(C) *Interior of Continents.* — The interior of a continent, being far from the sea, receives much less rainfall than a windward coast. Thus there are frequent periods of drought in central western Asia and in central United States. These droughts are less destructive in the northern part, because in a cool climate lighter rainfall suffices for crops. There are two reasons for this: (1) in cool climates the slight evaporation allows the dampness to remain long in the ground; (2) melting frost keeps the soil damp for a long time.

One striking peculiarity of the interior of continents is the great range of temperature between the warm or hot summers and the very cold winters (Figs. 431–435). During the summer day the temperature may rise above 100° — truly tropical heat; and in winter it may descend to the Arctic cold of even 40° below zero, giving a range of perhaps 140° in a single year. Minnesota and neighboring states illustrate this extreme, or *continental climate.* It is also illustrated in central northern Siberia, near the Arctic circle, where moderately warm summers are followed by bitterly cold winters. In fact, this is the coldest known place (Figs. 431, 435), and has been called the *cold pole* of the earth.

It is distance from the sea, and freedom from its influence, that account for the extreme climate of the interior of continents. The land warms in summer, when the sun, though low in the heavens, stays long above the horizon. In winter, on the other hand, the nights are very long, and during the short days the sun is low in the heavens. Under these conditions radiation is far in excess of the heat supplied, and the land becomes exceedingly cold.

Summary. — *Interiors of continents, being far from the sea, are subject to drought; and there is great range in temperature, from warm or hot summers to cold winters. This is known as a continental climate.*

(D) *East Coasts.* — Since the prevailing westerlies must cross the continent before reaching east coasts, one might expect to find arid climates there. Aridity is prevented,

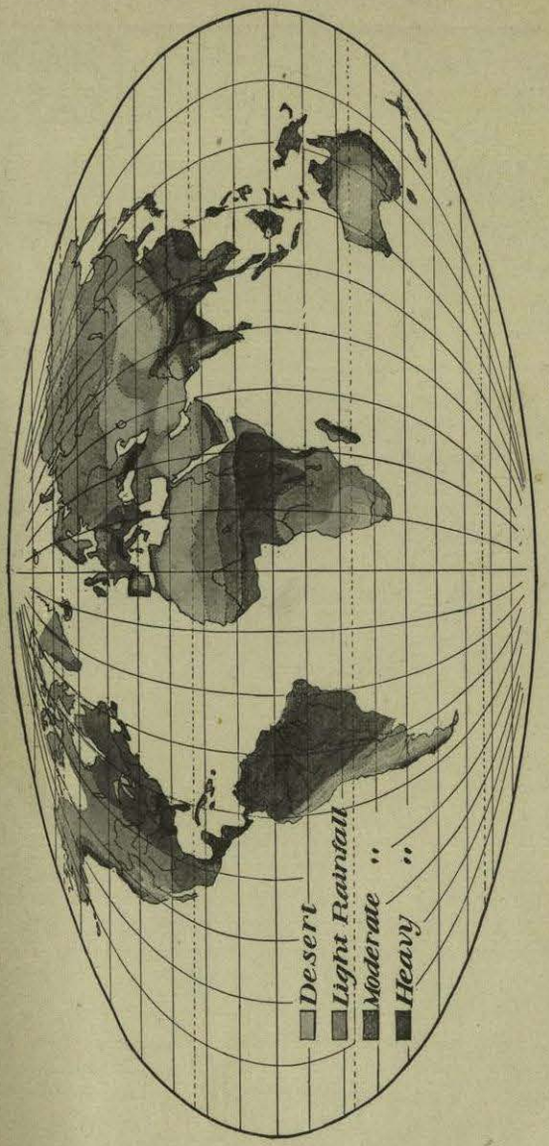

FIG. 444. — Rainfall map of the world.

