demagnetization of the line-wire follows much more rapidly, the secondary current is more intense, and consequently these coils more often suffer.

When a circuit protected by the "lightning-bridge" is struck, the lightning finds in its direct path not a space of air, but a bridge of conducting particles in very close proximity to one another; it connects these under the influence of the discharge, and renders the particles highly incandescent. Incandescent matter, as already demonstrated, offers a very free passage to electricity, and the secondary current finds an easier passage across the heated matter than through the coils. These lightning-bridges have been in use more than four years; there are upwards of 1000 doing duty in this country alone, and not a single case has occurred of a coil being fused when protected by them.

Four years have elapsed since the introduction by the author of induced magnetic needles for needle telegraphs; there are some thousands of them now doing daily work. The coils of the old pattern are being converted into induced magnet coils, and it is probable that induced magnet coils will entirely supersede the so-called permanent magnets used in needle-telegraph instruments.

METEOROLOGY.

Rainfall—its Variation with Elevation of the Gauge. By CHARLES CHAMBERS, *F.R.S.*

The fact is well known to meteorologists that the quantities of rain received in gauges placed at different heights above the ground diminish as the elevation of the gauge increases. Several attempts have been made to explain this phenomenon, but none of them are so satisfactory as to discourage the search for other causes that may contribute substantially or mainly to its production. Hence the submission for the consideration of the British Association of this further attempt.

One of the principal causes of rain is undoubtedly the transfer, effected by winds, of air charged with moisture in a warm damp district to a colder region, where the vapour it contains is partially condensed. The temperature of the lower as well as of the higher horizontal strata of the atmosphere being reduced by this transfer, it may fairly be inferred that condensation of vapour may also occur in the lower as well as the higher strata. The rain caught by a gauge at any given elevation will therefore be the sum of the condensations in all the strata above it, and thus the lower a gauge be placed, the greater will be the quantity of rain received by it.

Again, it is known by observation that there is at all times a greater or less difference of electrical tension between the atmosphere and the surface of the ground. If, then (in accordance with the views of Prof. Andrews as to the continuity of the liquid and gaseous states of matter, from which it follows that the changes of other physical properties must also be continuous), we regard the particles of vapour suspended in the air as electric bodies in relation to the dielectric principal constituents of the atmosphere, they will be polarized by induction from the electricity of the ground. This polarization will give rise to an attraction between every particle and the neighbouring particles above and below it; and being stronger in the particles nearer the ground than in those more remote, the tendency of the particles to coalesce (which will increase, by their mutual induction, as two neighbours approach each other) will be greatest near the ground. Thus it may be (each particle gathering to itself its neighbours successively till their united density exceeds that of the atmosphere generally) that some rain-drops are formed, and that in greatest abundance, near the ground. If this be the true cause of any substantial part of the phenomenon in question, then as the variation of intensity of electrical polarization of the particles will vary with height most rapidly near the ground, so the variation in the rainfall near the ground should be more rapid than at a greater elevation; and such is, indeed, the fact. Also, if the idea be correct, it will probably serve to explain other phenomena which it was not specially conceived to meet; and so it does. For, first, it requires that the rainfall over even ground, where the electrical tension is relatively weak, should be less than over similarly situated forest-land, where, at the tops of the trees, ends of branches, and edges of leaves, the tension is high; and this is in accordance with observation. And secondly, the tension being relatively high at the tops of the elevations of a mountainous district, the rainfall should be greater there than in the neighbouring plains; this, again, is borne out by observation. Further, at the commencement of a passing thunder-storm, a sudden heavy shower of rain will often fall for a few moments, and then suddenly cease. May not this arise from the approach, by the agency of opposite wind-currents, of detached masses of oppositely charged clouds, the process, just described, of formation of rain-drops going on rapidly in each mass as the two come near each other, and stopping when, by a flash of lightning between them, the two masses are brought into the same electrical condition?

An experimental test of this idea would be to repeat Dalton's measures of the pressure of vapour in the vacuum space of a mercurial barometer-tube (filling that space with air and a little water), and compare the values found when the mercury was charged with electricity and when not so charged. If in the former case a less pressure was found, we might conclude that the particles of vapour are really susceptible of electric induction, and the amount of difference existing would enable us to estimate whether the attractions of the particles upon each other were strong enough to cause the formation of rain-drops hypothetically attributed to them above.

