A0006176

Part 1 of 2

# INDEX

7-42a Standard Project Hurricane Isovels for a high speed of Translation of the Hurricane Center, Zone B.

7-43 SPH Criteria & Isovel Patterns, Zones (East Coast)

7-44 SPH Isovel Patterns, Norfolk area

7-45 SPH Parameters + Isovels, Zone C (Texas Coast)

7-45A SPH Isovels for a High Speed of Translation Zone C, (Texas Coast)

7-51 Pressures, Wind Speeds and Directions in Hurricane Audrey near La. Coast, June 27, 1957

7-51a Addendum to 7-51

7-53 Pressures and Winds over the Gulf of Mexico in Hurricane Flossy, Sept. 23-24, 1956

7-61 Relationships Between SPH Isovel Patterns and Probable Maximum Events for the New Orleans area.

7-61a The above continued.

7-62 SPH Wind Fields for Track C, Critical for North Shore of Lake Pontchartrain.

7-62a SPH Wind Field for Track C with a Rotated SPH Pattern

7-63 SPH Wind Fields for Track F with Forward Speed 5 Knots, critical To Area I

7-64 SPH Wind Fields for Track D with forward speeds of 5 and 15 Knots

7-65 SPH Wind Fields for Track B with forward speeds of 5 Knots

HUR No.

| | |
|---|---|
| 7-76A | Revised Surface Wind Charts for Hurricane Carla (1961) |
| 7-82 | Preliminary Analysis of Surface Winds in Hurricane Hilda, October 2-4, 1964 |
| 7-84 | Standard Project Hurricane Wind Field Patterns (revised) to Replace Existing Patterns in NHRP Report No. 33, for Zones B and C Aug. 17, 1965 |
| 7-85 | Ratio Chart to adjust Isovel Patterns in HUR 7-40 to Level of Updated SPH Patterns. |

U.S. DEPARTMENT OF COMMERCE
ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION
WEATHER BUREAU
WASHINGTON, D. C. 20235

January 25, 1966

IN REPLY REFER TO: W211

MEMORANDUM TO CORPS OF ENGINEERS

HUR 7-87A

SUBJECT: Surface Winds (30 ft.) Over Lake Pontchartrain, La. During Passage of Hurricane Betsy, September 9-10, 1965

References: 1. HUR 7-87 dated December 20, 1965, "Surface Winds (30 ft.) Over Gulf of Mexico in Hurricane Betsy, September 9 and 10, 1965."

2. Letter from N. O. District to OCE dated September 29, 1965

This memorandum supplements reference 1 and provides the surface wind (30 ft.) over Lake Pontchartrain during Hurricane Betsy, 1965. It consists of seven charts beginning 1800 CST September 9, 1965 and, by 3-hourly intervals, ending 1200 CST September 10, 1965. These charts may be used with corresponding time charts of reference 1.

The isovel charts are analyzed at 10-knot intervals with 5-knot values (dashed lines) where needed. Smooth streamlines over the Lake show the wind direction.

This analysis is based primarily on the observed winds at South Bascule, Lake Causeway; Weather Bureau Airport Station, Moisant Airport; and Huey Long Bridge. The latter two stations are reduced to over-water values at 30 ft. by standard relationships (figure 1-1 NHRP Report No. 39). More distant wind reports, and the pressure field are also guides to the wind speed profile along a radial from the storm center position.

Vance A. Myers
Chief, Hydrometeorological Branch
Office of Hydrology

Attachments
cc: 2 to OCE
4 sets of charts

ENGCW-EY 26 January 1966

SUBJECT: Hurricane Studies - Surface Winds over Lake Pontchartrain, La. During Hurricane Betsy, September 1965

(7-87A)

TO: Division Engineer
Lower Mississippi Valley Division

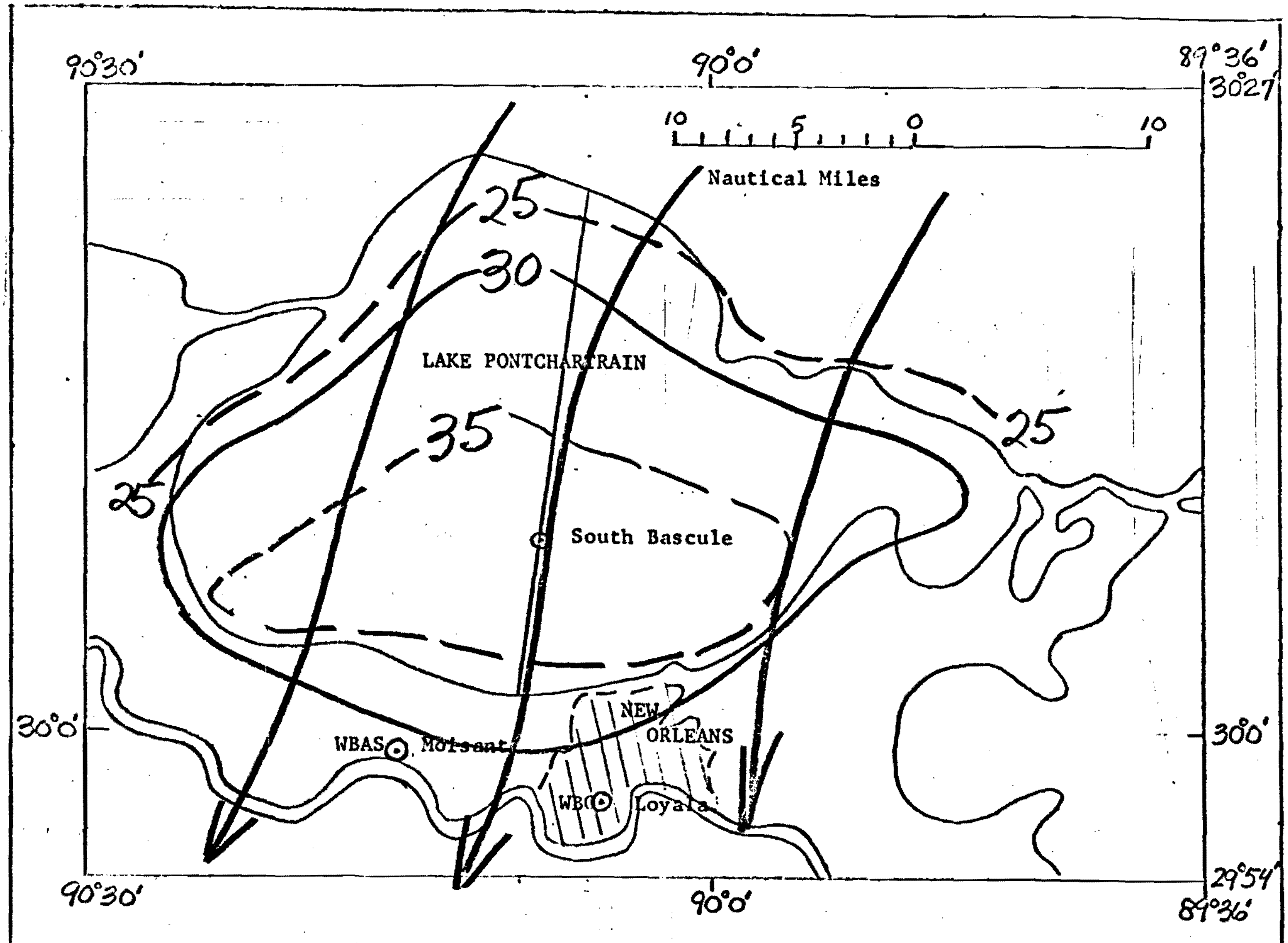
1. Reference is made to New Orleans District letter of 29 September 1965, subject, "Hurricane Study, Review of U.S. Weather Bureau Hydrometeorological Branch Hurricane Memorandums," requesting isovel patterns and related data for Hurricane Betsy, 8-10 September 1965. The Hydrometeorological Branch has completed preparation of surface wind charts over Lake Pontchartrain, Louisiana, during the passage of Hurricane Betsy. This supplements HUR 7-87 furnished by OCE letter of 22 December 1965, subject as above, and shows the wind fields in more detail over the lake.

2. The analysis consists of Memorandum HUR 7-87A with seven surface wind charts for the period 1800 CST 9 September 1965 to 1200 CST 10 September 1965. Two copies of the data are furnished directly to the New Orleans District.

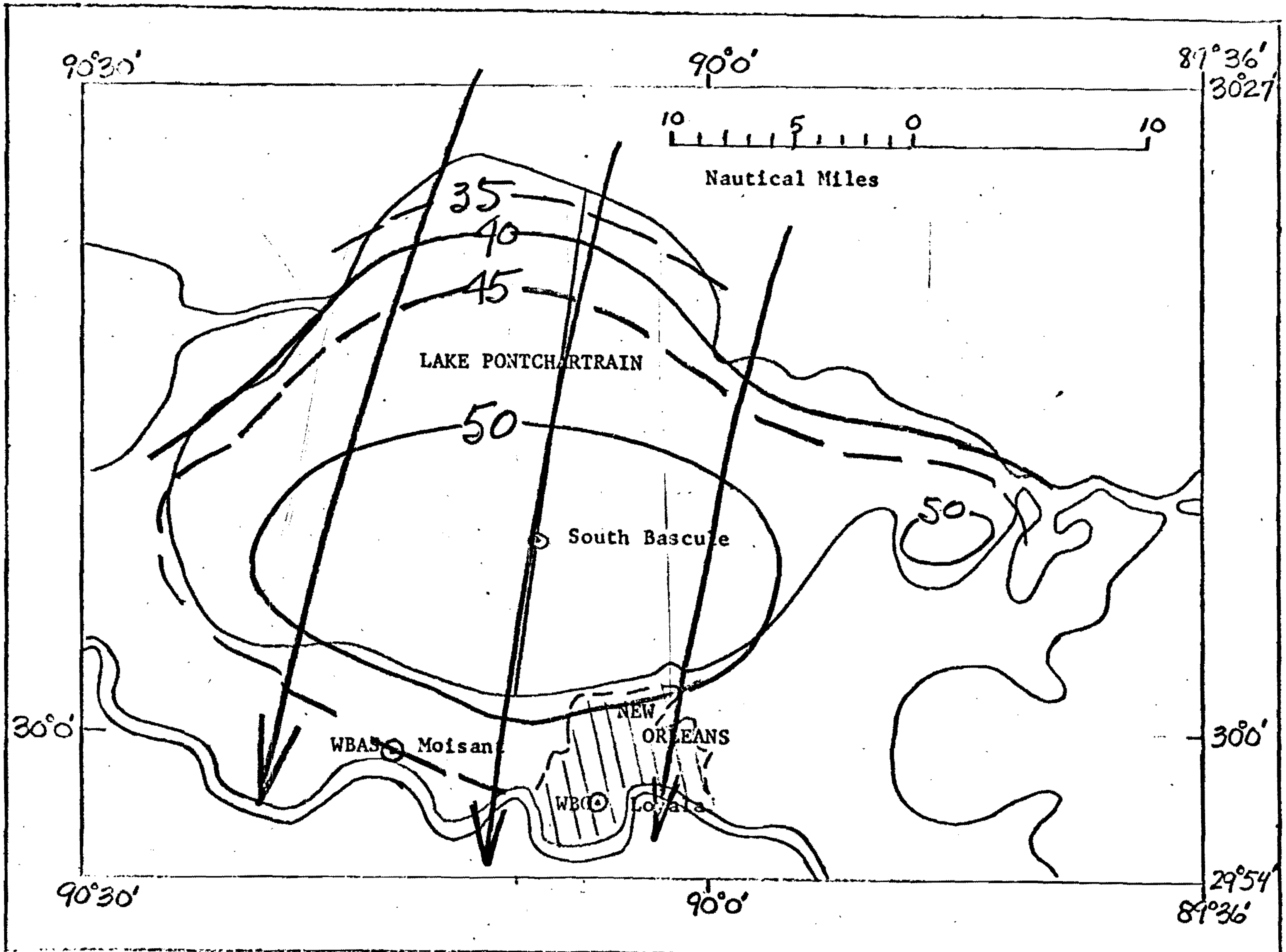
FOR THE CHIEF OF ENGINEERS:

WENDELL E. JOHNSON
Chief, Engineering Division
Civil Works

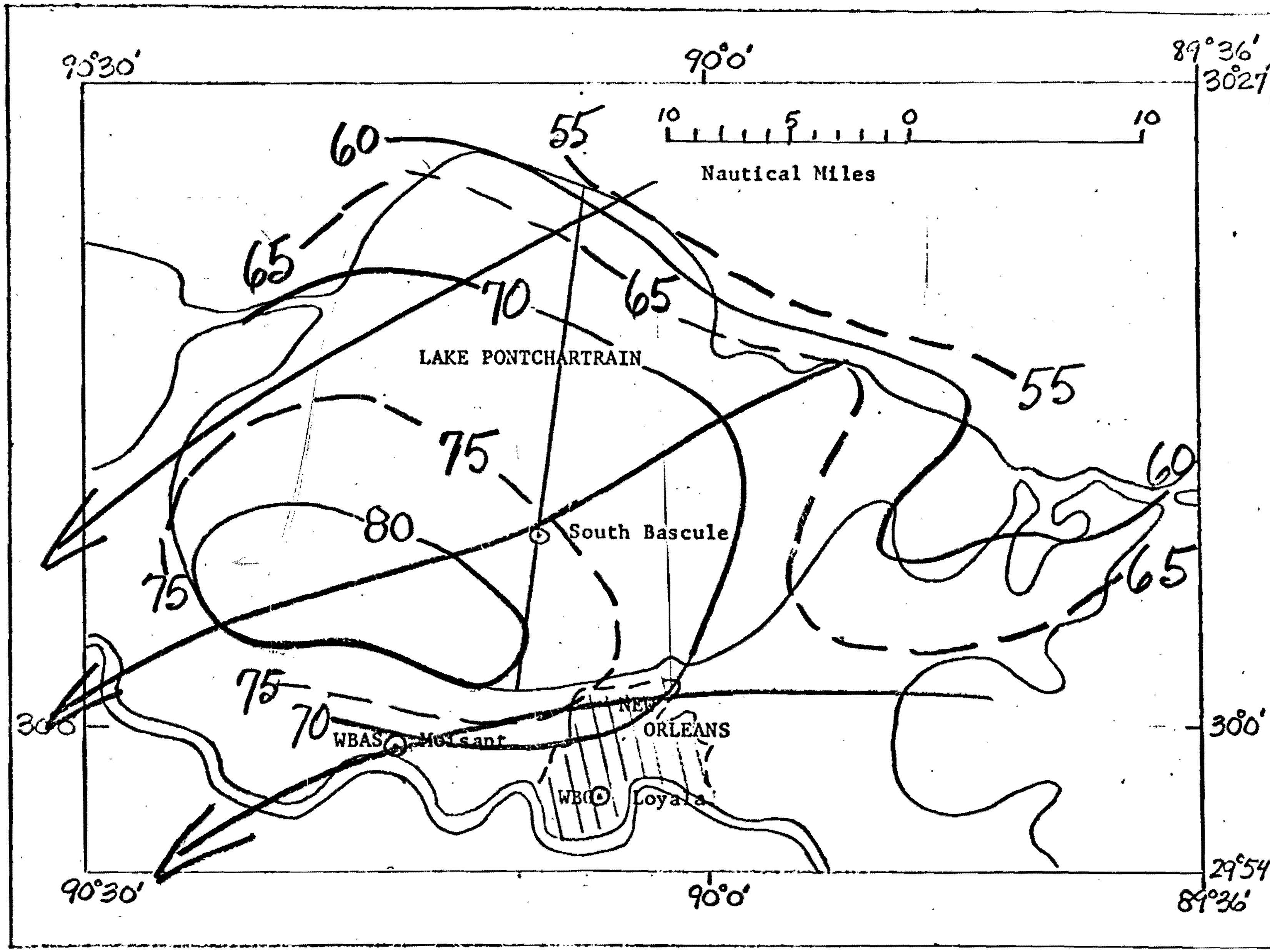
Cy furnished:
District Engineer, New Orleans
w/1 Incl
HUR 7-87A, 25 Jan 66 (dupe)



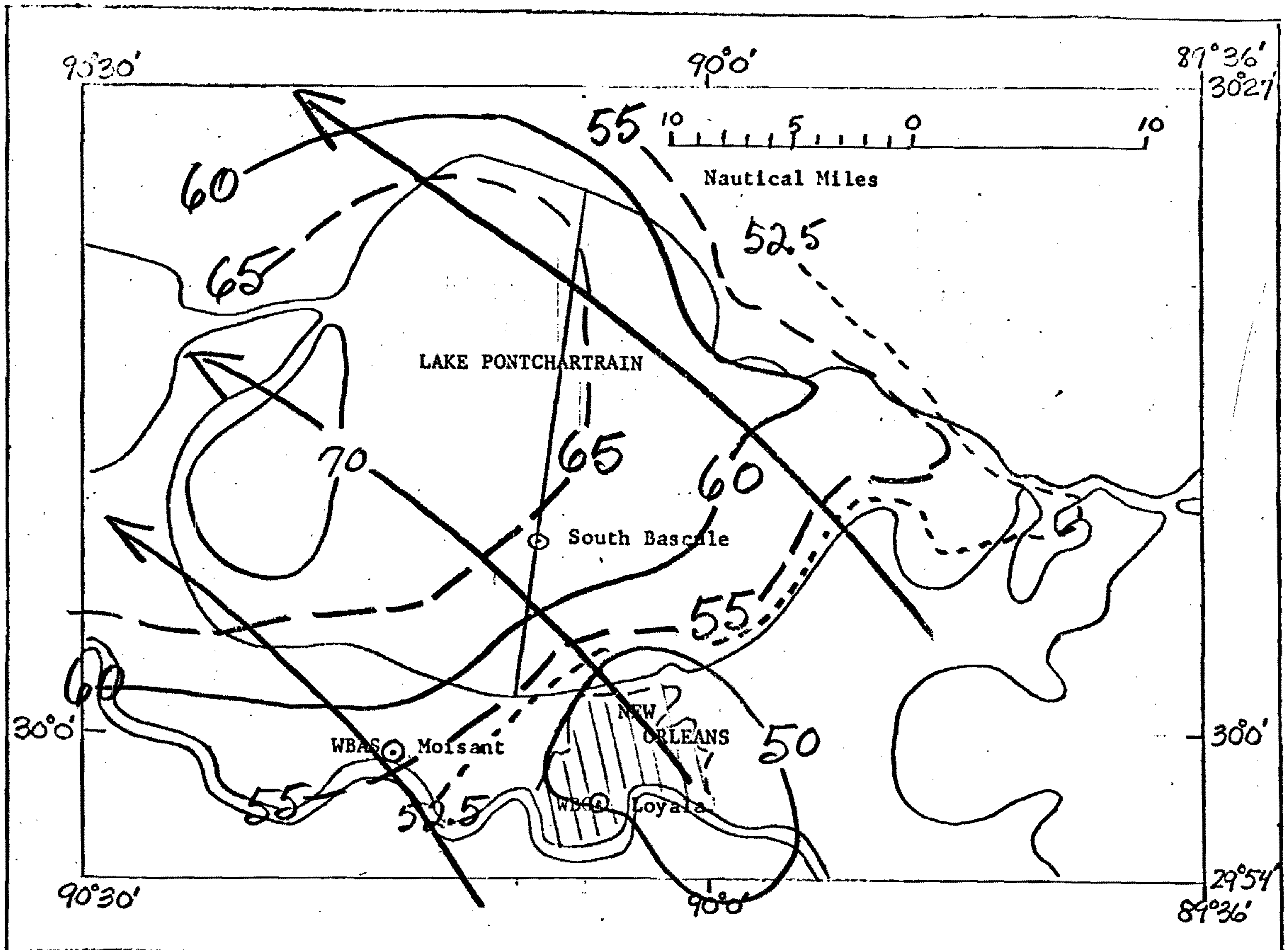

HURRICANE BETSY
SURFACE WINDS (30 FT.)
SEPT. 9, 1965 1800 CST
ISOVELS (KT.)



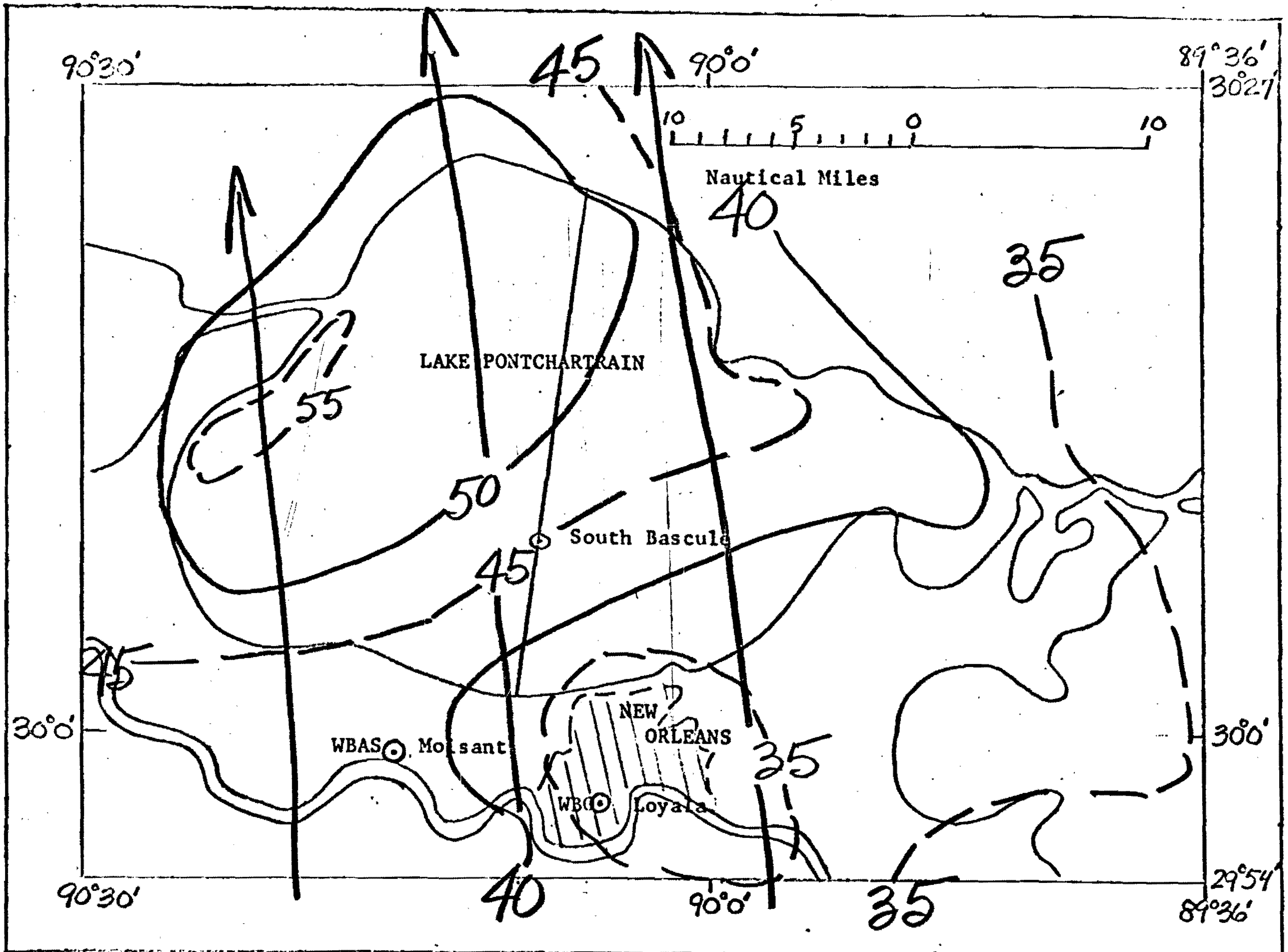

HURRICANE BETSY
SURFACE WINDS (30 FT.)
SEPT. 9, 1965 2100 CST
ISOVELS (KT.)



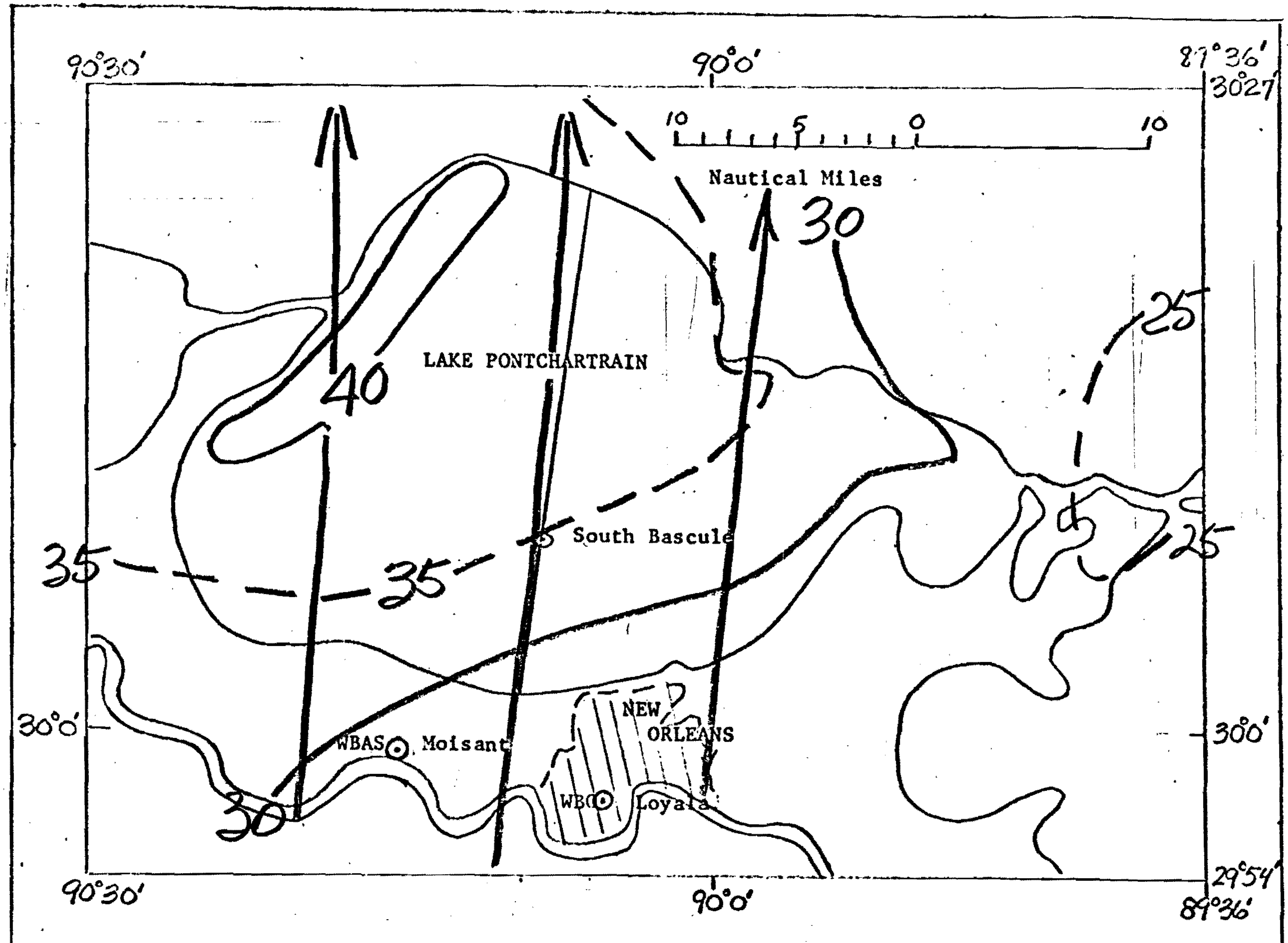

HURRICANE BETSY
SURFACE WINDS (30 FT.)
SEPT. 10, 1965 0000 CST
ISOVELS (KT.)



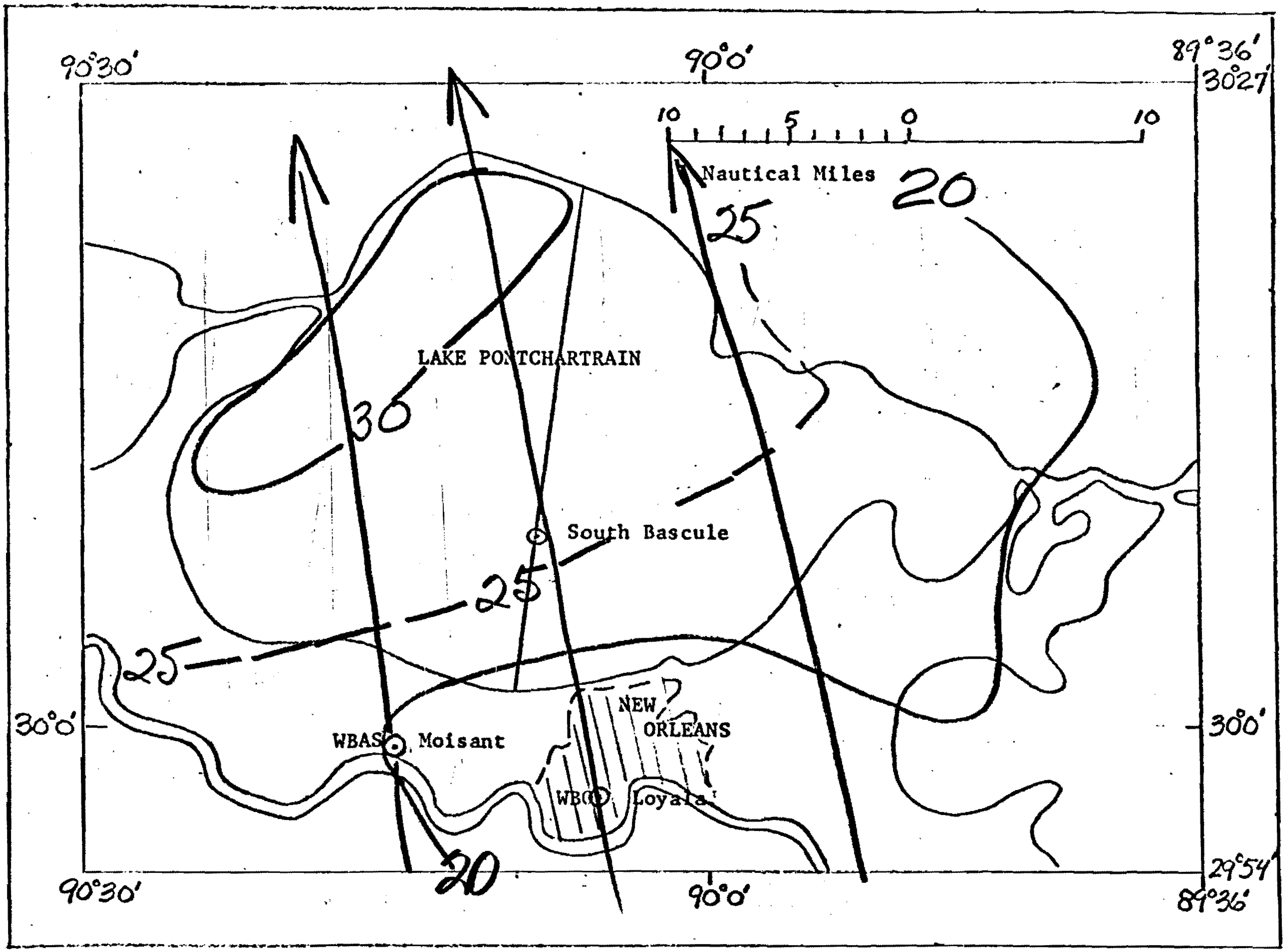

HURRICANE BETSY
SURFACE WINDS (30 FT.)
SEPT. 10, 1965 0300 CST
ISOVELS (KT.)




HURRICANE BETSY
SURFACE WINDS (30 FT.)
SEPT. 10, 1965 0600 CST
ISOVELS (KT.)




HURRICANE BETSY
SURFACE WINDS (30 FT.)
SEPT. 10, 1965 0900 CST
ISOVELS (KT.)




HURRICANE BETSY
SURFACE WINDS (30 FT.)
SEPT. 10, 1965 1200 CST
ISOVELS (KT.)

