The Operation of the Basic Wind System

A. V. Lott, Sellersburg

In a former paper (1) which was presented before this group the writer suggested that the general circulation of the atmosphere may be divided into individual units, all of which are formed according to the same general pattern. It is the purpose of this paper to discuss in greater detail the formation of these units, to show that the general features of one unit are similar to the general features of any other unit, and to describe the operation of the basic wind system which is suggested by the observed phenomena.

Early studies of the atmosphere were usually confined to the atmospheric layer which lies just above the earth's surface, that is, the troposphere. The observed movements in the troposphere indicated that the general circulation was probably a gravitational movement which was induced and maintained by the great temperature inequality between the equator and the poles. Later studies indicated that this early conception of the circulation was no longer tenable. Scientists found evidence which suggested the existence, in the upper atmosphere, of a circulation which was a "mirror reflection" (2) of the circulation in the troposphere. It seemed that the warm air of the equatorial region did not rise to the top of the atmosphere and flow away as an overflow, as was formerly believed, but rather, it moved upward until it met a cold current which descended from above. The two currents then combined at an intermediate level and flowed back toward the poles.

This particular type of circulation has never been adequately explained. However, it does imply that there must be a level of equal pressure at the intermediate altitude and, indeed, such a level is known to exist at approximately twenty kilometers above the earth's surface (2).

The high temperatures in the equatorial region cause the air in that region to expand. Expansion causes increasing pressure. The pressure continues to increase until the expanding air breaks through at some point of least resistance and flows away into a region of lower pressure. The points of least resistance in the equatorial region are found at intermediate altitudes rather than at the top of the atmosphere. Expansion must continue as long as the sun continues to shine upon the earth. Continuous expansion causes continuous pressure. Consequently, the air of the equatorial region is forced out of that region by continuous pressure. Therefore, it seems that the air which leaves the equatorial region through the antitrades cannot be compared to an overflow. These air-flows are more nearly like streams which are forced out under great pressure. This idea has not received due consideration hitherto, yet it seems to contain tremendous possibilities for productive research.

When a stream which moves under pressure flows out into a region of relatively quiet air it causes the air from the quiet area to be drawn

in toward the moving stream, while in its terminal area the stream tends to spread out in a fan-like or delta-like formation. This tends to produce a great eddy upon each side of the moving stream. The eddy that forms upon the right has a clockwise motion while the one that forms upon the left has a motion that is anticlockwise. Thus, a single atmospheric stream which is forced out of the equatorial region under pressure forms, somewhere in the higher latitudes, a great eddy which rotates with a clockwise motion and another great eddy whose motion is anticlockwise. A single stream with its two great eddies forms a unit of circulation.

A single unit of circulation covers an area of the earth's surface which is measured by approximately 120 degrees of longitude. However, the earth's surface is divided into 360 degrees of longitude. This suggests the probable existence of three units of circulation in each hemisphere, or a total of six units in the two hemispheres.

In the northern hemisphere the great eddies of the Pacific unit may be identified as the Pacific high and the Aleutian low; the great eddies of the Western unit may be identified as the Bermuda-Azores high and the North Atlantic low; and the eddies of the Eastern unit may be identified with the Asiatic high and a low which lies over western Siberia. The Siberian low is not as highly developed as the others because it lies over a land area, yet its existence may be recognized by statistical studies of the circulation (3). In the southern hemisphere the following eddies are paired together in their respective units: the south Pacific high and a low over the Ross sea in the Pacific unit; the south Atlantic high and a low over the Weddell sea in the Western unit; and a high over the Indian ocean and a low which is believed to lie near Enderby land in the Eastern unit.

The existence and the positions of all these pressure formations except the two lows of the Eastern unit are a matter of common knowledge. The position of the Siberian low may be determined by statistical studies of the circulation while the existence of a low near Enderby land will doubtless be verified when further exploration is made in that region. The approximate positions of the six pairs of eddies are shown in Figure 1. It may be observed that these general features, that is, the great eddies, of one unit are similar to the great eddies of any other unit except as they may be modified due to variations in the earth's surface.

