U. S. DEPARTMENT OF AGRICULTURE,
WEATHER BUREAU.

Weather Forecasting and Weather Types

ON THE

NORTH PACIFIC SLOPE

BY

B. S. PAGUE, Local Forecast Official,

AND

S. M. BLANDFORD, Observer.

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PREFACE.

For the purpose of placing in a comprehensive form the subject of storm development and movement, and the methods of forecasting the weather on the Pacific Coast, this little pamphlet is published. It is believed that the method of presenting to the mind of the layman the subject by means of charts is the best. There are many false theories prevalent in the mind of the public concerning storms in general. A lucid explanation of excepted theory concerning the Pacific Coast weather is contained herein. Especial attention is invited to the explanation of "Chinook" winds on page 10.

Weather Forecasting in all portions of the globe is a difficult problem, but in no place is it more difficult than on the North Pacific Slope. Storm movements are, in some instances, regular, and again erratic; the regular movements only are here given.

The matter contained herein was prepared by Mr. B. S. Pague, Local Forecast Official, Weather Bureau, Portland, Oregon, who is the official Weather Forecaster for the Pacific Northwest; and by Mr. S. M. Blandford, Observer, Weather Bureau, who for five years has been an assistant at Portland, Oregon.

Portland, Oregon, *August 15, 1897.*

WEATHER FORECASTING.

By B. S. PAGUE.

When it is considered that more interests are directly affected by weather changes than by any other factor or condition, it appears strange that more attention is not paid by the people to the study of the weather.

Forecasts have been made by the unscientific and by the scientific, yet none that are made reach that degree of perfection that is desirable. That they are daily of more value and that their accuracy is steadily increasing, will not be denied, yet much study and investigation is necessary to make the improvements, both as to accuracy and length of time of the forecast that is desired. The old-time almanac contained forecasts of the weather which were relied upon by many, yet those forecasts were oftentimes based on less data than mere general averages.

Then there is the so-called "weather forecast" issued by various people, who claim them to be based on the position of various planets. These forecasts are manifestly inaccurate, vague, and misleading, and should one of the "planet" forecasts be verified, a great victory is claimed for the forecaster. These forecasts may have their value, but they have certainly not shown it. It is not the purpose of this paper to discuss the forecasts of people who, at the best, and under the most charitable construction, can be designated by the word "charlatan," yet the scientific investigations of the U. S. Weather Bureau and its forecasts issued are so at variance with those of the faker, that this touching of the subject was necessary.

It should be understood that the weather predictions of the government and other scientific bureaus, made for a day or two in advance, are simple in principle, depending upon well-recognized physical deductions, and partly upon analogical conclusions. There is no mystery either in the theory or practice of such predictions, and the more numerous the observing stations, and the longer the work is continued, the more accurate will become the predictions.

There are also methods of making predictions for a long time in advance which are scientifically justifiable, and upon which considerable reliance may be placed. When the climatic conditions of a place have been carefully recorded, let us say, for every month for a long time, it becomes possible to predict, with great probability of accuracy, that certain conditions will prevail in any subsequent month; that there will be so much rain, or snow, or so many windy days. Such predicting is merely asserting that the average will prevail. Again, from collateral observations extending over a sufficiently long time, certain ill-defined cycles sometimes appear in weather changes, and by making use of these a general prediction may be made for any future time. While such long-range predictions as these are perfectly legitimate, the data are yet insufficient to make them of much importance.

There are other weather prophets who pretend to predict for the future, for weeks and even months ahead, and profess to do so by specially, often personally discovered laws, or by methods not known, at least not appreciated, by scientific bureaus. This kind of prophecy is generally as baseless as the rain-making claim, and should be entitled to no more consideration. Any one who claims to have discovered definite laws in the changes of the weather is mistaken. Any one who claims to have discovered cycles in the weather changes from a few observations of any sort, is also mistaken. The whole class of long-range weather predictions professedly based upon the conjunction or opposition of planets, upon the eclipses of the sun, moon, or other celestial bodies, or upon the observed action of animal nature, are unworthy of attention. In general, it may be said that all weather predictions not based upon long, systematic, and extended observations of the weather, are unworthy of consideration, and when any one is found making predictions without such data, he is simply guessing.

The Weather Bureau issues general forecasts from Washington City, Chicago, Ill., San Francisco, Cal., and Portland, Oregon. The forecasts issued from the centers are for a distinct and well-defined territory, and for a stated and stipulated period of time ranging from 24 to 36 hours. Under well-defined conditions, forecasts are issued for a greater period, sometimes for as much as three and four days. Such forecasts are exceptional and are only issued under well-defined conditions. The word "forecast," as used by the Weather Bureau, means that the conditions are such as to indicate that the weather will be as is stated. The forecast is in no sense a prophecy, as that word is usually and technically understood. The Bureau issues forecasts based on the current weather conditions. By study, observation, and experience, the forecast official knows that usually certain conditions produce certain results. The deductions the forecaster prepares in plain, terse language, and they are then issued to the public.

Weather observations are made at 5 A. M. and 5 P. M., 120th meridian, or Pacific Coast time; as soon as made, these observations are prepared in cipher, for economy and accuracy, and are at once telegraphed to certain centers, all, however, going direct to the central office of the Bureau in Washington City. As soon as received at the various forecast offices, the reports are translated and charted, and the forecasts are deduced. The Weather Bureau forecasts are verified from 85 to 90 per centum—a degree of accuracy very commendable.

There is no section of the North American continent that is more interesting to study and that will be more fruitful for results than the North Pacific Coast region, extending to and including Alaska. A thorough understanding of the meteorological conditions of this region will tend to explain, to a great extent, the weather changes which affect the climatic conditions of the United States. It has been the privilege and pleasure of the writer to study the weather of the Pacific Slope for the past ten years, and the most marked characteristics, as understood by him, are here given for the benefit of those who may be interested.

There are but two well-defined or marked types of the weather on the Pacific Slope, which for convenience it has pleased the writer to term as Winter and Summer types. These two parent types have some sixteen modifications, yet there are distinct family resemblances in each. It is acknowledged that the food of a storm is heat and moisture—without them the storm loses energy and is dissipated. The storm, like an animal, seeks its food, to enable it to retain life or energy and to grow, where it may find it with as little trouble as possible. A storm, again like an animal, can contain only so much food; hence, when it has enough it moves; when the supply is too great it also moves. It has been found that storm areas center during the winter months along the Washington or Vancouver Island Coasts; with the advance of Summer and the increasing heat, they retreat to the North. The rotation of the earth gives all areas of high or low pressure an easterly movement; hence the storm area retreating from an over-supply of food passes during the Summer season eastward about the latitude of Sitka, Alaska; from thence it moves towards the Great Lakes, where it may obtain more food. This movement, in high latitudes, is called the Summer movement of areas of low pressure. With the passage of the summer season and the increasing cold of winter, the storm areas move southward again, seeking their food supply and obtaining it about the 50th degree north latitude, and 125th degree west longitude, or about Vancouver Island. Here it fattens, as it were, i. e., gains energy, and moves eastward, about the 50th degree north latitude, crossing the Rocky Mountains and passing into Alberta or Saskatchewan, thence to the Mississippi Valley. This is the Winter movement of the storm area, and is what is termed the Winter type of weather conditions on the Pacific Slope. These Winter conditions are shown in several forms, in Charts Nos. 1, 2, and 3, on the following pages.

The movements of the low or storm areas having been briefly described, according to the idea of the writer, the movements of the areas of high pressure will now be briefly outlined: Off the Southwestern Coast of California is an area of perpetual high pressure; apparently from this immense area of high pressure move smaller areas of high pressure in a northeasterly direction, to the California Coast, about Cape Mendocino, from whence they move in winter slightly to the north of east to Southern Idaho, where they become central, sometimes move, but usually dissipate. In summer these areas of high pressure move northward along the coast to about Vancouver Island, whence they move easterly, following closely the path of the winter lows, crossing the Rocky Mountains thence towards the Mississippi Valley. This latter is termed the Summer type of the weather conditions, and is shown in charts Nos. 4 and 5, on the following pages. There is another movement of high pressures, almost exclusively confined to the winter season. These winter highs move from the north of Alberta in a southerly direction, sometimes having a westerly overflow to the Pacific Slope, but more often moving toward the Mississippi Valley.

