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by

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POST WAR METEOROLOGY IN CENTRAL EUROPE.[1]

By

Heinz Reuter [2]

During the war the whole weather service in Austria as well as in Germany was handled by the German Air Force. The main forecast centre was located in Berlin from where all necessary weather information, including the upper air data and the forecast map, were transmitted. No official public weather service was reestablished in Austria. Since 1945 in the same manner as before 1938 the Zentralanstalt fuer Meteorologie und Geodynamik in Vienna is responsible for all meteorological service in Austria including the public weather forecast, the climatological and the seismological service. At present the Austrian weather service does not deal with flight forecasts. Aviation forecasts are prepared by the different occupation powers. In addition to the Central Institute in Vienna, four smaller weather stations have been established in the four different occupation zones. Each of these stations produce a special forecast for the particular province. These provincial weather stations are connected to the Central Institute by a teletype system. From Vienna, as well as from the other stations, a public forecast is issued three times daily and an extended forecast for 3 days is issued twice a week. Every day a printed weather map is issued showing the analysed surface pressure distribution over Europe and containing all Austrian weather reports. The Director of the Meteorological Service of Austria is Prof. Dr. H.V. Ficker who is also the head of the Department of Meteorology at the University of Vienna.

In Western Germany just after the war three different weather services, according to the three occupation zones, have been established. But gradually the Meteorological Service in the U.S. zone located at Bad Kissingen became the main centre. The Director of this Service is Prof. Dr. L. Weikmann and the Forecast Section is directed by Dr. Scherhag. Western Germany is connected to the teletype system of western Europe but in Austria the weather reports from outside the country can only be received by radio. This holds also for all reports from eastern Europe including Russia. The main transmitting stations such as Dunstable, Frankfurt, Paris and Moscow transmit, in addition to the weather reports, analysed surface and upper air charts and forecast maps. The use made in our weather service of these analyses depends on circumstances.

1 Presented at the regular meeting of the Royal Meteorological Society, Canadian Branch, held in Toronto, March 30, 1950.

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If for any reason a lack of reports occurs for a certain area it is convenient to use the analysis. This is particularly true of the upper air charts. It has been interesting to compare the three forecast maps issued from Dunstable, Frankfurt and Moscow all of which include Austria. Experience has shown that at least for Central Europe the German forecast map gives the closest fit to the actual weather situation.

The methods used at present in Austria and Western Germany in preparing the forecast are to some extent different from those developed in other countries. One of the reasons is the long wartime isolation which made it necessary to develop their own methods. Furthermore the particular orographic features of Austria and the southern part of Germany made it necessary to carry out special investigations dealing with weather developments peculiar to mountanous regions. The long high mountain ridge of the Alps extending from the west to the east of Austria affects the whole weather developments considerably and for this reason quite different weather regimes exist in the northern and southern parts of Austria. On the other hand we obtain reports about the upper air conditions from a number of mountain stations every 3 hours. The highest stations are almost 10,000 feet above sea level, which means that these reports are coming from the 700 mb. level.

A main feature of the Austrian as well as the German Meteorology is the particular interest in all pressure changes especially in the 24 and 3 hour pressure tendencies. For this reason isallobaric charts are prepared insofar as possible. In Vienna at present only surface isallobaric charts are drawn whereas in Germany isallobaric charts for the upper levels are prepared every day as well. Usually for the construction of the 24 hours isallobars a tracing desk or a light table is used. In any case it is necessary to draw these maps very carefully since a good deal of the forecast depends on these charts. #

The basic chart of the German weather service is the forecast map. Scherhag has played a leading role in developing methods for their routine construction.

I will try to give you an idea of the history of this forecast map and about the theories applied to it.

The first attempt was made at the Hamburger Seewarte in 1933 to predict cyclone tracks using an upper air chart. This project was started by Scherhag, Pogade, Roediger and Pflugbeil. Each of them has produced a large number of contributions to that problem up to now.

The pressure measured at the surface provides and integrated measure of the whole atmosphere and is a meteorological element which is measured with great accuracy. So it seems to be necessary to deal with this value and not to try to omit it from the equations of motion.

The possibility of constructing a forecast map with the aid of the analyzed surface map, the thickness pattern and the 500 millibar contour map was first mentioned at the International Meeting of the Aerological Commission at Berlin in 1939.

