·48	,,	LoughSwilly, Carrablagh	4·76
,,	Builth, Abergwessin Vic.	5·24			

SEPTEMBER, 1892.

Div.		STATIONS. [The Roman numerals denote the division of the Annual Tables to which each station belongs.]	RAINFALL. Total Fall.	Difference from average 1880-9.	Greatest Fall in 24 hours. Dpth	Date	Days on which ·01 or more fell.	TEMPERATURE. Max. Deg.	Date	Min. Deg.	Date.	No. of Nights below 32°. In shade.	On grass.
			inches.	inches.	in.								
I.	ENGLAND.	London (Camden Square)	2·12	— ·39	·94	29	13	73·6	19	36·4	18	0	2
II.		Maidstone (Hunton Court)	2·01	— ·58	·57	21	13	...	...	...	...	...	...
,,		Strathfield Turgiss	2·76	+ ·31	·89	29	21	78·2	21	30·4	18	...	...
III.		Hitchin	2·83	+ ·33	1·13	21	12	70·0	13	37·0	17	0	...
,,		Winslow (Addington)	2·95	+ ·28	·75	29	13	72·0	13	33·0	18	0	1
IV.		Bury St. Edmunds (Westley)	3·86	+ 1·16	1·84	21	11	68·0	13	41·0	8	0	...
,,		Norwich (Cossey)	2·20	— ·46	·91	29	14	...	...	...	...	...	...
V.		Weymouth (Langton Herring)	2·61	+ ·19	1·04	29	11	68·0	10	44·0	8, 18	0	..
,,		Torquay, Babbacombe	2·12	— ·51	·73	29	13	70·5	10	36·5	18	0	1
,,		Bodmin (Fore Street)	3·21	— 1·26	·78	29	21	...	...	...	...	...	...
VI.		Stroud (Upfield)	2·66	- ·25	1·59	29	15	70·0	10	40·0	17*e*	0	...
,,		Church Stretton (Woolstaston)	2·96	+ ·46	1·10	20	24	65·0	1	39·0	18	0	...
,,		Tenbury (Orleton)	2·35	— ·26	·64	20	17	69·0	10	31·0	18	1	3
VII.		Leicester (Barkby)	2·03	— ·61	·59	20	17	72·0	13	32·0	7	1	1
,,		Boston	3·03	+ ·26	·85	20	15	70·0	6*b*	36·0	18	0	...
,,		Hesley Hall [Tickhill]	1·40	— ·76	·80	20	15	68·0	12*c*	37·0	18	0	...
VIII.		Manchester (Plymouth Grove)	3·62	+ ·15	·56	27	20	56·0	27	39·0	29	0	1
IX.		Wetherby (Ribston Hall)	·88	— 1·58	·33	30	7	...	...	...	...	...	..
,,		Skipton (Arncliffe)	5·89	+ 1·13	1·23	1	22	68·0	1	35·0	5	0	1
,,		Hull (Pearson Park)	1·34	— 1·10	.29	27	12	69·0	10*d*	39·0	4*f*	0	0
X.		Newcastle (Town Moor)	2·75	— ·03	·65	6	14	...	...	...	...	...	...
,,		Borrowdale (Seathwaite)	25·62	+13·89	5·80	18	23	...	...	...	...	...	...
XI.	WALES.	Cardiff (Ely)	4·60	+ ·86	1·55	29	17	..	...	...	...	...	...
,,		Haverfordwest	3·87	— ·53	·76	7	24	64·9	10	35·0	17	0	1
,,		Aberystwith, Gogerddan	4·85	+ ·58	1·05	30	20	66·0	10	35·0	17	0	...
,,		Llandudno	3·83	+ 1·61	·75	11	22	65·2	12	45·0	30	0	0
XII.	SCOTLAND.	Cargen [Dumfries]	4·34	+ ·78	1·08	1	20	64·4	10	34·0	22	0	...
,,		Jedburgh (Sunnyside)	2·57	— ·12	·41	27	18	65·0	4	30·0	22	1	...
XIV.		Old Cumnock	3·82	— ·01	·64	23	21	...	...	...	...	...	...
XV.		Lochgilphead (Kilmory)	7·49	+ 2·36	·94	12	24	...	...	32·0	20*g*	3	...
,,		Oban (Craigvarren)	11·60	...	2·33	12	25	62·9	6	36·9	22	0	0
,,		Mull (Quinish)	7·37	+ 2·34	1·15	17	25	..	...	...	...	...	...
XVI.		Loch Leven Sluices	2·40	— ·39	·40	13*a*	12	...	...	...	...	...	...
,,		Dundee (Eastern Necropolis)	1·45	— 1·06	·40	12	18	69·2	6	36·0	30	0	...
XVII.		Braemar	3·26	+ ·40	·90	26	17	61·0	6	22·5	21	3	9
,,		Aberdeen (Cranford)	1·91	...	·41	5	19	66·0	6	30·0	20*h*	3	...
XVIII.		Strome Ferry	9·45	+ 4·58	1·24	17	25	...	..	...	...	...	..
,,		Cawdor [Nairn]	2·82	+ ·07	·61	12	15	...	...	...	...	...	...
XIX.		Dunrobin	3·03	+ ·44	·59	30	18	65·0	6	35·0	30	0	...
,,		S. Ronaldsay (Roeberry)	2·69	+ ·03	·34	12	22	60·0	6	40·0	20*i*	0	...
XX.	IRELAND.	Darrynane Abbey	4·43	...	·86	7	21	...	...	...	...	...	...
,,		Waterford (Brook Lodge)	2·89	— ·03	·98	19	18	68·0	10	34·0	17	0	...
,,		O'Briensbridge (Ross)	4·88	...	·72	20	21	69·0	6	42·0	*j*	0	...
XXI.		Carlow (Browne's Hill)	2·88	+ ·06	·66	20	22	...	..	...	...	..	...
,,		Dublin (FitzWilliam Square)	2·63	+ ·66	·52	20	19	65·6	12	40·8	17	0	0
XXII.		Ballinasloe	4·76	+ 1·97	·79	1	25	65·0	14	41·0	28	0	0
,,		Clifden (Kylemore)	11·90	...	1·73	12	25	...	...	...	...	...	..
XXIII.		Waringstown	3·12	— ·04	·68	1	19	70·0	6	36·0	21	0	...
,,		Londonderry (Creggan Res.)	3·96	+ ·18	·56	26	25	...	...	...	...	..	...
,,		Omagh (Edenfel)	4·84	+ 1·46	·68	26	23	63·0	6	36·0	21	0	0