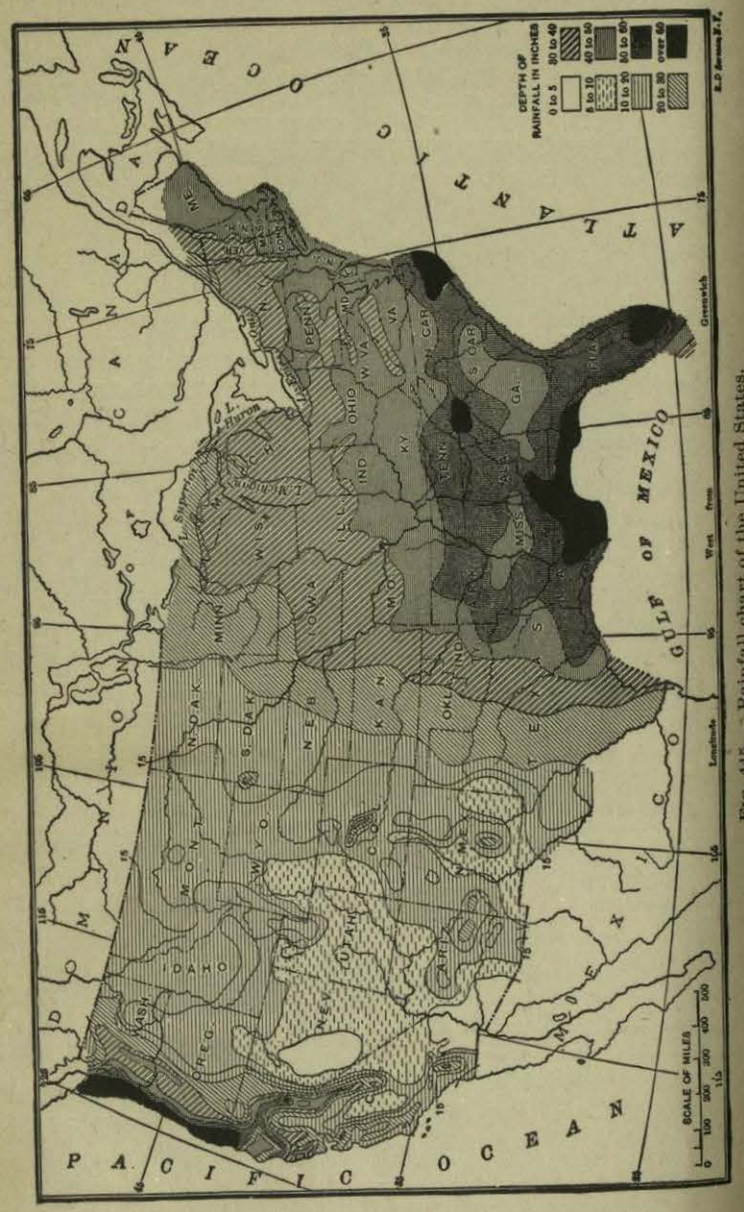

FIG. 445. — Rainfall chart of the United States.

however, by the winds of the cyclonic storm eddies (p. 262), which frequently replace the west winds. Some of these winds blow from the Atlantic or Gulf of Mexico, bringing the vapor which gives eastern United States its abundant rainfall.

Because of the influence of cyclonic storms, the climate of east coasts is variable. The west winds are dry and cool in summer, and dry and cold in winter ; but whenever storm winds blow from the sea, both the temperature and humidity are influenced by the ocean. Thus in northeastern United States the east winds are damp and chilly, being cooled in passing over the Labrador current ; and in summer they often bring fogs. The south winds, warmed in passing over the Gulf Stream or the Gulf of Mexico, are warm and damp. From day to day the weather varies (p. 265), one day being like the interior of continents, another like the equable ocean.

Summary. — *The cyclonic storm eddies of the west-wind belts give east coasts a very variable climate, with rain when winds bring abundant vapor from the sea.*

190. — Variable Winds of the Prevailing Westerlies. — Among the winds caused by the passage of cyclonic storms and anticyclones (p. 265) are some so distinctive that they deserve special names. The gentle south wind, which causes oppressively warm weather in summer, and unseasonable warmth in winter, may be called the *sirocco*. It is when the sirocco blows that thunder storms and tornadoes develop in summer, and thaws occur in winter.

Of the very opposite type are the west and northwest winds that sometimes blow on the rear of vigorous winter cyclones. These cold winds, often filled with snow, are called *blizzards* in Dakota and *northers* in Texas. Because of the marked difference in the barometric gradient (p. 255) between the cyclone and the anticyclone the air moves with great velocity, perhaps 40 to 60 miles an hour. The cold, and the fierce snow squalls, often cause destruction of life among sheep and cattle; even men are sometimes lost in the blinding snow, and frozen by the fierce cold. Milder forms of blizzard occur in northeastern United States.

A *cold wave* (Fig. 446) is a rapid drop in temperature during the passage of a well-developed anticyclone (p. 263). At such times a wave of cold air spreads over a large part of the country, even down to the Gulf (p. 286). This blanket of air descends from the cold northern interior and from aloft (Fig. 417); and since it is, therefore, warming as it spreads out, it is clear and dry. Through it radiation proceeds readily, causing very low temperatures in winter, refreshingly cool weather in summer, and early and late frosts in fall and spring (p. 246). The term cold wave, however, is commonly applied only to the winter condition.

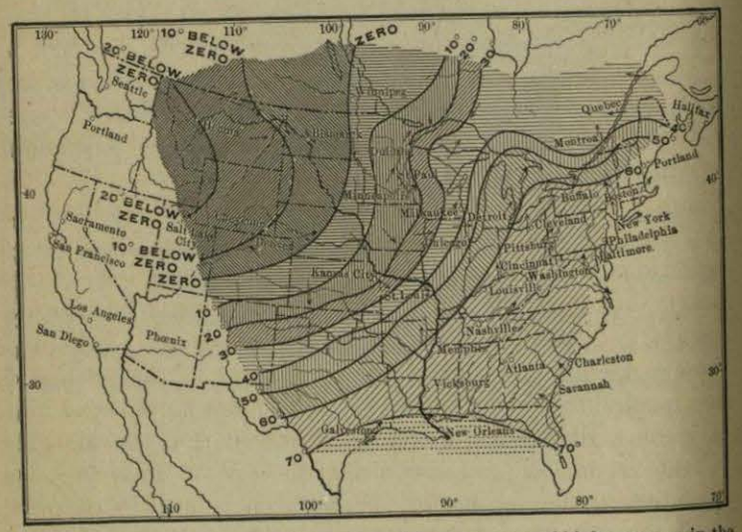

FIG. 446. — A cold wave, spreading outward from an area of high pressure in the northwest, November 27, 1896. Arrows show outward movement of the air.

The passage of cyclonic storms sometimes causes an exceedingly warm, dry wind, known as the *foehn* in the Alps and the *chinook* in the Rocky Mountains. These winds are caused by the rapid passage of air across mountains toward a storm center. As the air rises on one side it loses much of its vapor, descending as dry air on the opposite side. It descends so rapidly that it is warmed by compression, as the air in a bicycle pump is warmed

(p. 241). This warming lowers the relative humidity (p. 244) until the air becomes very dry; in fact, the Swiss formerly believed that the foehn came from the Sahara. In the warm, dry air, snow disappears rapidly, and houses become so dry that fires are greatly feared. Whole villages in Switzerland have been wiped out by fire during the foehn winds.

