northwestern corner to over 4,000 feet in the northeastern corner. The topography is characterized by a number of parallel ridges, running in a north-northwest direction. The northeastern part has more the character of an irregular and undulating table-land. Through the ridges and the plateaus the watercourses have cut deep and narrow canyons. The Yuba River with its branches drains the larger part of the district. Noncut Creek on the north and Bear River on the south are the only other streams of importance.

Geology.—Sedimentary formations occupy comparatively few areas in the district, all of which have been tentatively referred to the Calaveras formation, no fossils having been found in them. They consist of slates and quartzitic sandstones, usually with northerly strike and steep easterly dip. Diabase and porphyrite occupy large areas in the central and southern parts, as well as intrusive masses of granodiorite and gabbrodiorite. Amphibolites, resulting from the dynamo-metamorphism of diabase, gabbro and diorite, also occur in several places. The rocks of the district are principally massive, in contrast to those of the districts adjoining on the south and east. However, two lines traverse it along which extensive metamorphism has taken place and schistose rocks have been developed. The superjacent rocks, resting unconformably on the older series, consist of Neocene river gravels, together with beds of andesitic and rhyolitic tuffs. Comparatively small areas of these remain, the larger part having been carried away by erosion. Pleistocene shore gravels and alluvium occupy the southwestern corner. The Ione formation is not well exposed in this district, being in part covered by Pleistocene deposits, in part removed by erosion.

Economic Geology.—Important and rich Neocene gravel deposits in this district have been worked at Camptonville, Nevada City, North San Juan, Badger Hill, French Coral and Smartsville. Gold-quartz veins occur scattered throughout the area, but by far most of them are found in the immediate vicinity of Nevada City and Grass Valley. These districts are among the most important of the gold-mining regions in California. Many of the rocks of the district are adapted for building purposes. The only one in extensive use is the granodiorite, near Nevada City. The often deep-red soils in the foothill region are of residuary origin. Extensive areas of alluvial and sedimentary soils are found only in the southwestern corner.

INTERNATIONAL CLOUD OBSERVATIONS.

IN a series of papers on the storm tracks and allied phenomena, prepared under the direction of the Chief of the Weather Bureau, much has been written about the cyclonic circulation at the surface of the ground, but the subject would be very incomplete without alluding to the efforts that are being made to determine the circulations of the upper atmosphere all over the globe. Theoretical solutions, to some extent confirmed by observations, have been given, and yet the true connection between the general and the cyclonic circulation has not been properly cleared up and tested by experience. So far as the general movements are concerned, the components are somewhat as follows in the northern hemisphere, those south of the equator being counterparts. Along the meridian from Lat. 24° to the equator the component is south, to the pole it is north; in middle latitude, where the extra tropical cyclones prevail, there is a northern component in the middle cloud strata, and two southern components, one near the ground and one in the cirrus strata. Along the parallels of latitude there are two systems of components; from 0° to 35° latitude, a westerly component at the surface, and an easterly in the higher layers; from 35° to 90° latitude two easterly components, making a maximum and rapid eastward drift in the neighborhood of 54°. In the vertical, from 0° to 20° and from 70° to 90° latitude, there is an upward component; from 20° to 70° latitude, a downward component. The cyclonic and the anti-cyclonic motions to some extent spring out of these, but the really active part of them is confined to the strata within two miles of the ground, and yet the precise course of the stream lines is not comprehended throughout their extent.

Much light has been thrown upon the obscure features of these problems by observation at high altitudes, and especially by measurements of cloud heights and velocities, but still much remains to be done to reach satisfactory conclusions. It is thought that some account of these observations to be undertaken shortly, and a reference to the important literature regarding them, may be of interest to those who have these subjects at heart, especially those who are coöperating in the work of the U. S. Weather Bureau.

