MICROSEISMS AND WEATHER ON PALMER LAND PENINSULA, ANTARCTICA

Palmer Land Peninsula, Antarctica

South Latitude 68° - 12′
West Longitude 67° - 00′

IN OPERATION FROM

18 May 1947 through 15 February 1948

Compiled by

RONNE ANTARCTIC RESEARCH EXPEDITION

Under Contract with
Geophysics Branch
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no. 11

Prepared by

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OFFICE OF NAVAL RESEARCH
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National Oceanic and Atmospheric Administration

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FOREWORD

Submitted herewith is Technical Report No. 11 of the Ronne Antarctic Reserach Expedition, entitled "Microseisms and Weather on Palmer Land Peninsula, Antarctica." Data obtained in the Antarctic region are presented in the form of microseismic correlations with weather.

W.H. Leahy
Captain, USN
Assistant Chief of Research

26 April 1950

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PREFACE

Technical Report No. 11 is one in a series completed by members of the Ronne Antarctic Research Expedition, 1946-1948. This report was prepared by Andrew A. Thompson, geophysicist, who was in charge of the geophysical investigations for the expedition.

This report presents some of the results from a study of microseismic correlation with weather in the area of Palmer Land Peninsula, Antarctica. The seismological station was located at 68° 12' South Latitude, and 67° 00' West Longitude. and operated from 18 May 1947 through 15 February 1948. Two previous papers in this series concerning this station are titled "Establishment of Antarctic Seismological Station" and "Antarctic Seismological Bulletin." The latter includes the interpreted phases of earthquakes.

The seismological program of the expedition would not have been possible without the assistance and cooperation of the Office of Naval Research, the United States Coast and Geodetic Survey, the Jesuit Seismological Association and Columbia University.

Finn Ronne
Commander, USNR, Inactive
Expedition Leader

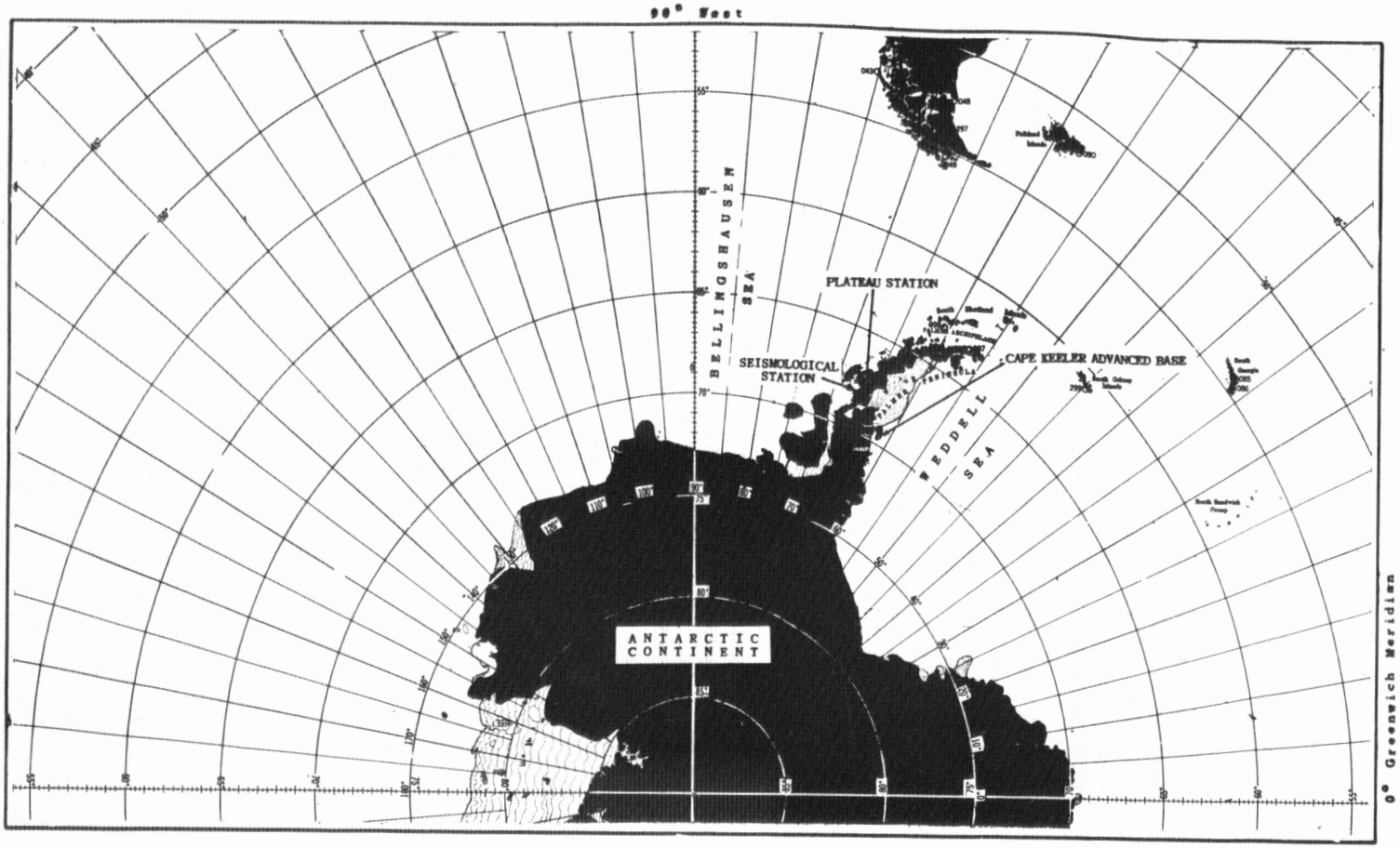

Figure 1 - Map of area covered by seismological station

MICROSEISMS AND WEATHER ON PALMER LAND PENINSULA, ANTARCTICA

INTRODUCTION

Since World War II, the seismograph has proved a valuable tool for the meteorologist. Although the underlying theory has still to be solved, there is correlation between microseisms and low-pressure storms, both tropical and extra-tropical. Microseisms are vibrations in the earth's crust having periods from two to seven seconds, and are picked up by seismographs of certain characteristics. The storm-detection possibilities were suggested when the seismographs at St. Louis University had successfully tracked the hurricane which devastated New England in 1938. The United States Navy became interested, since the war, and has been successfully tracking hurricanes in the Caribbean and typhoons of the western Pacific.[1] Others have found similar correlation with extra-tropical storms.[2] It is difficult to say what aspect of the storm creates these vibrations—is it in the fronts, the associated winds, or in the eye of the low. Cold fronts and winds independently seem to generate a characteristic type of microseism.[3] Those of long periods, six seconds, that are regular and modulated, seem to come from severe depressions some distance away; in fact, storms have been followed well over two thousand miles away. The Navy found that microseismic energy did not appear to carry across certain zones believed to be large faults dividing different structures.[4] This effect was found both in the Caribbean and Phillipine areas.

In order to get the direction of propagation of these surface waves, in other words a bearing on the disturbing influence, the tripartite-type station used by the Navy has proved most successful. Three seismographs are set out at measured distances and directions from each other and arranged to record together with the same time marks. By identifying the same wave on each trace, the relative time leads or lags will give a solution to the direction of propagation. For simplicity, an equilateral triangle with 8000-foot sides has been used. When the sides get too long, the same wave on all the traces becomes more difficult to identify. When the sides are too short the leads or lags become too small for accurate determination. Unfortunately, the Antarctic station had only one leg, consequently, bearings on the disturbance were impossible.

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[1] NAVAER 50-IR-189, "U.S. Navy Hurricane Microseismic Research Project" or "Tracking Hurricanes with the Seismograph," U.S. Navy Journal of Aeronautical Meteorology, 2: No. 1, pp. 6-12, October 1945

[2] Leet, L. Don, "Microseisms in New England," Geophysics, 12: No. 4, pp. 639-650, October 1947

[3] Gilmore, Marian H., "Microseisms Classified According to Type of Storm," Transactions A.G.U., August 1946

[4] Murphy, L. M., "Geological Effects on Microseisms in the Caribbean," Transactions, A.G.U., 28: No. 4, August 1947

The main base on the Ronne Antarctic Research Expedition was located on Palmer Land Peninsula, 68° 12' S, 67° 00' W, on the western coast of a glacier-clad mountainous plateau-peninsula projecting into prevailing westerly winds. (Figure 1, Frontispiece.) The area was a variable weather zone influenced by both the polar continental air usually moving from the southeast, and the warmer, polar maritime air moving with the westerlies. The Antarctic coast line has the lowest, average sea-level atmospheric pressure of any region in the world. At the main base on Stonington Island the yearly average pressure during 1947-1948 was 897 mb with spot extremes of 1024 and 944.7 mb.

Many strong lows were formed at the polar front or junction of these two oppositely moving air masses. The invariable direction from which all disturbances approached was westerly. The strength of the westerly movements of storms around latitudes 50°S to 60°S is so great that jokes have been made about an Australian shipmaster who sailed from Sidney to Perth via the South Atlantic Ocean since this was faster than bucking the prevailing westerlies. Julio Bustos Navarrete[5] cited that storms travel from New Zealand to South America in from 10-15 days, which is an average translation of 600 miles a day. They travel similarly through the Drake Passage to the South Orkneys.

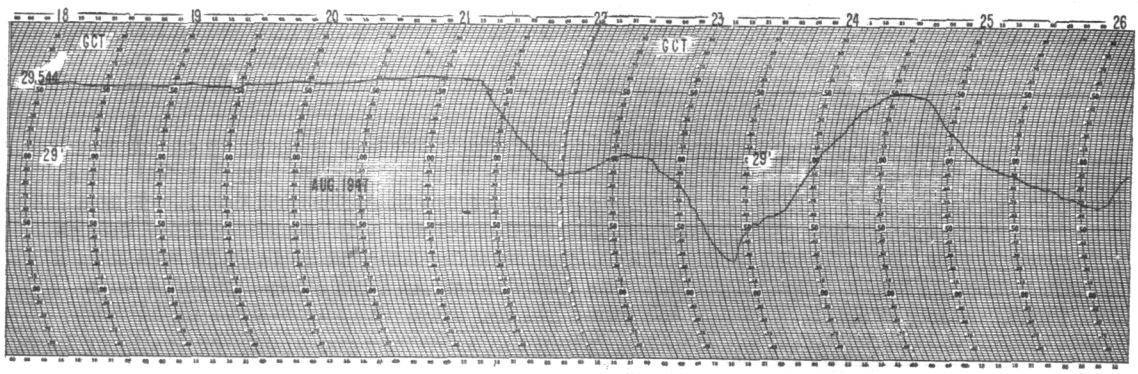


Figure 2 - Stonington Island barogram produced by a typical storm

[5]Navarrete, J. Bustos, "Preparacion Meteorologica de los Raids Aereos a la Region Antartica," Santiago de Chile.

Disturbances arrived at Stonington Island once every 3-5 days with an extensive rise of pressure between depressions. Figure 2 shows the Stonington Island barogram produced by a typical storm. Weather during the disturbance ran as follows:

Initial rise: 0000 G.C.T. on 23 August stratus overcast at 5000, 23° F, RH 70%, calm.

Large fall: 4000', 30°F, RH 60%, NNW 15 knots.

Second rise: Squally precipitation, poor visibility, 6°F, NW 20 knots.

Second peak: Short-lived clearing with 3/10 fractostratus at 400', -5°F, NNW 3 knots.

Second fall: On August 25 clouding, warming, precipitation, calm; then, dry 24 knot ESE wind with increasing ceilings as gradient slackens.

See also Figures 4 and 60. Figure 60 is a photograph of part of a seismogram. Each line represents an hour (parts of the lines are not shown), and the time marks are a minute apart. The top series of lines were produced by the Sprengnether seismograph, and the bottom series by the Neumann-Labarre.

INSTRUMENTS

To—Natural period of seismometer V—Magnification of seismometer

Neumann-Labarre

To = 2" (May 18, 1947 through June 10, 1947)
To = 3.5" (June 11, 1947 through November 30, 1947)[6]
To = 2" (December 1, 1947 through February 15, 1948)

f = Damping, just under critical

Orientation - To measure motion along a line 37°E of true north or 15°E of magnetic north

V = 5000.

Sprengnether, Series H[7]

To = 6-1/2" (May 24, 1947 through November 23, 1947)[7]
To = 20" (November 24, 1947 through December 13, 1947)[7]
To = 22" (December 14, 1947 through February 15, 1948)[7]

f = Damping, near critical

Orientation - May 24, 1947 through November 23, 1947 - To measure motion along a line 62° E of true north or 40° E of magnetic north
November 24, 1947 through December 13, 1947 - To measure motion

[6]Large weight used
[7]Natural period of seismonitor was adjusted to be the same as natural period of galvanometer in each case.

along a line 48°W of true north or 70°W of magnetic north
December 14, 1947 through February 15, 1948 - To measure motion along a line 2°E of true north or 20°W of magnetic north

V = 2000 to 3000.

Evaluation of Instruments

As would be expected, the Sprengnether Instrument was far more sensitive to microseisms than the Neumann-Labarre. The former is the type used in the Navy project mentioned in the Introduction. This instrument, operating at a period very close to that of the microseisms, had more desirable characteristics for these longer periods. When the Sprengnether was operating at a 22-second natural period; although to a lesser extent, it was still the sensitive seismograph as far as microseisms were concerned.

POSITION OF STATION - South Latitude 68° 11'40" West Longitude 67°.00'+

ELEVATION OF STATION - 24 feet above mean sea level

FOUNDATION OF STATION - Granite bed rock

RATE OF RECORDING COMPONENT - 15mm/minute

TIME MARKS - Navy chronometer checked to at least nearest half second against radio time signals. Checks were made once or twice a week.

SEISMOGRAM AVAILABILITY - The seismograms and other original data are available in the archives of the Geophysics Laboratory, Department of Geology, Columbia University, New York City.

RESULTS

There is correlation between lows of sufficient depth passing over the peninsula and microseismic activity at the main base. Studies so far indicate that the peak of the microseisms comes when the low-pressure storm reaches the Weddell Sea (Figure 1).

In the time between May 18 to June 24, 1947, for example, the barograms at the main base indicated the passing over of about seven low-pressure storms (Table I). Every one of these pressure minimums, except one, was followed by a microseismic peak amplitude. Five pressure minimums which stood out more than the others, were followed by the five largest microseismic amplitude peaks—none of the latter peaks being less than 42 mm.

During the periods May 24 to May 31 and June 8 to June 14, the microseismic amplitude never went above 2 mm; the pressure never went below 29.4 inches of Hg; and no marked minimums occurred (Table I, Figure 3). All microseismic amplitude peaks associated with the seven pressure minimums lagged. Six of the peaks lagged by 14 to 23 hours, but the seventh sustained itself from 2 to 32 hours after the associated pressure minimum. This much lag is about right to give the low time to reach the Weddell Sea.

There is some increase in microseisms, shown in many cases, when the low reaches the west side of the peninsula, especially if by way of Marguerite Bay. However, these are nothing like the peaks which usually follow. This can be seen in Figures 7, 50, 51, 54, and 55, which show information and data for November 1st and 2nd, and November 5th and 6th.

TABLE I
Barogram Minimums and Microseismic Peaks [1]

Date	Barogram Minimum		Date	Microseismic Peaks		Lag
	In. Hg.	Time (G.C.T.)		mm [2]	Time (G.C.T.)	(hours)
May 19	28.95	2200	May 20	42	0000 - 0600 May 21 [3]	2 - 32
22	29.1	1400	23	57	0600	16+
June 2	28.65	0700	June 3	71	0000	17
5	29.35	0100	5	40	2400	23 [4]
19	28.4	1600	20	65	0600	14
21	28.55	1600	27	65	1200	20
24	29.0	1000		No peak		

[1] These maximums and minimums were taken from different readings than those used for the graph (Figure 3). The readings used for this table should be more accurate. Therefore, the figures may not coincide.

[2] Distance in mm from peak to trough on seismogram

[3] Microseism rise began at 0600 G.C.T. on May 19th and, after reaching maximum, held peak for about 24 hours.

[4] Low small

Very little warning of a storm is given by the seismograph when a low is much to the west of the peninsula as is indicated by data for August 21st and 22nd (Figures 2, 4, and 60). Very little correlation is found with a storm passing north of the peninsula unless it swings southward into the Weddell Sea area. A very deep low passing north of the peninsula does show up, however as was observed on October 10th and 11th (Figures 6, 38, 39, and 40).

The above may be due to various causes. A line drawn up the west side of the peninsula and swinging east at Deception Island toward the Sandwich Islands may divide the area into two parts with definitely different geological structure. Usually the most significant rise in microseismic activity comes when a storm passes over the base, as is exemplified by data for August 22nd (Figure 4). Microseisms continue to rise until the storm is well into Weddell Sea, and usually drop fairly rapidly, when the low reaches the Sandwich Islands. This is shown by data for October 7th and November 2nd (Figures 6, 7, 36, and 51). Another possibility is that the lows deepen considerably after reaching the Weddell Sea.

It is hard to believe that the lag is due entirely to meteorological conditions. The Navy[8] definitely found that microseismic energy did not carry across certain zones believed to be large faults dividing different structures. The same type of thing was found in the Philippine area.

[8] Murphy, op. cit.

Another possible explanation for the lag is that the bottom of the Bellingshausen Sea is such that microseisms are not generated when a cyclone is in the vicinity.

To test between the generation and fault theories, it would be necessary to have a seismograph at the same time at the main base and on an island which is part of the Bellingshausen Sea Structure.

There was some correlation between sea swells recorded on the standard automatic tide machine and microseisms. However, most of the largest microseismic peaks were not accompanied by large sea swells. An exception is a microseismic peak on July 13 (Figure 9) which was accompanied by very large swells. Either this is another indication that microseisms come from the Weddell Sea, or ice conditions decidely damp out sea swells.

During the summer months of December and January there was evidence of but few disturbances. Microseismic activity was slight, with a few high peaks. Examples of this period are not included, due partly to lack of British Weather maps from November 13th on. They were unavailable also on many other dates.

Throughout this report it is fairly obvious that most of the conclusions are based on questionable evidence. The weather maps give only the probable weather picture (see paragraph introducing Weather Maps) and the expedition's weather stations were few (a total of three). Almost every possible bit of data was consulted and it was surprisingly extensive considering the area investigated.

There was a seismograph operating during the time in Punta Arenas, Chile, at the tip of South America. Corresponding microseism readings obtained from this station could answer many pertinent questions in regard to extent of travel of this energy in the area. The information would be of interest to the fault zone theory mentioned previously. Many microseisms were picked up, in fact they were very detrimental to this South American station as an earthquake recorder. The Antarctic station may have suffered a similar fate had there not been two seismographs to operate at different characteristics.

Had there been a tripartite direction finding station on Antarctica, many questions could have been answered in regard to meteorological conditions: From which disturbance are the microseisms coming? Do the large amplitudes always come from the east, and how much comes from the west? Microseisms coming from the south or southeast would give valuable information concerning generation on the continent or over ice. Do the bearings change direction slowly with storm travel, and can a good constant bearing be obtained? The character of the microseisms from the one station in Antarctica definitely indicates good bearings can be obtained—— proof of this statement is necessary.

This study of microseisms on the Antarctic continent is definitely exploratory. Most of the work does indicate, however, some interesting and useful possibilities with further investigations.

May 19 - June 24, 1947

Readings were taken at 1200 and 2400 G.C.T. each day.

A definite correlation is shown here between the presence of a passing cyclone, as indicated by pressure and wind recordings, and microseismic activity. Conversely, small microseism amplitudes seem to indicate the absence of any near-by disturbances.

The "Pressure Surges" are plotted by averaging all pressure readings for ten days, five days on each side of the plot. Likewise, "Microseism Amplitude Averages" are plotted from an average of all microseism readings in the adjacent ten days. Incidentally, this is an average of 20 readings, since two readings were taken per day. Generally, as the Pressure Surge reading is increasing the microseism amplitude average reading decreases, and vice versa.

"Mean Peak of Total Microseisms" is an estimated measurement of microseism amplitude from crest to trough. An effort is made to get an average of the larger waves by estimating from several of the build-ups. There is a personal error of possibly 10 percent. A special effort was made, however, to reflect accurately increases and decreases of microseism amplitudes.

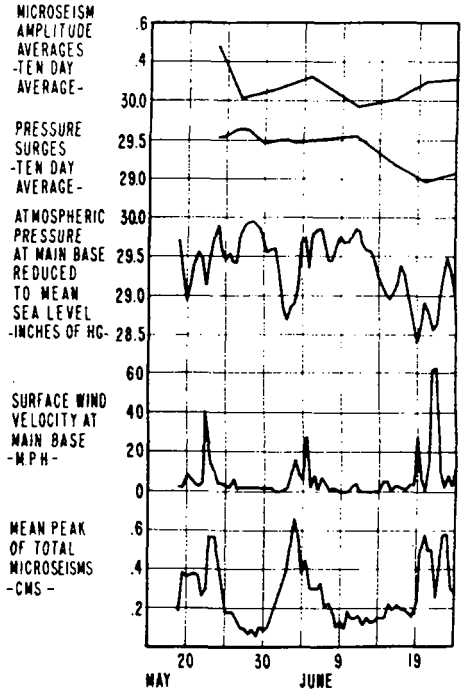


Figure 3 - Microseismic correlations, May 19 - June 24, 1947

August 9 - August 26, 1947

Readings were taken at 0600, 1200, 1800, and 2400 each day.

The microseism peak on August 10 and 22 correlates with disturbances as shown by pressure variations and weather maps, (Figures 11, 16). A photograph of the seismograms (Figure 60) brings out the sharp amplitude increase of August 22. The microseism increase and peak on August 15 and 16 (Figure 4) is more difficult to explain. Weather maps do show a low north of the peninsula on August 15. On August 16 the British Weather Intelligence reported disturbance due Palmer Land area but lacked verifying information. It is in such a case as this, as in so many other cases, that bearings on the disturbances would have been so helpful. As mentioned elsewhere in this report, all British weather maps with their cyclone locations are extremely doubtful as far as accurate location and certainty of existence is concerned. Of necessity, the weather picture is drawn from too little evidence. In such areas a tripartite may be a useful tool. Most all microseisms picked up are of a type which should give good bearings.

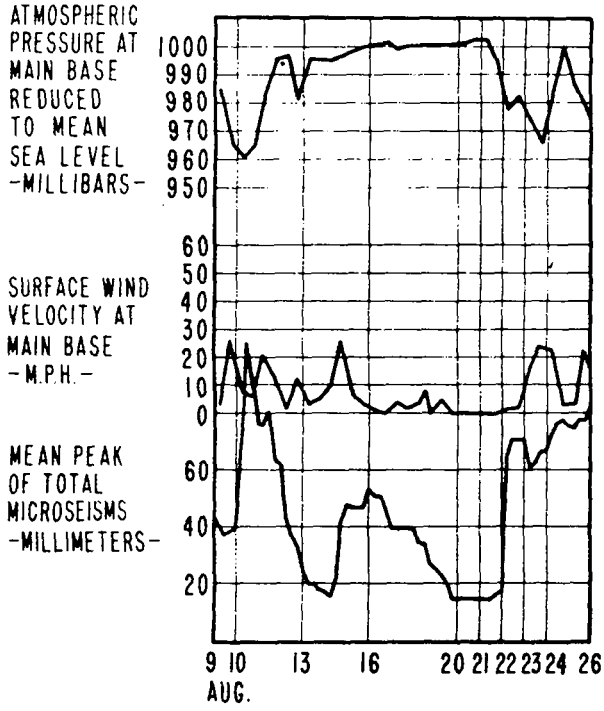


Figure 4 - Microseismic correlations, August 9 - August 26, 1947

September 5 - September 23, 1947

Readings were taken at 0000, 0600, 1200, and 2400 each day. The main base barograms are reproduced to correspond time-wise with the microseism amplitude readings. An 18 to 24 hour lag of microseism peak behind barogram minimum is evident. On September 15 when microseisms were strongest, a deep low is shown in the middle of the Weddell Sea on the weather maps (Figure 25). This weather situation always seems to produce the largest microseisms. At this time the Weddell Sea should be well frozen.

It is of interest to note that the depression that passed over the base on September 14 was the deepest of the year. The microseism peak on September 15 was practically the largest recorded. The depression passing over the peninsula on September 5th to 6th passed south of the main base according to British weather intelligence of the Falkland Islands. It is difficult to say whether the youth or the path of the storm caused the microseism peak to be smaller than usual. Without a bearing it is difficult to tell which storm produces the waves when there may be more than one disturbance in the vicinity.

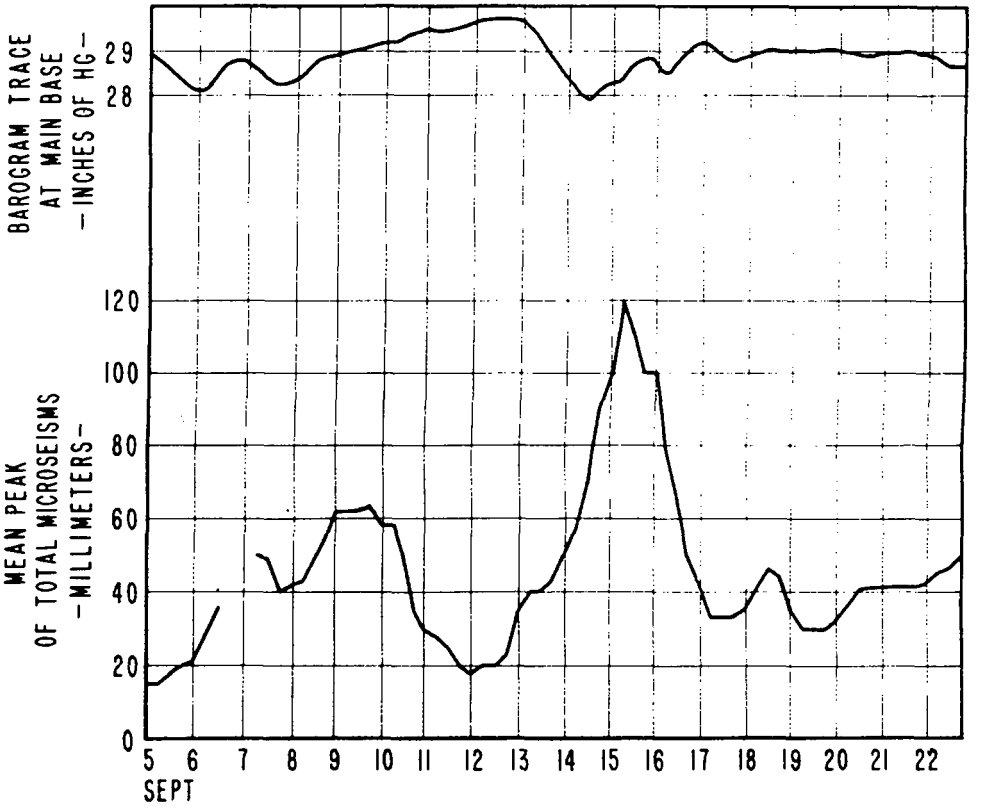


Figure 5 - Microseismic correlations, September 5 - September 23, 1947

October 1 - October 16, 1947

Microseism amplitude readings were taken at 0000, 0600, 1200, and 1800 each day. The pressure minimums at Cape Keeler fall closest to the microseism maximum in time, as should be expected if they are generated mainly from the Weddell Sea. The relative intensity of the barogram minimum seems to determine the relative intensity of the microseism maximum.

The disturbance of October 10th and 11th (Figures 39, 40) passed to the north of the peninsula causing a small rise in microseisms.

On October 1st and 2nd (Figures 30, 31) disturbances were in the vicinity, but not such severe depressions as are found on the 3rd and 4th (Figures 32, 33).

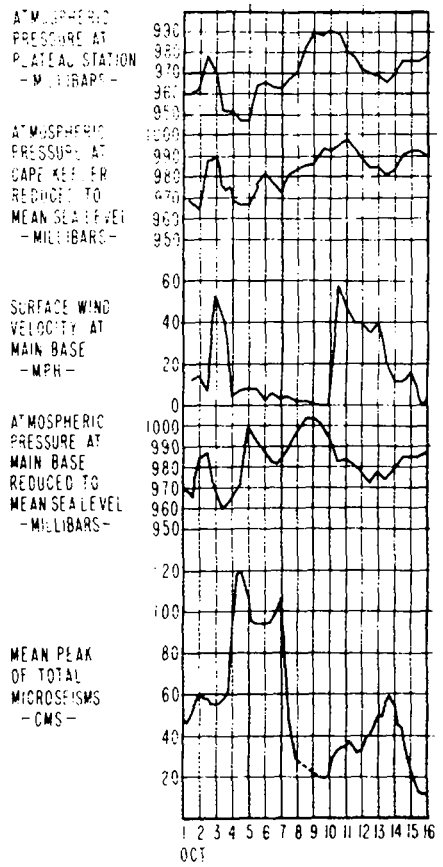


Figure 6 - Microseismic correlations, October 1 - October 16, 1947

October 25 - November 10, 1947

Readings were taken at 0000, 0600, 1200, and 2400 each day. The main base barograms are reproduced to correspond time-wise with the microseism amplitude readings. The plateau station and Cape Keeler station (Figure 1) pressure readings are also plotted as indicated. The plateau station is about 36' east of the main base and the Keeler station is about 4°12' east of main base.

Main Base 68° 12' S - 67° 00' W
Plateau station 68° 06' S - 66° 24' W
Keeler station 69° 42' S - 62° 48' W

The plateau station, 5800 feet above the other stations at sea level, should receive the pressure minimum from easterly moving depressions even before the main base. The Keeler station pressure minimum should follow the main base pressure minimum by about five hours for lows moving with an easterly speed of 20 mph. These two facts seem to be borne out by the graph (Figure 7). Again, there is evidence that the microseism peak comes when the disturbance is well into the Weddell Sea (ca. hundred miles).

The weather maps indicate a depression (972 mm) well south in the Weddell Sea which does not produce microseisms (Figure 43). Due to the doubtful character of this map, this fact need not be evidence that microseisms are not produced over ice which most likely occupies the area. There is strong evidence on the maps for November 1st and 2nd (Figures 50, 51) of a deep low passing into the southern part of the Weddell Sea, which situation produces very large microseisms. The strength of the low proves an important factor. In many cases a low which seemingly deepens as it moves in the Weddell Sea away from the station, is accompanied by a corresponding increase in microseisms as shown in Figure 50 for November 1.

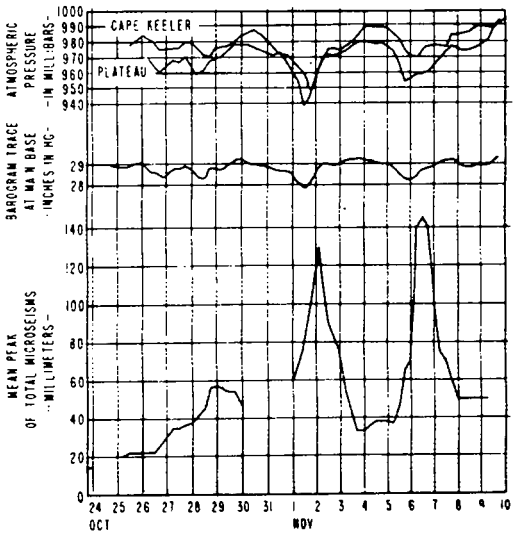


Figure 7 - Microseismic correlations, October 25 - November 10, 1947

WEATHER MAPS

The weather maps (Figures 8 - 57) are for the date and Greenwich Mean Time indicated on the maps—practically all the maps are for 1800 G.C.T. The maps were made with the aid of the British (Falkland Island Dependency Survey) meteorological data from their six bases in the area, ship reports, our station on the 6000-foot plateau 17 miles east of the Main Base, and our Base at Cape Keeler on the eastern side of the peninsula (Figure 1). The names and approximate locations of the British bases including our Main Base are as follows:

Ronne Antarctic Research Expedition Base
(Marguerite Bay); 68° 12' S-67°00'W (our Base)

Laurie Island in the South Orkneys;
60°45'S-44°30'W

Hope Bay; 63°15' S-56°45'W

Deception Island; 62°58'S-60°35'W

Port Lock Roy in the Argentines

The Falkland Islands

The weather maps give only the probable weather picture since they are made from limited data. The systems are many times badly located or completely left out for lack of evidence. The well developed and more obvious fronts and depressions are located as well as possible, however.

Original weather data is available from the author, negotiated through Geophysics Laboratory, Columbia University, New York City.