Summary. — *A sirocco is a warm, gentle south wind blowing toward a cyclonic storm; a blizzard, or norther, is a fierce, cold wind, with squalls of snow, in the area between well-defined cyclones and anticylones; a cold wave is the outspreading blanket of cold air in an anticyclone; the foehn, or chinook, is a warm, dry mountain wind made warm and dry by rapidly descending the mountain slopes in its passage toward a low pressure area.*

191. Weather of Eastern United States. — (A) *Summer Weather.* — The typical summer weather of eastern United States may be illustrated by the following actual instance. A cool, dry, gentle west wind is accompanied by a day of agreeable warmth, a night of refreshing coolness, and a nearly cloudless sky. An anticyclone is passing over the region, and following it is an area of moderately low pressure. As this approaches, the wind veers to the southeast, the temperature rises, the air becomes more humid, and both day and night are muggy and oppressive. On the morning of the second day, clouds fleck the sky, in the afternoon growing to thunder-heads. About four o'clock a thunder storm appears, preceded by a fierce squall; then comes heavy rain, accompanied by vivid lightning and crashing thunder. After the storm, a west wind blows and, as another anticylone passes, the air is again dry and refreshing.

This cycle is repeated with some regularity, though there are numerous variations. At times the low pressure areas are so poorly developed that for several weeks little rain falls. There is then a drought, during which streams and wells run dry, vegetation withers, and crops suffer. At other times a low pressure area is so well developed that, instead of scattered thunder storms,

there is general cloudiness and rain. This is especially true in late summer and early autumn, when hurricanes, accompanied by strong winds and heavy rains, pass up the coast.

Summary.—*Summer weather in eastern United States is variable, being warm and oppressive, often with thunder storms, when south winds blow toward moderately developed areas of low pressure, and cool and refreshing when anticyclones pass.*

(B) *Winter Weather* (Figs. 446–453).—Both cyclones and anticyclones are much better developed in winter than in summer. They pass over the country in fairly regular succession (p. 263), bringing alternate clear and cloudy weather. Their appearance is sometimes so regular that one day of the week has nearly the same kind of weather for several successive weeks.

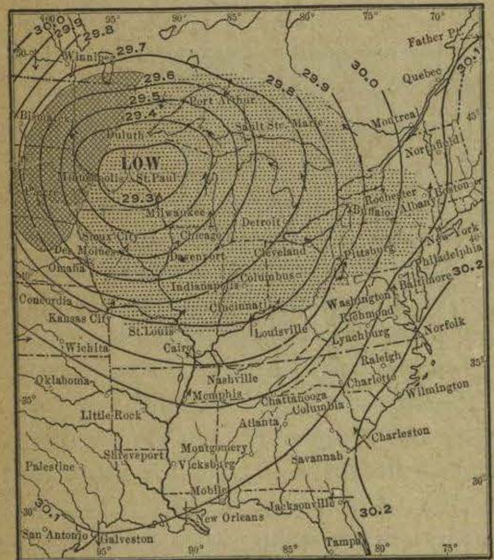

FIG. 447.—A winter storm, showing winds blowing toward a Low, and the large area over which rain (dotted) and snow (cross-lined) are falling.

During the passage of cyclones there may be rain, or snow, or both. The wind varies in velocity (p. 265) and veers through various quarters, bringing chilly air from the north or east, warm air from the south. While the south wind is blowing a thaw may set in, and, even in midwinter, rain may fall as far north as Canada. A thaw is often followed by a decided drop in temperature as the next anticyclone approaches.