These highs from the North occasionally, in winter, join with the highs from the Pacific, in Northern Utah or Southern Idaho. Areas of low pressure rarely move south of the Central Oregon Coast; when they do, they usually develop into very severe storms when crossing Arizona and

New Mexico, coming into the influence of the moist air from the Gulf of Mexico. On December 20, 1895, the writer prepared a short sketch of the weather conditions of 1895, which was published in the Monthly Weather Review, the official publication of the U. S. Weather Bureau, in the November, 1895, issue. It is very appropriate to reproduce the sketch as it appeared in that publication.

WEATHER TYPES OF THE NORTH PACIFIC SLOPE.

There are two distinct, well-defined types of weather on the North Pacific Slope, viz., the Summer type and the Winter type. These are illustrated by the following sketch of the meteorology of 1895:

On April 20th, the first type of summer weather conditions appeared over the North Pacific Slope, viz., an area of high barometric pressure moving northward along the Coast to Northwestern Washington, and thence eastward over the State of Washington. In the synopsis of April 20th it was officially announced at Portland that the conditions which would prevail until the first appearance of a Winter type of weather would be more in favor of fair weather than of rain, for it had been observed that after the first appearance of a pure type of summer conditions there is seldom a recurrence of the Winter type until the autumn.

The spring, summer and autumn were unusually dry. This was especially true of the period from September 15 to November 1, which was the driest recorded in the history of this portion of the country during the past fifty years. Experience had shown that no general or continued rain would occur until the first appearance of the winter type of storms, and this knowledge was used in the daily forecasts issuing regularly from the Weather Bureau Office at Portland, Oregon. This winter type finally appeared on the morning of Tuesday, November 12.

On Monday morning, November 11, 1895, there was no appearance of any storm disturbance, but by noon of that day the rapid fall in the barometer indicated the approach of a well-defined disturbance, and from the evening reports of this date the approaching storm was forecast. The morning reports of November 12 showed that the storm area was central over Northwestern Washington and that the trough of the depression extended northeastward toward British Columbia, thereby indicating the probable path of the storm. Warnings of aproaching rains and high winds had been issued on the evening of November 11, or from twelve to twenty hours before the storm arrived. The morning reports of November 12 showed that an area of high barometer was approaching from the southwest toward California. General precipitation occurred over Washington, Oregon, and Idaho on the 12th and 13th, and heavy gales from the south and east prevailed along the coast of Northern Oregon and Washington.

The morning reports of November 13 showed that the low was now central north of Eastern Montana, and that the high pressure was moving inland over Southern Oregon and Northern California. The morning reports of November 14 showed the low area in about the same position, but more distinctly defined, and the high area central near the region where Oregon, Idaho, Nevada, and Utah come nearest together. The morning reports of the 15th showed the high over Oregon and Northern Nevada, and the low slightly east of its position of the previous day.

The feature to which attention is especially called is the passage of the low eastward over Washington and the formation of the area of high pressure. This movement of the low and formation of the high was the first of the kind to occur in the autumn of 1895, and indicated that the wet or winter season had set in over the North Pacific Slope.

The conditions under which areas of high pressure form and move are those under which Chinook winds are formed over the Northwestern portion of the United States. As the low pressure passes to the north and the movement of the wind is from the high on the south and southwest to the low on the northeast side of the mountains, therefore the air flowing down the mountain sides is dynamically heated.

That the high pressure produced the rise in the temperature and the wind called Chinook in the present case is shown by the following:

On the morning of November 12, the barometer at Portland was 29.86, the temperature 36°; on the morning of the 15th the barometer was 30.62, and the temperature 56°, a rise in pressure of 0.76 of an inch and a rise of 20° in the temperature. At Roseburg the rise in the barometer was 0.72 of an inch, and the temperature rose 16°; at Seattle the barometer rose 0.72 of an inch, and the temperature 16°; at Baker City the barometer rise 0.66 of an inch, and the temperature 12°; at Spokane the barometer rose 0.42 of an inch, and the temperature rose 26°; at Helena the barometer rose 0.20 of an inch, and the temperature 30°. Chinook winds occurred in Montana on November 16 and 17.

The following, from the November report of the Montana State Weather Service, may, in this connection, be of interest:

A cold wave signal having been ordered for that date (November 17), and the weather at the time of receipt of order being very warm and pleasant, the observer (Mr. R. M. Crawford, at Helena) decided to pay more than ordinary attention to the expected change. About 3:30 P. M., the wind, which had been blowing gently from the north, veering at times to the northeast, with a velocity of about 9 miles an hour, stiffened quickly and came directly from the north, lowering the temperature 6° in less than five minutes.

The indications were that the temperature would fall much lower, but suddenly dark, vaporous-looking clouds appeared in the extreme southwest; with them simultaneously a strong gale from the same quarter, blowing at the rate of at least 40 miles an hour. The gale seemed to meet the wind coming in from the north, and drove it in a whirl directly toward the northeast, across the prairie, in a funnel-shaped cone, plainly perceptible for a long distance by the dust gathered. The temperature quickly rose to 58°, the maximum recorded for this date, and the Chinook had mastered the cold wave.

Under some circumstances, a rise from 0.25 to 0.75 inch in pressure will produce colder weather, but under other conditions, such as those that prevailed on this occasion, a rise in pressure will produce a rise in temperature, or Chinook winds, over the northwest portions of the United States. The rise in temperature in the latter case, accompanying a rise in pressure, can only be ascribed to dynamic heating.

The following table, showing pressure and temperature at 8 A. M., 75th meridian time, from November 8 to 18, inclusive, at the regular Weather Bureau Stations, in the region now under consideration, illustrates the conditions prevailing during the first Chinook in the autumn of 1895:

Nov., 1895......	Portland.		Roseburg.		Seattle.		Baker City.		Spokane.		Helena.	
	Bar.......	Temp.....	Bar.......	Temp.....	Bar.......	Temp.....	Bar.......	Temp.....	Bar.......	Temp.....	Bar.......	Temp.....
8....	30.36	34	30.34	26	30.36	46	30.32	30	30.42	32	30.30	34
9....	30.16	34	30.18	32	30.10	42	30.26	26	30.26	32	30.30	28
10....	30.12	48	31.14	46	30.02	48	30.04	34	30.04	36	30.22	26
11....	30.36	36	30.30	36	30.32	40	30.22	32	30.32	30	30.28	28
12....	29.86	36	29.90	38	29.98	40	29.96	20	30.02	24	30.10	24
13....	30.34	44	30.40	36	30.26	40	30.34	20	30.30	32	30.12	34
14....	30.40	50	30.48	46	30.28	54	30.38	32	30.32	42	30.32	42
15....	30.62	56	30.62	52	30.50	56	30.62	32	30.44	50	30.30	54
16....	30.58	46	30.52	48	30.56	48	30.60	28	30.50	42	30.32	50
17....	30.32	44	30.30	42	30.26	48	30.38	32	30.18	40	30.08	44
18....	30.36	44	30.30	42	30.36	50	30.32	30	30.26	38	30.00	50

In the same issue of the Monthly Weather Review appeared the following:

LONG-RANGE FORECASTS IN OREGON.

The following extract from the weather synopsis and general forecast by Mr. B. S. Pague, Local Forecast Official at Portland, Or., was published on his morning weather map for November 12, 1895:

"The first storm of the season is shown on the map this morning. The conditions, as shown, are those peculiar to the winter season and represent the passage of the dry season and the appearance of the wet season. On April 20th last, the first type of summer, dry conditions, appeared.

"It was then stated that from this date, April 20th, the rain would be light and of a local, more than a general, nature. The conditions from April 20th to date show how well the remarks then made were verified. The phenomenal dry season, which has prevailed over the Pacific Northwest for the past six weeks, was due to the storm areas passing from the north, east of the Rocky Mountains, to the southeast, toward the Great Lakes; usually, the storm areas have this movement during the months from June to the middle of September, when they assume their winter course, and move southward along the coast line, striking land about Vancouver Island, then moving eastward, or at times move in other directions. The period of dry weather is now over; it is probable that short periods of fair weather may prevail, but it is not probable that any extended period of fair weather will again prevail until next spring. Since April 20th last, the conditions were more in favor of dry weather than of wet weather; from now on the reverse of this will be true.

"The precipitation over the Pacific Northwest, since January 1, has been about 30 per cent deficient, and it is reasonable to assume that for the remainder of the year there will be an excess."