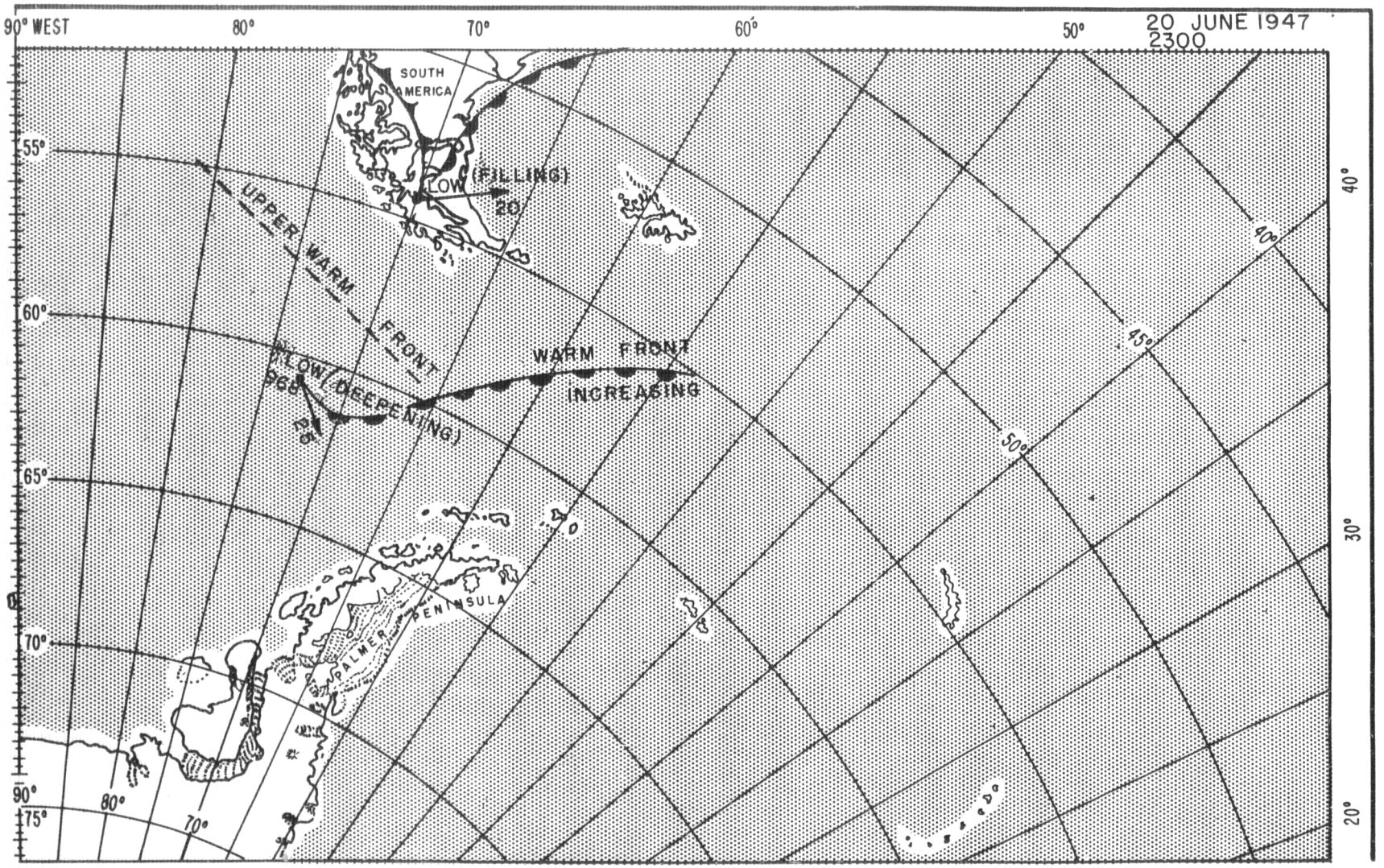

90° WEST
80°
70°
60°
50°
20 JUNE 1947
2300
SOUTH AMERICA
55°
60°
65°
70°
LOW (FILLING)
20
UPPER WARM FRONT
WARM FRONT
INCREASING
LOW (DEEPENING)
968
25
PALMER PENINSULA
90°
75°
80°
70°
40°
30°
20°
40°
45°
50°

Figure 8

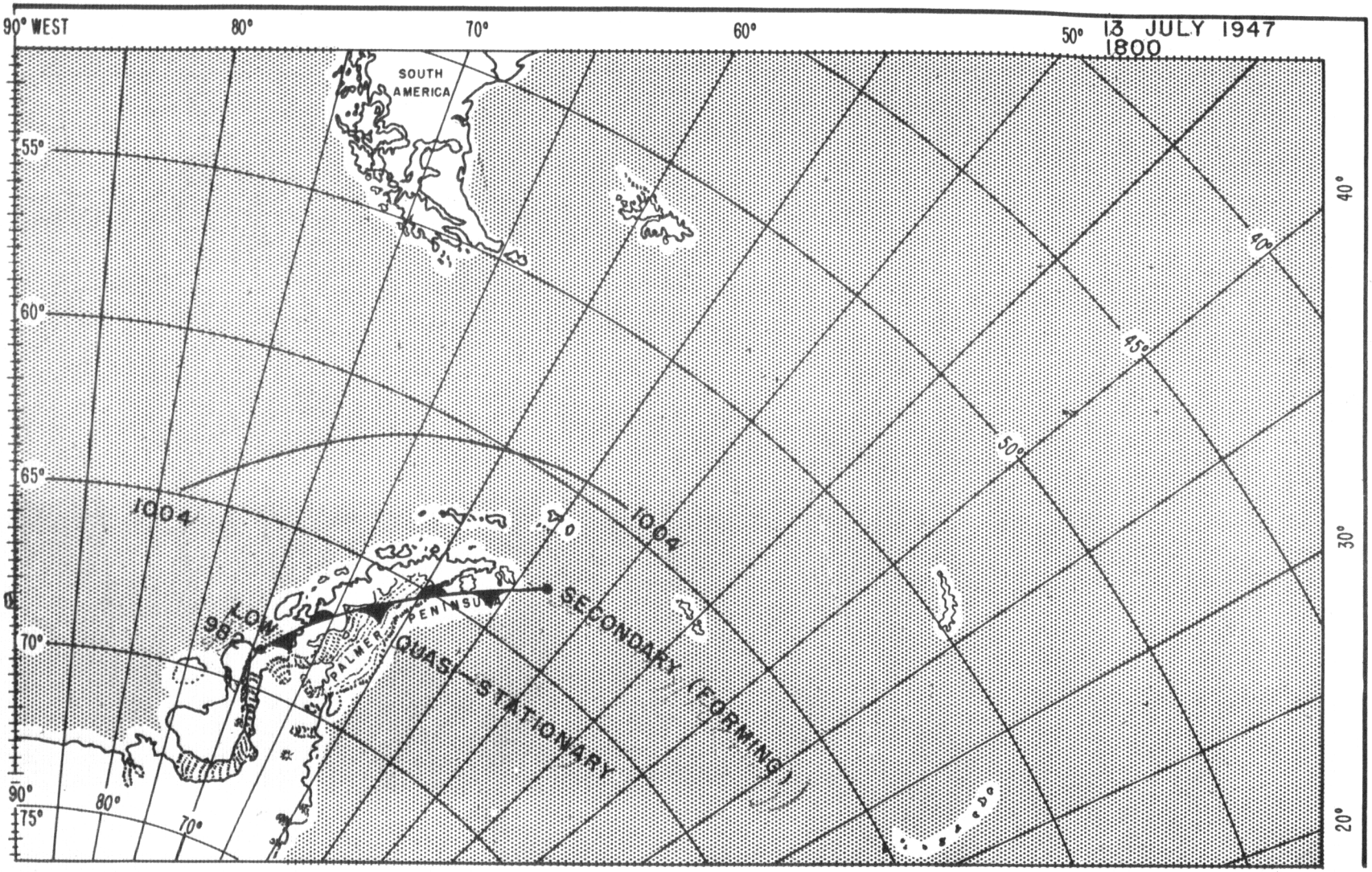

90° WEST
80°
70°
60°
50°
13 JULY 1947
1800
SOUTH AMERICA
55°
60°
65°
70°
90°
75°
80°
70°
40°
30°
20°
40°
45°
50°
1004
1004
LOW
982
PALMER PENINSULA
SECONDARY (FORMING)
QUASI-STATIONARY

Figure 9

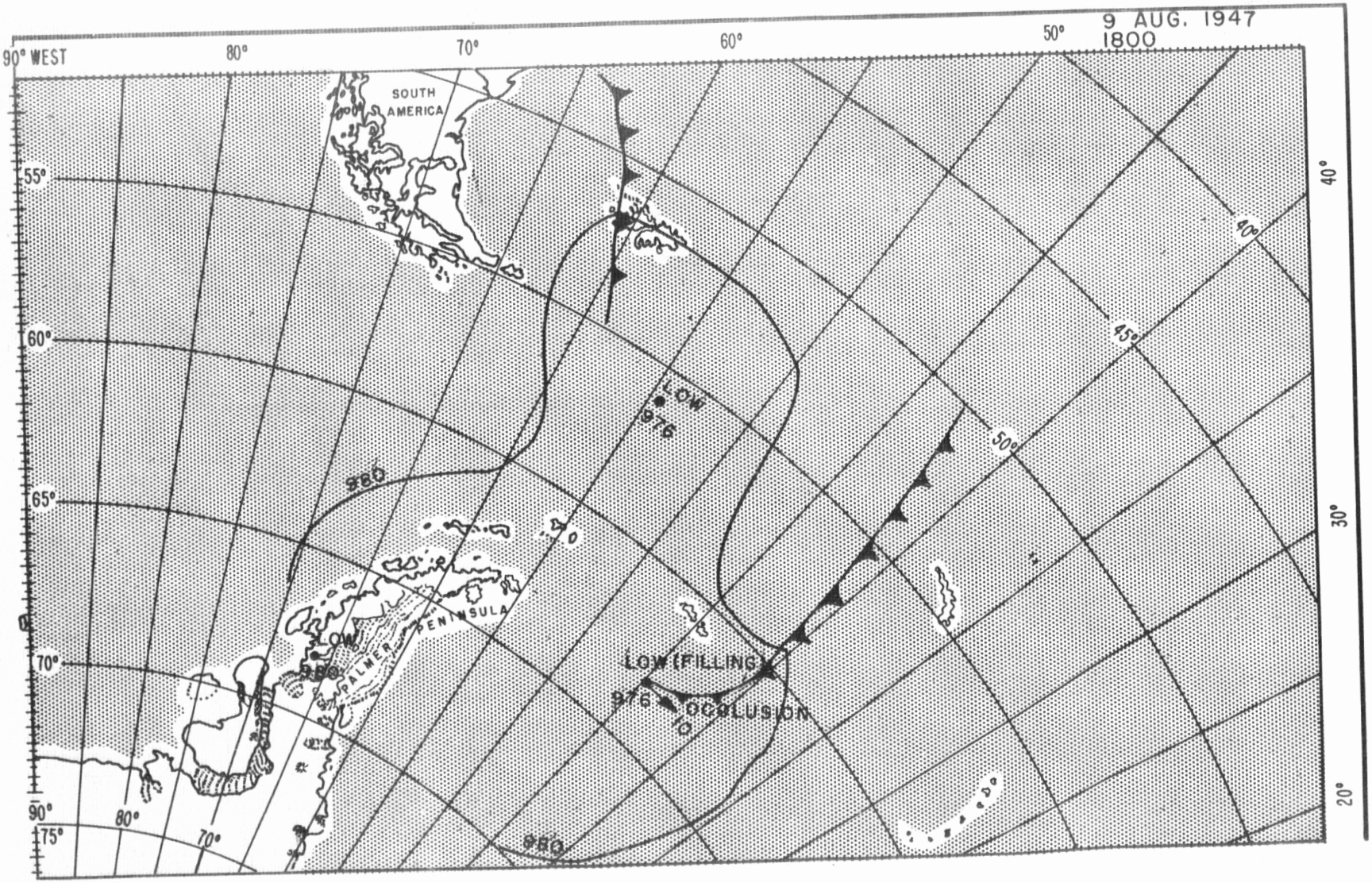

9 AUG. 1947
1800
90° WEST
80°
70°
60°
50°
40°
30°
20°
55°
60°
65°
70°
75°
SOUTH AMERICA
LOW
976
980
LOW
980
PALMER PENINSULA
LOW (FILLING)
976
OCCLUSION
980

Figure 10

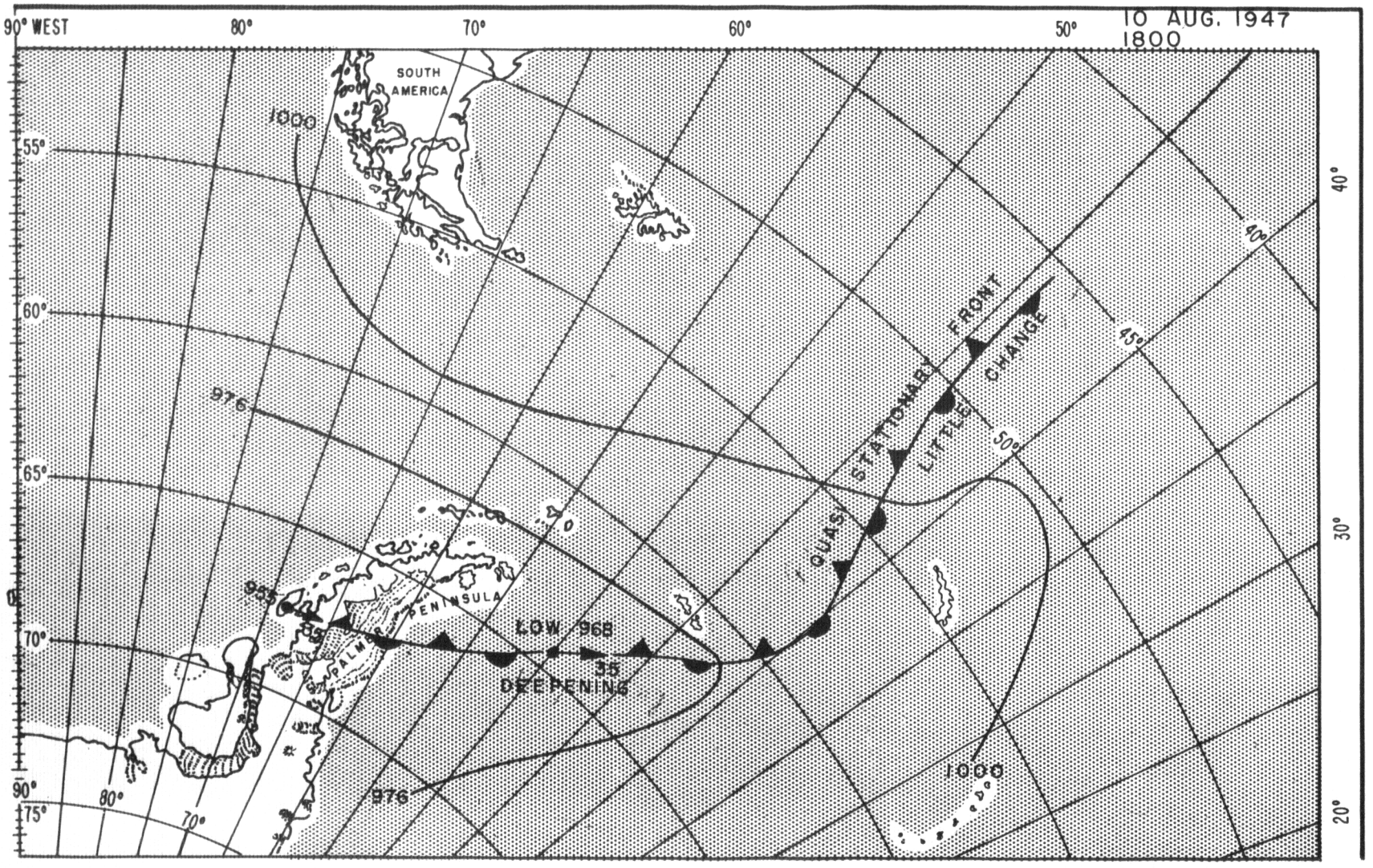

10 AUG. 1947
1800
90° WEST
80°
70°
60°
50°
40°
30°
20°
55°
60°
65°
70°
75°
90°
80°
70°
SOUTH AMERICA
1000
976
955
LOW 968
35
DEEPENING
PALMER PENINSULA
QUASI STATIONARY FRONT
LITTLE CHANGE
40°
45°
50°
1000
976

Figure 11

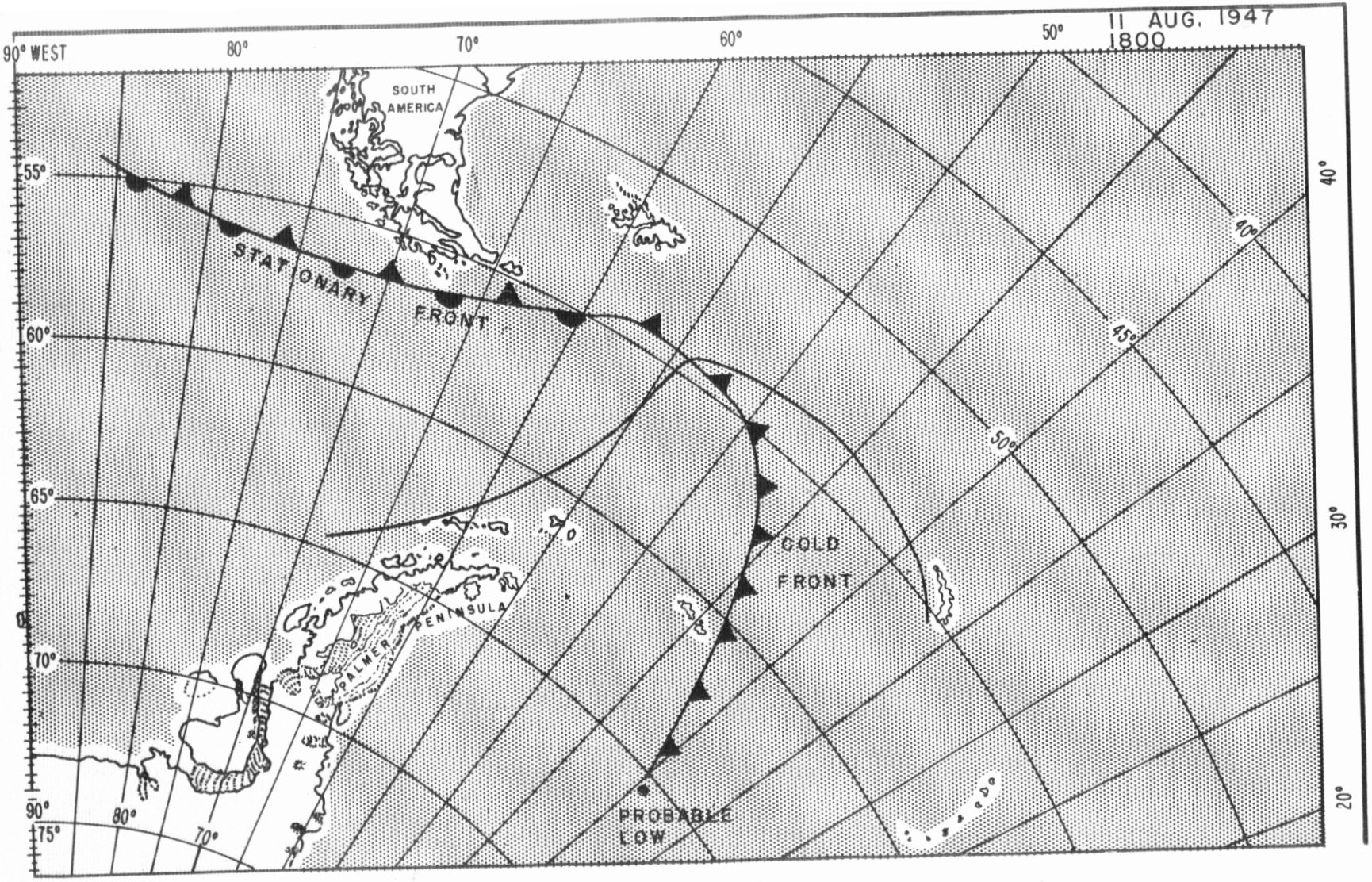

11 AUG. 1947
1800
90° WEST
80°
70°
60°
50°
40°
30°
20°
55°
60°
65°
70°
75°
SOUTH AMERICA
STATIONARY FRONT
COLD FRONT
PALMER PENINSULA
PROBABLE LOW

Figure 12

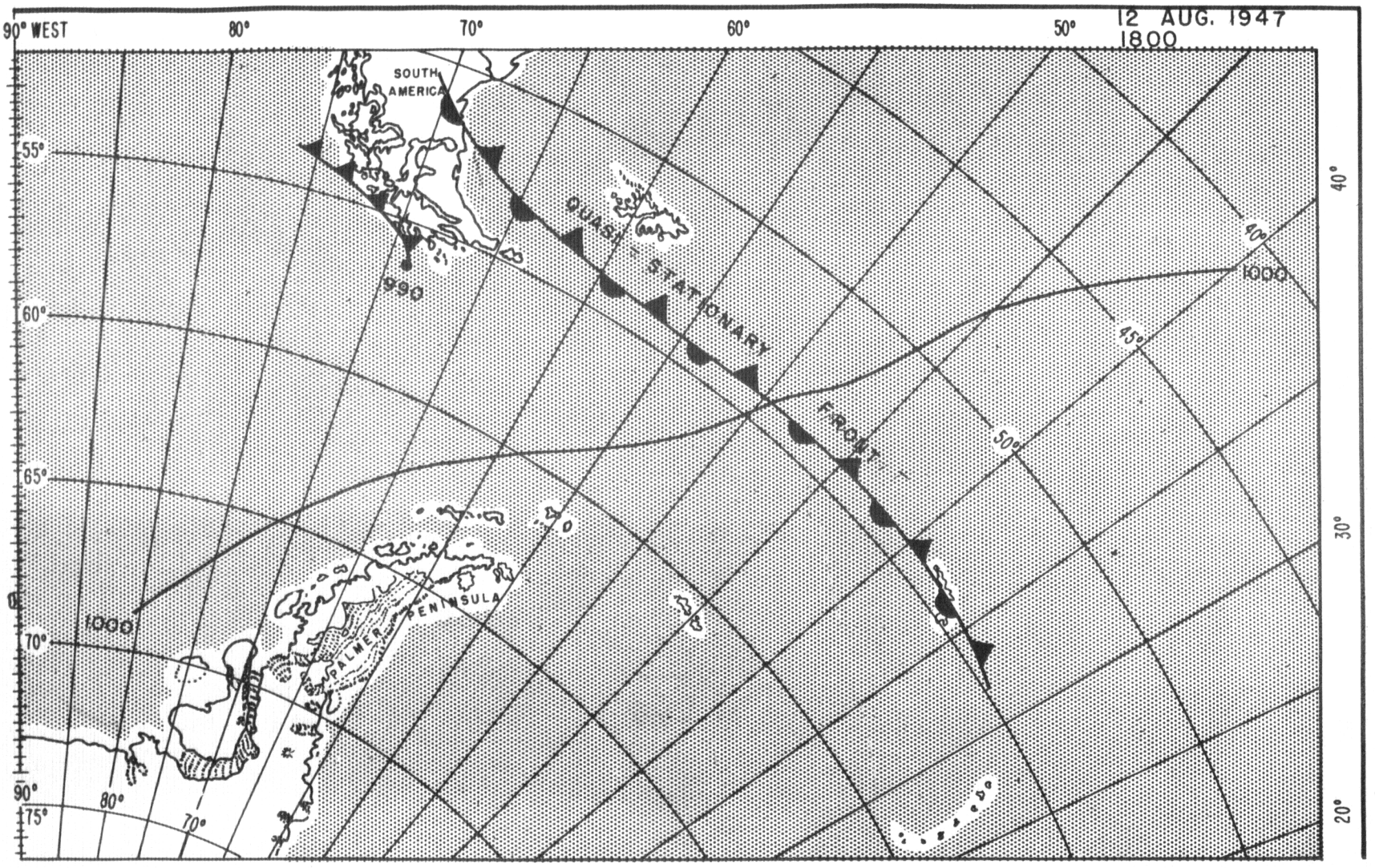

12 AUG. 1947
1800
90° WEST
80°
70°
60°
50°
40°
30°
20°
55°
60°
65°
70°
75°
SOUTH AMERICA
QUASI-STATIONARY FRONT
PALMER PENINSULA
990
1000
1000
40°
45°
50°

Figure 13

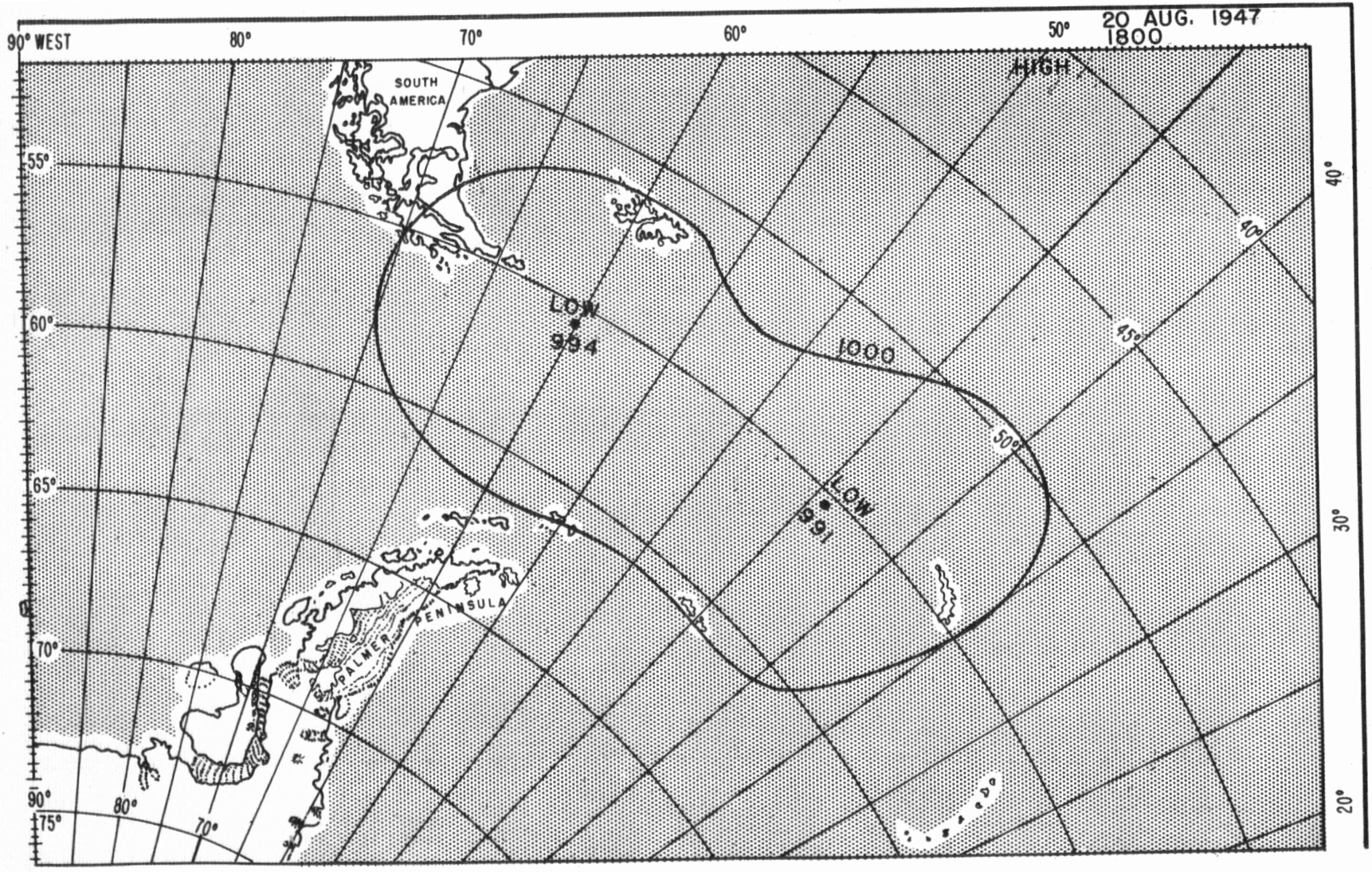

20 AUG. 1947
1800
90° WEST
80°
70°
60°
50°
HIGH
SOUTH AMERICA
55°
60°
65°
70°
LOW
994
1000
LOW
991
40°
45°
50°
40°
30°
20°
PALMER PENINSULA
90°
80°
70°
75°

Figure 14

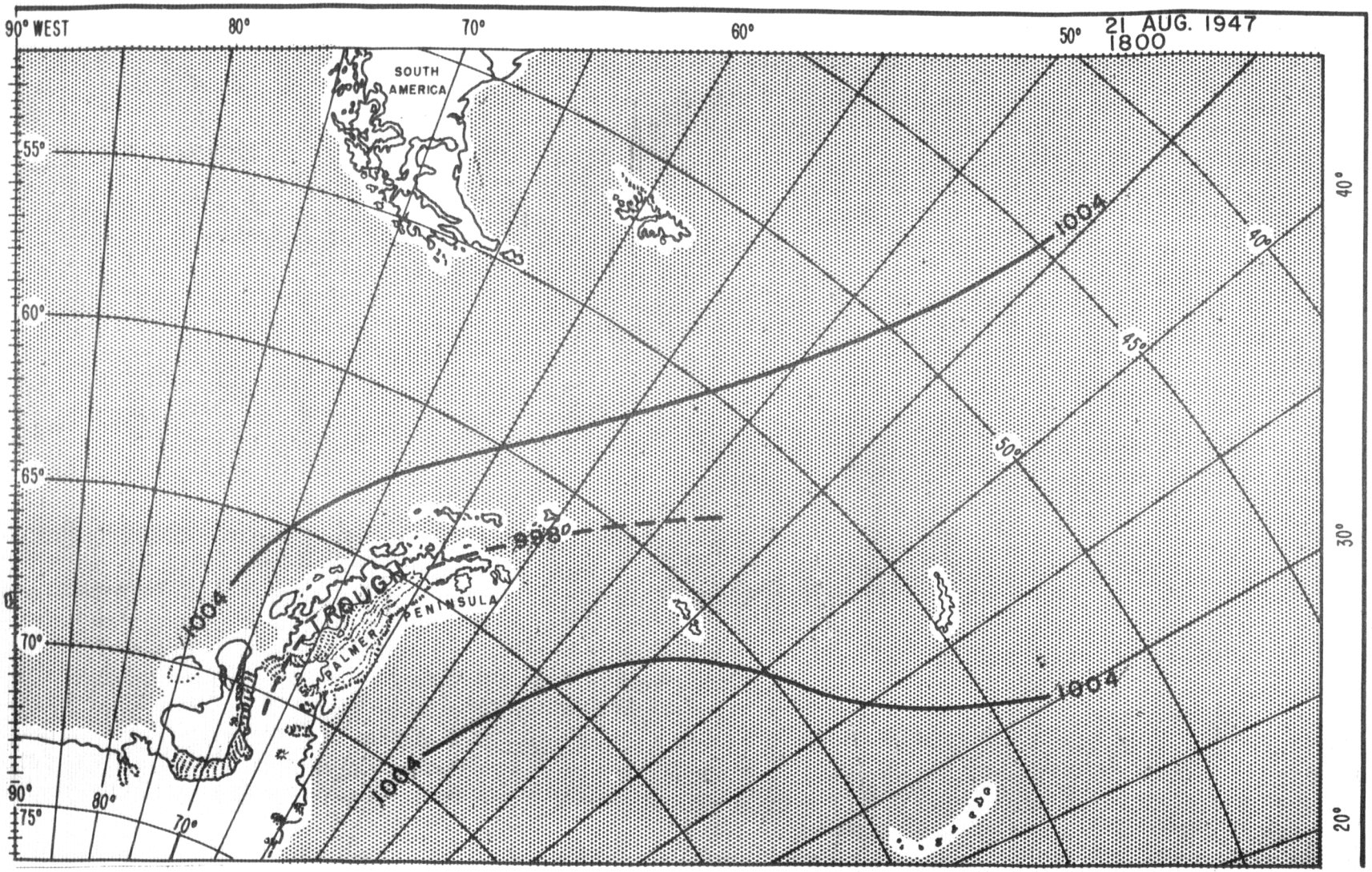

21 AUG. 1947
1800
90° WEST
80°
70°
60°
50°
SOUTH AMERICA
55°
60°
65°
70°
75°
90°
80°
70°
40°
30°
20°
40°
45°
50°
1004
1004
1004
1004
TROUGH
PALMER PENINSULA

Figure 15

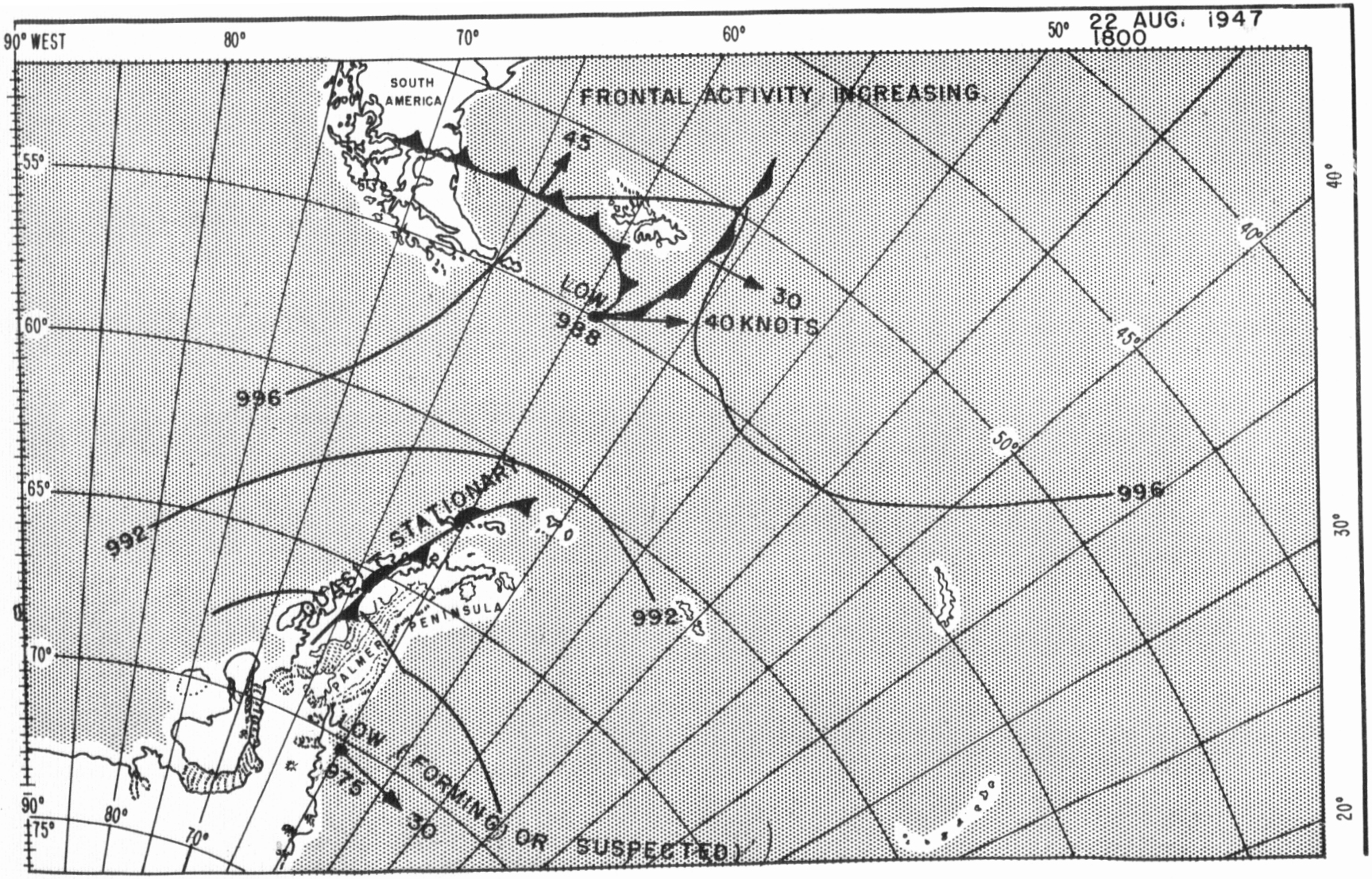

22 AUG. 1947
1800
90° WEST
80°
70°
60°
50°
SOUTH AMERICA
FRONTAL ACTIVITY INCREASING
45
30
40 KNOTS
LOW
988
996
992
STATIONARY
PALMER PENINSULA
LOW (FORMING OR SUSPECTED)
975
30
55°
60°
65°
70°
75°
90°
80°
70°
40°
45°
50°
40°
30°
20°