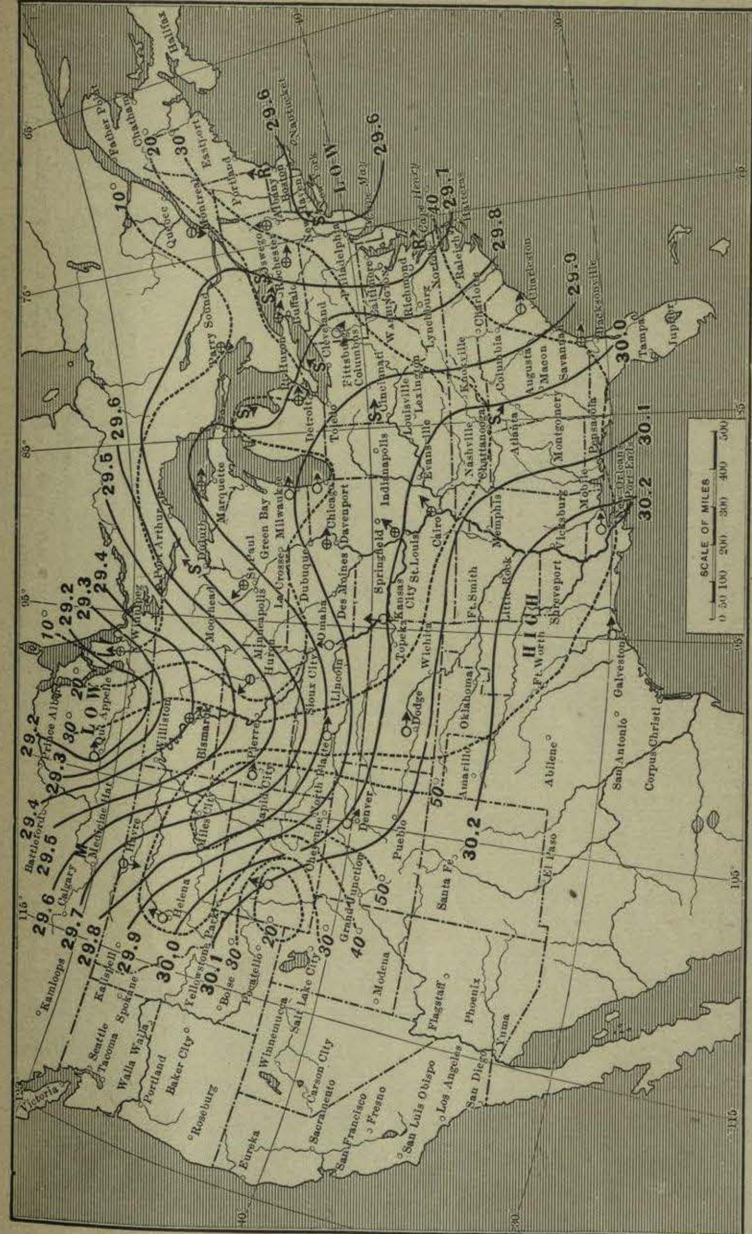

FIG. 448.—Weather map, January 6, 1903, showing a low pressure area in the Northwest. The heavy lines (isobars) show barometric pressure (29.2 being the number of inches the air pushes the mercury into the tube of the barometer). The dotted lines (isotherms) pass through places with equal temperature. The arrows point in the direction the wind is blowing. A plain circle O means clear weather; ⊕ partly cloudy; R rain; S snow.

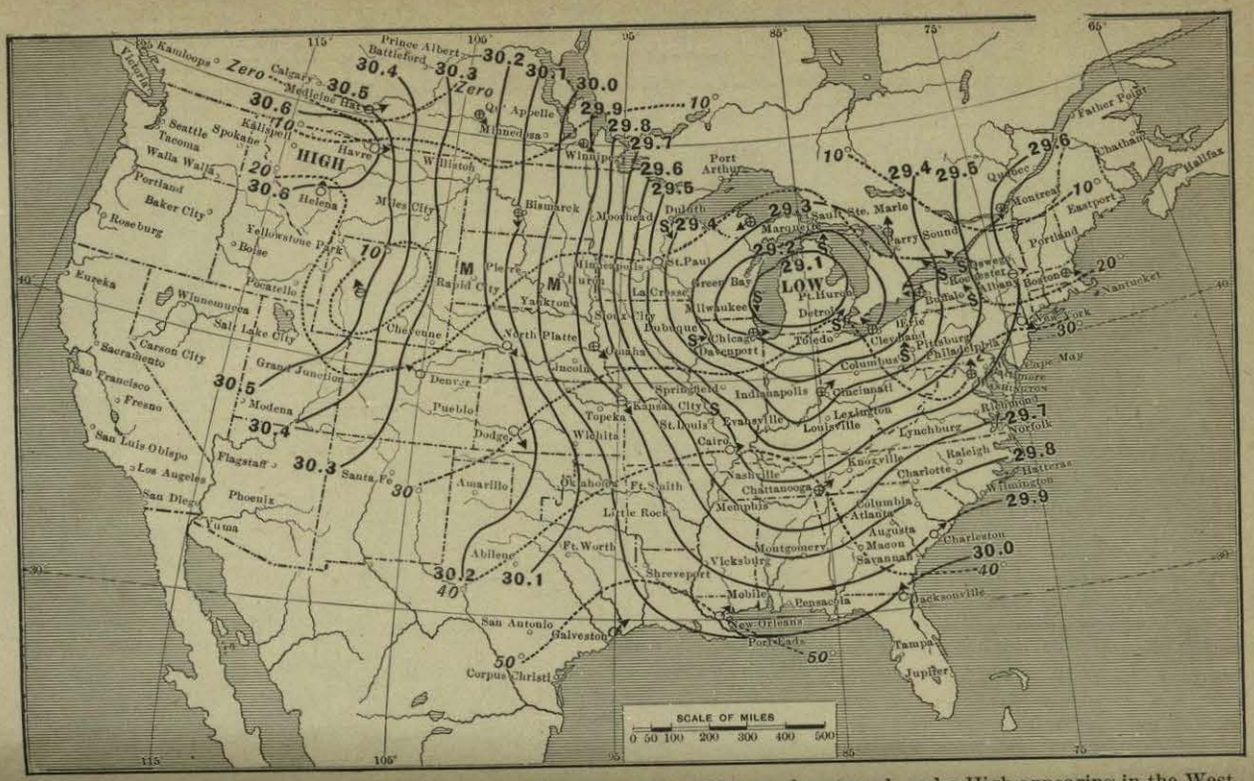

FIG. 449. — Weather map, January 7, 1903, showing the storm (Fig. 448) moved eastward, and a High appearing in the West. Symbols same as Fig. 448.