(Note—By Editor of Monthly Weather Review).—The importance of long-range predictions, especially when based upon a broad study of atmospheric conditions over the whole globe, cannot be overestimated. The changes in the course of storm tracks may be spoken of as either the cause or the concomitant of changes in the weather and climate. In a narrow sense they are the cause, but in a broader sense they may often be considered as simply accompanying or correlated phenomena. The weather on the immediate coast of Oregon and Washington depends so largely upon what is called the general circulation of the atmosphere over the North and South Pacific Oceans that it may be reasonably hoped that the study of this latter subject will elucidate the matter and render these seasonal forecasts highly accurate and satisfactory.)

Long-range weather forecasts are only possible if made on the lines suggested by the Editor, Prof. Cleveland Abbe, of the Monthly Weather Review. It appears to the writer that no section of the country affords a more fruitful field for investigation than the Pacific Northwest to determine the laws governing storms, their development and movements. The investigation so far enables an accurate forecast to be made of winter and summer conditions, as has been shown on the preceding pages. With the extension of telegraphic communication to Alaska, and meteorological reports therefrom, a great advance will be made in the accuracy of all forecasts, and the length of time the forecast is for. A more thorough study may make it possible to determine in at least a general way the probable weather during the prevalence of the Winter and Summer types. These are results that are hoped for, and the writer expects to see realized.

The change from Summer, or dry, to Winter, or wet, conditions is heralded by a gradual weaker movement of the high areas to the 50th or 52d degree north latitude, and a more distinct southern deflection of the storm areas to those latitudes, until finally the energy of the highs becomes so reduced that they move northward and then eastward about the 40th degree north latitude, and the low area moves southward to about the 50th degree north latitude. The information can then be issued that the rainy season has commenced. A long period, i. e., three or more days, of rain is improbable until these conditions first appear, and then when the movements are reversed, the lows retreating to the north, and the highs moving northward to the 50th degree north latitude, then any rainy period in excess of three days is again improbable. These facts have been established and can be recorded as the first rules toward long-range forecasts.

In the Winter conditions, as has been before noted, areas of high pressure appear over Alberta and move southeastward to the Dakotas, thence toward the Great Lakes. In its southward movement it overflows the mountains to the west, when there is an area of low pressure central about the mouth of the Columbia River. Under these conditions cold weather and snow, changing to fair, cold weather over Washington, Oregon and Idaho, prevails, and then the low or storm area will sometimes move southeastward over California, and become a storm of great energy before it has spent its force. Chart No. 1, on the following pages, shows conditions mentioned above. An examination of Chart No. 1 will show what the writer terms the

"California dip" in the isobars 29.5 to 30.2, i. e., stretching to the southeast of the low, the isobars "dip" toward California and Nevada, and such a formation precedes general rain in California, and usually indicates the movement of the entire storm in the direction of the "dip." While Chart No. 1 shows typical rain conditions, yet it is not the common type of movements of winter low or storm areas which prevail. Conditions shown in Chart No. 1 produce temperatures much below the normal over Oregon and Washington. Charts Nos. 2 and 3 are the more common types of winter storms. Chart No. 2 is given so as to illustrate the conditions in which Chinook winds have their origin. The following description of Chinook winds, prepared by the writer, is here published, for the first time, by permission of the Chief of the Weather Bureau. The Chinook wind is known to all residents of the northwest portion of the United States, and few agree on the causes and origin of the wind. The writer feels that his explanation will stand the test of the most careful investigation, and that the ideas advanced will be accepted as the true explanation of this ever-welcome wind.

CHINOOK WINDS.

(Study Chart No. 2 in this connection.)

The term "Chinook wind" had its origin from the tribe of Chinook Indians (now almost extinct, but which was very strong and powerful some sixty to seventy-five years ago), that had its home in the southwestern portion of Washington, on the Columbia River. Local historians relate how the northwest wind in the winter season, being the harbinger of fair weather, was called by the trappers at Astoria "the wind from over Chinook camp."

As the trappers scattered to the east of the Cascades, they occasionally encountered a warm southerly wind which gradually assumed the name of Chinook wind. It was so named from its mildness, resembling to an extent the mild, balmy wind from over Chinook camp. As the trappers spread over the northwestern portion of the United States, the warm southerly wind of winter continued to be called by them "Chinook wind," until the term became common, and was finally accepted by meteorologists.

The term was first used, so far as research among the files of the Monthly Weather Review, published by the U. S. Meteorological Service, Washington, D. C., in connection with the warm, south, southwest, west, northwest and sometimes north, winds in Montana.

To the earlier extension of the military telegraph lines in Montana than in Washington and Oregon, is due the fact that the term Chinook was first applied to the warm winds of Montana. The operators or observers employed on these telegraph lines used the local common name applied to the wind by the stockmen in their reports. The name was thus first applied to the wind in Montana, and yet to a large extent some meteorologists are of the opinion that the Chinook winds are only east of the Rocky Mountains, and the name is erroneously applied to warm southerly winds in winter to the west of the Rocky Mountains.

As the term had its origin west of the Rocky Mountains, really to the west of the Cascades, the writer maintains that the term "Chinook wind" can be and is properly applied to the warm southerly winds of winter west of the Rocky and Cascade Mountains. The Chinook is more readily observed in Montana and to the north thereof, due to the preceding low temperature and the rapid and marked rise produced by the Chinook, though marked rises in temperature west of the Rocky and west of the Cascade Mountains are frequently observed. In the American Meteorological Journal, Vol. 3, p. 469, is to be found the following definition of a Chinook: "Warm, dry, westerly, or northerly winds, occurring on the eastern slopes of the mountains of the Northwest, beginning at any hour of the day, and continuing from a few hours to several days." This definition is perfectly correct so far as it goes; but the writer's idea of the definition of a Chinook is: A warm, dry, or moist wind from the southeast, south, or southwest, west of the Rocky Mountains, and from the southwest, west, or northwest, to the east of the Rocky Mountains, beginning at any hour of the day or night, and continuing from a few hours to several days. Such definition is more in accord with the causes which produce these warm winds and agrees with the original application of the term as understood by those who originated or created it.

Chinook winds, according to the writer's definition of the term, only occur under one kind of atmospheric condition, and without this condition Chinooks are impossible.

Preceding a Chinook, by from two to six days, an area of low barometric pressure is along the Washington or Oregon Coast, and an area of high barometric pressure overlies Montana and the British provinces to the north. This area of high pressure has low temperatures, from 10° to 20° below zero. The position of these two opposite atmospheric conditions produces north to east winds over Idaho, Washington, and Oregon, and the temperature decreases and snow falls to the east of the Cascades, extending over Idaho and Montana, and sometimes to the west of the Cascades. At the end of about three days the high pressure moves southeastward to the Northern Mississippi Valley, thence to the Great Lakes and on eastward. When the high pressure begins to move, the low pressure along the coast advances northward to about the 50th degree north latitude; thence along that parallel, or near to it, across British Columbia and Saskatchewan; thence towards the Great Lakes. Coincident with the northward movement of the low pressure along the coast, there appears along the Central California Coast an area of high pressure which rapidly increases in density and moves east and northeastward to Northeastern Nevada, Northern Utah, and Southern Idaho, where it becomes central by the time the low pressure is moving eastward over British Columbia. The low on the north and its passage eastward causes the air to move from the high, central about Salt Lake, to the low. These are the conditions from which a Chinook results.

Now, the elevation of the land where the high is central is much greater than that of the land where the low is crossing; secondly, the high barometric pressure indicates a greater mass of air extending upward from the earth to a much greater elevation than the air where the low pressure is located. Hence, in the movement of the air from the high to the low there is a great decline, and in making this descent the air is gradually compressed, and with the compression warmth is generated, in this way dynamically heating the air as it reaches the lower levels, giving the first warming effects of the Chinook. The meeting of the warmer air with the moist air of the low pressure causes condensation, and rain is the result. The passage of the area of low pressure eastward produces general precipitation, and, meeting the mountains, the moisture which the air contains is more rapidly condensed, and the greater portion or all of its moisture lost on the windward side of the mountains. the winds to the east of the mountains being warm and dry, and, due to the cyclonic movement of the air, are westerly and northerly. Moist air expands during its rise up the side of the mountain, and is then again compressed in its descent without having any heat added or withdrawn. Furthermore, if the expansion and subsequent compression takes place without the precipitation of moisture, the air will reach the same level on the leeward side of the mountain at the same temperature it had at the corresponding level on the windward side. When precipitation has occurred the air will reach the summit of the mountain at a higher temperature than the theoretical rate of decrease which elevation would assign to it, and in this changed condition the initial temperature will be reached at a pressure much lower than the initial pressure. Continuing in its descent, the original level will be reached with a higher temperature than at the starting point, and the air will be much drier, and these conditions will be more marked in proportion as the original mass of air is warm and moist or cold and dry. It will be thus seen that the definition of the Chinook as quoted is correct so far as it relates to the eastern side of the Rocky Mountains, but it is not at all applicable to the Chinook to the west of the Rocky Mountains.