Figure 16

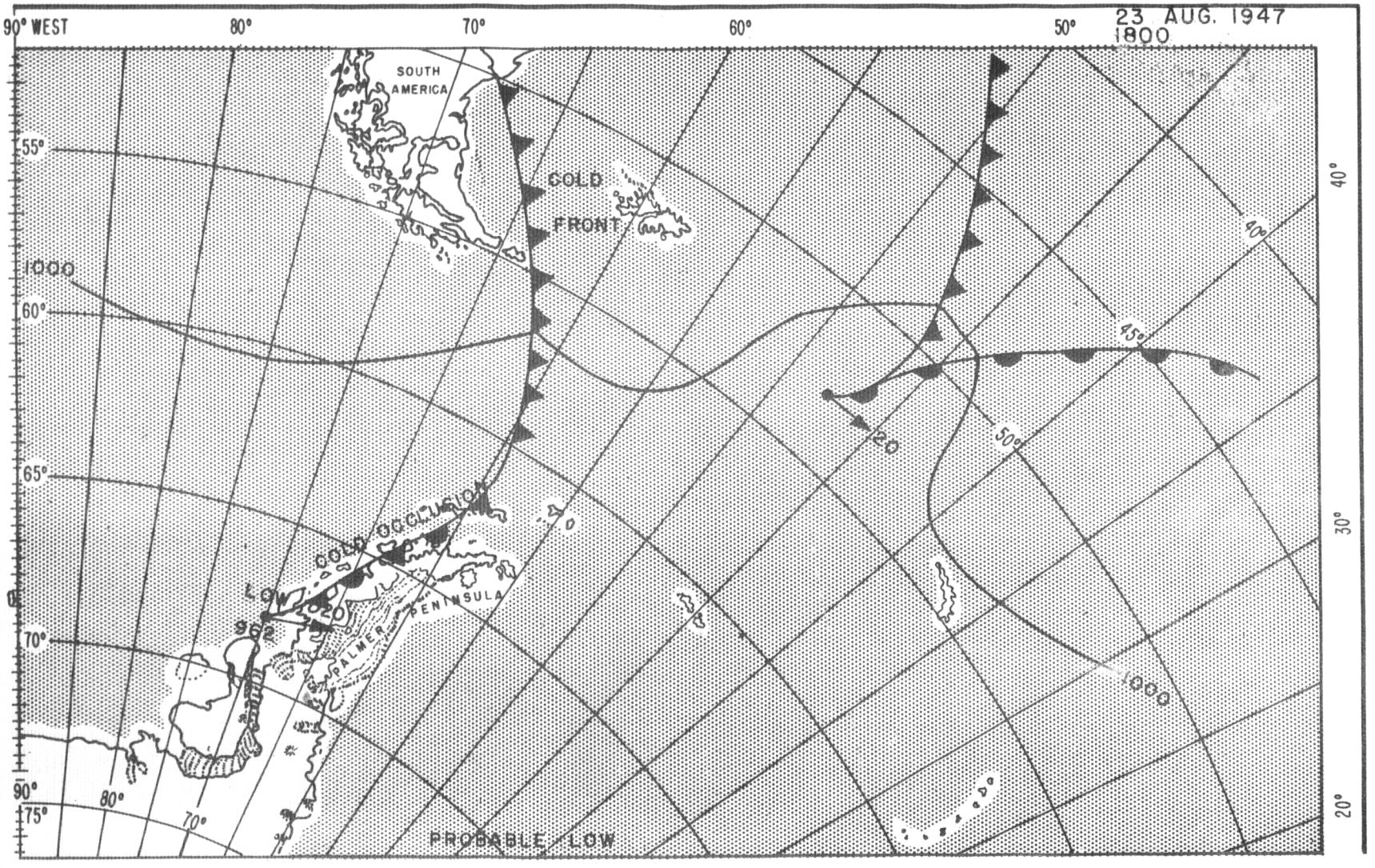

23 AUG. 1947
1800
90° WEST
80°
70°
60°
50°
40°
30°
20°
SOUTH AMERICA
COLD FRONT
COLD OCCLUSION
LOW
962
PALMER PENINSULA
PROBABLE LOW
1000
55°
60°
65°
70°
75°
90°
80°
70°
40°
45°
50°
20
0
1000

Figure 17

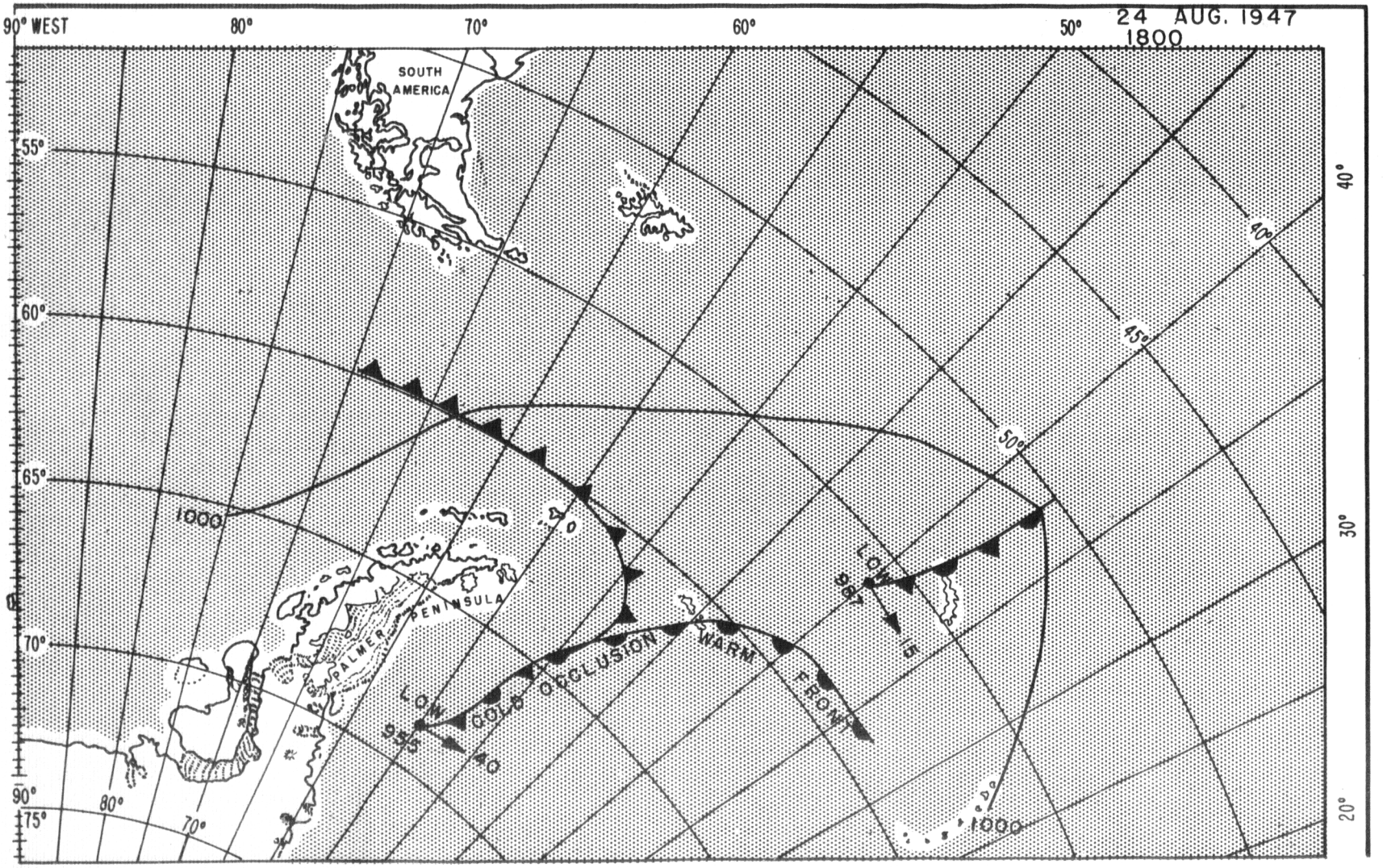

24 AUG. 1947
1800
90° WEST
80°
70°
60°
50°
SOUTH AMERICA
55°
60°
65°
70°
75°
40°
30°
20°
40°
45°
50°
1000
PALMER PENINSULA
LOW
955
40
COLD OCCLUSION
WARM FRONT
LOW
987
15
1000

Figure 18

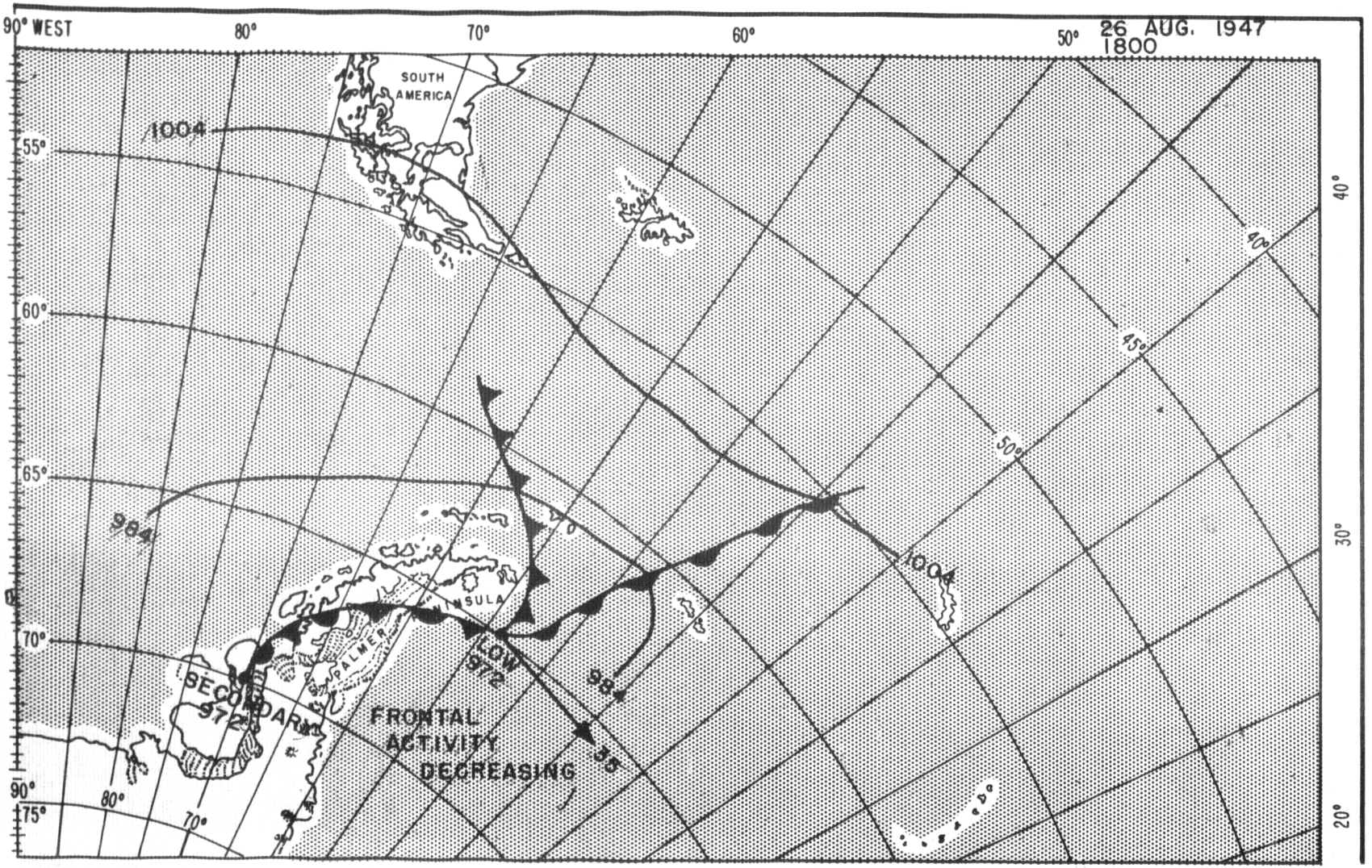

90° WEST
80°
70°
60°
50°
26 AUG. 1947
1800
SOUTH AMERICA
1004
55°
60°
65°
70°
984
PALMER
INSULA
LOW
972
984
1004
SECONDARY
972
FRONTAL
ACTIVITY
DECREASING
35
90°
75°
80°
70°
40°
45°
50°
40°
30°
20°

Figure 19

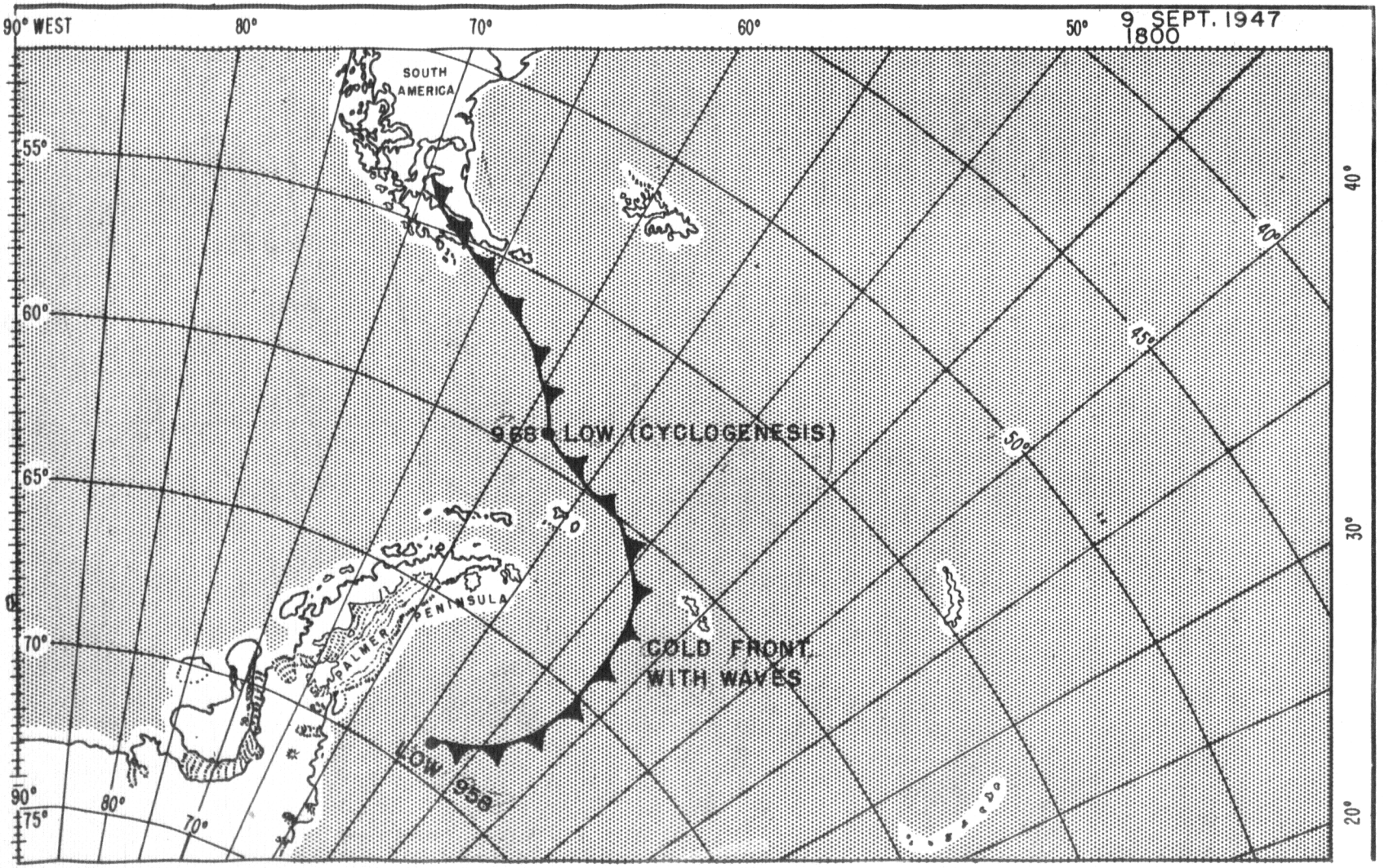

90° WEST
80°
70°
60°
50°
9 SEPT. 1947
1800
SOUTH AMERICA
55°
60°
65°
70°
75°
90°
80°
70°
40°
30°
20°
40°
45°
50°
968 LOW (CYCLOGENESIS)
PALMER PENINSULA
COLD FRONT WITH WAVES
LOW 958

Figure 20

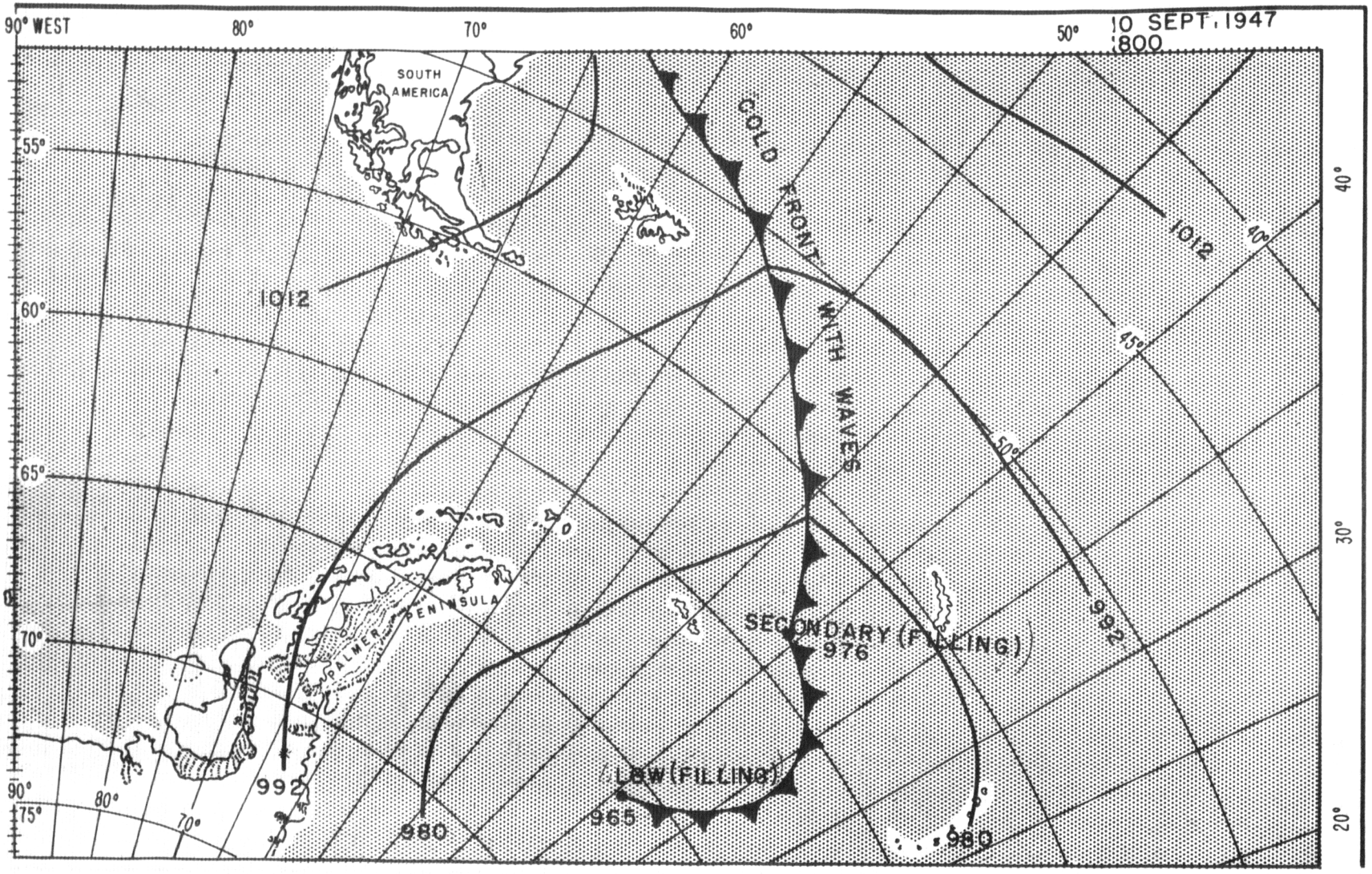

90° WEST
80°
70°
60°
50°
10 SEPT. 1947
1800
SOUTH AMERICA
COLD FRONT WITH WAVES
1012
1012
40°
45°
50°
992
SECONDARY (FILLING)
976
LOW (FILLING)
965
980
980
992
PALMER PENINSULA
55°
60°
65°
70°
90°
75°
80°
70°
40°
30°
20°

Figure 21

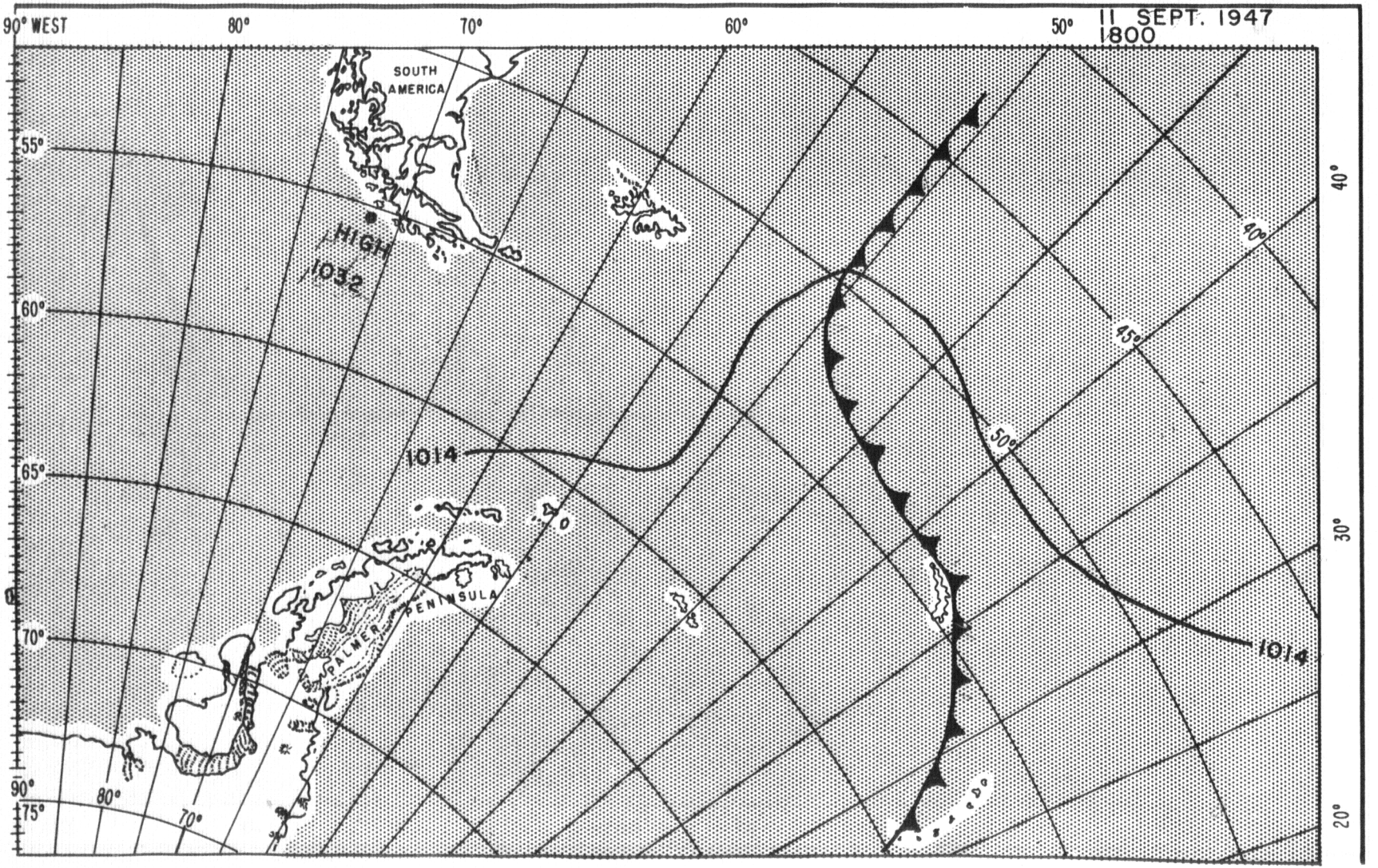

11 SEPT. 1947
1800
90° WEST
80°
70°
60°
50°
40°
30°
20°
55°
60°
65°
70°
75°
90°
80°
70°
40°
45°
50°
SOUTH AMERICA
HIGH
1032
1014
1014
PALMER PENINSULA

Figure 22

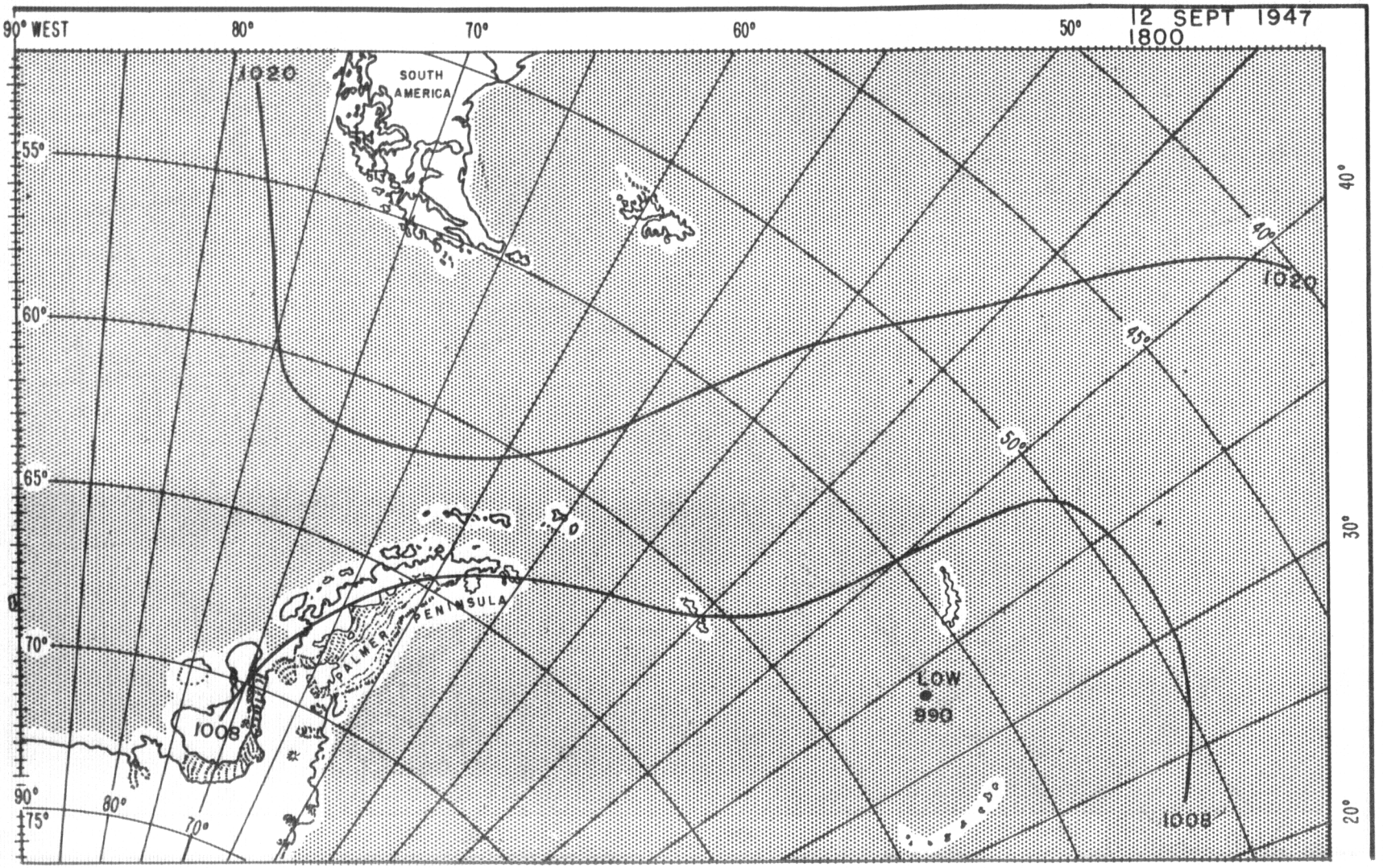

12 SEPT 1947
1800
90° WEST
80°
70°
60°
50°
40°
30°
20°
55°
60°
65°
70°
75°
90°
80°
70°
SOUTH AMERICA
PALMER PENINSULA
1020
1020
1008
1008
LOW
990
40°
45°
50°

Figure 23

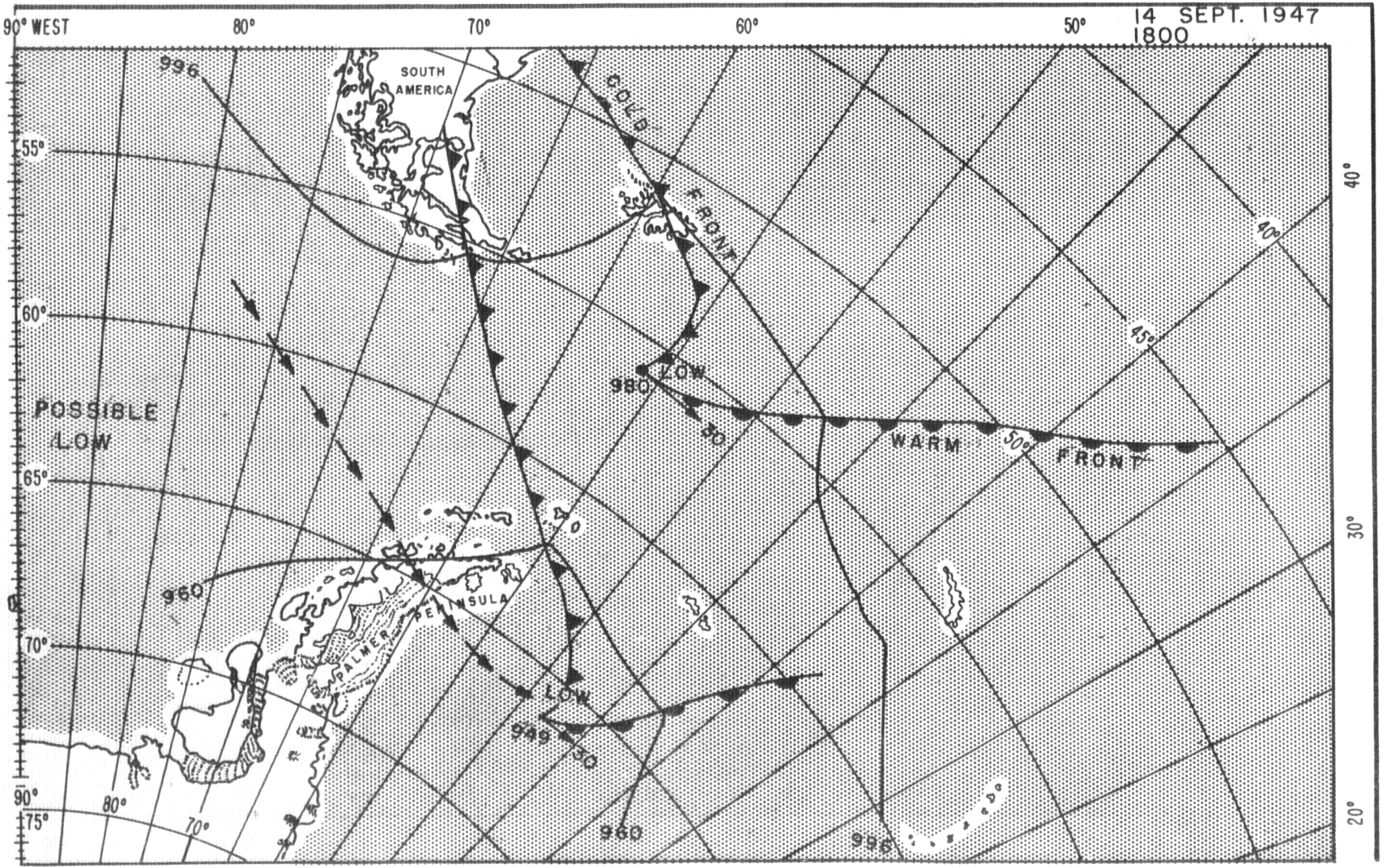

14 SEPT. 1947
1800
90° WEST
80°
70°
60°
50°
40°
30°
20°
55°
60°
65°
70°
75°
90°
80°
70°
SOUTH AMERICA
COLD FRONT
WARM FRONT
LOW
980
LOW
949
POSSIBLE LOW
PALMER PENINSULA
996
960
960
996
40
45°
50°
30

Figure 24

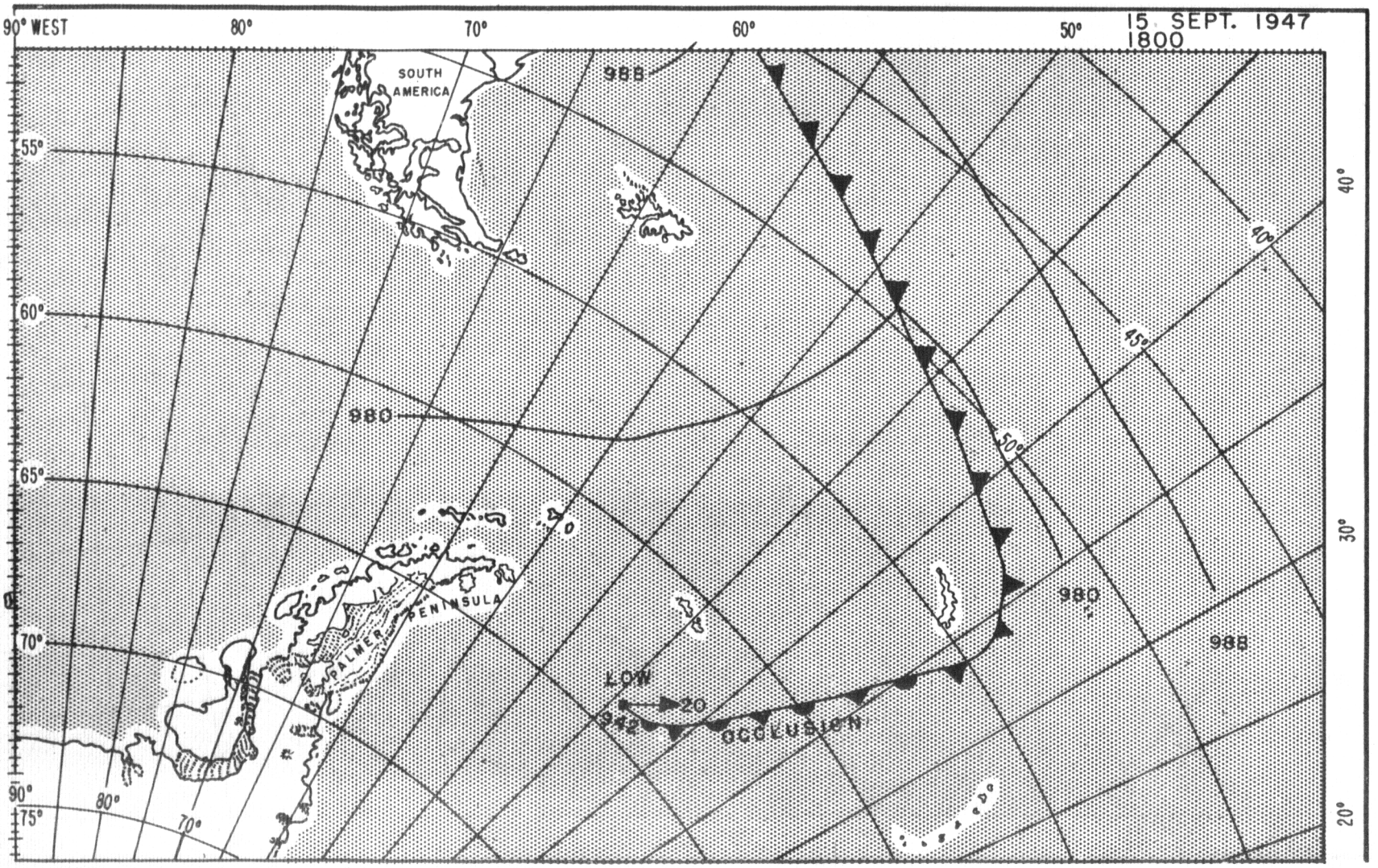

15 SEPT. 1947
1800
90° WEST
80°
70°
60°
50°
40°
30°
20°
55°
60°
65°
70°
75°
90°
80°
70°
SOUTH AMERICA
988
980
40
45
50
40
30
980
988
PALMER PENINSULA
LOW
942
20
OCCLUSION