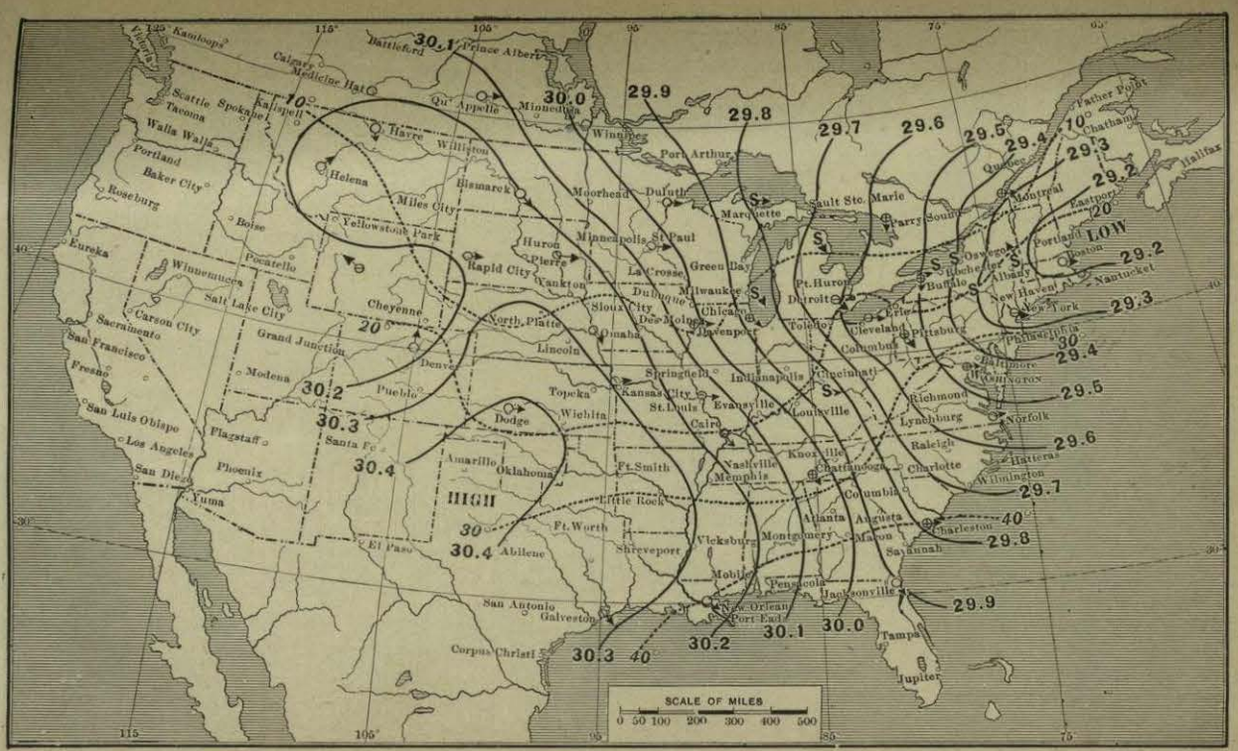

FIG. 450. — Weather map, January 8, 1903, showing the storm (Fig. 448) just leaving the coast. Symbols same as Fig. 448. Describe the changes in pressure, temperature, and wind direction accompanying the passage of this storm. (Figs. 448, 449, 450.)

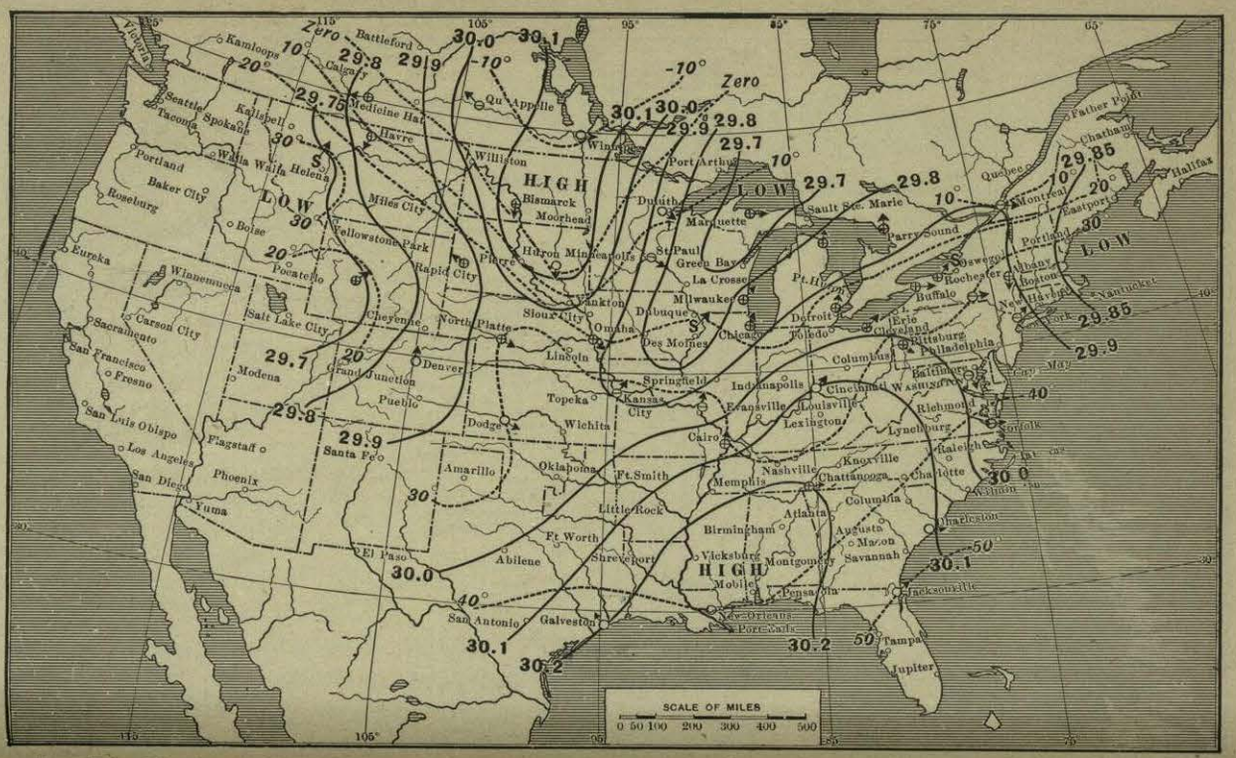

FIG. 451. — Weather conditions, January 22, 1903, showing a high pressure area in the West. Symbols same as Fig. 448.