Many persons, residents of the country affected by Chinook winds, are of the opinion that they come from the warmth of the Japan Gulf currents, but such is not the case. Chinooks are not warm winds from the ocean, but are formed, according to the writer's idea, in the manner outlined above.

In the November, 1895, Monthly Weather Review, p. 148, the following by the writer hereof appeared, which in this connection may be of interest and value, for a new thought is advanced relative to the comparative mildness of the winter temperatures over Washington and Oregon:

"It is not, as I understand, admitted by all that Chinook winds occur west of the Cascades. From my knowledge of conditions over the Pacific Northwest, I maintain that perfect forms of Chinooks occur west of the Cascades and Rocky Mountains. The degree of moisture in the Chinook winds varies with the conditions and the country over which they blow (at Walla Walla, Wash., for example, sometimes the very dry Chinook occurs, which causes the snow to disappear without leaving any water behind it); again, under another Chinook the snow is melted and little evaporation takes place. The explanation of this is as follows: In the first case, there is little or no movement of the upper currents from off the ocean, hence the expansion and heating of the air will allow dry air to be brought into contact with the snow which evaporates as it melts. In the second case, there is a decided movement of air from the ocean inland, and the dryness of the Chinook is overcome by the vastness of the supply of moist air. The Rocky Mountains bar the moist air, and, therefore, to the east of the Rockies the dry Chinook usually prevails.

"From November to March the mean temperature over Washington and Oregon is materially higher than it is to the east of the Rocky Mountains over the country having the same latitude. This mild winter temperature is generally ascribed to the proximity of the ocean, and to the Japan current. While the ocean does modify the otherwise low temperature, yet the mean temperature is as much or more influenced by the dynamic heating of the air of Chinook winds. If, during the winter season, the low is off the California Coast, the cold air on the northeast flows southwestward and gives the low temperatures over Washington and Oregon; if the low is passing eastward over British Columbia, and a high is central about Salt Lake City, then the dynamic heating, or Chinook wind, prevails, and high temperature occurs.

"In these two instances the oceanic influence is only indirect. Comparatively high temperatures also occur in connection with lows moving from off the California Coast northward along the Oregon and Washington Coasts, gradually extending inland; in this latter case the oceanic influence on the mean temperature is of direct effect.

"Low mean temperatures occur from November to March, when the lows are frequent and move southward along the Coast to the Columbia River or farther south (they seldom move much to the south of the Columbia). Mean temperatures above the normal occur when the lows pass eastward at a high latitude, about British Columbia. In the latter case the Chinook or dynamic heating prevails."

WINTER CONDITIONS.

Chart No. 3 is a typical one of the conditions which prevail in winter. It is a beautiful illustration of the successive movements of storm areas, while the high pressure remains central over Northern Utah and evidently fed from the permanent high off the Southwest California Coast.

THUNDER STORMS.

Chart No. 4 is an illustration of the conditions as they prevail when thunder storms occur over Oregon, Washington, and Idaho, or over portions of these States. Conditions which produce thunder storms, as a rule, originate in the heated valleys of California, whence the storms move northeastward to Southeastern Oregon, where their energy is fully developed and thunder storms result. Under these conditions high pressures are present over Northwestern Washington and thunder storms are more usual on the west and northwest side of the areas of low pressure than upon any other side of the lows.

SUMMER CONDITIONS.

Chart No. 5 is an excellent illustration of the summer conditions over the Pacific Northwest. The area of low pressure is shown to be central over Manitoba, and evidently moved from the ocean eastward about the 57th degree north latitude, and southeastward over Alberta to its present position; it is now a dry low, but may develop moisture when coming within the influence of the humid atmosphere from the Great Lakes.

The high pressure moved northward along the California and Oregon Coasts; when it was central off the Northern California Coast, cloudy and foggy weather prevailed over the western portion of Oregon and Washington, with slightly lower temperatures and scattered showers. When the high became central over Northwestern Washington, then the clouds and fog were dissipated, and clear, balmy, ideal weather prevailed; with the movement of the high eastward the temperatures increased, and when it was central to the north and northeast of Northeastern Washington, very warm weather prevailed. The hot, dry winds which occasionally damage the grain crop of Eastern Washington and Eastern Oregon occur when the high is in the position last mentioned. The high crosses the Rocky Mountains, and another high appears off the California Coast. It requires from five to seven days for the high to appear, make its north and then eastward movement, and to cross the Rocky Mountains. These facts being known, the writer has been very successful in making forecasts covering periods of about one week. Such forecasts were made for Washington, Oregon, and Idaho during the summer season of 1895 and 1896, and the result warrants further efforts in this line.

THE WEATHER MAPS.

The Weather Maps issued from the U. S. Weather Bureau Station in Portland, Or., present an outline map of the United States from the Great Lakes westward, and of the British Possessions to the north of the western portion of the United States, showing the stations where weather observations are taken daily at 8 A. M. and 8 P. M., seventy-fifth meridian time (5 A. M. and 5 P. M., 120th meridian time, and telegraphed to Washington, Portland, Seattle, and other cities. These observations consist of readings of the barometer, thermometer (wet and dry), direction and velocity of wind, state of sky (whether cloudy or otherwise), and amount of rain or snow. Solid lines, called isobars, are drawn through points having the same pressure; a separate line being drawn for each difference of one-tenth of an inch in the height of the barometer. Dotted lines, called isotherms, connecting places having the same temperature, are drawn for each ten degrees of the thermometer. Heavy dotted lines, inclosing areas where a great change in temperature has occurred within the last twenty-four hours, are sometimes added. The direction of the wind is indicated by an arrow flying with the wind, or opposite to the ordinary vane. Shaded areas show where rain or snow has been falling since the last observation.

The general movement of storms is from west to east, with the trend of the atmosphere, which moves in a series of atmospheric waves, the crests of which are designated on the maps "highs" and the troughs or depressions "lows." The storms affecting the weather on the North Pacific Coast, as a rule, come from the north. The winds blow spirally inward into a storm and spirally outward from an area of high pressure; hence, when the storm area is in the north, the winds come from the south, and as the storm area moves eastward the winds veer to the westward.

There are two distinct types of weather on the North Pacific Coast, for convenience called the Summer and Winter types. As the heat of summer increases, the storm areas retreat to the north, and are carried eastward about the latitude of Sitka, Alaska; once east of the chain of mountains, they do not again materially affect the weather to the west, but move southeastward toward the Great Lakes, and thence across New England or down the St. Lawrence Valley into the Atlantic Ocean. As these storm areas retreat to the northward, the rains over the Pacific Northwest decrease, until finally, during midsummer, almost absolute dryness prevails. Occasional showers prevail in summer, sometimes from the influence of the lows passing to the eastward of the Rocky Mountains, their influence extending to the westward; more frequently, however, the occasional summer showers occur from thunder storms. These storms are quite rare on the Pacific Northwest, and when they occur are, as a rule, produced from a low passing to the northeast from the Central California Valleys toward Northern Idaho. The thunder storms usually occur on the west, northwest, and north of these lows. As the heat of summer decreases, the path of the lows gradually moves southerly until, by the 1st of November, it follows the course of the Japan current to Vancouver Island, whence the storms pass eastward, following quite closely the international boundary line, until the eastern side of the Rocky Mountains is reached, when their course is southeastward toward the Great Lakes. With the southern deflection of the storm movements, the rains increase in amount and frequency. The greater portion of the rains is deposited on the western side of the Coast Range of mountains; and about two-thirds as much is deposited between the Coast and Cascade Ranges. In the passage of the storm area over the Cascade Range, the air is forced to such a height, and so much of its moisture is lost by this action, that but a small percentage remains to be deposited on the eastern side of the Cascade Mountains.

The Summer type of weather consists of areas of high pressure moving northward along the Coast line from Cape Mendocino to Vancouver Island; thence they move eastward, following closely the path of the low pressures in winter. With the approach of high pressures the temperature decreases, the cloudiness over Washington and Oregon increases, and occasionally rain falls west of the Cascades; fog results west of the Cascades when the center of high pressure is about the mouth of the Columbia River. The cloudiness decreases when the center of the high is over Puget Sound, and when the center crosses the Cascade Mountains the weather becomes clear and the temperature rises. The highest temperatures occur when the center of the high has passed and is to the northeast of Spokane. When the high pressure first appears off Cape Mendocino, cooler weather may be expected for two days, then one day of stationary temperature, then two or three days of warmer weather.

