drawn according to the Clapeyron method. Of these two methods of presentation, the former is better adapted for graphic computations, while the latter offers special advantages for theoretical investigations. On the other hand, both methods have one defect which is, indeed, of only very minor fundamental importance, but which may yet be found annoying by those who have had little experience in considerations of this kind.

This defect arises from the fact that in both of these methods the changes of condition experienced by an ascending mass of air are represented by falling curves and those of a descending mass of air by rising curves. This, however, is a difficulty that can easily be overcome by changing the coördinates, as has already been done by Prof. William M. Davis for the Hertzian diagrams.

I will, however, here assume that the more generalized Clapeyron method is employed in its usual form; that is to say, the volume is represented by the abscissæ and the pressure by the ordinates. If we represent a cycle by this method, then, as is well known, the areas of the surfaces inclosed by the diagram are a measure of the work done or consumed. In the extension of this theorem, as used by me, the simple diagram is replaced by the projection of the space-curve representing the change in condition, and hereafter I shall refer to this projection briefly as the diagram.

The question whether in this process work is done or consumed, can be answered at once from the direction along which the curve is traversed. If the change in condition proceeds in such a way that the diagram inclosing the surface is traversed in a clockwise direction, then heat is consumed and by this process work is gained; in the opposite case, work is consumed and heat is gained. Therefore in any atmospheric cycle, e. g., in the exchange of air between cyclone and anticyclone, it suffices to enter in the diagram the actually observed values of the pressure and volume (or what amounts to the same thing, the values of pressure and temperature) in order to at once recognize whether in this process we have to do with a consumption or a gain of heat.

If, for instance, we assume that the atmospheric ascent took place in a summer cyclone in which the temperature is lower than in the attendant anticyclone, then the representative diagram will be traversed in a counter-clockwise direction. In this case, therefore, there is a consumption of work and a gain of heat. But such a process can not possibly contain within itself the germ [or cause] of its existence, since the earth receives energy from without only in the form of heat, which is delivered by the sun at a higher temperature and subsequently radiated from the earth at a lower temperature.

The great atmospheric cycle as conditioned by the general circulation must, therefore, be traversed in an opposite direction to that just described. It must, in fact, be one in which heat is converted into work.

Processes such as that above imagined, although they do seem to correspond to the interchange between cyclone and anticyclone in summer time, are nevertheless never to be explained by the convection theory, but are only conceivable in case the great cycle of the general circulation delivers an excess of mechanical energy in order to develop or sustain smaller processes of the opposite kind.

From this it is clear that even pure thermodynamic considerations may lead to results that are of the greatest importance for the understanding of dynamic processes. Consequently, we recognize that it is a problem of the highest importance to test numerically by means of well-established observations the considerations here set forth. The construction of such diagrams by use of actually observed data would lead to the most far-reaching conclusions.

Of course, it will not be easy to obtain the values for truly closed cycles, since probably only a part of the air that is raised in the cyclone and transported over to the neighboring anticyclone returns again into the same cyclone. Still the classification of temperatures observed at different heights, according to the cyclonal or anticyclonal character of the weather, will be a contribution in this direction.

In this work the data given by observations on mountain tops can, of course, be used only with great caution. The really decisive figures can only be expected from scientific balloon voyages. Among such voyages the most favorable for the investigation of the questions here considered are those in which the ascent takes place in an area of low pressure but the descent in the neighboring anticyclone, or conversely. Then the ascending and descending portions of the curve actually belong together. Such voyages have already been made, but it is of the highest importance that in these voyages numerous observations be obtained, not only during the ascent but also during the descent.

Unfortunately all these investigations suffer from the misfortune that in the atmosphere we have to do, not with masses of air that are subject simply to variations of pressure and gain or loss of heat, but with the fact that mixtures with other masses of air of different temperatures and moistures are always going on at the same time. So long as the amount of moisture remains the same, and we do not leave the dry stage, then the mixture with air of other temperatures acts precisely as if a warming or cooling had occurred, but the case is more complicated when the moisture is variable.

If, in a current of ascending or descending air, the quantity of moisture in a unit mass remains unchanged, then we are justified in supposing that no mixture with other masses of air has taken place. The change in the quantity of moisture, therefore, gives in a certain sense a measure of the degree of mixture with foreign masses of air, but always only under the assumption that it has not left the dry stage.