U.S. DEPARTMENT OF COMMERCE
ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION
WEATHER BUREAU
WASHINGTON, D. C. 20235

December 20, 1965

IN REPLY REFER TO:
W2/WMI

MEMORANDUM TO CORPS OF ENGINEERS

HUR 7-87

SUBJECT: Surface Winds (30 ft.) over Gulf of Mexico in Hurricane Betsy, September 9 and 10, 1965

Reference: Letter from New Orleans District to OCE dated September 29, 1965

Enclosed are four sets of copies of preliminary analyses of the wind (30 ft.) over the Gulf of Mexico and the Mississippi Delta region during the passage of Hurricane Betsy, 1965. A chart of the storm track is also included.

Each set contains 13 charts, covering the period from 0000 CST of the 9th to 1800 CST of the 10th at 3-hourly intervals except 6-hour intervals for the first three charts.

The isovels are for 10-knot intervals, continuous lines, except an occasional 5-knot isovel (dashed line) has been supplied to facilitate reading the values. For wind directions, the angle of incurvature is zero from the center of the storm outward to about 1.2 times the radius of maximum winds, R. Elsewhere, wind direction arrows, true at the arrow head, are provided. Direct linear interpolation between successive charts is generally valid.

Table 1 lists pertinent characteristics of Betsy.

Vance A. Myers
Chief, Hydrometeorological Branch
Office of Hydrology

Enclosures
cc: 2 to OCE
4 sets of charts

Table 1

CHARACTERISTICS - "BETSY", SEPT., 1965

| Date/Time (CST) | | $P_o$ (mb.) central pressure in inches | $P_n$ (mb.) | R (n. mi.) | $V_m$ (kts.) RF | $V_m$ (kts.) LR | $V_h$ Speed (kt.) | $V_h$ Direction (deg.) |
|---|---|---|---|---|---|---|---|---|
| 9 | 0000 | 28.05 950 | 1012.5 | 20 | 100 | 89.5 | 16.6 | 280 |
| | 0600 | 28.08 951 | 1013.0 | 23.5 | 100 | 92 | 12 | 295 |
| | 1200 | 28.02 949 | 1014.0 | 27 | 101.5 | 91.5 | 16 | 321 |
| | 1500 | 27.87 944 | 1013.0 | 28.5 | 105 | 95 | 15.5 | 320 |
| | 1800 | 27.79 941 | 1012.0 29.9[illegible] | 30 | 106.5 | 96 | 16.3 | 316 |
| | 2100 | 27.79 941 | 1012.5 29.90 | 32 | 106 | 95 | 17 | 314 |
| 10 | 0000 | * | * | * | * | * | 16.5 | 318 |
| | 0300 | | | | | | 13.7 | 320 |
| | 0600 | | | | | | 13.4 | 321 |
| | 0900 | | | | | | 13.5 | 339 |
| | 1200 | | | | | | 12.7 | 355 |
| | 1500 | | | | | | 11.8 | 358 |
| | 1800 | | | | | | 11.8 | 5 |

*Storm center inland.

Legend:

$P_o$ = central pressure

$P_n$ = average peripheral pressure

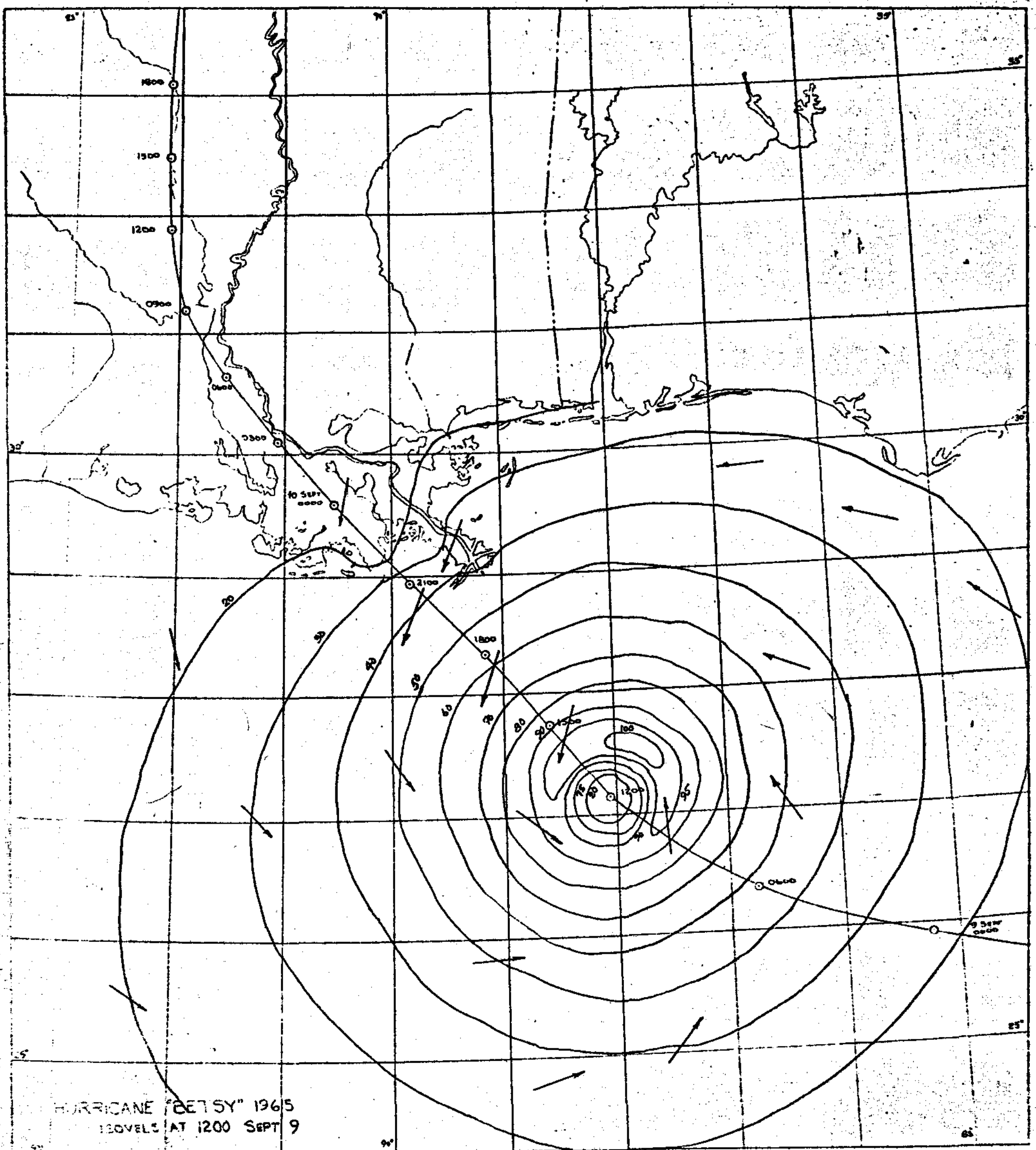
$V_m$ = maximum sustained 30 ft. surface windspeed

RF = Right front quadrant

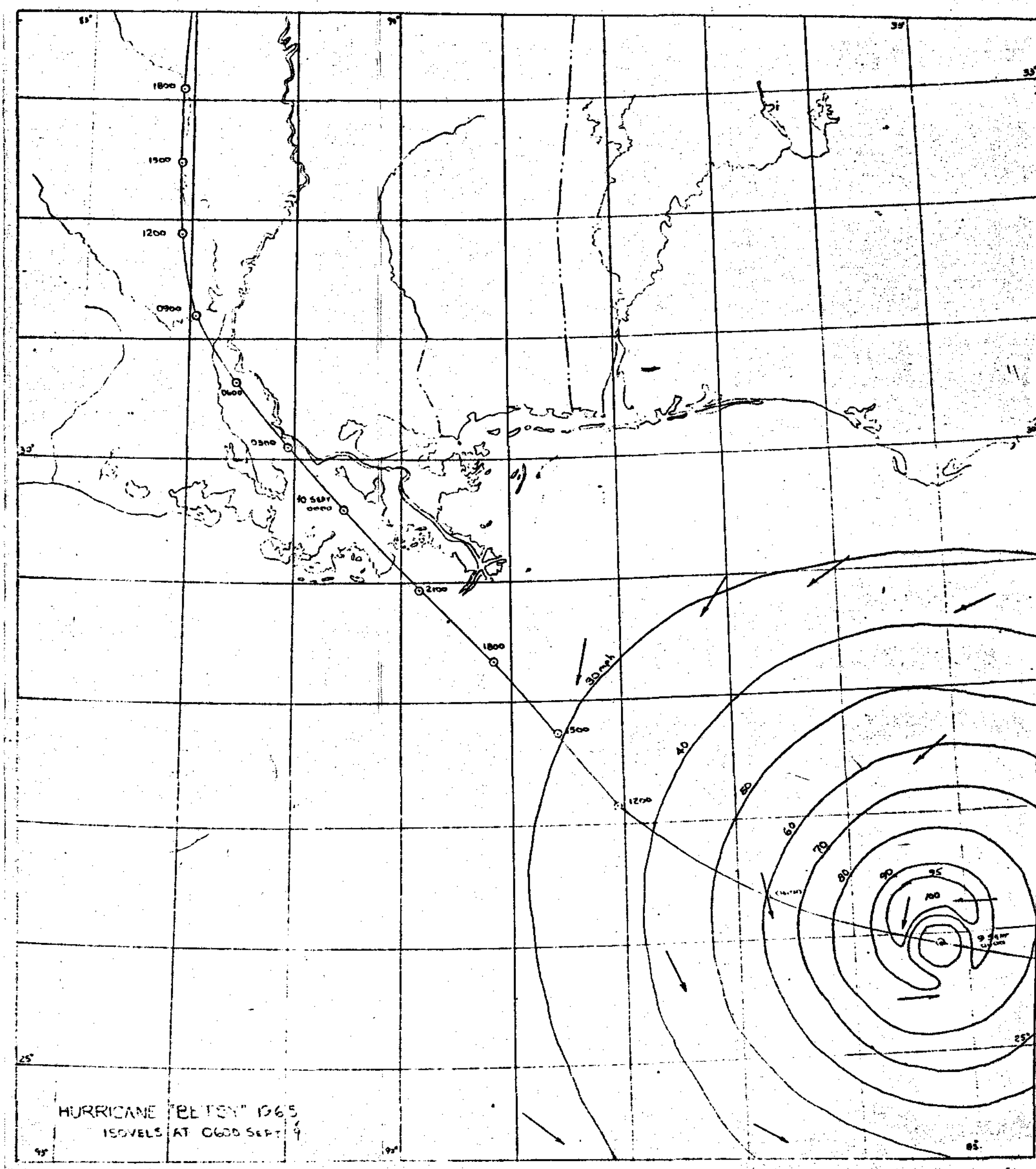
LR = Left rear quadrant

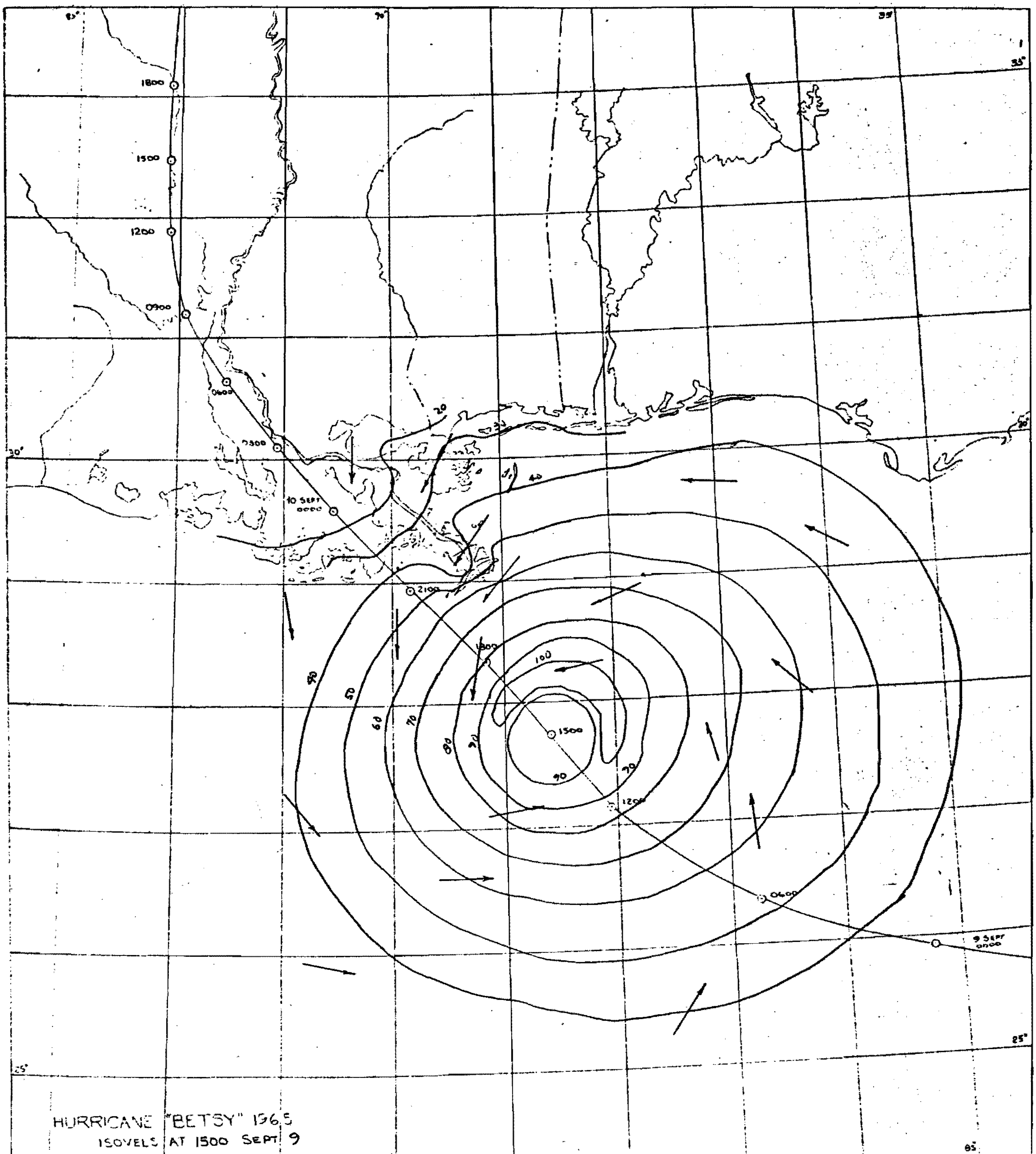
$V_h$ = forward velocity of hurricane center; direction is point of compass toward which it is moving

R = radius of maximum winds

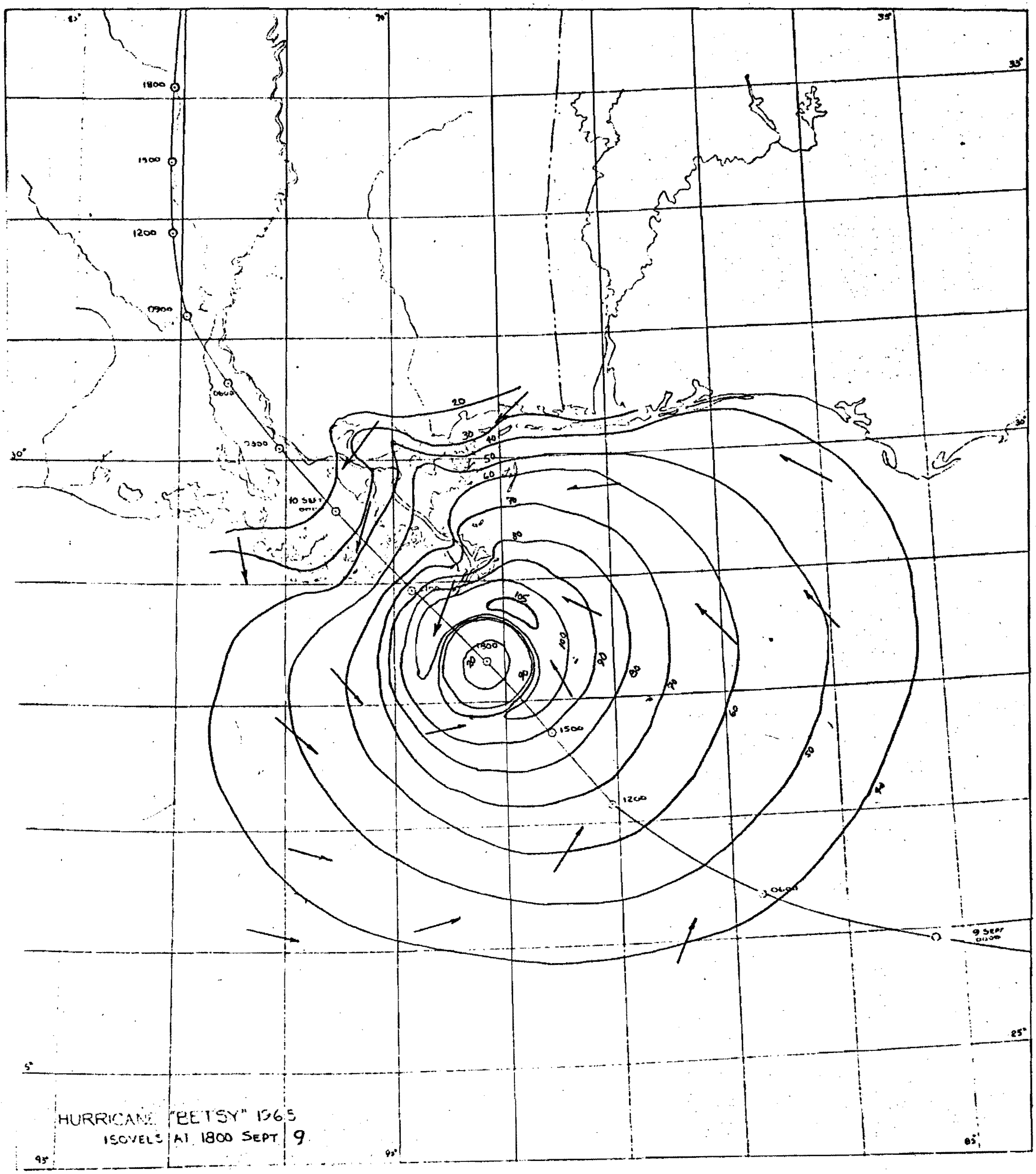



HURRICANE "BETSY" 1965
ISOVELS AT 1200 SEPT 9

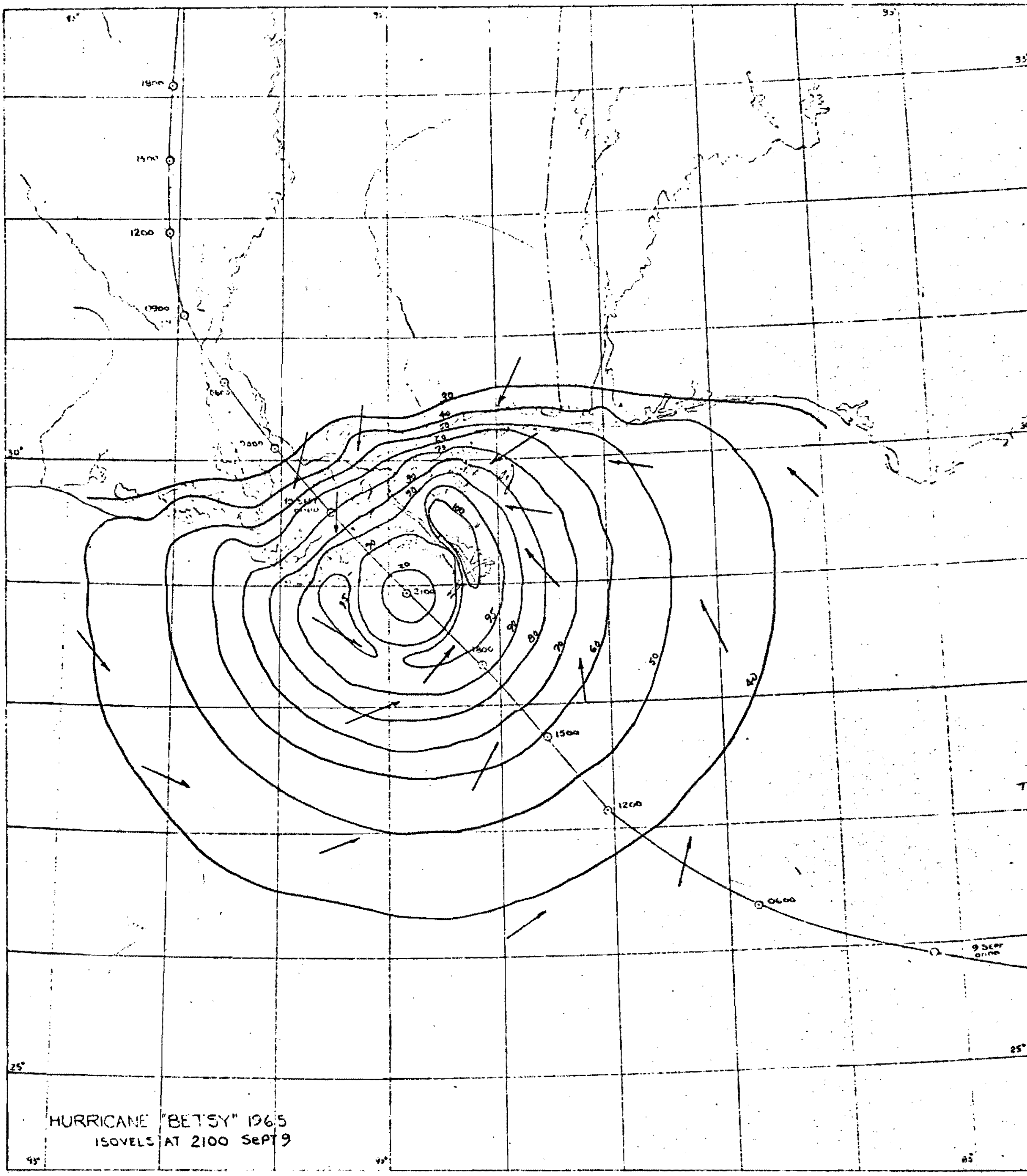

30 mph
40
50
60
70
80
90
95
100
10 SEPT 0000
9 SEPT
1800
1500
1200
0900
0600
0300
2100
33°
30°
25°
85°
95°
HURRICANE "BETSY" 1965
ISOVELS AT 0600 SEPT 9

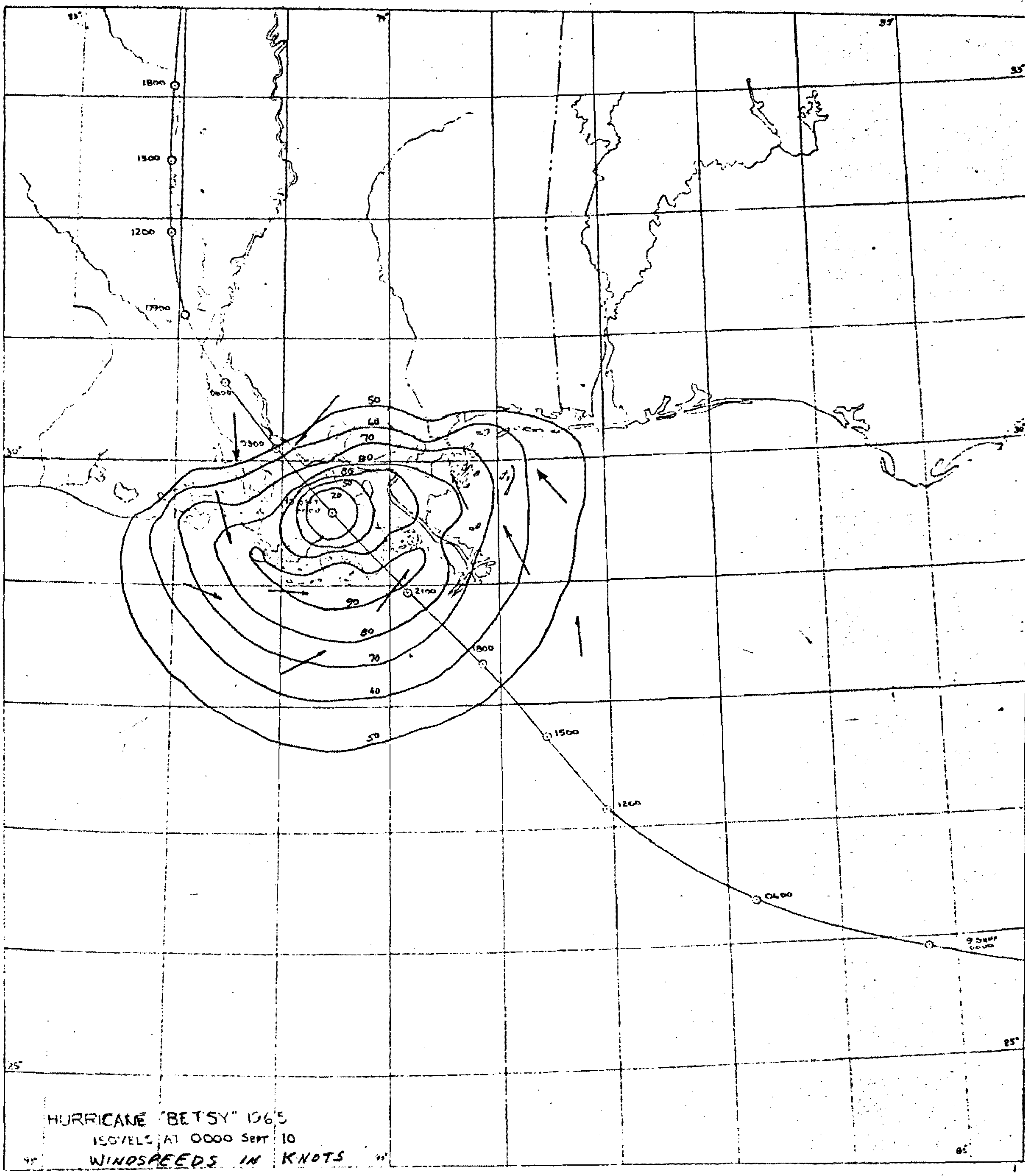


1800
1500
1200
0900
0600
0300
10 SEPT 0000
2100
1800
1500
1200
0600
9 SEPT 0000
20
30
40
50
60
70
80
90
100
30°
25°
35°
85°
90°
95°
HURRICANE "BETSY" 1965
ISOVELS AT 1500 SEPT 9

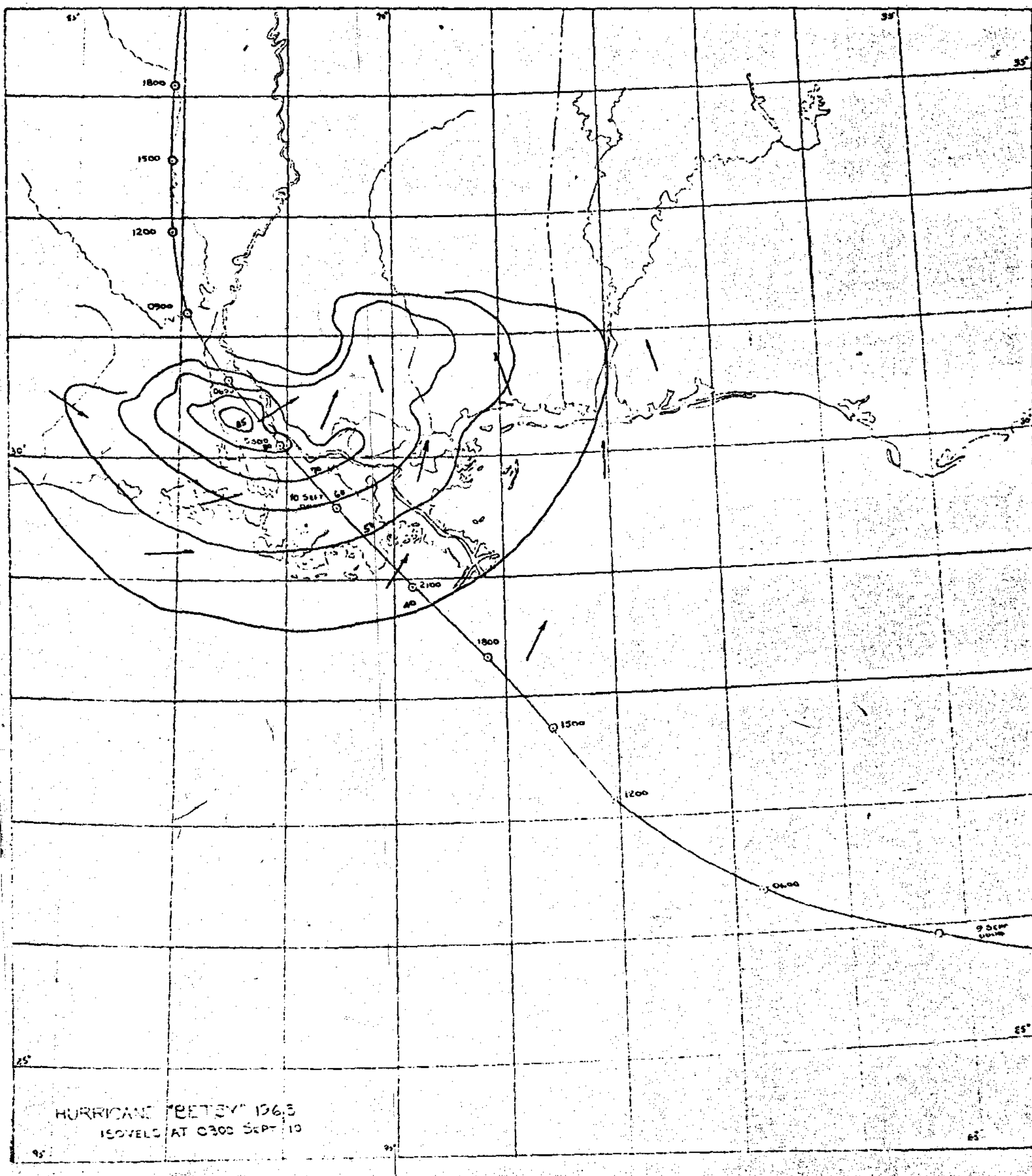


HURRICANE "BETSY" 1965
ISOVELS AT 1800 SEPT 9
10 SEPT
9 SEPT
1800
1500
1200
0900
0600
0300
20
30
40
50
60
70
80
90
100
105


HURRICANE "BETSY" 1965
ISOVELS AT 2100 SEPT 9



HURRICANE "BETSY" 1965
ISOVELS AT 0000 SEPT 10
WINDSPEEDS IN KNOTS




HURRICANE "BETSY" 1965
ISOVELS AT 0300 SEPT 10

UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
WASHINGTON

Environmental Science Services Administration

February 17, 1966

IN REPLY ADDRESS
CHIEF, U.S. WEATHER BUREAU
WASHINGTON 25, D.C.
AND REFER TO
W211

MEMORANDUM TO CORPS OF ENGINEERS

HUR 7-85A

SUBJECT: Ratio Chart to Adjust Isovel Patterns in HUR 7-40 to Level of Updated SPH Patterns

References:
1. Letter to Hydromet Branch from OCE, dated January 20, 1966
2. MEMORANDUM HUR 7-40, "Louisiana Hurricane of September 29, 1915, Transposed to a Critical Track."
3. MEMORANDUM HUR 7-84, "Standard Project Hurricane Wind Field Patterns (revised) to Replace Existing Patterns in NHRP Report No. 33, for Zones B and C."

Herein presented is a chart of ratio lines which, used as factors, will adjust the wind speed values in the isovel charts in HUR 7-40 to correspond to wind speed values (at 30 ft.) in the updated SPH moving along the same track as that included in HUR 7-40.

