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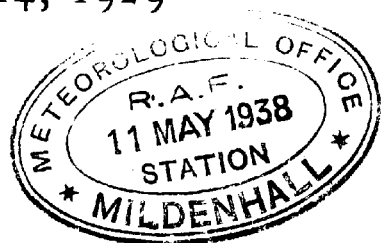
METEOROLOGICAL OFFICE
PROFESSIONAL NOTES No. 60

(Last Number of Volume IV)

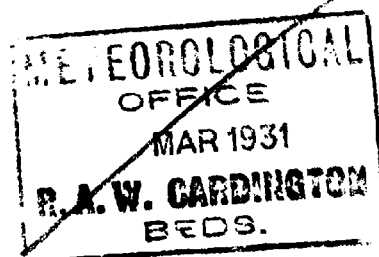
WEATHER CONDITIONS OVER
THE CENTRAL AND WESTERN
MEDITERRANEAN

during the period February 10—14, 1929

By G. A. BULL, B.Sc.



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1930

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WEATHER CONDITIONS OVER THE CENTRAL AND WESTERN MEDITERRANEAN DURING THE PERIOD FEBRUARY 10-14, 1929

By G. A. BULL, B.Sc.

During the period February 10-14, 1929, there occurred the great outbreak of very cold air from Russia which gave over nearly all Europe one of the coldest spells for a century. Accounts of the cold spell in the British Isles at this time are given by Douglas* and Crichton†. While an intense anticyclone covered the European continent deep depressions occupied the Mediterranean and conditions there were very stormy.

The method of investigation employed in this *Note* is that of air mass and frontal analysis developed principally in Norway. Little has yet been published on the application of frontology to the Mediterranean. A paper by Mariolopoulos on the "Formation of local Mediterranean depressions and the Norwegian theory of the polar front‡" deals briefly with the subject, mentioning the well known replacement of warm "scirocco" winds by the cold "mistral" or "bora" as a depression passes eastward along the basin, but offering no detailed analysis.

For the present analysis the working charts of the Meteorological Office, Malta, were supplemented by data obtained from daily weather reports of other countries and studied in conjunction with autographic records, a number of which, additional to those for Malta, were made available by the courtesy of the Meteorological Institutions at Lisbon, Corunna, Mahon, Barcelona and Algiers. In Plates I to IX portions of these charts are reproduced upon a reduced scale, which it is hoped may give sufficient detail to enable the reader to follow the analysis. In what follows, the meteorological situation of each day will be briefly described and analysed.

February 10.—(Plate I). On the morning of February 10 an intense anticyclone lay over Finland and north Russia and the extremely cold air, which may be referred to as "Arctic air," from Siberia and Russia had, in its westward movement to the south of the anticyclone, reached a line extending from the western Black Sea across the Balkans and Austria to western Germany and Norway.

From a depression near Iceland a long trough of low pressure containing an occlusion extended to southern France, while a shallow area of low pressure, filled with old maritime polar air occupied the central and western Mediterranean. The occlusion turned westwards as a cold front along the Cantabrian Mountains of northern Spain back into the Atlantic. The occlusion itself soon retreated westwards over the British Isles and northern France before the advancing stream of Arctic air, but the extension

* *Q. J. R. Meteor. Soc.* **55**, 1929, p. 230.

† *Meteor. Mag., London*, **64**, 1929, p. 23.

‡ *Paris, C. R. Acad. sci.* **177**, p. 597.

over the Cantabrian Mountains remained stationary. The portion over southern France was advancing south-eastwards and on entering the north-west Mediterranean the air behind it was sufficiently cold for it to act as a marked cold front.

February 11.—(Plates II and III). This front passed over Barcelona at 0500* on the following morning (11th) and over Mahon at 0700. At Mahon temperature fell 9° F. very rapidly (Fig. 1) while the dew-point fell 7° F. A good deal of this fall of temperature was probably due to the accompanying rain, but the dew-point remained low and continued to fall. The dew-point gives a most useful indication of differences of air mass in the Mediterranean where the warm sea rapidly destroys contrasts of surface temperature. The Mahon barogram shows a rise in pressure beginning at this time. At Barcelona the passage of the front is marked in the barogram but not in the thermogram. The dew-point there at 0700, on the 11th, was, however, 11° F. lower than at 1800 on the 10th. From Plate II, which shows the situation at 0700 on February 11, it is seen that the Arctic air had then reached eastern England and the Alps and was beginning to enter the Adriatic from the Balkans. In the Adriatic the temperature contrast between this cold air and the air already there was very great, being of the order of 20° F. The advent of the cold air produced a rapid deepening of the old dying Mediterranean depression, an effect often noticed in the Mediterranean.

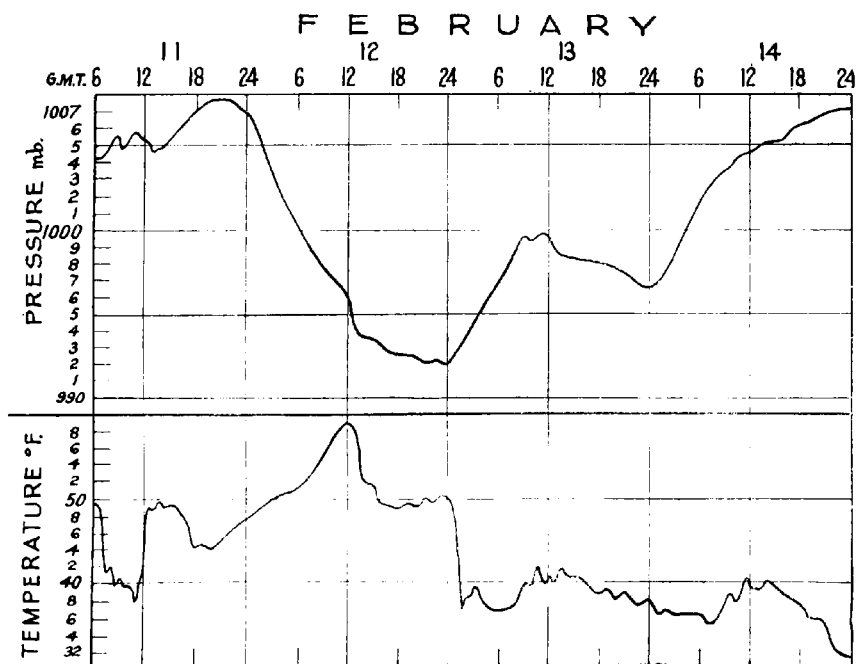


FIG. 1.—Mahon.