But these are questions whose thorough explanation would lead us too far. At present it is only necessary to show that from the diagrams of atmospheric cycles constructed from data actually observed, the most important conclusions can be drawn as to the general circulation of the atmosphere. In the construction of these diagrams, however, we need above all a knowledge of the temperature and the moisture at different altitudes in the regions of ascending and descending currents and at different times of the day and the year. Moreover, the investigations should not be confined to processes going on in middle latitudes; they must especially bear upon the great circulation between the region of equatorial calms and the high pressure zones of the "horse" latitudes.

ICE STORMS OF NEW ENGLAND.

A welcome study of the ice storms (verglas; Glatteis) that have been observed over New England and notably at Blue Hill Observatory, Mass., has just come from the pen of Charles F. Brooks.[1]

[1] Brooks, Charles F. The ice storms of New England. Cambridge, 1914. 8 p. 2 pl. 4°. (Harvard University publication.) [Reprinted from Annals, Obs. Harv. Coll., v. 73, pt. 1.]

The author finds the following combinations of conditions which may produce ice storms when there is precipitation:

I. Temperature of the air below 0°C.
II. Temperature of the air above 0°C. and
  A. Temperature of the rain below 0°C.
    1. From passing through a stratum of cold air;
    2. From cooling by evaporation in nonsaturated air.
  B. Temperature of the rain above 0°C. and
    Temperature of the objects coated, below 0°C.
    1. Because of residual cold;
    2. From cooling by evaporation in nonsaturated air.

He finds that no heavy ice storm occurs when the temperature of the surface air is above 0°C., and that no considerable ice storm has occurred at Blue Hill, Mass., under such conditions; but the above considerations show it to be not impossible. When the temperature of objects and the temperature of the lower air also is above 0°C., it is clear that even undercooled rain and such ice pellets as may reach the ground will not be able to form an ice coating. When the air is below 0°C., undercooled rain or ice pellets will not adhere in the frozen state to objects at a higher temperature; but the dripping water will freeze into icicles. If the lower air is warmer and the undercooled rain, etc., does succeed in forming an ice coating on previously cooled objects, still the surrounding air will cause the ice coating to melt without forming icicles. Ice storms may occur with a temperature as low as −13°C.; it may rain hard or gently; the wind may be from any direction, a gale or a calm; the temperature may rise, fall, or remain stationary.

The author then presents a diagram showing graphically the vertical and horizontal distribution of temperature conditions as they affected the precipitation that accompanied the storm of January 5–6, 1910, at Blue Hill. It appears from that study that the ice storm lasted about six hours at the valley station (18 meters above sea level) and a little over one hour at the summit (195 meters above sea level), while a neighboring station standing above 400 meters would have experienced no ice storm at all. "Thus local topography has a great effect on the intensity and extent of an ice storm."

Upon inquiring into the distributions of pressure and wind that cause these ice-storm temperature inversions it appears that there are three general wind conditions which produce them:

(1) Warm air arriving over residual cold air (the "southerly" type).

(2) Cold air coming in below while warm air is arriving above (the "northeasterly" type).

(3) Cold air from the north or west pushing in below a rain cloud (the "northwesterly" type).

The ideal conditions for the first type occur when, after the air next the ground has been strongly cooled by radiation during an anticyclone, a cyclone advances rapidly toward New England. The conditions during January 5–6, 1910, already referred to, furnish an excellent illustration. A pronounced anticyclone (1,043 mbars)[2] had been replaced within 24 hours by a cyclone from the west-southwest bringing a large supply of warm, moist air on south winds in front of a trough extending to the Gulf of Mexico.

The ideal conditions for the second type are presented when there is a good supply of warm southern air from an active cyclone in the south at the same time that an anticyclone in the north is supplying cold air. The northeast wind blowing toward the southern cyclone is pushing cold air in under the warm air flowing northward from the eastern portion of the cyclone to the south. Often, however, the undercurrent from the northeast is not cold enough to wholly counteract the warming effect of the south wind overhead, then the temperature may remain stationary or even rise slowly instead of falling. An ice storm of this "northeasterly" type occurred February 19–22, 1898, also on December 23, 1908, and February 9, 1905. In this last case a kite flight at Blue Hill showed the lower wind ESE. with gradually falling temperature (−1° to −2° C.), the valley temperature being a few degrees higher. Up to almost 800 meters the V. T. G. was nearly the normal adiabatic one; but at 885 meters there was an inversion to +0.5° from a minimum of −3° C. at 760 meters. At that level was the base of an arriving warm southeast wind; snow had been falling for the preceding hour and a half. A similar ice storm occurred over all of northern Germany on October 19–21, 1898 (see full account in Das Wetter, Berlin, November, 1898, p. 247–260); but in that case both the northeasterly and the northwesterly types were in progress simultaneously at different levels.