The attention of meteorologists, in the early developments of the subject were, naturally almost exclusively confined to studies on the data furnished by the lowest stratum of the atmosphere. The circulation and physical conditions of the air in the higher strata were investigated to some extent by means of the theoretical considerations and the general movements of clouds. It has, however, become apparent that a scientific knowledge of the action of the currents in cyclones and anti-cyclones can be obtained only by a determined attack upon the physics of the upper levels of the atmosphere. Progress in meteorology, working along the original lines at the surface of the ground, has for a number of years been disappointing, and it is well known that in the art of forecasting almost exactly the same methods that were perfected twenty years ago are still employed. There seems to be little hope of improving this state of affairs, unless a radically new way of dealing with the data can be devised, which will efficiently supplement the system now in use.

The Chief of the Weather Bureau has expressed the opinion that there are two or three lines of investigation promising the wished-for results. One is the practical development of the knowledge already gained regarding the polar magnetic radiation from the sun. The serious difficulty in the way of doing this has been the expensive and complicated nature of first-class magnetic observatories, which must necessarily limit the number in the United States. What was wanted was a simple, inexpensive and yet reliable instrument, that could be utilized as readily as a barometer, thermometer or a watch. It seems now, after a couple years of trial, that such an apparatus is in hand, and a record of its performance will be published, with a description of it, beginning in the January number of the *Weather Review* for 1896.

Another process for getting at the action of the upper air is the transportation of barometers, thermometers and other apparatus into the higher levels. This can evidently be done by mountain stations, balloons and kites, and experiments are being conducted by the Weather Bureau to carry out this purpose as far as practicable.

A third line of investigation is the study of the clouds in all their aspects; the conditions under which the several forms are developed; the heights of the several levels, the variations of the same in the diurnal and annual periods, and particularly in connection with the cyclonic circulation of the lower strata; the direction and velocity of movement in the general circulation of the currents of the atmosphere as well as around the barometric maxima and minima. The fact that clouds are present almost every day in a series of forms which pass from one to the other by delicate gradations, each of which must indicate specific physical properties, shows that this is a very rich field of research, which has been only imperfectly cultivated. Many interesting conclusions have been developed by observers of such phenomena in the past fifteen years, but only during the past five years has the conviction become general that this is one of the most important studies for the practical meteorologist.

With the view of reducing the details to uniformity of method, and to secure coöperation among the observers in different countries, an organization has been completed which will go into effect this spring. A brief history of the movement is as follows: The measurement of cloud heights is an old problem and many devices have been invented for the solution of the practical difficulties, of which a full account may be found in the Report of the Chief Signal Officer, Part 2, 1887, by Prof. Cleveland Abbe. More or less systematic observations, extending over considerable periods of time, have been made at Berlin, Upsala, Storlien, Kew and Blue Hill, (Mass.), by methods depending upon triangulation. Besides the simple trigonometric formulæ, another system for computing the shortest distance between the two sight lines, devised by Ekholm and Hagström, Upsala, also a process for reducing the points on a photograph plate exposed in a photogrammeter by Åkerblom, Upsala, have been successfully used and are recommended as the best known.

The following are the leading papers on cloud observations:

1. Mesures des hauteurs et des mouvements des nuages, par N. Ekolm et K. L. Hagström, Upsala, 1884.

2. Des Principales méthodes employeés pour observer et mesurer les nuages, par Hildebrandsson et Hagström, Upsala, 1893.

3. De l'emploi des photogrammètres pour mesurer la hauteur des nuages, par Akerblom, Upsala, 1894.

4. Observations made at the Blue Hill Meteorological Observatory, Annals Harvard College, Vol. XXX., Part III., by H. H. Clayton and P. S. Fergusson, 1892.

At the International conference, Munich, 1891, a committee was appointed to consider the question of concerted observations on the direction of motion and the height of clouds. This committee recommended that observations on the direction of motion and the height of clouds should be commenced at certain stations distributed over the globe, and continued for one year; that short instructions be prepared for these observations; that the scheme of cloud classification put forth by M. M. Hildebrandsson and Abercromby be adopted, and a cloud atlas illustrative thereof be published.