* All times are G.M.T.

On the front in the Atlantic, to which reference has already been made, there had formed during the 10th a moderately deep depression which moved south-eastwards along it and at 0700, on the 11th, was centred over southern Ireland. This depression continued its south-eastward movement and, deepening, began to affect the north-west Mediterranean. The cold front which had been moving southwards over the western Mediterranean ceased its southward movement in its western part and began to move back as the warm front of the depression from the Atlantic. Confirmatory evidence of these movements of air masses is supplied by the autographic records and weather records of individual stations. During the morning and the afternoon of the 11th, Mahon had northerly winds, cumuliform clouds and a low dew-point of 35° F., but by 1800 the wind had become SW. and rain was falling. The returning front passed over Mahon at 2000. Temperature rose steadily from that time until 1200 on the 12th, the total rise being 15.5° F. in that period. The highest temperature reached, 59° F., is 5° F. above the mean temperature of the sea at Mahon in February. In its south-east portion, this front, however, continued to move rapidly onwards as a cold front. It reached the coast of east Algeria and north Tunisia by 1800 (February 11) and moving on at about 30 mi./hr., which was a little below the component of geostrophic wind normal to it, passed Malta at 0115 on the following morning.

February 12.—(Plates IV and V). The autographic records of its passage at Malta are shown in Fig. 2 and are of some interest. The squall on its arrival was a double one. Wind had been SW. with a mean speed of 18–20 mi./hr. when at 0110 there came a squall of gale force and the direction veered to WNW. After this the wind lulled rapidly and backed to WSW. before the main squall which occurred at 0200 when speed rose to a mean of 30 mi./hr. and the direction became steady from WNW. Heavy showers accompanied both squalls. No *crochets* are shown by the barograph, merely the cessation of a slight fall of pressure and its alteration into a slight rise. Temperature fell 2° F. with the first squall. By 0700 the front had passed Tripoli.

During the 12th Malta lay in the current of maritime polar air and had cumulo-nimbus clouds and passing showers. The decrease of temperature as compared with the previous day was not large at the surface, maxima being 58° and 54° F., but was decidedly larger in the upper levels. Observations of upper air temperature by aeroplane are available for 0800 on the 11th and 0730 on the 12th. They show a fall of temperature of approximately 7° F. at 1,000 feet, 5° F. at 2,000 feet, 7° F. at 3,000 feet, 7° F. at 4,000 feet, 9° F. at 5,000 feet, 8° F. at 6,000 feet, 6° F. at 8,000 feet, 5° F. at 9,000 feet, and 3° F. at 10,000 feet. The surface dew-point fell from 49° F. at 1800 on the 11th to 39° F. at 0700 on the 12th.

The depression which had formed in the Atlantic on the 11th moved south-eastwards along the front upon which it formed and,

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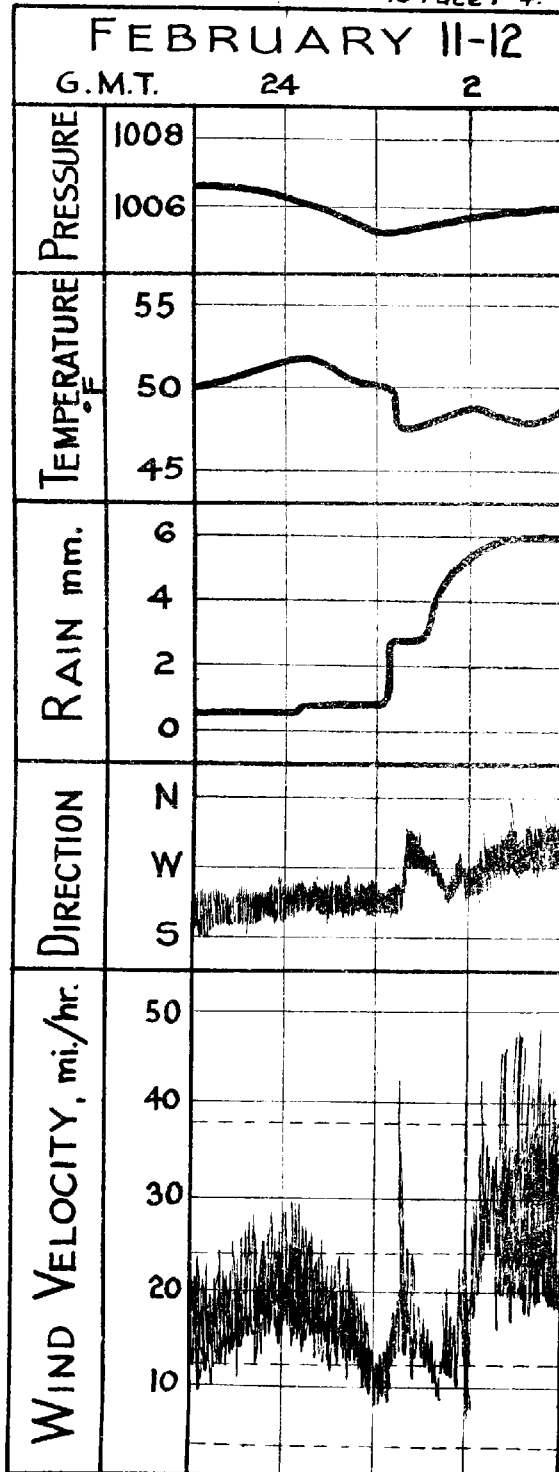


FIG.2.

MALTA

passing over southern France on the morning of the 12th, was centred at 1300 in the region of Marseilles. Its warm front had passed Ajaccio by this time and its cold front reached Mahon at about 1400.