On a Scale for computing Humidity. By Professor J. D. EVERETT, *D.C.L.*

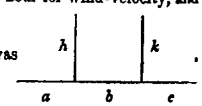
The scale in question is the invention of Mr. H. C. Russell, of Sydney Observatory. It consists of a sheet of paper ruled with vertical lines, each corresponding to a degree of the dry-bulb. These are traversed by a set of curved lines, each corresponding to a degree of humidity. A detached strip of paper divided into parts which correspond to every even tenth of a degree of difference between dry- and wet-bulb is applied (with its zero on the saturation-line) to the line representing the given dry-bulb temperature, and the curved line which cuts it at the division corresponding to the given difference indicates the resulting humidity.

The scale is based on Glaisher's Tables; and any other table of double entry might be represented by a scale constructed on the same plan. Interpolation is much easier with such a scale than with a table.

Barometric Predictions of Weather. By FRANCIS GALTON, *F.R.S.*

It is notorious that the movements of the barometric column corrrespond in some sense to the changes of the weather, and especially to those of the wind's velocity; but they certainly take no notice of the rapid and tumultuous changes of its velocity which are recorded by the jagged lines of a pressure-anemometer. They therefore correspond to mean values of the weather; but the way in which, and the period of time for which those means should be taken, has yet to be determined. Comparison was made between a curve formed on the principle that the ordinate of each point represented the mean velocity of the wind for half an hour previous to, and half an hour subsequent to the moment indicated by the abscissa of that point, and it was drawn on the same time-scale as the corresponding barogram; the velocity-scale was so adjusted as to allow about the same range in the diagram for the two curves, and the ordinates were measured from above downwards (were, in fact, negative ordinates), in order that the increase of wind should be indicated by a descending curve, to correspond with the descending barogram, and *vice versâ*. The curve so made was called a curve of 1-hour period av. wind vel., and similar curves were drawn for 3-hour, 6-hour, 12-hour, 16-hour periods, and some others. It was manifest, on comparing these with the barogram, that a period of 1 hour was far too short, for its curve showed many large irregularities, of which the barogram took no cognisance; a period of 3 hours was much better; of 6 hours better still; and the maximum of correspondence began at 12 hours, and ended at 16, beyond which time the wind-velocity curve was less irregular than the barogram. The correspondence was equally good at all periods, for which trial was made, between 12 and 16 hours, some parts agreeing better at the shorter, and others at the longer period. The former period is selected for discussion in this memoir. The data are derived from those of the continuous weather-records lately published by the Meteorological Committee for the first quarter of 1869, so far as they refer to Falmouth. The correspondence of the 12-hour period av. wind vel. curves for Falmouth, with the barogram, is fairly satisfactory. The flexures of the two curves are, on the whole, simultaneous, since neither curve habitually anticipates the other; but they are seldom absolutely simultaneous. They correspond in extreme positions as closely as in near ones, proving that it is not the absolute height of the barometer, but the variations in its height, which indicate changes of weather. The dominant influence of the wind-velocity upon the barometer was made manifest by underlining with different colours the epochs of polar and equatorial winds, and showing that the correspondence of the two curves was, on the whole, much the same, whatever might be the quality of the wind.

The reason of this correspondence of the barogram with a 12-hour av. vel. curve was then discussed, and was described as similar to that which causes a suitably constructed barometer, when plunged into troubled water, to sympathize, not solely with the height of wave exactly above its cistern, but also with that of every point in a surface area whose diameter is a function of the depth of immersion. So the barometer sympathizes with the condition of the air for some distance on all sides of it; and as there is a general easterly movement of the air over England, it appears that the diameter of the circle of air which affects the barometer is such as to require, on the average, 12 hours to pass over an observatory. A barometer would therefore be affected by an atmospheric wave of exceptional magnitude before it reached the observatory. According to this argument, the effects of the independent variables, temperature, and damp must be treated on the same system of 12-hour period of average as the wind's velocity. Consequently the following formula is easily deduced. Let h, k be two successive barometric heights, at an interval of 6 hours, a the 6-hour interval that precedes h, b the 6-hour interval between h and k, and c the 6-hour interval which succeeds k. Call v_a, t_a, d_a the 6-hourly average during the period a of wind-velocity, temperature, and vapour-tension, and use a similar notation for b and c. The units adopted were hundredths of an inch for barometer and vapour-tension miles per hour for wind-velocity, and degrees Fahr. for temperature. The general formula was