In the winter season these highs pass eastward over Southern Oregon and become central about the Great Salt Lake; due to their influence, higher temperatures prevail to the north, northwest, and northeast, especially during, or after, the passage eastward of a storm area in the path above mentioned.

Areas of high pressure also move southerly from the Arctic Region to the north of Montana. During the winter season these high-pressure areas frequently retard the eastern movement of the storm areas from Vancouver Island or the Washington Coast, and then result several days of rain west of the Cascades, and sometimes snow to the east of them. When the high pressure area is sufficiently large and dense, and the temperatures low, the storm areas are forced south of the Columbia River; the cold air flows from the northeast, and then results heavy snow to east of the Cascades, and occasionally to the west of them. During the winter season the lows follow each other in quick succession; gales prevail along the coast, and general rain results. In the spring, after the first movement of high pressure from off the California Coast northward to Vancouver Island, thence eastward, the winter season or type of storm is at an end. In the autumn, after the first winter type of storm appears, the summer types cease.

SENSIBLE TEMPERATURES.

EFFECT OF HEAT ON THE BODY IN OREGON.

By B. S. Pague.

Much has been said and written of the climate of Oregon, of its lack of sunshine, its rainfall, its temperature and of all phases of the weather, but seldom is anything said of the physiological effect of the heat in Oregon. It is well known that on account of its long sea coast, its mountain ranges and its great plateau region, that within the boundaries of the State may be found any climate that may be desired, save that of the semi-tropical or tropical type. The snow-capped mountains and higher mountain regions have temperatures equal to the Arctic region, the plateau the climate of Minnesota and Canada, the valleys that delightful climate peculiar to Virginia or France. The greater portion of the State has a pleasant mean temperature, while the immediate coast has a climate free from heat and free from cold.

Throughout the great valley of the Columbia, over the greater portion of the plateau region and in the Rogue River Valley, maximum temperatures of from 100° to 108° are recorded during the heat of summer. These high temperatures would be sufficient to produce heat prostration and sunstroke, were it not for the safeguards which nature has provided. Temperatures of from 85° to 95° are recorded every summer in the great Willamette Valley, and in the Umpqua Valley—these two valleys, together with the Rogue River Valley, comprise what is called Western Oregon, excluding the coast region. Facetious remarks are often made that "it rains 13 mouths in the year in Oregon." The name applied to Oregonians is "Webfeet." The section of the United States having the greatest cloudiness is the northwestern portion of the United States, decreasing over Western Oregon, while over Eastern Washington and more especially over Eastern Oregon the cloudiness is not so great as over the thickly settled portion of the country surrounding the Great Lakes, the Atlantic and Gulf Coast States. These data are here inserted to enable an explanation to be made concerning the rainfall and cloudiness before going into the main subject of this paper. The sunshine at Portland, which is less than that which prevails over the great valleys between the Coast and Cascade Ranges, averages 35 per centum of the possible. In summer the actual sunshine ranges as high as 65 per cent. of the possible, while in winter it decreases to as low as 15 per cent. of the possible. This is less sunshine than that which prevails over the greater portion of the United States. As vegetation has naturally but little growth during the winter months, the absence of sunshine is practically no detriment, while in the spring, summer and autumn, during the growing and ripening season, the sunshine is fully sufficient for all needs, whether for growth, physical comfort or pleasure. The rainfall is not excessive in the great valleys, for it is less than 50 inches annually. Along the immediate coast, excessive precipitation, i. e., 65 inches or more, occurs almost annually. The rainy period might be so called from October 15 to March 15. From March 15 to June 15, and from September 15 to October 15, showers prevail. From June 15 to September 15, the real summer or dry season, showers are rare. Hence it is seen that the facetious remark and the sobriquet are both in error. From October 15 to March 15, a period of 150 days, rain falls on an average on from 90 to 100 days; so that, even during the mid-rainy season, the number of days on which rain falls is not markedly excessive. However, sufficient in this connection to state that the death rate in Oregon is the smallest of any State in the Union, crops always mature and are very prolific, hence the climate cannot certainly be said to be injurious, but rather it is on the whole one of the most pleasant and delightful that can be found anywhere in the whole country, and, considering all things, few climates in the world equal it for its many pleasant and advantageous features. With this digression, the real subject of this paper can now be more intelligently discussed.

The temperatures noted are those from the United States Weather Bureau records, and show the temperature of the air, the thermometer being in the shade, exposed in a standard thermometer shelter. The reason that there are fewer injurious effects from the high temperature is that, while the degree of heat noted is that which is actually recorded, due to causes which will be explained, the temperature affecting animal and vegetable life may be less.

The temperature of living bodies is influenced by temperature of air, its moisture and its rate of movement; living bodies differing, as a rule, from inorganic masses, in that the former exude constantly a more or less variable amount of moisture to be evaporated, and thereby introduce a factor in cooling not found normally in the latter class of bodies, i. e., evaporation.

By sensible temperature is meant that which is felt at the surface of the skin. The body, when in a healthy state, is constantly furnishing moisture to the skin, which stands in drops, or, as they are called, "beads of perspiration." This moisture is evaporated by the air. The cooling effect of the evaporation is the safeguard against injurious effects by extreme heat. When water is changed from the liquid to the vapor condition, a certain quantity of heat is utilized, which during the evaporation is changed into latent heat, and is no longer sensible. A feeling of coldness therefore results from the change, and as long as evaporation continues, the surface where it takes place is cooler than the general temperature of the surrounding air. When one is heated, a fan is used to give relief and make one more comfortable. The motion of the fan causes a more rapid movement of the air; this air moved by the fan against the face has the same temperature as that which is not disturbed. The cooling effect comes from the more rapid evaporation of moisture from the face and exposed portions of the body, and from the increased convectional loss of heat caused by the more rapid movement of the air. This lower temperature, felt by the face under the influence of the fanning, is the sensible temperature.

Inasmuch as the temperature of the wet bulb thermometer is that of an evaporating surface, influenced by the prevalent meteorological conditions, in some instances, especially when the atmospheric temperature is very high and the effusion of perspiration consequently great, the sensible temperature will in all probability be less than that of the air, and greater than that of the wet bulb thermometer. Perhaps midway between would be as fair an approximation as could be made in the present state of our climatologic knowledge. For that reason it will perhaps assist our appreciation of climatic features of every region to consider the temperature of the wet bulb thermometer in connection with that of the air thermometer. The following statement of average air and wet bulb thermometer readings is given for Portland, Oregon, for the months of June to September inclusive, from readings made during the greatest heat of the day. The data are based on 10 years' records:

Months.	1890.		1891.		1892.		1893.		1894.		1895.		1896.	
	Air........	Wet Thermometer.	Air........	Wet Thermometer.	Air........	Wet Thermometer.	Air........	Wet Thermometer.	Air........	Wet Thermometer.	Air........	Wet Thermometer.	Air........	Wet Thermometer.
June	69	59	66	56	70	57	63	54	63	55	70	57	69	56
July	75	61	78	63	73	59	74	60	77	62	74	59	80	63
August	76	63	80	65	77	62	76	61	79	64	75	60	73	62
September	73	59	67	58	70	60	62	56	66	56	63	53	69	57

In this table it is seen that the wet thermometer temperature is on an average about 14° lower than the air temperature; while on the day of extreme high temperature mentioned the difference was 33°, and this difference is dependent upon the amount of moisture in the air. If the air were as moist as that found in the region of the Great Lakes, and along the Atlantic seaboard, and the temperature as high as it now is at times, the effect of the heat might be injurious.