Figure 25

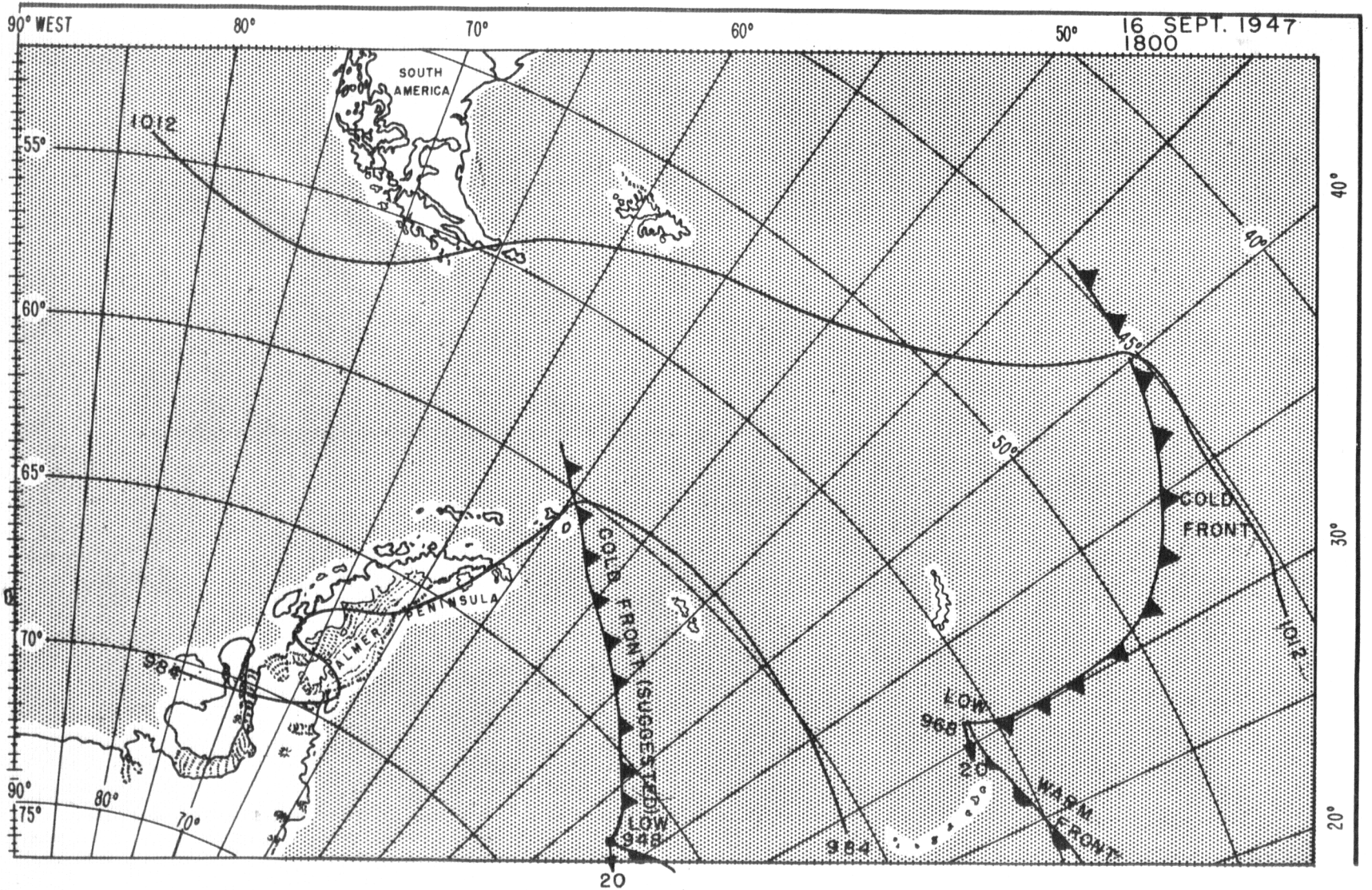

16 SEPT. 1947
1800
90° WEST
80°
70°
60°
50°
40°
30°
20°
SOUTH AMERICA
1012
55°
60°
65°
70°
75°
90°
80°
70°
984
ALMER
PENINSULA
COLD FRONT (SUGGESTED)
LOW
948
20
984
LOW
968
20
WARM FRONT
COLD FRONT
1012
40°
45°
50°

Figure 26

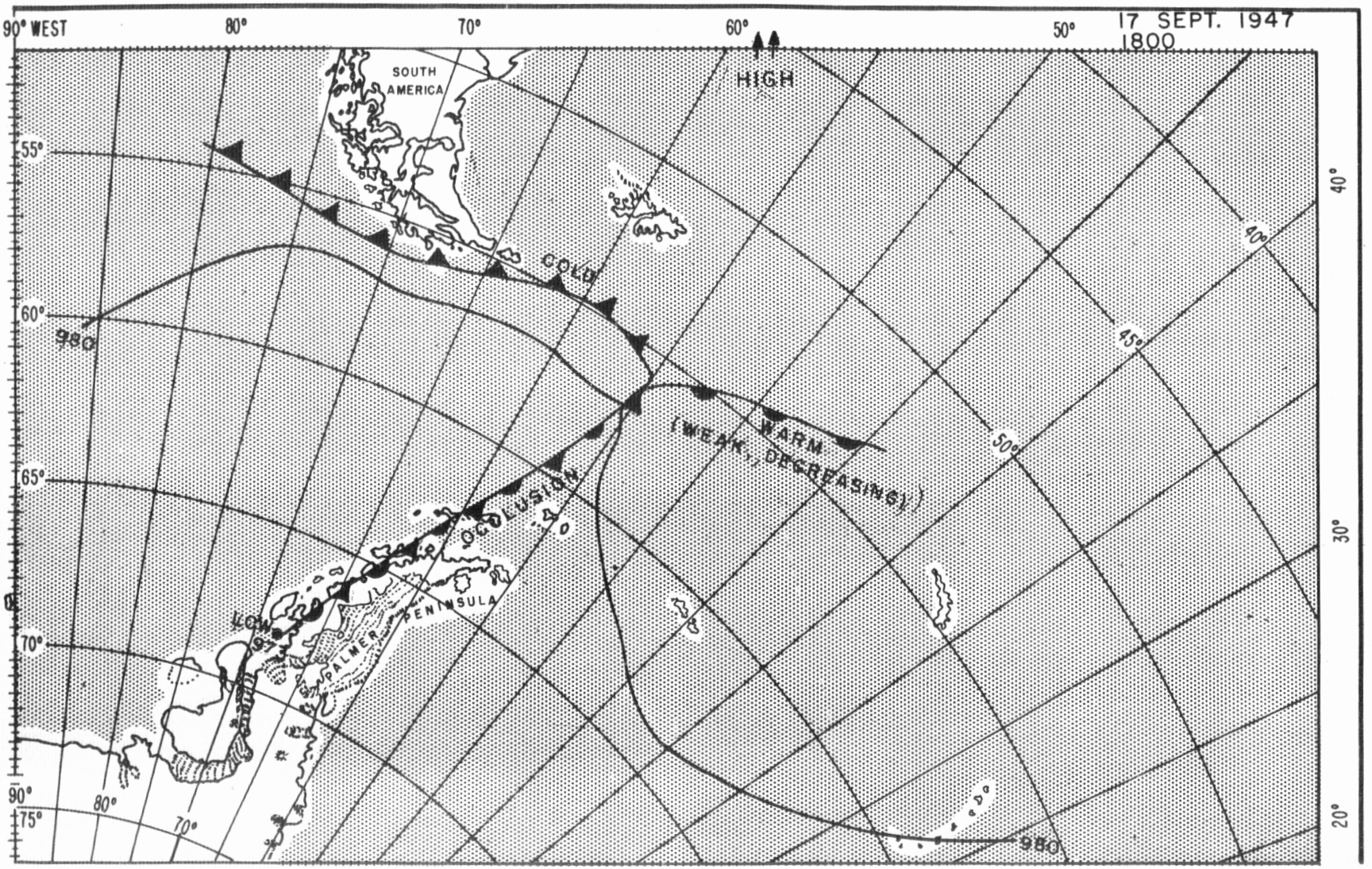
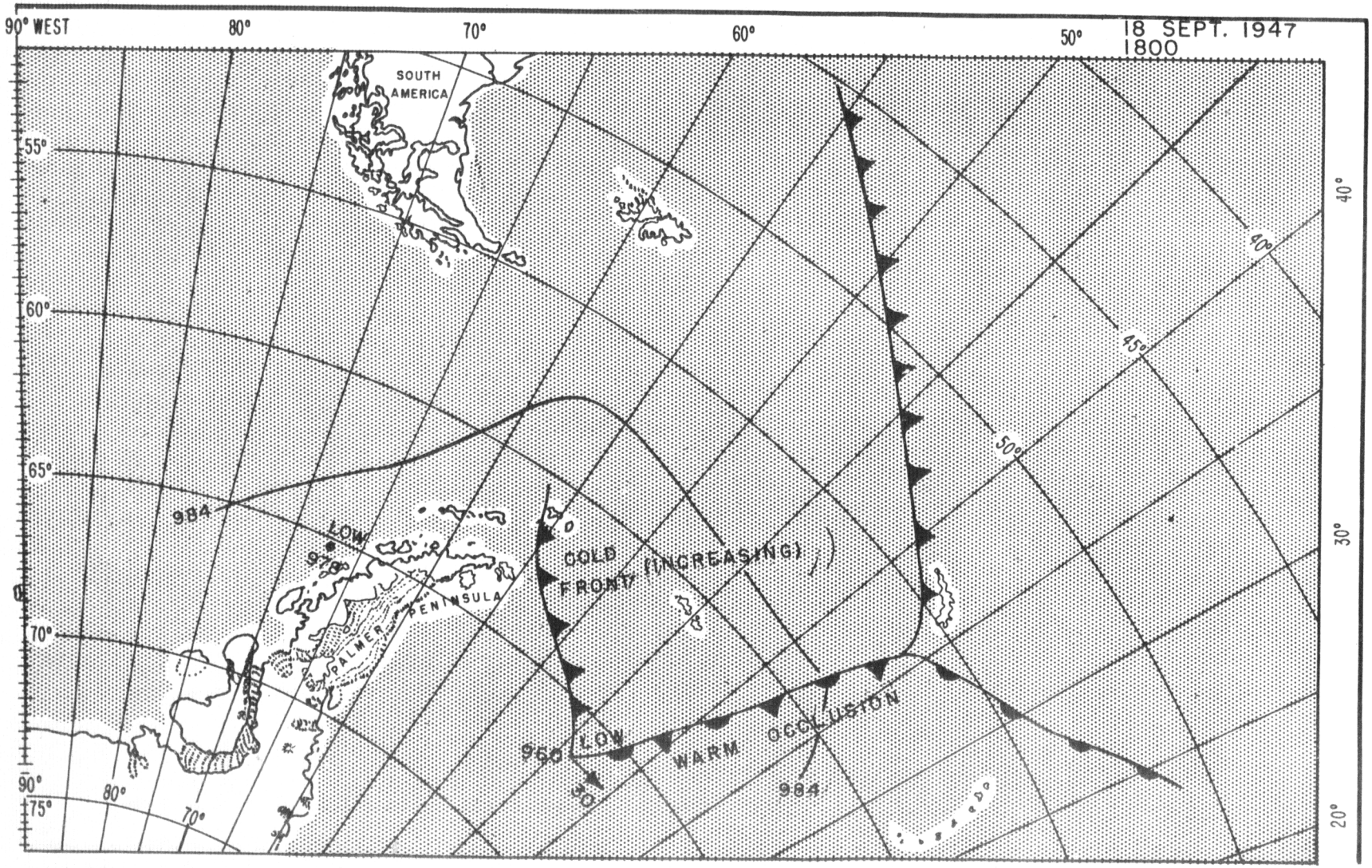

17 SEPT. 1947
1800
90° WEST
80°
70°
60°
50°
HIGH
SOUTH AMERICA
55°
60°
65°
70°
75°
40°
45°
50°
30°
20°
COLD
WARM
(WEAK, DECREASING)
OCCLUSION
LOW
PALMER PENINSULA
980
980
90°
80°
70°

Figure 27


18 SEPT. 1947
1800
90° WEST
80°
70°
60°
50°
40°
30°
20°
55°
60°
65°
70°
75°
90°
80°
70°
SOUTH AMERICA
PALMER PENINSULA
LOW
978
984
COLD FRONT (INCREASING)
960 LOW
WARM OCCLUSION
984
30
40
45
50

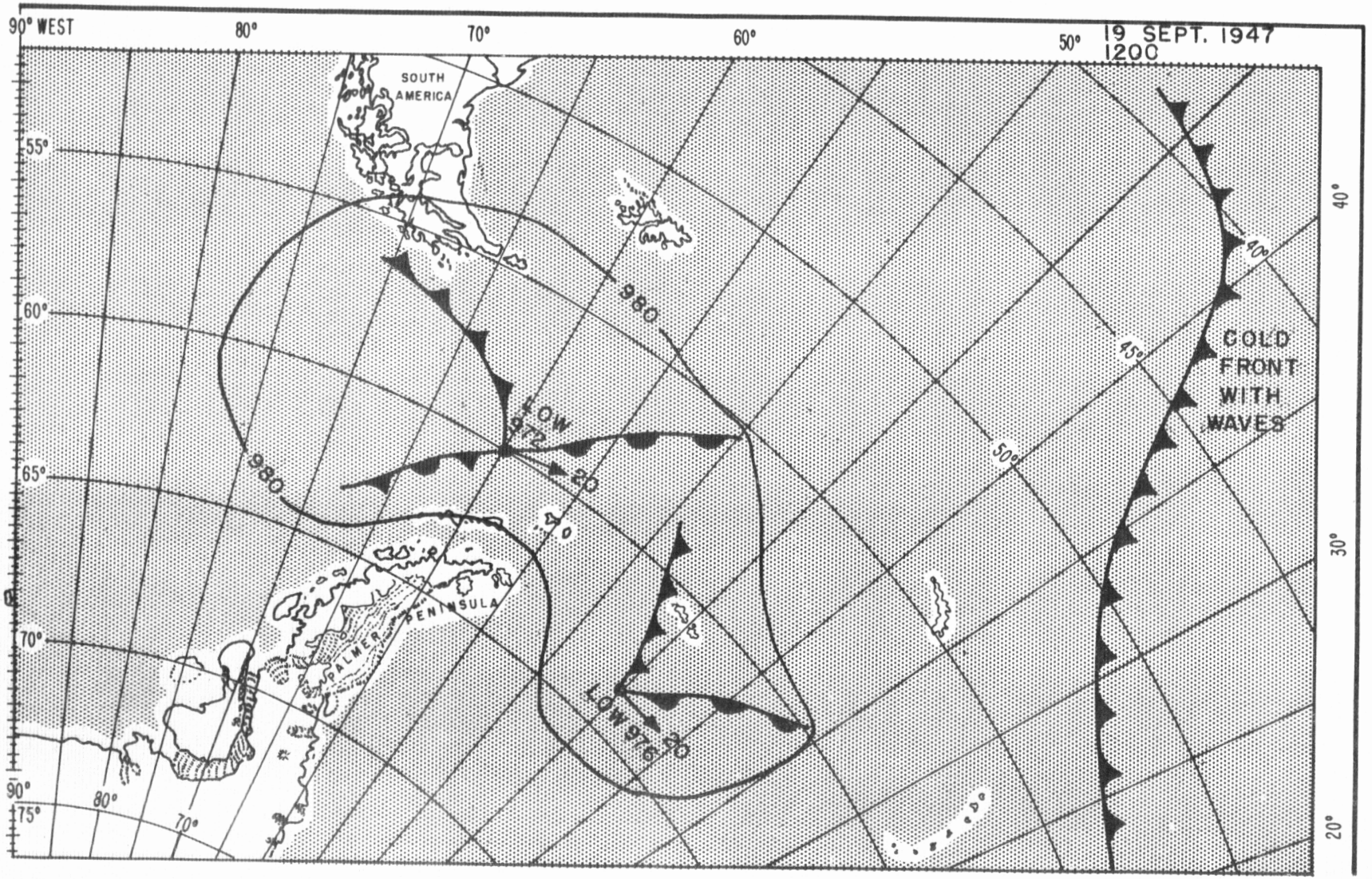

19 SEPT. 1947
1200
90° WEST
80°
70°
60°
50°
SOUTH AMERICA
55°
60°
65°
70°
75°
90°
80°
70°
40°
30°
20°
980
980
LOW 972
20
40
LOW 976
20
40
45°
50°
COLD FRONT WITH WAVES
PALMER PENINSULA

Figure 29

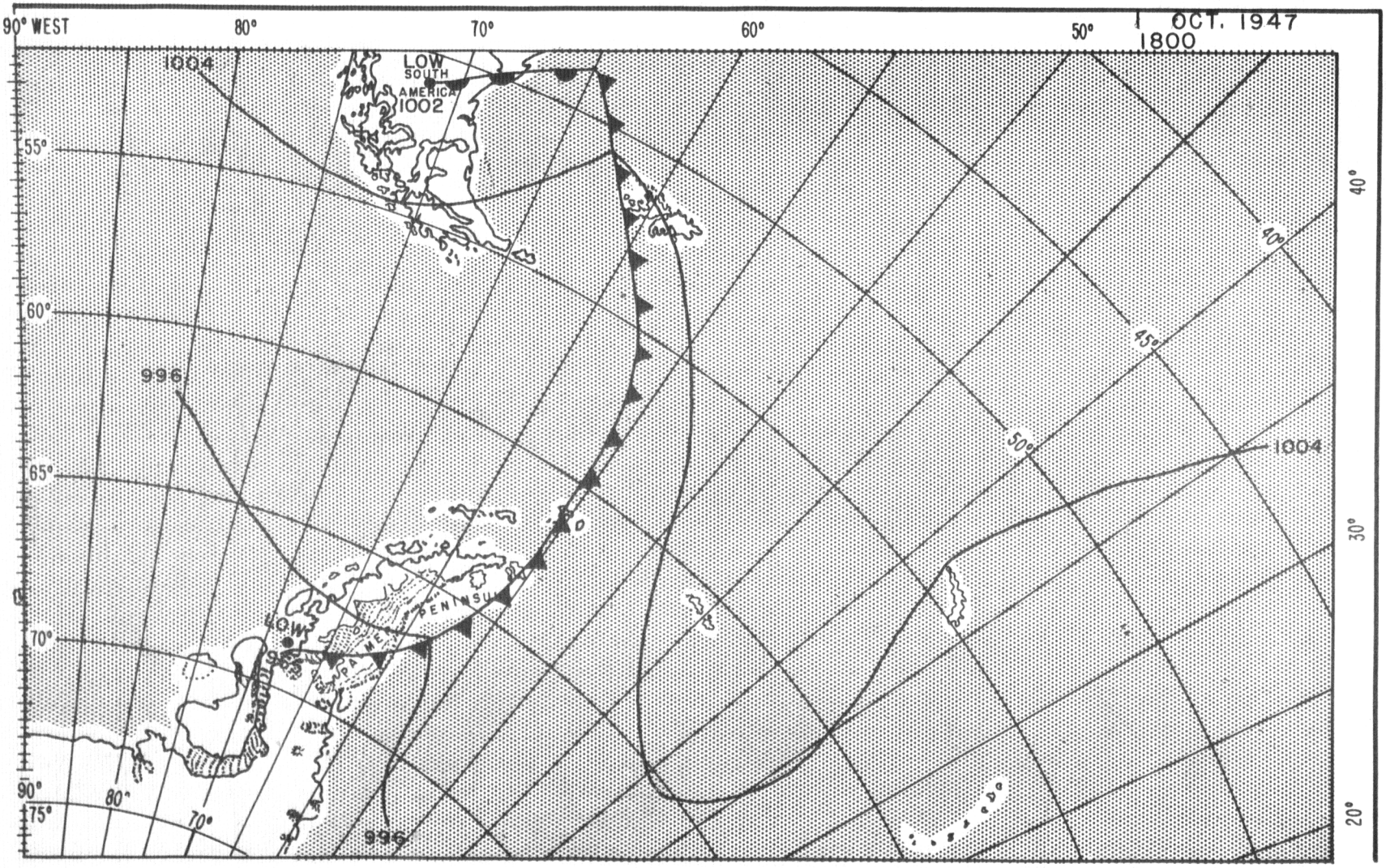

1 OCT. 1947
1800
90° WEST
80°
70°
60°
50°
40°
30°
20°
55°
60°
65°
70°
75°
90°
80°
70°
45°
50°
1004
1002
996
LOW
SOUTH
AMERICA
LOW
PENINSULA

Figure 30

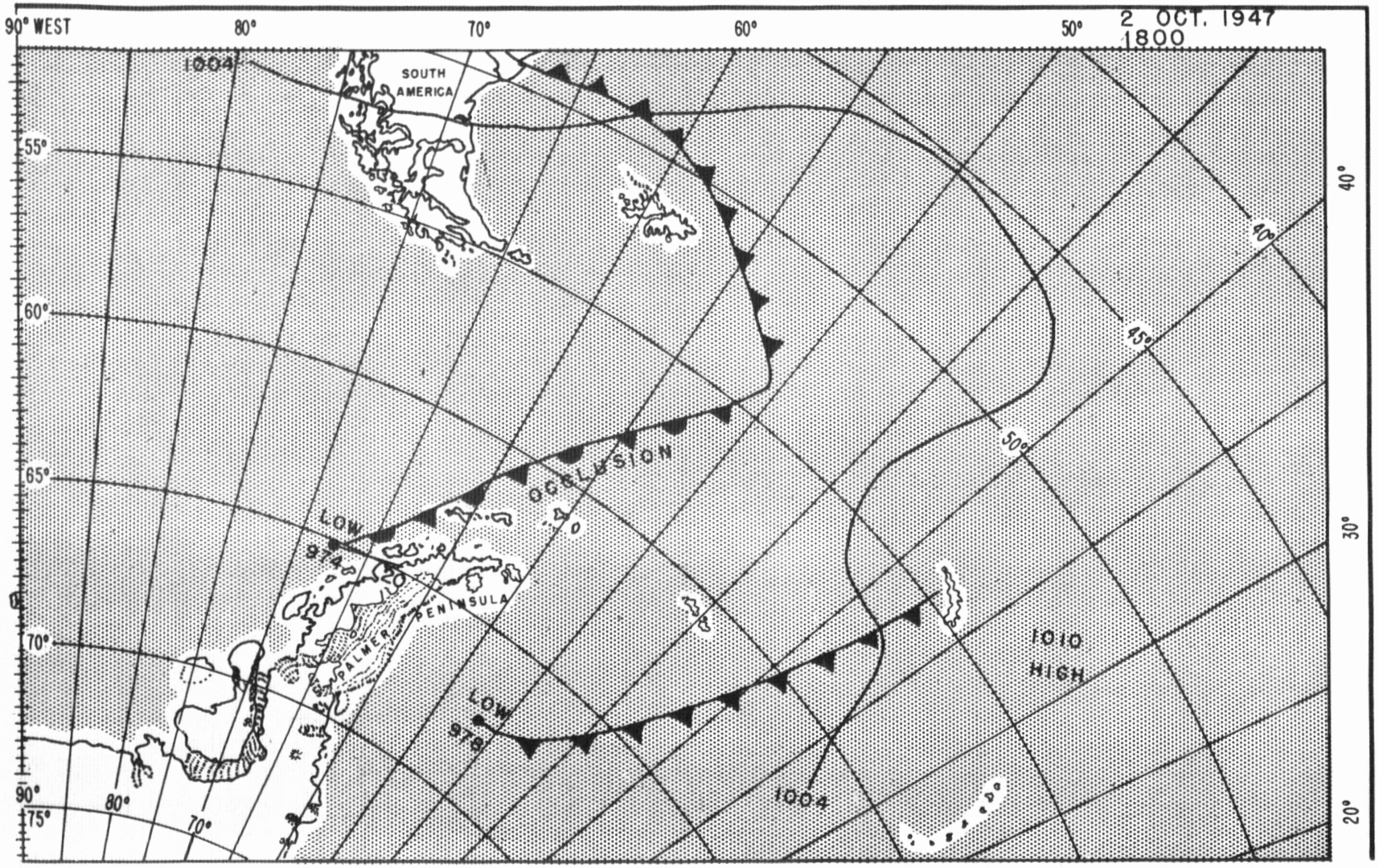

90° WEST
80°
70°
60°
50°
2 OCT. 1947
1800
1004
SOUTH AMERICA
55°
60°
65°
70°
75°
90°
80°
70°
40°
30°
20°
40°
45°
50°
OCCLUSION
LOW
974
20
40
PALMER PENINSULA
LOW
978
1010
HIGH
1004

Figure 31

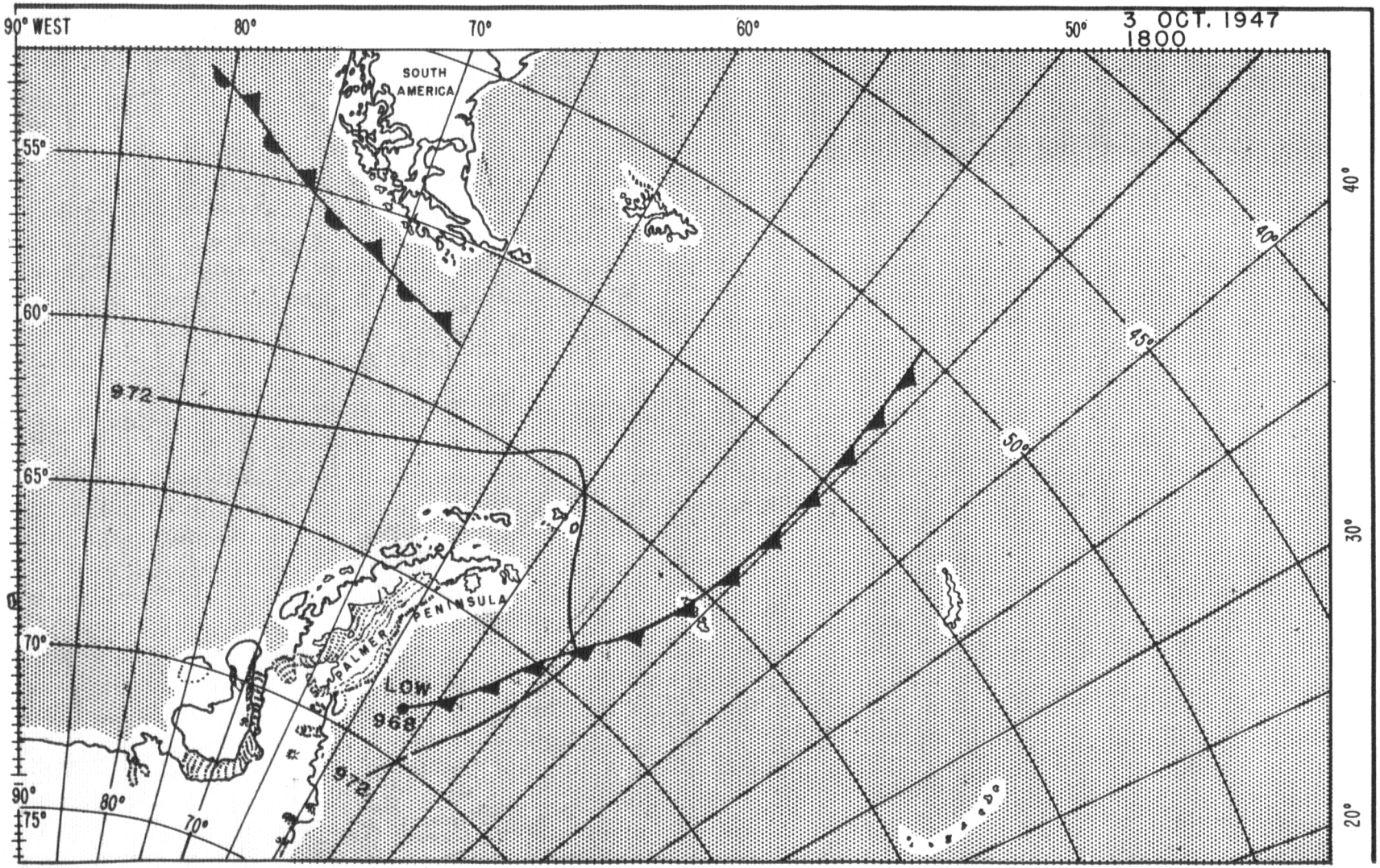

3 OCT. 1947
1800
90° WEST
80°
70°
60°
50°
40°
30°
20°
55°
60°
65°
70°
75°
90°
80°
70°
SOUTH AMERICA
PALMER PENINSULA
LOW
968
972
972
40°
45°
50°

Figure 32

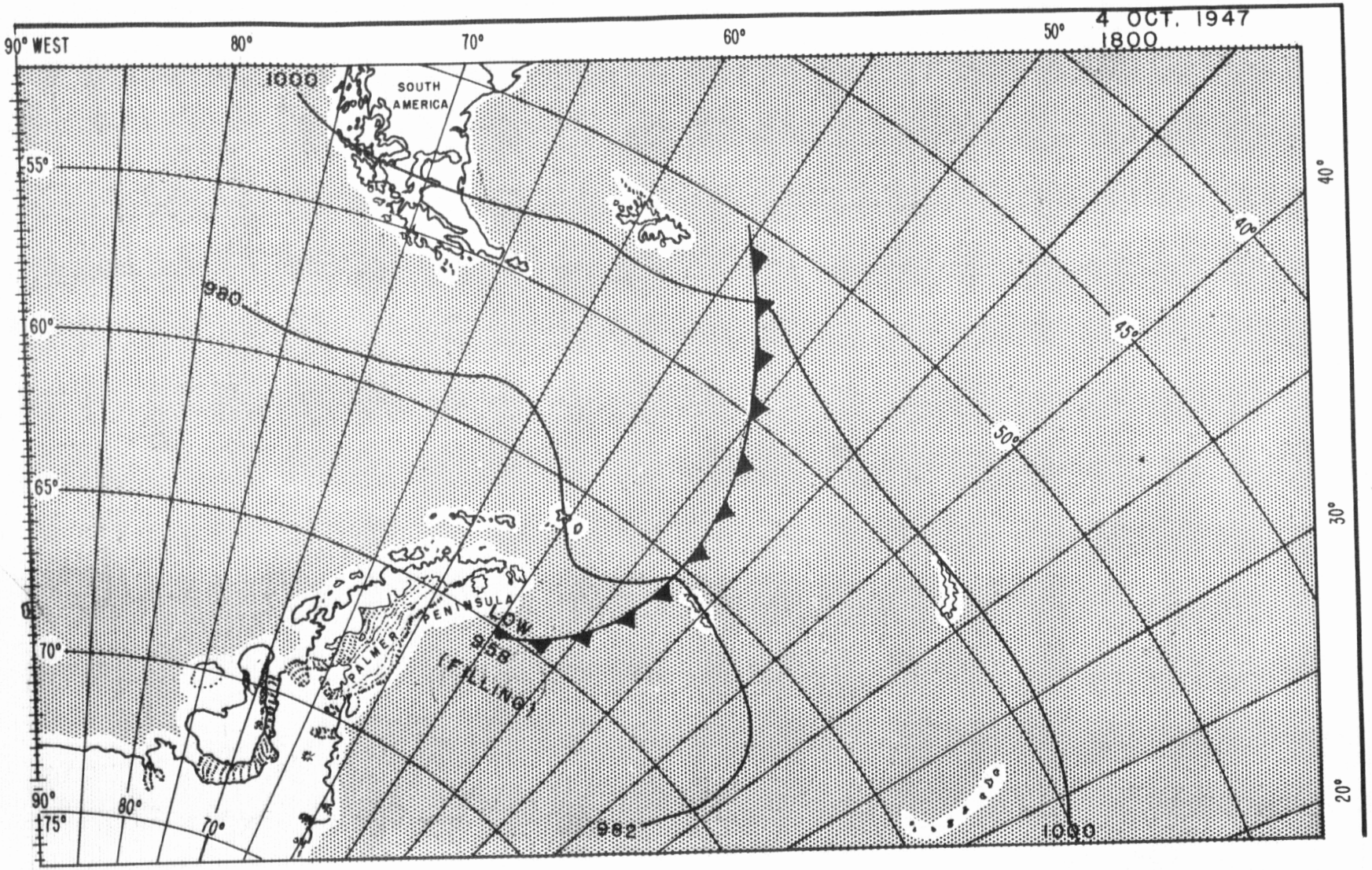

4 OCT. 1947
1800
90° WEST
80°
70°
60°
50°
40°
30°
20°
55°
60°
65°
70°
75°
1000
SOUTH AMERICA
980
PALMER PENINSULA
LOW
958
(FALLING)
982
1000
40°
45°
50°