At Mahon a change in wind direction occurred from SW. at 1300 to WNW. at 1800. The thermograph shows a fall of 6° F. in temperature between 1400 and 1800 and pressure ceased falling at the latter time. Dew-point fell 6° F. between 1300 and 1800. On the Barcelona autographic records, the passage of this front is not shown very definitely, the only indications are that pressure ceased falling after 1600 while dew-point was 7° F. lower at 1800 than at 1300. It is probable that the cold air was held up somewhat along the Pyrenees and its arrival at Barcelona thereby delayed, while föhn effect may account for the Barcelona thermogram not showing cold-front passages well. This front of maritime polar air moving south-east at about 30 mi./hr. reached Algiers at 2000, when 6 mm. of rain fell in a heavy shower and a sharp *crochet* is shown by the barograph, Fig. 3. The western part of the front passed Lisbon at 1300, but it was moving much more slowly there.

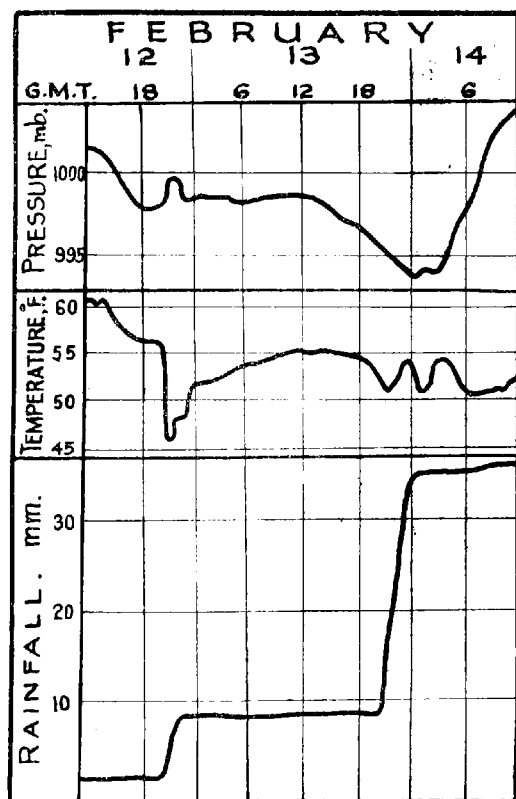


FIG. 3.—Algiers.

In the north the Arctic air overtook the occlusion over the Atlantic and the combined front moved on rapidly southwards.

February 13.—(Plates VI and VII). The situation at 0700 on the 13th is a most interesting one. The depression which moved into the Mediterranean from the Atlantic on the 12th had joined with the old depression over central Italy to form a depression with the very low (for the Mediterranean) central pressure of 990 mb. Snow was falling over a wide area covering all northern Italy and the western Balkans, the sharp front along the Adriatic with its temperature difference of 20° F. remaining almost stationary. Two fronts were to be distinguished over the western Mediterranean and the Iberian Peninsula. The more southerly of these ran from between Rome and Naples south-westward to north Tunisia, westward to southern Spain and thence over Portugal into the Atlantic. This was the front of the maritime polar air. To the west of Portugal an important development was taking place. Falling pressure was reported from Portugal while the return over Lisbon as a warm front, of the front that has just been under consideration is shown by the autographic records for the early hours of the morning. A small rain area covered north Portugal. It is evident that a depression had formed on this front out in the Atlantic and was moving eastwards along it. This might have been expected since Horta (Azores) had a WSW. wind of force 5 and a temperature of 61° F. at 1800 on the previous evening (February 12) showing the existence of a vigorous current of warm air in that region ready to cut into the cold front and cause cyclonic development.

The second front lay to the north of the first and roughly parallel to it. To the north of it lay the Arctic air. It reached Mahon at midnight between the 12th and 13th where its passage is strikingly shown by a fall in temperature of 10·5° F. (see Fig. 1), by a rapid increase of pressure and by a change of dew-point from 46° F. at 1800 on the 12th to 18° F. at 0700 on the 13th. The time of passage at Barcelona was 2000 on the 12th. Here also the dew-point fell to 18° F., while the minimum temperature for the night was 32° F., 14° F. lower than during the previous night. With the eastward movement of the main depression over Italy the northerly gradient in the western Mediterranean was slight and the Arctic front moved only slowly southwards. Mahon remained in this Arctic air for three days, during which temperature did not rise above 41° F., which is 13° F. below the mean temperature of the surrounding sea for February, while dew-point averaged 25° F. This front ran north-westwards over northern Spain. It is difficult to disentangle the fronts over central Italy, but it is clear that the Arctic air had reached Florence (temperature 21° F.) but not Rome (temperature 37° F.) by the morning of the 13th. The front that had passed Malta on the morning of the 12th was by then over western Egypt between Marsa Matruh and Alexandria.

In the forecast service at Malta the formation of the depression to the west of Portugal was not recognised until later and the