Sunstrokes are produced by heat. The normal temperature of a healthy person is 98.4°; if it rises above 99.5° or sinks below 97.3°, some form of disease in indicated. If a person is shown to have a temperature of 106°, the prognosis is unfavorable, and 110° is almost certain to be fatal. Hence it can be seen that evaporation is absolutely necessary to cool the body during periods of very high temperature, else the blood becomes heated and death ensues. The physiological and social conditions favorable to sunstroke are, anxiety, worry, overwork, irregularities in food, overcrowding and bad ventilation, and, to a marked degree, intemperance. One using beer, whiskey, or other blood-heating drinks, is much more predisposed to sunstroke than one using pure water. Personal uncleanliness, which, among other things, prevents the healthy action of the skin; tight garments, which impede the functions alike of the heart and lungs, and living in overcrowded and unsanitary dwellings, have an equally hurtful tendency. To overcome the unpleasant and debilitating effects of heat, as much as possible, it is necessary to keep a clean, healthy skin, to avoid alcoholic drinks, and to have pure food and pure air. To obtain the beneficial effects of the reduction of temperature by evaporation, the shade must be sought, and the direct rays of the sun avoided. Beneficial effects may be obtained by a natural or artificial breeze or wind, and for parts of the body covered by clothing they may be obtained by adapting the clothes to the free passage of air and moisture. For hot weather and in the shade, the color of the clothing is of less consequence than the texture, together with sufficient looseness to permit of the free access of air.

WEATHER TYPES.

By S. M. BLANDFORD.

One of the duties of the U. S. Weather Bureau is the charting of meteorological conditions, and the issuing of forecasts. On the Pacific Coast there are two places where general forecasts are made. Portland and San Francisco. The territory covered by the forecasts of the Portland office embraces Oregon, Washington, and Idaho. Twice each day forecasts are made. In case severe winds on the coast and Sound are liable to occur, forecasts are sometimes specially made. A daily chart is issued each day, for the benefit of the public, showing the weather conditions, position of the storm, etc. It is for the benefit of those who desire to study the daily weather charts that five distinct types of the weather have been selected for publication. In the Eastern States, to a large extent, and on the Pacific Coast quite generally, the people are making many valuable uses of the information furnished in the daily weather map.

While many in Oregon are making a practical use of this information to the advancement of their business, there are many who are ignorant of the purpose for which they are issued. It is to enable this class to make a money value through increased knowledge of the daily actual and probable weather changes that these charts are offered. This information is of especial utility to the farmer, as well as to the commercial classes in the city.

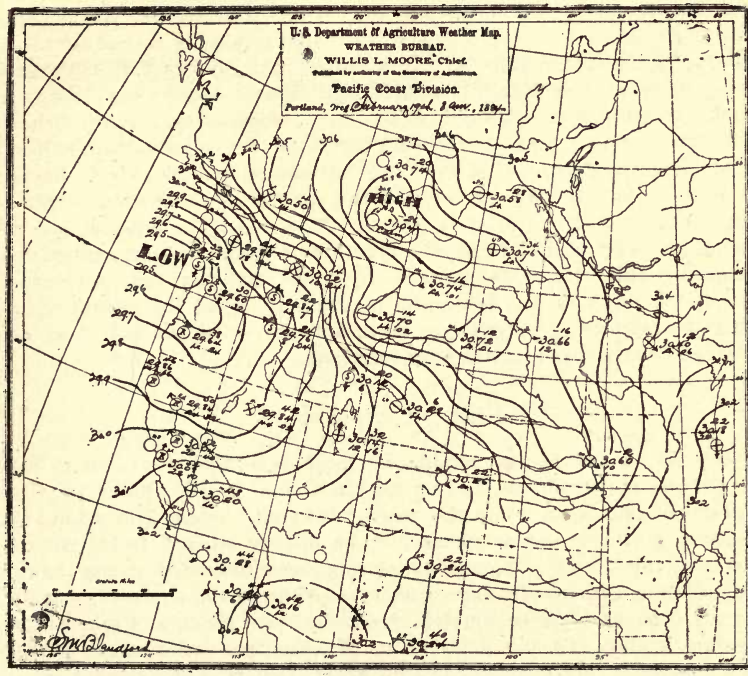
In the study of these charts it must be remembered that the arrows fly with the wind. The first four figures to the right of a station denote the reading of the barometer; the figures above the barometer figures denote temperature; the wind velocity and precipitation figures are below the barometer. The letter "S" at a station denotes snow, and the letter "R" denotes rain; a cross denotes cloudy; one mark indicates fair, and the absence of characters or marks means clear weather. The lines in the chart connect places of equal barometric pressure, and are drawn to each tenth of an inch.

A WINTER STORM.

Chart No. 1 shows a typical winter storm, though there are some extreme features. The terms "low" and "high," which are used in the description of weather types, are used to describe the condition of the atmospheric pressure as reading low or high. In Chart No. 1 the "low" is off the Washington Coast, and the "high" is over the British Possessions. They represent areas of low and high atmospheric pressure. The "low," representing an area of low atmospheric pressure, is necessarily the center of the storm. The "high," representing the territory where the barometric pressure is great, is generally an indication of fair weather influence.

As regards the wind circulation about the areas of low and high pressure, in the Northern Hemisphere they blow spirally inward and around the "low," opposite to the movement of the hands of a watch, and they blow outward from the "high." The first is a cyclonic and the latter an anti-cyclonic movement.

Chart No. 1 shows that this law is being obeyed, except where intervention of the mountains makes a change.



(Chart No. 1.)

During the winter, storms seek a low latitude. The well-beaten track of the winter storm is between latitude 45 and 50, where they strike the Pacific Coast. From the Pacific Coast they usually move somewhat to the northeastward for about a thousand miles, and then southeastward toward the Great Lakes.

This type of storm is frequent on the Pacific Coast. Its presence means continued stormy weather, with rain and snow to the west of the Cascades in Washington and Oregon, while in the mountains and elevated districts of Oregon, Washington, and Idaho, snow invariably follows. The presence of the "high" over the British Northwest means that the "low" or storm which is located on the coast will receive its supply of cold air from that source. The tendency of the "high" is toward checking the eastern progress of the "low." Since all storms move from a westerly to an easterly point, the "high" in Chart No 1, preceding the storm, acts as a barrier, causing the "low" to remain nearly stationary on the coast. One of the characteristics of a winter "low" whose progress is checked by a "high" is to develop energy. With the disappearance of a "high" to the east, the general course of the "low" is to follow. In the present case, the "low" of February 19 moved south into California, thence east. Such a movement, owing to its infrequency, is erratic. "Highs" that continue permanent in the British Northwest have the tendency to force the "lows" southward. The reading of the barometer was abnormally high over the British Northwest for several days, which resulted in the storm being gradually forced south.

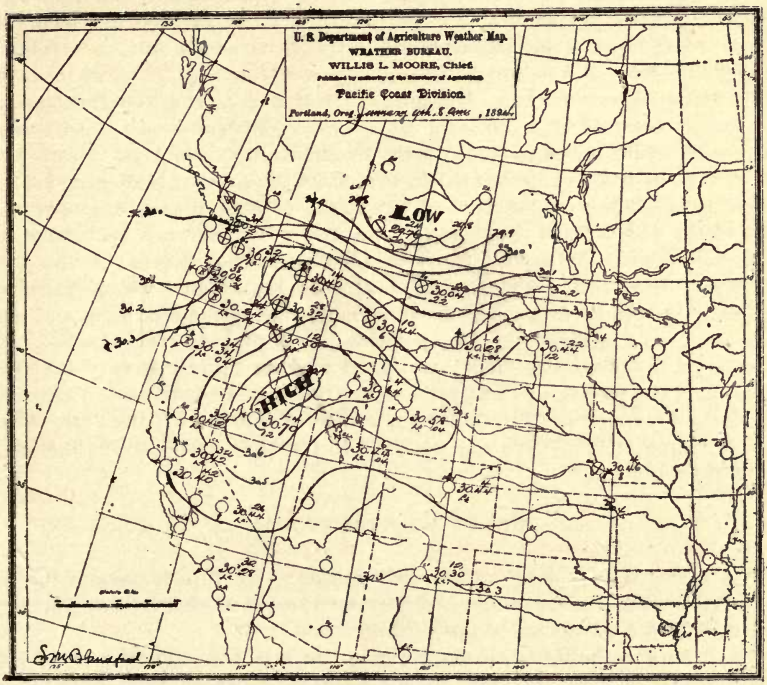
The most marked feature of the weather that follows the movement of all storms from the North Pacific Coast States southward is the cold northerly winds. While the storm or "low" remains central on the coast, the "high" acts as a feeder; the cold air from the "high" rushing into the field of moisture surrounding the "low" causes snow. With the disappearance of the "low" southward through the influence of the "high," the temperature equalizes and the snow ceases. The relative weight or energy of areas of low and high barometric pressure is taken into consideration in determining their probable course. It is in this way that forecasts are made, and, though the layman, who makes a study of the charts, may not possess the skill of an expert, yet he is able, by conscientious study of the weather charts, to make satisfactory forecasts.

