narrow limits, as regards their temperature. The deflexions of the isothermals near the Baltic, Mediterranean, Black, and Caspian Seas and the freshwater lakes of America all point to the disturbing influence of these sheets of water on the temperature.

The height and direction of mountain ranges is an important element in determining climate. If the ranges are perpendicular to the prevailing winds and of a considerable height, they drain the winds of much of their moisture, thus causing to places to leeward colder winters and hotter summers, by partially removing their protecting screen of vapour, and exposing them more completely to solar and terrestrial radiation. Of this Norway and Sweden and the British Islands form excellent illustrations. It is this that makes the most important distinctions among climates in regions near each other, as respects both animal and vegetable life. With regard to the decrease of temperature with height, very much yet remains to be done before an approximation to the law of decrease can be stated. During the five months observations were made on Ben Nevis in the summer of 1881 the difference between the mean temperature at sea-level adjoining and at the top of the Ben, 4406 feet above the sea, was 15°·7, which shows a mean decrease of 1° Fahr. for every 280 feet of elevation. The actual differences from day to day varied from 1°·4 to 23°·2. As Ben Nevis forms a peak, and is in the very middle of the strong winds from the Atlantic, it is highly probable that this rate of decrease is a close approximation to the true decrease of the temperature of the air during the summer months in that part of the British Islands. When observations are made on elevated plateaus of some extent, the rate of decrease deduced from the observations will be less than the true rate in the free atmosphere in summer and greater in winter. The rate is thus a variable quantity, varying with latitude, situation, dampness or dryness of the air, calm or windy weather, and particularly with the season of the year. One degree Fahrenheit for every 300 is the rate of decrease generally assumed.

Amount of Aqueous Vapour.—It is scarcely possible to overestimate the importance of a knowledge of the horizontal and vertical distribution in the atmosphere of its aqueous vapour, for it may be truly said that it forms one of the prime factors in all the larger problems of atmospheric physics. A first rough approximation to the geographical distribution of the vapour of the atmosphere was published by Mohn in 1875 in his *Grundzüge der Meteorologie*, p. 84, in which vapour-pressure curves are drawn for the globe for January and July. These leave much still to be done, not only in a further discussion of observations already made, but also in improvement of the methods of observation and in the tables for their reduction. The chief point of interest in Mohn's vapour curves is their striking resemblance to the isothermals of the same months, and they also suggest that this line of inquiry is yet destined to make large contributions to our knowledge of the unceasing changes which occur in the pressure, temperature, cloud, rain, and movements of the atmosphere.

Still less is known of the vertical distribution of aqueous vapour. It decreases, like temperature, with the height, and if the statement generally made be at all correct, that half of the whole vapour of the atmosphere is contained in the lowest 6000 feet, and that at 20,000 feet high there is only about a tenth of what is at the earth's surface, the rate of decrease with height proceeds at a greatly more rapid rate than is consistent with the supposition that it forms an independent vapour atmosphere existing under its own pressure. The establishment of an increased number of high-level stations, and a more systematic inquiry than has yet been attempted into the upper currents of the atmosphere, are much needed in the further development of this branch of meteorology. In carrying out the inquiry, invaluable assistance will be obtained from observations of the diurnal range of the barometer and from well-devised methods of observing the effects of solar radiation at the earth's surface.

Amount of Cloud.—In Scotland, which lies completely within the region swept by the south-westerly winds from the Atlantic, and presents a well-defined mountain range lying across the track of these winds, the clouds have a distinct annual period. In the west, at places quite open to these westerly breezes, the amounts of cloud in spring, summer, autumn, and winter are respectively 67, 69, 71, and 74, and the annual mean 70.[1] In the east, in such districts as East and Mid Lothian, which have extensive ranges of hills between them and the Atlantic, the proportions are 59, 63, 62, and 60, and the annual mean 61. Thus about a tenth more of the sky is covered with cloud at the western as compared with the eastern situations, and the distribution of cloud differs materially in western and eastern climates. In the west winter is the cloudiest season, but in the east it is summer, and these are respectively the months when most rain falls in the several climates. Everywhere spring is the season when the sky is clearest. In England, owing to the protection afforded by Ireland and Wales to the west and the comparative absence of ranges of hills, the amount of cloud is less than in Scotland, and it is more equally distributed over the country. The minimum amount occurs in spring, and the maximum in winter and autumn.

Some of the best illustrations of the seasonal variation in the distribution of cloud are afforded by the Old Continent. These variations are the simple consequence of the systems of wind caused by the high winter and low summer pressures of that continent. In eastern Siberia the prevailing winds in winter are N.W. or continental, and in summer S.E. or oceanic; and accordingly at Ajan, Nertchinsk, and Blagoweshtchensk the mean amounts of cloud in these two seasons are 18 and 44. On the other hand, in western Siberia and eastern Europe the prevailing winds in winter are S.W., or from lower to higher latitudes, and in summer N.W., or from higher to lower latitudes. Kazan may be taken as fairly representing this extensive region, and there the amounts of cloud for the four seasons beginning with winter are 71, 48, 44, and 62. As the N.W. winds of summer rise over the Ural mountains in their course, condensation of the aqueous vapour is increased, and hence over this region the cloud in winter and summer is nearly the same, the mean amounts at Bogoslovsk, Ekaterinburg, and Zlatoust being respectively 53 and 52. At Tiflis and Kutais, situated on the high ground which lies between the Black Sea and the south of the Caspian Sea, the means for winter and summer are 53 and 55. On the eastern coast of the Black Sea the westerly winds of summer are accompanied with the annual maximum cloud, the winter and summer amounts at Redut-Kale being 59 and 69. In Central Siberia, to which the S.W. winds of winter do not extend, and to the north of latitude 55°, the amount of cloud is much diminished, and the cloudiness of summer is nearly the same as that of winter.