$$h-k=m(v_{a+b}-v_{b+c})+n(t_{a+b}-t_{b+c})+r(d_{a+b}-d_{b+c}).$$

The coefficient m was found $=-2$ by taking a number of selected equations in which neither t nor d had materially varied during the period discussed; n was found $=-1$ by taking the extreme range of the barometer under the influence of changed temperature alone, the other variables being constant; and d was assumed $=-1$ also, that is, it was taken at its real value, but with a negative ordinate; all the ordinates are negative, because v, t, and d all decrease as h increases. Now

$$v_{a+b}-v_{b+c}=\tfrac{1}{2}\{(v_a+v_b)-(v_b+v_c)\}=\tfrac{1}{2}(v_a-v_c),$$

and similarly for t and d, whence

$$h-k=(v_c-v_a)+\tfrac{1}{2}(t_c-t_a)+\tfrac{1}{2}(d_c-d_a), \text{ or}$$

$$v_c=(h-k)+v_a+\tfrac{1}{2}(t_a-t_c)+\tfrac{1}{2}(d_a-d_c).$$

It will be observed that v_b is necessarily eliminated. Comparison was made between the value of v_c as predicted by this equation with its value as ascertained by fact. About 100 cases of marked changes of weather were taken, and it appeared that the average error was one-third greater than if v_c had been predicted as simply equal to v_b. The reason why the average error is so large, notwithstanding the

general truth of the principle of prediction is, first, that correctness in the result depends on the correctness of all the elements of the formula, but their values are only mean values and cannot be relied on in individual cases; secondly, any error in the theoretical expectation of the value of v_{b+c} is, on the whole, doubled in the prediction of v_c, because the difference between what was expected of v_{b+c} and what was fulfilled in v_b, is heaped on to v_c, which has, therefore, to bear the entire error of expectation of v_{b+c}. It was concluded from this, and from other previous deductions from some years of Dublin observations, to which reference was made, that the fame of the barometer is due to its success in predicting a type of storm very rarely met with in the British Isles, but frequently in hurricane-latitudes, when the fall of the mercury far outstrips the increasing severity of the weather. In ordinary gales, and much more in ordinary weather, the author considered the barometer to be useless as a guide when consulted without a knowledge of what is occurring at adjacent stations—in short, without such information as is supplied by the 'Daily Weather Report.'

On the Temperature of the Air at 4 feet, 22 feet, and 50 feet above the Ground. By JAMES GLAISHER, *F.R.S., F.R.A.S.*

In the report to the British Association, for 1866, on the experiments made by means of balloon, I stated that the law of decrease of temperature with increase of elevation was variable throughout the day, and variable in different seasons of the year, that at about sunset the temperature was nearly the same up to 2000 feet, and that at night (from the only two night-ascents) the temperature of the air increased from the earth upwards. From this it was evident that, instead of only a few ascents being necessary, a much larger number were required than it was possible for me to make. Fortunately, in the second year of the balloon experiments, I planted at the Royal Observatory, Greenwich, a dry- and a wet-bulb thermometer at the height of 22 feet above the soil, readings of which have been taken daily since that time, at the hours of 9 A.M., Noon, 3 P.M. and 9 P.M. Sometimes readings at the higher point were above those at 4 feet from the ground; but no particular value was attached to this fact, until, on the observations made in M. Giffard's captive balloon being reduced, the results proved that the decrease of temperature with increase of elevation had a diurnal range, and was different at different hours of the day, the changes being greatest at about midday, and least at or about sunset (see Report for 1869), whilst sensible changes occurred within 30 feet of the earth. In consequence, the observations made at the height of 22 feet were reduced by taking the differences between the readings of the two thermometers, and affixing the sign plus (+) to that difference when the temperature was higher at the higher elevation, and the sign *minus* (−) when *vice versâ*. All the observations made in the years 1867–70 were treated in this way.

By selecting the greatest number with a + sign, and the greatest with a − sign in each month, it was found that in the *winter* months the temperature at 22 feet height ranged from 2 to 4 degrees above, and from 1 to 2 degrees below, that at 4 feet, and in the *summer* months from 4 to 5 degrees above to 5 or 6 degrees below that at 4 feet height, as will be seen by the following Table:—

		(+).	(−).
1867–70,	January	4·3	1·9
	February	2·6	1·5
	March	1·9	4·9
	April	4·2	5·5
	May	4·7	6·1
	June	4·1	6·6
	July	4·3	5·5
	August	5·2	6·1
1867–69,	September	4·0	4·8
	October	3·5	3·3
	November	4·8	2·6
	December	2·3	1·2