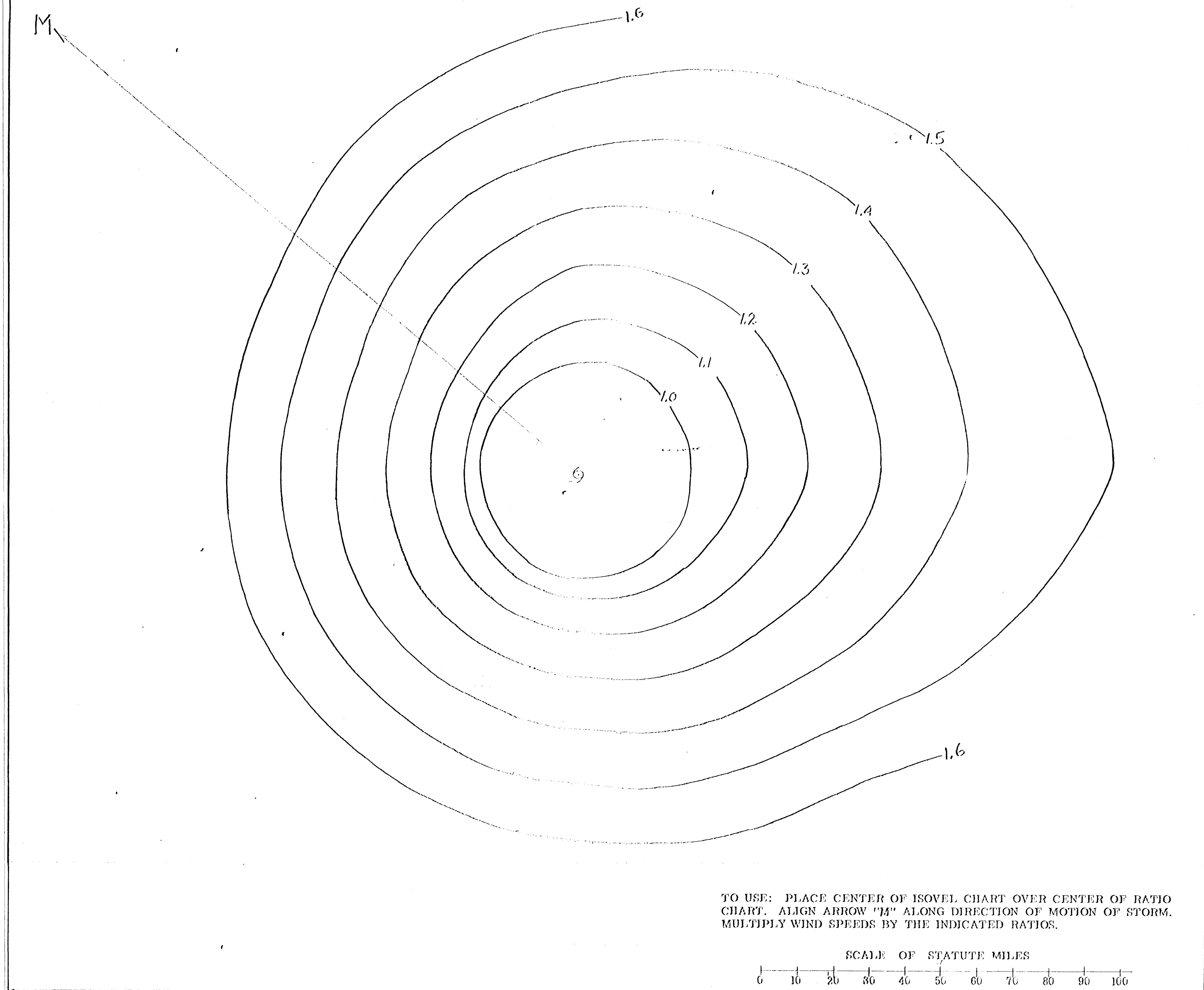
Charts of the updated SPH isovel fields are presented in HUR 7-84 (ref. 3). That memorandum also includes a discussion of the considerations leading to the revisions in the SPH isovel fields in Zones B and C in the Gulf of Mexico (approximately from Apalachicola, Fla., to Brownsville, Tex.).

To adjust any isovel pattern in HUR 7-40 place the figure over the adjustment chart, with centers corresponding and with direction of motion of the storm aligned with direction arrow M. Multiply the wind speed at any point on the pattern with the ratio at that point. Linear interpolation between ratio isolines is valid. The area within the 1.00 ratio line has a value of 1.00 throughout (i.e., the speed values from storm center out to a distance of the radius of maximum wind are not changed).

Vance A. Myers

Vance A. Myers
Chief, Hydrometeorological Branch

Attachments:
cc: 2 to OCE
4 copies of chart



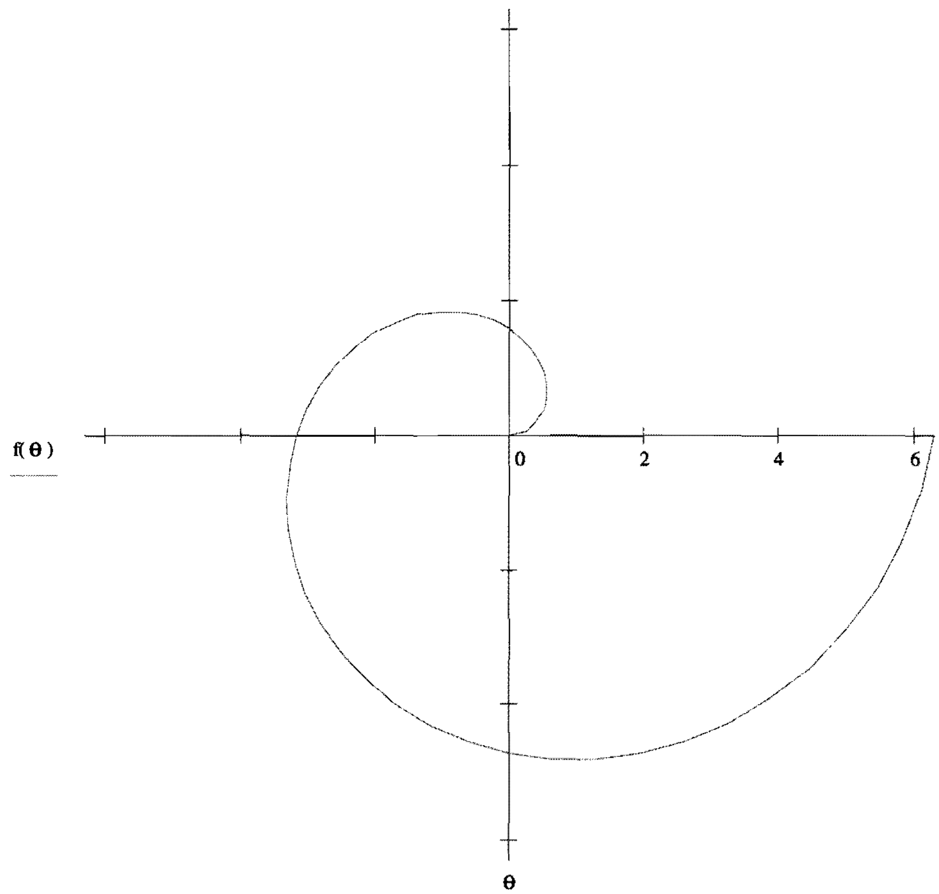

Ratio Chart to adjust isovels of 1915 Hurricane Transposed
(HUR 7-40) to revised SPH isovels (HUR 7-84)

$a := 1$

$\theta := 0, \frac{\pi}{24} .. 2\pi$

$f(\theta) := a \cdot \theta$

Archimedian spiral



**DEPARTMENT OF THE ARMY**
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20315

IN REPLY REFER TO
ENGCW-EY

8 November 1965

SUBJECT: Hurricane Study, Review of U.S. Weather Bureau Hydrometeorological Branch Hurricane Memorandums

TO: Division Engineer
Lower Mississippi Valley Division

1. Reference is made to New Orleans District letter of 29 September 1965, requesting review of hurricane memoranda prepared by the Weather Bureau, and to OCE 1st Indorsement thereto.

2. The Hydrometeorological Branch has completed review of memoranda HUR 7-62, 7-62A, 7-63, 7-64 and 7-65. Transmitted herewith is Memorandum HUR 7-85 which gives a means of adjusting the isovel patterns in the memoranda listed above to reflect the revisions in the basic SPH isovel patterns presented in HUR 7-84. A sample of an adjustment is also included.

FOR THE CHIEF OF ENGINEERS:

1 Incl
HMB Memo HUR 7-85,
3 Nov 65 (dupe)

WENDELL E. JOHNSON
Chief, Engineering Division
Civil Works

LMVED-PH (OCE 8 Nov 65) 1st Ind

DA, Lower Miss. Valley Div, CE, Vicksburg, Miss. 39181 16 Nov 65

TO: District Engineer, New Orleans District, ATTN: LMNED-H

1 Incl
dupe cy wd

G.B.D.

HUR 7-85 Removed and

Placed in Binder Aug 1976

HUR 7-87

ENGCW-EY

22 December 1965

SUBJECT: Hurricane Studies - Surface Winds over Gulf of Mexico in Hurricane Betsy, 9-10 September 1965

TO: Division Engineer
Lower Mississippi Valley Division

1. Reference is made to New Orleans District letter of 29 September 1965 subject, "Hurricane Study, Review of U.S. Weather Bureau Hydrometeorological Branch Hurricane Memorandums," requesting isovel patterns and related data for Hurricane Betsy, 8-10 September 1965. The Hydrometeorological Branch of the Weather Bureau has completed preparation of the surface wind fields over the Gulf of Mexico and the Mississippi Delta region during the passage of Hurricane Betsy, two copies of which are furnished directly to the New Orleans District.

2. The study consists of HMS Memorandum HUR 7-87, a storm tracts chart and 13 wind charts, covering the period from 0000 hours CST 9 September to 1800 hours CST 10 September at 3-hour intervals except 6-hour intervals for the first three charts.

FOR THE CHIEF OF ENGINEERS:

WENDELL E. JOHNSON
Chief, Engineering Division
Civil Works

1 Incl
HUR 7-87 (dupe)

Copy furnished:
Dist Engr, New Orleans
w/1 Incl
HUR 7-87 (dupe)

U[illegible] STATES DEPARTMENT OF C[illegible]ERCE
WEATHER BUREAU
WASHINGTON

October 21, 1959

IN REPLY, PLEASE ADDRESS
CHIEF, U. S. WEATHER BUREAU
WASHINGTON 25, D. C.
AND REFER TO

0-6.12

TO : Mr. A. L. Cochran, Civil Works
Office of Chief of Engineers
Corps of Engineers

FROM : Hydrometeorological Section

SUBJECT: Memorandum HUR 7-65, SPH Wind Fields for Track B with forward speed of 5 knots

Herewith is transmitted the subject memorandum which furnishes isovel charts for track B of the New Orleans Hurricane Study.

Charles S. Gilman, Chief
Hydrometeorological Section

2 cc with att. to OCE
2 cc with att. to BEB

UN[illegible] STATES DEPARTMENT OF C[illegible]RCE
WEATHER BUREAU
WASHINGTON

October 21, 1959

IN REPLY, PLEASE ADDRESS
CHIEF, U. S. WEATHER BUREAU
WASHINGTON 25, D. C.
AND REFER TO

0-6.12

MEMORANDUM TO CORPS OF ENGINEERS

HUR 7-65

FROM : Hydrometeorological Section

SUBJECT: SPH Wind Fields for Track B with Forward Speed of 5 Knots

References: 1. Memorandum from OCE to HMS, 17 August 1959 and Conference at OCE 11-13 August 1959, Subject, New Orleans Hurricane Studies.

2. HUR 7-62, SPH Wind Fields for Track C (revised), Critical for North Shore of Lake Pontchartrain, September 8, 1959.

This memorandum presents wind directions and speeds according to Standard Project Hurricane criteria for track B, critical for Grand Isle and the portions of Area II west of the Mississippi as specified in reference /1_/. The SPH over-water pattern was rotated 36 degrees clockwise from the track C direction given in the over-water pattern of reference /2_/. Filling, shore line and friction adjustments were made in a similar manner as the procedure used in HUR 7-62.

Isovel charts are enclosed at 2-hour intervals from -10 hours to +4 hours and at 1-hour intervals from +4 hours to +17 hours (the times are hours before and after the hurricane center crossed the coast).

Also enclosed are a track map and a spiral. The spiral is used for determining wind directions as described in reference /2_/.

In the map legends, $R_m$ = radius of maximum winds in nautical miles and F. S. = forward speed of hurricane center in knots.

Charles S. Gilman, Chief
Hydrometeorological Section

2 cc with att. to OCE
2 cc with att. to BEB

ENGWE 22 October 1959

SUBJECT: Hurricane Study, Meteorological Criteria, New Orleans District

TO: Division Engineer
U. S. Army Engineer Division, Lower Mississippi Valley
Vicksburg, Mississippi

1. In accordance with paragraph 1b of inclosure No. 3 of notes on conference held in OCE on 11-13 August 1959, subject, "Hurricane Protection Studies (PL 71), New Orleans District", the Hydrometeorological Section of the Weather Bureau has furnished a memorandum for the meteorological criteria specified therein. Two copies of the memorandum, HUR 7-65, subject, "SPH Wind Fields for Track B with Forward Speed of 5 Knots", dated 21 October 1959, are inclosed.

2. Duplicate copies of the memorandum have been furnished the Beach Erosion Board. The remaining data outlined in inclosure No. 3 of the conference notes will be forwarded as soon as received from the Weather Bureau.

FOR THE CHIEF OF ENGINEERS:

1 Incl (dup)
HMS Memo HUR 7-65,
21 Oct 59

F. B. SLICHTER
Chief, Engineering Division
Civil Works

LMVGK 1st Ind

U. S. Army Engr Div, Lower Mississippi Valley, Vicksburg, Miss 29 1959

TO: District Engineer, U. S. Army Engr Dist, New Orleans

1 Incl
n/c

G.B.D.

UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
WASHINGTON

October 7, 1959

IN REPLY, PLEASE ADDRESS
CHIEF, U. S. WEATHER BUREAU
WASHINGTON 25, D. C.
AND REFER TO
0-6.12

MEMORANDUM TO CORPS OF ENGINEERS

HUR 7-64

FROM : Hydrometeorological Section

SUBJECT: SPH Wind Fields for Track D with forward speeds of 5 and 15 knots

References: 1. Memorandum from OCE to HMS, 17 August 1959 and Conference at OCE 11-13 August 1959, Subject, New Orleans Hurricane Studies

2. HUR 7-62, SPH Wind Fields for Track C (revised), Critical for North Shore of Lake Pontchartrain, September 8, 1959

This memorandum presents wind directions and speeds according to Standard Project Hurricane criteria for track D, critical for north coast of Grand Isle and Pointe-a-la-Hache as specified in reference [1]. The SPH over-water pattern was rotated 58 degrees ~~counter~~clockwise from the track C direction given in the over-water pattern of reference [2]. Shore line and friction adjustments were made in a similar manner as the procedure used in HUR 7-62. Since the hurricane center crossed the lower Mississippi Delta for only a brief period, no filling adjustment was made and the isovel charts are applicable to both 5 and 15 knot forward speeds, e.g., the -6 hour map with a forward speed of 5 knots is the same as the -2 hour map with a forward speed of 15 knots.

Isovel charts are enclosed at 4 hour intervals for the 5 knot forward speed from -24 hours to -12 hours and at 2 hour intervals from -12 hours to +6 hours (the times are hours before and after the hurricane center crossed the coast).

Also enclosed are a track map and a spiral. The spiral is used for determining wind directions as described in reference [2].

In the map legends, $R_m$ = radius of maximum winds in nautical miles and F. S. = forward speed of hurricane center in knots.

Charles S. Gilman, Chief
Hydrometeorological Section

2 cc with att. to OCE
2 cc with att. to HMS

ENGWE 8 October 1959

SUBJECT: Hurricane Study, Meteorological Criteria, New Orleans District

TO: Division Engineer
U. S. Army Engineer Division, Lower Mississippi Valley
Vicksburg, Mississippi

1. In accordance with paragraph 1b of inclosure #3 of notes on conference held in OCE on 11-13 August 1959, subject, "Hurricane Protection Studies (PL 71), New Orleans District", the Hydrometeorological Section of the Weather Bureau has furnished a memorandum for the meteorological criteria specified therein. Two copies of the memorandum, HUR 7-64, subject, "SPH Wind Fields for Track D with forward speeds of 5 and 15 knots", dated 7 October 1959, are inclosed.

2. Duplicate copies of the memorandum have been furnished the Beach Erosion Board. The remaining data outlined in inclosure #3 of the conference notes will be forwarded as soon as received from the Weather Bureau.

FOR THE CHIEF OF ENGINEERS:

1 Incl (dup)
HMS Memo HUR 7-64, 7 Oct 59

F. B. SLICHTER
Chief, Engineering Division
Civil Works

LMVGK 1st Ind

U. S. Army Engr Div, Lower Mississippi Valley, Vicksburg, Miss. 13 OCT 1959

TO: District Engineer, U. S. Army Engr Dist, New Orleans

1 Incl
n/c

G.B.D.

**UNITED STATES DEPARTMENT OF COMMERCE**
**WEATHER BUREAU**
**WASHINGTON**

September 21, 1959

IN REPLY, PLEASE ADDRESS
CHIEF, U. S. WEATHER BUREAU
WASHINGTON 25, D. C.
AND REFER TO

0-6.12

MEMORANDUM TO CORPS OF ENGINEERS

HUR 7-63

FROM : Hydrometeorological Section

SUBJECT : SPH Wind Fields for Track F with Forward Speed 5 Knots, Critical for Area I (Lake Borgne, Rigolets and south and north shore of Lake Pontchartrain)

References: 1. Memorandum from OCE to HMS, 17 August 1959 and Conference at OCE, 11-13 August 1959, Subject, New Orleans Hurricane Studies.

2. HUR 7-62, SPH Wind Fields for Track C ~~(revised~~) Critical for North Shore of Lake Pontchartrain, September 8, 1959.

This memorandum presents wind directions and speeds according to Standard Project Hurricane criteria for track F, critical for Area I (Lake Borgne, Rigolets and the south and north shore of Lake Pontchartrain) for a forward speed of 5 knots (as specified in reference /1/). The SPH over-water pattern was rotated 18 degrees counter-clockwise from the track C direction given in the over-water pattern of reference /2/. Filling, shore line and friction adjustments were made in a similar manner as the procedure used in HUR 7-62.

Isovel charts are enclosed at 2-hour intervals from -5 hours to +1 hours, at 1-hour intervals from +1 hours to +14 hours and at 2-hour intervals from +14 hours to +18 hours (the times are hours before and after the hurricane center crossed the coast.)

Wind directions at any time and location can be determined from the enclosed spiral which is a copy of the spiral enclosed with HUR 7-62. It is used by placing the "X" mark over the hurricane center and rotating the spiral until it is superimposed upon the point at which the wind direction is desired. The wind direction at this point is tangent to the spiral and blows counter-clockwise around the hurricane center.

In the map legends, $R_M$ ≡ radius of maximum winds and F. S. ≡ forward speed of hurricane center.

Charles S Gilman
Charles S. Gilman, Chief
Hydrometeorological Section

Attachments
cc: 2 to OCE with Att.
2 to BEB with Att.

UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
WASHINGTON

September 28, 1959

IN REPLY, PLEASE ADDRESS
CHIEF, U. S. WEATHER BUREAU
WASHINGTON 25, D. C.
AND REFER TO

0-6.12

TO : Mr. A. L. Cochran, Civil Works
Office of Chief of Engineers
Corps of Engineers

FROM : Hydrometeorological Section

SUBJECT: HUR 7-62A, SPH Wind Field for Track C with a Rotated SPH Pattern

Herewith is transmitted the isovel chart to supplement the track C isovel charts sent under HUR 7-62. This is in response to a conversation between Mr. Nunn of your office and Mr. Goodyear of this office September 10, 1959.

Charles S. Gilman, Chief
Hydrometeorological Section

Attachments

cc: 4 to OCE with attachments

/

UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
WASHINGTON

September 28, 1959

IN REPLY, PLEASE ADDRESS
CHIEF, U. S. WEATHER BUREAU
WASHINGTON 25, D. C.
AND REFER TO

0-6.12

+ 18 HR.
TRACK C

MEMORANDUM TO CORPS OF ENGINEERS

HUR 7-62A

FROM : Hydrometeorological Section

SUBJECT: SPH Wind Field for Track C with a Rotated SPH Pattern

Reference: HUR 7-62, SPH Wind Fields for Track C (revised) Critical for North Shore of Lake Pontchartrain, September 8, 1959

The question has been raised that an orientation of the SPH isovel pattern different from that used in HUR 7-62 might give a stronger onshore wind component along the north shore of Lake Pontchartrain at a later critical time. The enclosed pattern was obtained by rotating the over-water SPH pattern 34 degrees counterclockwise from the orientation of the pattern used with track C (shown on the over-water map of HUR 7-62) and applying filling and friction adjustments.

A comparison of this +18 hour map with the +14 hour (critical time) map from HUR 7-62 indicates a considerably weaker wind field over Lake Pontchartrain on the +18 hour map. The north shore of Lake Pontchartrain has been assumed to extend from A through C as shown on the +18 hour map.

The following general conclusions seem evident:

1. The +14 hour map enclosed with HUR 7-62 gives a larger overall onshore component from A through C.

2. The +18 hour map enclosed with this memorandum gives a smaller overall onshore component with a much smaller component along AB, but with a larger onshore component along BC.

Charles S. Gilman, Chief
Hydrometeorological Section

Attachments

cc: 4 to OCE with attachments

UNITED STATES DEPARTMENT OF COMMERCE

WEATHER BUREAU

WASHINGTON 25

September 8, 1959

IN REPLY, PLEASE ADDRESS
CHIEF OF BUREAU
AND REFER TO

O-6.12

TO : Mr. A. L. Cochran, Civil Works
Office of Chief of Engineers
Corps of Engineers

FROM : Hydrometeorological Section

SUBJECT: MEMORANDUM HUR 7-62, SPH Wind Fields for Track C [redacted])
Critical for North Shore of Lake Pontchartrain

Herewith is transmitted the subject memorandum which furnishes isovel charts for track C of the New Orleans hurricane study.

Charles S. Gilman, Chief
Hydrometeorolgical Section

5 cc with att. to OCE
2 cc with att. to BEB

UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
WASHINGTON 25

September 8, 1959

IN REPLY, PLEASE ADDRESS
CHIEF OF BUREAU
AND REFER TO
0-6.12

MEMORANDUM TO CORPS OF ENGINEERS

HUR 7-62

FROM : Hydrometeorological Section

SUBJECT : SPH Wind Fields for Track C ~~(revised)~~ Critical for North Shore of Lake Pontchartrain

References: 1. Memorandum from OCE to HMS, 17 August 1959, Subject, Hurricane Criteria Required for the New Orleans Hurricane Studies.

2. Conference at OCE, 11-13 August 1959, subject, New Orleans Hurricane Studies.

3. HUR 7-42, Standard Project Hurricane Parameters and Isovels Mid-Gulf Coast U. S., Zone B, October 11, 1957.

4. HUR 7-40, Louisiana Hurricane of September 29, 1915, Transposed to a Critical Track, September 6, 1957.

5. HUR 7-39, Revised Wind Fields Vicinity of Lake Pontchartrain, Hurricane of September 29, 1915.

Isovel Charts

This memorandum presents wind directions and speeds according to Standard Project Hurricane criteria for track C (revised), critical for the north shore of Lake Pontchartrain as outlined in reference /1/. The original track set forth in reference /2/ was revised so that the hurricane passed 10 nautical miles west of the original track when in the vicinity of Lake Pontchartrain. This transposition had the effect of bringing the strongest winds onto the north shore of Lake Pontchartrain at the critical time. No revision was made in the southern part of the track since this alignment gave the strongest easterly winds over Mississippi Sound.

For the forward speed of 5 knots the critical time is +14 to 16 ~~hours~~ (14 hours from the time the hurricane center crosses the coastline). In addition to a track map, isovel maps have been prepared at 2-hour intervals HM 104 from -4 hours to +20 hours and for the hour before and after critical time.

For the forward speed of 15 knots the critical time is +5 hours. A track map and isovel maps from -1 to +9 hours at two hour intervals and for the hour before and after critical time have been prepared.

Wind directions at any time and location can be determined from the enclosed spiral. In accordance with HUR 7-42, reference /3/, the overlays were prepared with an angle of incurvature of 20 degrees out to the radius of maximum winds (30 nautical miles), 20-25 degrees from the radius of maximum winds to 1.2 times the radius of maximum winds (30-36 nautical miles) and 25 degrees incurvature beyond this point. The spiral is made for the 1:458,596 map base. In order to use the spiral, the "X" mark is placed over the hurricane center and the spiral is free to rotate. Rotate the spiral untill the spiral intersects the point from which the wind direction is desired. The wind direction at a given point is then tangent to the curve at that point. HMS 10 Sept. 54

**Basis of Isovel Charts**

1. SPH Pattern. The SPH pattern for a medium speed of translation (10 knots) and a large radius of maximum winds (30 nautical miles) in /3/ is applicable to forward speeds of 5-20 knots as stated in the reference. This pattern is the basis of all isovel charts for both forward speeds. The isovel pattern was aligned so that the radius of maximum winds gave the strongest onshore component at the critical time. A copy of this basic pattern for determining over-water wind speeds where not shown on the other charts is enclosed.

2. Filling adjustment. After the hurricane center crossed the coast, the SPH map was adjusted for filling according to the time adjustment factors given in Table 1 of HUR 7-40 /4/ and explained in HUR 7-39 /5/. Beyond 14 hours the adjustment factors were extrapolated linearly to 20 hours.

3. Shore Line Adjustment. Using topographic maps of the Lake Pontchartrain-Mississippi Delta region and with a knowledge of onshore wind speeds, a rough estimate was made of the land-sea boundary as flooding occurred and this approximate shore line was used to make an adjustment for friction.

4. Friction Adjustment. Winds were reduced due to friction rapidly at the coast to 85% of the over-water speed for wooded and built-up areas and 95% for marshy areas. Greater reductions were used farther inland. A similar procedure was used for constructing land-to-water transition zones.

95%

In the map legends, $R_m$ = radius of maximum winds and c = forward speed of hurricane.

Note: Spiral sld

Charles S. Gilman, Chief
Hydrometeorological Section

3 with att. to OCE
2 to BRB

UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
WASHINGTON

November 15, 1961

IN REPLY, PLEASE ADDRESS
CHIEF, U. S. WEATHER BUREAU
WASHINGTON 25, D. C.
AND REFER TO

O-6.12

TO : Mr. A. L. Cochran, Civil Works
Office of Chief of Engineers
Corps of Engineers

FROM : Hydrometeorological Section

SUBJECT: Memorandum HUR 7-61a, "Relationships Between SPH Isovel Patterns and Probable Maximum Events for the New Orleans Area, continued"

The reference memorandum is transmitted, discussing the question of effect of recent hurricanes on probable maximum hurricane intensity guidelines.

Vance A. Myers
Chief, Hydrometeorological Section

cc: 2 to OCE

UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
WASHINGTON

November 15, 1961

IN REPLY, PLEASE ADDRESS
CHIEF, U. S. WEATHER BUREAU
WASHINGTON 25, D. C.
AND REFER TO

0-6.12

MEMORANDUM TO CORPS OF ENGINEERS

HUR 7-61a

FROM : Hydrometeorological Section

SUBJECT : "Relationships Between SPH Isovel Patterns and Probable Maximum Events for the New Orleans Area, continued"

References: (1) HUR 7-61, "Relationships Between SPH Isovel Patterns and Probable Maximum Events for the New Orleans Area"

(2) NHRP Report No. 33, "Meteorological Considerations Pertinent to Standard Project Hurricane, Atlantic and Gulf Coasts of the United States"

"Carla", 1961, was reported to be one of the largest and most severe of hurricanes to hit the Gulf Coast area during the last several decades. The question has been raised whether this storm calls for any changes in probable maximum hurricane criteria in reference (1).

Pressure

"Carla" had a central pressure of 27.50 inches just before entering the coast near Port O'Connor, Texas. Extrapolating this value from its point of occurrence to the latitude of New Orleans, using figure 4-B of HUR 2-1 yields a central pressure index of 27.72 inches, considerably higher than the 26.90 inches proposed for the PMH at this latitude in reference (1).

Wind

Two opposing considerations apply.

The wind in a probable maximum hurricane is derived primarily from the CPI, using empirical relations from past large storms. The three most recent severe hurricanes in the Gulf of Mexico, Carla, Donna of 1960 on the west coast of Florida, and Audrey of 1957 in Texas-Louisiana, all appear to have had somewhat stronger maximum sustained windspeeds in comparison with their respective CPI's than relations previously used would call for. All were moving at moderate forward speeds.

Only a preliminary appraisal of readily available data has been made for Donna and Carla, but it seems likely that analysis of these two severe storms will call for some increase in winds to be expected for a given CPI for severe hurricanes in the Gulf region. Tentatively, a factor of 1.25 is proposed to convert the moderate speed of translation SPH wind patterns of reference (2) and previous memoranda to PMH, instead of 1.14.

The other consideration relates to the effect of speed of forward motion on a PMH. In reference (2) and previous memoranda speeds on the right-hand side of the track are increased by approximately one-half the speed of forward motion for fast-moving SPH's. This increase is not considered fully applicable to probable maximum hurricanes, as increasing forward motion yields little or no increase in energy available to produce wind. The moderate-speed-SPH X 1.25 wind field proposed above applies to a PMH of any forward speed.

(If the old factor of 1.14 has been applied to high speed of translation SPH patterns, this also yields a pattern representative of PMH on the more severe side of the storm, being of about the same intensity as the wind pattern proposed above).

## Conclusion

No change in CPI for probable maximum hurricane. Tentatively increase factor to convert SPH winds of NHRP Report No. 33 to probable maximum level to 1.25, but apply to moderate speed of translation SPH patterns only.

Vance A. Myers
Chief, Hydrometeorological Section

cc: 2 to OCE

UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
WASHINGTON 25

August 21, 1959

IN REPLY, PLEASE ADDRESS
CHIEF OF BUREAU
AND REFER TO

0-6.12

TO : Mr. A. L. Cochran, Civil Works
Office of Chief of Engineers
Corps of Engineers

FROM : Hydrometeorological Section

SUBJECT: Memorandum HUR 7-61, dated August 21, 1959, Relationships Between SPH Isovel Patterns and Probable Maximum Events for the New Orleans Area

Reference: OCE Memorandum, August 17, 1959, Hurricane Criteria for the New Orleans Hurricane Studies.

Enclosed is the subject memorandum which deals with some considerations regarding the characteristics of a Probable Maximum Hurricane (PMH) at the latitude and zone of coastal Louisiana and coefficients for converting the generalized SPH to a PMH.

Charles S. Gilman, Chief
Hydrometeorological Section

Attachments

cc: 5 with att. to OCE
2 with att. to BEB

UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
WASHINGTON

August 21, 1959

IN REPLY, PLEASE ADDRESS
CHIEF, U. S. WEATHER BUREAU
WASHINGTON 25, D. C.
AND REFER TO

0-6.12

MEMORANDUM TO CORPS OF ENGINEERS

HUR 7-61

FROM : Hydrometeorological Section

SUBJECT : Relationships Between SPH Isovel Patterns and Probable Maximum Events for the New Orleans Area

References: (1) HMS Memorandum HUR 7-59, March 3, 1959, Relationships between SPH Isovel Patterns and Probable Maximum Events for Lower New England Area.

(2) Corps of Engineers, Jacksonville District Partial Definite Project Report, Central and Southern Florida Project for Flood Control and Other Purposes, Part IV, Lake Okeechobee and Outlets, Section 2--Design Memorandum, Hurricane Winds over Lake Okeechobee.

* (3) HMS Memorandum HUR 2-1, June 18, 1957, Frequency of Central Pressure Indices along Atlantic Coast.

(4) R. H. Simpson, "Exploring the Eye of Typhoon Marge 1951", Bulletin of the American Meteorological Society, vol. 33, No. 7, September 1952.

* (5) HMS Memorandum HUR 2-1, June 18, 1957, Frequency of Central Pressure Indices along Atlantic Coast.

(6) HMS Memorandum HUR 7-42, October 11, 1957, Standard Project Hurricane Parameters and Isovels, Mid-Gulf Coast U. S., Zone B, and Standard Project Hurricane, Lake Pontchartrain.

The Probable Maximum Hurricane (PMH) discussed here is conceived as a storm possessing a combination of characteristics that will produce the physical maximum water height (surge) superimposed on the astronomical tide. These characteristics are then related to those of the SPH already developed for Zone B (reference [ 6 ]).

The parameters that determine surge height are essentially of two types, physiographic and meteorologic, and only the latter will be discussed here. Since the optimum forward speed of a PMH is dependent on physiographic factors, a range of forward speeds is given.

The approach in determining the PMH characteristics here is similar to that in Memorandum HUR 7-59. All "quotes", therefore, refer to HUR 7-59.