a And 18, 27. *b* And 12, 15. *c* And 13, 19. *d* And 13. *e* And 29. *f* And 5, 18. *g* And 21, 30. *h* And 21, 29. *i* And 29. *j* Various.

+Shows that the fall was above the average ; —that it was below it.

METEOROLOGICAL NOTES ON SEPTEMBER, 1892.

ABBREVIATIONS.—Bar. for Barometer; Ther. for Thermometer; Max. for Maximum; Min. for Minimum; T for Thunder; L for Lightning; T S for Thunderstorm; R for Rain; H for Hail. S for Snow.

ENGLAND.

STRATHFIELD TURGISS.—A changeable month, with a cold snap on the 18th, causing much damage. A heavy gale on 29th, with much R; T on 20th.

ADDINGTON.—Generally fine until the 18th, then unsettled until the end. On the 18th the min. on grass fell to 29°, and tender plants were killed. On the 20th, about 7 p.m., a severe TS, with heavy R occurred, a horse being killed by L at Winslow.

BURY ST. EDMUNDS, WESTLEY.—Fine weather for finishing the harvest till the 19th, very wet after. Very heavy R and H with T on 21st, and T was heard on 19th, 20th and 30th; S.W. wind on 14 days.

LANGTON HERRING.—On the whole a beautiful month, very favourable for finishing harvest operations. Mean temp. very near the average of 20 years. A fine solar halo seen on 12th; T and L on 20th and 21st; T on 28th. Total R for the nine months of the year, 4·38 below the average.

BABBACOMBE.—A cold, cloudy, rather showery month. A large excess of S.W. and deficiency of E winds, and a large daily and total range of temp. It was showery from 1st to 3rd, 7th to 9th, 12th to 16th, 20th to 25th and 27th to 30th, but no R was recorded in the 9 days, 3rd to 11th. Distant TSS on 20th and 21st.