CHINOOK CONDITIONS.

Chart No. 2 represents conditions most favorable to Chinook winds. It is generally considered by the people living in the States of Oregon, Washington, and Idaho that the word "Chinook," applied to wind, means any warm southerly wind, whether it be dry or moist. It is thought by many that the direct influence which produces the wind comes from the ocean. This is a grave mistake. Chart No. 2 shows the controlling influence to be an area of high barometric pressure over Nevada, Utah, Colorado, Wyoming, Idaho, and the portions of Washington and Oregon lying east of the Cascades. The center of this great field of high pressure is over Northern Nevada, Southern Idaho, and Northern Utah. From the center the greatest influence will be exerted. Chart No. 2 shows the temperature on the morning of January 9, 1894, as follows: Roseburg, 34°; Portland, 34°; Fort Canby, 38°; Seattle, 32°; Walla Walla, 28°; Spokane, 14°; Helena, 10°; Miles City, —6°; Havre, 20°; and Bismarck, —22°. Twenty-four hours later the records at Portland showed the temperature to be as follows: Roseburg, 44°; Portland, 42°; Fort Canby, 42°; Seattle, 40°; Walla Walla, 46°; Spokane, 34°; Helena, 38°; Miles City, 40°; Havre, 32°; and Bismarck, 32°.

It will be observed that the rise in temperature in twenty-four hours was as follows: Roseburg, 10°; Portland, 8°; Fort Canby, 4°; Seattle 8°; Walla Walla, 18°; Spokane, 20°; Helena, 28°; Miles City, 46°; Havre, 12°; and Bismarck, 54°. In this case, as in all other cases when Chinook winds are produced, the area of high pressure is located as stated above, while a low area or storm is passing over the British Northwest. The greater the rapidity of the storm, the higher the wind velocity and the temperature become.

The principle involved is simple. The storm in passing over the north causes an indraught of the air from the "high" toward the "low." In the Columbia and Walla Walla Valleys, and the passes of the Blue Mountains, Chinook winds are usually of a pronounced type, while under the same conditions they are moderate in the valleys of Western Oregon and Western Washington. Though moderate and moist, they are nevertheless Chinook winds.



(Chart No. 2.)

Were it possible to trace the course and measure the temperature of a cubic foot of air that drifts from the "high" in Northern Nevada toward a "low" in British Columbia, we would notice a rise in temperature of 1.6° for every 300 feet of descent (called dynamic heating) from the high plains of Nevada to nearly sea level, where it would reach the Willamette Valley, for this would be its course.

When reaching the Willamette Valley, where the local atmosphere would be cool and moist, condensation would take place, since the dynamically heated air would be warmer. During the time the process of condensation is going on in the western portions of Oregon, the storm would be passing over the British Northwest, and its center would have changed to Alberta, in which case there would be a rush of air through the gorges of the Columbia River, and over the Cascades toward the storm center. This cubic foot of air would undergo another change; in passing over the Cascades, most of its moisture would be lost in condensation, by the meeting of the cooler currents on the higher elevation. By the time this air would have fallen to the plains and valleys of Eastern Washington and Idaho it would not only be warmed through its descent but dry through condensation of its moisture. It is in this way that the great flow of air from the "high" to the "low" produces the balmy but moist Chinook wind in the valleys of Western Oregon and Western Washington, and the warm and dry Chinook to the east of the Cascades. The farther the wind progresses to the east, the warmer and drier it becomes, the principles of dynamic heating of the air being most perfect as the air flows over the Bitter Root Mountains into Montana. In Montana and the Dakotas the Chinook is a westerly wind, and its dryness and ability to absorb snow or other moisture is compared with the Foehn wind of the Alps. In explanation of the conditions represented in the chart the area of high pressure was formed through the conjunction of two areas of high pressure, one moving south from the British Northwest, and the other moving east from the California Coast. This movement is shown by the records of the U. S. Weather Bureau on January 8th, 1894, the movements being especially rapidly. The "low" first made its appearance during the afternoon and night of the 8th, and arrived at its position, as shown by the chart, by the morning of the 9th. The "low" continued moving rapidly toward the Great Lakes, and the effects of the Chinook continued in Oregon and Washington for twenty-four hours. Without the presence of the "high," the "low" would probably have moved south and resulted in freezing temperatures instead of the balmy Chinook.

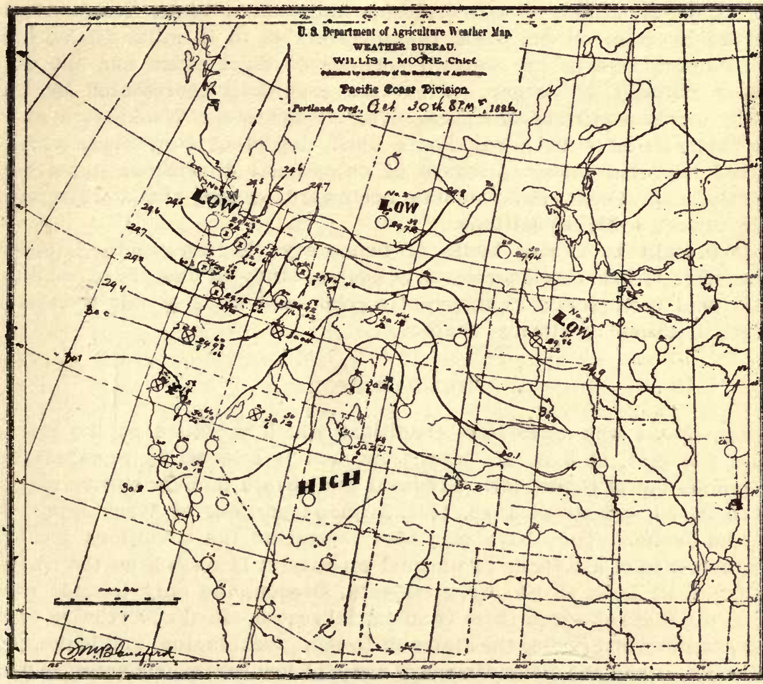
FIRST WINTER STORM.

The first "Winter low" of the fall season. By this is meant the first storm in the fall season which appears on the coast and follows the track usually followed by storms in the winter season.

The difference between an early and a late fall is in the date on which a storm of such a character first makes its appearance on the coast. In the summer season storms of the character of the North Pacific Coast winter storms move eastward at a latitude too far north to influence the weather of the Pacific Coast of the United States; with the approach of the fall season these storms seek a lower latitude in search of heat, one of the essential attributes of a storm. As the conditions which cause one storm to seek a lower latitude are still present, other storms are influenced in the same direction, resulting in a succession of storms.

Chart No. 3 shows three "lows," or stages of practically one storm, in progress around an area of high atmospheric pressure. This is a type of weather common to the fall and winter seasons. It is not unusual that three "lows" appear on a single daily weather chart, covering 1,500 miles to the east of the Pacific Coast line.

The chart represents an area of high barometric pressure prevailng over California, Nevada, Utah, Southern Idaho, and Southern Montana. Anti-cyclonic winds are blowing out from the area of high pressure toward the "lows" or storms. A brisk to high southeasterly wind is blowing in Oregon and Washington, while a severe southwesterly gale is raging at the mouth of the Columbia River and along the Washington Coast.



(Chart No. 3.)

Heavy rain is falling in all portions of Western Washington, while light rain is falling in Eastern Washington and Western Oregon. The "low" or storm, which is represented as central about Tatoosh Island, Washington, is the immediate cause of the weather prevailing in Oregon and Washington. Each of the "lows" represented on the chart as preceding the one which is central on Tatoosh Island had its center at or about Tatoosh Island, twenty-four and forty-eight hours before, respectively. The only one of the storms which is instrumental in influencing the weather on the coast is the Tatoosh Island "low"; the others have passed to the east, where there is little moisture or heat to continue the development and activity peculiar to the position on the coast.

Since the field of supply of air necessary to continue the storm in activity is to the south and southeast, it is essential in order to continue the perfect and regular storm progression that the "high" or base of air supply should not become exhausted. With the exhaustion of the high-pressure area on the south and southeast, the regular storm progression as shown on the chart disappears the winds on the coast and interior abate their fury, the precipitation assumes a different character, and the temperature becomes much colder.