Since 1941, a forecast map has been issued everyday by the central German meteorological group. In order to prove the accuracy of this map the correlation factor between the predicted and the actual pressure change for 20 stations in Central Europe has been computed. This factor is of the order 0.7 to 0.8.

The problem of the steering mechanism.

For an understanding of the methods used for the forecast map the problem of the so called "steering mechanism" is of greatest importance. Therefore I would like to direct your attention to the basic ideas about this problem as they have developed in Germany during the last 20 years.

In an investigation dealing with the big storm of July 4th, 1928, over Central Europe Dr. Ficker showed for the first time that it would have been possible to predict the track of this storm following the upper air wind direction. He described this mechanism by the word "steering".

Later on Muegge and the Frankfurt School directed special attention to the steering problem. Muegge pointed out that the upper air current steers the pressure tendency (i.e. the isallobars) more than the pressure distribution itself.

Moeller came to the conclusion that those upper air levels in which the contours show the straightest traces are responsible for the steering i.e. a level which is not yet disturbed by the surface depression.

Furthermore it was found by the Frankfurt School that each point of the pressure wave is steered - not only the centre of the low.

Scherhag showed later on that for the displacement of the isallobaric distribution the best fit to the observations was given by use of 50 to 60% of the gradient wind velocity in the 500 mb. contours.

At this point it must be mentioned that the so called warm sector rule by Bjerknes, Solberg and Palmén for the displacement of a surface depression is to some extent the same statement viz: the track of the upper air pattern is quite similar to the streamlines in the warm sector of a cyclone as long as the upper air current is not seriously affected by the surface depression.

From the intensive study of a great number of synoptic situations Sherhag came to the following conclusions:

1. If an anticyclone shows closed isobars up to great heights it is impossible for a surface pressure wave to penetrate the area covered by the anticyclone. In this case the surface pressure wave is steered in a clockwise manner around the high pressure. (Anticyclonic steering).

2. If, on the other hand, a cyclone extends from the surface up to great heights a small surface pressure wave is steered in a counterclockwise manner around the cyclone. (Cyclonic steering).

These statements hold as long as the steered pressure wave is small compared with the steering area.

This last statement can be also expressed in other words: A pressure tendency area follows the upper air current as long as it cannot be recognized as a small deformation in these patterns.

It is a particular feature of the German weather service that the 500, 225 and 91 mb. levels are used rather than the International Standard Levels 500, 300, 200 and 100 mb. The reason was that the average pressure at equidistant levels over Berlin, i.e. at 5000, 10000 and 15000 metres, has been found to be 500 mb., 225 mb., and 91 mb. respectively. I don't believe that the use of these rather peculiar levels can be justified from this view point. Actually the methods used for the construction of the forecast map do not depend essentially on the use of these specific levels.

All these statements have been proved by a great number of synoptic investigations. Although some of them may be open to serious objections from a theoretical point of view, we have in any case, to consider the empirical facts. The steering mechanism is very complicated and therefore it seems to be rather difficult to find a theoretical explanation for all details. The complex nature can, for instance, be seen by the fact that the steering occurs only with 50 to 60% of the upper air wind velocity.

It was found that the 225 mb., or even the 91 mb., contours are affected by the surface depression.

A particular case has been investigated by Scherhag dealing with the separated solitary upper cyclones for which he used the name "cold pool" or "cold dome" (Kaltlufttropfen). Without trying to find an explanation for the origin of these upper air cyclones (a problem which was studied by Rossby and his collaborators) Scherhag stated that these upper air lows are steered by the surface wind or the gradient wind in the 1000 mb. level. In his opinion the surface pressure distribution is the least disturbed one in this particular case.

It is quite clear that the main condition for an accurate weather forecast is the correct analysis of the surface map. That means first of all the determination of the different air masses. Since the methods of air mass analysis are well known I will not discuss them in detail. But I want only to mention that it has been the experience in Germany and Austria that it is better to consider only the main air masses rather than to go into more detail.

In practice it is often much easier (as Dr. Sutcliffe has pointed out) to locate the fronts than to define the air masses and the method adopted is usually a compromise. Naturally in order to define the air masses, all available upper air data especially the thickness pattern 500/1000 mb. are used.