BODMIN.—A seasonable, but mild month. Some very warm days. A large number of rainy days.

WOOLSTASTON.—A showery month, tedious for harvest, much grain remaining in the fields at the end. Mean temp. 53°·3. Large flocks of wild geese passed over about the middle of the month.

TENBURY, ORLETON.—A cold month, not at all suitable for the harvest. More than two thirds of the total R fell on three days, but the weather was generally damp, with very little warm sun. L on 2nd and 3rd.

BARKBY VICARAGE.—The first 19 days were excellent for completing the harvest, and water was very scarce during that time. Mean temp. 54°·2.

SEATHWAITE.—Falls of R exceeding one inch occurred on 8 days, exceeding two inches on 3 days, and exceeding five inches on the 1st and 18th Fall nearly twice the average.

WALES.

HAVERFORDWEST.—The bad weather of the last three days of August, continued more or less throughout this month, two consecutive dry days occurring only twice; consequently harvest operations were carried on with difficulty. About the 12th and 19th, exceedingly close relaxing air prevailed with high night temp. From the 27th to the end the weather was stormy and cold, as well as wet.

SCOTLAND.

CARGEN.—Another cold ungenial month; mean temp. 2°·5 below the average The temp. of the four months, June to September, has been considerably below the average, and this, combined with an excessive rainfall in June and August, and a great want of sunshine during the whole period, has been most detrimental to vegetation.

JEDBURGH.—The weather generally was unsettled, which retarded harvesting; most of the cereal crops were still in the fields at the close, and in the higher districts much was uncut.

OBAN, CRAIGVARREN.—The excessive and continual rains of this month, following upon the previous rainy months, have been most disastrous for all crops, except turnips, the corn being specially injured.

ABERDEEN, CRANFORD.—Westerly winds prevailed almost throughout the month. A TS occurred on 30th, lasting from 7.30 p.m. to 9 p.m.

ROEBERRY.—A very good month upon the whole; R nearly half an inch below the average of 25 years; temp. also below the average. Late harvest, commenced only on the 27th.

IRELAND.

DARRYNANE ABBEY.—A cold, ungenial wintry month.

WATERFORD BROOK LODGE.—Rainfall below the average, but the weather very broken for getting in the harvest. Mean temp. 54°.

O'BRIENSBRIDGE, ROSS.—A very unfavourable month for harvesting; R frequent and often heavy; temp. low. Many gales, mostly from S.W. H showers, with T on 26th and 28th.

DUBLIN.—The month was changeable throughout. High winds from westerly points prevailed; showers fell frequently, and at times the weather was decidedly cold for the time of year; this was particularly the case during the last four days. The mean temp. (53°·8) is 2°·0 below the average, and the max. was exactly 10° lower than that of September 1891.

EDENFEL.—A wet and unsettled month with but little intermission, and characterized by strong winds, amounting at times to gales, with heavy R and humid atmosphere. Two-thirds of the grain was still in the fields at the close.

BUTTERFLIES.

To the Editor of the Meteorological Magazine.

SIR,—I do not know what is the connection between Meteorological conditions and Entomological appearances. But the fact is, that this month of September there has been an unusual number of the Clouded Yellow butterfly (*Colias Edusa*) in this neighbourhood. A good many more males than females, which I suppose is characteristic of the species. Its last appearance here was in 1877.

I remember a similar plentiful appearance of a rare moth in the year 1846 at Drumlanrig Castle, Dumfrieshire. The *Sphinx Convolvuli*, "the Convolvulus Hawk-Moth." I saw it in great numbers, but I have never seen it since that time.—I am, yours truly,

JOHN MATHISON.

Addington, Sept. 20th, 1892.

IRISH WEATHER MAXIMS.

(Suggested by six weeks of rain, with generally high and steady barometer.)

Very high and rising fast:
Steady rain and sure to last.

Steady high after low:
Floods of rain, or hail, or snow.

Falling fast:
Fine at last!

Rapid fall after high:
Sun at last, and very dry.

Yours, PADDY.