The unceasing circulation of air around the anticyclonic centers of action of each hemisphere tends to draw the air away from the region which lies between two adjacent anticyclones. This reduces the pressure within the region and the area then tends to develop into a cyclonic area. Thus cyclonic areas tend to develop on the tropical side of the anticyclonic centers of action, one area developing between two adjacent anticyclones. This produces three areas in each hemisphere which are favorable for the formation and development of tropical cyclones of the permanent, semi-permanent, or migratory type. The approximate positions of these tropical cyclonic areas may be determined by studying Figure 1. They lie near and extend below the tropics and

are found between any two adjacent anticyclones. It may be observed that four of the six tropical cyclonic areas lie over a water surface. Consequently, they are about equally developed and the storms of one area are similar to the storms of any other area. The other two areas lie mostly over land surfaces. Therefore the individual storms do not develop to an intensity which is comparable to the storms which develop over a water surface. These tropical cyclonic areas, like all other general features of the units of circulation, are separated by approximately 120 degrees of longitude, and this particular feature of one unit is similar

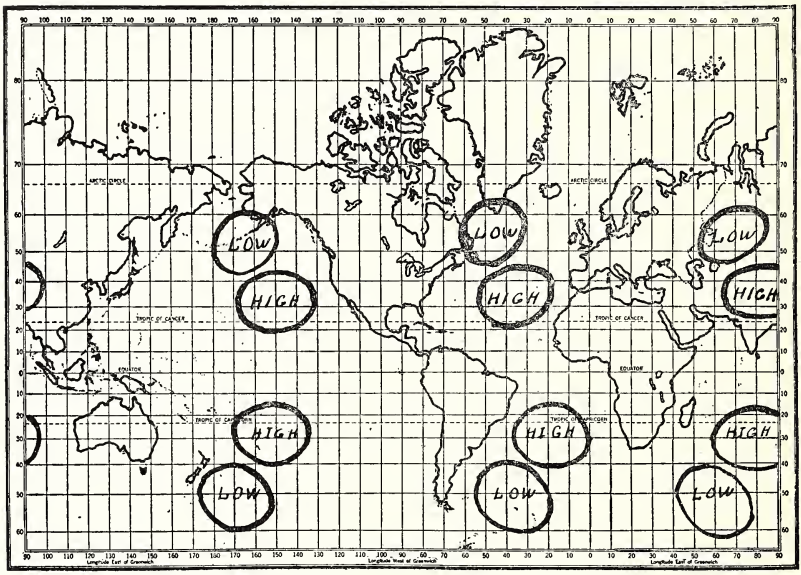

Fig. 1. This shows the approximate positions of the two great eddies of each unit of circulation. They may be identified as the great centers of action of the general circulation. The actual positions are subject to seasonal and other variations as explained in the text.

to the corresponding feature of any other unit except as modifications are introduced due to variations in the earth's surface.

The tropical cyclonic area of each unit is connected with the extra-tropical cyclonic area of the same unit by a pressure trough which, in the northern hemisphere, extends in a southwest to northeast direction between the two pressure areas. The pressure trough of the Western unit extends in a southwest to northeast direction across the United States; the trough of the Eastern unit extends in a southwest to northeast direction across Europe; and the corresponding formation of the Pacific unit extends in a southwest to northeast direction across eastern Asia and the western Pacific ocean.

Similar pressure formations occur in the southern hemisphere. The approximate positions of these pressure troughs are shown in Figure 2.

Note that they are separated from each other by approximately 120 degrees of longitude. Many disturbances which form in the tropical cyclonic areas pass through these pressure troughs into the extra-tropical cyclonic belt.