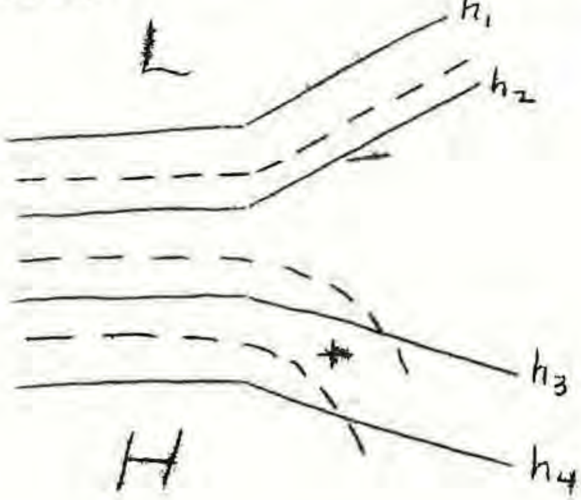
In 1928 Bergeron introduced into Meteorology the idea of the so called frontal zone (Frontalzone). This frontal zone is defined by an area in which two different air masses have been approached closer than a distance of 1000 km. I am not intending to talk too much about this well known theory. I shall only outline the theory and conclusions made by Scherhag and others dealing with the upper air situation connected with this frontal zone.

It is evident that above the frontal zone a speed up of the upper air current has to occur. As you know this problem is closely connected with the "Jet Stream" theory and the question is, what is the cause and what is the effect. Actually many European Meteorologists believe that the confluence of these two different air masses is the cause for the high wind velocity observed in upper levels.

If we look at the contour lines and the actual stream lines at the 500 mb. level, we find that they are not coincident. The deviation of the streamlines from the contours will be found in the entrance of the frontal zone and in the exit or Delta of the frontal zone. Scherhag's so called "divergence theory" is based on the assumption that the streamlines of the upper air current are not coincident with the contour lines in the area of the frontal zone. First of all it must be mentioned that experience has shown that in the large majority of the cases investigated, cyclogenesis has occurred only in the Delta of the frontal zone whereas the filling up of the cyclones has been observed in the entrance of the frontal zone.

In 1927 Ryd developed a theory of the cyclones investigating the role of the kinetic energy of the upper air current. He came to the following conclusion:

Because of the high kinetic energy of the current in the Delta of the frontal zone a deviation of the streamlines towards the higher pressure must occur.



In other words he has shown that, in the area marked by a plus sign, a pressure rise, and, in the area marked by a minus sign, a pressure fall must be expected. Ryd gave in this way a theoretical basis for the observed pressure fall in the Delta area and the cyclogenesis connected with it. Scherhag has investigated the development of the cyclones in the Delta. Roediger, also, has published a great number of papers dealing with this subject. Although some of his conclusions are based on Ryds theory many can be only considered as more or less empirical rules. The most important of these rules are summarised as follows:

1. If the upper air contours are divergent, pressure fall can be observed at the surface except if there is a well marked convergence in the surface isobars. Scherhag has emphasised that simple fanning of isobars does not in itself constitute divergence. Ryd's postulate has provided the working hypothesis.

2. If the upper air contours are convergent pressure rise can be expected unless at the surface a divergence is observed.

3. A surface low (cyclone) will be stationary if a divergence of the contours can be observed aloft (immediately over the centre).

4. An anticyclone (high) is likely to become stationary if the upper air contours show a convergence (immediately over the centre).

5. Cyclogenesis occurs in the majority of the cases in the Delta of the frontal zone whereas the dissipation of cyclones is likely in the entrance of the frontal zone.

6. If on account of a large pressure fall an upper air low with closed isobars is established, the surface issalobars will show a splitting off.

7. The isallobaric areas in the surface map are steered by the 500 mb. contours with a velocity of about 50 to 60% of the velocity in this level. If the 500 mb. level is disturbed by the surface depression the next higher undisturbed level must be used.

The theories outlined above and the resulting rules from them are used to construct the daily forecast map.

Before the forecast map can be constructed a carefully analysed surface map, the thickness pattern and contour lines of all upper levels must be available. Furthermore the three and 24-hours issalobars have still to be drawn before one can start to predict the expected pressure change 24 hours in advance. It may be mentioned that the three hours issalobars have to be used when the weather regime is to be expected to change very rapidly. In practice it is sometimes useful to consider that roughly the 3 hours pressure tendency is 1/5 of the 24 hours tendency.