Figure 33

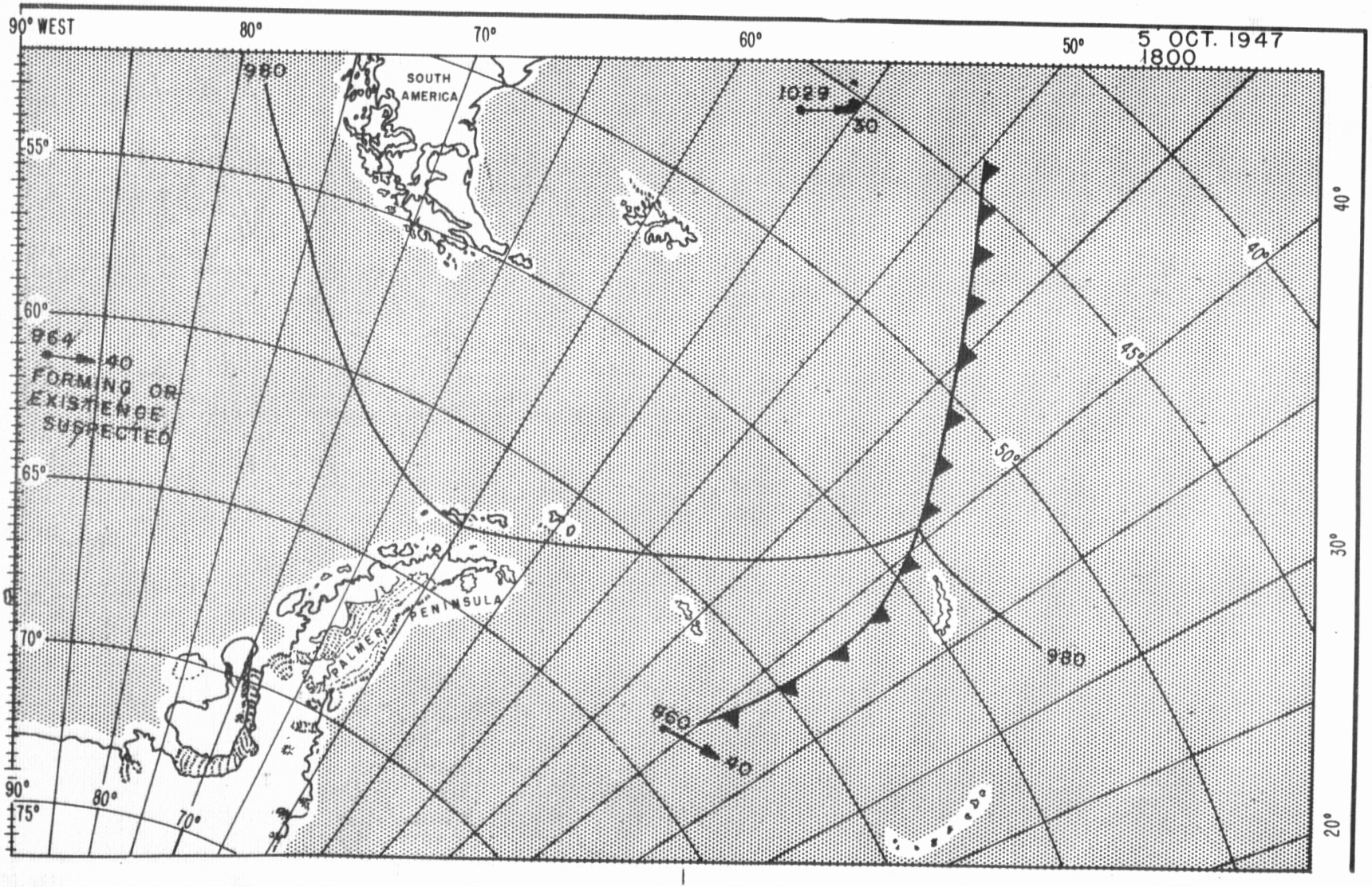

5 OCT. 1947
1800
90° WEST
80°
70°
60°
50°
40°
30°
20°
55°
60°
65°
70°
75°
90°
80°
70°
SOUTH AMERICA
980
1029
30
964
40
FORMING OR EXISTENCE SUSPECTED
40°
45°
50°
980
960
40
PALMER PENINSULA

Figure 34

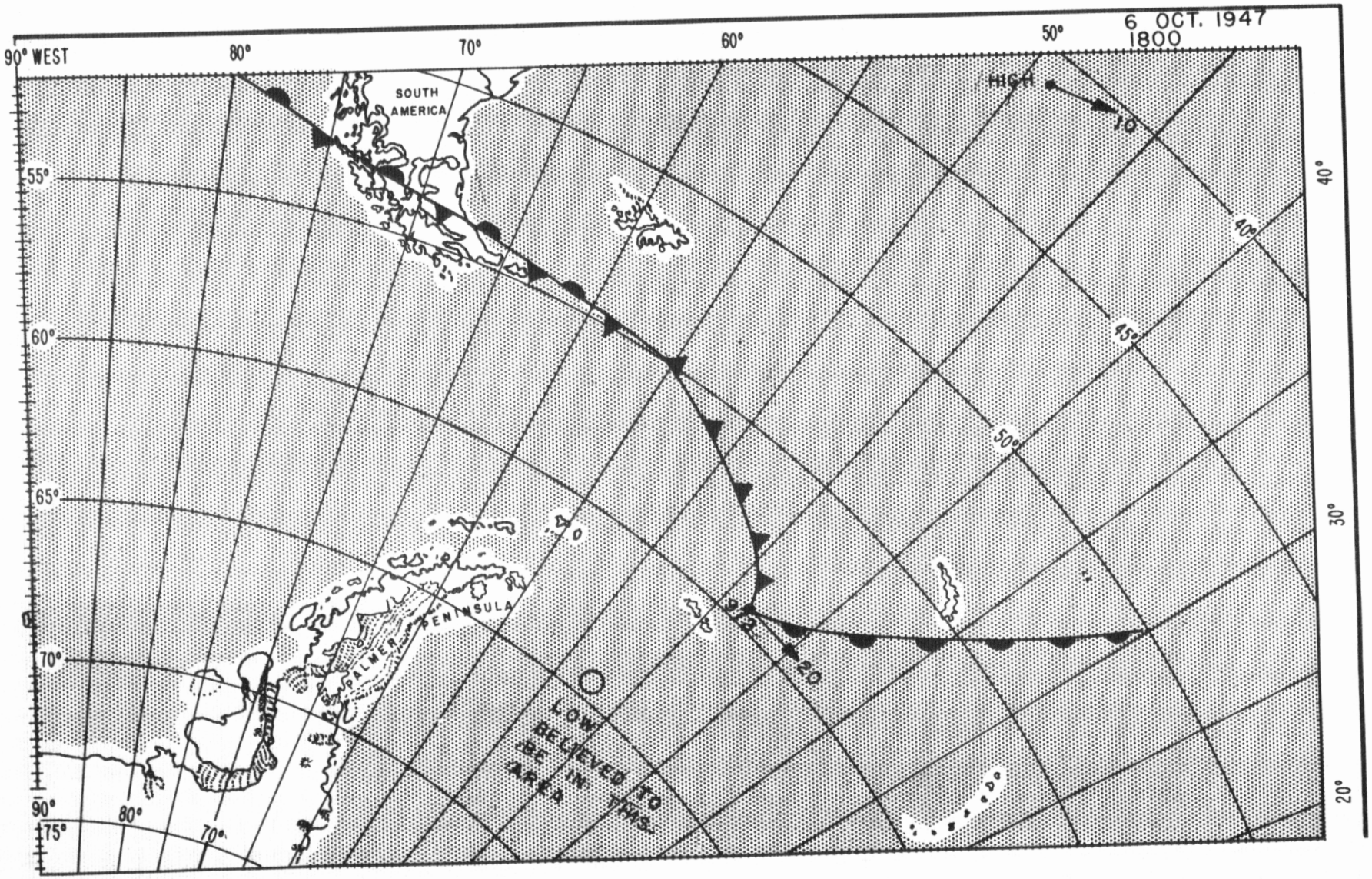

6 OCT. 1947
1800
90° WEST
80°
70°
60°
50°
40°
30°
20°
55°
60°
65°
70°
75°
90°
80°
70°
SOUTH AMERICA
HIGH
10
40°
45°
50°
0
12
20
PALMER PENINSULA
LOW BELIEVED TO BE IN THIS AREA

Figure 35

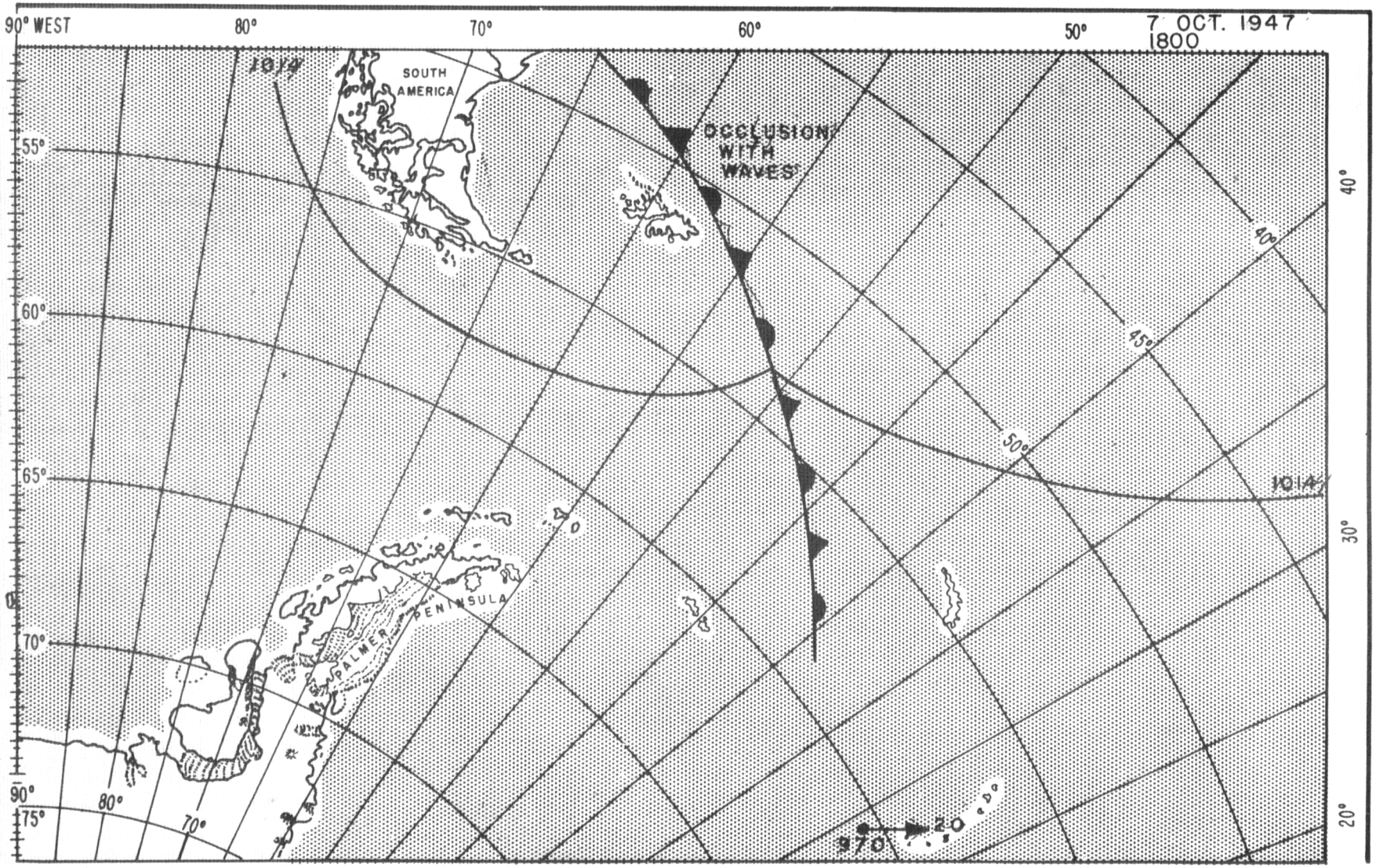

7 OCT. 1947
1800
90° WEST
80°
70°
60°
50°
40°
30°
20°
55°
60°
65°
70°
75°
90°
80°
70°
1014
1014
40
45
50
SOUTH AMERICA
OCCLUSION WITH WAVES
PALMER PENINSULA
970
20

Figure 36

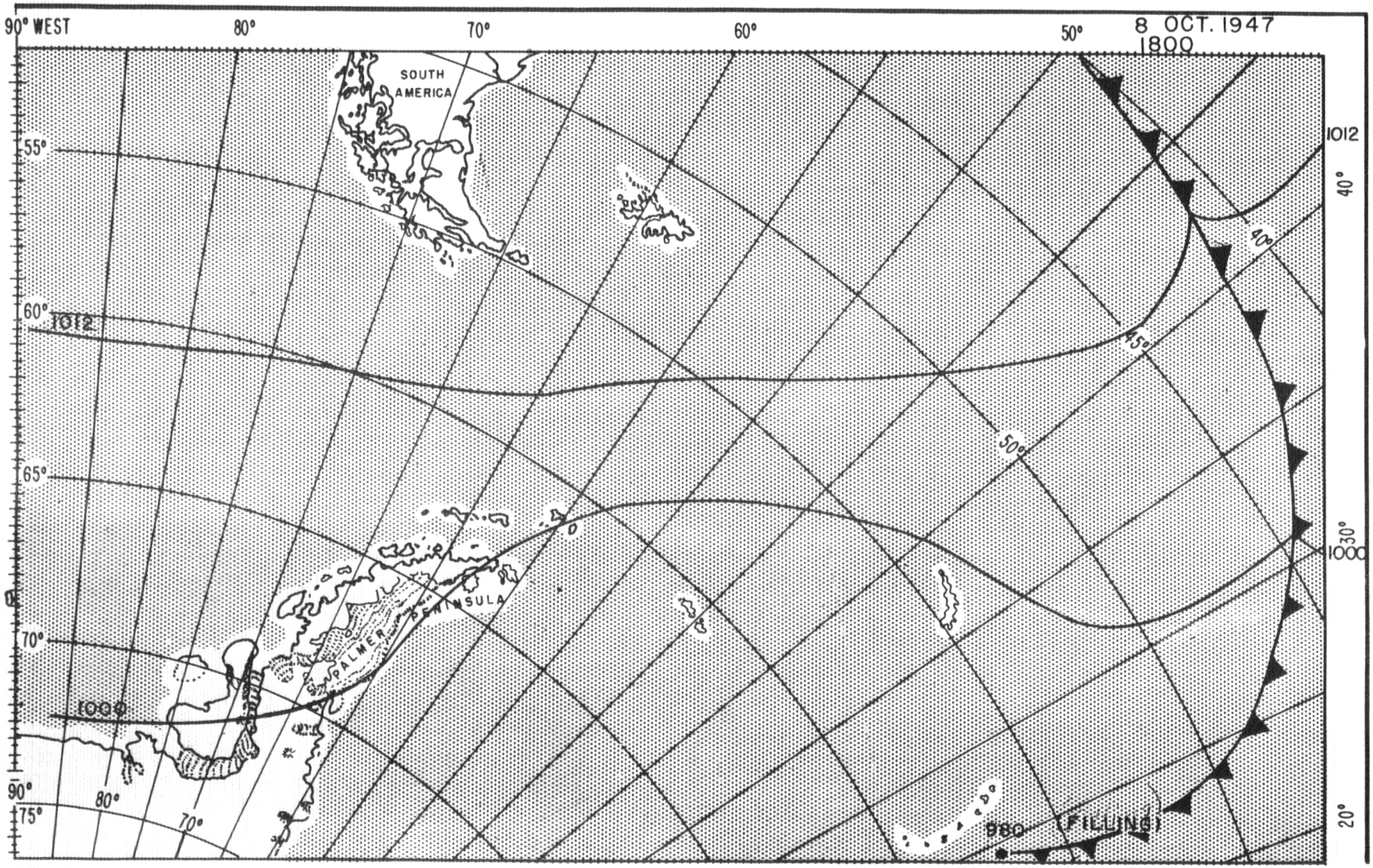

90° WEST
80°
70°
60°
50°
8 OCT. 1947
1800
SOUTH AMERICA
55°
60°
65°
70°
75°
90°
80°
70°
1012
1000
PALMER PENINSULA
40°
45°
50°
1012
40°
30°
1000
20°
980
(FILLING)

Figure 37

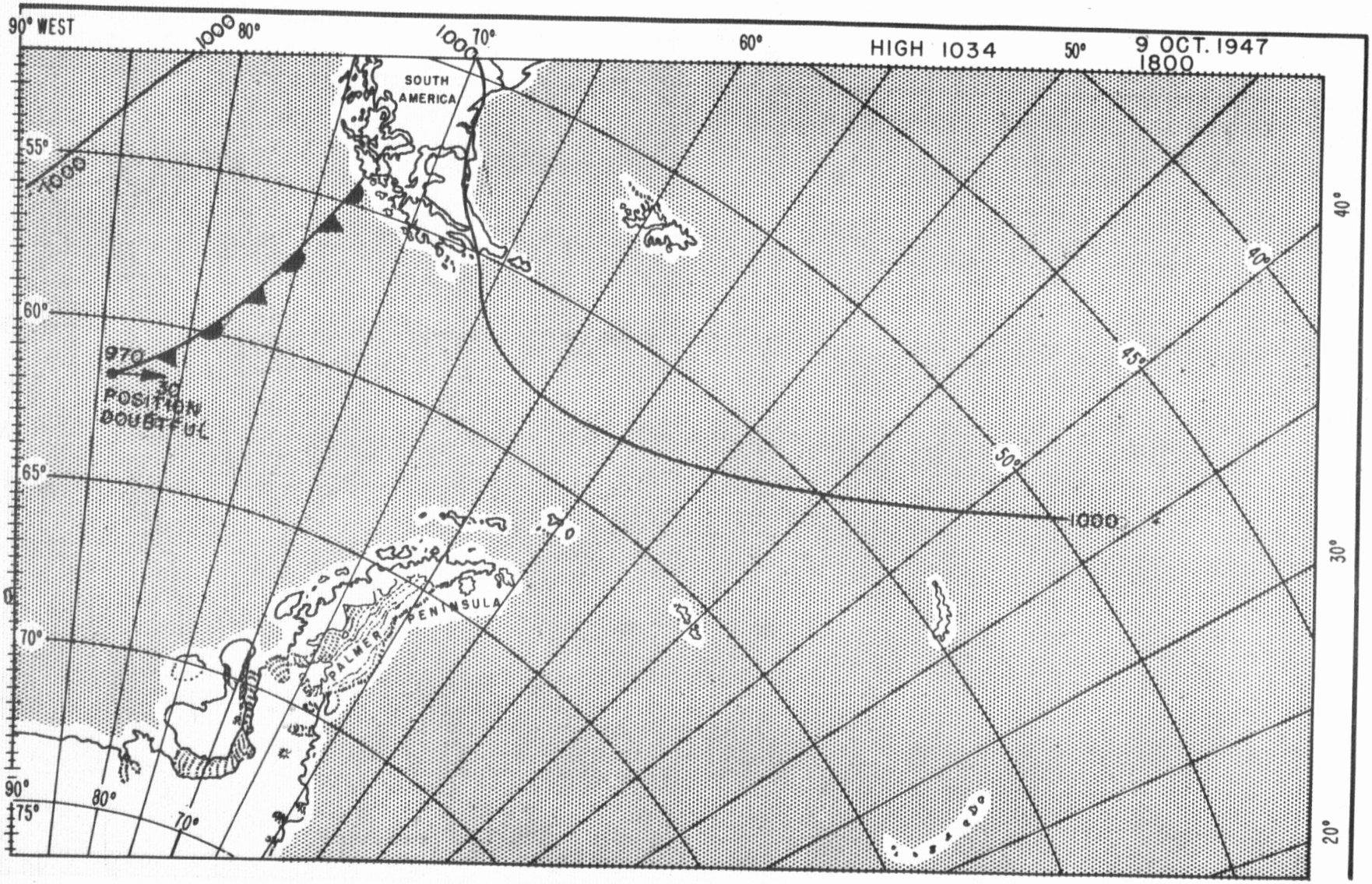

90° WEST
80°
70°
60°
50°
HIGH 1034
9 OCT. 1947
1800
SOUTH AMERICA
55°
60°
65°
70°
75°
90°
80°
70°
1000
970
30
POSITION DOUBTFUL
PALMER PENINSULA
40°
45°
50°
30°
20°

Figure 38

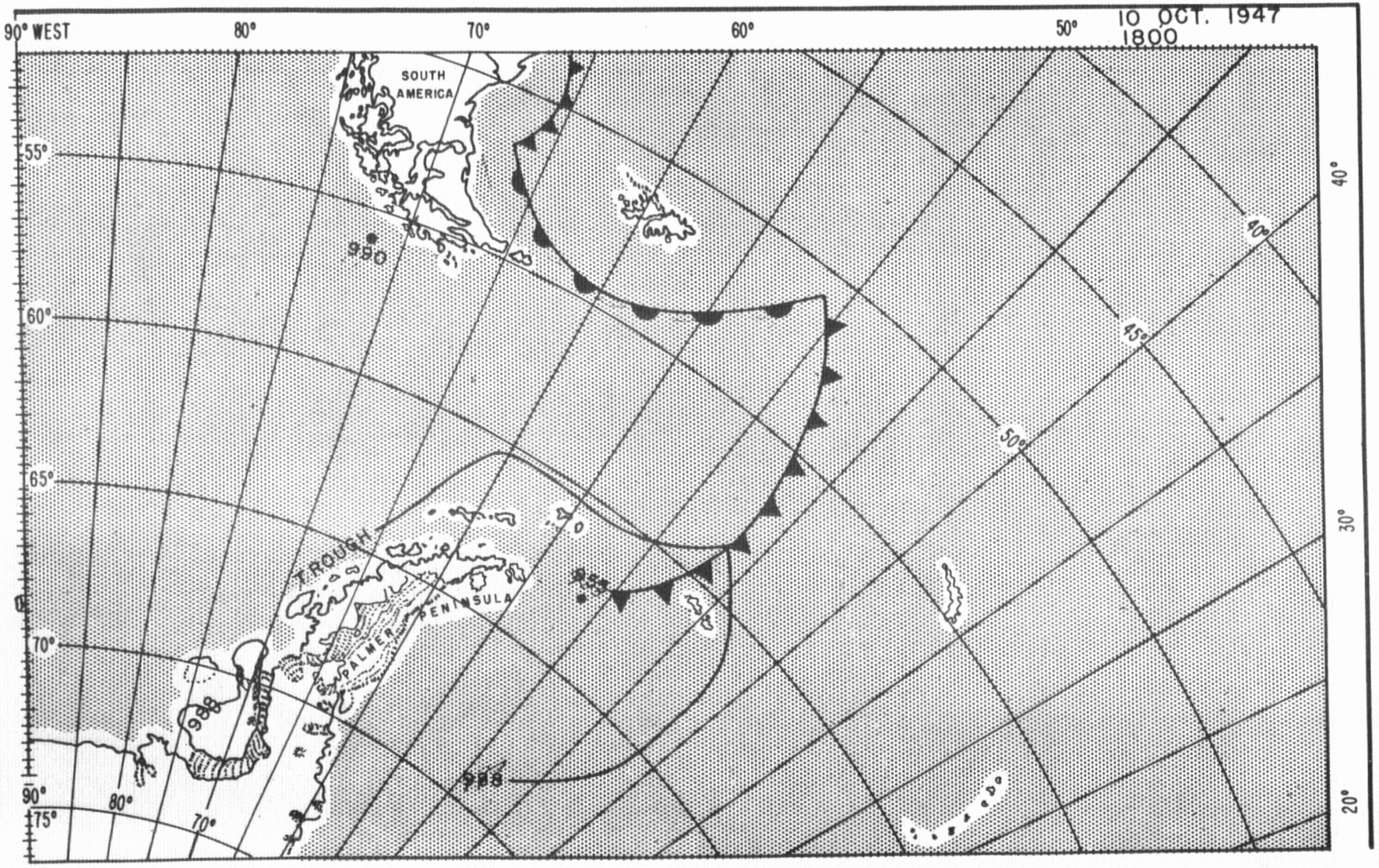

10 OCT. 1947
1800
90° WEST
80°
70°
60°
50°
40°
30°
20°
55°
60°
65°
70°
75°
SOUTH AMERICA
990
988
988
988
TROUGH
PALMER PENINSULA
40°
45°
50°

Figure 39

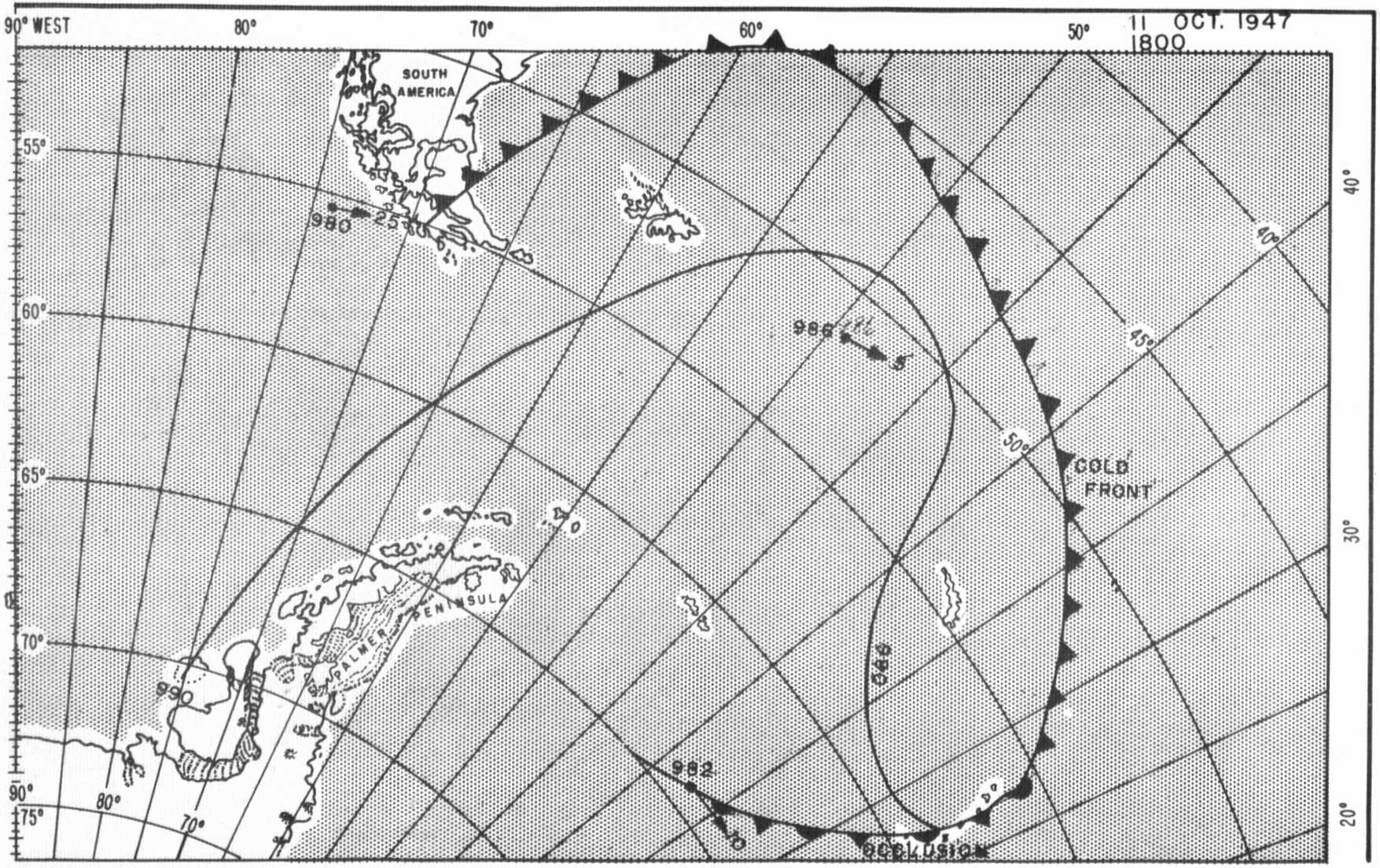

11 OCT. 1947
1800
90° WEST
80°
70°
60°
50°
40°
30°
20°
55°
60°
65°
70°
75°
SOUTH AMERICA
PALMER PENINSULA
COLD FRONT
OCCLUSION
980
25
988
5
990
982
949
40°
45°
50°

Figure 40

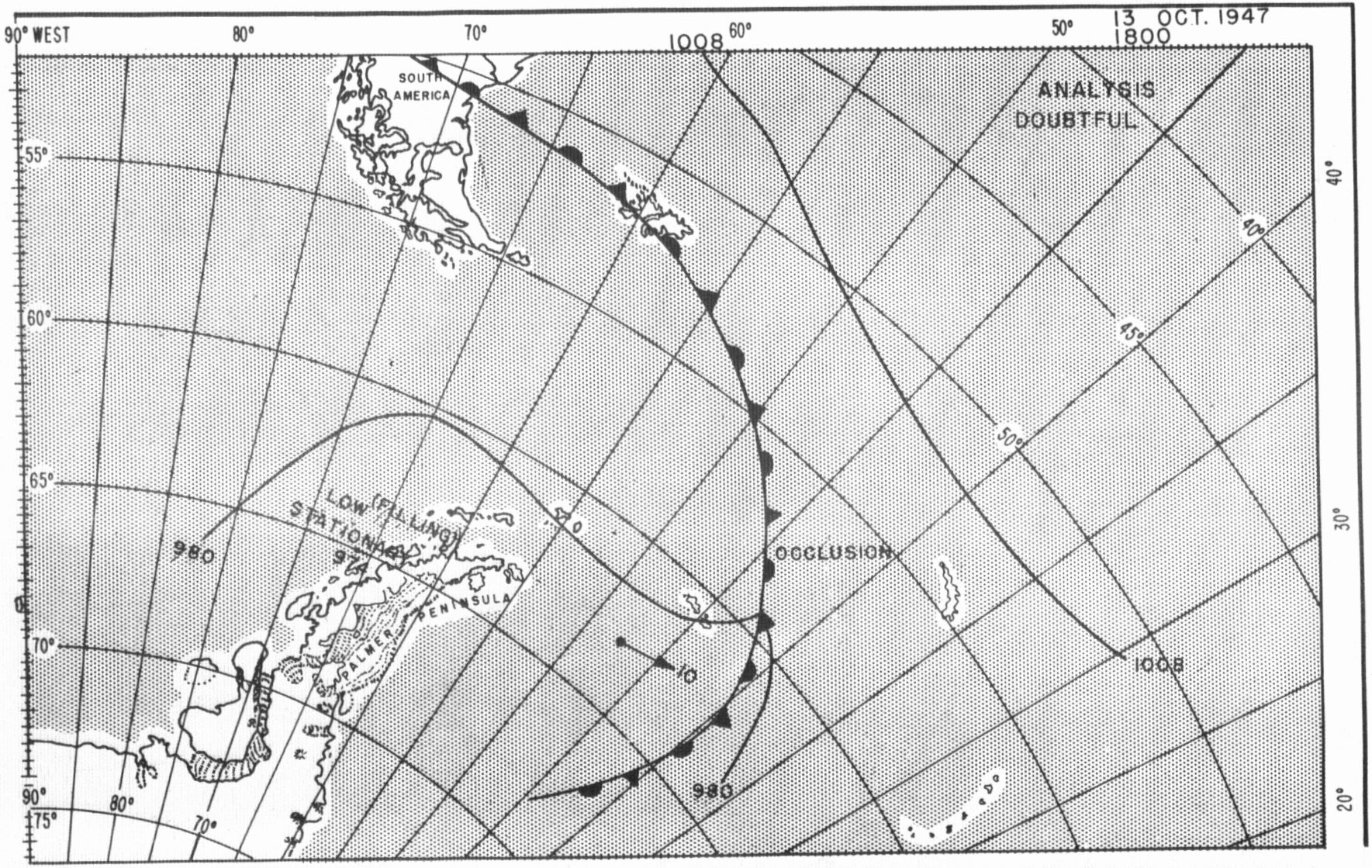

13 OCT. 1947
1800
90° WEST
80°
70°
60°
50°
1008
SOUTH AMERICA
ANALYSIS DOUBTFUL
55°
60°
65°
70°
75°
40°
30°
20°
40°
45°
50°
LOW (FILLING)
STATIONARY
974
980
OCCLUSION
PALMER PENINSULA
10
1008
980

Figure 41

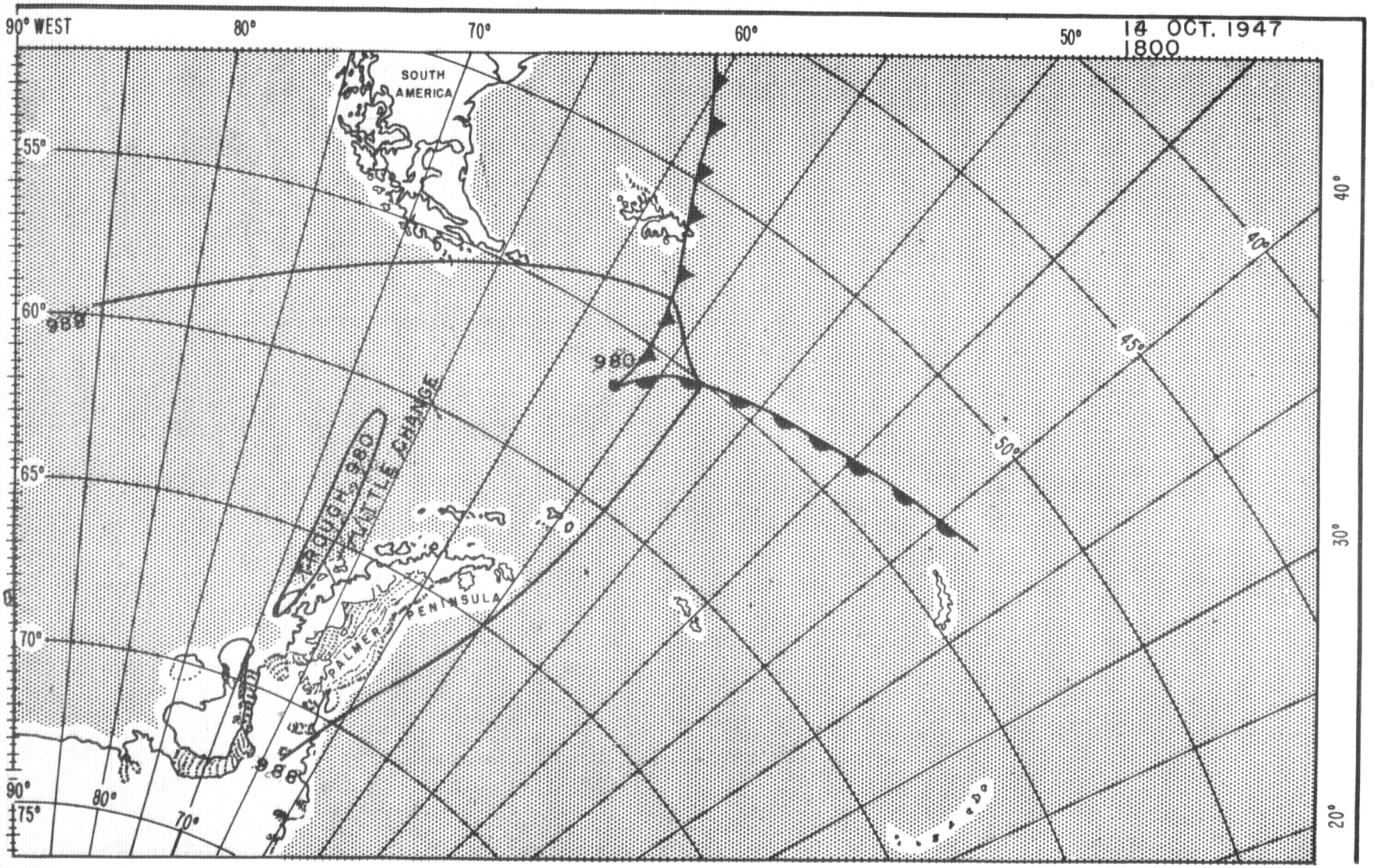

90° WEST
80°
70°
60°
50°
14 OCT. 1947
1800
SOUTH AMERICA
55°
60°
65°
70°
75°
40°
45°
50°
30°
20°
988
980
TROUGH 980
LITTLE CHANGE
PALMER PENINSULA
988