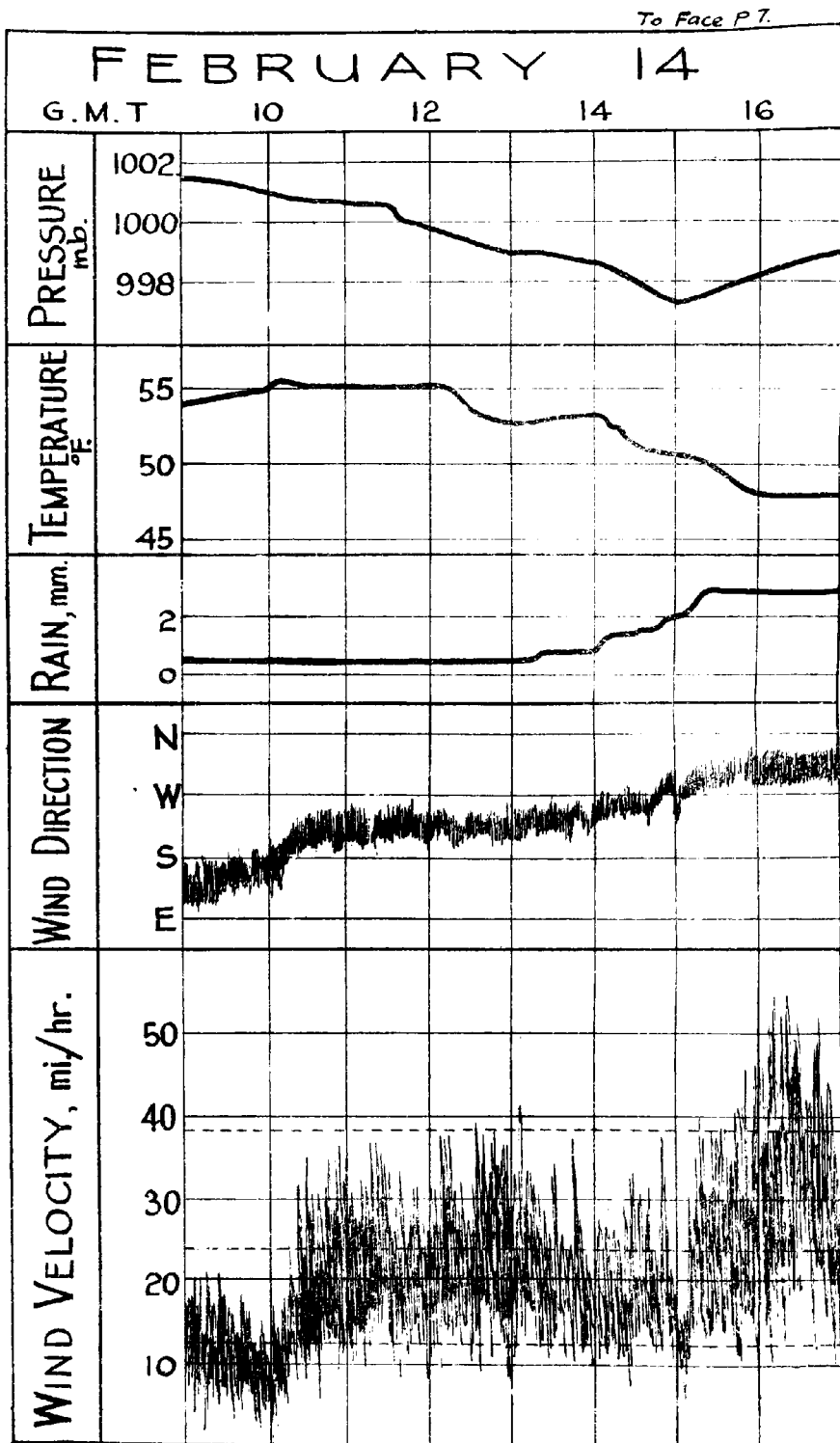


FIG. 4.

MALTA

forecast for Malta issued on completion of the chart for 0700 on February 13 was based on the anticipation that the south-eastward movement of the Arctic front would continue; it accordingly indicated the early arrival of a strong north-westerly wind with exceptionally cold weather. The depression, however, moved rapidly eastwards and the strong NW. wind did not set in until a day later (February 14). The maritime cold front reached Malta at 1100 (February 13) only to return next morning (February 14) as the warm front of the depression. It brought a veer of wind to WNW., a squall of 50 mi./hr. and a heavy shower. Subsequently the wind backed slowly to W. and after averaging 25 mi./hr. for a few hours fell off to calm by 0300 next morning (February 14).

The depression meanwhile continued to move eastwards over Portugal and Spain at about 40 mi./hr., the geostrophic wind in its warm sector being W. at roughly 50 mi./hr. Its cold front passed Lisbon at 1300 February 13 and Gibraltar at 2000 while Algiers was reached at 2400.

February 14.—(Plates VIII and IX.) In the early hours of the 14th Algiers had heavy thunderstorms with hail, but the dew-point remained above 40° F., showing that only the maritime polar air had arrived and not the Arctic air. The autographic records from Algiers reproduced in Fig. 3 show the passage of the front there at midnight. The cold air flooded all Algeria well into the Sahara, stations there reporting strong north-westerly winds and showers at 0700 on the 14th.

The depression moving east over North Africa reached northern Tunisia at 0700 having deepened to 997 mb. The warm front reached Malta at 1000 and is well shown in the anemogram. Direction veered in 15 minutes from SSE. to SW., while the mean speed increased from 10 mi./hr. to 22 mi./hr. There was much upper cloud before its arrival, cirrus, alto-cumulus and alto-stratus and the latter thickened sufficiently to give a little rain. Warm fronts in the southern Mediterranean are seldom accompanied by marked precipitation and, on the whole, are much less important factors in the weather than cold fronts.

Malta remained in the warm sector until 1500, the barometer falling continuously, the fall becoming accentuated as the cold front approached. Rapid falls of pressure take place before the arrival of cold fronts at Malta, a phenomenon that is not so marked in the British Isles.

At 1500 the wind direction veered from WSW. to WNW. The wind lulled as the direction changed but rose rapidly after and for the rest of the day averaged 30 mi./hr. with gusts of over 50 mi./hr. Flat strato-cumulus clouds prevailed in the warm sector but were replaced after the passage of the cold front by cumulo-nimbi from which fell heavy showers.

Fig. 4 shows the autographic records of the passages of the warm and cold fronts. The dew-point which had been 41° F. at 0700 and 47° F. at 1300, fell to 38° F. at 1800 and the flow from north-west of polar air continuing, the dew-point reached the low value of 33° F. by next morning (February 15). Heavy squalls accompanied by hail and rain showers occurred during the night and probably the Arctic air, now stale after a long fetch across the Mediterranean, arrived during one of these.

The maximum temperature on the 15th was 6° F. lower than that on the 14th and was 10° F. below the mean for the month.

The depression continued to move away eastwards to Greece while the front upon which it formed remained quasi-stationary in its western part and another depression formed upon it two days later.

This example shows the importance of fronts and air masses for Mediterranean weather, but considerably more investigation will be needed before their application will be on as sound a basis as it is for northern Europe.

The author is indebted to Dr. T. Bergeron, of the Norwegian Meteorological Office, who spent the winter 1928 at Malta, for most of his knowledge of the application of frontal analysis.

Numerous suggestions were made by Dr. Bergeron when the charts were being analysed in the ordinary forecast routine at Malta. The author is also much indebted to Mr. C. K. M. Douglas for valuable criticisms and suggestions.

CHARTS.