As the result of these propositions, the coöperative international cloud observations will begin May 1, 1896, and continue one year. As far as known, the theodolite method will be employed at Washington, D. C., Blue Hill, Mass., and Christiania; the photogrammeter method at Upsala, Paris, Potsdam, Petersburg, Nijni Novgorod, Manila, Batavia, Melbourne and probably Kew, Calcutta and Sydney. The difficulty in cloud observations is to have two observers, separated by a base line nearly one mile long, set their sight lines on exactly the same point of a rapidly moving and dissolving cloud. The advantages of the theodolites is that the instruments are cheaper, many more observations can be taken with the same labor and the calculations are the briefest possible by any method. The observations that must be rejected at the outset can be determined by a small plotting machine, being a model of the real base line and instruments, such as invented by H. H. Clayton, at Blue Hill. Photographs, on the other hand, possess the advantages of giving definitely the point on the cloud, but the difficulty of securing photographs of all kinds of clouds in all weather is very great, and the cost of the work much more for the same number of individual observations. The international classification of cloud forms has been issued, and it will be adopted by the Weather Bureau and go into operation July 1, 1896, throughout the service. Suitable instructions and illustrative forms have been prepared for the observers, with which they are to become familiar before the date mentioned. The atlas of cloud forms issued by the Committee is now ready for distribution, and may be purchased of M. Teisserenc de Bort, Bureau Central Meteorologique, 176, rue de l'Universite, Paris, France.

Besides the observations with theodolites and photogrammeters for the actual heights and velocity of motion of clouds at the primary stations, a number of secondary stations for the relative motions, and the other available data, will be established in each country. In the United States there will probably be ten such stations under the immediate control of the Weather Bureau, equipped with nephoscopes for the observations. It is very desirable that the network of the stations be made as complete as possible in all parts of the country, and it is hoped that this opportunity for coöperation may be embraced by other persons willing to do some valuable scientific work. The colleges might profitably instruct their students in such observations at a very moderate expense. A first-class nephoscope can be made for twenty dollars, and serviceable ones at lower rates. The observations would require half an hour's work three times a day, between 8–9 a. m., 1–2 p. m., 5–6 p. m. The Weather Bureau will furnish suitable instructions to observers, and will aid them as far as possible in explaining the very simple computations that would be needed to prepare the observations for final discussion.

There are many forms of nephoscopes in use, but the one devised by Prof. Marvin, of the Weather Bureau, seems to be especially well adapted to the requirements. A description of it will be found in the January number of the *Weather Review*. It may be said in this place that its best feature is the device for keeping the sighting knob exactly twelve centimeters above the mirror in every possible position, so that the unit of height becomes 1000 meters, and the velocity in meters per second at that height is just one third the number of millimeters passed over by the image in 25 seconds. This makes the computations very easy, and when the height of the cloud level is known from the theodolite work, the actual velocity is obtained by simply identifying the cloud observed from its form as belonging to such a level. The mean of a large number of observations gives a true velocity. The base line at Washington is about 1360 meters long, one end on the Weather Bureau building, and the other on the War, State and Navy building. The ratios of velocity by the theodolites and nephoscopes at this station, in the different cloud levels, gives the means of using other nephoscope observations, provided the naming of the cloud forms is carefully done.

The ultimate problem is to obtain the coördinate velocities of the several components in the general circulation, and the relation that these have to the cyclonic circulations which depend upon them. The importance of these solutions to the art of forecasting, and the fact that voluntary observations made in widely separated parts of the United States are needed as contributions to the network, together with the simplicity that pertains to nephoscope work, induces the hope that some interested in the physics of the air may take up the task of coöperation.

FRANK H. BIGELOW.

WASHINGTON, D. C.