Physical considerations

> Kinetic energy. "The kinetic energy of the winds in a hurricane is produced by air flowing across the isobars toward lower pressure. In order that the total kinetic energy in the air column making up the hurricane may remain constant against the dissipating effects of friction, or increase, there must be ascending air that is warmer than the volume-compensating descending air. Ordinarily, in the atmosphere, an ascending current becomes colder than its surroundings and a descending current becomes warmer than its surroundings. This condition tends to inhibit the development of kinetic energy in the absence of a pre-existing horizontal temperature difference."

The exception to this general rule occurs when the lower layers are very warm and moist and the upper layers relatively cool. The release of latent heat when the lower air rises compensates for the adiabatic cooling enough to insure that it remain warmer than the sinking air, thus giving a kinetic-energy-producing system. The atmosphere is then referred to as being convectively unstable.

Because the sea surface is most effective as a heat source from June through October, the convective instability is most pronounced during this season. The strength of the effective heat source depends on sea-surface temperature and insolation, relatively fixed factors. The development of extreme instability is inhibited by the dissipative action of local convection and this action, in turn, depends, in part, on fixed physical properties of the air.

> "Therefore the maximum convective instability that could accumulate and be available to drive a great hurricane of the maximum probable category is not extraordinarily in excess of what must have been present for severe past hurricanes.

> Central pressure. Apparently, the one most significant characteristic of a hurricane is its central pressure, and many empirical relations between this and other characteristics of the hurricane (at least in its mature stages) have been devised. Taken together with pressures around the periphery of the storm the central pressure sets a limit on how much kinetic energy can be concentrated in an area; as the storm moves away from the Tropics, and consequently farther from a good source of warm moist air, the central pressure rises somewhat and the radius of maximum wind may increase.

We may estimate the lowest probable $p_o$ for a hurricane in the Tropics on the basis of simple hydrostatic reasoning, using certain assumptions of maximization and utilizing the idea of subsidence in the eye."

Hydrostatic computation. Assume a hurricane extending to the 100-mb level (a mean height of 54,410 feet in August), with a surface temperature of 78°F, saturated. Assume now a condition in which this saturated air rises moist adiabatically around the eye to the 100-mb level. Air at the 100-mb level having the same temperature as the air brought up moist adiabatically from the surface descends dry adiabatically in the eye. The vertical temperature distribution is now such that hydrostatic computations show a surface pressure of 25.50 inches of mercury.

Limitations. Certain physical limitations which militate against such an extreme low pressure as described above are immediately apparent: (1) ascents and descents of air are less complete and clear-cut than was assumed in the above example. For example, studies in actual hurricanes made by Palmen (1948) indicate that air at the 400-mb level in the eye appears to have descended from the 200 mb while lower down the vertical displacements are even smaller; (2) any process which assumes large amounts of descending air must of necessity be an energy-consuming process. These limitations suggest that a central pressure of 25.50 inches is probably below the lowest likely to occur.

The lowest pressure ever recorded (in a typhoon) was 26.185 inches. There is no reason to suppose this was the lowest that nature could possibly produce. It is concluded, therefore, that a value near 26.00" is typical for the PMH value in the Tropics."

## Statistical considerations

Points of reference. The following references and actual occurrences must also be considered in a discussion of the PMH for the New Orleans Zone: (1) PMH for Lake Okeechobee, reference [2]; (2) Generalized SPH studies, reference [6]; (3) minimum pressure of 26.35 inches in the Florida Keys storm of September 2, 1935; (4) lowest sea-level pressure ever observed of 26.185 inches on August 18, 1927, 460 miles east of Luzon, near 16°N; and (5) minimum pressure of 26.43 inches in a mature typhoon near 20°N, 135°E, in August 1951, reference [4].

Extrapolation of tropical central pressures northward. One method of estimating the central pressure for a PMH at the New Orleans Zone is to extrapolate northward to the 29°N latitude the lowest central pressures observed in the various tropical hurricanes mentioned in the preceding paragraph. This extrapolation is accomplished using figure 4-B of

HUR 2-1 (reference [3]). This extrapolation yields a lowest central pressure of 27.10 inches at 29°N.

The Pacific typhoons and physical considerations just discussed suggest the possibility that a lower value is reasonable. Similar extrapolation yields a lowest value of about 27.00 inches.

Further considerations. Meteorologically, the entire Gulf of Mexico may be said to be in the Tropics during a great part of the hurricane season. By this we mean that the air and water surface have essentially the same characteristics as, say, the Caribbean. One might then ask, "What is the probability of an occurrence such as that of the 1935 Florida Keys (central pressure = 26.35 inches) at coastal Louisiana?"

Figure 1, appended, shows plots, by rank, of all the available central pressures at the coast lines of hurricanes that entered the coast in Florida (line F) and anywhere in U. S. coastal Gulf (line G). Only central pressures of 28.50 inches and below are shown. The straight lines have been fitted by eye to the data--(the Florida Key hurricane, point A, not considered in drawing the straight line for F).

Assume that if a storm such as the Labor Day Hurricane were to occur on the Louisiana Coast it would occupy the same relative position to the left end of line G as A (the Labor Day case) has to line F. This leads to a value of about 26.80 inches.

This higher value for an extreme case is meteorologically and physiographically reasonable; storms along the northern Gulf are more subject to the effects of drier air from the continent and to the effects of upper troughs moving in from the north and west.

On September 21, 1934, a minimum central pressure of 26.93 inches was recorded in a typhoon that hit Japan near 33°N latitude. Again, we are forced to assume that any value of central pressure that has occurred at 33°N latitude could also occur to the south, at 29°N latitude.

Choice of PMH central pressure. The Labor Day Hurricane in the Florida Keys is so far out of line from the rest of the data that its probability of occurrence is very likely no better than once in a thousand years. Therefore the value of 26.80 inches at the Louisiana Coast is not suggested in the PMH considerations unless an extremely low probability value is desired.

The other considerations discussed, plus the case at 33°N mentioned above, yield a lowest value of 26.90 inches (assuming nature is capable of a value slightly lower than has ever occurred, taking latitude and other factors into consideration).

This central pressure would yield wind speeds that are about 114% of the SPH wind speeds.

> Radius of maximum winds. "Work done in examining hurricane characteristics to determine generalized criteria for the SPH indicates some tendency for the lower central pressures to be associated with smaller radii of maximum winds. This tendency is too slight to be a reliable guide in PMH criteria. The radius of maximum wind for the PMH should be the same as or slightly larger than that of the large radius SPH."

Forward speed. Forward speeds from about 5 to 30 or 35 knots are acceptable for the PMH. Speeds above this would imply inflow conditions resulting in higher central pressures.

Conclusions. It is considered that the most reasonable coefficient to convert the SPH isovels to an MPH event is 114%. For example, the 100 mph SPH isovel becomes 114 mph, etc.

For the radius of maximum winds, it is suggested that a value equal to, or slightly larger than, that of the SPH be used.

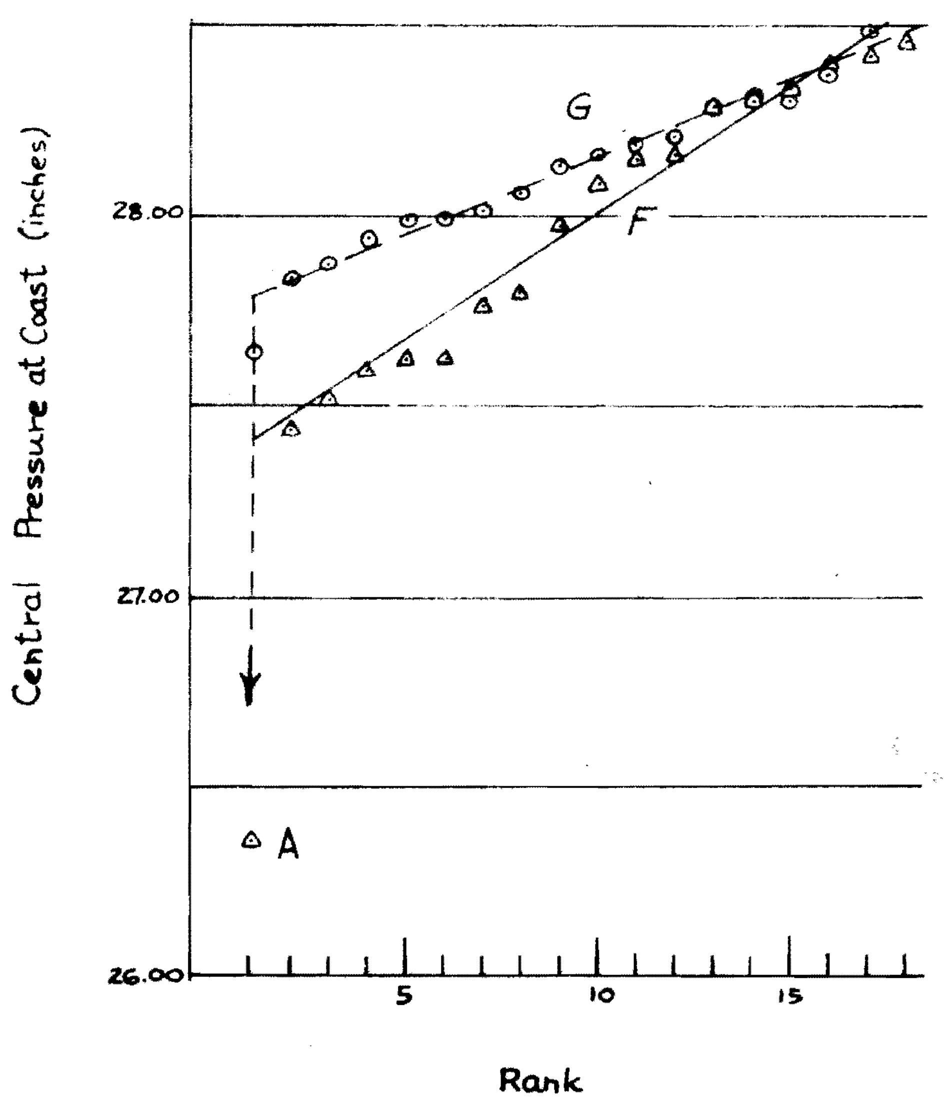
Any forward speed of translation between 5 and 35 knots is meteorologically acceptable.

Charles S. Gilman, Chief
Hydrometeorological Section

Attachments

cc: 5 with att. to OCE
2 with att. to BEB

Fig. 1. Graph of rank of central pressures at coast for hurricanes less than 28.50 inches (1890 - 1957) for Florida (F) and Gulf Coast (G).



Lulu

UNITED STATES DEPARTMENT OF COMMERCE

WEATHER BUREAU

WASHINGTON

June 19, 1958

IN REPLY, PLEASE ADDRESS
CHIEF, U. S. WEATHER BUREAU
WASHINGTON 25, D. C.
AND REFER TO

0-6.12

MEMORANDUM TO THE CORPS OF ENGINEERS

HUR 7-53

FROM : Hydrometeorological Section

SUBJECT : Pressure and Winds over the Gulf of Mexico in Hurricane Flossy, September 23-24, 1956

REFERENCE: OCE Memorandum, March 17, 1958

Introduction

This study of wind and pressures in the hurricane, as it approached and crossed the Mississippi River Delta during the period from 1800 CST September 23 to 1230 CST September 24, 1956, was made as an aid in computing storm surge hydrographs along the mid-Gulf coast.

Track

The track of Hurricane Flossy on September 23 and 24, 1956 with hourly positions of the center indicated is shown in figure 1. The storm moved off the Yucatan Peninsula into the Gulf of Mexico on September 22. It moved northward across the Gulf during the 23rd then recurved to the northeast just off the Louisiana coast. The center crossed the Mississippi River Delta between Buras and Burrwood, La. between 0300 CST and 0600 CST September 24. Continuing northeastward, the center moved inland near Valparaiso, Fla. about 1700 CST September 24.

Pressure

Central pressure. The storm deepened slowly as it moved northward across the Gulf of Mexico. At about 1600 CST September 23 when the storm was centered 130 nautical miles south of New Orleans, La., a reconnaissance flight reported a central pressure of 29.06 inches. On the early morning of the 24th at the time the hurricane center moved across the Mississippi Delta, the central pressure was computed to be near 28.80 inches. This value was based on the minimum pressure of 29.03 inches reported at Burrwood as the center passed to the north of the station, and a pressure observation of 28.94 inches from a ship that passed within the eye of the storm about 0900 CST September 24. Later on the 24th, aircraft reconnaissance reported a minimum pressure of 28.76 inches when the storm was centered just off Pensacola, Fla. At 1725 CST when the center was crossing the coast, a dredge within the eye at Destin, Fla. also observed a minimum pressure of 28.76 inches.

Asymmetry of the pressure field. The pressure distribution around the hurricane was asymmetrical. The strongest pressure gradient near the center, but beyond the radius of maximum wind, was in the forward sector. The pressure gradient was weakest south of the center. In the right sector of the storm, at a distance of 100 miles from the center and beyond, the pressure gradient was greater than the gradients that occurred at this distance in the other directions (figure 2). The proximity of the subtropical High to the northeast probably contributed to the larger pressure gradient in this sector at a distance from the center.

Pressure profiles. Figure 2 shows pressure profiles in the forward sector of the storm at 1830 CST September 23 using the reconnaissance observation of 29.06 inches at 1600 CST as the minimum pressure and for the period from 0000 CST to 0930 CST September 24 when the storm had deepened and developed hurricane force winds. Beyond 35 miles from the center the two visually-fitted curves correspond well to pressure profiles derived from an exponential formula indicated by dashed lines. Ships observations of pressure in each quadrant for the period from 1200 CST September 23 to 0000 CST September 24 when the storm was moving north to northeastward are plotted in figure 2 to indicate the difference in the pressure distribution in the right sector from the distribution in the forward sector. Observations at Burrwood and New Orleans are also plotted on the chart. A curve has been visually fitted to the observations in the right sector to indicate the probable average slope of the pressure profile in that sector.

Wind

Data. Isovel patterns were constructed from ship observations of wind speed, wind speeds observed at coastal stations and adjusted to 30-ft over-water speeds, and over-water wind speed profiles computed from pressure profiles in the forward sector of the storm.

Composite wind speed chart. To determine the features of the wind field that persisted over a period of time for use with the wind speeds reported at 3-hourly intervals by the ships and coastal stations, a composite chart of wind observations was constructed and analyzed (figure 3). A number of ship reports and wind speeds observed at coastal stations and adjusted to 30-ft over-water speeds for the period from 1200 CST September 23 to 1230 September 24 were plotted showing the position of the observation from the storm center in relation to the direction of forward motion. Isovels were drawn to the data with extra weight being given to the observations made at 0000 CST September 24 and later.

Considerable smoothing was necessary in analyzing the ship reports because large variations in speed were frequently reported within a small area. These variations may have resulted from squalls in the area which affected only part of the ships, from observers overestimating or underestimating the wind speed, differences in the actual times of the observations, and transmittal errors.

The maximum isovels in the right side of the storm were based largely on the autographic wind speed records at Burrwood, La. In the left sector, the maximum isovels where the data were lacking are based on 30-ft over-water speeds computed from pressures, (figure 4). The 0000-0930 CST September 24 mean pressure profile in the forward sector (figure 2) was used for this purpose.

Wind speed distribution. The composite wind speed pattern (figure 3) is quite asymmetrical. Speeds are considerably higher at about 100 miles from the center in the right sector than for the same distance in other directions. An inspection of weather charts for the period suggests that the storm circulation in this sector was reinforced by the sub-tropical High. As a qualitative check on the validity of the wind speed observations in the right sector, gradient wind speeds for that sector were computed. The computed speeds in the right sector remained higher than the computed speeds in the forward sector beyond 60 miles from the center over the distances compared. Both the stronger pressure gradient and the larger radius of curvature of air parcels in that sector would lead to higher wind speeds.

## Deflection angle

A composite wind deflection angle (the angle between the wind direction and a tangent to a circle about the center) pattern over open water was prepared from a plot of deflection angles from ship reports at 1200 CST, 1800 CST September 23, 0000 CST and 0600 CST September 24 and from reports from Burrwood, La. from 1800 CST September 23 to 0200 CST September 24 (figure 5). The chart is aligned to the north. Near the radius of maximum wind deflection angles of 20° were assumed because of a limited number of reports. The deflection angle chart is not applicable in the northern portion of the hurricane north of 29° 30'N latitude just off the Mississippi, Alabama and northwestern Florida coast. Deflection angles in that portion of the storm were near 90 degrees.

## Isovel charts

Isovel charts at 3-hourly intervals were constructed for the period from 1830 CST September 23 to 1230 CST September 24 (figures 6-12). Where observations were available, isovels were drawn to the observed speeds. This analysis was then compared to the composite wind speed pattern (figure 3) for consistency and for aid in constructing the isovels where there were no observations. The wind speed profile computed from the pressure profile at 1830 CST September 23 in the forward sector of the storm (figure 4) was used to construct the isovels near the radius of maximum winds at that time. The isovel pattern at 2130 CST September 23 was interpolated between the 1830 CST pattern and the 0030 CST September 24 pattern. At 0330 CST and 0930 CST September 24 when little or no ship observations were available, the composite wind speed chart adjusted for coastal observations and for continuity with adjacent patterns was used to construct the isovel pattern over the Gulf.

Wind direction south of latitude 29°30' are determined from the deflection angle chart (figure 5). Wind directions in the Gulf north of latitude 29°30' were determined by streamline analysis of observed wind directions. These derived wind directions are indicated by heavy arrows on the isovel charts.

Observations at coastal stations were taken on the half hour and ship observations were made on the hour. The position of the hurricane center is indicated at the half hour on the isovel charts, figures 6-12. This difference in the time of the ship observation and the chart time caused the ship observations plotted on the isovel chart to be displaced about five miles (the average forward speed of the storm was 10 knots) from the center. Because of the few observations near the center this displacement is not considered significant. All data shown in the composite chart and the pressure profiles were plotted relative to the distance of the observation point from the center at the time of observation.

Table 1

**PARAMETERS OF THE SEPTEMBER 24, 1956 HURRICANE NEAR BURRWOOD, LA.**

$P_o$, Central pressure (inches), 28.80*

$P_n$, Asymptotic pressure (inches), 29.97*

$V_{gx}$, Maximum gradient wind (mph), 74**

R, Radius of maximum winds (nautical miles)

| | |
|---|---|
| | Computed 30* |
| | Observed 22 |
| C, 4-Hour average forward speed at the Coast (knots) | 10 |

<u>At Burrwood, La</u>.

Lowest observed pressure (inches), 29.03

Minimum distance from station to storm track (nautical miles), 17

*Computed from the exponential profile based on the best fit of the following formula to the data

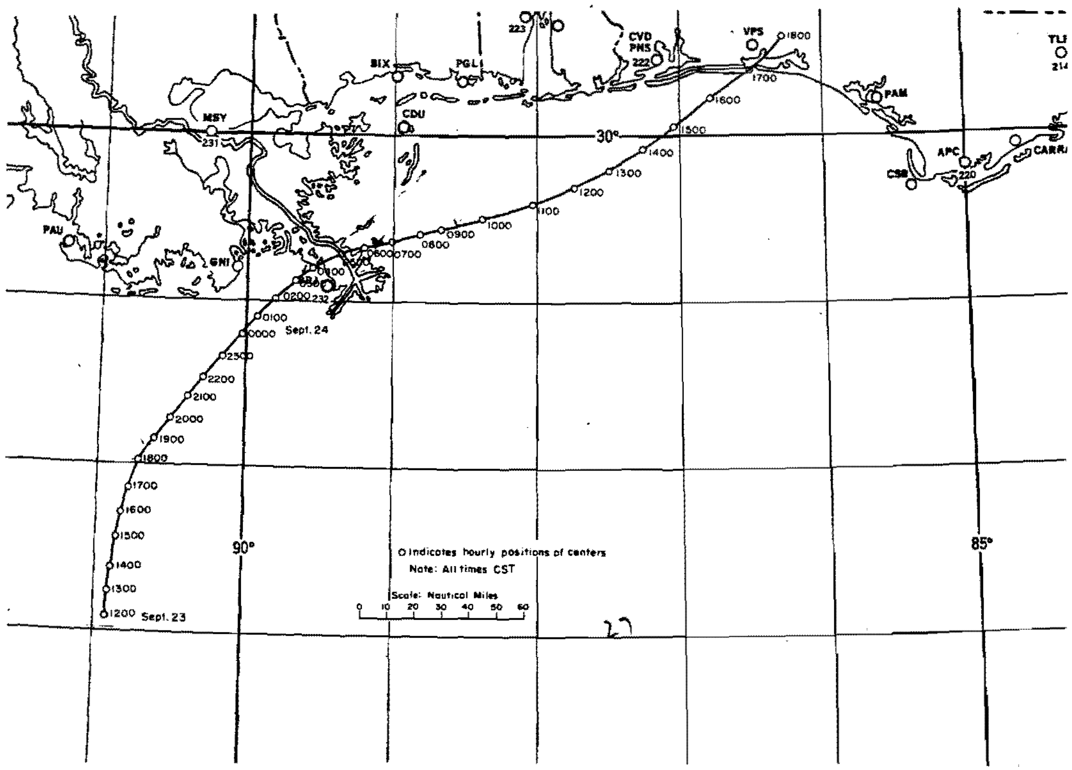
$$\frac{P - P_o}{P_n - P_o} = 0^{-R/r}$$

where P is the pressure at radius r, R the radius of maximum winds, $P_o$ the central pressure, and $P_n$ the asymptotic pressure.