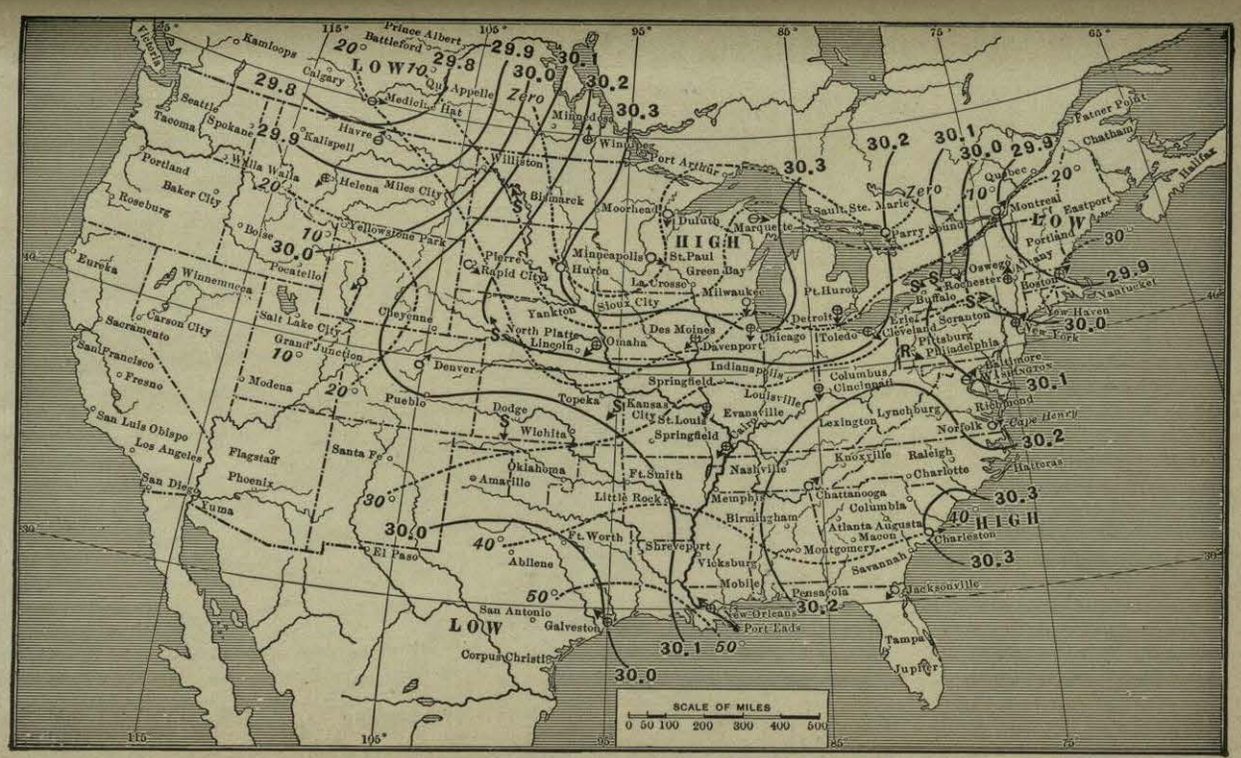

FIG. 452. — Weather conditions, January 23, 1903. The High has moved eastward. Symbols same as Fig. 448.

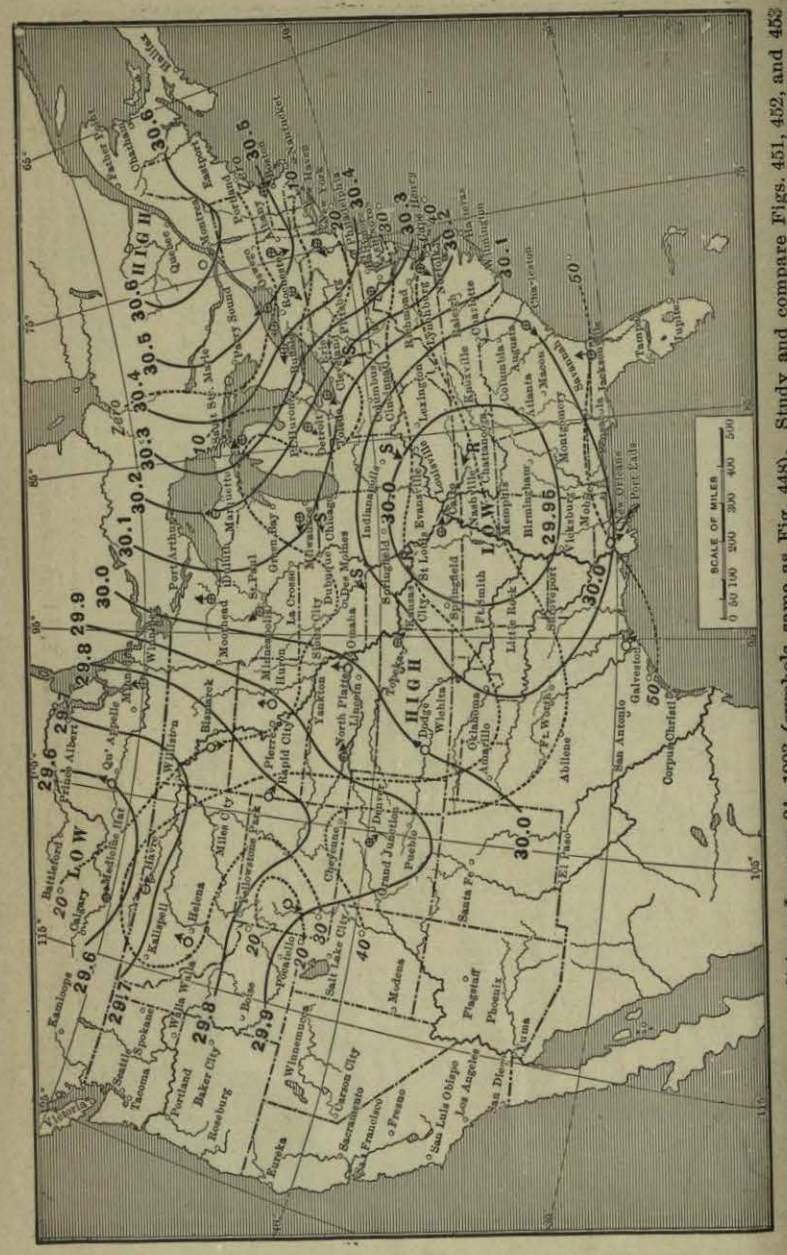

FIG. 453. — Weather conditions, January 24, 1903 (symbols same as Fig. 448). Study and compare Figs. 451, 452, and 453 to see what changes occur. Note the changes in temperature; in cloudiness; in wind direction. Compare and contrast these changes with those in Figs. 448, 449, and 450