Direction and Beaufort force of wind, present and past weather, and barometric tendency are shown for each station. Past weather letter is contained in brackets. The following symbols are employed for fronts:—

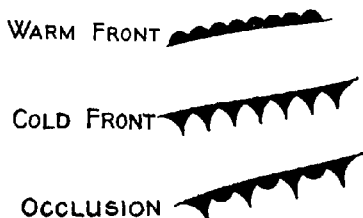
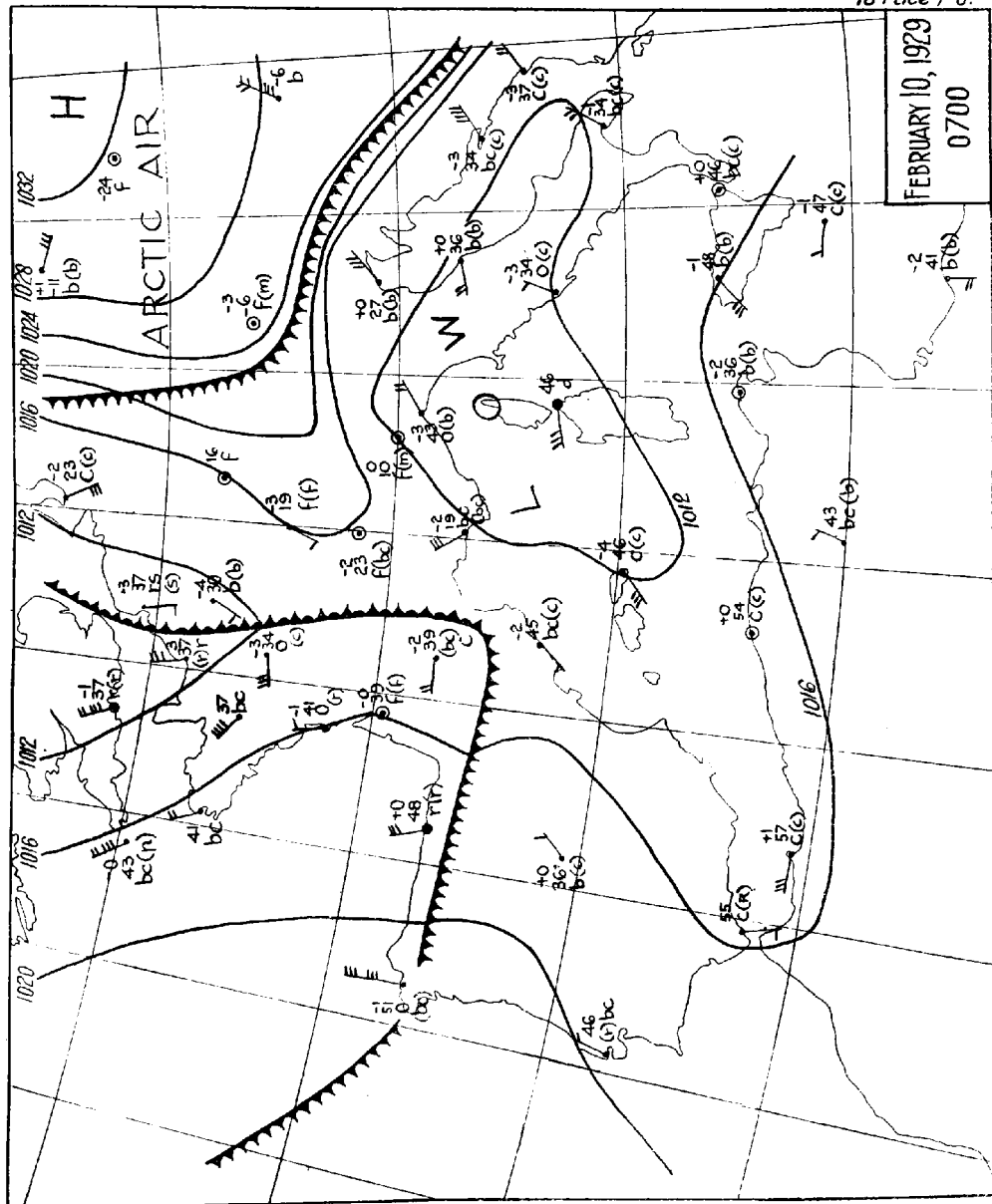


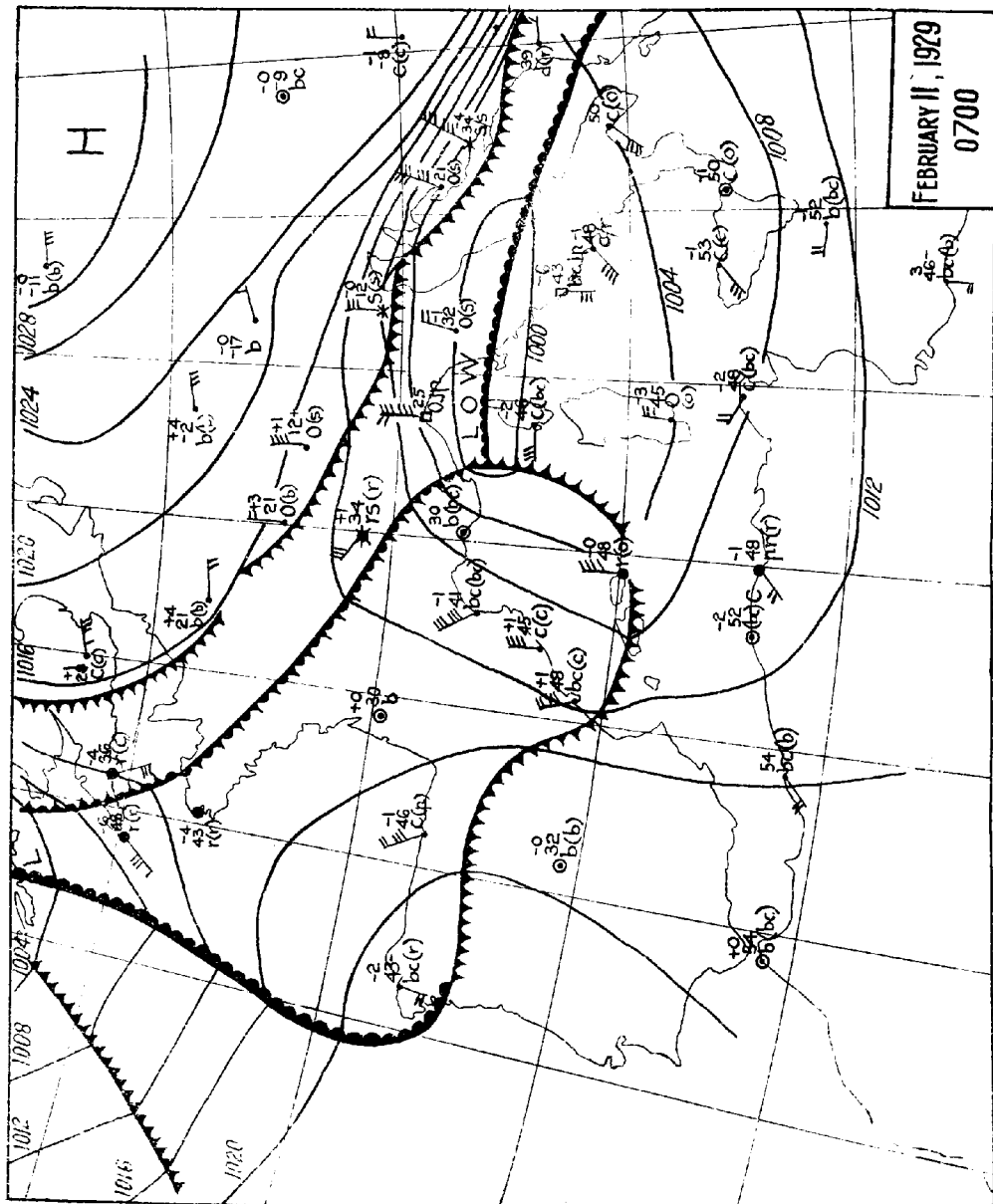
PLATE I.