Another outstanding feature of the general circulation has been called the continental anticyclone. The term "continental anticyclone" is not satisfactory because it gives the impression that the continent is in some way responsible for the existence of the pressure area. In reality, this type of pressure area seems to be a part of the basic wind system and as such it must form in exactly the same position even though the continent did not exist. The continental area seems to act only

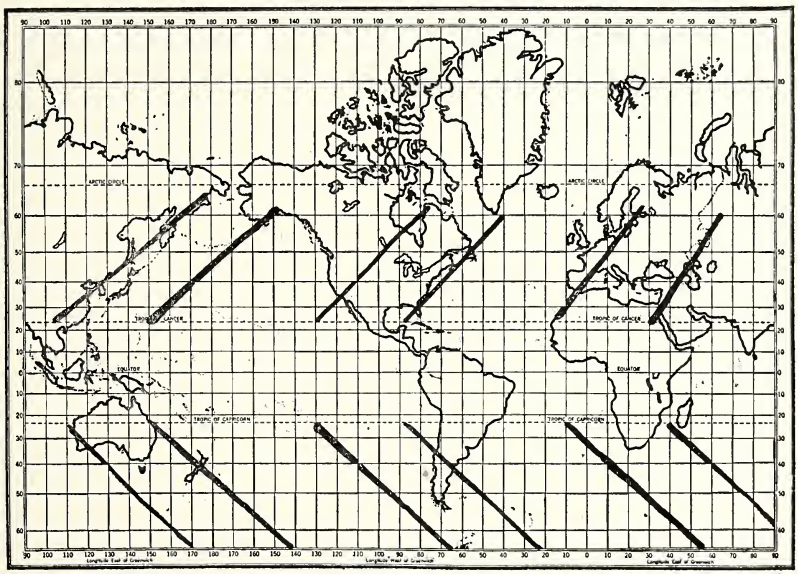

Fig. 2. The tropical and extra-tropical cyclonic areas of each unit are connected by a pressure trough. The illustration shows the approximate positions of the six great pressure troughs of the basic wind system. The actual positions are also subject to variation.

as a modifying factor. Indeed, surface conditions seem to act as modifying factors of all formations of the basic wind system.

Continental anticyclones may be divided into three classes as follows: true centers of action, anticyclonic air-flows, and stationary anticyclones of migratory type. The first class is well illustrated by the Asiatic anticyclone which develops to such great intensity during the winter months. The nucleus of this air mass is shown in Figure 1 as a true center of action. It has exactly the same origin as the Bermuda-Azores high and the Pacific high, both of which lie over a water surface. A good example of the anticyclonic air-flow is found in the winter anticyclone which forms over Canada during periods of weak circulation.

This pressure area never forms over that region during periods of strong circulation (3). This anticyclone is really an air-flow from the Eastern unit (Eurasian land mass) which moves northeastward during periods of weak circulation and enters North America from the northwest. A similar air-flow from the Pacific unit (Pacific ocean) moves northeast and enters Europe from the northwest. Another similar movement occurs in the Western unit (America and western Atlantic ocean) and enters Eastern Asia from the northwest. The approximate positions of these air-flows during periods of weak circulation are shown in Figure 3. Note that they are separated by approximately 120 degrees of longitude. It should be understood that this class of "continental" anticyclones changes its position according to changes in the direction of air-flow. When the circulation is strong and the general air movement is more nearly from west to east this anticyclone lies over the United States rather than over Canada, and the corresponding anticyclones of the other units also change their positions accordingly.