In India, in all regions which lie open to the summer monsoon, the minimum amount of cloud occurs during the winter and the maximum in summer,—the mean amounts being 19 and 74 at Calcutta, 16 and 86 at Bombay, 48 and 71 at Colombo, and 25 and 90 at Rangoon. At Trincomalee, on the east coast of Ceylon, and thus exposed to the rains of the N.E. monsoon of winter, and largely protected from the rains of the S.W. monsoon of summer, the amounts of cloud in these seasons are 52 and 59. At Darjiling (6912 feet) and Chakrata (7022 feet high), both on the Himalayas, whither the summer monsoon penetrates, the mean amounts are respectively 53 and 86, and 43 and 73. At Leh, in Kashmir, the amounts are 59 and 51, the excess being thus in winter. In the Punjab and to westwards, or those regions in southern Asia to which the summer monsoon does not extend, the cloud in winter is everywhere greater than in summer. Thus the amounts are 24 and 18 at Mooltan, 38 and 25 at Peshawar, 27 and 19 at Jacobabad, and at Quetta, in Baluchistan, 5500 feet high, 42 and 14. Similar relations as to cloud obtain in Australia and the other continents where high pressures rule in the interior during the cold months and low pressures during the warm months of the year. The maximum cloud occurs with winds from the sea and winds advancing into the colder regions of higher latitudes, and the minimum with winds which have traversed an extensive track of land and winds advancing into the warmer regions of lower latitudes. As the subject, however, is essentially one with rainfall, it is not necessary to prosecute it further.

[1] In this section the amount of cloud is stated in percentages of the sky covered with cloud.

The other atmospheric movements on which the amount of cloud depends are the ascending and descending currents of the atmosphere,—the ascending currents with clouded skies occurring in the belt of calms and over cyclonic areas and regions, and the descending currents with comparatively clear skies over anticyclonic regions. The region of maximum vapour and densest cloud-screen on the globe is the equatorial belt of calms between the trades, which has an annual movement northward and southward with the sun as already explained. To ascensional movements is to be ascribed part of the cloudiness of the southern and eastern sides of the winter cyclonic regions of the North Atlantic and North Pacific, and of the cyclonic regions of low summer pressure in the interior of Asia and other continents. On the other hand the comparatively small amount of cloud in the anticyclonic regions of the Atlantic and Pacific Oceans, and in the high-pressure regions of the interior of Asia and other continents during the cold months of the year, is due to the vast down-currents which occupy the centres of the anticyclones, and which become relatively drier as they descend owing to the increasing pressure to which the air is subjected.

Distribution of Atmospheric Pressure.—The importance of a knowledge of the distribution of atmospheric pressure, or of the mass of the atmosphere, over the globe in its varying amounts from month to month is self-evident. Observations teach us that winds are simply the movements of the atmosphere that set in from where there is a surplus towards where there is a deficiency of air; and observations also teach that isobaric maps (*i.e.*, maps showing the relative distribution of mean pressure) and maps showing the prevailing winds are in accordance with each other. Since prevailing winds to a large extent determine the temperature and rainfall of the regions they traverse, isobaric maps may be considered as furnishing the key to the more important questions of meteorological inquiry. At the time of the first publication of isobaric maps of the globe in 1868, it was impossible to do more than present the subject in its broad general features, owing to the scantiness and quality of the materials then existing. But since then meteorological stations have been largely multiplied in all parts of the civilized world, and the general adoption of the issue of storm warnings has necessitated the use of more accurate barometers and uniform methods of observing. Since there is thus now the means of a more exact representation of this fundamental datum of meteorology, we have prepared a new set of isobaric maps, showing the distribution of the earth's atmosphere and the prevailing winds for January (fig. 14), July (fig. 17), and the year. They have been constructed from mean values calculated for the same eleven years (1870–80 inclusive) as the isothermal maps figs. 10 to 13, pressure of 30·0 inches and upwards being represented by solid lines, and of 29·9 inches and under by dotted lines, while the arrows show the directions of the prevailing winds at the localities indicated by the respective arrow-points.