The first step is to forecast the pressure changes. After this has been done it is easy to forecast the surface pressure distribution. Although the simple steering mechanism is rather easy to handle, the problem of deepening and filling up of a depression is much more complicated. If therefore the forecast map shows obviously unnatural situations it has to be revised by experience. The deepening process can be recognized in many cases by comparing the 3 hours issalobars with the 24 hours. If an area shows only small 24 hours pressure change but a large 3 hours tendency a deepening can be expected. In order to locate the fronts it is convenient to draw them as a first approximation at those places where convergence occurs in the forecasted map. But it is necessary to correct this location considering the displacement of the fronts using the gradient wind of the surface map.

As I have stated before the particular orographic features of Austria have made it necessary to introduce special methods in the forecast routine. About 20 years ago Prof. Ficker developed a theory of cyclones. In his opinion the life history and the development of a cyclone can best be explained by two different pressure waves propagating in the same direction but with different speeds. He called the upper air wave the primary and the surface wave the secondary wave without attempting to decide which one plays the dominating role. His theory was previously proved by means of the mountain stations and later on by radiosonde ascents and has been verified in many details. In principle 5 or 6 different cases can be considered using the 24 hours temperature and pressure change at a mountain station and at a station in the valley.

1. 

No essential pressure change at the upper (mountain) station. Pressure fall at the valley station. Increasing temperature in the layer between the valley and the mountain.

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2. 

Heavy pressure fall at the valley station. The beginning of falling pressure at the mountain station accompanied with a small decrease in temperature at the upper level (Prefrontal cooling). In the valley still increasing temperature. (Outbreak of cold air can be expected in the next 24 hours.

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3. 

Outbreak of cold air in the lower layers with decreasing temperature and increasing pressure in the valley station but still decreasing pressure at the mountain. Continuous rainfall or snow in the mountain region.

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4. 

Beginning of increasing pressure at the upper level . Continuous pressure rise at the valley station. Only a slight further decrease of temperature. Change to better weather with ending precipitation and becoming clear can be expected for the next 24 hours.

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5.  Increase of pressure at the valley and the mountain station. At the same time increasing temperature in the layer between the valley and the upper level.

6. Building up of a dynamic high. Continuous fine weather can be expected until the pressure at the valley station begins to fall again, which leads back to the first case.

I have tried in my talk to outline the methods used at present in Central Europe for short range weather forecast. It should be mentioned that also other methods have been developed and used at several European stations. But most of these methods have only restricted possibilities for application at another place since they depend on the particular features of the country. These special forecast methods deal with thunderstorm warnings, Foehn effects, and so on.

In addition to this talk about the short range forecast routine in Central Europe you probably would like to hear a few words about the long range forecasts. At present, no long range forecasts are issued in Austria. Our extended forecast for 3 days in advance is based on hemispheric maps, especially upper air charts, which are now drawn once a day. The methods adopted for this extended forecast are due largely to Rossby's theories about the long waves in the westerlies. However, we use these methods only in order to obtain a general idea of the displacements of the centres of action. Our Institute has also attempted to introduce an absolutely different method in the long range forecast routine. This method is not yet published and is in the state of development but the idea on which the method is based may be of some interest to you. From experience we came to the conclusion that for a certain weather regime in our country, i.e. in Central Europe, not only are the locations of the centres of action (dominating anticyclones and cyclones) but the areas covered by highs and lows are also of great importance. In order to introduce an objective method to prove these rather vague ideas we have started to evaluate every day for the dominating highs (Azores high) and lows (Icelandic low) the area covered by a certain isobar with the aid of a polarimeter. The result was plotted against time. In addition to this method we also have evaluated for every day for a given area in SW, NW, and NE Europe the mean pressure, again using a polarimeter. The results have been plotted against time in graphs now available for a period more than one year. Experience has shown that some periodic fluctuations could be found; a kind of long range pressure waves in the different parts of Europe. But this result has not been so important for a long range forecast routine, as another result obtained from these graphs. It has become evident to us that a change in the whole weather regime can be recognized at least 3to 4 days in advance in the pressure tendencies of the different considered areas. For instance if the pressure is increasing in the northern area and at the same time decreasing in the south western part of Europe an outbreak of cold air can be expected even if there are no other signs in the available synoptic weather charts.