**Theoretical friction-free wind speed at R.

Vance A. Myers
for Charles S. Gilman, Chief
Hydrometeorological Section

Copies
10 to OCE
1 to BEB




27

**Figure 1.** <u>TRACK OF HURRICANE FLOSSY</u>

SEPTEMBER 23-24, 1956

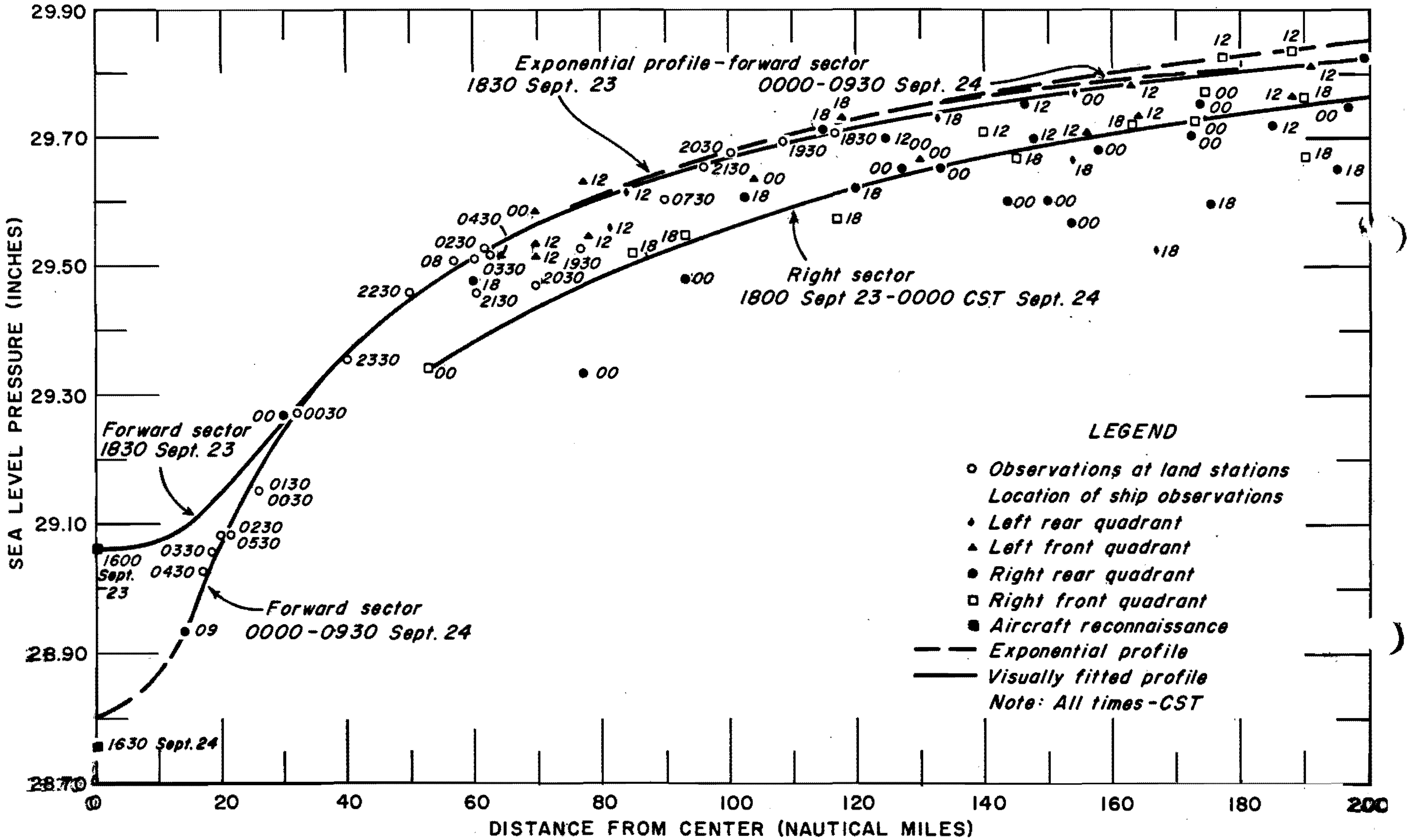


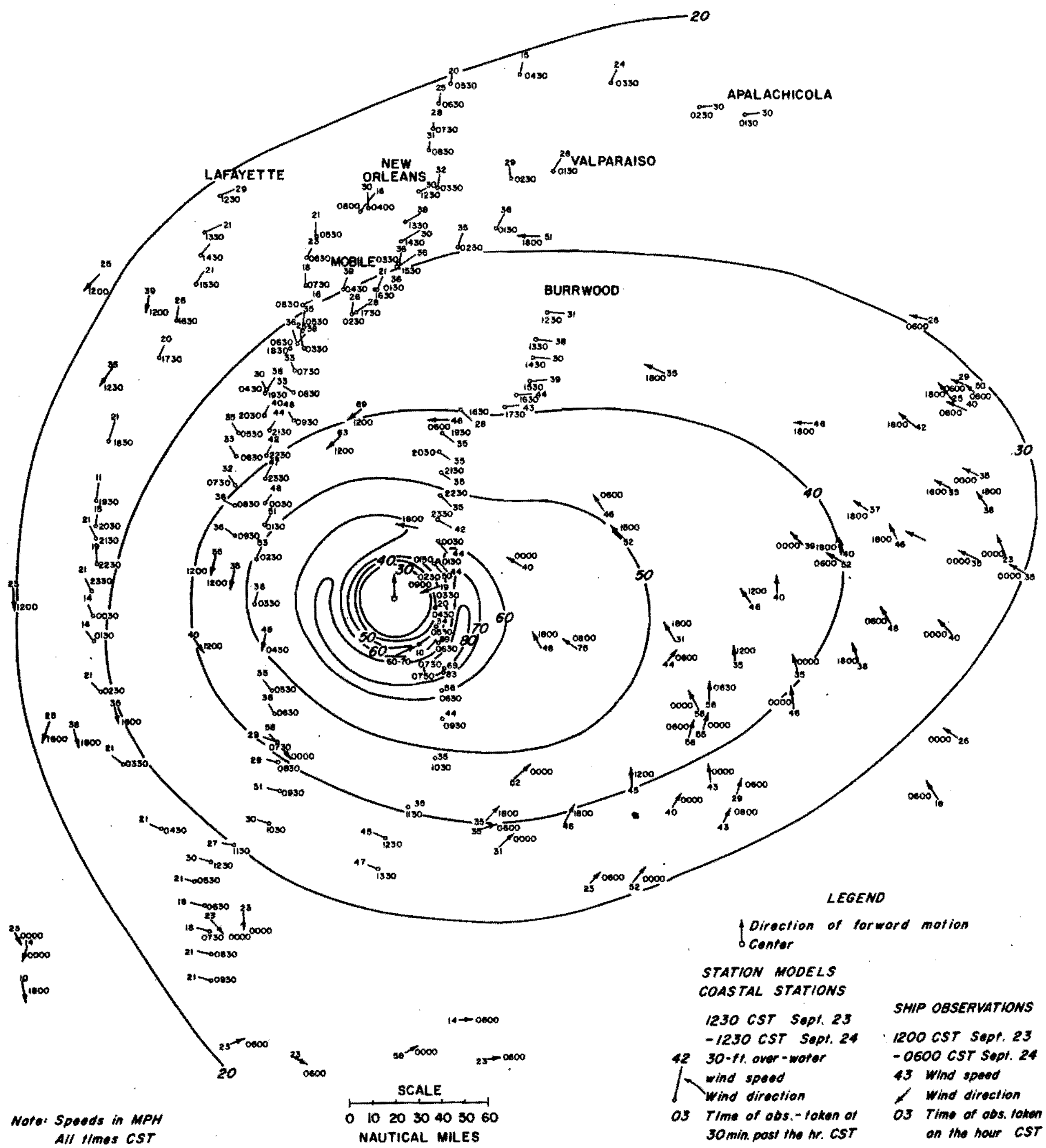

**Figure 2**

**PRESSURE PROFILES IN THE FORWARD AND RIGHT SECTORS OF HURRICANE FLOSSY**

**SEPTEMBER 23-24, 1956**

**Figure 3. COMPOSITE WIND-SPEED PATTERN**
**HURRICANE FLOSSY**

**1230 CST SEPTEMBER 23-**
**1230 CST SEPTEMBER 24, 1956**



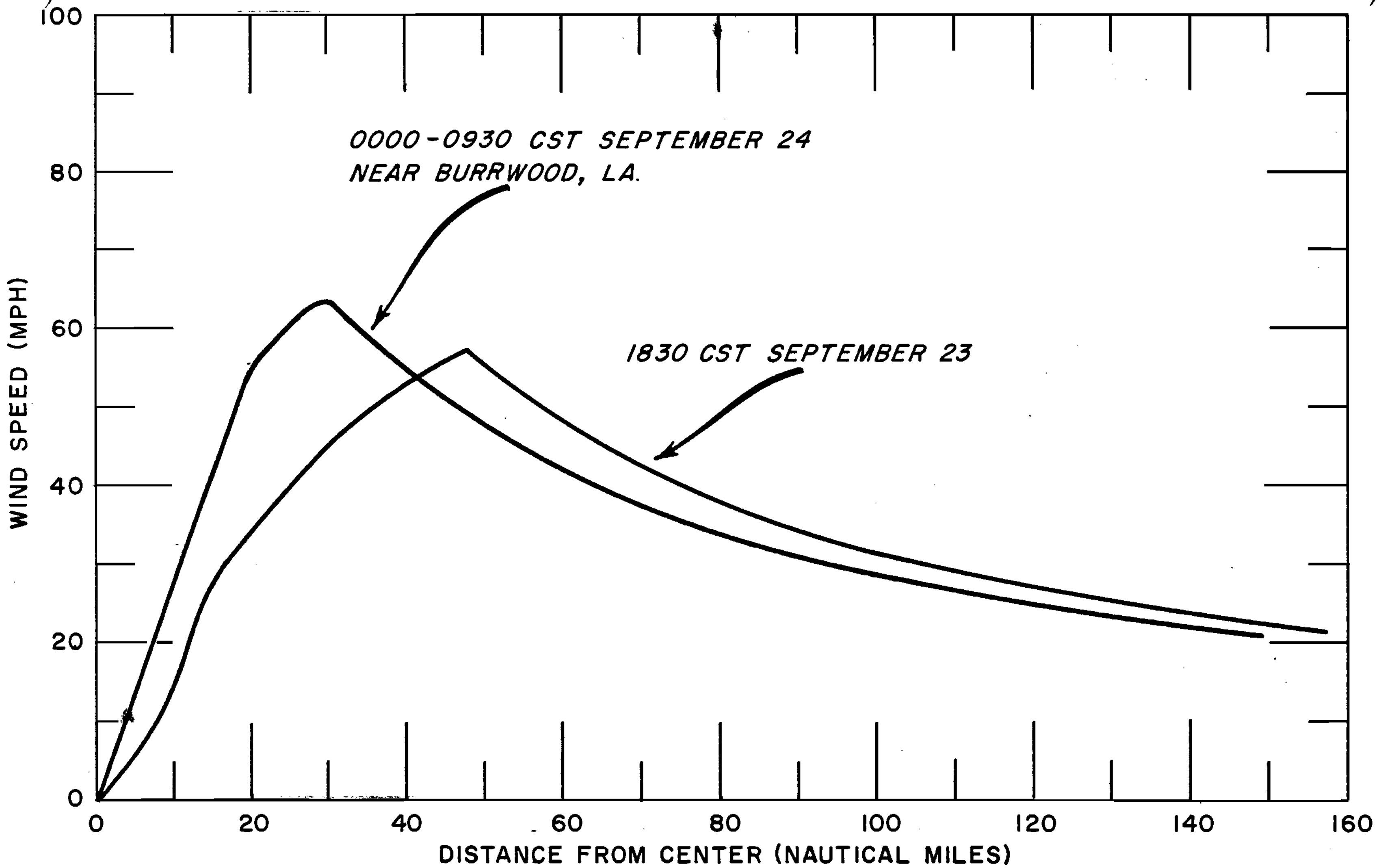



Figure 4. COMPUTED 30-FT OVER-WATER WIND SPEED PROFILES FORWARD SECTOR
HURRICANE FLOSSY

SEPTEMBER 23-24, 1956

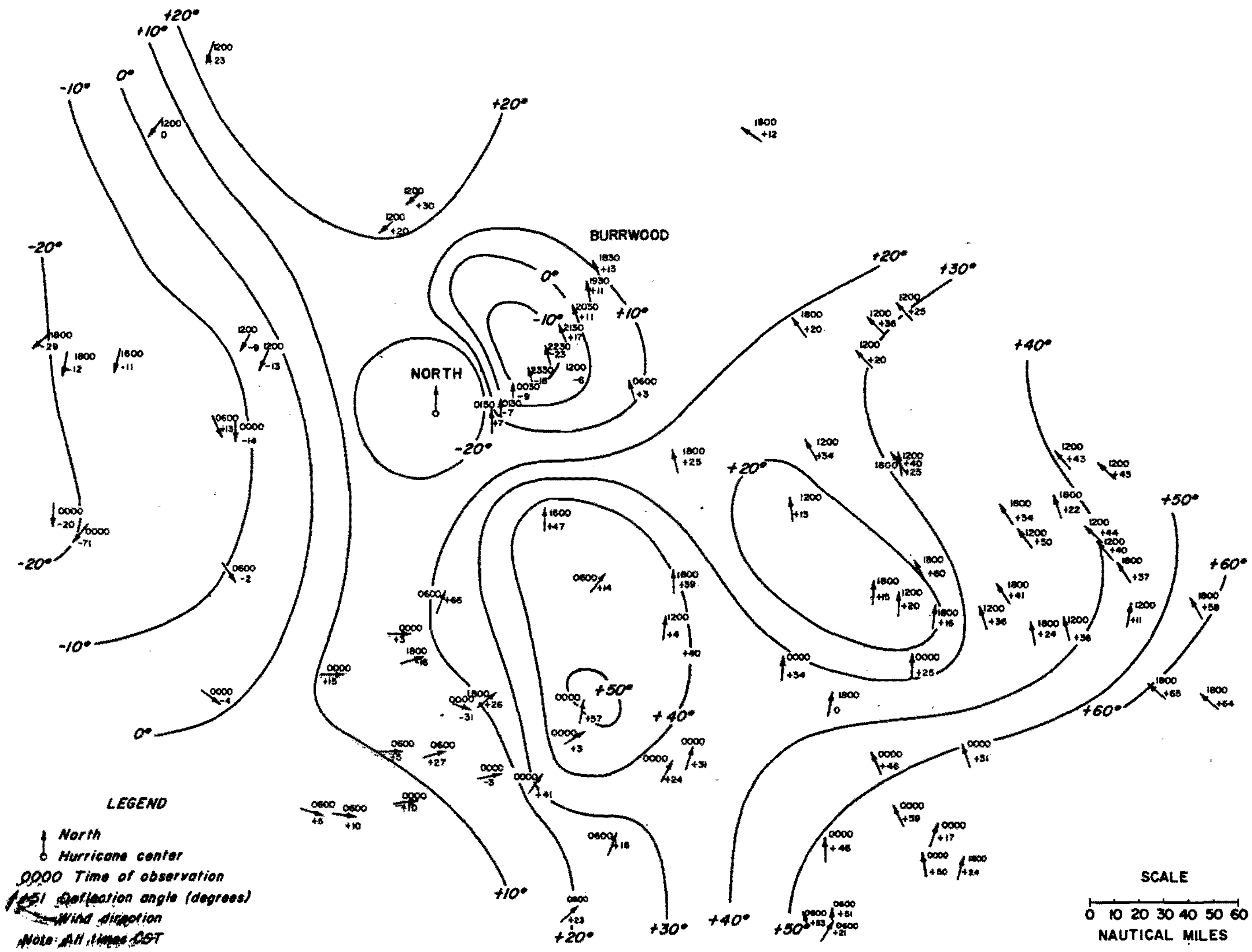


Figure 5. WIND DEFLECTION ANGLES SOUTH OF LATITUDE 29°30'N
HURRICANE FLOSSY

1830 CST SEPTEMBER 23 to
1230 CST SEPTEMBER 24, 1956

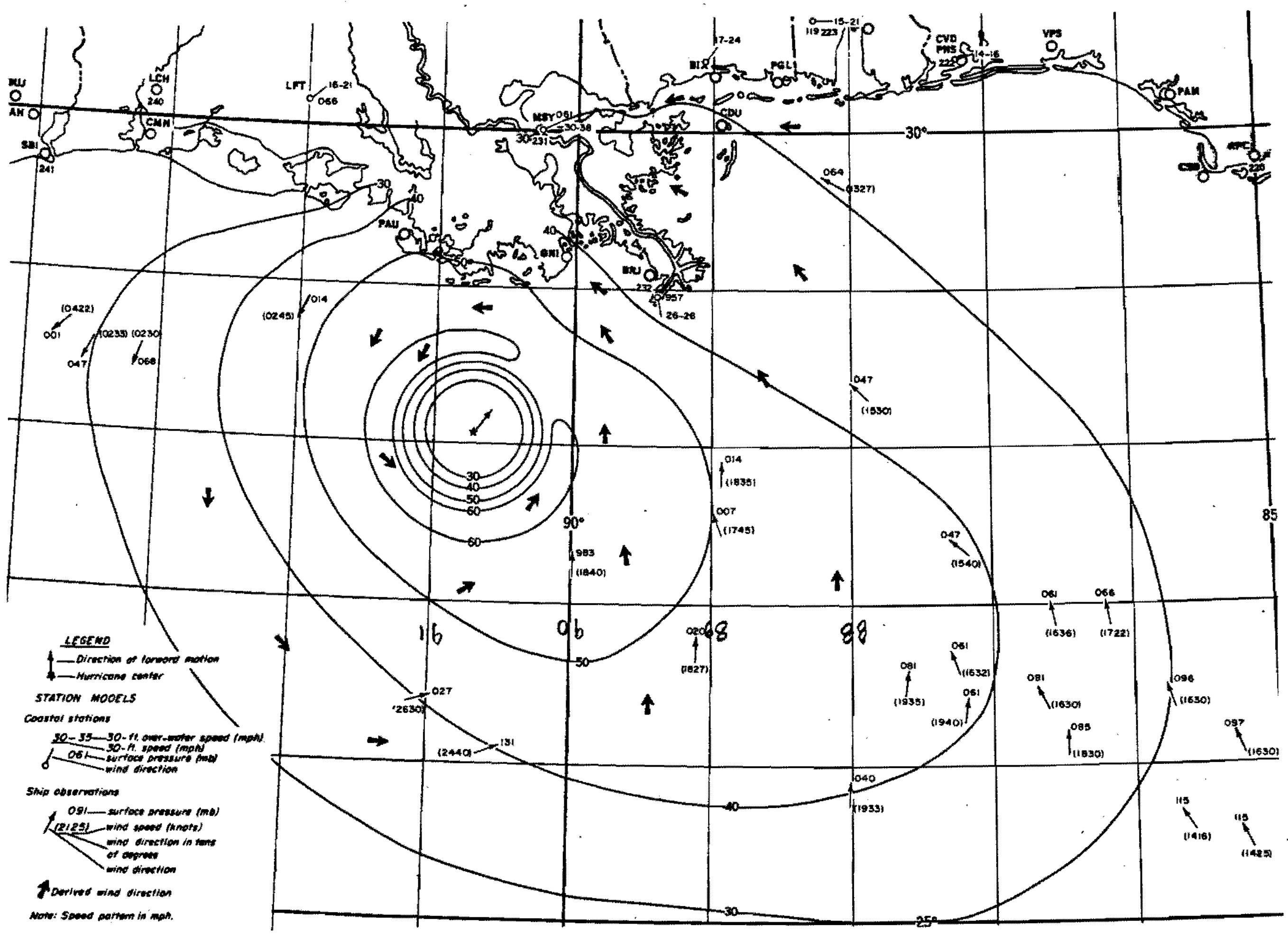



Figure 6. ESTIMATED 30-FT WIND SPEED AND DIRECTION
HURRICANE FLOSSY

1830 CST SEPTEMBER 23, 1956

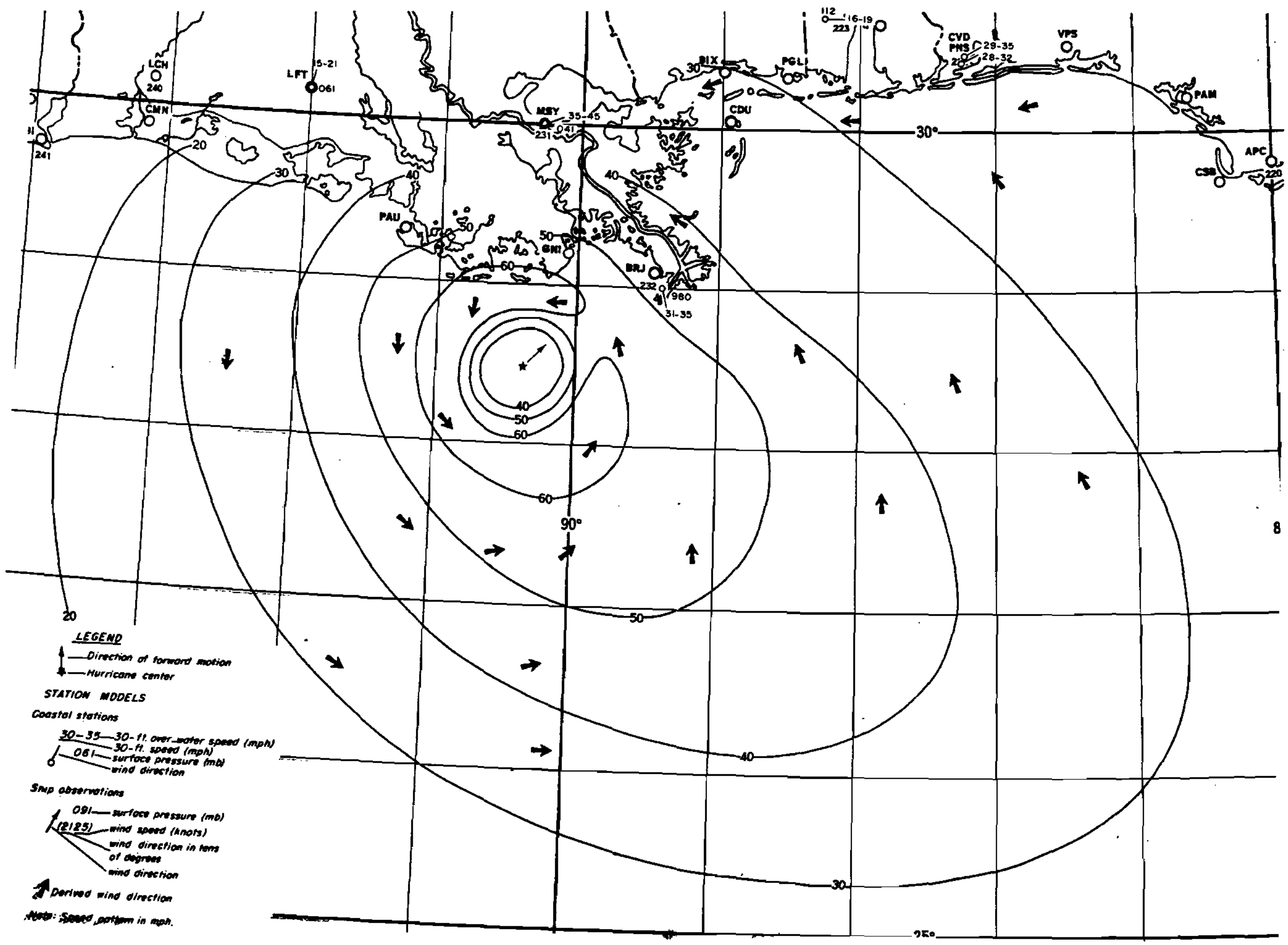



Figure 7. ESTIMATED 30-FT WIND SPEED AND DIRECTION
HURRICANE FLOSSY

2130 CST SEPTEMBER 23, 1956

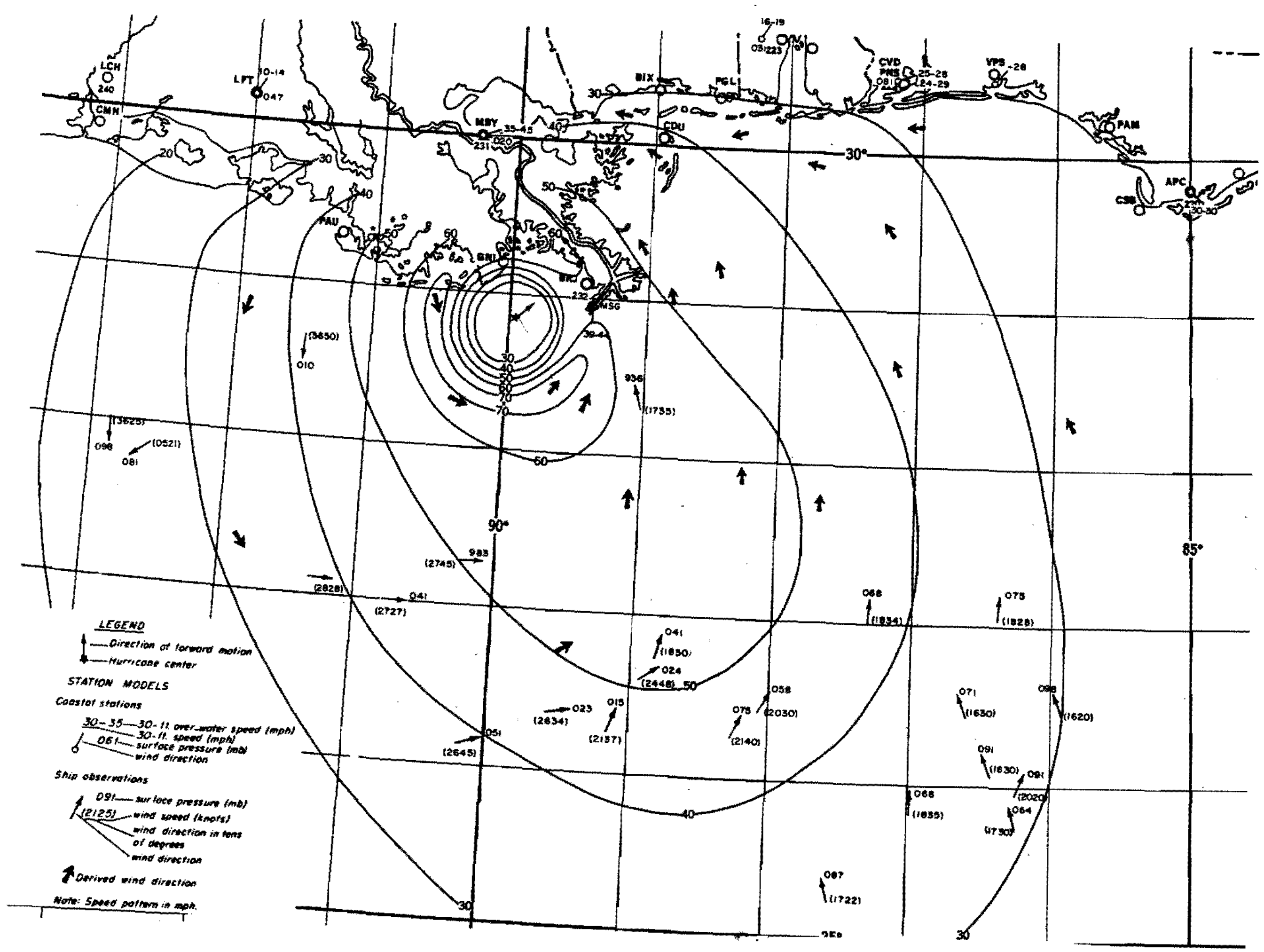



Figure 8. ESTIMATED 30-FT WIND SPEED AND DIRECTION
HURRICANE FLOSSY

0030 CST SEPTEMBER 24, 1956

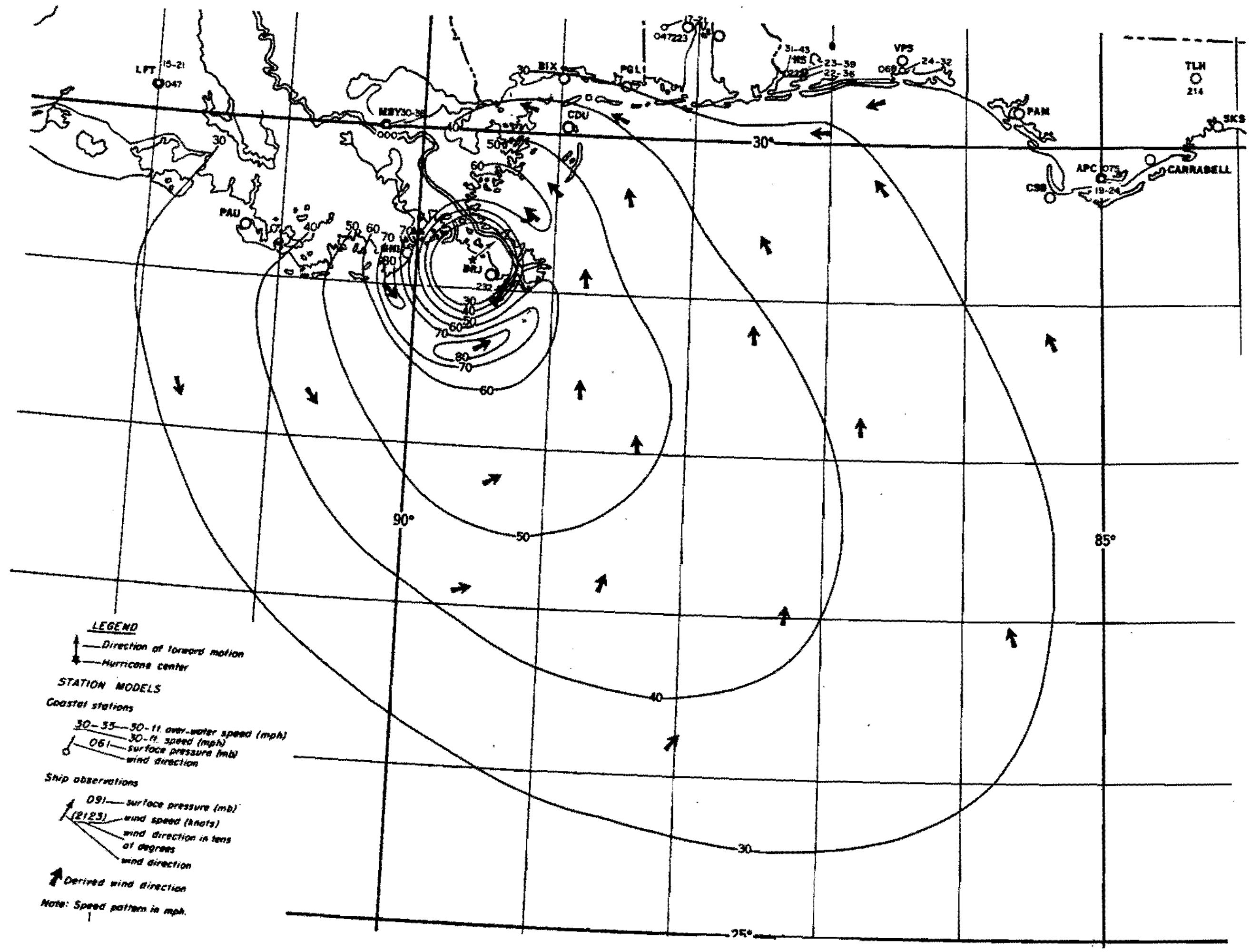



Figure 9. ESTIMATED 30-FT WIND SPEED AND DIRECTION
HURRICANE FLOSSY

0330 CST SEPTEMBER 24, 1956

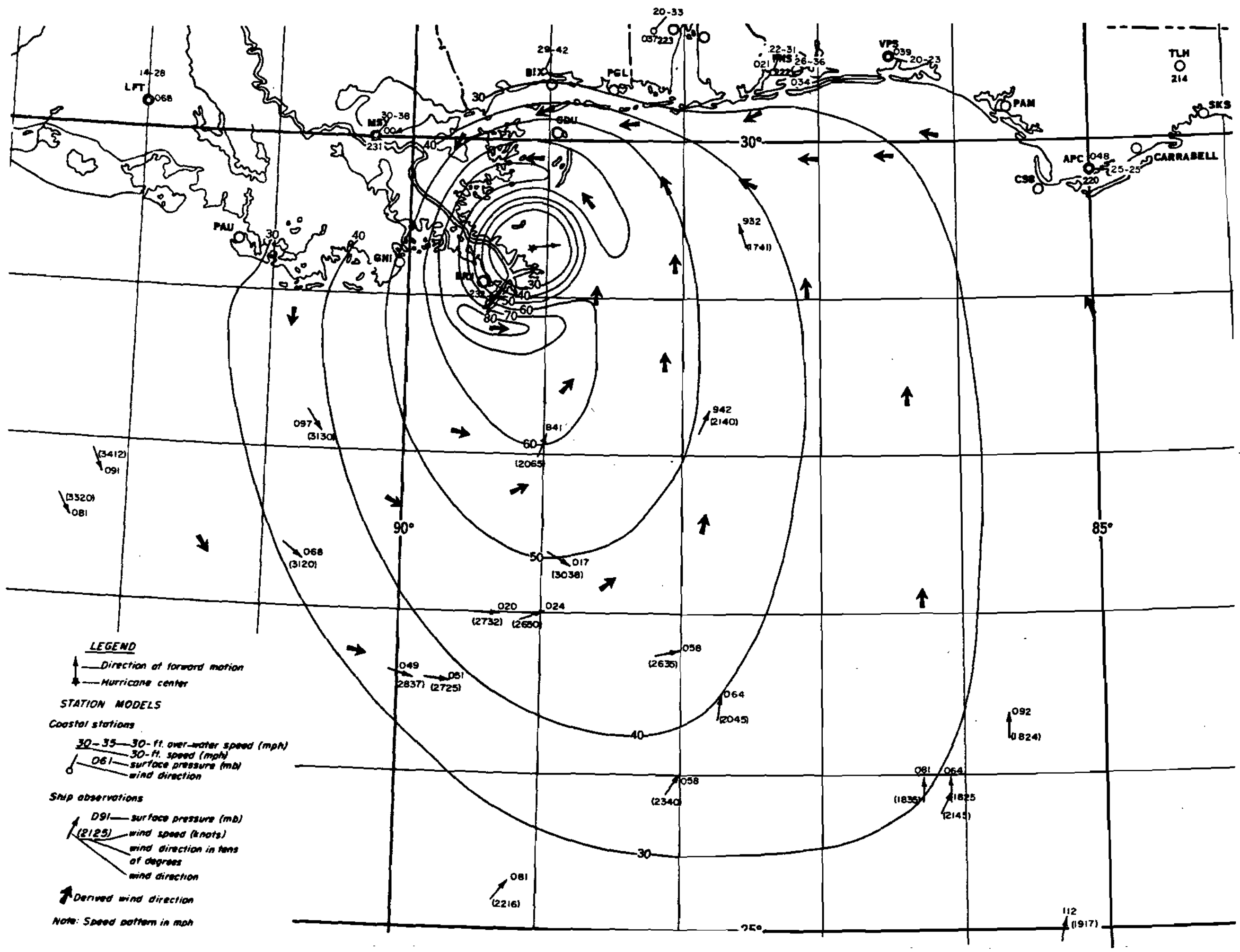



**Figure 10. ESTIMATED 30-FT WIND SPEED AND DIRECTION HURRICANE FLOSSY**

0630 CST SEPTEMBER 24, 1956

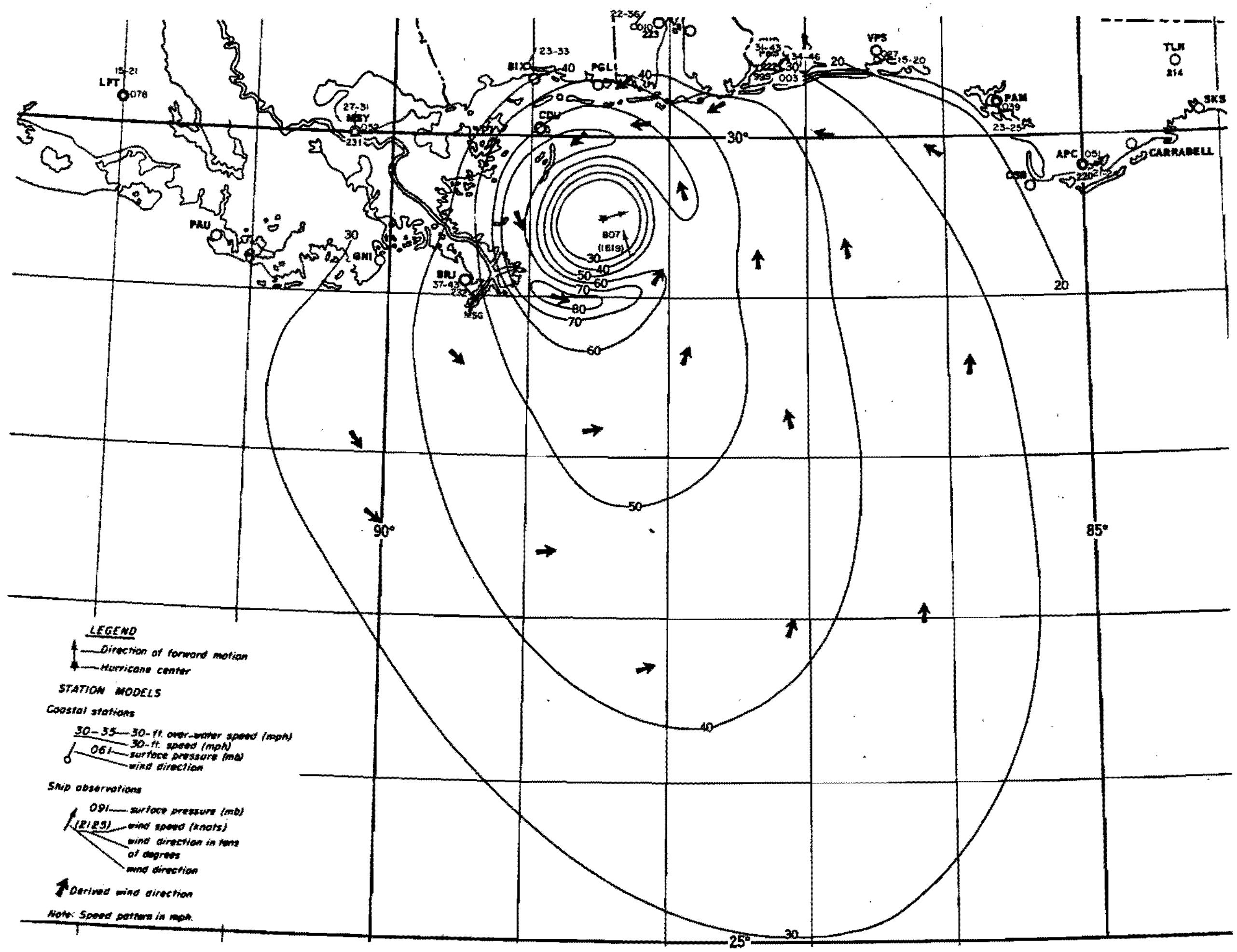



Figure 11. ESTIMATED 30-FT WIND SPEED AND DIRECTION
HURRICANE FLOSSY

0930 CST SEPTEMBER 24, 1956

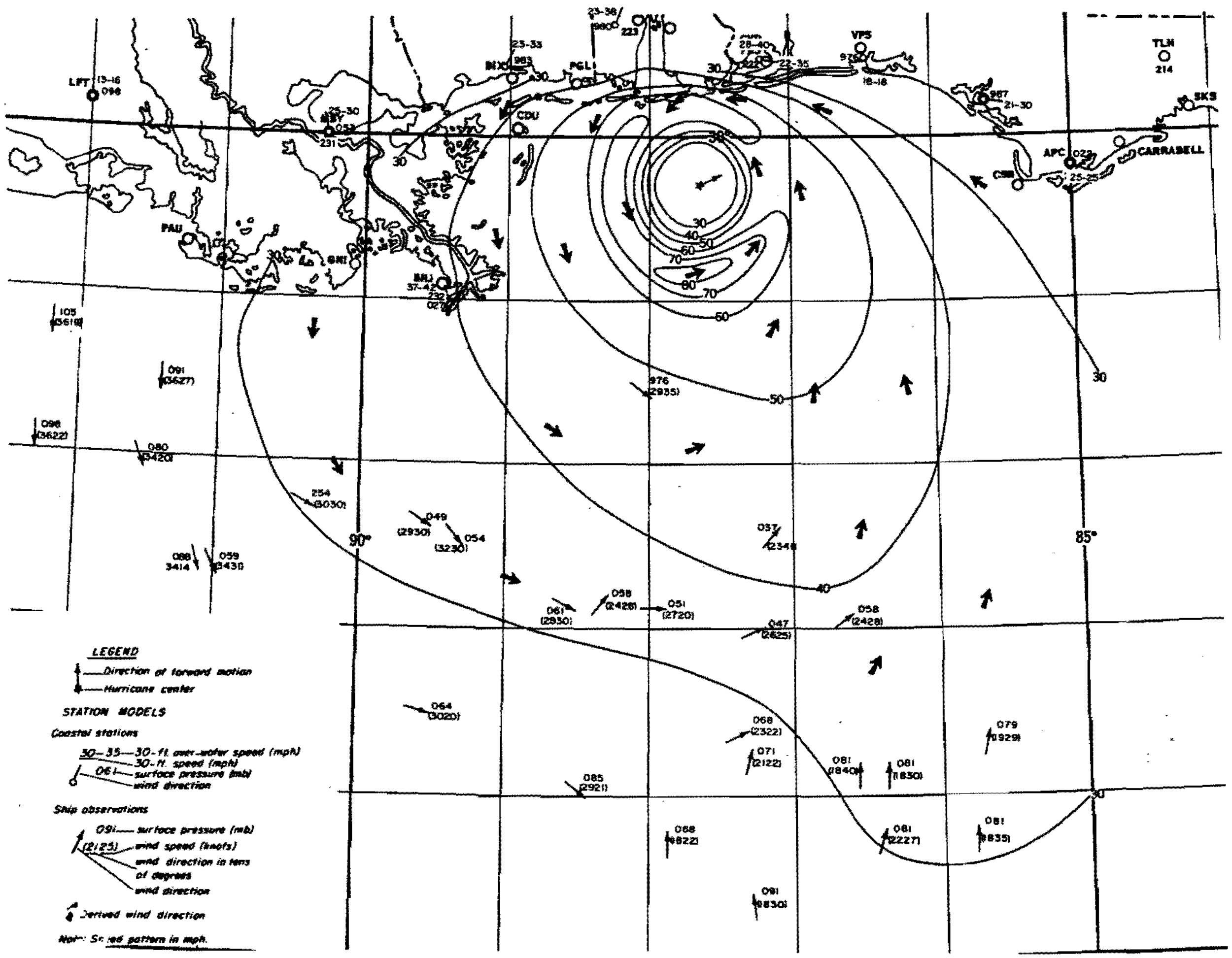



Figure 12. ESTIMATED 30-FT WIND SPEED AND DIRECTION HURRICANE FLOSSY

1230 CST SEPTEMBER 24, 1956

UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
WASHINGTON

June 19, 1958

IN REPLY, PLEASE ADDRESS
CHIEF, U. S. WEATHER BUREAU
WASHINGTON 25, D. C.
AND REFER TO

0-6.12

MEMORANDUM TO THE CORPS OF ENGINEERS

HUR 7-53

FROM : Hydrometeorological Section

SUBJECT : Pressure and Winds over the Gulf of Mexico in Hurricane Flossy, September 23-24, 1956

REFERENCE: OCE Memorandum, March 17, 1958

## Introduction

This study of wind and pressures in the hurricane, as it approached and crossed the Mississippi River Delta during the period from 1800 CST September 23 to 1230 CST September 24, 1956, was made as an aid in computing storm surge hydrographs along the mid-Gulf coast.