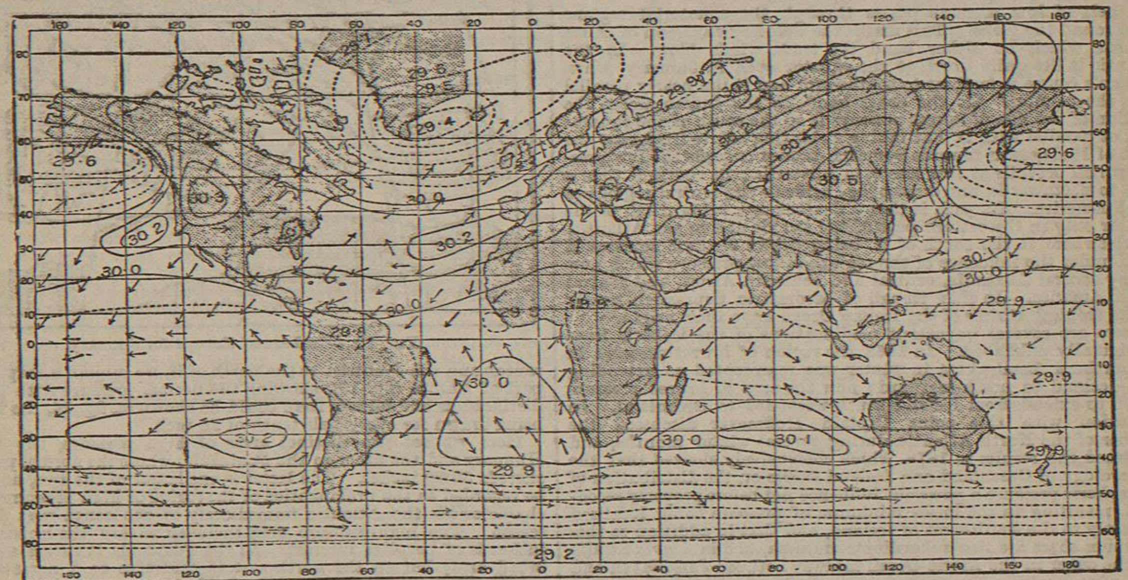

FIG. 14.—January Isobars of the Globe and Prevailing Winds.

Mean Atmospheric Pressure in January (fig. 14).—In this month, when the influence of the sun on the northern hemisphere falls to the minimum, the greatest pressures are massed over the continents of that hemisphere, and the least pressures over the northern parts of the Atlantic and Pacific Oceans, over the Antarctic Ocean and southern hemisphere generally. In the southern hemisphere there are three patches where pressure rises to 30 inches, viz., in the Atlantic between South America and Africa, south of the Indian Ocean, and in the Pacific between Australia and South America.

In the northern hemisphere, on the other hand, pressure rises in Central Asia to upwards of 30·5 inches, the mean pressure for January being at least 30·4 inches at Peking, Semipalatinsk, and Yenisei, and fully 30·5 inches at Irkutsk and Nertchinsk, in the upper basin of the Amur. This is the region where the normal atmospheric pressure attains to a maximum which is much higher than is reached in any other region or at any other time of the year. It will be observed that this region of highest pressure occupies a position near the centre of the largest continent. The area of high barometer is continued westward through Europe, through the horse latitudes of the Atlantic to Carolina, and thence through the United States to California, whence it crosses the Pacific to Asia. This belt of high pressure thus completely encircles the globe, broadening as it passes the land and contracting as it crosses the ocean. Its greatest breadth is over Asia and its least over the Pacific, or where land and ocean attain respectively their maximum dimensions.

Pressures greatly under the average cover the northern portions of the Pacific and Atlantic and also the greater part of the Arctic regions. In the north of the Pacific the normal pressure falls to about 29·6 inches between Kamchatka and Alaska. In the north of the Atlantic, however, a still lower mean pressure obtains over a narrow belt stretching from Iceland to the south of Greenland, the normal at Stykkisholm in the north-west of Iceland being 29·385 inches, and at Ivigtut in Greenland 29·361 inches. This low average for Ivigtut is the lowest normal known to occur anywhere and at any season in the northern hemisphere, and it is significant that the place is immediately to the north of that part of the Atlantic where a considerable number of the storms which sweep over Europe have their origin, and where not a few of the storms which cross the Atlantic from America develop intensity.

It has been seen that the highest mean pressure occurs near the centre of the largest extent of land; but as regards the two oceans the lowest pressure is met with in the northern division of the Atlantic, which is the lesser ocean. An inspection of fig. 14 shows, however, that the low-pressure area of the Atlantic is bounded to southward by systems of much higher pressures than are to be found in the Pacific. The result of this arrangement is that much stronger winds blow northward over the Atlantic and round upon Iceland; and, as these more quickly advance into colder latitudes, there is thus a greater and more frequent concentration of vapour and lowering of the barometer in the north of the Atlantic. The heavy rainfall of north-western Europe may be referred to as confirming this view.

A belt of low pressure passes through the equatorial regions quite round the globe. This marks the well-known region of calms towards which on either hand the trade winds blow. In the Atlantic it lies quite north of the equator even in January, when the sun's course is farthest to southward, and it lies nearly parallel with the equator. On the other hand, in the Indian Ocean the position of the line of lowest pressure is to the south of the equator and not parallel with it, but taking a slanting course from near the north of Madagascar towards Sumatra, thence towards the low pressure which prevails at this season in Australia; its course is then a little to northwards, and crosses the Pacific to the central regions of South America. Its path is thus a devious one, being north of the equator only in the eastern part of the Pacific and in the Atlantic, but elsewhere to the south of it, being drawn farthest southward when under the influence of the regions of low pressure which now occupy central Australia, central and southern Africa, and central South America. In this trough of barometric depression nearly all the tropical storms of the Indian Ocean have their origin.