The "northwesterly" type is about the reverse of the first or "southerly" type. The cold air wedges in below while rain is still falling above. The changes in the form of the precipitation occur in the opposite order also. The "wind-shift line," or boundary between two currents having different directions and temperatures, is of common occurrence but its passage is not frequently accompanied by an ice storm. February 15, 1906, presented a representative storm of this type over the United States, although the beginning of the storm belonged to type 2.

Owing to the fact that a single ice storm often falls under two or even three of the types described, we may best classify them according to the positions and movements of the highs and lows producing them. Two large divisions may be made on this basis: *A*. Storms in which anticyclones in the north dominate cyclones on the south; *B*. Storms occurring from cyclones and anticyclones in the usual regular sequence. All the 31 ice storms occurring under conditions *A* were either of type 2 or a combination of types 2 and 3; 11 of these were severe storms.

Most of the ice storms studied occur under conditions *B*, the severe ones being most common when the low comes from the Gulf of Mexico. The following tabulation shows the frequencies of the different types:

	Storms.
1. Southerly type	67
2. Northeasterly type	116
3. Northwesterly type	59

The "northeasterly" type is favored by southern lows and northern highs; the "southerly" type by the low crowding in close behind the high; and the "northwesterly" type comes most frequently when the high arrives close behind the low.

The distribution of ice storms by months was as follows:

January	48
February	46
March	40
April	7
November	10
December	27
Average year	12

The earliest fall storm came on November 8–10, 1894, and the latest spring storm was on April 30, 1909.

Among extraordinary features accompanying different storms at Blue Hill may be mentioned an inversion of 8° C., lasting many hours during the storm of January

[2] The author used the Harvard College notation of absolute units; perhaps in conformity with the ideas put forward by Prof. A. E. Kennelly in this REVIEW, March, 1914, 42: 141, section 3. The editor here adheres to the prevailing international usage among meteorologists, viz, the bar of Bjerknes.

22–23, 1904. During this storm the alternating gusts that affected only the top of the Hill caused simultaneous temperature fluctuations of 5° in either direction, lasting but as many seconds, as though the summit of the Hill were precisely at the waving boundary between the upper warm current and the lower cold current. The week January 12–17, 1909, brought three severe ice storms to the Hill. The kite flight of the 15th occurred between two of these storms and showed a most interesting rapid destruction of the inversion by the advent of the anticyclone, there being an inversion of 6° between 950 m. and 1,050 m. at 11 a. m., by noon the inversion had diminished in strength but doubled its areal extent, and at 4 p. m. it had disappeared. During this time the summit temperature at Blue Hill had remained stationary.

Mr. Brooks concludes as follows:

Regions of strong cyclonic action bringing precipitation and highly variable temperatures seem to be most subject to ice storms. Thus eastern North America and western Europe are particularly susceptible. Toward the continental interiors when cyclones are weaker there is a diminishing frequency of ice storms. In this country, as in Europe, cyclones frequently support an ice storm for a considerable distance across country. For instance, the ice storm of February 21–22, 1913, began in Texas and eventually crossed New England. The storm of January 5, 1910, was reported as causing much damage in New Jersey the morning of January 5.

To forecast these storms for New England is even more uncertain than to forecast rain or snow, for the belt of occurrence is generally narrow. Ice storms may be much more local than snow storms. Predictions must be based on the occurrence of cyclonic and anticyclonic positions favorable for ice storms, and in making forecasts indications of an ice storm already in progress in the West would help. * * *—[C. A., jr.]

AN APPRECIATION.

In the Belgian journal Ciel et Terre (Brussels) for June, 1914, we find published a full-sized official reprint copy of the Daily Weather Map of the Northern Hemisphere for May 1, 1914, as published by the United States Weather Bureau. This reprint serves to illustrate an article by Vandevyver[1] in the same issue of that bulletin, extracts from which are presented below as they will undoubtedly interest American meteorologists at this time.