## Track

The track of Hurricane Flossy on September 23 and 24, 1956 with hourly positions of the center indicated is shown in figure 1. The storm moved off the Yucatan Peninsula into the Gulf of Mexico on September 22. It moved northward across the Gulf during the 23rd then recurved to the northeast just off the Louisiana coast. The center crossed the Mississippi River Delta between Buras and Burrwood, La. between 0300 CST and 0600 CST September 24. Continuing northeastward, the center moved inland near Valparaiso, Fla. about 1700 CST September 24.

## Pressure

Central pressure. The storm deepened slowly as it moved northward across the Gulf of Mexico. At about 1600 CST September 23 when the storm was centered 130 nautical miles south of New Orleans, La., a reconnaissance flight reported a central pressure of 29.06 inches. On the early morning of the 24th at the time the hurricane center moved across the Mississippi Delta, the central pressure was computed to be near 28.80 inches. This value was based on the minimum pressure of 29.03 inches reported at Burrwood as the center passed to the north of the station, and a pressure observation of 28.94 inches from a ship that passed within the eye of the storm about 0900 CST September 24. Later on the 24th, aircraft reconnaissance reported a minimum pressure of 28.76 inches when the storm was centered just off Pensacola, Fla. At 1725 CST when the center was crossing the coast, a dredge within the eye at Destin, Fla. also observed a minimum pressure of 28.76 inches.

Asymmetry of the pressure field. The pressure distribution around the hurricane was asymmetrical. The strongest pressure gradient near the center, but beyond the radius of maximum wind, was in the forward sector. The pressure gradient was weakest south of the center. In the right sector of the storm, at a distance of 100 miles from the center and beyond, the pressure gradient was greater than the gradients that occurred at this distance in the other directions (figure 2). The proximity of the subtropical High to the northeast probably contributed to the larger pressure gradient in this sector at a distance from the center.

Pressure profiles. Figure 2 shows pressure profiles in the forward sector of the storm at 1830 CST September 23 using the reconnaissance observation of 29.06 inches at 1600 CST as the minimum pressure and for the period from 0000 CST to 0030 CST September 24 when the storm had deepened and developed hurricane force winds. Beyond 35 miles from the center the two visually-fitted curves correspond well to pressure profiles derived from an exponential formula indicated by dashed lines. Ships observations of pressure in each quadrant for the period from 1200 CST September 23 to 0000 CST September 24 when the storm was moving north to northeastward are plotted in figure 2 to indicate the difference in the pressure distribution in the right sector from the distribution in the forward sector. Observations at Burrwood and New Orleans are also plotted on the chart. A curve has been visually fitted to the observations in the right sector to indicate the probable average slope of the pressure profile in that sector.

## Wind

Data. Isovel patterns were constructed from ship observations of wind speed, wind speeds observed at coastal stations and adjusted to 30-ft over-water speeds, and over-water wind speed profiles computed from pressure profiles in the forward sector of the storm.

Composite wind speed chart. To determine the features of the wind field that persisted over a period of time for use with the wind speeds reported at 3-hourly intervals by the ships and coastal stations, a composite chart of wind observations was constructed and analyzed (figure 3). A number of ship reports and wind speeds observed at coastal stations and adjusted to 30-ft over-water speeds for the period from 1200 CST September 23 to 1230 September 24 were plotted showing the position of the observation from the storm center in relation to the direction of forward motion. Isovels were drawn to the data with extra weight being given to the observations made at 0000 CST September 24 and later.

Considerable smoothing was necessary in analyzing the ship reports because large variations in speed were frequently reported within a small area. These variations may have resulted from squalls in the area which affected only part of the ships, from observers overestimating or underestimating the wind speed, differences in the actual times of the observations, and transmittal errors.

The maximum isovels in the right side of the storm were based largely on the autographic wind speed records at Burrwood, La. In the left sector, the maximum isovels where the data were lacking are based on 30-ft over-water speeds computed from pressures, (figure 4). The 0000-0930 CST September 24 mean pressure profile in the forward sector (figure 2) was used for this purpose.

Wind speed distribution. The composite wind speed pattern (figure 3) is quite asymmetrical. Speeds are considerably higher at about 100 miles from the center in the right sector than for the same distance in other directions. An inspection of weather charts for the period suggests that the storm circulation in this sector was reinforced by the sub-tropical High. As a qualitative check on the validity of the wind speed observations in the right sector, gradient wind speeds for that sector were computed. The computed speeds in the right sector remained higher than the computed speeds in the forward sector beyond 60 miles from the center over the distances compared. Both the stronger pressure gradient and the larger radius of curvature of air parcels in that sector would lead to higher wind speeds.

## Deflection angle

A composite wind deflection angle (the angle between the wind direction and a tangent to a circle about the center) pattern over open water was prepared from a plot of deflection angles from ship reports at 1200 CST, 1800 CST September 23, 0000 CST and 0600 CST September 24 and from reports from Burrwood, La. from 1800 CST September 23 to 0200 CST September 24 (figure 5). The chart is aligned to the north. Near the radius of maximum wind deflection angles of 20° were assumed because of a limited number of reports. The deflection angle chart is not applicable in the northern portion of the hurricane north of 29° 30'N latitude just off the Mississippi, Alabama and northwestern Florida coast. Deflection angles in that portion of the storm were near 90 degrees.

## Isovel charts

Isovel charts at 3-hourly intervals were constructed for the period from 1830 CST September 23 to 1230 CST September 24 (figures 6-12). Where observations were available, isovels were drawn to the observed speeds. This analysis was then compared to the composite wind speed pattern (figure 3) for consistency and for aid in constructing the isovels where there were no observations. The wind speed profile computed from the pressure profile at 1830 CST September 23 in the forward sector of the storm (figure 4) was used to construct the isovels near the radius of maximum winds at that time. The isovel pattern at 2130 CST September 23 was interpolated between the 1830 CST pattern and the 0030 CST September 24 pattern. At 0330 CST and 0930 CST September 24 when little or no ship observations were available, the composite wind speed chart adjusted for coastal observations and for continuity with adjacent patterns was used to construct the isovel pattern over the Gulf.

Wind direction south of latitude 29°30' are determined from the deflection angle chart (figure 5). Wind directions in the Gulf north of latitude 29°30' were determined by streamline analysis of observed wind directions. These derived wind directions are indicated by heavy arrows on the isovel charts.

Observations at coastal stations were taken on the half hour and ship observations were made on the hour. The position of the hurricane center is indicated at the half hour on the isovel charts, figures 6-12. This difference in the time of the ship observation and the chart time caused the ship observations plotted on the isovel chart to be displaced about five miles (the average forward speed of the storm was 10 knots) from the center. Because of the few observations near the center this displacement is not considered significant. All data shown in the composite chart and the pressure profiles were plotted relative to the distance of the observation point from the center at the time of observation.

Table 1

PARAMETERS OF THE SEPTEMBER 24, 1956 HURRICANE NEAR BURRWOOD, LA.

$P_o$, Central pressure (inches), 28.80*

$P_n$, Asymptotic pressure (inches), 29.97*

$V_{gx}$, Maximum gradient wind (mph), 74**

R, Radius of maximum winds (nautical miles)

| | |
|---|---|
| Computed | 30* |
| Observed | 22 |

C, 4-Hour average forward speed at the Coast (knots) 10

<u>At Burrwood, La</u>.

Lowest observed pressure (inches), 29.03

Minimum distance from station to storm track (nautical miles), 17

*Computed from the exponential profile based on the best fit of the following formula to the data

$$\frac{P - P_o}{P_n - P_o} = e^{-R/r}$$

where P is the pressure at radius r, R the radius of maximum winds, $P_o$ the central pressure, and $P_n$ the asymptotic pressure.