There are several important modifications of the isobaric lines as originally published. In 1868 the region of lowest pressure in the northern hemisphere in winter was represented as extending from Iceland to north-eastward; now the area of lowest pressure is seen to extend from Iceland south-westward to Greenland. In connexion with this point Captain Hoffmeyer discussed the weather of the North Atlantic during several winter months, and published the results in 1878, which conclusively showed that the meteorology of Greenland and Iceland exerts on the distribution of atmospheric pressure a powerful influence not before properly recognized, resulting in the mean minimum of pressure being localized distinctly to the south-west of Iceland, and that in addition to this minimum there are two subordinate minima, one in Davis Straits and the other in the Arctic Ocean midway between Jan Mayen and the Lofoten Isles. The investigation further established the fact that, when any particular one of these three minima plays an important part, the other two either do not appear at all or occupy quite a subordinate place, and that according as one or other of these minima of pressure predominates so is the character of the weather, as regards mildness or severity, of the winter of north-western Europe and regions surrounding the North Atlantic. As regards the British Islands, the displacement of the minima to westward of the position shown in fig. 14 means milder winter weather, whereas a position more in the direction of the north of Norway means severer winter weather.

Another change implying important consequences is seen in the United States, where, instead of one, two distinct centres of maximum pressure occur, or rather the high pressure of the western and central States is separated from that of the south-eastern States by a region of lower pressure occupying the region of the Mississippi States. Professor Loomis first drew attention to this peculiarity in 1879 in an inquiry into the distribution of pressure over the United States, and established the fact that there are two distinct areas of high pressure, the larger having its centre in Utah, and the less overspreading the greater portion of the south-eastern and southern States, and that these two areas of high pressure are clearly separated from each other by a broad extensive region of lower pressure stretching in a south-western direction from the region of the great lakes to western Texas. The reason assigned by Professor Loomis is undoubtedly correct, that the relatively low normal pressure of the Mississippi States is due to the fact that the path usually taken by the barometric minima of American storms in the earlier part of their course is from Texas to the lakes. Since, on the other hand, the centres of comparatively few storms, with their low barometer readings, cross the southern and south-eastern States, the normal winter pressure is higher there than it is along the Mississippi.

Another important modification occurs in India, where the isobar of 30 inches is deflected to the south-east toward Madras and thence towards the north-east to near Akyab in Arakan. This remarkable deflexion well shows the important influence exerted on the course of the isobar by large well-defined sheets of water and extensive tracts of land. The distribution of pressure here indicated, by which south of lat. 22° the normal pressure is considerably higher in the east than in the west of India, has, through the agency of the winds resulting from it, the most intimate and vital bearings on the distribution of the winter rains and temperature over considerable portions of India; and the same relations hold, but in a degree still more striking, in the meteorology of Ceylon.

The remarkable effect in interrupting or changing the course of the isobars is particularly well illustrated by the lines in the region of the Aral, Caspian, and Black Seas. As the point is of no small importance in meteorology, and is best illustrated by the Mediterranean and the countries to the north of it, we subjoin a map of this part of Europe (fig. 15), showing the normal pressure with greater distinctness and fulness than could be shown on fig. 14, the isobars being drawn for every half-tenth of an inch.

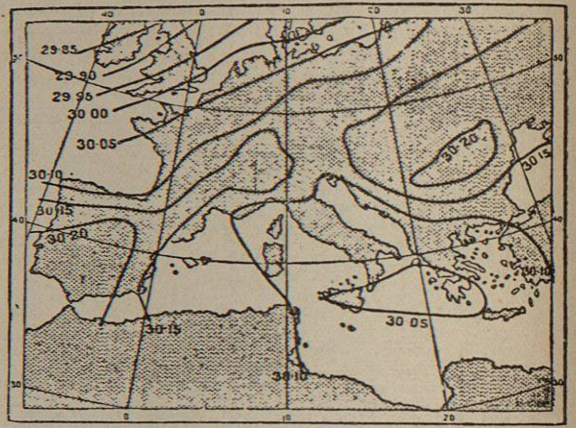

Fig. 15.—Isobars of Europe for January.

Here we see two distinct areas of high pressure, the one in Hungary and the other in the Peninsula, where the normal pressure exceeds 30·20 inches. The latter is the larger of the two, and may be regarded as the prolongation of the region of high pressure which characterizes the Atlantic immediately to the south-west at this season. The high-pressure area included within the isobar 30·15 inches is of peculiar interest. In the Peninsula it covers a pretty broad area, but to the north-east it contracts to a narrow neck between the Bay of Biscay and the Gulf of Lyons, and again expands to north-eastward covering the distance from Carlsruhe to Modena, its prolongation eastward being there somewhat suddenly interrupted. At some distance to the eastward the second region of high pressure is met with, which is properly a part of the high pressure that overspreads the interior of the Old Continent in the winter months, its western limit being the isobar of 30·15 inches, which passes round by Pinsk, Cracow, Vienna, Laibach and the upper southern slopes of the basin of the Danube, Sebastopol, and thence southward in the direction of Cyprus.