Figure 42

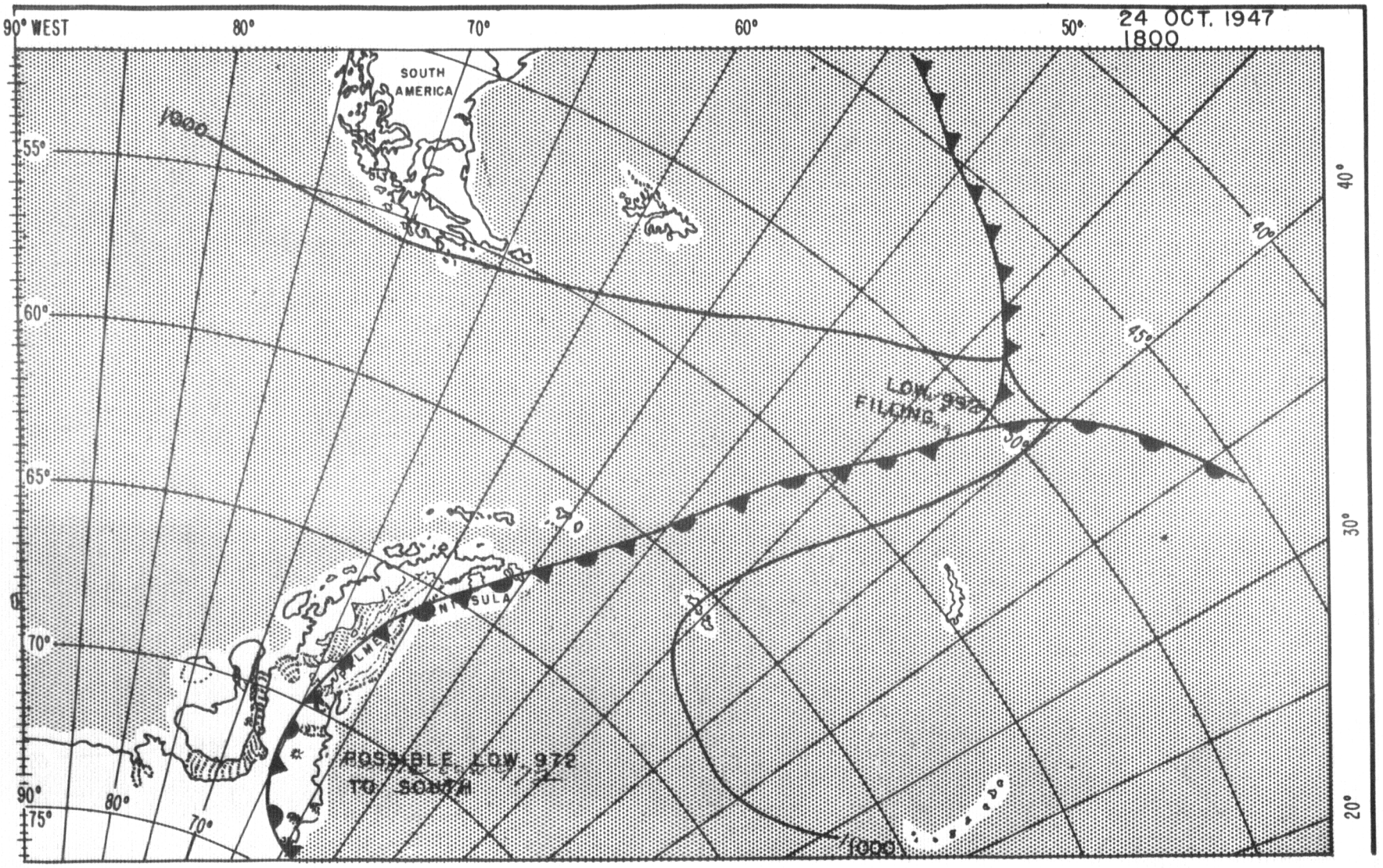

24 OCT. 1947
1800
90° WEST
80°
70°
60°
50°
SOUTH AMERICA
1000
55°
60°
65°
70°
75°
90°
80°
70°
40°
30°
20°
40°
45°
50°
LOW 992
FILLING
POSSIBLE LOW 972
TO SOUTH
1000

Figure 43

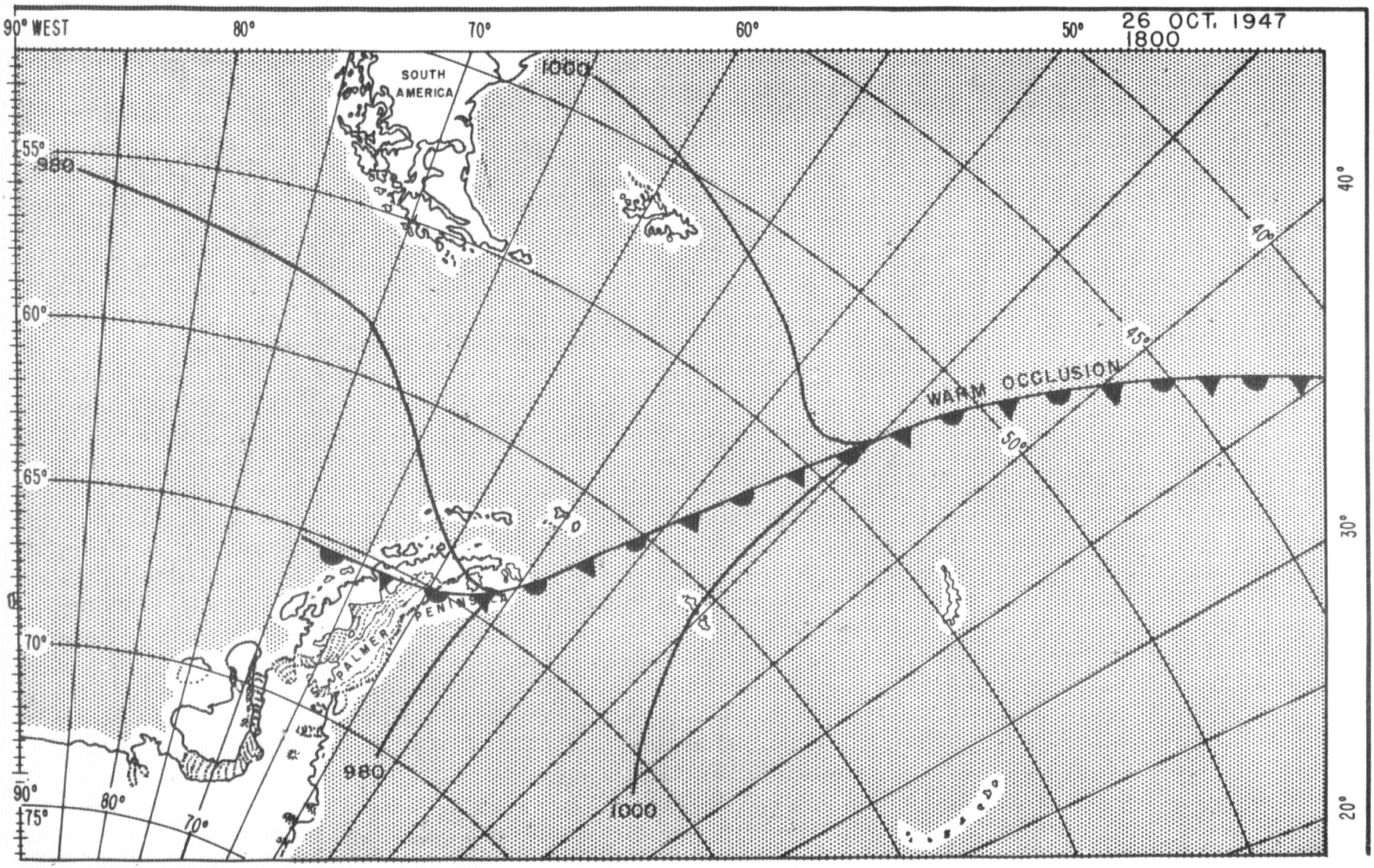

26 OCT. 1947
1800
90° WEST
80°
70°
60°
50°
40°
30°
20°
SOUTH AMERICA
1000
980
55°
60°
65°
70°
75°
90°
80°
70°
40°
45°
50°
WARM OCCLUSION
PALMER PENINSULA
980
1000

Figure 44

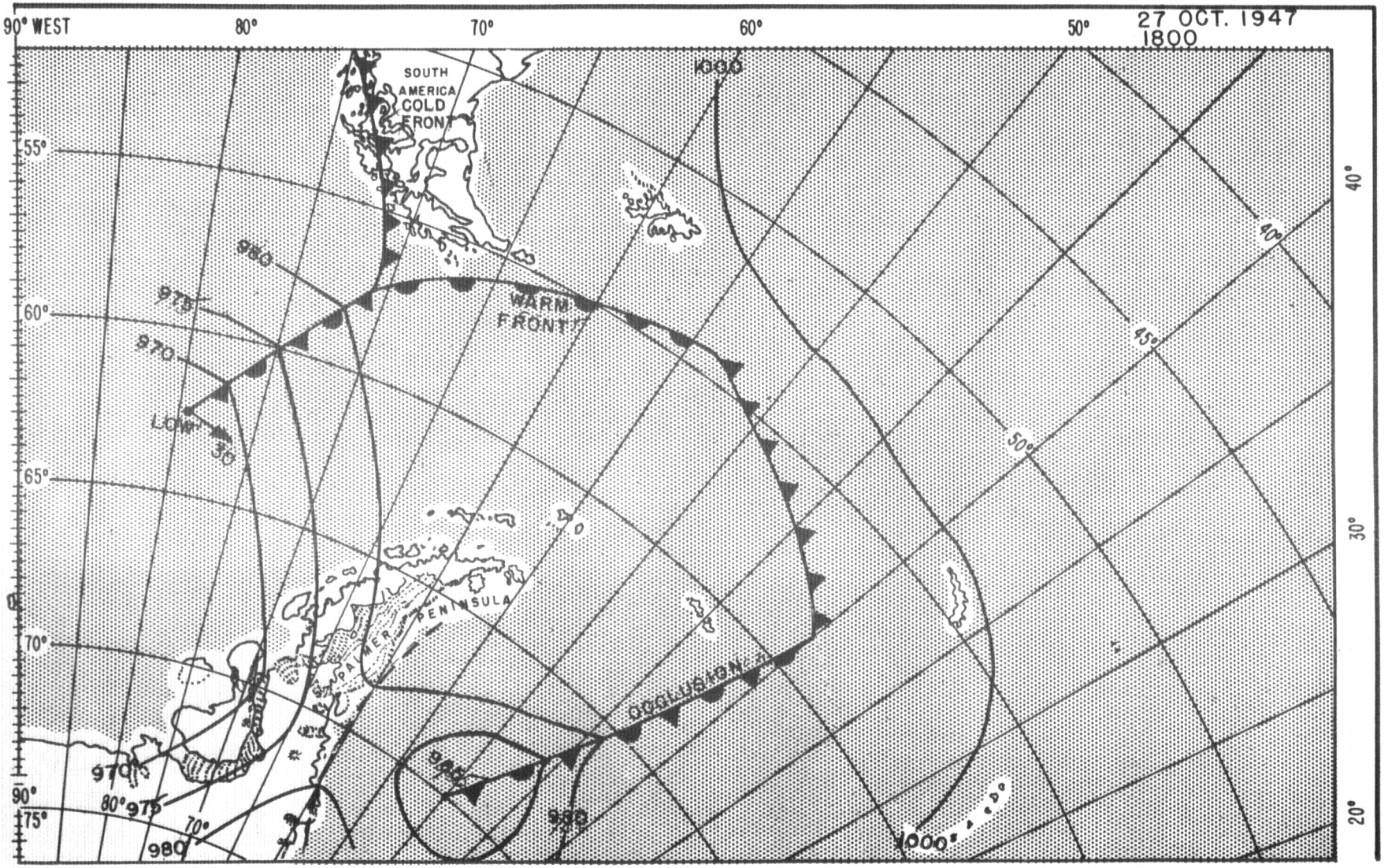

27 OCT. 1947
1800
90° WEST
80°
70°
60°
50°
SOUTH AMERICA COLD FRONT
WARM FRONT
OCCLUSION
PALMER PENINSULA
LOW
55°
60°
65°
70°
75°
90°
40°
30°
20°
1000
980
975
970
30
40°
45°
50°
80°
70°

Figure 45

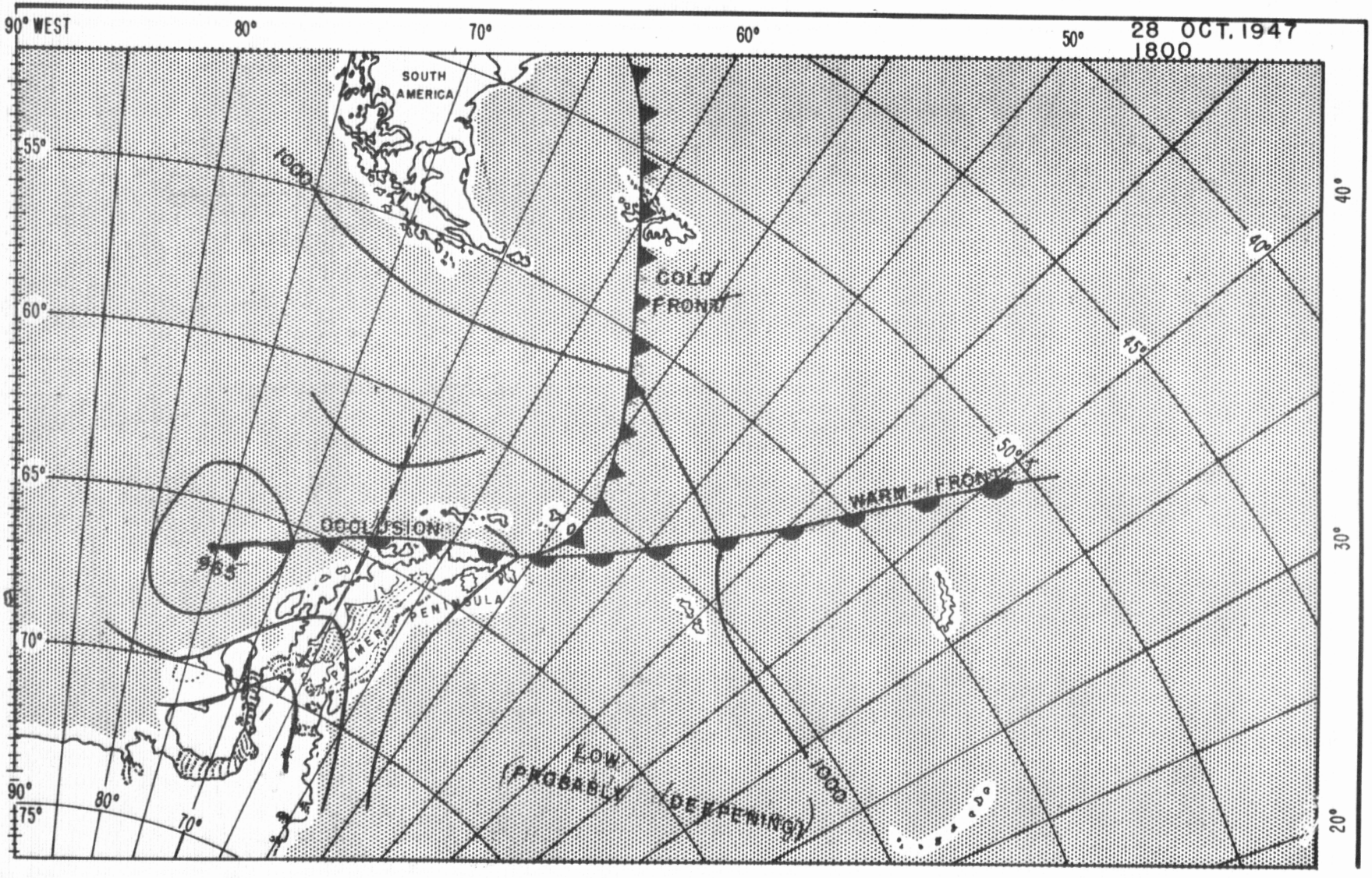

90° WEST
80°
70°
60°
50°
28 OCT. 1947
1800
SOUTH AMERICA
55°
60°
65°
70°
75°
90°
80°
70°
1000
COLD FRONT
40°
45°
50°
WARM FRONT
OCCLUSION
965
PALMER PENINSULA
LOW (PROBABLY DEEPENING)
1000
40°
30°
20°

Figure 46

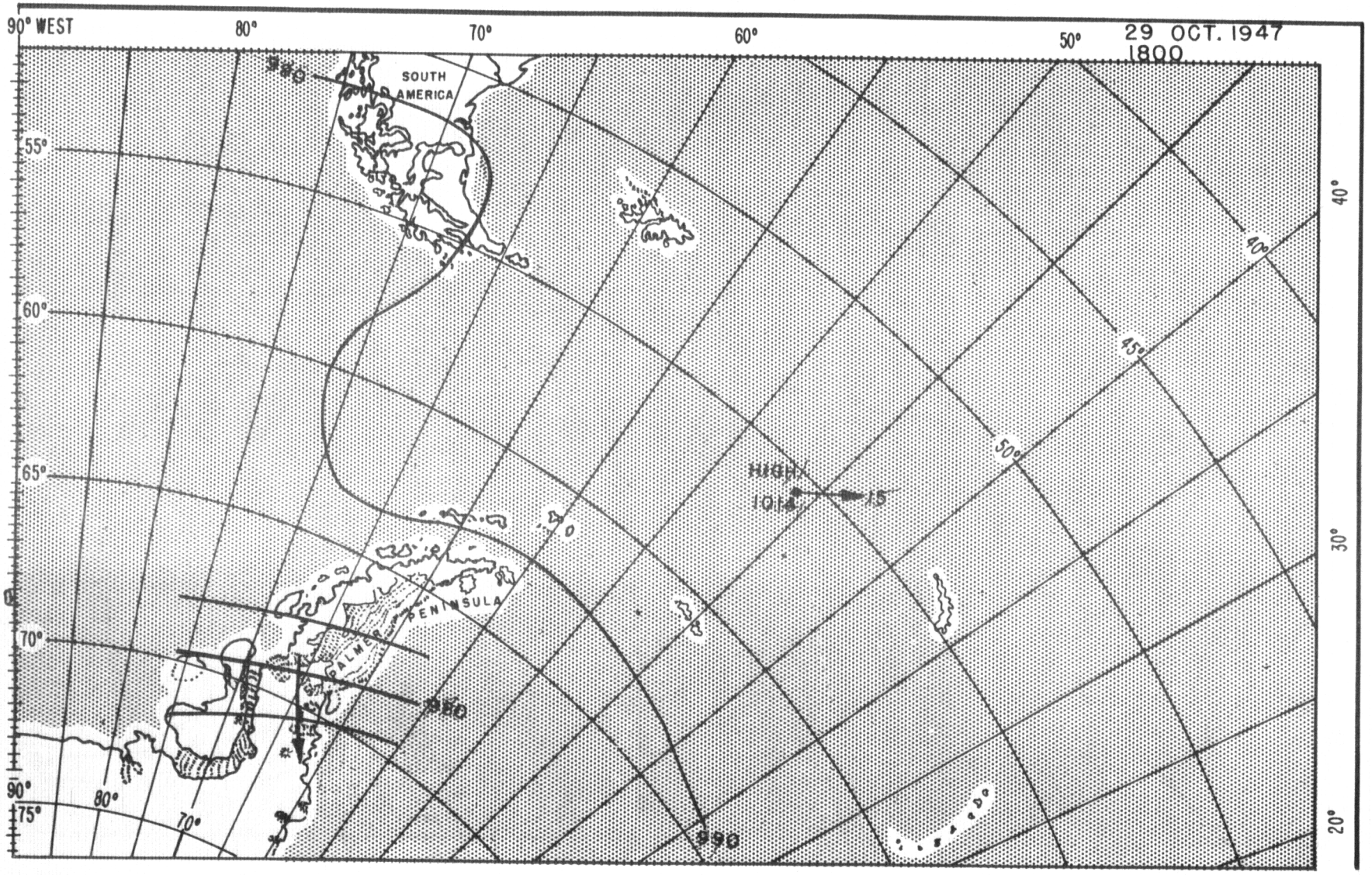

90° WEST
80°
70°
60°
50°
29 OCT. 1947
1800
SOUTH AMERICA
55°
60°
65°
70°
75°
40°
30°
20°
HIGH
1014
15
0
45°
50°
PENINSULA
990
990
990
990

Figure 47

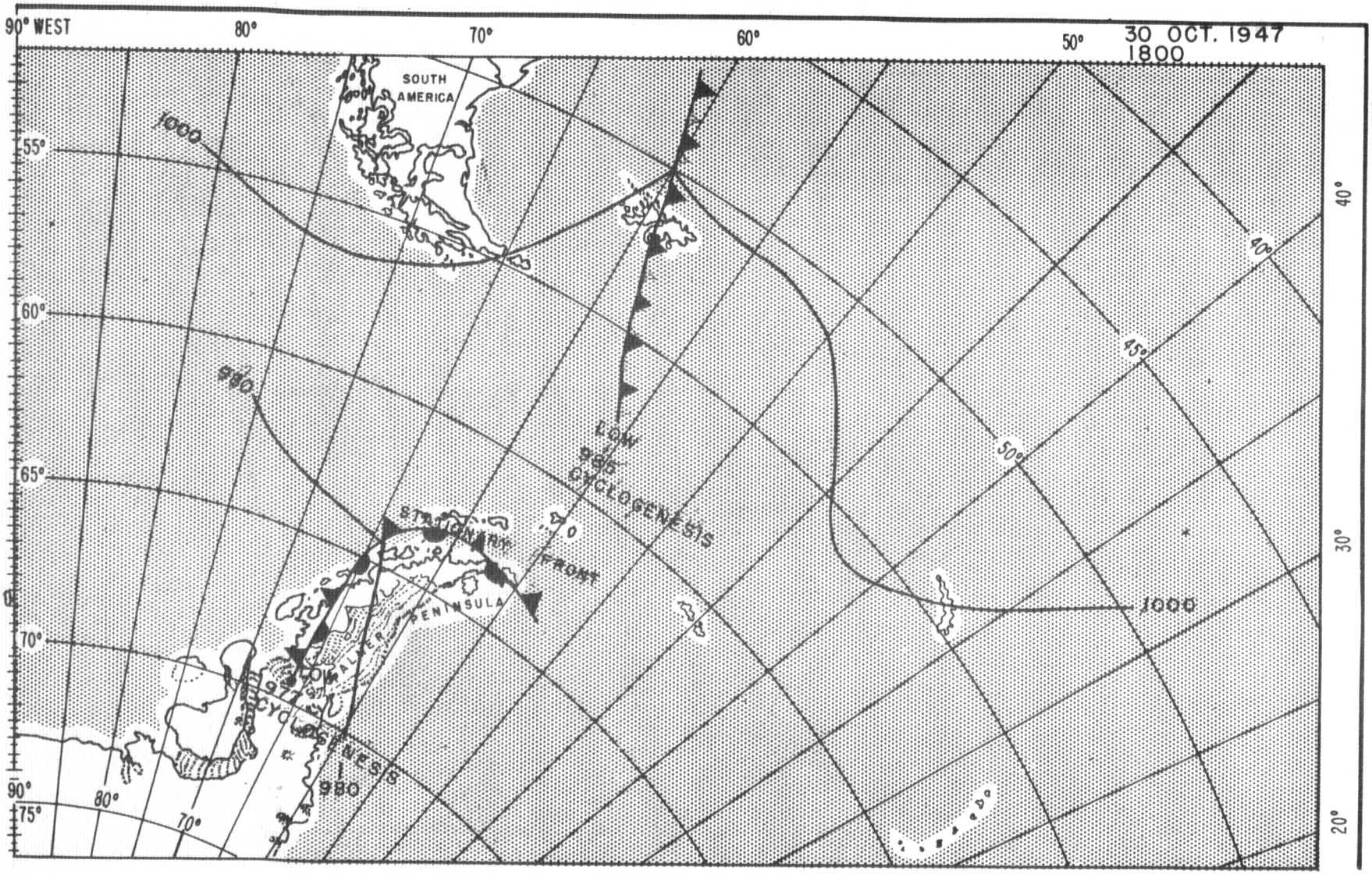

90° WEST
80°
70°
60°
50°
30 OCT. 1947
1800
SOUTH AMERICA
1000
55°
60°
65°
70°
75°
90°
80°
70°
980
LOW
985
CYCLOGENESIS
STATIONARY FRONT
PENINSULA
LOW
977
CYCLOGENESIS
980
1000
40°
45°
50°
40°
30°
20°

Figure 48

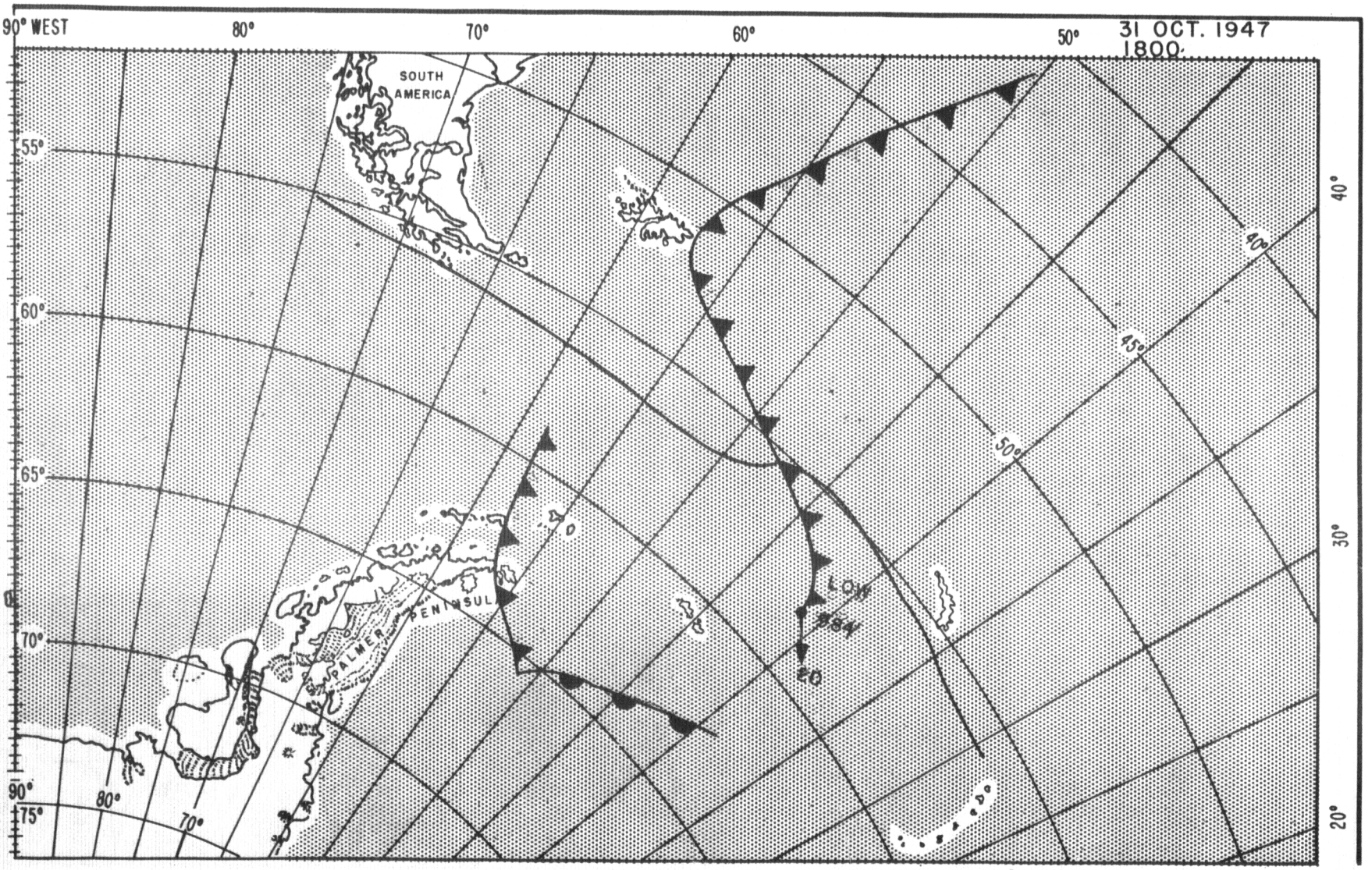

31 OCT. 1947
1800
90° WEST
80°
70°
60°
50°
SOUTH AMERICA
55°
60°
65°
70°
90°
75°
80°
70°
PALMER PENINSULA
LOW
40°
45°
50°
40°
30°
20°

Figure 49

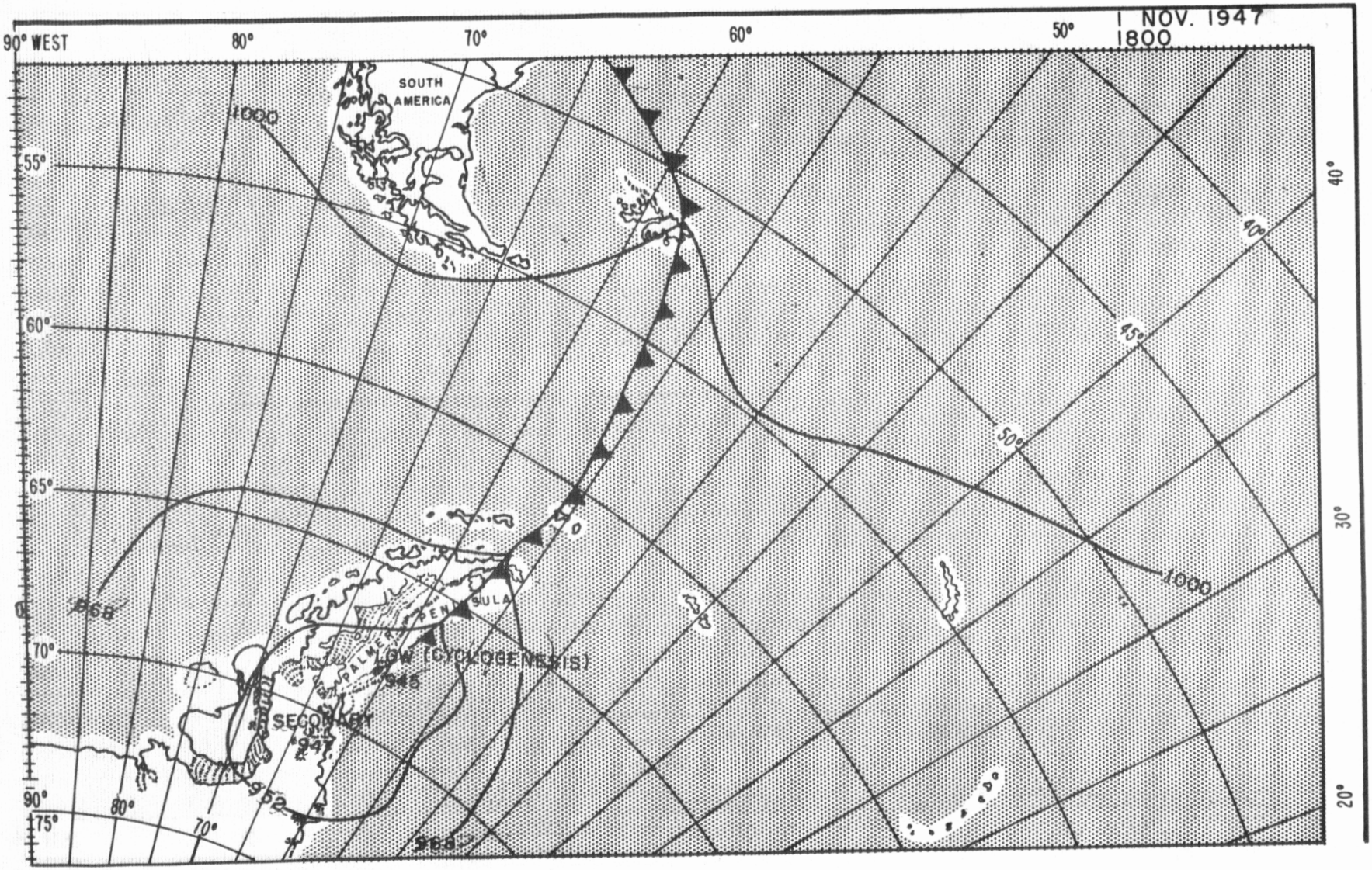

1 NOV. 1947
1800
90° WEST
80°
70°
60°
50°
40°
30°
20°
SOUTH AMERICA
1000
55°
60°
65°
70°
75°
90°
80°
70°
40°
45°
50°
1000
PALMER PENINSULA
LOW (CYCLOGENESIS)
945
SECONDARY
947
952
968
968