**Theoretical friction-free wind speed at R.

for Charles S. Gilman, Chief
Hydrometeorological Section

Vance A. Myers

Copies
10 to OCE
1 to BEB

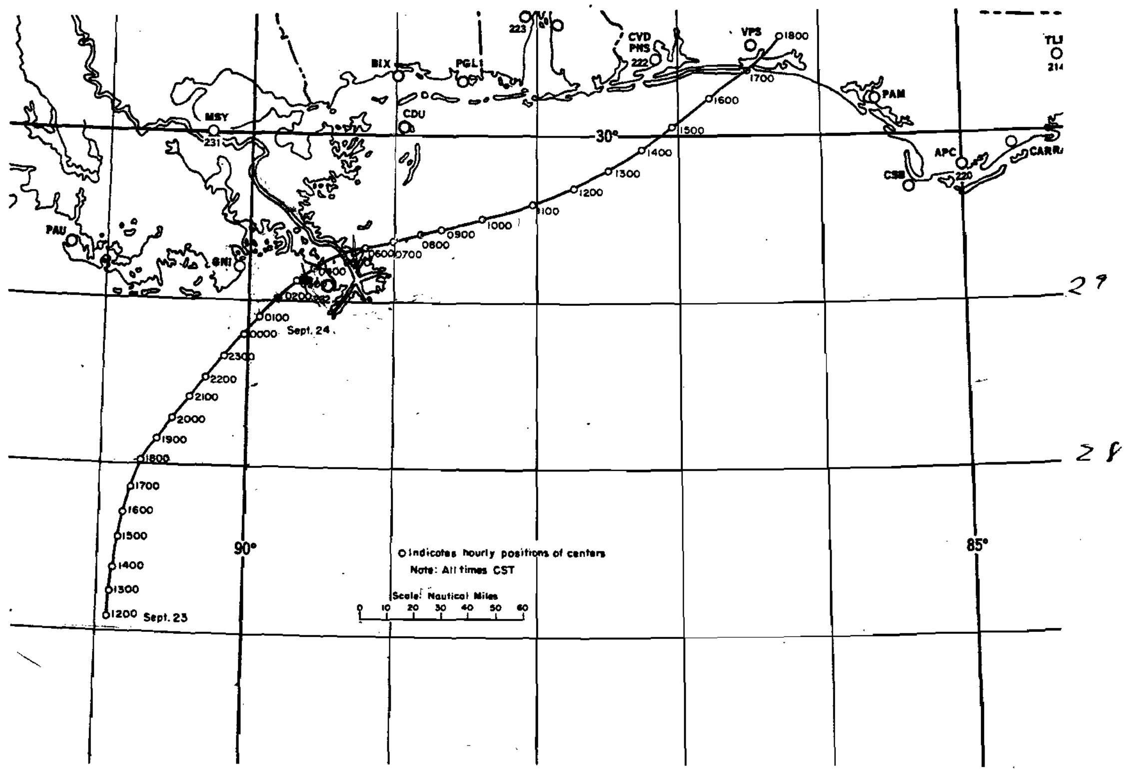



**Figure 1. TRACK OF HURRICANE FLOSSY**

**SEPTEMBER 23-24, 1956**

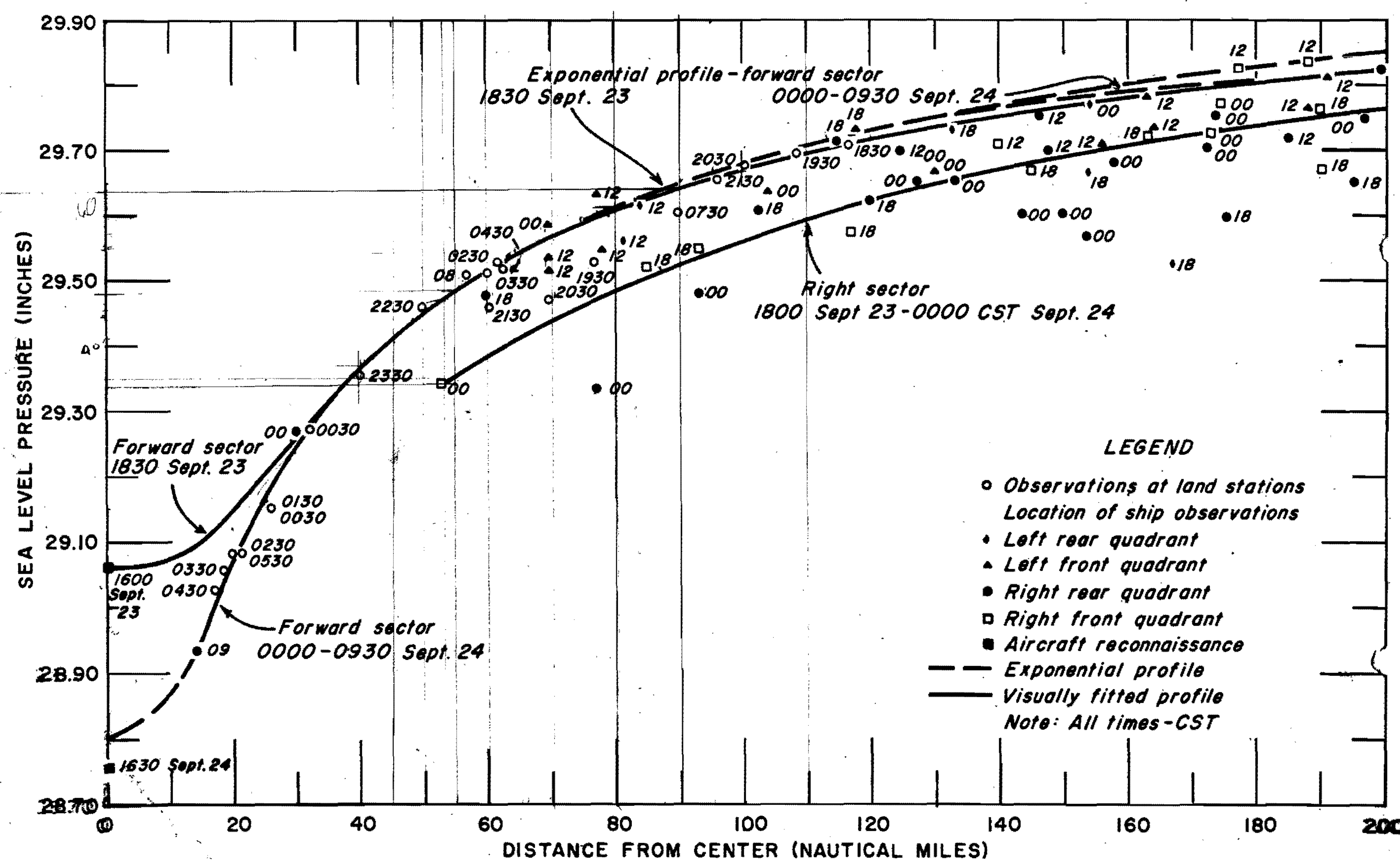


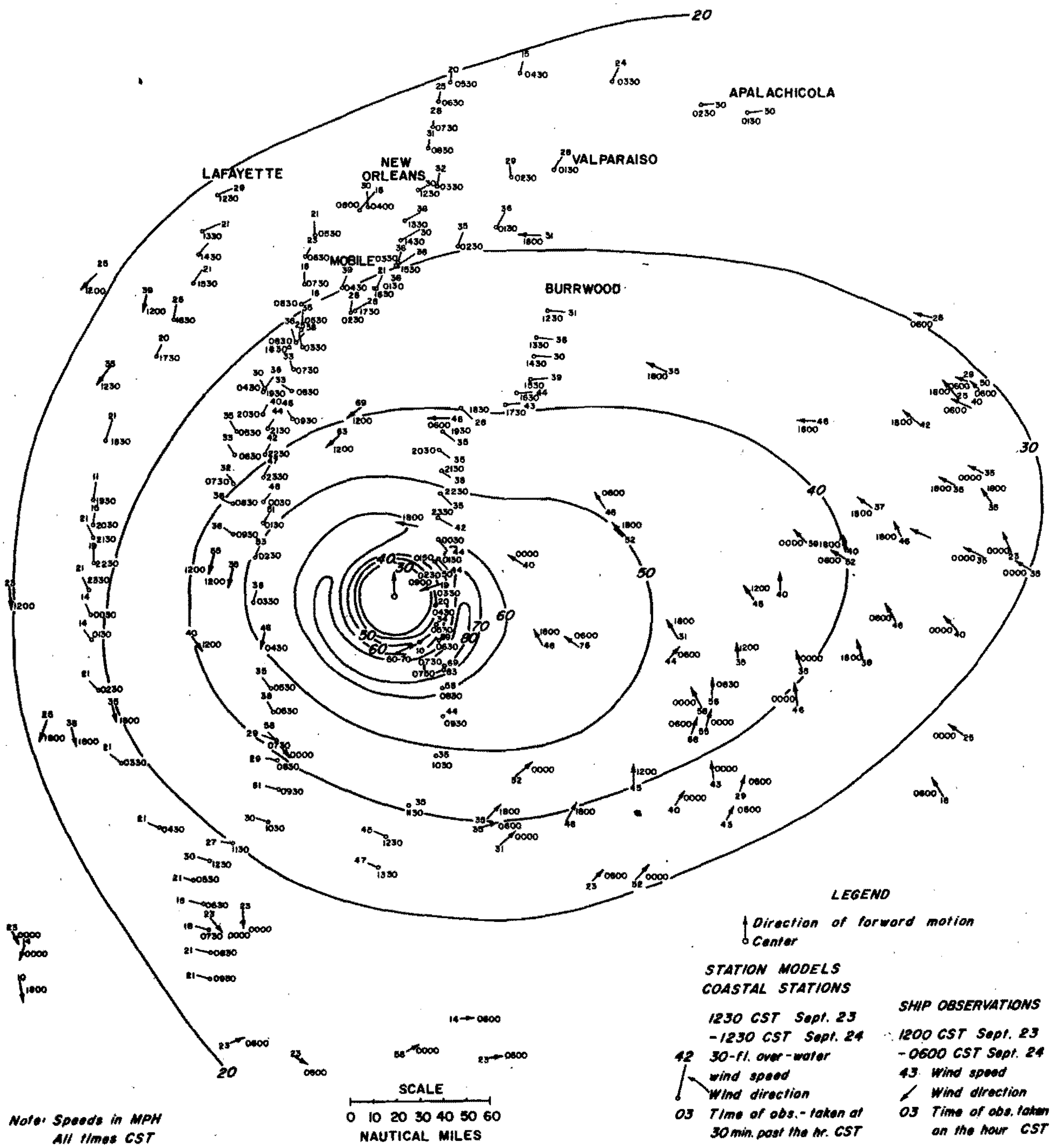

**Figure 2**

**PRESSURE PROFILES IN THE FORWARD AND RIGHT SECTORS OF HURRICANE FLOSSY**

**SEPTEMBER 23-24, 1956**

Figure 3. COMPOSITE WIND-SPEED PATTERN
HURRICANE FLOSSY

1230 CST SEPTEMBER 23-
1230 CST SEPTEMBER 24, 1956



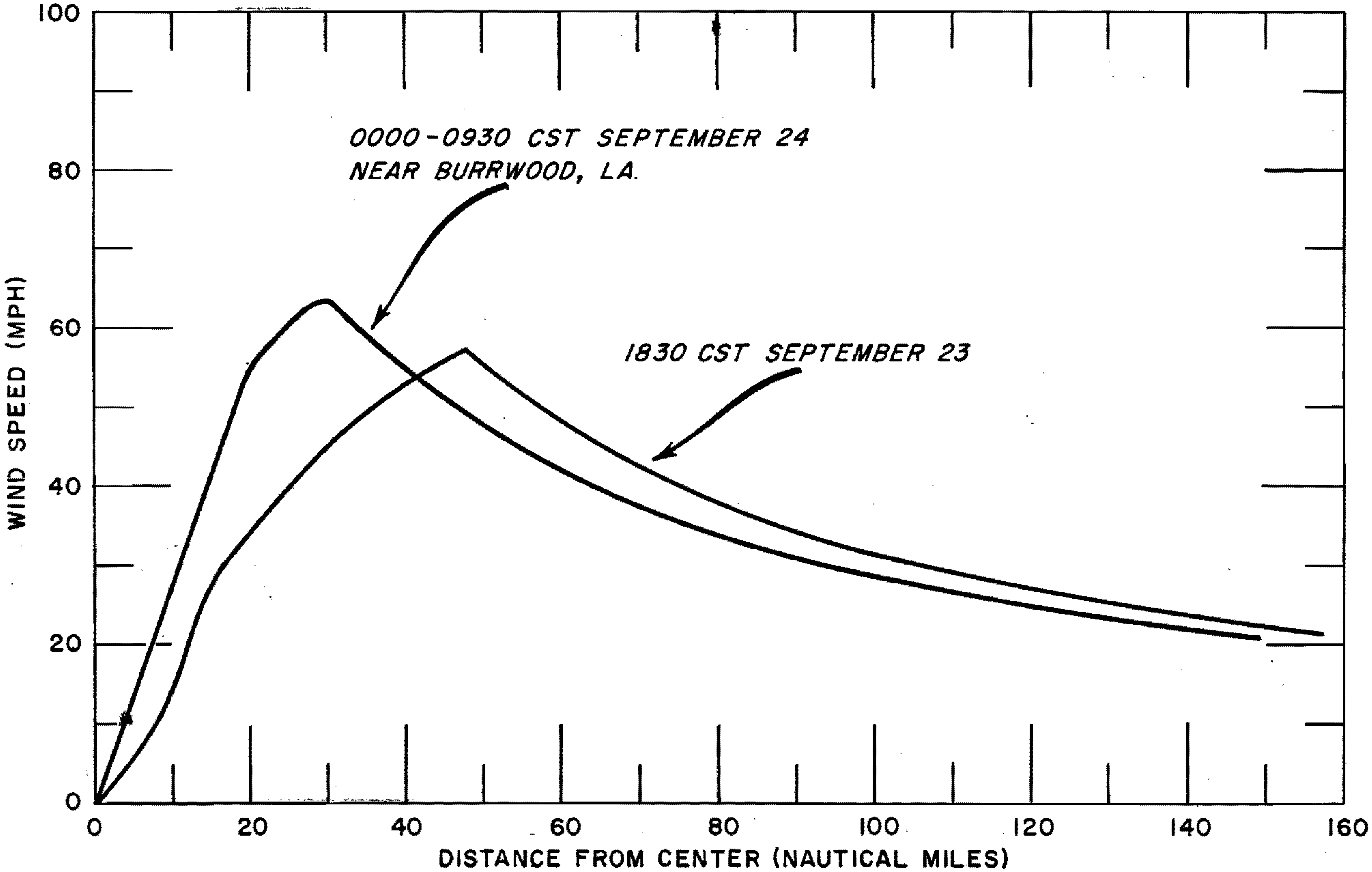



Figure 4. COMPUTED 30-FT OVER-WATER WIND SPEED PROFILES FORWARD SECTOR
HURRICANE FLOSSY

SEPTEMBER 23-24, 1956

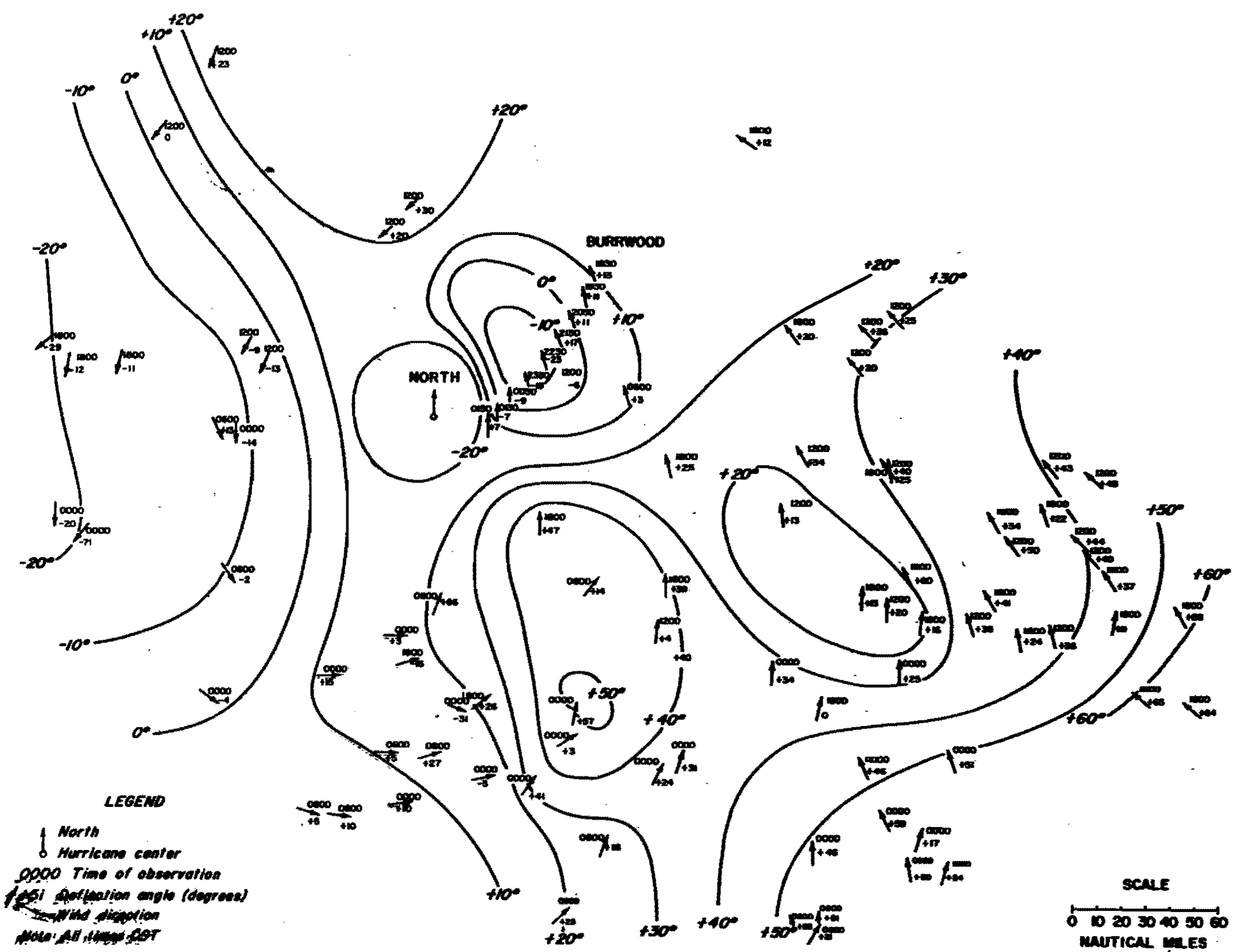



Figure 5. WIND DEFLECTION ANGLES SOUTH OF LATITUDE 29°30'N
HURRICANE FLOSSY

1830 CST SEPTEMBER 23 to
1230 CST SEPTEMBER 24, 1956

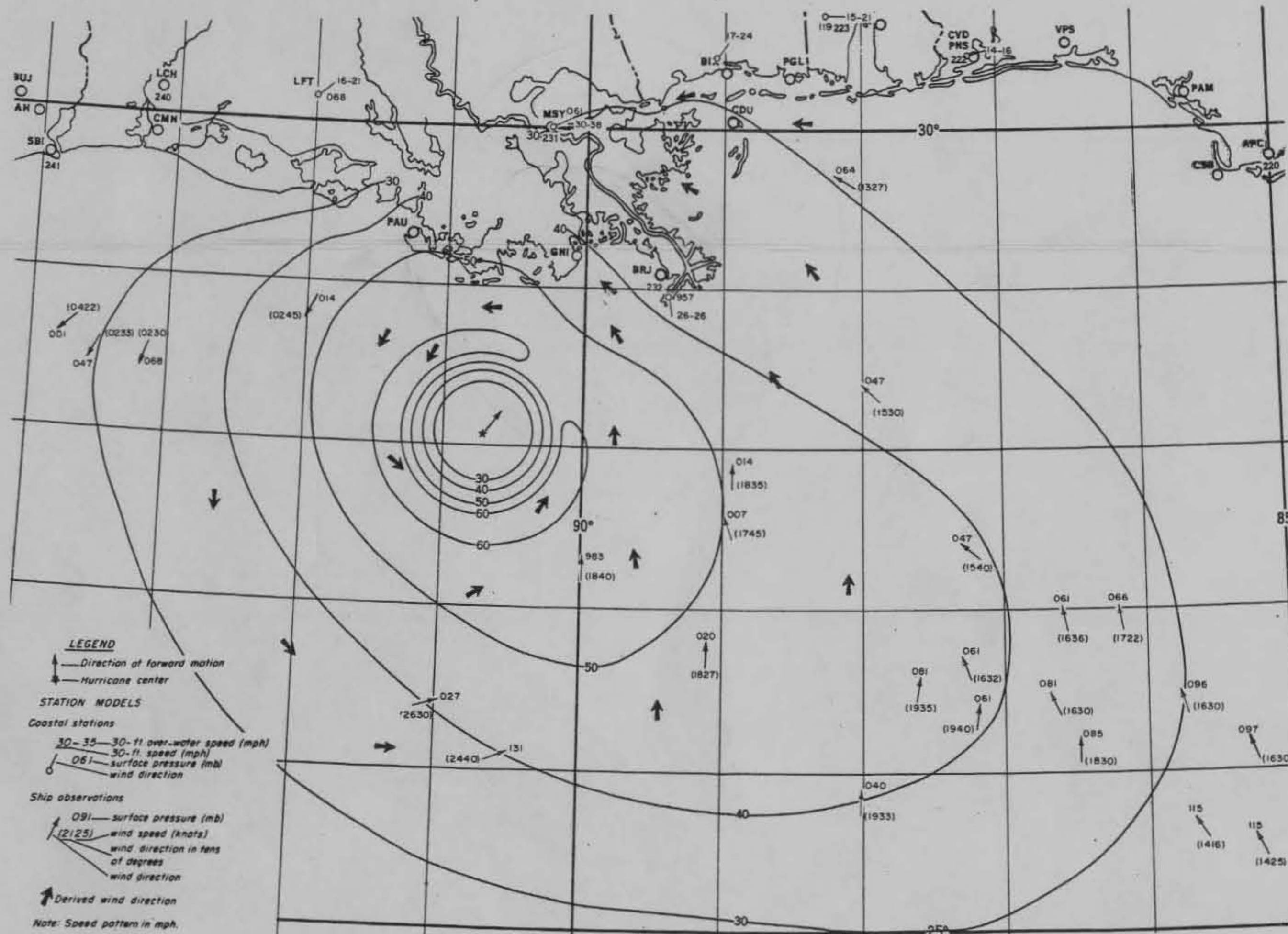


Figure 6. ESTIMATED 30-FT WIND SPEED AND DIRECTION
HURRICANE FLOSSY

1830 CST SEPTEMBER 23, 1956

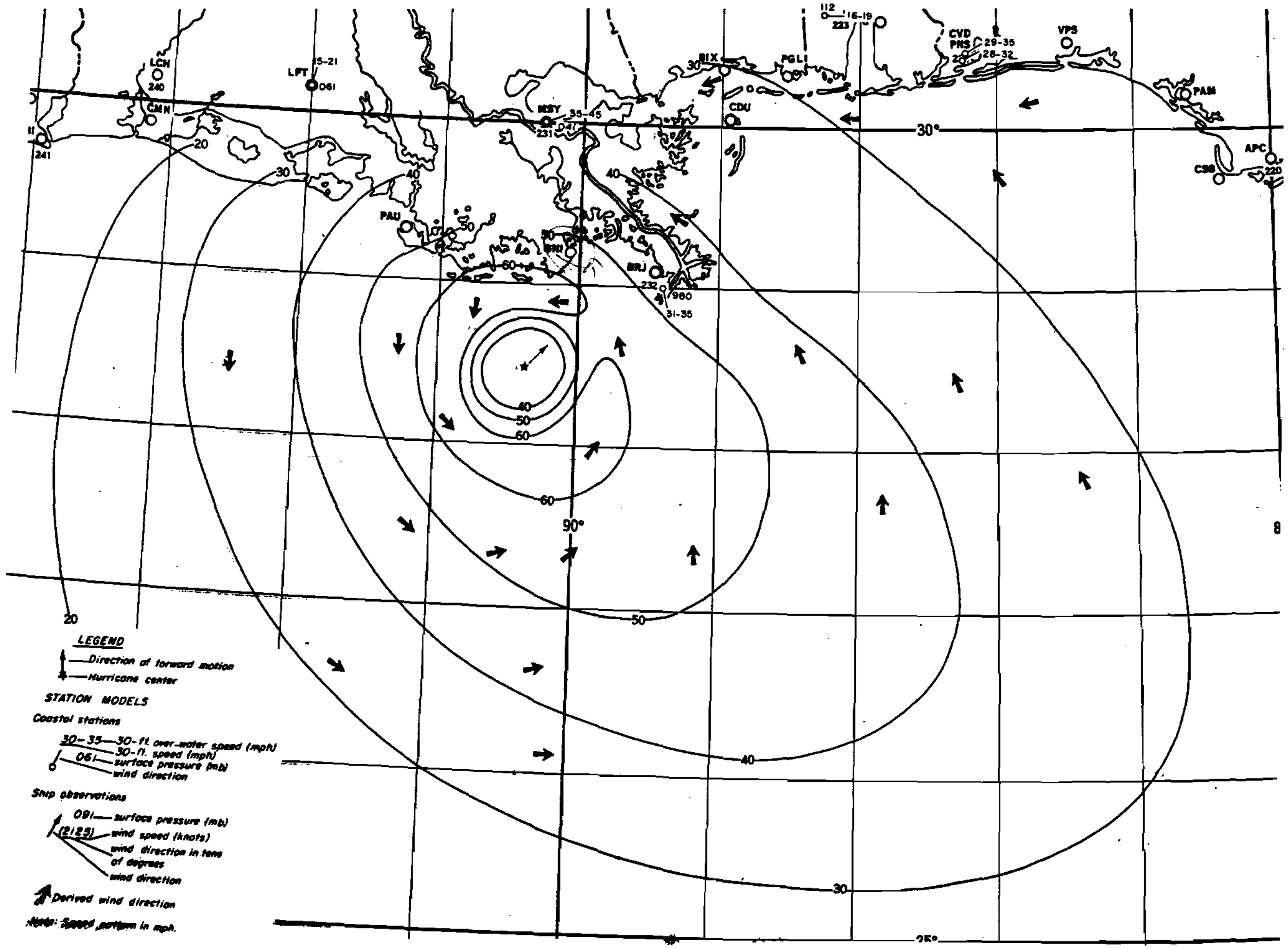


Figure 7. ESTIMATED 30-FT WIND SPEED AND DIRECTION
HURRICANE FLOSSY

2130 CST SEPTEMBER 23, 1956

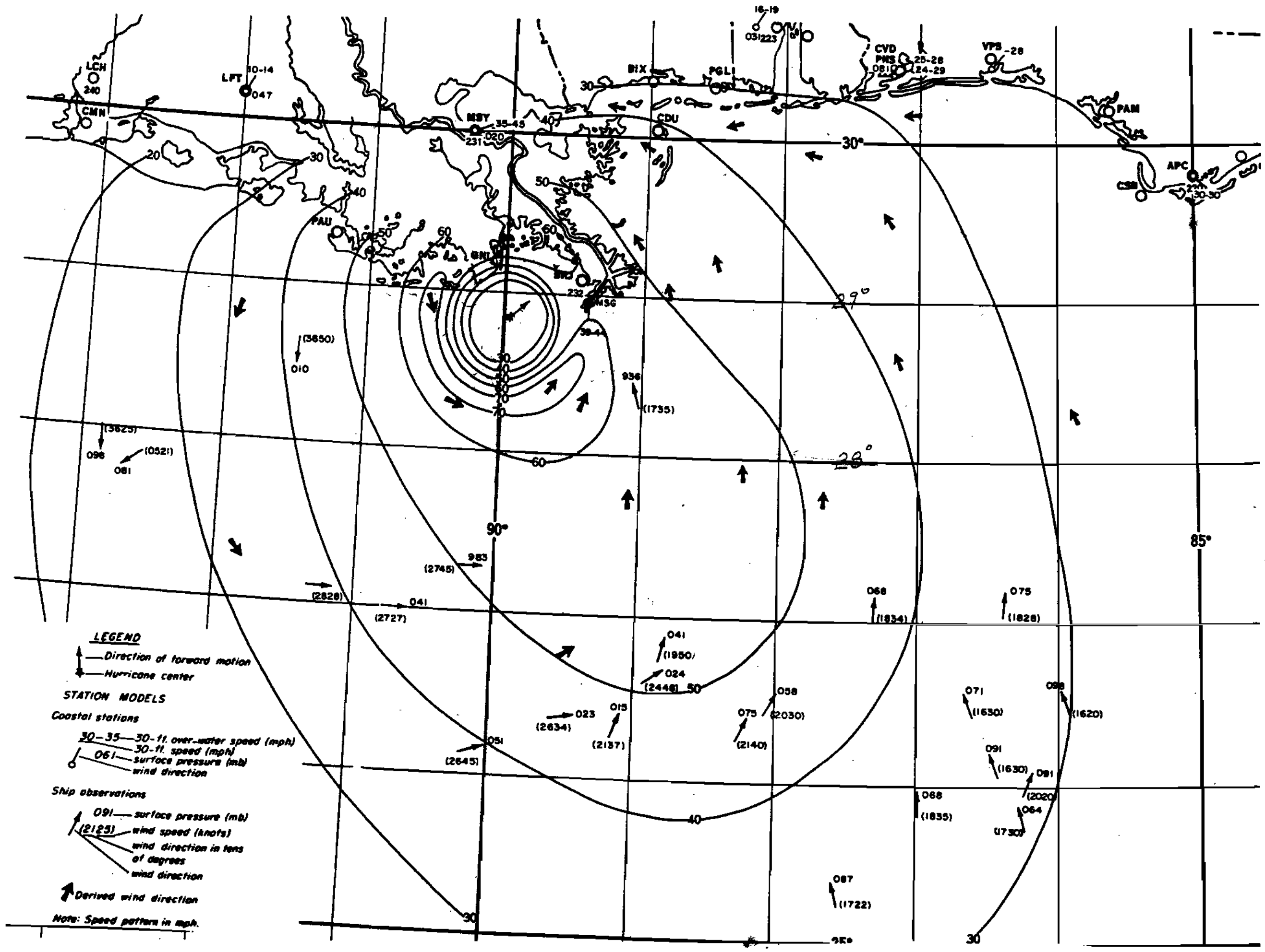



**Figure 8.** ESTIMATED 30-FT WIND SPEED AND DIRECTION
HURRICANE FLOSSY

0030 CST SEPTEMBER 24, 1956

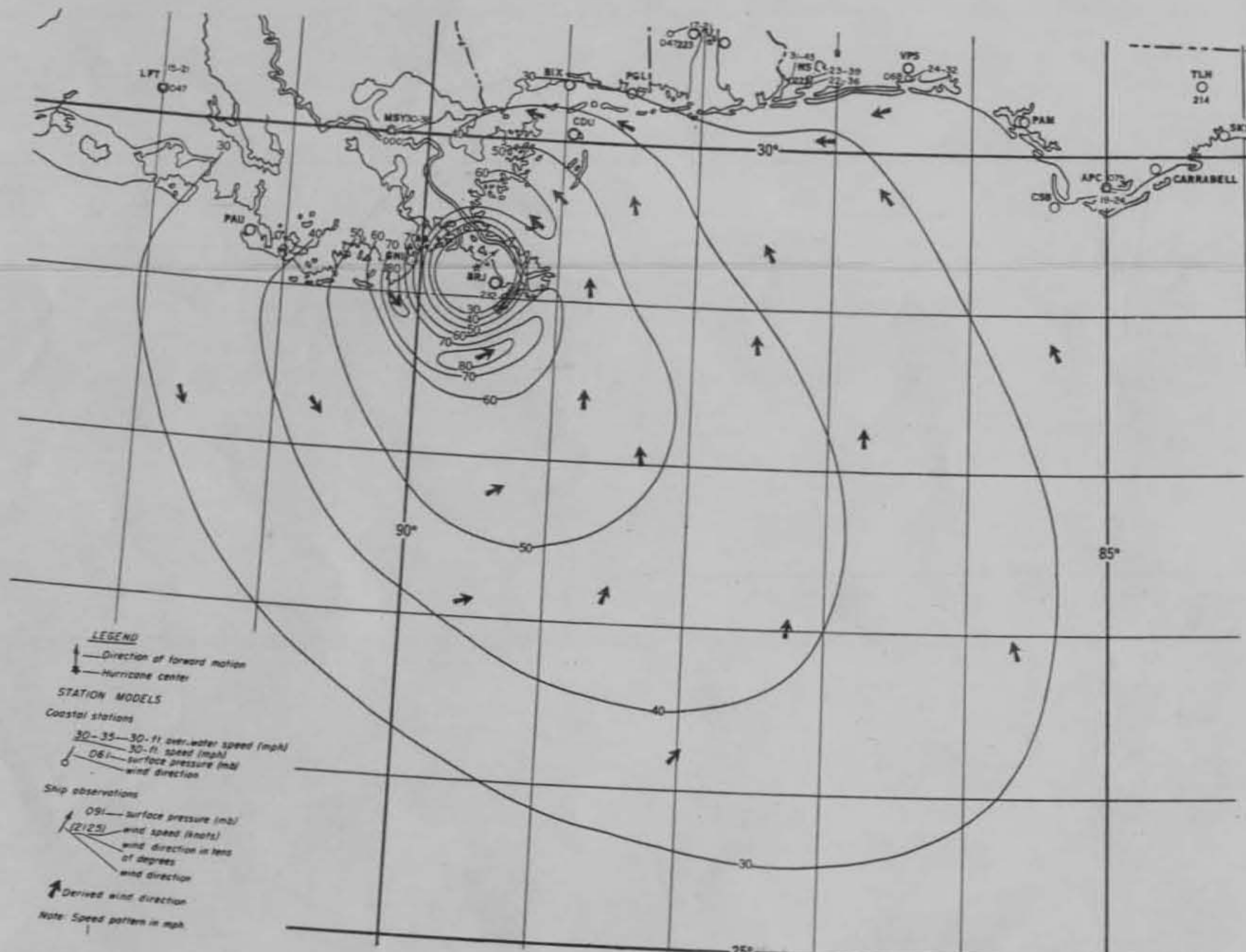
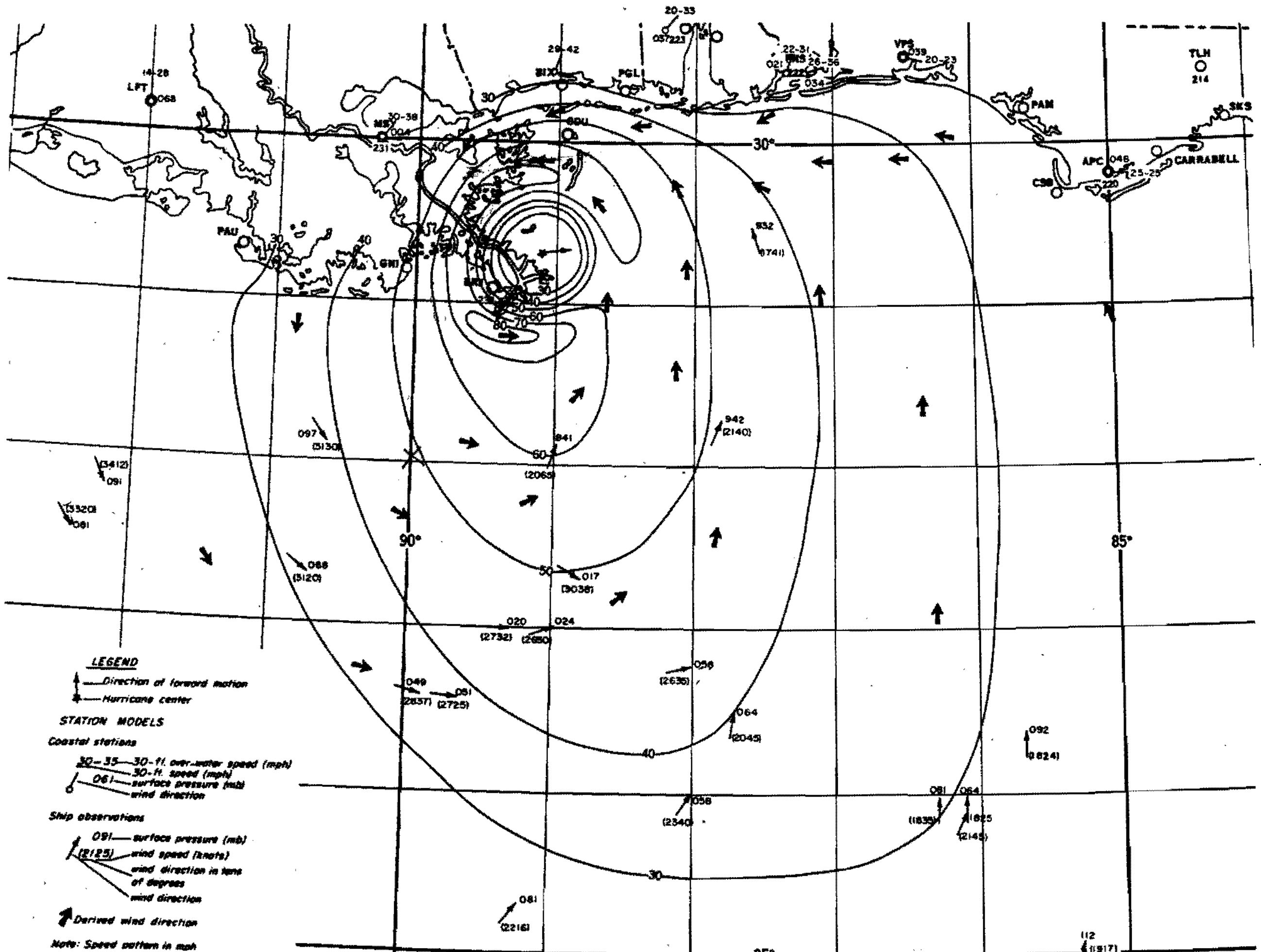



Figure 9. ESTIMATED 30-FT WIND SPEED AND DIRECTION HURRICANE FLOSSY

0330 CST SEPTEMBER 24, 1956




# Figure 10. ESTIMATED 30-FT WIND SPEED AND DIRECTION HURRICANE FLOSSY

0630 CST SEPTEMBER 24, 1956

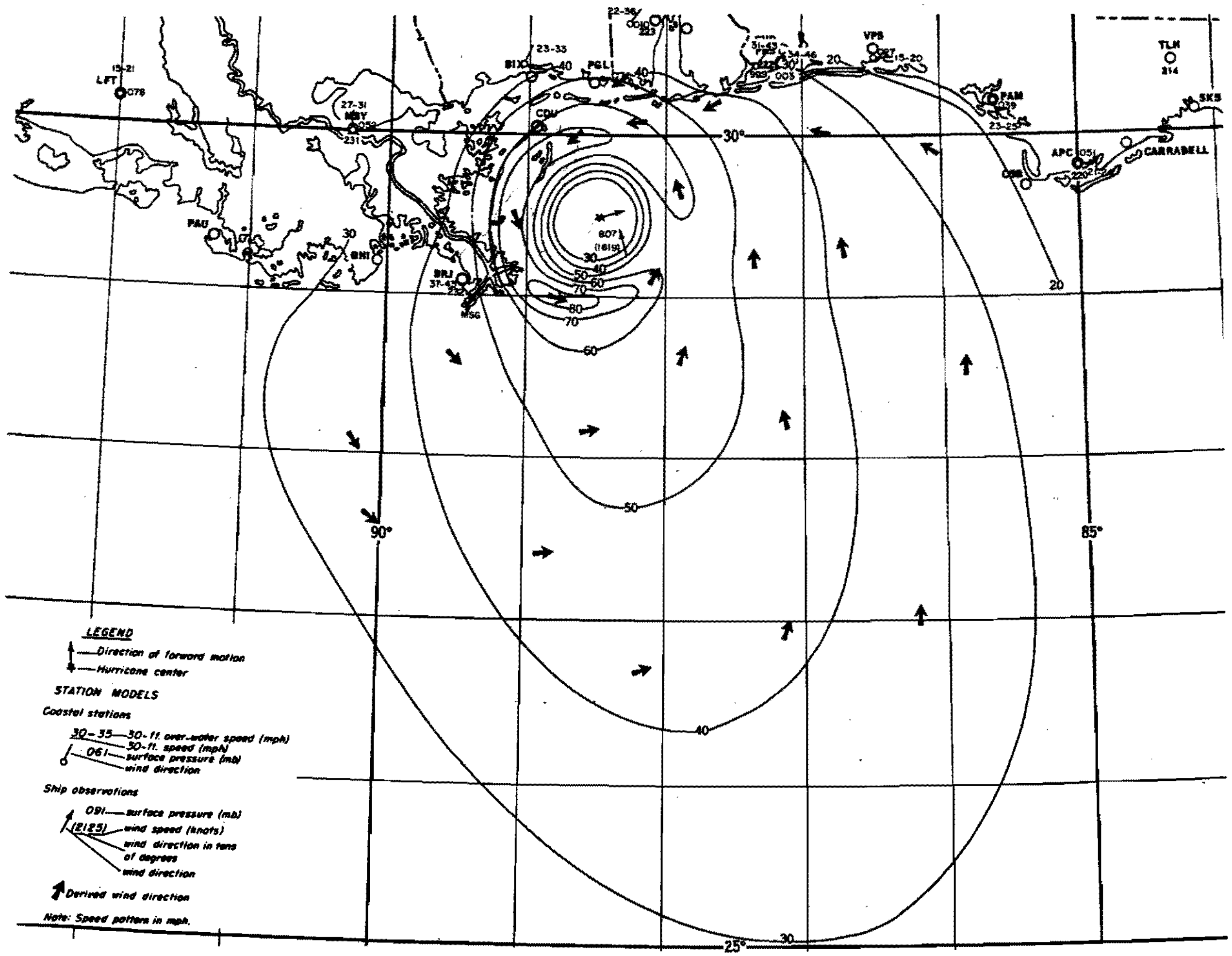



Figure 11. ESTIMATED 30-FT WIND SPEED AND DIRECTION
HURRICANE FLOSSY

0930 CST SEPTEMBER 24, 1956

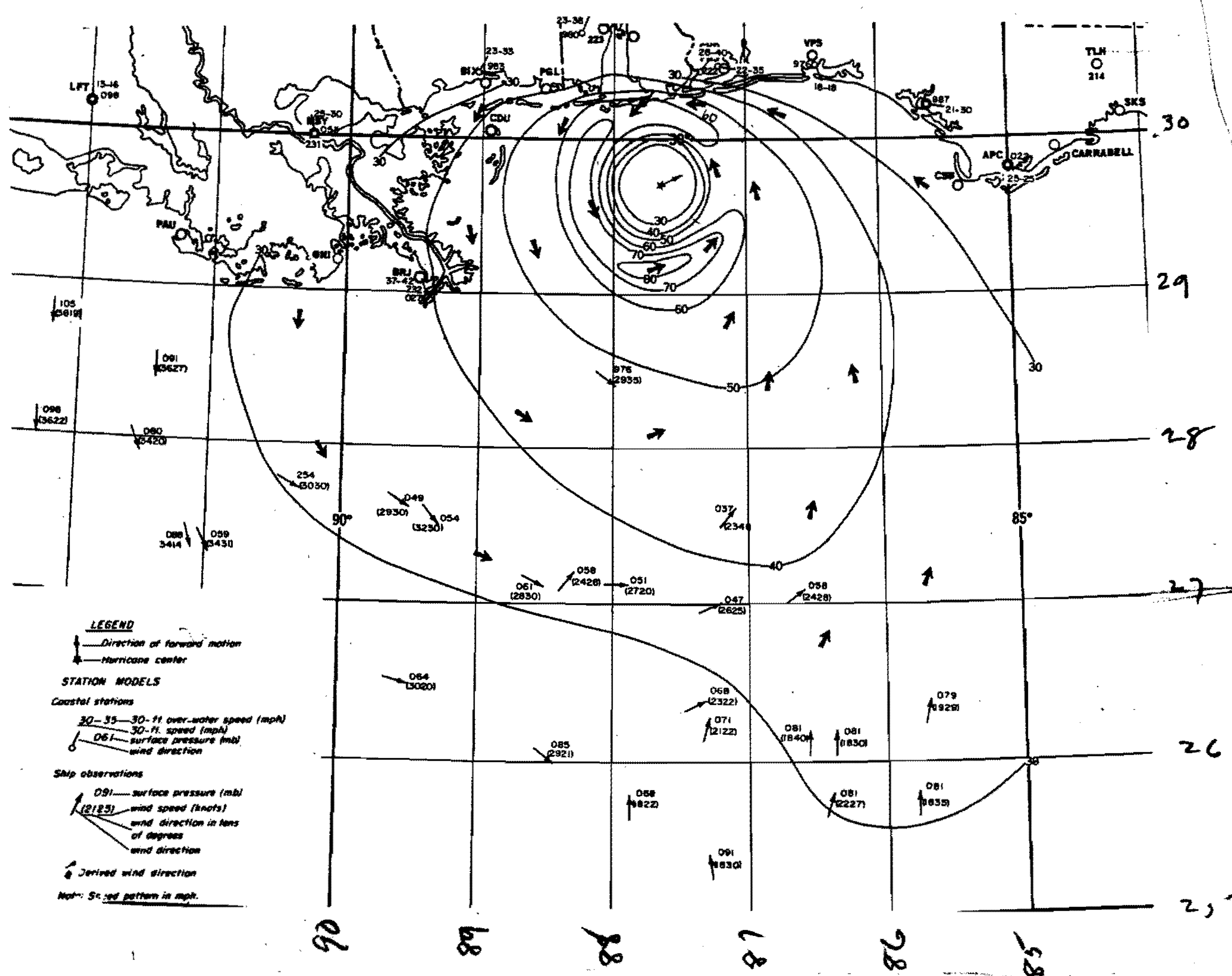



Figure 12. ESTIMATED 30-FT WIND SPEED AND DIRECTION HURRICANE FLOSSY

1230 CST SEPTEMBER 24, 1956

USCOMM-WB-DC

RETURN
TO
TIDAL SECTION

July 9, 1964

H-1.12

TO : Mr. A. L. Cochran, Civil Works
Office of Chief of Engineers
Corps of Engineers

FROM : Hydrometeorological Section

SUBJECT: Wind Speeds and Directions in Hurricane Audrey near the Louisiana Coast, June 27, 1957, HUR 7-51a

References: (1) Telephone request from Mr. Dwight Mann of the Office of Chief of Engineers, U. S. Corps of Engineers

(2) HUR 7-51, March 25, 1958

(3) National Hurricane Research Project, Report #68, "Criteria for a Standard Project Northeaster for New England North of Cape Cod," Appendix C and figure 37

Herewith transmitted is the subject memorandum. It is an addendum to HUR 7-51, and contains charts for times in between those previously given in HUR 7-51, and extends the wind field charts to cover the rest of the calendar day previously unreported, 1400 CST through 2400 CST.

The memorandum furnishes 16 isovel charts (surface wind speeds and directions) covering the period 0000 CST to 2400 CST, June 27, 1957, over the Gulf of Mexico near the Louisiana coast during the occurrence of Hurricane Audrey. The charts cover the period 0000 to 0600 CST at two-hourly intervals, 0600 to 1200 CST at one-hourly intervals, and 1200 to 2400 CST at two-hourly intervals.

Vance A. Myers
Chief, Hydrometeorological
Section

cc: 3 to OCE

HVGoodyear/lu

Incl #8

RETURN
TO
July 9, 1964 TIDAL SECTION

H-1.12

MEMORANDUM TO THE CORPS OF ENGINEERS

HUR 7-51a

FROM : Hydrometeorological Section

SUBJECT : Wind Speeds and Directions in Hurricane Audrey near the Louisiana Coast, June 27, 1957

References: (1) Telephone request from Mr. Dwight Nunn of the Office of Chief of Engineers, U. S. Corps of Engineers

(2) HUR 7-51, March 25, 1958

(3) National Hurricane Research Project, Report #68, "Criteria for a Standard Project Northeaster for New England North of Cape Cod," Appendix C and figure 37

Figures 1 through 16 are surface isovel patterns in the Gulf of Mexico near the Louisiana coast for the period 0000 CST to 2400 CST, June 27, 1957. During this period Hurricane Audrey approached the mainland from the south, entered the coast near Cameron, Louisiana near 0830 CST and subsequently recurved northeastward.

The figures cover the period from 0000 CST to 0600 CST at two-hourly intervals, then one-hourly to 1200 CST, then two-hourly to 2400 CST.

Figures 1, 4 and 6 are copies (on a slightly larger scale) of figures 5, 6 and 7 in HUR 7-51 and are repeated in this memorandum so as to furnish a complete set for the calendar day.

Figures 2, 3, 5, 7, 8, 9 and 10 were developed by direct time and space interpolation using figures 5 through 8 in HUR 7-51. All available surface reports (land and ship) were inspected as a check for consistency and validity of values of winds and directions in the interpolated charts.

The remainder of the charts, 1400 CST through 2400 CST, figures 11-16 were constructed by first developing the isovel charts for 1800 CST (0000 GMT of the 28th) and for 2400 CST (0600 GMT of the 28th). North American and Northern Hemisphere Surface Charts were used, as well as all available land and ship surface reports. In areas where reports were not available the surface winds were estimated by utilizing the geostrophic wind [3] as measured from the analyzed North American Surface Charts. The wind directions were drawn with a deflection angle of approximately 25 degrees as indicated by previous work in HUR 7-51.

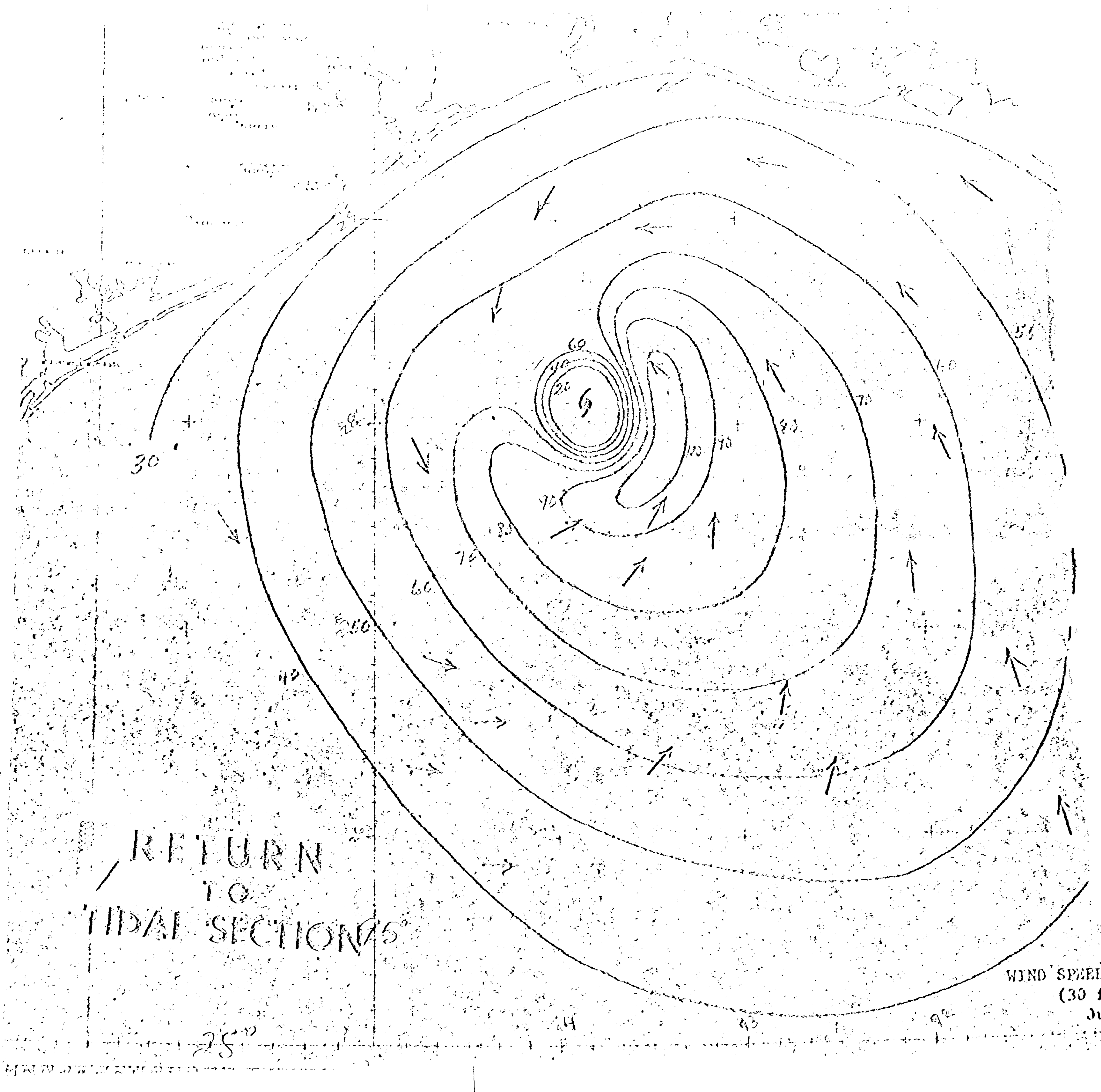
The other charts, figures 11, 12, 14 and 15 were then drawn by interpolation and use of surface observations where available.