The position of the latter of these regions of high pressure is approximately midway between the south coasts of Asia Minor and the Baltic. In other words, its position occupies the interior of this part of the Old Continent; and it is instructive to note that the position of the Black Sea and the Greek archipelago in the south portion of this region pushes the isobar of 30·15 inches a good deal to northward. The position of the region of high pressure in the Peninsula, France, and Switzerland is also decidedly inland. It does not, however, exactly occupy the middle space of the land lying between the Mediterranean and the North Sea, owing no doubt to the circumstance that the very steep barometric gradient from France to Iceland greatly lowers the pressure over the whole of the northern half of France. It follows that the abnormally high pressure which so remarkably characterizes the interior of the Old Continent during the cold months of winter is represented, though in a greatly reduced form, westwards through the central districts of that continent.

These two regions of high pressure are separated from each other by a large area of comparatively low pressure overspreading the greater portion of the Mediterranean Sea,—marked off in fig. 15 by the isobar of 30·10 inches, within which pressure is everywhere less than 30·10 inches. This region includes an area of still lower pressure within the isobar of 30·05 inches, bounded by Sicily, Corfu, Athens, and Crete. Hence the singularly low pressure which characterizes the northern part of the Atlantic at this season has its analogue in the south of Europe, which is unquestionably due to the higher temperature and larger humidity of the climates of southern Europe which they owe to the Mediterranean.

It is deserving of special notice that, while the increase of the normal pressure of January from Genoa to Geneva is 0·081 inch, it is only 0·021 inch from Trieste to Riva, and that to the north of the Adriatic as far as latitude 50° pressure is considerably lower than obtains to the west and east of that region. An examination of the daily weather maps of Europe shows that not unfrequently the storms of north-western Europe on advancing as far to eastward as Denmark seem to connect themselves in some degree with Mediterranean storms prevailing at the time through a north and south prolongation of a system of low pressures. The comparative frequency with which this occurs is probably occasioned by the general drift to eastward of the atmosphere of Europe, considered as a whole, taken in connexion with the high mountainous ridge which bounds the Adriatic on its eastern side, from which it follows that the air overspreading the deep basin of the Adriatic is often highly saturated with vapour, and this highly saturated air is drawn northwards through central Europe when north-western storms of Europe with low barometric depression centres pass across Denmark and the Baltic. Thus the low normal pressure to the north of the Adriatic, separating the two regions of high pressure to the east and west of it, is in some respects analogous to the low normal pressure of the Mississippi valley, which separates the higher normal pressures of the Rocky Mountains and of the south-eastern of the United States.

The influence of land and water respectively in the cold season of the year is well shown in fig. 16, which represents for every 0·020 inch the normal pressure over the British Islands in January, drawn from means calculated for two hundred and ninety-five stations.[1]

It is in the winter months that the isobars of the British Islands crowd most closely together, and in accordance therewith strong winds are then most prevalent. The crowding of the isobars reaches the maximum in January, forming what is probably the steepest mean monthly barometric gradient that occurs at any season anywhere on the globe. The point, however, to which attention is here drawn is the remarkable influence of St George's Channel and the Irish Sea in diminishing the pressures as they cross these seas, and of the land in increasing the pressure, which is seen in the curves occupying approximately the central districts of Great Britain from the Isle of Wight to Cape Wrath. This shows on a comparatively small scale the influence of the land in

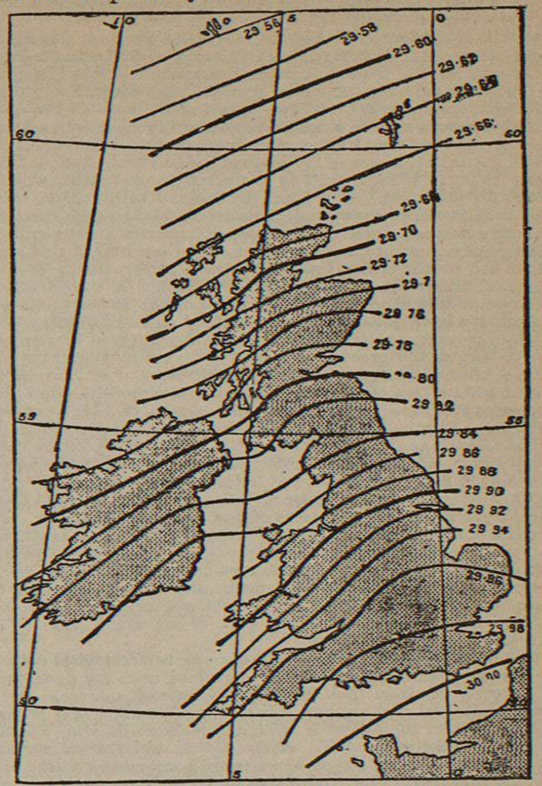

Fig. 16 —Isobars of the British Islands for January.

raising the normal pressure, and of the sea in lowering it, during the

Fig. 17.—July Isobars of the Globe and Prevailing Winds.

all months of the year, just as is seen on the grand scale in central Siberia and the north of the Atlantic.

[1] See *Journal of Scot. Meteorological Society*, vol. vi. pp. 4–21.