The map on the back [of the Daily Weather Map of the United States] (in equidistant English projection) seems made especially to delight the meteorologist who aspires always to see things from above, secretly hoping that he may thus more rapidly solve the problems presented by the elements in whose midst we live.

At a glance one may now grasp the situation over the whole Northern Hemisphere as regards cyclones and anticyclones which play, as we know, so important a rôle in the forces of nature, and we see at the same time the distribution of temperatures.

What is particularly interesting to the professional is the day-to-day comparison of these charts; we certainly make no mistake in predicting that this innovation will be productive of discoveries, and that detailed study of these charts will put us on the right track, if not of the real and complex causes of the origins of these variations, at least of the systems to which their movements belong—which will add great weight to the value of the forecasts.

At first glance the notations of the map are a little disconcerting. The fact is that here the C. G. S. system of absolute units has been adopted for the barometric pressures, and the readings are expressed *in bars;* the bar corresponding to a force of 10 dynes (1,000 millibars being equal to 29.53 inches, or 750.06 mm. of the normal mercury column), and the temperature is given in terms of the absolute zero, −273° C.

It goes without saying that, from a strictly scientific standpoint, one can but approve of the adoption of these units; but in consideration of the fact that, on the one hand, the very young science of meteorology must be made to appeal to all its well-wishers (and for this very reason must reach out beyond the limited circle of the profession) and on the other hand, in view of the wide distribution planned for this chart, it is not a priori clear what advantage is to be gained by thus breaking away from the deeply rooted customs of the general public.

Except for this gentle criticism, which is, moreover, but an expression of a personal opinion and detracts nothing from the work of the Weather Bureau, we are certain that our readers will unreservedly admire the excellent chart that we present.

I have collected,[2] for teaching purposes, samples of a large number of meteorological charts published in Europe, and we must admit that the American publication far surpasses the similar ones that have been secured from other countries.

Undoubtedly the reader will ask for the cause of this inferiority. There are various reasons; I believe one of the most important is the scattering of our efforts. The practical Americans have concentrated the whole meteorological service of their vast territory at one single point and have thus been able to give the resulting total the scope that we see before us. In Europe, on the other hand, each country is confined to its own boundaries, be they broad or narrow, and gives only what these permit. *The total interest, energy, and initiative Europe thus expends, probably equals if it does not exceed that dedicated by our trans-Atlantic neighbors;* but our efforts lack coordination and, to use a business phrase, our enormous general expenses tie up a large portion of our capital.[3]

Because of its geographical location [on the western shores of the continent] all of western Europe is in a rather difficult position from the meteorological point of view. * * *

In short everything seems to argue in favor of the creation of a central meteorological service for Europe, well planned and well organized such as is that which exists for America. But alas, our ancient Europe, with its yet more ancient ideas, has difficulty in escaping from the grip of chauvinism. We allow ourselves to be stifled under the enormous expenses incurred by our military affairs * * * and we can not find on our old earth one voice carrying weight enough to stop these follies. We throw our millions into the gulf of an almost criminal insanity without being able to bring about that calm of which we have such need, and to which we all aspire. America, taking a broader view, has thus far relegated to the background that which we have placed first, and she can thus further the greater good of humanity by giving more liberally to science and to progress.

Let us thank her for this beautiful example that she sets us, and vow that some day Europe, wiser, shall do as well.

NORTHERN HEMISPHERE MAP INTERRUPTED.

The following announcement appears on the Weather Map of the Northern Hemisphere for August 6, 1914:

Owing to the state of war involving the great nations of Europe, the meteorological observations from regions in Europe and Asia heretofore employed by the Weather Bureau in the construction of its chart of the Northern Hemisphere are no longer received, and the issue of this map will be suspended from this date until such time as the reports can be resumed. The publication of the daily map of the United States will be continued as heretofore, and those recipients of the map of the Northern Hemisphere who make application therefor, including paid subscriptions, will be listed to receive the weather map of the United States. Unless application is received the map will not be sent, except to paid subscriptions.

C. F. MARVIN,
Chief of Bureau.

[1] Vandevyver. Les nouvelles cartes synoptiques du "Weather Bureau" de Washington. Ciel et terre, Bruxelles, 1914, juin, 35: 169–172.

[2] Such a collection may be seen, displayed in frames in the library of the Washington office of the U. S. Weather Bureau.—[C. A., jr.]

[3] Italics are ours.—EDITOR.