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FEBRUARY 10, 1929
0700

PLATE II.



FEBRUARY 11, 1929
1800

PLATE IV.

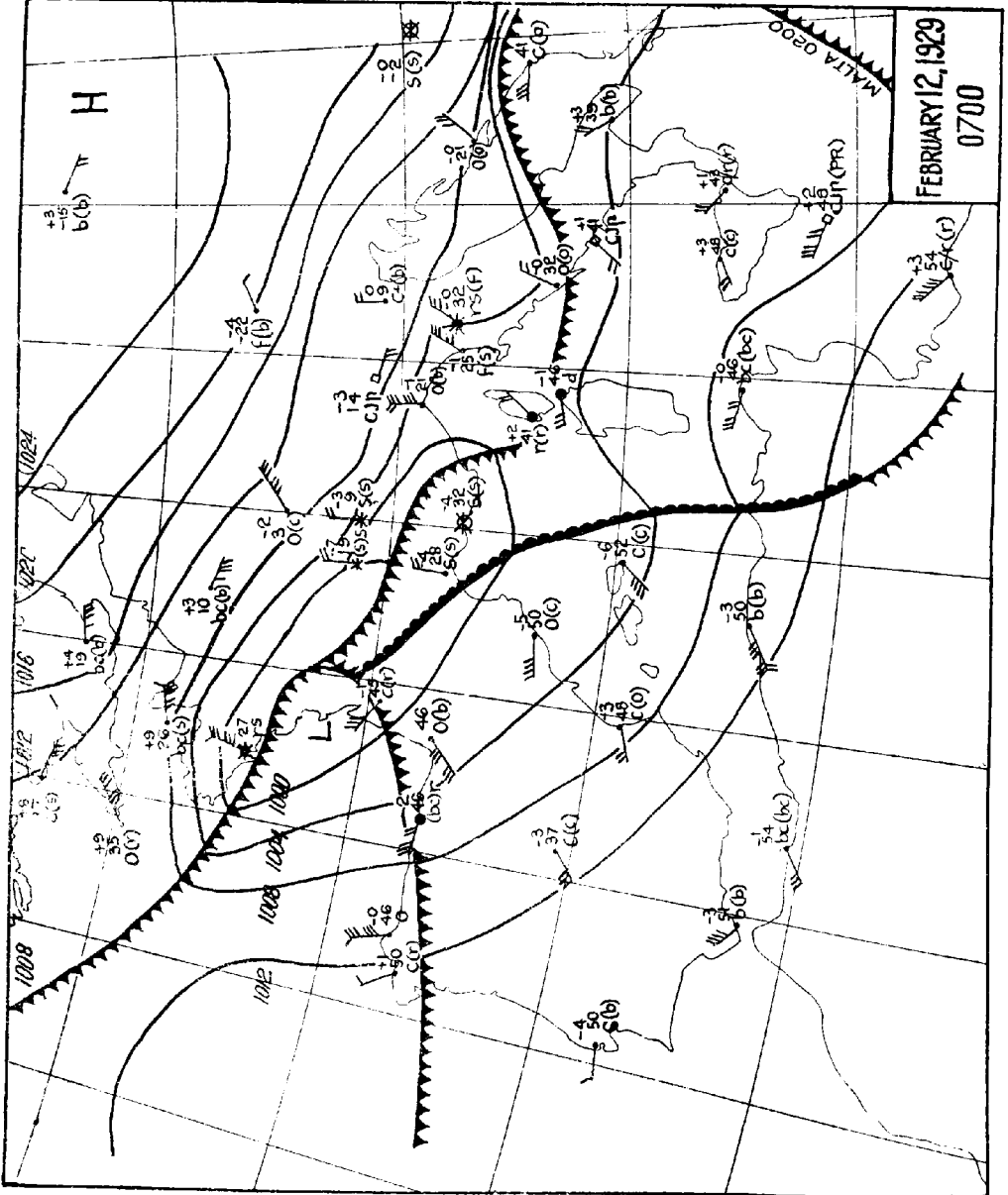


PLATE V.