Mean Atmospheric Pressure in July (fig. 17).—In this month the physical conditions are the reverse of what obtains in January, the effects of the influence of the sun on the temperature and humidity of the atmosphere rising to the maximum in the northern and falling to the minimum in the southern hemisphere. With the solar conditions reversed, a comparison of figs. 14 and 17 shows that the distribution of atmospheric pressure in July is, considered in a broad sense, the reverse of what takes place in January.

In the southern hemisphere atmospheric pressure during the winter season is above the general average of 30 inches between lat. 10° and 40° S. This belt of high pressure encircles the globe, and embraces four regions where pressure rises considerably above this general high average. These regions are in South Africa, about lat. 20°, where it rises to a little above 30·20 inches; in Australia, where it rises on the Murray river very nearly to 30·20 inches; in South America, where in the basin of the La Plata, about lat. 30°, it rises to 30·13 inches; and in the ocean to westwards, where it reaches 30·02 inches. The point to be noted with respect to the position of these centres of high pressure at this season is that they occur over surfaces between latitudes 20° and 36°. As compared with January, pressure in July over nearly the whole of this broad belt of the southern hemisphere is about two-tenths of an inch higher, which is the simple result of season. A comparison of January and July shows that this large accession to the pressure of the southern hemisphere is accompanied by an extraordinary diminution of pressure over the continents of the northern hemisphere

Now, just as the greatest excess of pressure during the winter of the northern hemisphere occurs in the continent of Asia, so the greatest diminution of pressure in the summer months takes place in the same continent. The position, however, of these two extremes is far from being in the same region or even near each other. In the Old Continent the maximum occurs in the valley of the upper Amur, where, at Nertchinsk, the normal pressure in January is about 30·500 inches; whereas the lowest normal pressure in July is 29·412 inches, and occurs, so far as observation enables us to locate it, at Jacobabad on the west side of the basin of the Indus. The difference of these two normals is 1·188 inch; and over no inconsiderable portion of central Asia the normal pressure of July is an inch less than that of January. In other words, the influence of the sun in summer as exerted on the temperature and aqueous vapour of the atmosphere and atmospheric movements resulting therefrom is so powerful as to remove a thirtieth part of the whole mass of the air from this extensive region.

The large extension in recent years of good meteorological stations over the Russian and Indian empires enables us to lay down with much greater precision than formerly the lines of pressure. Of the changes indicated by the new isobars, the most important perhaps is the position of the region of minimum pressure in Asia, which is now seen to occupy the basin of the Indus, and thence stretches over a somewhat broad region to westward nearly as far as the head of the Persian Gulf. The point is of no small importance in atmospheric physics, inasmuch as it places the region of least normal pressure in July as close geographically to the region where at the time terrestrial temperature is highest as the region of highest normal pressure in January is situated with respect to the region where in that month terrestrial temperature is lowest in Asia.

The July isobars of India are of singular interest, and imply consequences of the utmost practical advantage to the empire. From Cutch southward the normal pressure is everywhere higher, and considerably so, along the whole of the west than it is in the east in the same latitudes, the difference being approximately half a tenth of an inch. This is represented on the map by the slanting of the isobars from north-west to south-east as they cross this part of India; and it is to be noted that the east and west coasts of Ceylon show the same manner of distribution of the pressure. The consequence of this peculiarity in the distribution of the pressure is that the summer monsoon blows more directly from the ocean over western and southern India than would have been the case if the isobars had lain due east and west, and thus probably precipitates in its course a more abundant rainfall over this part of the empire. But a more important consequence follows from the geographical distribution of the pressure over the valley of the Ganges. If the normal pressure there had diminished in the manner it does over India to the south of the Gangetic valley, the winds would have been south-westerly and the summer climate practically rainless. This, however, is not the case, but the normal pressure diminishes westwards along the valley of the Ganges, as the following mean July pressures will show:—Calcutta, 29·576 inches; Patna, 29·535 inches; Lucknow, 29·522 inches; Roorkee, 29·505 inches; and in crossing westward into the Punjab pressure falls still lower—to 29·439 inches at Mooltan and 29·412 inches at Jacobabad. Indeed pressure in July is 0·220 inches lower at Jacobabad than at Sibsagar on the Brahmaputra, nearly in the same latitude. It necessarily follows from this distribution of the pressure that the summer monsoon, which blows northward over the Bay of Bengal, is deflected into an E.S.E. wind which fills the whole valley of the Ganges, distributing on its way a most generous rainfall over that magnificent region.

The influence of the land in lowering the pressure in summer is well illustrated by the course of the isobars over western Siberia and Russia, where pressure is seen to fall relatively lowest along the middle line of the Old Continent. In this connexion it is interesting to note the course of the isobar of 29·90 inches over that part of Europe where the breadth of the land is considerably increased—between the Baltic and Constantinople. In contradistinction to this the influence of the Aral, Caspian, and Black Seas in maintaining a higher pressure appears in the remarkable prolongation eastward of the isobars of higher pressure over the region of these seas, being in striking contrast to the lower pressures which prevail to the north and south.