Figure 50

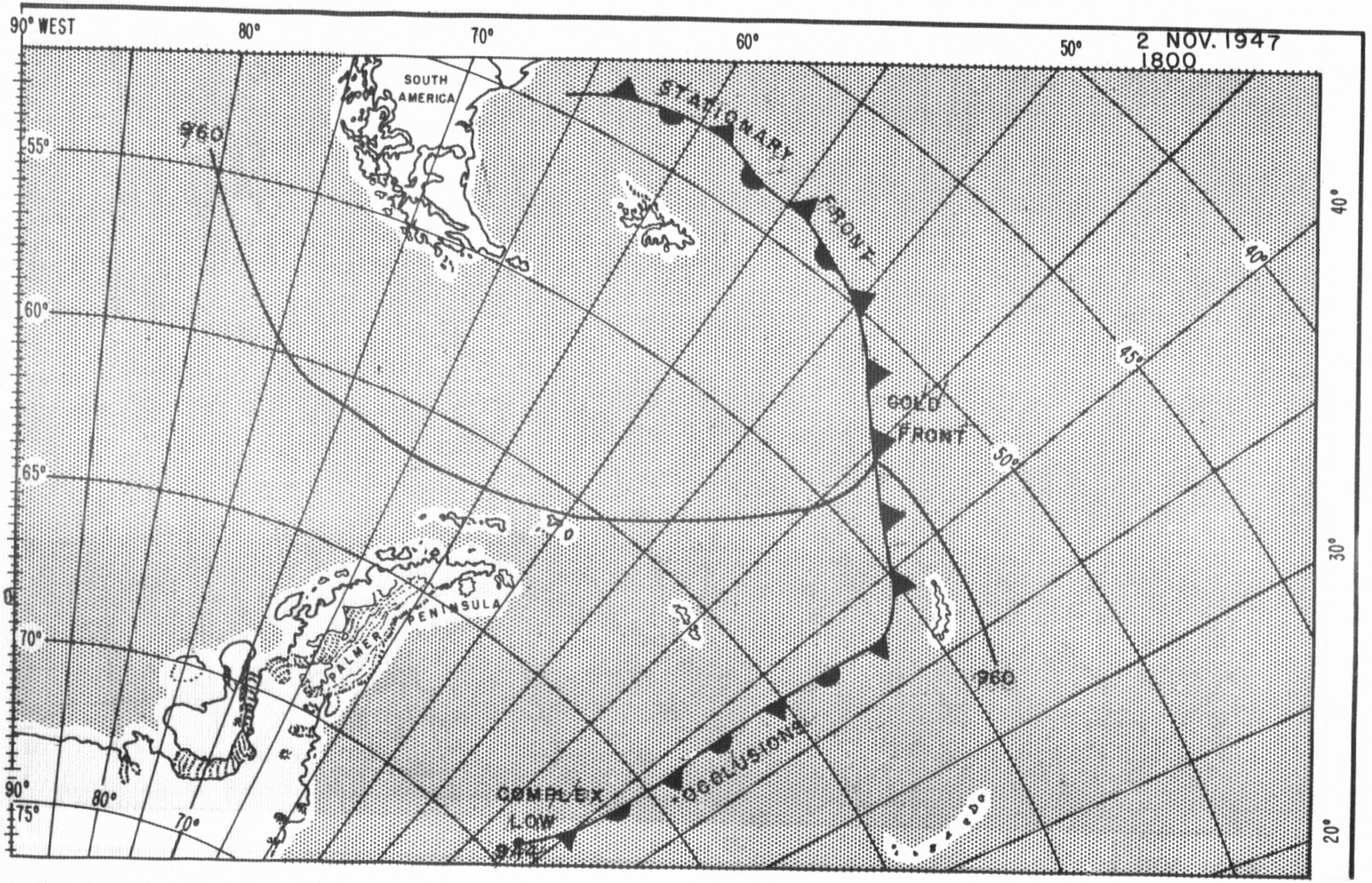

90° WEST
80°
70°
60°
50°
2 NOV. 1947
1800
SOUTH AMERICA
STATIONARY FRONT
COLD FRONT
OCCLUSION
COMPLEX LOW
PALMER PENINSULA
960
55°
60°
65°
70°
75°
90°
80°
70°
40°
45°
50°
30°
20°

Figure 51

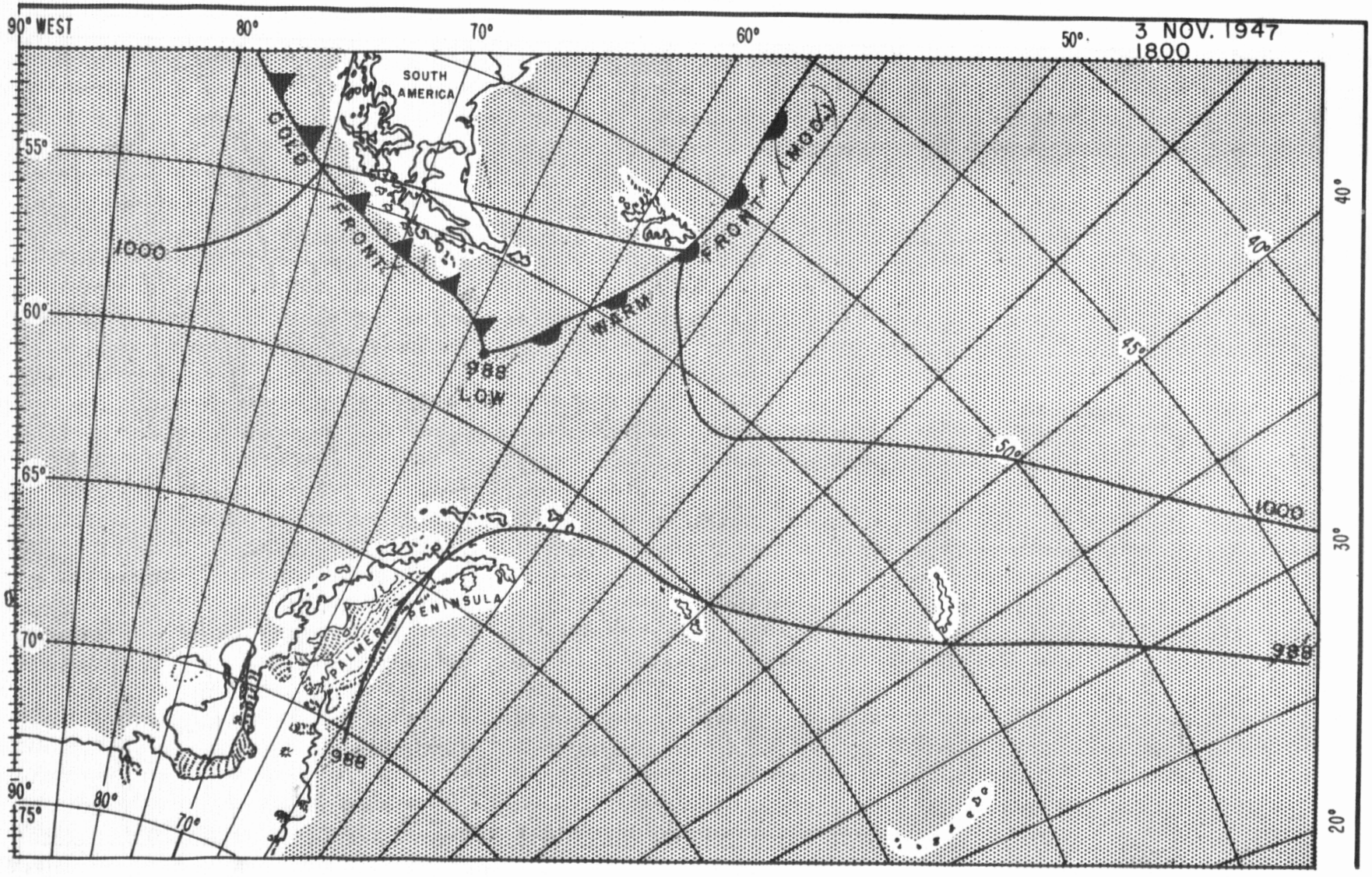

90° WEST
80°
70°
60°
50°
3 NOV. 1947
1800
SOUTH AMERICA
COLD FRONT
WARM FRONT (MOD.)
988
LOW
1000
500
988
PALMER PENINSULA
55°
60°
65°
70°
75°
40°
45°
30°
20°

Figure 52

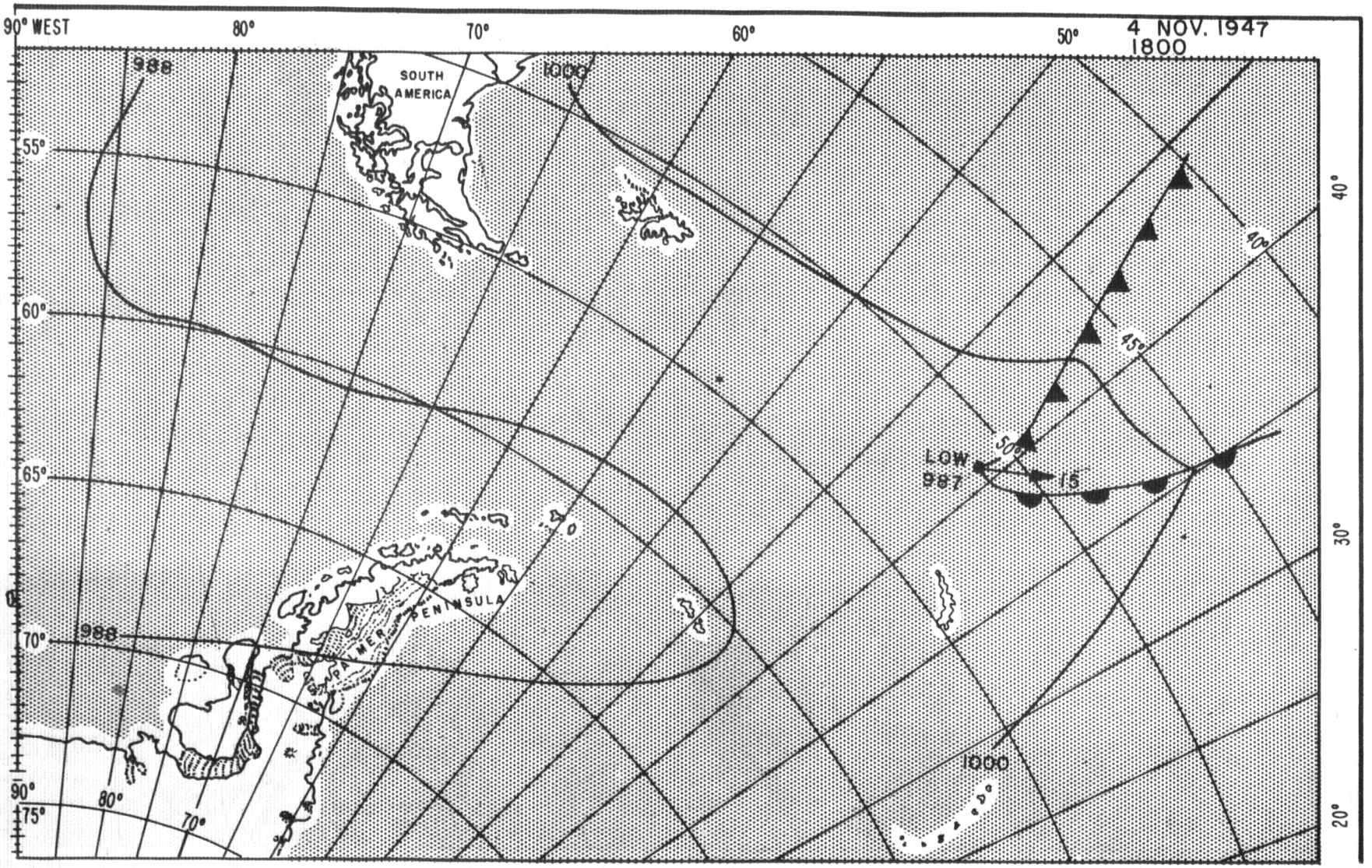

4 NOV. 1947
1800
90° WEST
80°
70°
60°
50°
40°
30°
20°
SOUTH AMERICA
988
1000
55°
60°
65°
70°
75°
LOW
987
15
45
40
50
70
PENINSULA

Figure 53

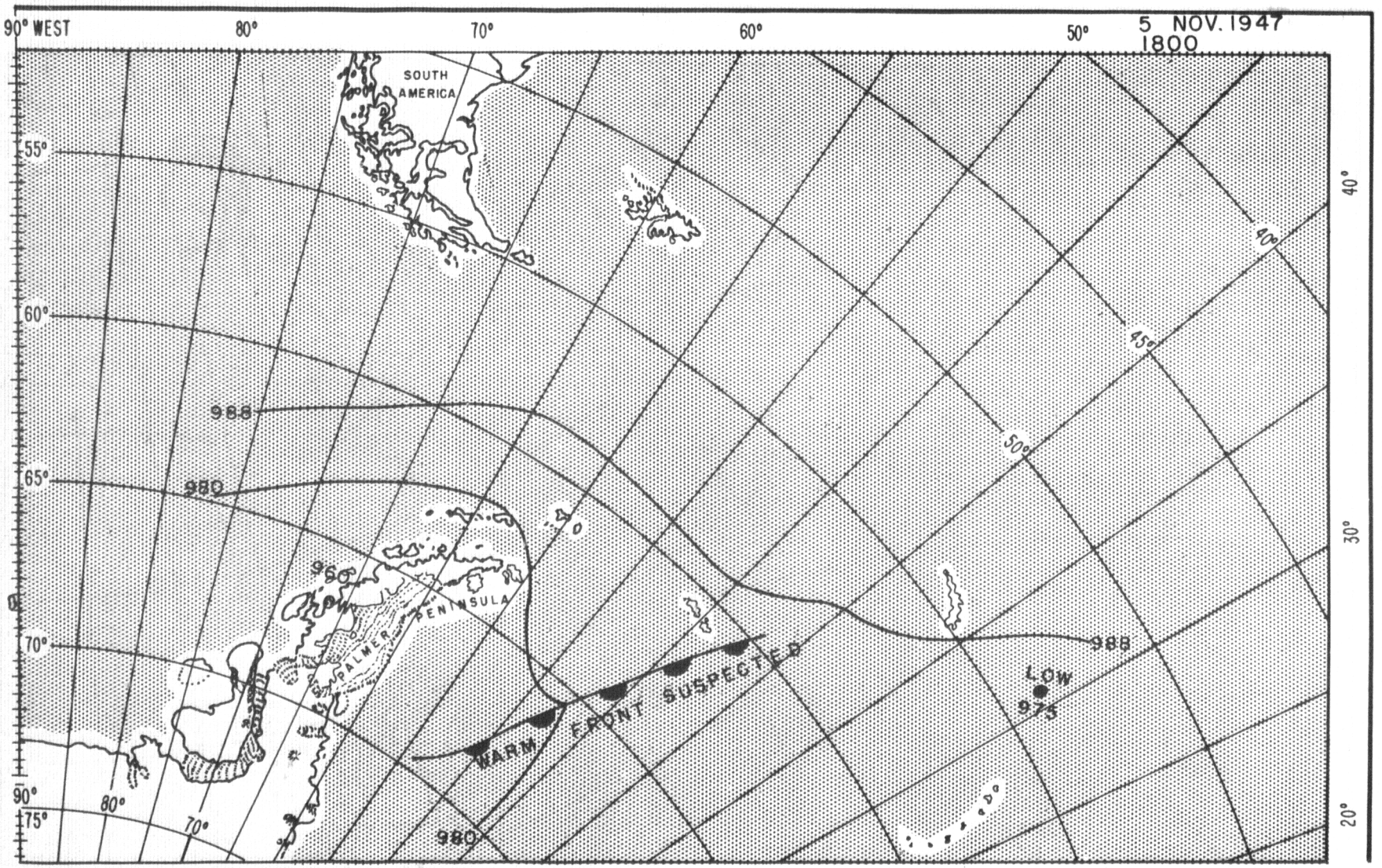

5 NOV. 1947
1800
90° WEST
80°
70°
60°
50°
SOUTH AMERICA
55°
60°
65°
70°
75°
40°
30°
20°
40°
45°
50°
988
980
960
988
980
LOW
975
PALMER PENINSULA
WARM FRONT SUSPECTED

Figure 54

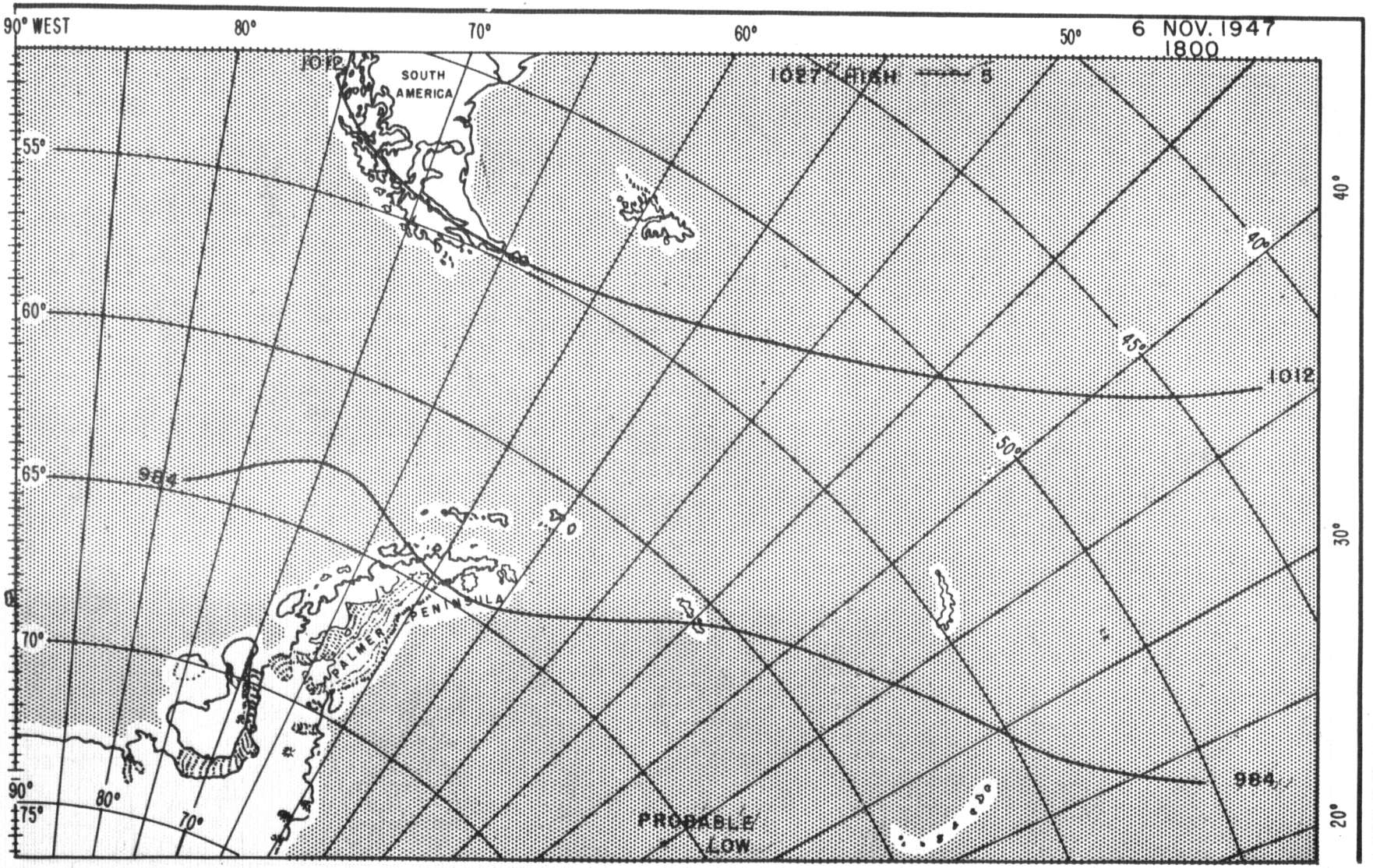

90° WEST
80°
70°
60°
50°
6 NOV. 1947
1800
1012
SOUTH AMERICA
1027 HIGH
5
55°
60°
65°
70°
75°
40°
30°
20°
400
450
500
1012
984
PALMER PENINSULA
PROBABLE LOW

Figure 55

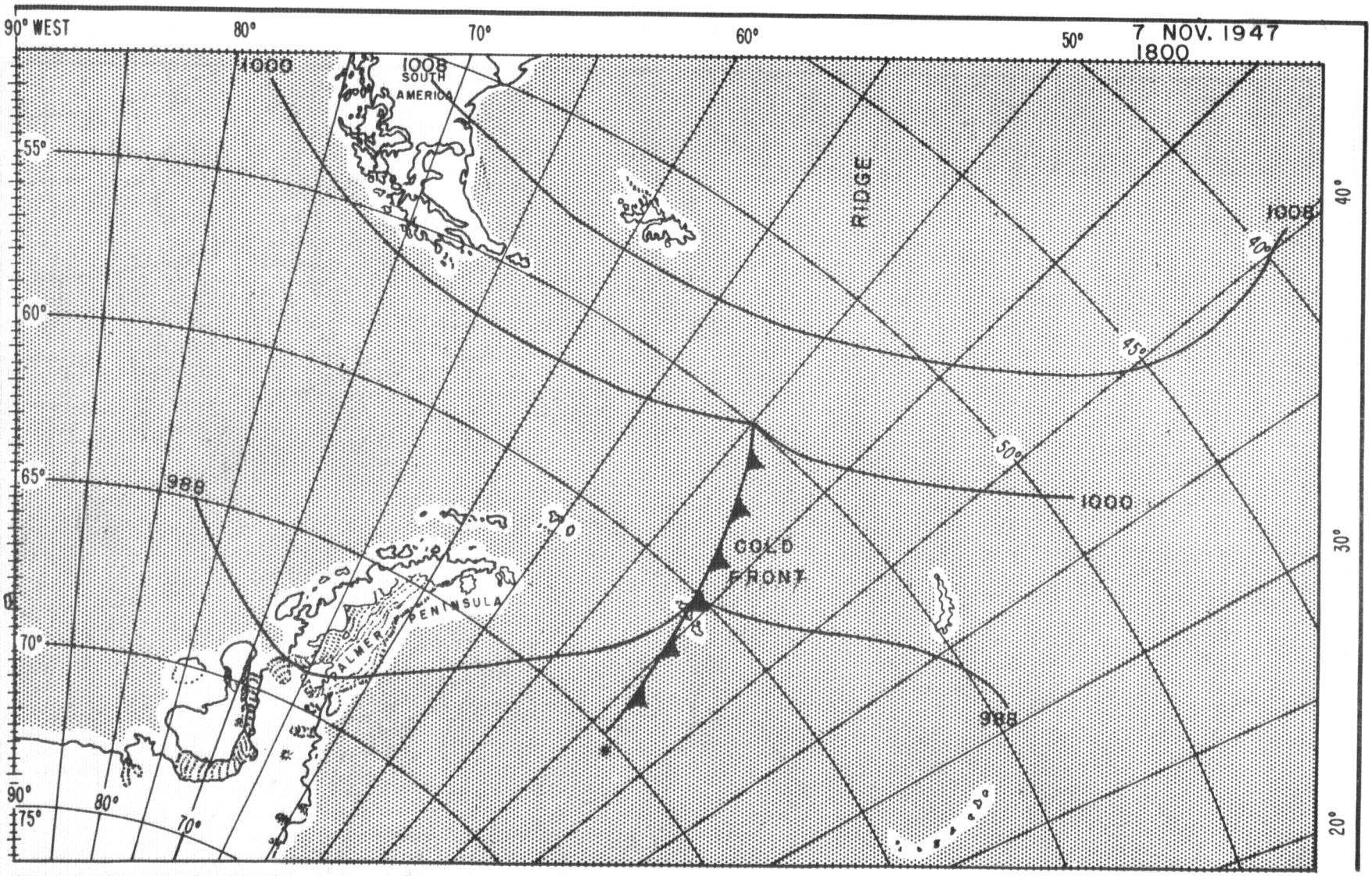

90° WEST
80°
70°
60°
50°
7 NOV. 1947
1800
1000
1008
SOUTH
AMERICA
55°
60°
65°
70°
988
RIDGE
1008
40°
45°
50°
1000
COLD
FRONT
PENINSULA
ALMER
988
40°
30°
20°
90°
75°
80°
70°

Figure 56

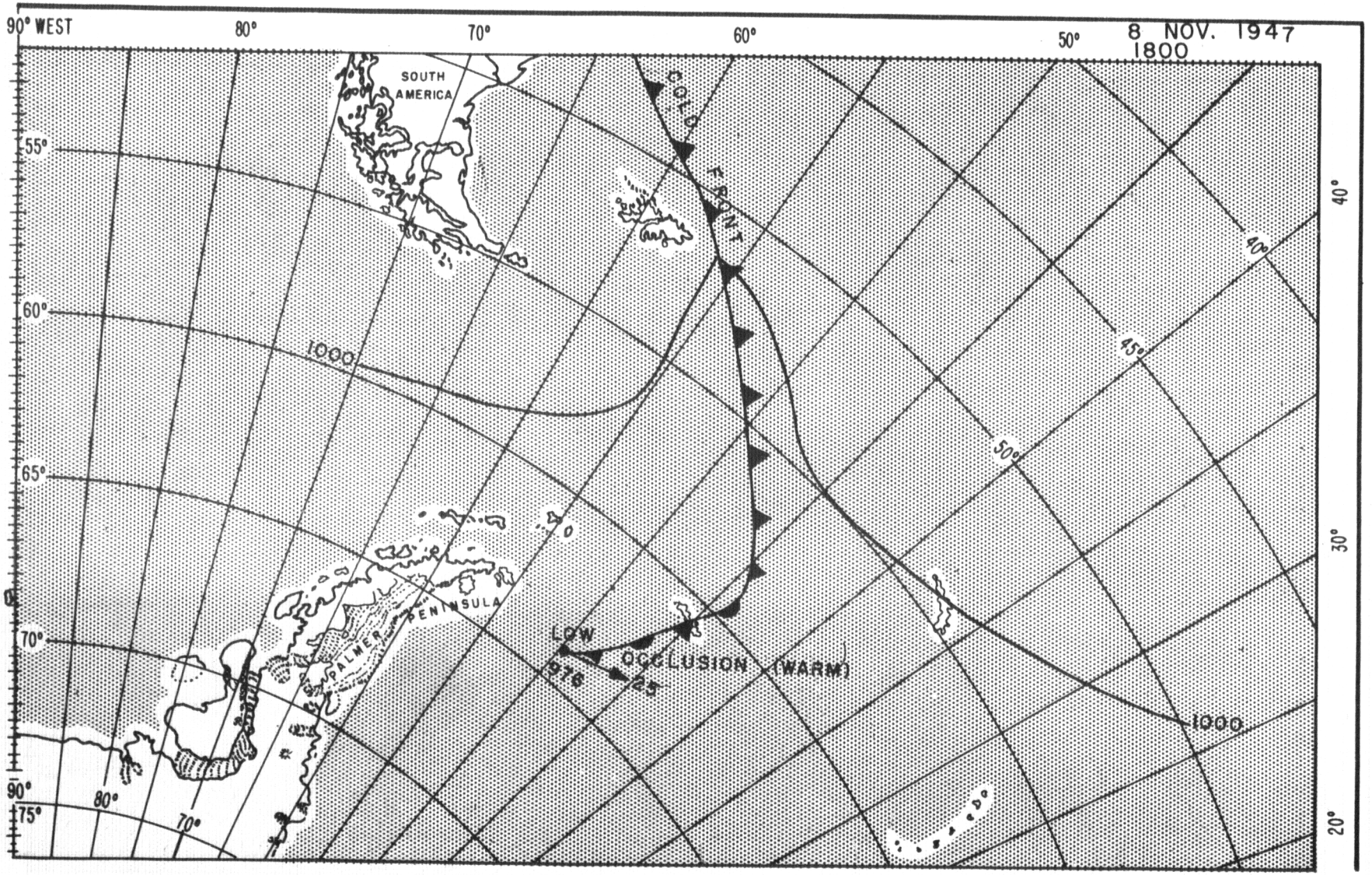

90° WEST
80°
70°
60°
50°
8 NOV. 1947
1800
SOUTH AMERICA
COLD FRONT
55°
60°
65°
70°
75°
90°
80°
70°
40°
45°
50°
30°
20°
1000
1000
PALMER PENINSULA
LOW
976
OCCLUSION (WARM)
125

Figure 57

APPENDIX A

Microseismic Amplitude, Period, and Character Data

Recordings are listed at 0000, 0600, 1200, and 1800 G.C.T. each day.

These measurements were made at a different time and irrespective of the measurements from which most of the graphs were made. Lack of agreement between the readings will give some idea of the personal error involved in measuring the mean peak of total microseism amplitude. The following readings should be somewhat more accurate, having been taken under slightly better conditions. Graphs shown in Figures 5, and 7, were taken from the following measurements, however.

Character

I	irregular (Figure 58)
M	half way between irregular and smooth or medium (Figure 59)
S	smooth (Figure 60)
VS	very smooth