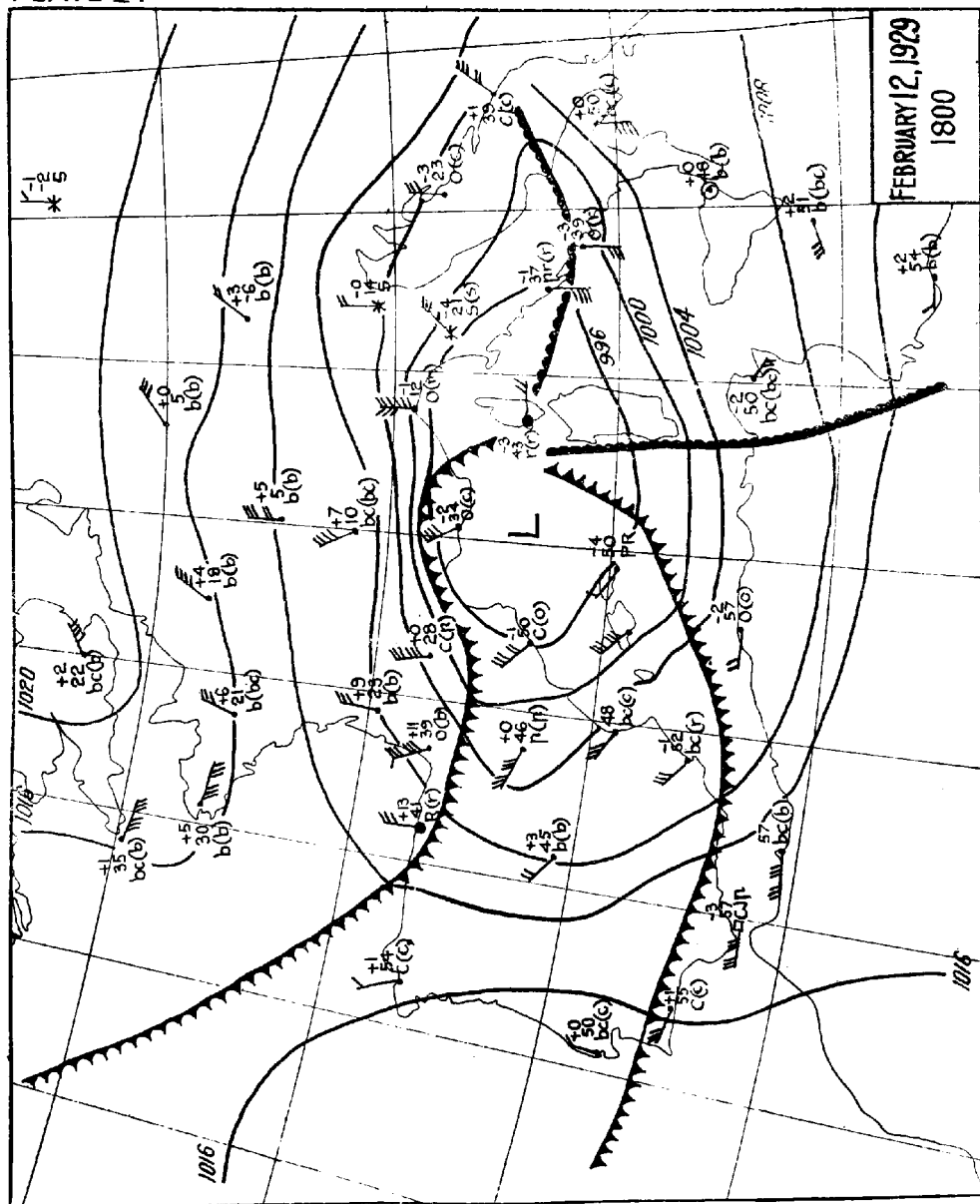
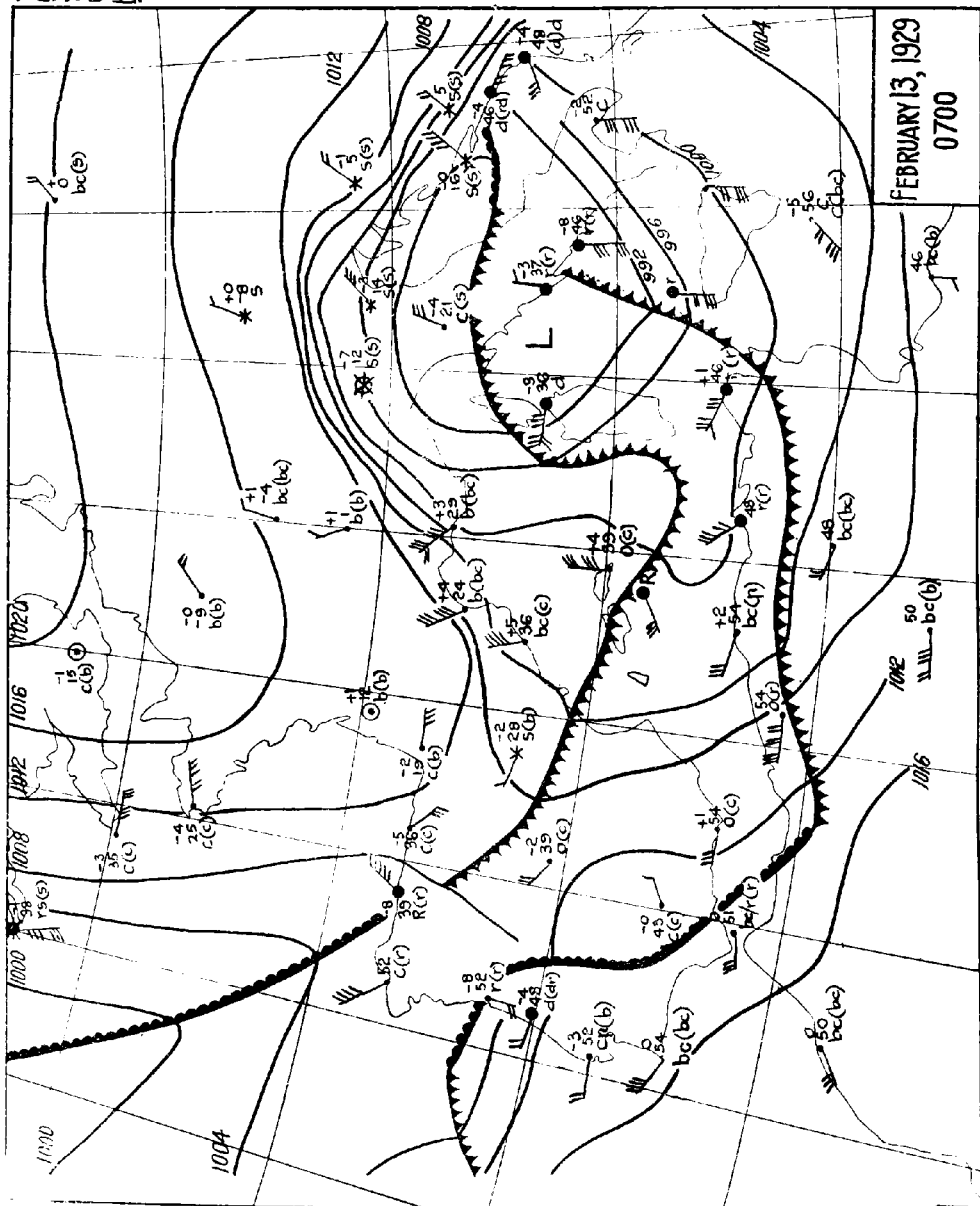
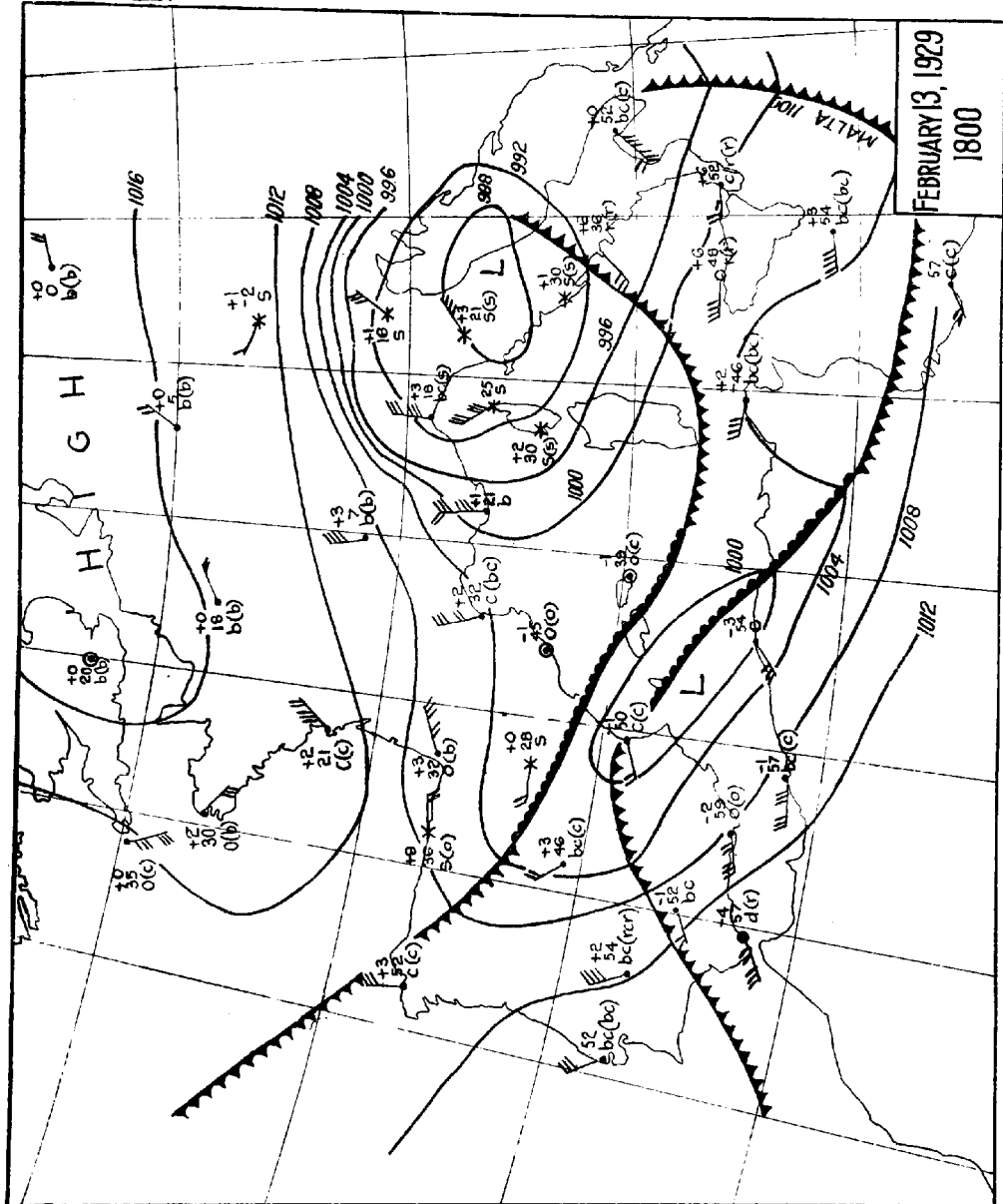


PLATE VI.



FEBRUARY 13, 1929
0700

PLATE VII.



FEBRUARY 14, 1929
0700

LATE IX.

FEBRUARY 14, 1929
1800

The chart displays a complex weather pattern over the North Atlantic and Eastern United States. Key features include:

- Pressure Systems:** A prominent low-pressure center (marked with a circle containing '0') is located off the coast of New England. Another low-pressure area is visible further south, near the Gulf of Mexico.
- Fronts:** Several frontal boundaries are depicted with characteristic symbols: solid lines with triangles for cold fronts, dashed lines for warm fronts, and lines with alternating triangles and semicircles for occluded fronts.
- Weather Symbols:** Various symbols indicate atmospheric conditions such as clouds (clouds with numbers), precipitation (rain or snow icons), and visibility (sun/moon symbols).
- Data Points:** Numerous numerical values are scattered throughout the chart, often accompanied by letters in parentheses (e.g., +19 b(b), -3 c(e)). These likely represent temperature, wind speed, or other meteorological measurements at specific locations.
- Geographic Labels:** Latitude lines (1008, 1012, 1016) and longitude lines (9100, 9102, 9104, 9106) are clearly marked to provide spatial context.

FEBRUARY 14, 1929
1800