The lowering of the normal pressure is very decided in the inland regions of Spain, North Italy, and Scandinavia. The effect is most strongly seen in Spain, the largest and compactest of these regions. Thus, while the normal pressure diminishes between Lisbon and Barcelona from 30·086 to 30·048 inches, the sea-level pressure at Madrid falls nearly to 30·000, and the pressure at Saragossa and Valladolid is nearly as low. This lowering of the pressure over the interior influences materially its summer climate. As remarkable an illustration of the principle as can be pointed to anywhere is seen in the north of Italy; for, while the normal pressure at Moncalieri is 29·941 inches, at Genoa on the coast the relatively high normal of 29·992 inches is maintained, the distance of the two places being about 40 miles. To the east pressure rises to 29·970 inches at Venice, and to westward to 30·023 inches at Geneva. Over Scandinavia, along the west coast from the Arctic circle southward, the normal pressure equals or exceeds 29·80 inches, the variation being comparatively small; and along the coast from the head of the Gulf of Bothnia to the south-east of Sweden pressure also exceeds 29·80 inches, and the increase from north to south proceeds at a slow rate. In, however, the strictly inland districts to the north-east of Christiania, which lie immediately to the east of the Scandinavian mountains, and sheltered by that lofty range from the winds of the Atlantic, pressure is considerably lower than it is along the east and west coasts of the peninsula. Owing to this peculiar distribution of the pressure, the winds which necessarily result from it give a much finer summer climate to the south-east of Norway and to the strictly inland part of Sweden than would otherwise be the case.

The remarkable curving northward of the isobar of 29·80 inches so as to include Lapland within it points probably to the influence of the White Sea and the wonderful lake system of Lapland in maintaining a higher summer pressure over that country, by which the northerly winds that blow towards the low-pressure region of Central Asia, to the serious deterioration of the summer climate of northern Siberia, do not extend so far to westward as Lapland.

The distribution of the normal pressure over North America is quite analogous to what prevails over Asia, but, the continent being less, the diminution of pressure in the interior is also correspondingly less. The highest normal pressure, 30·077 inches, is found in the south-east in Florida, and the lowest, 29·780 inches, in Utah, the difference being thus 0·297 inch. Another region of relatively high pressure is in the north-western States and British Columbia to the north; the maximum, near the mouth of the Columbia river, reaches 30·062 inches, being thus nearly as high as what occurs in Florida. These two regions are merely extensions of important high-pressure areas which at this season are highly characteristic features of the meteorology of the North Pacific and North Atlantic respectively.

Of these two regions of high pressure the one overspreading the Atlantic between the United States and Africa is the more striking, being not only the region where pressure is highest anywhere on the globe during the months of June, July, and August, but where the normal pressure reaches the highest point attained at any season over the ocean. The highest point reached by the normal pressure over the land at any season occurs, as has been pointed out, near the centre of Asia, or approximately in the middle region of the largest continuous land surface on the globe during the coldest months of the year. On the other hand, the highest pressure over the ocean occurs during the warmest months of the year, and not over the largest water surface, but in the middle regions of the North Atlantic, where the breadth is only about half that of the water surface of the North Pacific.

From the essential differences between these two sets of phenomena it may be inferred that the extraordinarily high pressure which is so marked a feature of the meteorology of Central Asia during the cold months of the year is a direct consequence of the lowering of the temperature of the land of Asia and of the atmosphere resting on it during the time of the year when the effects of solar radiation are at the annual minimum, and of terrestrial radiation at the annual maximum. But the determination of the place and time of highest pressure over the ocean must be regarded as indirectly brought about. The physical conditions under which it occurs are these:—it happens (1) at the time of the year when the earth presents the largest surface of land to the sun, and (2) over that part of the ocean which is most completely surrounded by these highly heated land surfaces. This high summer pressure of the Atlantic has its origin in the upper currents of the atmosphere.

Mean Atmospheric Pressure for the Year.—The distribution of the annual atmospheric pressure may be considered as representing

the sums of the influences directly and indirectly at work throughout the year in increasing or diminishing the pressure of the atmosphere. There are two regions of high pressure, the one north and the other south of the equator, which pass completely round the globe as broad belts of high pressure. The belt of high pressure in the southern hemisphere lies nearly parallel to the equator, and is of nearly uniform breadth throughout; but the belt north of the equator has a very irregular outline, and shows great differences in its breadth and its inclination to the equator. These irregularities wholly depend on the peculiar distribution of land and water which obtains in the northern hemisphere.

These two zones of high pressure enclose between them the comparatively low pressure of the tropics, through the centre of which runs a narrower belt of still lower pressure, towards which the trade-winds on either hand blow. Considered in a broad sense, there are only three regions of low pressure, the equatorial one just referred to, and one round each pole bounded by or contained within the zones of high pressure just described. The most remarkable of these, so far as it is known, is the region of low pressure about the south pole, which remains low throughout the year, playing the principal rôle in the wind-systems of the Antarctic zone, in its heavy snowfall and rainfall, and in the enormous icebergs which form so striking a feature of the water of the Southern Ocean.

The depression around the north pole contains within its area two distinct centres of still lower pressure, the one filling the northern part of the Atlantic and the other that of the Pacific. Of these two the low-pressure area round Iceland is the deeper, and is probably occasioned by the steeper barometric gradients and stronger winds which prevail over the North Atlantic. The broad equatorial zone of low pressure also contains two distinct regions characterized by still lower pressures. The larger of the two stretches across southern Asia from Assam to the head of the Persian Gulf, and is entirely due to the very low pressures which form so marked a feature in the summer meteorology of that part of Asia. The regions of the middle Indus and upper Ganges occupy the centre of this low-pressure area, where normal pressure falls short of 29·80 inches. The second area of lowest equatorial pressure is in the centre of Africa.