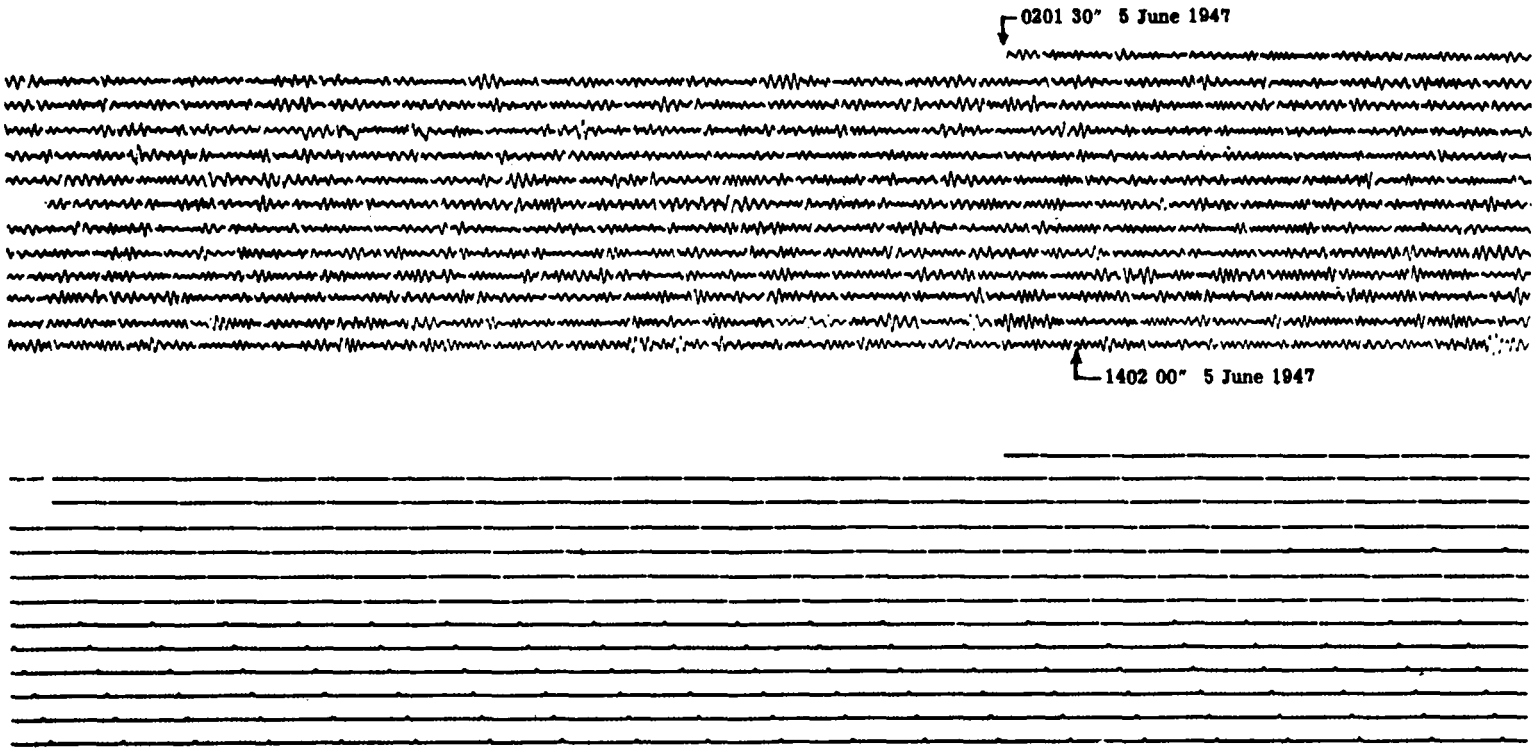


Figure 58 - Seismogram, June 5, 1947

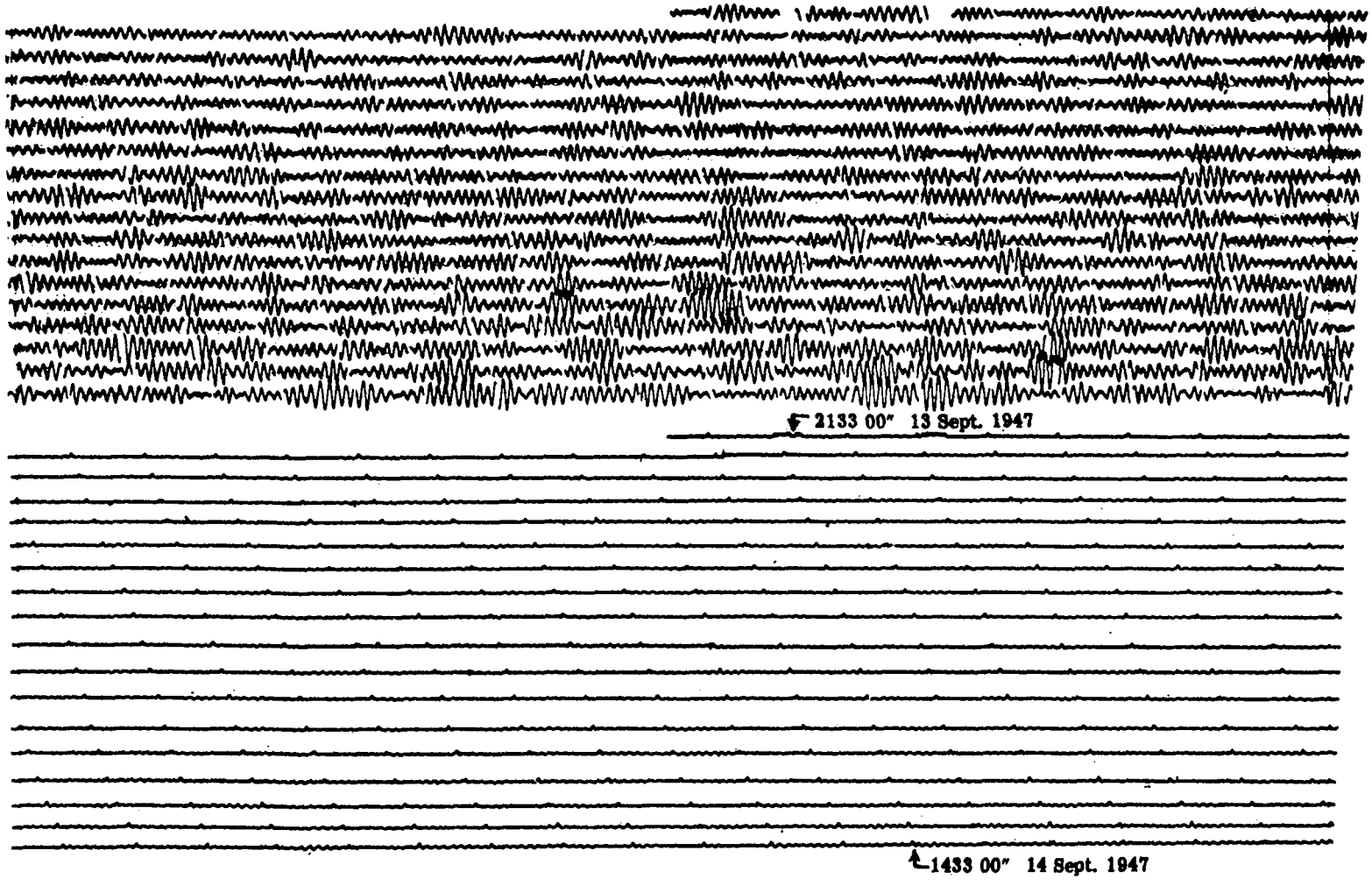


Figure 59 - Seismograms, September 13, 14, 1947

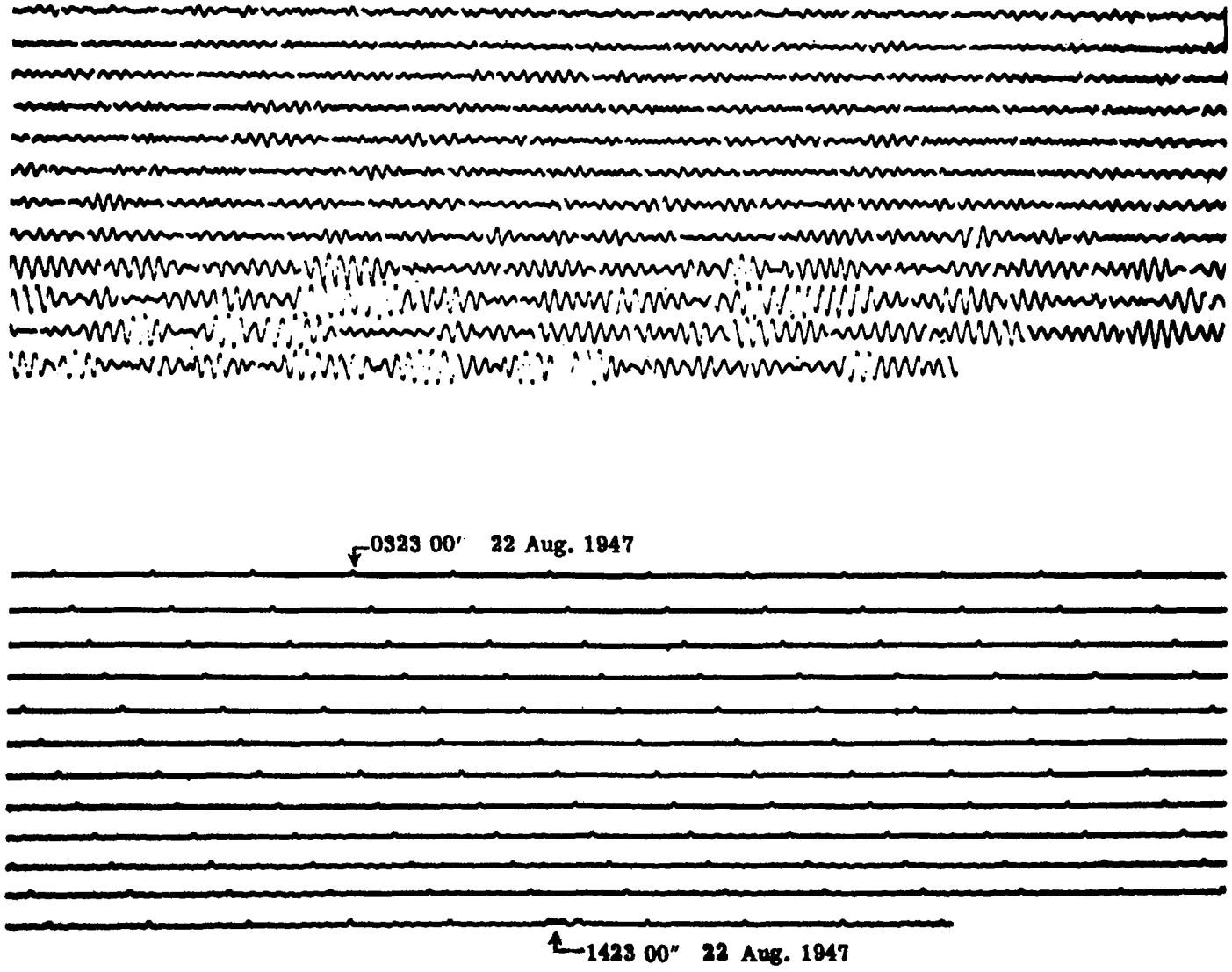


Figure 60 - Seismogram, August 22, 1947

If there is, apparently, more than one phase with a seemingly different character, the character of each phase is sometimes included, example "M, S." MS, however, would mean half way between M(medium) and S(smooth).

The smoother the character of the wave, the more accurate and constant is the bearing theoretically from such a direction finding station as the tripartite.

There is evidence of the periods becoming somewhat longer and the character of the waves becoming smoother as the storm moves farther from the station, usually into the Weddell Sea. Large amplitudes and smoothness seem to go together. These observations are logical.

Amplitudes in the following list are estimated measurements of microseism amplitudes from crest to trough on the seismogram. An effort is made to get an average of the larger waves by estimating from several of the build-ups. A special effort is made to reflect accurately increases and decreases of microseism amplitudes.

Date (1947)	Time (G.C.T.)	Amplitude (mm)	Period (sec)	Character	Notes
May 19	0000	20	5.45	M	
	0600	23	6.0	M	
	1200	29		M	
	1800	31	4.6	I	
20	0000	39		I	
	0600	39	5.45	MI	
	1200	39		MI	
	1800	40	5.45		
21	0000	42			
	0600	39			
	1200	36			
	1800	34	5.45	MI	
22	0000	33			
	0600	32			
	1200	34		MI	
	1800	40	5.0	I	
23	0000	48			
	0600	57	5.45	I	
24					No readings
25	1800	18	5.0	MI	
26	0000	20	5.0	MI	
	1800	15	4.3	M	
27	0000	15	4.3	M	
	0600	16			
	1200	16			
	1800	14			
28	0000	13			
	0600	12			
	1200	10			
	1800	10			
29	0000	10			
	0600	10	4.6		
	1200	12			
	1800	13	5.0	M	
30	0000	13			
	0600	13			
	1200	12			
	1800	12			

Date (1947)	Time (G.C.T.)	Amplitude (mm)	Period (sec)	Character	Notes
May 31					No readings
June 1					No readings
2	0000	37	5.0	M	
	0600	48			
	1200	49	5.45		
	1800	68	5.45	S	
3	0000	71	6.0		
	0600	66		S	
	1200	60	6.0		
	1800	40	6.0		
4	0000	44	6.0	S	
	0600	45	6.7	VS	
	1200	40	6.7	VS, I	New, irregular phase coming in
	1800	31		VS, I	
5	0000	31	4.6, 6.7	VS, I	
	0600	29	4.6	I	
	1200	32	5.0	I	Last trace of smooth
	1800	35	5.45	M	
6	0000	40	5.45	M	
	0600	36	6.0	M	
	1200	28		S	
	1800	22	6.7	S	
7	0000	20	7.5	VS	
	0600	20	6.7	VS	
	1200	18	6.7	VS	
	1800	16	6.7, 4.6	VS, I	Possible new, irregular phase coming in
8	0000	16		VS, I	
	0600	15		VS, I	
9	0000	15		M	
	0600	12		M	
	1200	11		M	
	1800	11	4.6	I	
10	0000	14			
	0600	17	5.0	I	
	1200	16	5.45		
	1800	14	5.45	M	

Date (1947)	Time (G.C.T.)	Amplitude (mm)	Period (sec)	Character	Notes
June 11	0000	14		M	
	0600	13			
	1200	15	6.7, 6.0	M	
	1800	15		M	
12	0000	15		M	
	0600	14	6.0	M	
	1200	13		M	
	1800	12			
13	0000	12	6.7	MS	
	0600	12	6.7	MS	
	1200	11			
	1800	13			
14	0000	14			
	0600	14			
	1200	14	7.5	S	
	1800	17	6.7	S	
15	0000	15			
	0600	15	6.7		
	1200	15			
	1800	15			
16	0000	15		MS	Long period starts
	0600	16		MS	
	1200	17		MS	
	1800	18			
17	0000	19			
	0600	20	6.0	M	
	1200	21		M	
	1800				
18	0000				
	0600	14	6.0	MS	Long period stops
	1200	14			
	1800	17		M	
19	0000	19	6.0	MS	
	0600	23	6.0		
	1200	25			
	1800	40	6.7	S	
20	0000	58	6.7	S	
	0600	65	6.7	S	
	1200	65	6.7	S	
	1800	58	7.1	VS	

Date (1947)	Time (G.C.T.)	Amplitude (mm)	Period (sec)	Character	Notes
June 21	0000	50	6.7	VS	
	0600	40	6.7		
	1200	35	4.3, 6.7	I, S	New, irregular wave
	1800	35	4.3, 6.7	I, M	
22	0000	40	6.7	M	Irregular wave leaving
	0600	45	6.7	M	
	1200	65	6.7	M	
	1800	60	6.7	MS	
23	0000	55	6.7	MS	
	0600	50	7.1	S	
	1200	52	7.1	S	
	1800	32	7.1	S	
24	0000	20	6.0	M, S	
	0600	20		I, S	New, irregular phase
	1200	15	5.0	I	
	1800	15	4.6	I	
25	0000	15	4.6	I	
	1800	10	5.0	I	
26	0000	10		I	
	0600	15		M	
	1200	20		MS	
	1800	25	6.7	S	
27	0000	25	6.7	S	
	0600	26	6.7	S	
	1200	26	6.7	S	
	1800	27	6.7		
28	0000	28		S, I	New, irregular phase in
	0600	27	5.0	I	
	1200	23	5.0	I	
	1800	20		I	
29	0000	20		I	
	0600	20		I	
	1200	16		IM	
	1800	17		IM	
30	0000	20		M	
	0600	22			
	1200	25		M	
	1800	30		MS	

Date (1947)	Time (G.C.T.)	Amplitude (mm)	Period (sec)	Character	Notes
July 1	0000	38		M	Another wave in
	0600	43		IS	Two waves
	1200	43		I, S	Two waves
	1800	42		I, S	Two waves
2	0000	42		I, S	Two waves
	0600	42		S, I	Two waves
	1200	40		S, I	Two waves
	1800	42			Two waves
3	0000	43		M	Two waves
	0600	43		M	Two waves
	1200	50			Two waves
	1800	55	6.3		Two waves
4	0000	60	6.3	M	One phase predominant
	0600	74	6.7	M	One phase predominant
	1200	78	6.7	M	One phase predominant
	1800	78	6.7	M	One phase predominant
5	0000	78	6.7	M	One phase predominant
	0600	78	6.7	M	One phase predominant
	1200	80	6.7	M	One phase predominant
	1800	80	6.7		One phase predominant
6	0000	77	6.7	MS	One phase predominant
	0600	75			
	1200	75			
	1800	75	6.7		
7	0000	76	6.7	MS	
	0600	70			
	1200	65			
	1800	58	7.1		
8	0000	55			
	0600	58			
	1200	60			
	1800	65			
9	0000	67	6.7		
	0600	65	7.5	S	
	1200	70	7.5	S	
	1800	70		S	
10	0000	70		S	
	0600	68		S	
	1200	67	7.5	S	
	1800	57		S	

Date (1947)	Time (G.C.T.)	Amplitude (mm)	Period (sec)	Character	Notes
July 11	0000	50	6.7		
	0600	48			
	1200	45	7.1	MS	
	1800	43		MS	
12	0000	38	7.5	MS	
	0600	50	7.1		
	1200	60		S	
	1800	72	7.1	S	
13	0000	82	7.5	S	
	0600	87	7.5		
	1200	87			
	1800	88	7.5		
14	0000	110	7.5	S	Violent
	0600	100	7.5	S	
	1200	95		S	
	1800	80	7.7	S	
15	0000	60		VS	
	0600	52	7.6		
	1200	42	8.0	VS	
	1800	35			
16	0000	25	6.0	M	Possible irregular phase in
	0600	25			
	1200	25			
	1800	30		MI	
17	0000	30			
	0600	32		MI	
	1200	40			
	1800	42			
18	0000	45	7.5	M	
	0600	55	7.5	MS	
	1200	56			
	1800	70	7.5		
19	0000	77			
	0600	80	7.5	MS	
	1200	82	7.5	M	Possible two periods
	1800	79	7.5		Possible two periods
20	0000	79	6.7		Possible two periods
	0600	75	6.7		Possible two periods
	1200	65	6.7		Possible two periods
	1800	62			Possible two periods

Date (1947)	Time (G.C.T.)	Amplitude (mm)	Period (sec)	Character	Notes
July 21	0000	55	6.0	M, M	Possible two periods
	0600	50			
	1200	50			
	1800	50			
22	0000	50	6.7	MS	One period predominant
	0600	50			
	1200	55	6.6	MS	
	1800	53			
23	0000	45	6.0		
	0600	42	6.0	S	
	1200	35	6.7	S	
	1800	33			
24	0000	30	6.6	S	
	0600	29			
	1200	25			
	1800	21		S	
25	0000	21			
	0600	35	6.6	I, S	
	1200	36	5.7	I, S	Long period
	1800	42		I, S	Long period
26	0000	50	6.7	I, S	Long period
	0600			I, S	Long period
	1000				Long period stops
	1200	62	6.7	S	
	1800	60		S	
27	0000	52	6.8	S	
	0600	40		VS	
	1200	32	6.9	VS	
	1800	32	7.1	VS	
28	0000	28	7.5	S	
	0600	23	7.1	S	
	1200	20	7.1		
	1800	20			
29	0000	20		M	
	0600	23	7.5	S	Long period phase coming in
	1200	32	7.5	VS	
	1800	52			
30	0000	60	7.7	VS	
	0600	53	7.7	VS	
	1200	50		VS	
	1800	38			

Date (1947)	Time (G.C.T.)	Amplitude (mm)	Period (sec)	Character	Notes
July 31	0000	35	7.5	VS	
	0600	32			
	1200	32	7.5	VS	
	1800	32			Possible new long phase
Aug. 1	0000	33		M	
	0600	39	6.7		
	1200	41			
	1800	43	6.9	S	
2	0000	55			
	0600	60	6.8	S	
	1200	60			
	1800	55	6.7	MS	
3	0000	50	6.7		
	0600	40			
	1200	35			
	1800	24	6.7	M	
4	0000	22		M	Possible new wave
	0600	22			
	1200	23			
	1800	23			
5	0000	23			
	0600	33	7.5		
	1200	40	7.5	MS	
	1800	45	7.5		
6	0000	48	7.5	S	
	0600	50			
	1200	51	7.1	MS	
7	0600	45	7.1	MS	
	1200	45			
	1800	44			
8	0600	49	6.7		
	1200	50			
	1800	49			
9	0000	47			
	0600	45			
	1200	43			
	1800	43			
10	0000	44			
	0600	46			
	1000-1400				Large increase
	1200	55			
	1800	90			

Date (1947)	Time (G.C.T.)	Amplitude (mm)	Period (sec)	Character	Notes
Aug. 11	0000	90	8.6	S, S, M	Two periods, one predominant
	0600	83	8.0		Two periods, one predominant
	1200	83			Two periods, one predominant
	1800	85			
12	0000	73			
	0600	60			
	1200	42			
	1800	40			
13	0000	31			
	0600	22			
	1200	20			
	1800	20		M	
14	0000	20		M	
	0600	21		I	New, irregular phase coming in
	1200	21		I	New, irregular phase coming in
	1800	26		I	New, irregular phase coming in
	1800-2400				Increase in intensity
15	0000	44	6.0		
	0600	44			
	1200	40			
	1800	48	6.0		
16	0000	50			
	0600	50			
	1200	50			
	1800	42			
17	0000	40			
	0600	40			
	1200	36			
	1800	38			
18	0000	40			
	0600	40			
	1200	40			
	1800	32			
19	0000	26			
	0600	24			
	1200	21			
	1800	20			
20	0000	20			
	0600	20			
	1200	19			
	1800	18			

Date (1947)	Time (G.C.T.)	Amplitude (mm)	Period (sec)	Character	Notes
Aug. 21	0000	13			
	0600	13			
	1200	13			
	1800	14			
22	0000	15			Longer period
	0600	16			
	1000-1400				Sharp increase
	1200	55			
	1800	70			
23	0000	75	7.5		
	0600	70			
	1200	58			A decrease for several hours
	1800	62			
24	0000	60			
	0600	60			
	1200	61			
	1800	70			
25	0000	82	7.4		
	0600	80	7.4		
	1200	77			
	1800	83			
26	0000	75			
	0600	70			
	1200	80			
	1600	79			
27	0000	60			
	0600	45	7.5	S	
	1200	40			
	1800	34			
28	0000	33			
	0600	32			Long period (30 sec) starts; ends 1600 G.C.T.
	1200	30			
	1800	32		I	Very irregular phase has come in
29	0000	36		I	Very irregular phase has come in
	0600	40		I	Very irregular phase has come in
	1200	42		I	
	1800	44		I	Two phases

Date (1947)	Time (G.C.T.)	Amplitude (mm)	Period (sec)	Character	Notes
Aug. 30	0000	45		I	
	0600	49		I	Rapid, increasing violence
	1200	59		I	
	1800	70		I	
31	0000	95			Two phases
	0600	110			Two phases
	1200	100			Two phases
	1800	100			Two phases
Sept. 1	0000	100	7.5		
	0600	110			
	1200	110			
	1800	110			
2	0000	100			Smoother
	0600	85			
	1200	80			
	1800	62			
3	0000	52			
	0600	35			
	1200	30			
	1800	20			
4	0000	20			
	0600	19			
	1200	15			
	1800	15			
5	0000	15			
	0600	15			
	1200	18			
	1800	20			New phase in
6	0000	21			
	0600	28			
	1200	35			
7	0600	50	6.7	M,S	
	1200	49			
	1800	40			
8	0000	42			
	0600	43			
	1200	50			
	1800	55			

Date (1947)	Time (G.C.T.)	Amplitude (mm)	Period (sec)	Character	Notes
Sept. 9	0000	62			
	0600	62			
	1200	62			Two periods
	1800	63			
10	0000	58			Long period
	0600	58			Long period
	1200	50			Long period
	1800	35			Long period
11	0000	30			Long period
	0600	28			Long period
	1200	25			Long period
	1800	20			Long period stops
12	0000	18			
	0600	20			
	1200	20			
	1800	23			New phase
13	0000	35			
	0600	40			
	1200	40			
	1800	43			
14	0000	50			
	0600	57			
	1200	70			
	1800	90			
15	0000	100			
	0600	120	7.6		
	1200	110			
	1800	100			
16	0000	100			
	0600	80			
	1200	65			
	1800	50			
17	0000	42			
	0600	33			
	1200	33			
	1800	33			
18	0000	35			
	0600	42			
	1200	46			
	1800	44			

Date (1947)	Time (G.C.T.)	Amplitude (mm)	Period (sec)	Character	Notes
Sept. 19	0000	35			
	0600	30			
	1200	30		M, S	
	1800	30			New, irregular phase
20	0000	32		I	
	0600	36		I	
	1200	40			
	1800	41			
21	0000	41			
	0600	41			
	1200	41			
	1800	41			
22	0000	42			
	0600	45			
	1200	46			
	1800	50			
23	0000	60			
	0600	60			
	1200	59	7.5		
	1800	50			
24	0000	40			
	0600	35			
	1200	35			
	1800	37			
25	0000	35			
	0600	25			
	1200	25			
	1800	25			
26	0000	33			
	0600	34			Rapid increase
	1200	45			
	1800	50		IM	
27	0000	50			
	0600	45			
	1200	38			
	1800	38			
28	0000	50			
	0600	50			
	1200	55			
	1800	75			

Date (1947)	Time (G.C.T.)	Amplitude (mm)	Period (sec)	Character	Notes
Sept. 29	0000	80	7.5		Possible two phases
	0600	75			Possible two phases
	1200	72		MI	Possible two phases
	1800	65			Possible two phases
30	0000	55			
	0600	52			
	1200	50			
	1800	50		I	
Oct. 1	0000	50		I	
	0600	48		I	
	1200	50			Very irregular
	1800	52			
2	0000	60			
	0600	60			
	1200	52			
	1800	50			Less irregular
3	0000	50			
	0600	55			
	1200	60			
	1800	61			Increasing rapidly
4	0000	75			Increasing rapidly
	0600	110			Increasing rapidly
	1200	110	7.5		Two waves
	1800	109			
5	0000	90			
	0600	85			
	1200	85			
	1800	85			
6	0000	85			
	0600	85			
	1200	90			
	1800	110			
7	0000	100			
	0600	70			
	1200	48			
	1800	38			
8	0000	28			
9	1200	19			
	1800	22			

Date (1947)	Time (G.C.T.)	Amplitude (mm)	Period (sec)	Character	Notes
Oct. 10	0000	25			
	0600	28			
	1200	32			
	1800	35	6.3		
11	0000	35			
	0600	38			
	1200	35			
	1800	33			
12	0000	34			
	0600	39			
	1200	41			
	1800	45	6.7		
13	0000	50			
	0600	50			
	1200	57			
	1800	59			
14	0000	55			
	0600	46			
	1200	44			
	1800	35			
15	0000	30			
	0600	22			
	1200	11			
	1800	09			
16	1200	15			
	1800	15		M	
17	0000	15		M	
	0600	14		M	
	1200	13		I	
	1800	13		I	
18	0000	13			
	0600	13			
	1200	13			
	1800	15			
19	0000	18			
	0600	19			
	1200	20			
	1800	21			

Date (1947)	Time (G.C.T.)	Amplitude (mm)	Period (sec)	Character	Notes
Oct. 20	0000	23			
	0600	25			
	1200	27	6.0		
	1800	30			
21	0000	32			
	0600	34			
	1200	40			
	1800	42			
22	0000	46			
	0600	38			
	1200	30			
	1800	22			
23	0000	20			
	0600	16			
	1200	16			
	1800	14			
24	0000	14			
25	0600	20			
	1200	22			
	1800	22			
26	0000	22			
	0600	22			
	1200	22			
	1800	26			
27	0000	30			
	0600	35		MI	
	1200	35		MI	
	1800	37			
28	0000	38			Increasing rapidly
	0600	42		I	Increasing rapidly
	1200	46		I	Increasing rapidly
	1800	56			
29	0000	57			
	0600	56			
	1200	54			
	1800	54			
30	0000	47		I	
31					No reading

Date (1947)	Time (G.C.T.)	Amplitude (mm)	Period (sec)	Character	Notes
Nov. 1	0000	60			
	0600	67			Rapid increase
	1200	77			Rapid increase
	1800	100			Rapid increase
2	0300	130			
	0600	110			
	1200	90			
3	0000	75			
	0600	55			
	1200	42			
	1800	33			
4	0000	33			
	0600	36			
	1200	40			
	1800	40			
5	0000	40			
	0600	39			
	1200	45			
	1800	65			
6	0000	70			
	0600	140			Very rapid increase
	1200	150			
	1800	140			
7	0000	100			
	0600	75			
	1200	70			
	1800	60			
8	0000	50			
	1200	50			
9	0600	50			
	1200	50			
	1800	45			
10	0000	37			
	0600	37			
	1200	40		I	
	1800	45		I	
11	0000	47		I	
	0600	55			
	1200	60			
	1800	62			

Date (1947)	Time (G.C.T.)	Amplitude (mm)	Period (sec)	Character	Notes
Nov. 12	0000	62		II	
	0600	60			
	1200	59			
	1800	55			

* * *

APPENDIX B

Upper Air and Direction Data*

Date	Time	Surface	Meters																					
			216	414	612	801	990	1170	1350	1530	1710	1890	2070	2250	2430	2610	2790	2970	3150	3330	3510	3690	3870	4050
June 29	0220	C						315 21	257 24	266 22	245 34	251 22	245 37	253 34										
30	1800	130 30	SE	SE	ESE	E	E		008 7	14 7	353 8	345 10	317 5	300 7	310 10	275 10	287 11	280 6	278 9	272 10	252 14	252 13	269 18	
July 1	1800	120 30			95 9	14 15	13 28	15 22	5 20	13 21	13 11	351 16	341 18	345 13	349 15									
5	0800	C						150 1		357 2	347 6	344 5	326 4	020 8		329 7								
6	1145	C			50 4	50 4	29 6	356 11	339 12	333 12	354 11	288 21	315 13											
15	1630	NW 8	NW 8	NW 8	242 8		342 5																	
19	2000	NNE 12	15 12	15 12	350 12	350 12	343 19	338 19																
22	1545	ESE 27		111 18	150 14	106 15	81 10	51 9	50 4	91 3	90 8													
26	1530	ESE 12	102 8	100 7	113 12	129 12	129 8	135 9	142 12	143 14	136 16	120 27	120 29	117 17	130 17									
29	1800	ESE 3	103 7	176 3	139 4	173 5	182 3	186 5																
30	1430	ESE 8		009 17	5 33	358 20	353 22	340 21	333 52	306 37	313 48	308 53	308 53	309 38	311 48	317 62	303 52							
31	1615	WSW 2	121 2	13 2	324 7	337 15	344 16	331 18	318 18															
Aug. 2	1345	E 6	90 4	95 3	102 2	114 2	220 2	227 2	227 13	223 5	207 5	237 18	235 8	227 9	219 11	215 11	237 8	241 10	242 10	240 10				
4	1430		153 1	133 1	146 1	64 9	16 11	338 20	347 26	348 23	355 23	359 18	354 23	341 24	341 27	342 31	335 29	343 38	341 36	336 29	338 22	334 26	333 26	334 28
4	1800				75 8	2 18	2 12	350 15																
6	1630	E 9		90 2	154 10	108 4			347 21	337 18	327 23	321 21	307 26	302 30	297 26	292 28	287 31	288 22	284 25	274 21	282 24	271 18	267 23	268 21
7	1500	NE 2	45 9	22 13	23 13	5 15	15 26	13 33	9 32	5 50	348 40	341 51	339 38	342 36	340 28	346 26	352 46	354 46						
9	1430	ESE 2		20 2	20 2	338 8	338 10	323 15	306 15	291 17	291 17	302 18	295 18	289 20	289 20	285 24	282 23	289 30	285 42	282 32	276 23	284 28	282 28	280 28
12	1500	E 2	90 3	90 3	77 5	17 10	7 20	353 24	337 25	321 21	328 16	329 20	322 21	339 28										
13	1500	E 3	120 2	150 8	125 4	69 2	6 3	11 5	4 5	54 6	93 4	141 5	218 3	201 13	215 13	195 23	190 36	197 37	197 32	203 40	201 39	201 38	202 37	202 50
14	1410	ESE 26	101 13	76 12	47 12	29 11	23 13	24 16	22 12	6 7	9 8	22 11	21 17	38 21	38 23	38 23	27 19	17 14	18 15	26 21	40 21	39 22	34 22	42 19
14	2000	250 2	- 2	- 2	48 2	163 8	87 5	352 9	350 8	347 5	58 2	100 6	36 12	33 12	40 16									
15	1400	E 15	20 7	335 12	95 3	30 1	2 8	19 13	6 22	350 22	337 18	346 16	349 20	350 22										
15	2100	ESE 3	310 1	360 2	20 2	20 3	1 11	2 18	8 23	9 19	355 10	346 14	350 24											
16	1500	C				0 5	16 16	13 22	13 28	13 23	348 19	326 38	332 37	339 28	328 17	341 21	316 26	312 28						
17	1800	NE 2		330 4		110 10	110 6	90 4	74 8	71 9	108 4	76 2	1 4	326 3	200 2	110 5	0 0	0 0	105 2	105 2	0	0	0	0
18	1900	60 8					108 6	143 3	290 3	350 4	70 2	150 2	170 6	185 5	176 3	151 4	99 8	63 11	78 18	78 20	78 16	71 17	70 20	65 18
19	1500	50 1	2	10 2	340 1	301 4	285 3	280 6	274 4	267 5	217 4	192 6	204 5	188 4	158 6	149 5	156 5	197 6	197 2	197 3	166 4	90 4	95 8	122 7
21	1800	C		20 2	6 3	315 4		1 6	325 9	347 9	12 4	30 2	90 4	100 2	85 3	35 7	40 8	15 7	390 6	352 5	354 5	290 3		60 2

Date	Time	Surface	Meters 216	414	612	801	990	1170	1350	1530	1710	1890	2070	2250	2430	2610	2790	2970	3150	3330	3510	3690	3870	4050
Aug. 22	1500	60 5	10 3	19 17	35 20	20 15	19 13	7 13	325 17	325 13														
23	1500	40 18	27 15	35 16	23 17	21 23	18 33	14 40	9 55	0 62	350 52	348 52	337 46	333 42	332 48									
26	1900	S 2	320 6	332 19	330 12	317 10	304 14	297 26	291 26	291 25	290 26	290 26	277 23	273 25	264 29	265 31	262 32							
27	1430	C												311 6	311 5	292 5	287 6	286 11	286 9	286 11	293 11	298 12	294 15	294 9
Sept. 2	1725	C	337 3	337 7	337 10	317 14	347 18	330 18	331 4	230 11	230 22	210 22	206 27	221 20	216 29	206 31	221 36	214 27	211 28	218 33	218 30	211 32	210 34	204 28
5	2000	NNE 9	357 12	349 16	352 19	352 25	347 28	344 27																
6	1430	NW-NE 10	347 6	349 11	324 21	287 14	292 12	254 24	256 29	249 31	245 35	249 34	248 34	246 41	247 43	235 41	234 42	232 50	231 44	226 46	235 40	244 34	227 32	269 32
8	1820	NNW 10	312 12	359 5	005 3	332 8	325 6	300 7	343 7	325 9	327 9	310 14	315 17	315 19	313 20	300 20	312 22	325 22	348 20					
9	1500	C		298 3	302 1	355 3	217 4	278 4	234 4	206 7	194 10	177 6	185 10	168 14	156 15	147 12	131 16	128 22	159 26	160 28	160 27	151 30	144 36	142 38
9	1900	SE 2	81 3	4 3	330 2	300 4	274 5	257 9	247 12	206 13	219 21	202 27	199 21	213 29	175 28	209 24	193 28	201 23	181 26	192 28	182 28	203 26	200 26	200 28
10	1500	C	73 5	29 4	337 4	328 8	17 8	354 5	220 11	225 15	206 16	202 18	205 23	205 30	198 32	196 30	200 37	200 29	192 32	195 28	195 29	195 25	196 22	196 25
10	2055	NE 4							194 20	173 22	165 26	165 28	180 24	? 60	200 60	199 54	199 58	203 50	203 45	204 22				
13	1300	NE 15	14 28	351 14	351 18	351 18	354 23	351 41	344 52	336 62	334 52	329 40	27	324 27	332 56									
13	1800	N 23	16 22	6 14	4 22	357 30	357 36	354 45	342 35	334 30	334 39	306 26	314 34											
14	2000	NNE 16	32 13	38 14	34 14	34 20	36 28	21 32	7 35	341 21	7 17	338 21												
14	2200	ESE 32	106 12	121 4	57 3	66 3	83 4	85 3	85 6	101 7	90 11	108 9	89 7	66 6	7 9	354 15	0 19	349 11	42 7	90 9	65 12	65 11	90 10	
15	1800	E 2	80 2	340 6	330 11	350 18	354 17	286 9	263 9	282 22	197 27	234 27	232 29	218 37	214 38	204 42	208 52	205 48	209 56	205 58	204 50	203 58		
Oct. 26	1400	55 15	54 22	48 17	33 14	32 18	356 33	9 33	0 40	354 35	353 36	354 40												
26	1700				352 11		14 20	12 31		0 28		355 27	358 28		348 25	352 30		351 32		357 32	1 35		352 24	358 36
30	2300	340 19			347 20		347 20	347 20		347 28		347 32	335 32		330 35	319 38		318 318		318 43	318 38			
31	1300	NE 13	25 19	17 16	4 8	6 10	5 13	4 20	350 25	336 28														
Nov. 2	1000			60 6			300 14	272 20		275 22		259 26	256 36		258 34	252 41		245 40		243 40	241 50		246 50	248 56
2	1247		192 2	114 2	18 5	350 12	358 13	314 18	314 21	278 22	263 13	268 26	268 29	268 38	269 33	255 36	271 24	261 40	263 44	255 38	261 44			
3	1500	C	130 4	165 5	137 4	328 10	50 8	234 10	182 13	175 22	193 28	208 16	215 20	224 26	223 32	229 34	233 32	238 34	236 32	245 34	40 52	246 44		
3	1900	C		170 2	57 6		232 3	185 20		200 18		206 18	239 20		235 26	248 28		242 35		246 35	246 37		249 38	254 46
4	1100	C	95 10	300 5	72 4	64 7	31 8	19 8	17 7	8 5	356 3	78 6	36 4	327 7	302 15	256 16	251 18	249 16						
4	1600	350 2		109 8	312 3		36 9	6 13		358 12		358 8	312 11		278 10	256 14		256 14		269 18	257 20		255 25	253 25
5	1300	ESE 13	105 2	76 3	29 7	60 18	26 18	24 18	32 19	21 26	28 33	25 43	24 42	23 37	23 34	18 40	18 56	5 30	8 28	14 36	15 30	15 20		
7	2300	150 3		130 6	95 4		95 4	64 7		318 6		326 6	300 8		286 20	309 15		275 17		263 20	252 20		251 28	270 28
8	1500	ESE 24	100 20	69 6	43 9	46 32	14 24	10 20	1 22	344 27	324 27	318 25	316 23	316 22	328 22									

*Top figure in altitude data indicates direction from which wind is coming. Therefore 180 indicates a due south wind. Bottom figure indicates force of wind in knots.

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