The anticyclones which frequently remain almost stationary over the southeastern part of the United States for days or even for weeks at a time are good examples of the third class of "continental" anticyclones. These formations seem to be anticyclonic air masses that move along in the anticyclonic air-flow until they reach the eastern side of the pressure trough. They may remain stagnant at this point

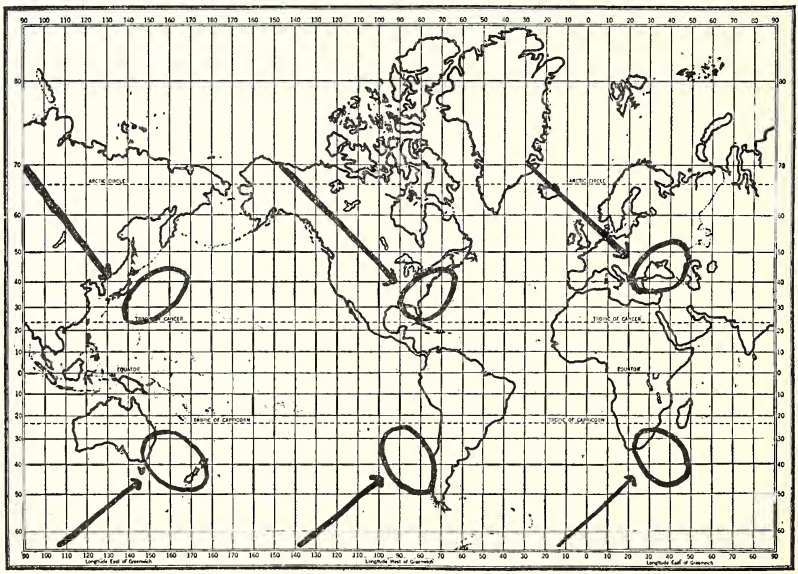

Fig. 3. The oblique lines represent the paths of anticyclonic air-flows which form the so-called "continental" anticyclones. These air-flows, as explained in the text, should be traced on a globe. The elliptical areas represent the approximate positions of the stationary anticyclones of migratory type. The actual positions of the anticyclones and air-flows are subject to seasonal and other variations as explained in the text.

for several days before moving poleward through the pressure trough. The corresponding formations of the other units lie at approximately 120 degrees farther east over southeastern Europe and southwestern Asia, and 120 degrees farther west over the Pacific ocean just east of Japan. Similar pressure formations occur in the three units of the southern hemisphere. The approximate positions of these formations are shown in Figure 3. These anticyclones may form either over a land or over a water surface. The surface condition is not responsible for their formation yet it may cause some modification in their development.

In this study of the basic wind system particular attention should be given to one outstanding fact. All prominent pressure formations of the general circulation are separated by approximately 120 degrees of longitude from duplicate formations which are alike in all essential features. In other words, the general circulation may be divided into individual units, all of which are formed according to the same general pattern. The general features of one unit are similar to the general features of any other unit except as they may be modified due to variations in the earth's surface.

The general features of the several units are essential parts of the basic wind system, yet they do not remain permanently in exactly the same position. They are known to shift their positions in an east-west direction according to weakness or strength in the circulation (3). The writer has also observed a shift in a latitudinal direction which seems to be far more important than the longitudinal movement. Both movements seem to be associated with a more powerful or less powerful sun. A more powerful sun seems to cause the general features of the several units to develop eastward and toward the equator, while a less powerful sun causes them to develop westward and toward the poles.

The observed phenomena suggest that the basic wind system consists of six units of circulation which are formed by atmospheric streams that are forced out of the equatorial region under considerable pressure. Similar streams which are produced in a similar manner form units of circulation that are alike in all essential features. Similar units of circulation tend to produce similar weather and similar climatic conditions in corresponding areas of the several units except as those conditions may be modified due to variations in the earth's surface.

This conception of the basic wind system should aid in the solution of many problems that confront meteorologists, climatologists, geographers, geologists, archaeologists, and workers in other sciences which are either directly or indirectly affected by weather and climate.

References

1. Lott, A. V., 1940. The true value of the earth's rotation as a deflective factor. Proc. Indiana Acad. Sci. **49**:119-130.

2. Humphreys, W. J., 1929. Physics of the air, Second edition, McGraw, New York.

3. Allen, R. A., Statistical studies of certain characteristics of the general circulation of the northern hemisphere. Quar. Jour. Roy. Met. Soc. Sup., **66**:88-101.