It may be here pointed out that the whole of these areas of low mean annual pressure possess the common characteristic of an excessive amount of moisture in the atmosphere. The Arctic and Antarctic zones of low pressure, and the equatorial low-pressure zone generally, may be regarded as all but wholly occasioned by the comparatively large amount of vapour in their atmosphere. As regards the region of low pressure of southern Asia in summer, it is remarkable that, while the eastern half which overspreads the valley of the Ganges is characterized by a moist atmosphere and large rainfall, the western half of it is singularly dry and practically rainless, and that the central portion of this remarkable depression occupies a region where at the time the climate is one of the driest and hottest anywhere to be found on the globe. Hence, while the vapour is the more important of the disturbing influences at work in the atmosphere, the temperature also plays no inconspicuous part directly in destroying atmospheric equilibrium, from which result winds, storms, and many other atmospheric changes.

The Prevailing Winds of the Globe.—If atmospheric pressure were equal in all parts of the earth we should have the physical conditions of a stagnant atmosphere. Such, however, is not the case. Let there be produced a concentration of aqueous vapour over a particular region, or let one region show a higher temperature than what prevails around it, then from the different densities, and consequently different pressures thereby produced, the equilibrium of the atmosphere is destroyed, and, as might be expected from the laws of aerial fluids, movements of the air, or winds, set in to restore the equilibrium. Now every one of the isobaric maps we have given, as well as every isobaric map which has been made from recorded observations, indicates very considerable disturbance of the equilibrium at the surface of the earth. All observation shows that the prevailing winds of any region at any season of the year are simply the expression of the atmospheric movements which result from the disturbance of the equilibrium of the atmosphere indicated by the isobaric maps for that season and region.

All winds may be regarded as caused directly by differences of atmospheric pressure, just as the flow of rivers is caused by differences of level, the motion of the air and the motion of the water being both referable to gravitation. The wind blows from a region of higher towards a region of lower pressure,—in other words from where there is a surplus to where there is a deficiency of air; and this takes place whether the differences of pressure be measurable by the barometer, as is generally the case, or not readily measurable, as in the case of sea breezes, squalls, and sudden gusts of wind which are of short duration.

So far as is known, differences of atmospheric pressure, and consequently all winds, originate in changes occurring either in the temperature or the humidity of the air over restricted regions. Thus, if two regions contiguous to each other come to be of unequal temperature, the air of the warmer region, being specifically lighter, will ascend, and the heavier air of the colder region will flow in below to take its place. Of this class of winds the sea and land breezes are the best examples. Again, if the air of one region comes to be more highly charged with aqueous vapour than the air of surrounding regions, the air of the more humid region being lighter will ascend, while the heavier air of the drier regions will flow in below and take its place. Since part of the vapour will be condensed into cloud or rain as it ascends, heat is thereby disengaged, and the equilibrium still further disturbed. In this way originate gales, storms, tempests, hurricanes, and all the more violent commotions of the atmosphere, except some of the forms of the whirlwind, such as dust storms, in the production of which very great differences of temperature are more immediately and exclusively concerned.

The Trade-Winds.—From fig. 14, giving the isobarics for January, it is seen that atmospheric pressure in the Atlantic is lower near the equator than it is to north and south of it; and the arrows indicate that to the north of the tract of lowest pressure N.E. winds prevail and to the south of it S.E. winds. These are the well-known N.E. and S.E. trade-winds, which thus blow from regions of high pressure towards the tract of lower pressure situated midway between them. The trade-winds do not blow directly to where the lowest pressure is, but in a slanting direction at an angle of about half a degree. The deviation from the direct course is due to the influence of the rotation of the earth on its axis from west to east,—an influence to which all winds and all currents of the ocean are subject.

In virtue of this rotation, objects on the earth's surface at the equator are carried round towards the east at the rate of about 17 miles a minute. On receding from the equator, however, this rate of velocity is being continually diminished, so that at 60° N. lat. it is only about 8½ miles a minute, and at the poles nothing. From this it follows that a wind blowing along the earth's surface in the direction of the equator is constantly arriving at places which have a greater eastward velocity than itself. As the wind thus lags behind, these places come up, as it were, against it, the result being an east wind. Since, therefore, the wind north of the equator is under the influence of two forces—one, the low pressure near the equator, drawing it southwards, and the other, the rotation of the earth, deflecting it eastwards—it will, by the law of the composition of forces, take an intermediate direction, and blow from north-east. For the same reason, south of the equator the south is deflected into a south-east wind.

In the Atlantic the north trades prevail between latitudes 7° and 30° N., and the south trades between latitudes 3° N. and 25° S. These limits are not stationary, but follow the sun, being farthest to the south in February and to the north in August. The tract of low pressure between these wind systems is named the region of calms, owing to the calm weather which often prevails there, and it is also characterized by the frequent occurrence of heavy rains. This region of calms varies its position with that of the sun, reaching its most northern limit, lat. 11° N.,