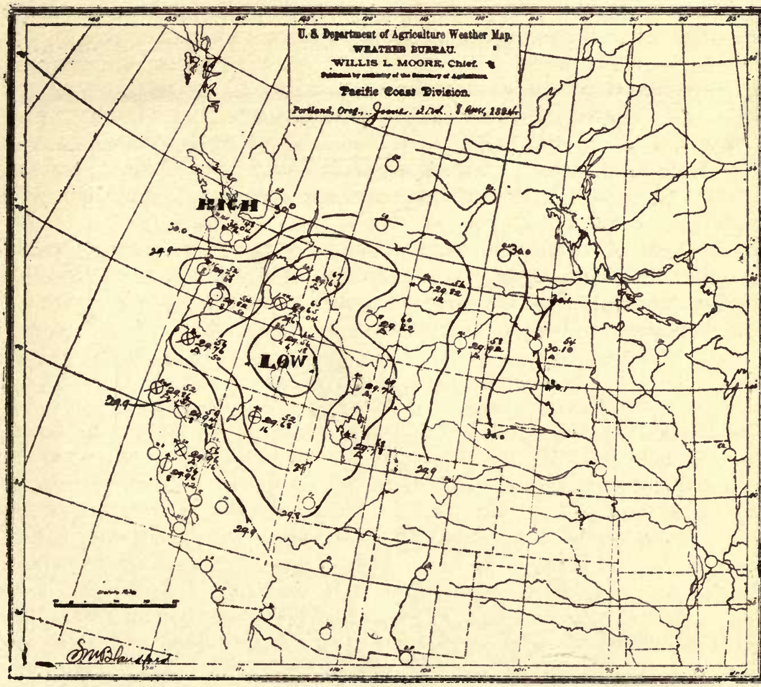
Storm No. 3 first made its appearance on the coast in the afternoon and evening of October 28th. and was noted in the morning daily weather chart at Portland as typical of the first appearance of a winter storm. It was attended by gales on the coast, ranging from 40 to 60 miles an hour, and having heavy rain in the western portions of Washington and the northwestern portions of Oregon. From the conditions represented by Chart No. 3, storms continued to appear over Northwestern Washington at regular intervals of twenty-four hours until the 2d of November, when an area of high barometric pressure of exceptional dimensions appeared on the California Coast, and, moving northward, caused the storms on the north to seek a higher latitude.

Since eight to twelve hours of temporary clearing weather follow a storm after it has taken an easterly course, study of the above conditions would tend to explain why apparently good local signs of fair weather are so soon followed by stormy weather.

THUNDER STORM.

Chart No. 4 was made from conditions which prevailed on the morning of June 3, 1894, at 5 A. M., local time, and is selected to represent typical thunder-storm conditions. Frequent and severe thunder storms occurred on the 2d, 3d and 4th of June, 1894, in many portions of Washington, Oregon and Idaho. The above map also represents the conditions preceding the occurrence of a tornado of unusual severity at 11 o'clock on the morning of June 3, at Long Creek, Grant County, Oregon, the only tornado occurring in the State of which there is an official record. In the Northwest Pacific Coast territory, embracing the States of Oregon, Washington, and Idaho, thunder storms attend the advancement of areas of low barometric pressure which have their origin, as a rule, in the northern interior portions of California. These areas of low pressure are the result of excessive heat in Northern and Central California, the temperature frequently rising to 104° to 108° and remaining warm for many consecutive days. Two or three days of excessive warm weather usually suffices to produce a local barometric depression. These areas of low pressure advance northward into Southern Oregon, thence easterly into Eastern Oregon and Southern Idaho, or northeasterly into Eastern Oregon, Eastern Washington, and Northern Idaho. With the advancement of the areas of low pressure the area covered by them increases. While the conditions most productive of thunder storms have their origin more frequently in California, the rule is not unvarying. On June 2 and 3, 1894, through the agency of excessive heat throughout Oregon, portions of Nevada and Washington, an area of low barometric pressure was formed over Oregon which caused general thunder storms and furnished the data for the chart presented herewith.

Thunder storms are frequent in Eastern and Southern Oregon, Eastern Washington, and in Idaho. They rarely occur in the western portions of Washington, and Northwestern Oregon. The rarity of thunder storms is so marked in sections of Western Washington and Northwestern Oregon that season after season passes without so much as a distant peal of thunder being heard.

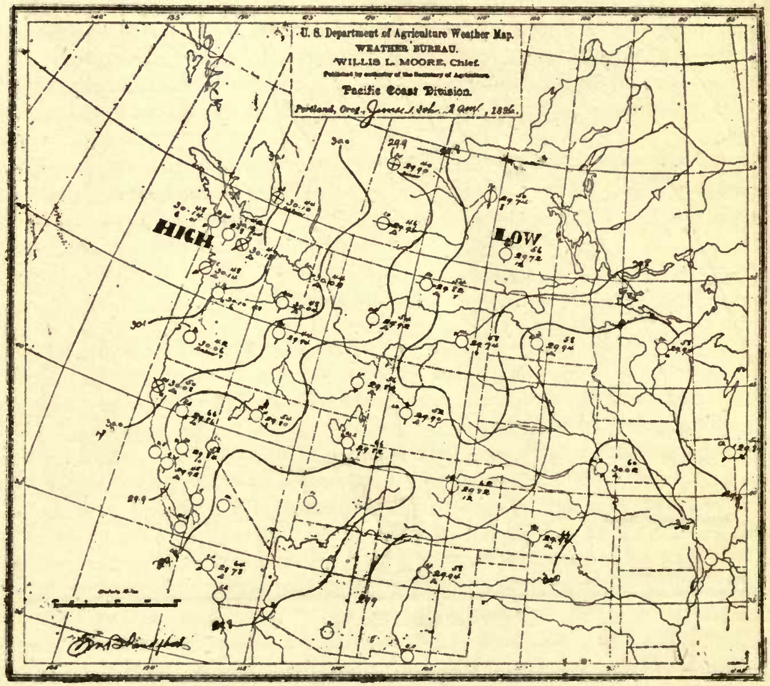


(Chart No. 4.)

Thunder storms are more frequent during the months of June and July than at any other time, and are almost invariably attended by severe hail of a character to damage crops, and at times imperil the lives of grazing animals. Owing to the small area covered by a thunder storm, several have been known to be raging at the same moment within a single barometric depression; for this reason thunder storm forecasting is unsatisfactory work. That a thunder storm will occur somewhere within an area of low pressure within a specified time can be forecasted with great accuracy, but the exact position of the storm within the area of low pressure is a more difficult problem, and one which requires the light of more frequent telegraphic reports at a greater number of reporting stations.

SUMMER WEATHER CONDITIONS.

Chart No. 5 represents the appearance of the first summer "high" on the Pacific Coast during the season of 1896. Study of Pacific Coast weather types has determined that there is a well-defined area of high barometric pressure which appears on the North California or Oregon Coast sometimes in the spring or early summer, which, by a characteristic northerly movement, is indicative of a decided change about to commence in the general character of the weather for the remainder of the season. It is important for the



(Chart No. 5.)

student of the weather or one whose business is affected by weather changes, to know that such a distinguishing feature of the weather develops each spring, and by access to the Daily Weather Maps furnished by the United States Weather Bureau its appearance can be ascertained. It is important for him to know that there is a type of weather which develops each spring and which marks the time between winter and summer.

It is to be understood that when the "summer high" appears a change in the weather of a summer-like character is about to commence; this is quite certain, whether the high appears in March or in June. It is not to be understood that with the appearance of the "high" the rains will cease, but that the rains will be more showery and less frequent. Increase in the amount of sunshine, higher temperatures, and more frequent periods of fair weather should follow the first appearance of a "summer high." With the appearance of the "summer high" general and prolonged spells of rainfall should cease and temperatures normal or above should follow.

Chart No. 5 was made from conditions which existed on the morning of June 13, 1896. The "high" is represented as prevailing over Western Washington, extending westward along latitude 48° north. This "high," which is considered typical of summer, moved from the southwest, showing first on the California Coast. It continued moving north along the coast in British Columbia, thence easterly; which is the movement typical of the "summer high" which distinguishes it from the "highs" of the winter season that appear on the California Coast, move northward to about latitude 45°, thence east to the North American plateau, where their progress is frequently checked.

In the spring of 1895, the "summer high" appeared on April 20th; the character of the weather then changed and farming operations progressed with only slight interruptions from the weather. In the spring of 1896 the "summer high" not having appeared until June 13th, the season was considered six weeks late, farming operations were impeded by rain, and seed decayed in the ground, owing to the cool weather.

Knowledge concerning this feature of Pacific Coast weather is of incalculable value, since it may be regarded as the initial sign of spring.

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