Few climates of the world are so variable as these of the stormy west-wind belts; and the changes in weather are very trying to the health. Consequently many diseases, such as pneumonia, grippe, and consumption, are common in these severe climates.

Summary. — *The winter weather of the west-wind belts is exceedingly variable, being cold during the passage of anticyclones, and relatively warm during the passage of cyclonic storms, whose south winds may even cause midwinter thaws.*

192. Climate of the South Temperate Zone. — Owing to the fact that there is so much water in the southern hemisphere, the changes in temperature are less extreme there than in the northern hemisphere (Fig. 435); and the winds blow with more strength and steadiness than over the irregular lands (p. 261). Otherwise the climates of the two temperate zones are much alike. Over the Southern Ocean the summer weather is damp and chilly, the winter raw and cold, though without extreme changes from warm to exceedingly cold weather. Storms are frequent and fierce, and this is why rounding Cape Horn is so dreaded by sailors.

Summary. — *Excepting for stronger, steadier winds, more uniform coolness, and less decided changes in temperature, the climate of the south temperate zone is similar to that of the north temperate.*

193. Arctic Climates. — (A) *Near the Circle.* — In summer, when the sun is above the horizon both day and night, the air, though cool and sometimes raw, is never very cold. The warmth melts the frost to a depth of two or three feet, making the soil damp and swampy. Then the grass becomes green, flowers blossom, and birds and insects appear. As in other places visited by the westerlies, storms appear in fairly regular succession, bringing rain or squalls of snow. Fogs are common on the sea and along the coast, where damp winds are chilled in passing over cold water.

In the late summer, when the sun commences to set, the days grow cooler and the nights cold. Insects disappear, birds move southward, and the land is covered with snow.

The soil freezes again, and a skim of ice appears on the ocean, growing thicker as the days become shorter. The Eskimo then gives up his kayak and takes to the sledge in search of seal, his chief food. Finally the sun is absent even at noon, and then the weather, both day and night, is bitterly cold. In winter the principal changes are those accompanying the passage of cyclonic storms. Sometimes, even in midwinter, the temperature rises so high that the Eskimo snow houses, or igloos (Fig. 525), begin to melt.

With the coming of spring the sun reappears, the snow melts, and the Eskimo abandons his igloo for a skin tent, or tupic (Fig. 524). The sea ice begins to break up and float away, and the Eskimo returns to his kayak for hunting. Then comes the summer day.

Summary. — *The Arctic summer, near the Circle, is cool, damp, and stormy. In winter, when the sun is below the horizon even at midday, the ground is frozen and snow-covered, the sea covered with ice, and the weather bitterly cold.*

(B) *Nearer the Pole.* — As near the pole as man has gone the climate has been found similar to that just described; but the Arctic winter night is longer and colder, the summer cooler. Even there the warmth of the summer sun is sufficient to remove the snow from much of the low ground near the coast. In upper Greenland, the northernmost land known, and far north of the highest Eskimo settlements, Peary found flowers blossoming, insects humming, and musk oxen roaming about in summer.

The sea which surrounds the North Pole is everywhere covered with ice floes (p. 194), over which Abruzzi, Nansen, Peary, and others have tried to reach the pole. They must make their dash in early spring, because in summer the ice is too broken to cross on sledges, yet not open enough to allow ships to pass through. Consequently those who have tried to reach the pole have gone as far north as ships will carry them, and remained through the cold, dreary Arctic night in order to be ready for an early start. At last Peary overcame the difficulties of ice and climate that had so long baffled explorers, and in April, 1909, reached the North Pole.

Summary. — *As far north as man has gone, the climate is similar to that nearer the Arctic Circle, though cooler in summer and colder in winter, because the sun is lower and longer below the horizon. Plants and animals live on the northmost known land. In summer the sea ice breaks up so that travel over it by sledge is impossible.*

Topical Outline, Questions, and Suggestions.

Topical Outline. — 181. **Difference between Weather and Climate.** — Weather; climate; illustration of difference; kinds of climate.

182. **Zones of heat.** — (A) *The Five Zones:* reason for division; the zones; boundaries. (B) *Influence of Altitude:* effect of highlands; isotherms; isothermal charts; Pacific slope. (C) *Influence of Water:* contrast ocean and land; illustrations; temperature ranges. (D) *Influence of Winds:* contrast western Europe and eastern United States; eastern and western United States. (E) *Influence of Ocean Currents:* effect on winds; transference to land; contrast western Europe and eastern America. (F) *Influence of Topography:* local influences; mountain barriers; western United States; Mediterranean.

183. **Belt of Calms.** — Warmth; rain; weather on the ocean; on the land; forests; mankind.

184. **Rainy Trade-wind Belts.** — Effect of warming air; evaporation of sea water; east-facing coasts; instances; forests; Hawaiian Islands.