In Germany, as far as I know, only a 10 day long range forecast is issued at present. The method adopted to this forecast is based on the work of Dr. F. Baur. It is impossible to describe in few words this method but I hope that most of you have at least heard of his work. The experience has shown that his method for a period of one week up to 10 days in advance can be applied with some success for forecasting.

During the war Baur's institute also produced forecasts one month in advance, but actually these forecasts were not too good and have not been used very much in practice.

In order to illustrate the deepening process according to Scherhag's theory. I want to show you a particular weather situation.. If we look at the surface map of March 22nd (Fig. I), we recognize two waves in the Polar front; one of them in the west of the U. S., and one at the east coast. The waves are more marked by the frontal system given by the analysis, than by the isobars as separate lows. In Fig. II, the upper air contours (500 mb) of the same date are shown together with the surface frontal system. Regarding the surface waves, we notice that there is a well marked fanning or a divergence in Scherhag's terminology of the contours immediately over the centre in both cases. Therefore, a deepening and the formation of separate lows can be expected. Actually, the surface map of the following day (Fig.III) shows this development. Besides a displacement to the North East as expected on account of the ste.ering mechanism, a rapid deepening of the order of magnitude of 8 mb has occurred in both cases.

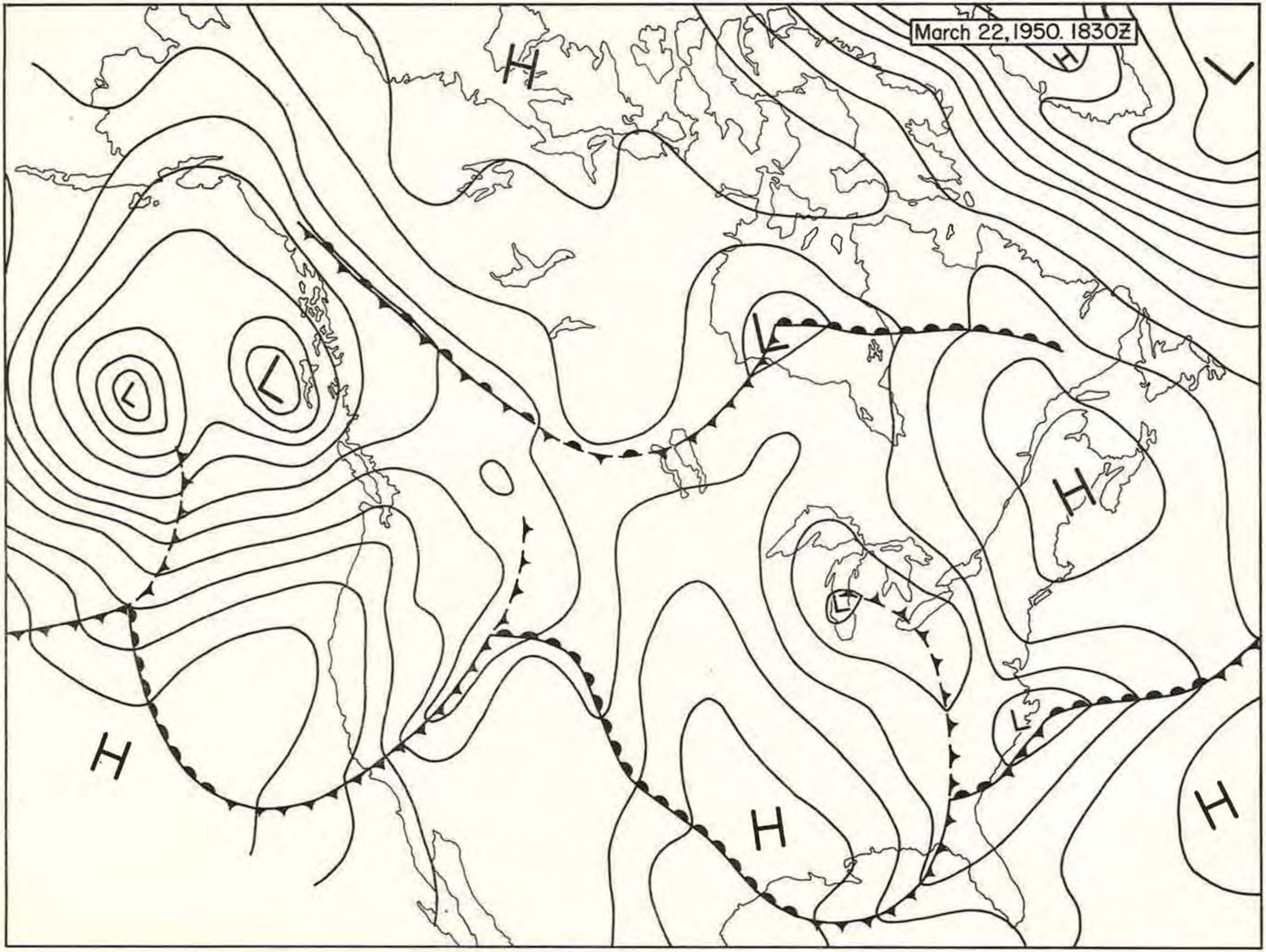


Fig. I

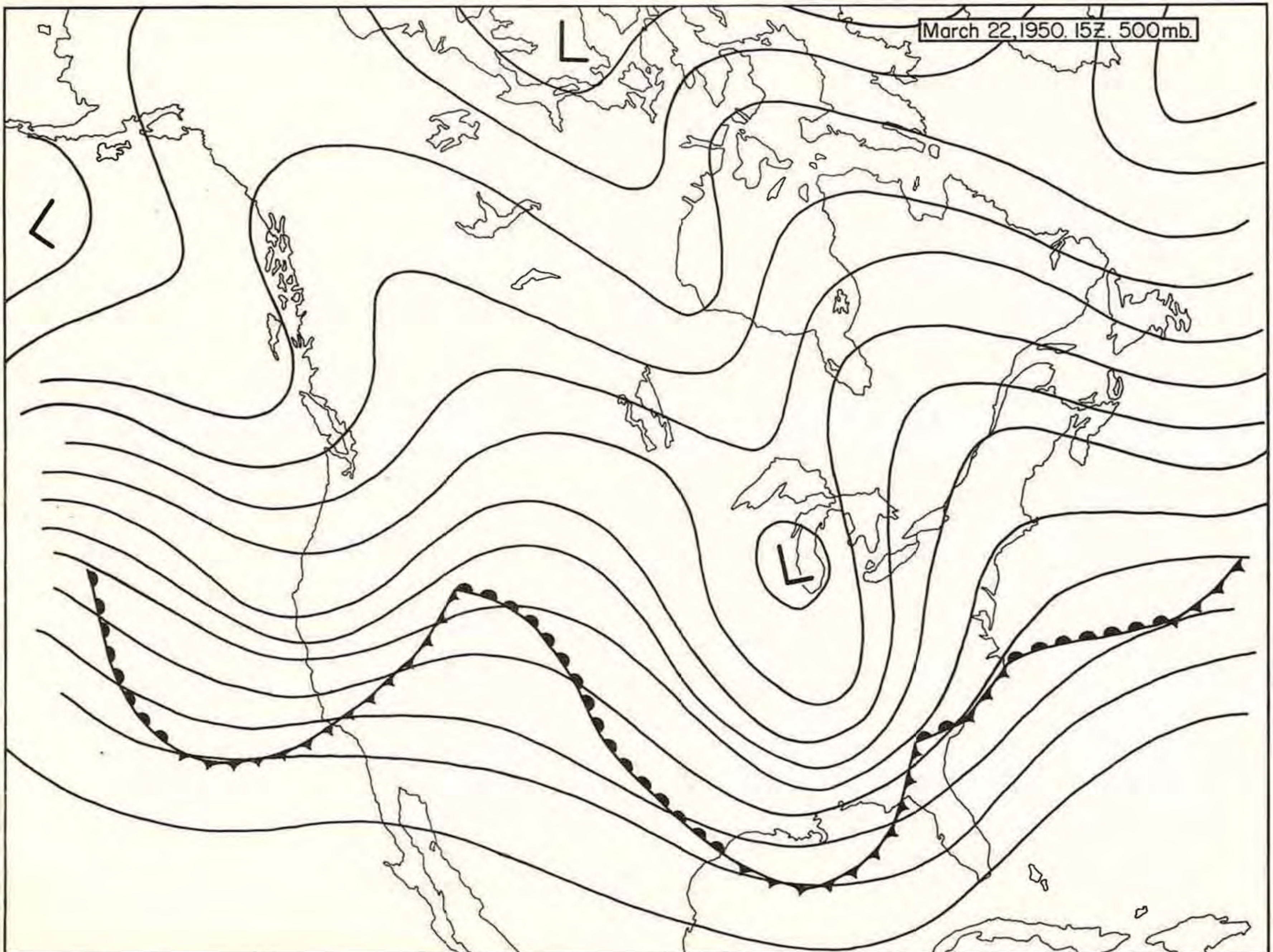
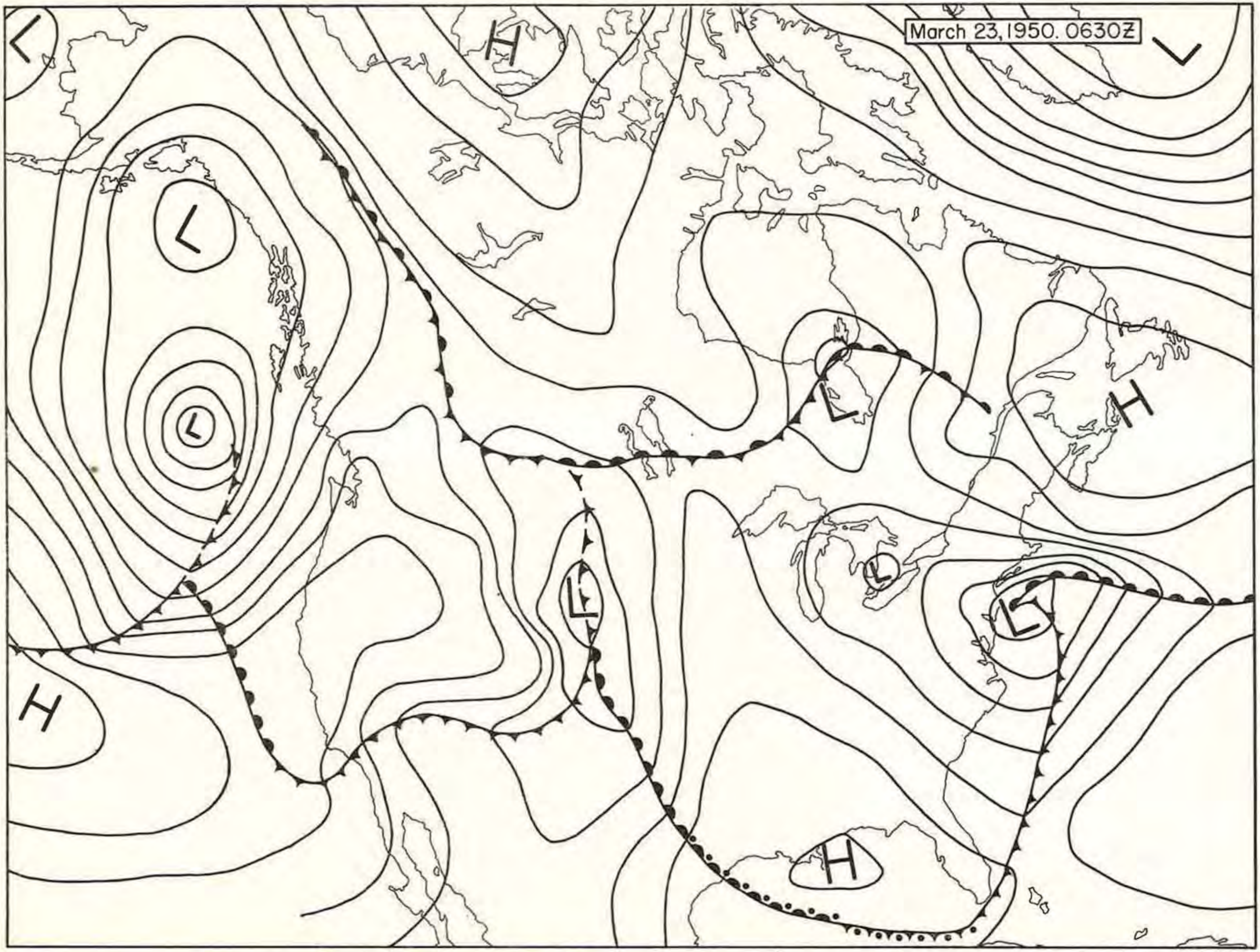


FIG. 2



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