185. **Desert Trade-wind Belts.** — Explanation; rainfall; desert belts; horse-latitude arid climate; desert life; weather conditions.

186. **Savanna Belts.** — Location; cause of peculiar climate; effect on vegetation; instances of savannas; animals; man.

187. **The Indian Climate.** — Hot, windy season; hot, calm season; the rains; short, hot period; winter monsoon; effect of these changes on vegetation; heavy rains at base of Himalayas.

188. **Variation (in Temperate Zones) from North to South.** — (A) *Temperature:* near polar circles; near tropics; vegetation. (B) *Rainfall:* in the north; in the south; steppes. (C) *Effect of Mountains:* Contrast southern Europe and United States; effect on people.

189. **Variation (in Temperate Zones) from West to East.** — (A) *West Coasts:* climate of west coasts; contrast British Isles and eastern United States; rainfall of western United States; Chile. (B) *Effect of North-south Mountains:* western Europe; interior of Europe; western United States; country east of mountains. (C) *Interior of Continents:* rainfall; droughts; the cool north; great temperature range; continental climate; instances; explanation. (D) *East Coasts:* effect of storms on rainfall; in causing variable climate; changes from day to day.

190. **Variable Winds of the Prevailing Westerlies.** — (*a*) Sirocco nature; cause; effects. (*b*) Blizzards or northers: location; reason for strong winds; effects. (*c*) Cold waves: nature; location; cause of cold; effects. (*d*) Foehn or chinook: location; cause of warmth; cause of dryness; effects.

191. **Weather of Eastern United States.** — (A) *Summer Weather:* (*a*) typical cycle: anticyclone; warm south winds; thunder storms; anticyclone. (*b*) Variations from cycle: droughts; general rain. (B) *Winter Weather:* regular succession of cyclones and anticyclones; precipitation; wind changes; thaws; effect of changes on health.

192. **Climate of the South Temperate Zone.** — Effect of water on temperature; on winds; summer weather; winter weather; storms.

193. **Arctic Climates.** — (A) *Near the Circle:* summer climate; plants and animals; storms; fog; change in autumn; effect on life; winter climate; effect on Eskimos; spring climate; effect on Eskimos. (B) *Nearer the Pole:* resemblance to conditions farther south; differences; life; sea ice; time of making dash toward the pole.

QUESTIONS. — 181. What is weather? Climate? Illustrate the difference. Name some different kinds of climate.

182. (A) Why may the earth be divided into zones of heat? What about the boundaries? (B) What is the influence of highlands? What is an isotherm? An isothermal chart? What is the condition on the Pacific slope? (C) What differences are there over land and water? Give illustrations. (D) Give illustrations of the influence of winds on climate. (E) How do ocean currents affect climate? Give instances. (F) What effect has topography on climate? Give instances.

183. What is the climate of the belt of calms? What is the weather on the ocean? On the land? What effect has the climate on man?

184. What effect have the trade winds on the sea? On rising coasts?

185. Why are there deserts in the trade-wind belts? Where are the great desert belts? Why are the horse latitudes arid? What are the life conditions in the desert? What are the weather conditions?

186. What is the cause of the savannas? What are the conditions there. What effect have these conditions on life?

187. Describe the Indian climate: the seasons; their cause; their effect on vegetation; the heavy rains.

188. (A) What are the conditions near the polar circle? How do the temperature and vegetation change toward the tropics? (B) How does the rainfall vary from north to south? What are steppes? Where found? What are the conditions there? (C) What is the result of the absence of lofty mountains in southern United States?

189. Why are there differences in climate from west to east?

(A) What is the climate of west-facing coasts? Why? Give illustrations. (B) Contrast central Europe with the arid West. Explain the condition in the United States. (C) What is the condition of rainfall in the interior? Why are droughts less destructive in the north? What are the temperature conditions? Why? (D) What is the cause for rainfall on east-facing coasts? How does the climate vary? Why?

190. What is the sirocco? The norther? The blizzard? What is the cause of each? Their effect? What is the cause of cold waves? Explain the foehn or the chinook wind. What are their effects?

191. (A) Describe a cycle of typical summer weather in eastern United States. What causes variations from this cycle? (B) Describe the winter weather. What causes thaws? What is the effect of the changes?

192. How does the climate of the south temperate zone differ from that of the north?

193. (A) Describe the Arctic climate in the different seasons. How do these changes influence life? (B) What is the condition of climate nearer the pole? Why is it so difficult to reach the pole?

SUGGESTIONS. — (1) Trace one or two of the isothermal lines across the charts for the United States (Figs. 433, 434) and endeavor to explain the irregularities. Do the same for one or two isotherms in the northern hemisphere of the world charts (Figs. 431, 432). Follow one or two in the southern hemisphere and account for the difference between their regularity and the irregularity of those in the northern hemisphere. (2) Make isothermal charts of the United States and the world, copying upon outline maps the isotherms in the book. (3) Study the Appendix on weather maps (Appendix H) and work out the suggestions. (4) Select and study weather maps illustrating cold waves. (5) From a series of three weather maps for successive days, describe the weather changes at a given place — say Boston or Chicago. Write down the temperature, wind direction, etc., for each of the days. (6) Make a record of local weather changes for a week. Write a short description of these changes. (7) Write a description of the climate of your home.

Reference Books. — WARD, *Hann's Handbook of Climatology*, Macmillan Co., New York, 1903, $3.00; GREELY, *American Weather*, Dodd, Mead & Co., New York, 1888, $2.50; TURNER, *Climate of New York State*, Chapter XI, *Physical Geography of New York State*, Macmillan Co., New York, 1902, $3.50; CROLL, *Climate and Time*, Appleton & Co., New York, 1890, $2.50. (See also references at end of Chapter XII.)