Vance A. Myers
Chief, Hydrometeorological
Section

Attachments

cc: 3 to OCE with attachments

HVGoodyear/lm



30
60
70
80
90
RETURN
TO
TIDAL SECTIONS
WIND SPEED
(30
25°
93
92

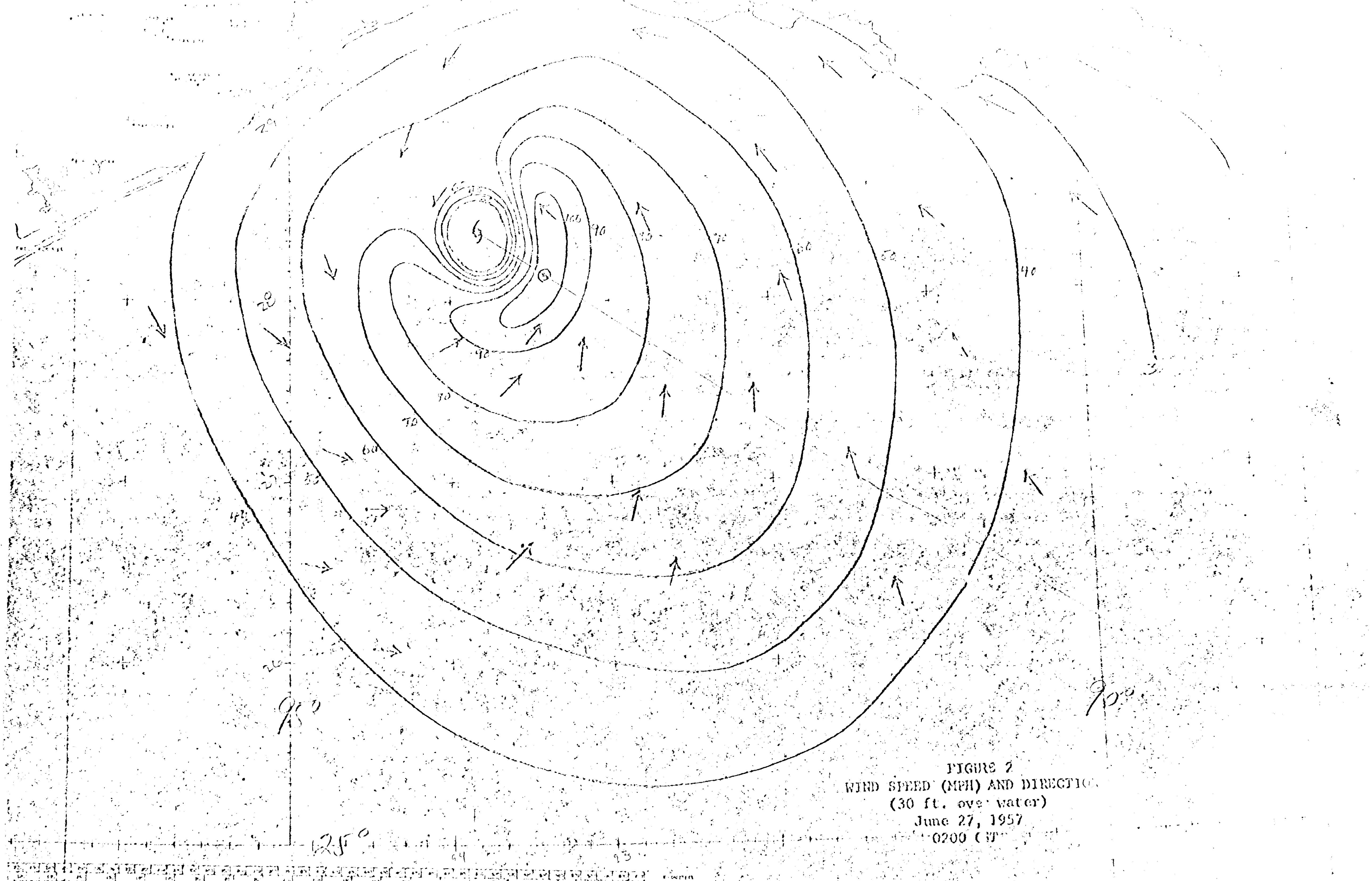


FIGURE 2
WIND SPEED (MPH) AND DIRECTIO[N]
(30 ft. ove[r] water)
June 27, 1957
0200 (CST)

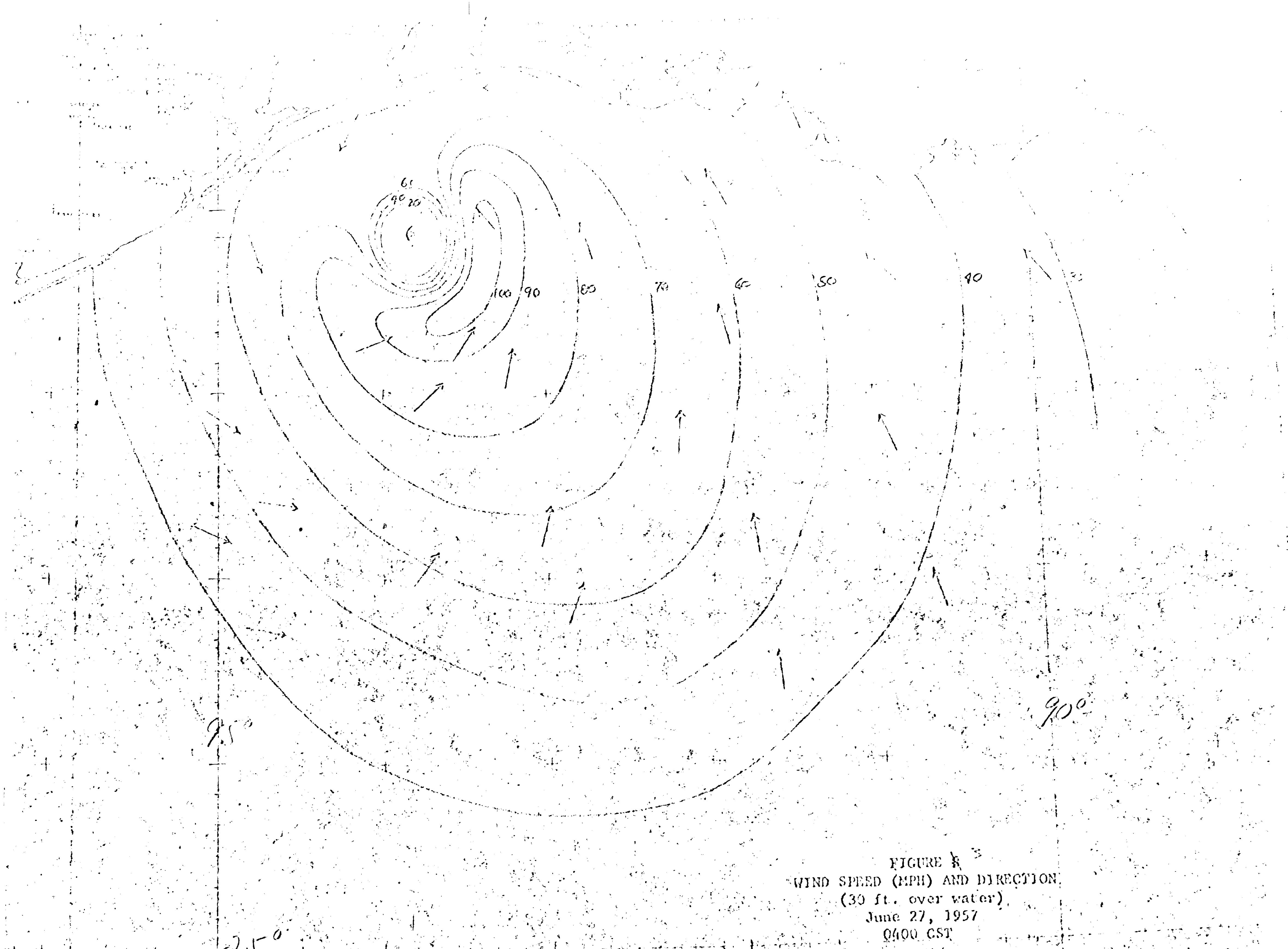



FIGURE ~~8~~ 3
WIND SPEED (MPH) AND DIRECTION
(30 ft. over water)
June 27, 1957
0400 CST

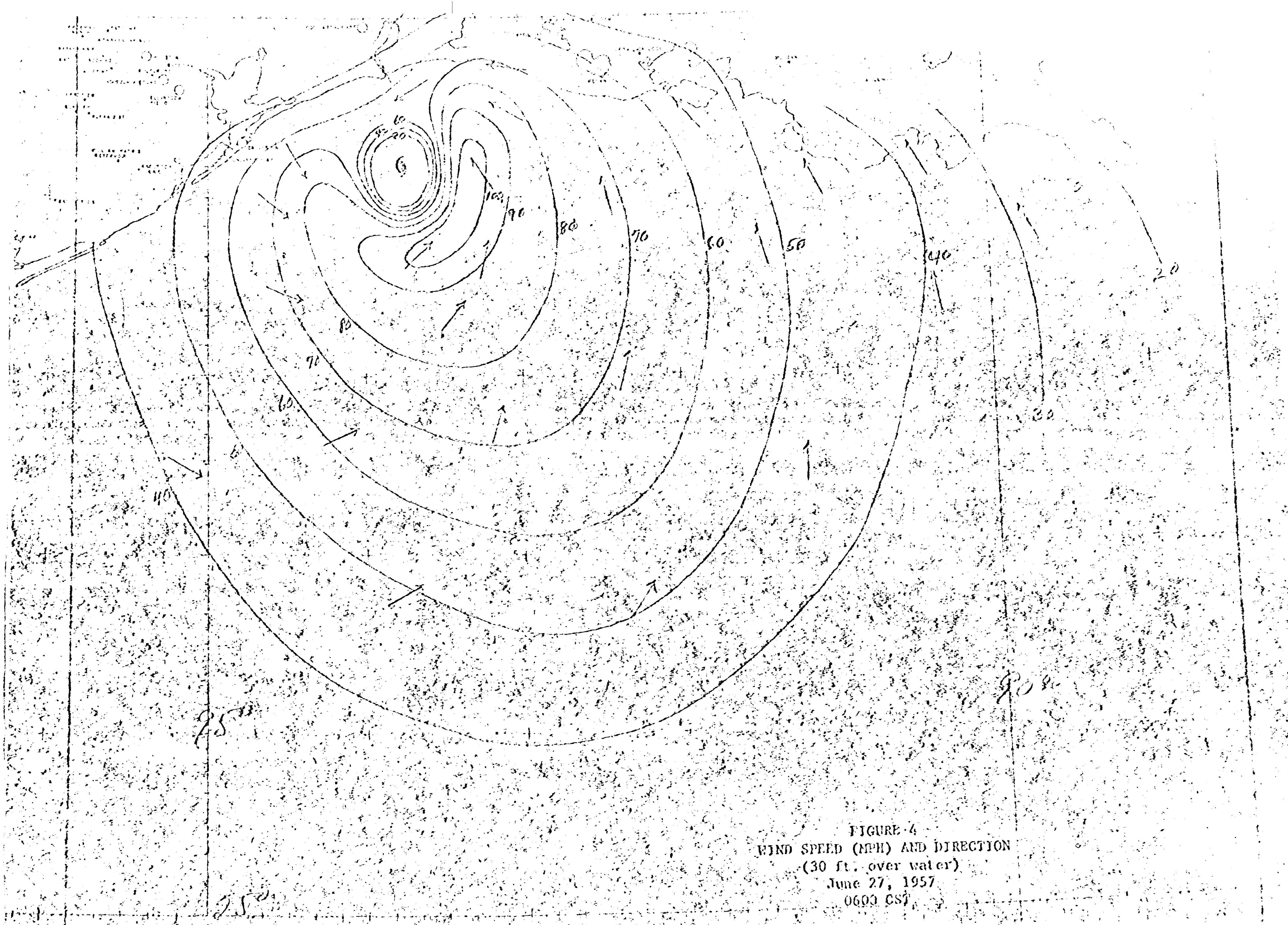



FIGURE 4
WIND SPEED (MPH) AND DIRECTION
(30 ft. over water)
June 27, 1957
0600 CST

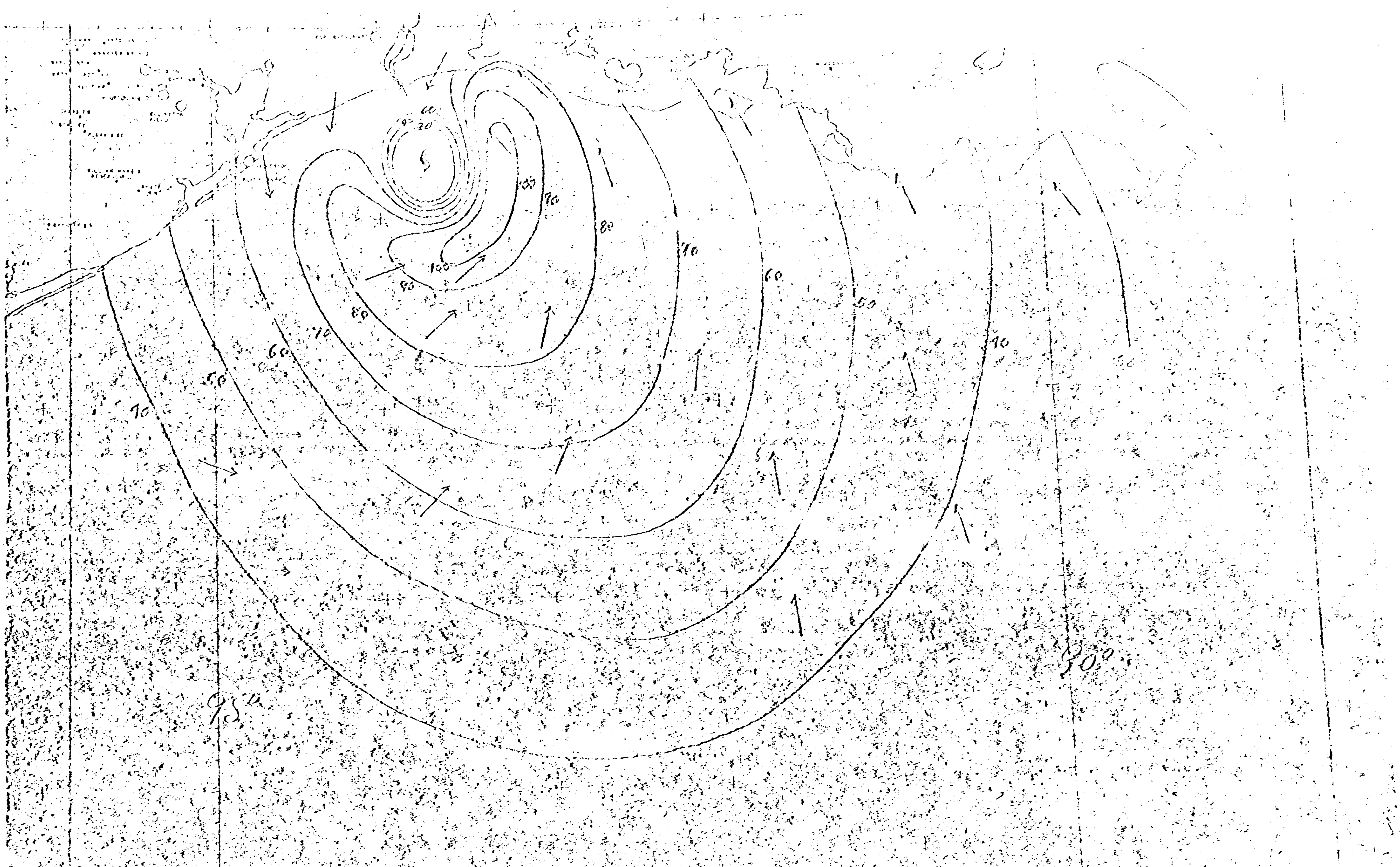



FIGURE 5
WIND SPEED (MPH) AND DIRECTION
(80 ft. over water)
June 27, 1957
0700 CST

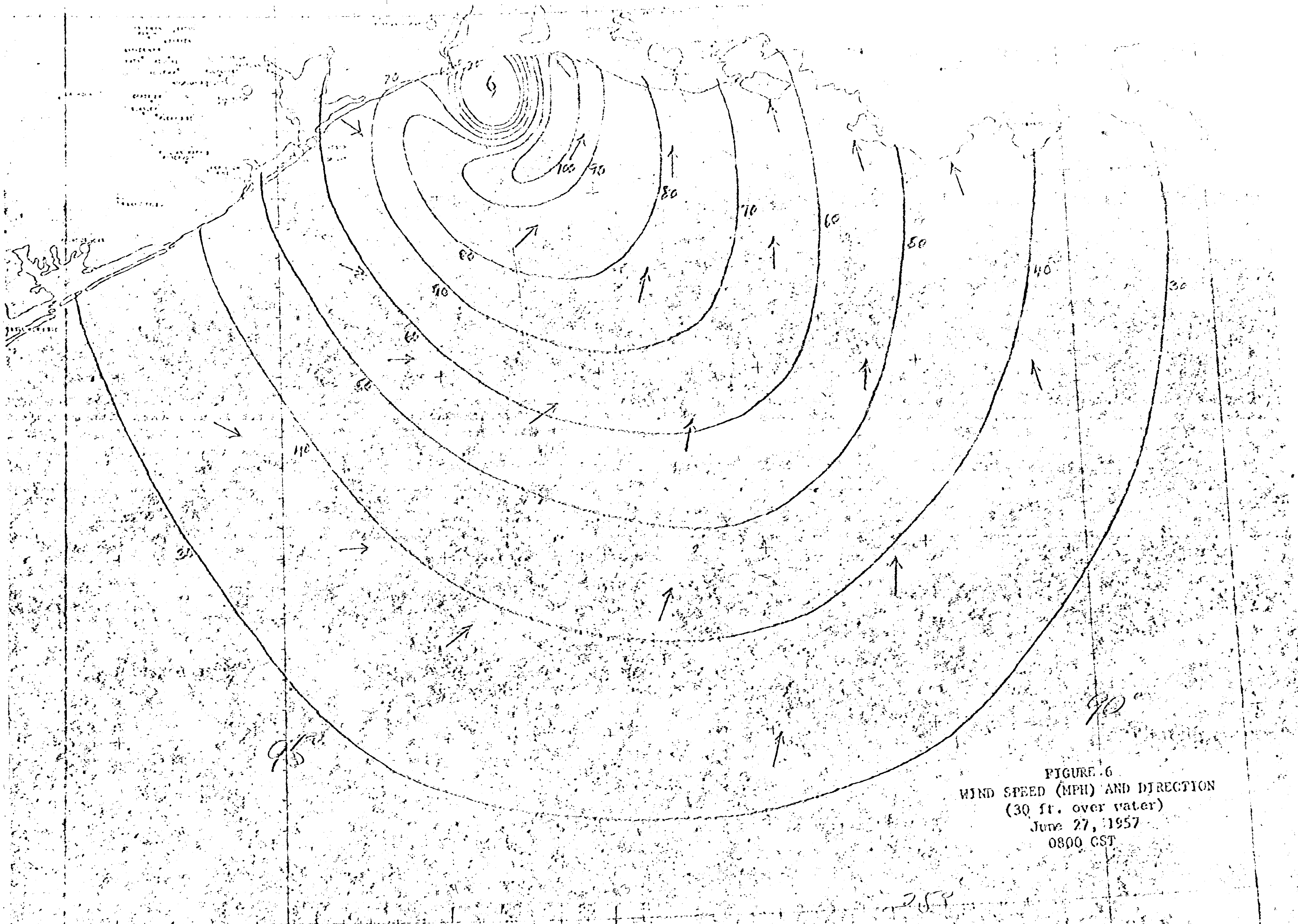



FIGURE 6
WIND SPEED (MPH) AND DIRECTION
(30 ft. over water)
June 27, 1957
0800 CST

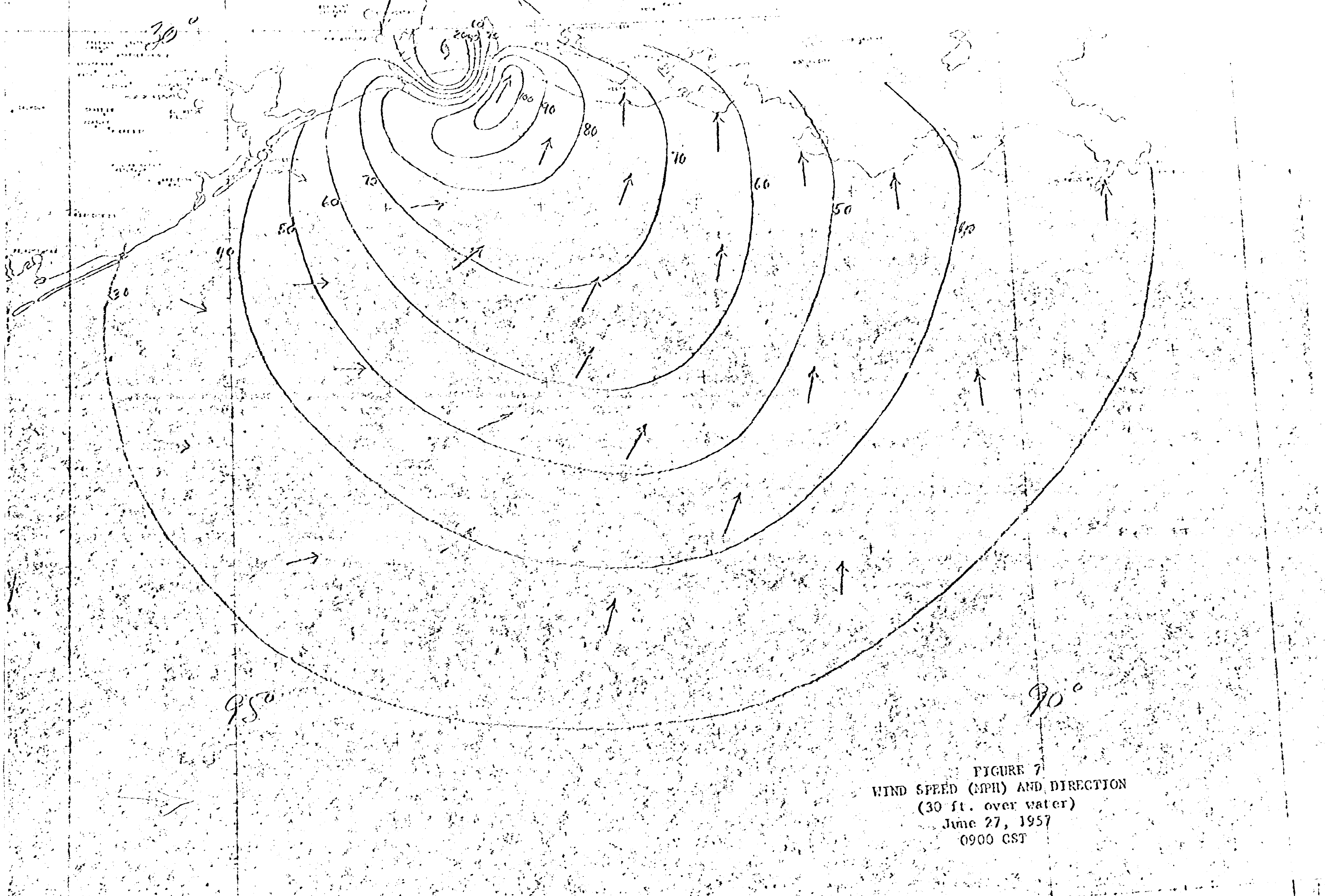



FIGURE 7
WIND SPEED (MPH) AND DIRECTION
(30 ft. over water)
June 27, 1957
0900 CST

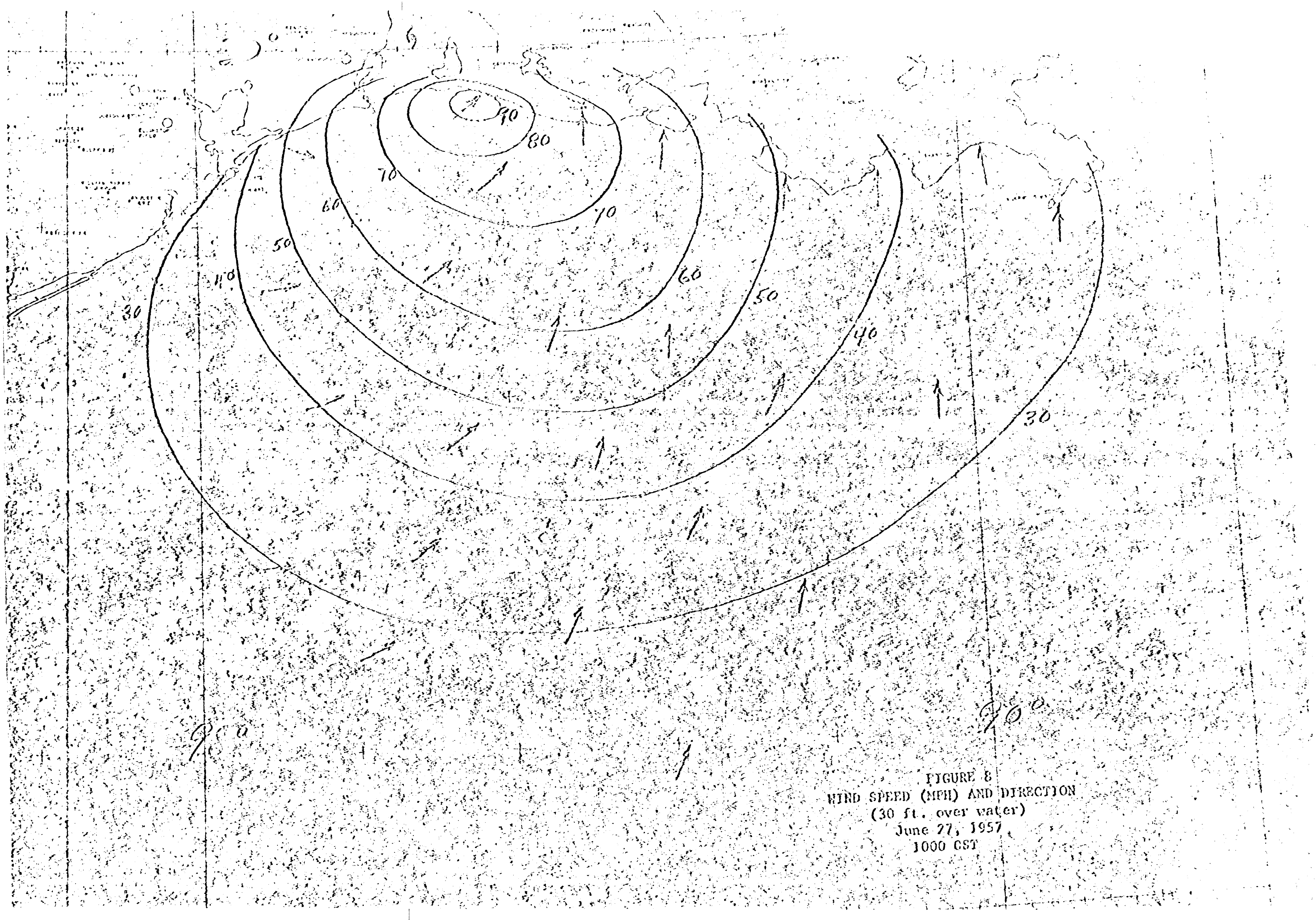



FIGURE 8
WIND SPEED (MPH) AND DIRECTION
(30 ft. over water)
June 27, 1957
1000 CST

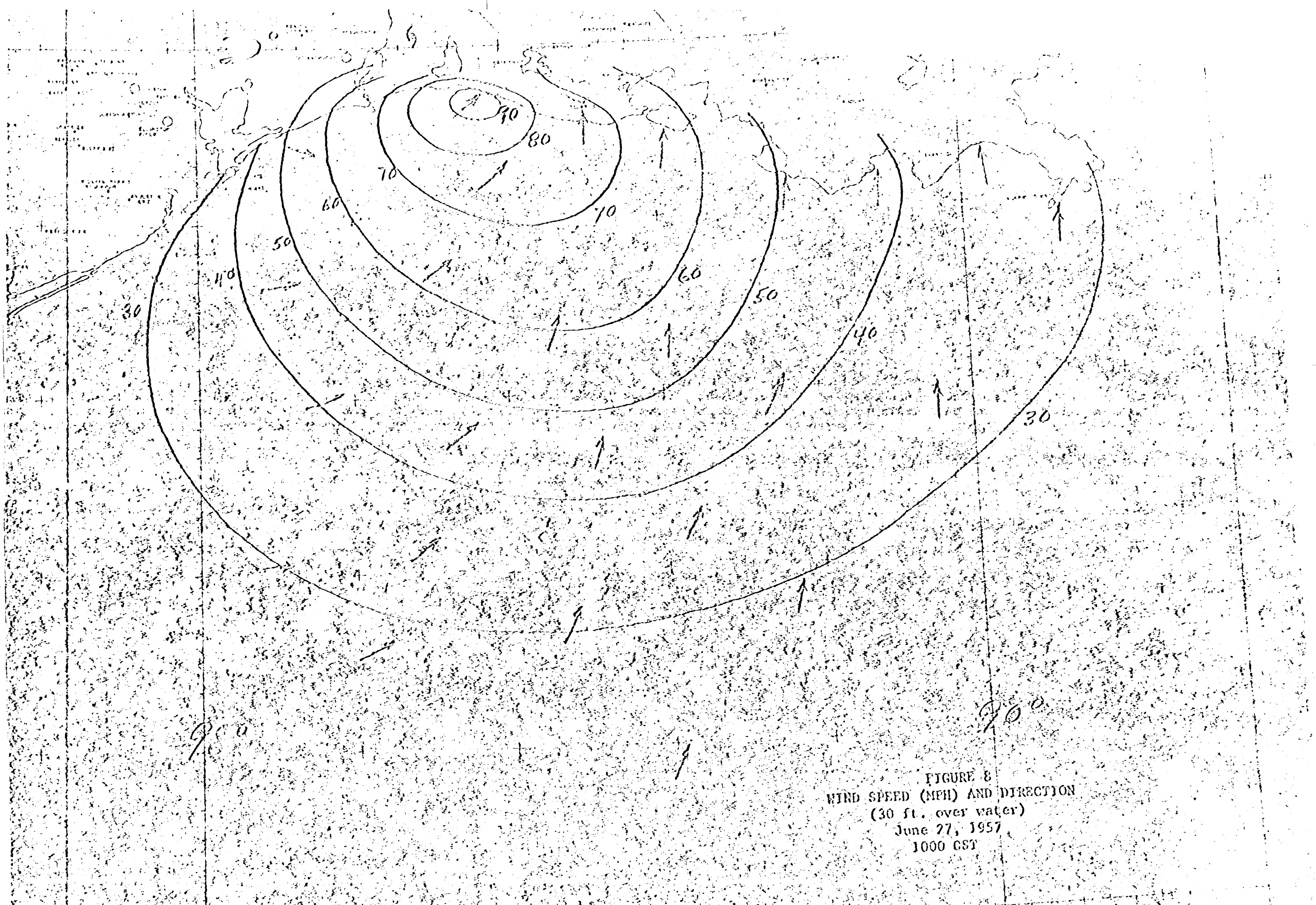



FIGURE 8
WIND SPEED (MPH) AND DIRECTION
(30 ft. over water)
June 27, 1957
1000 CST

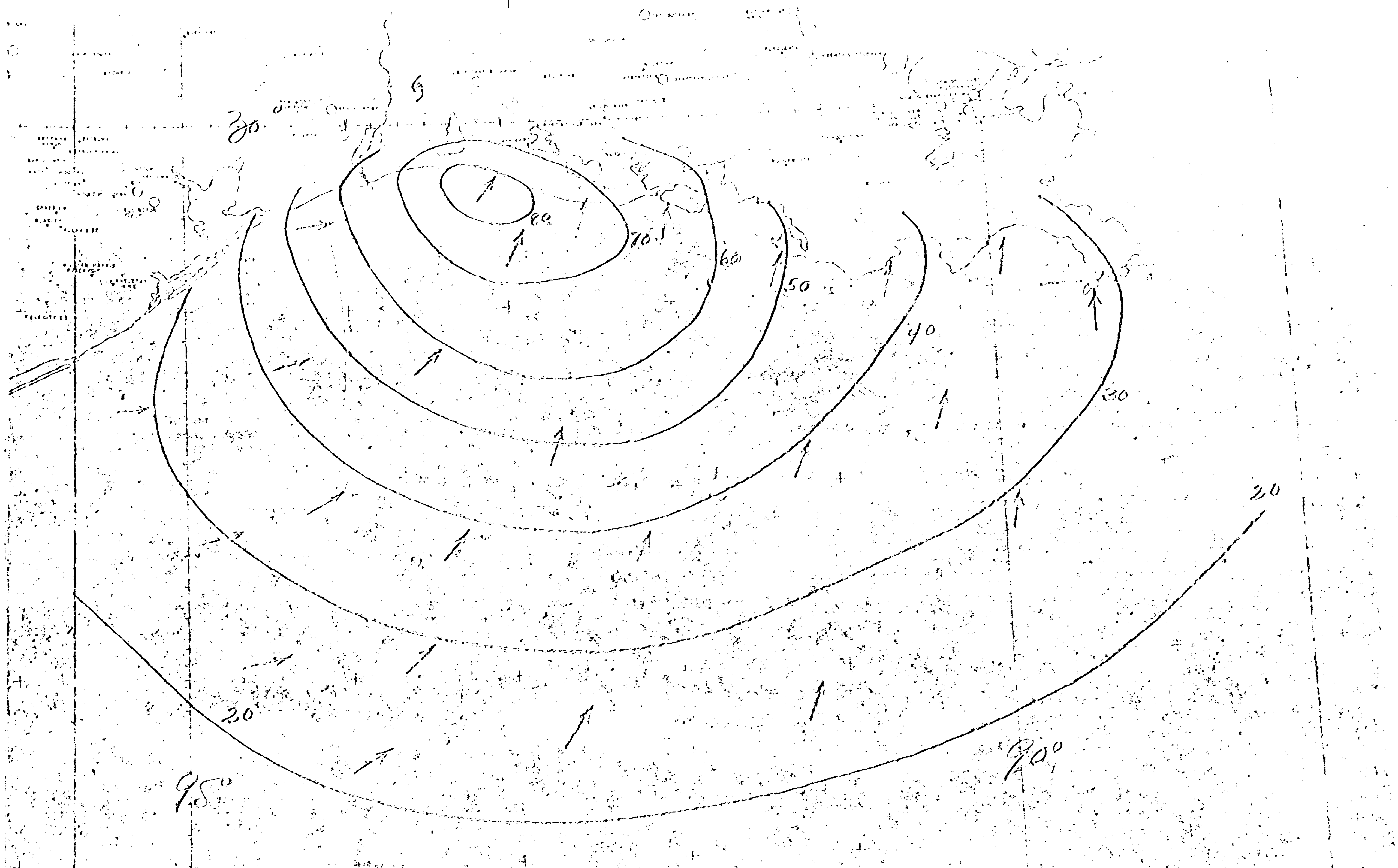



FIGURE 9
WIND SPEED (MPH) AND DIRECTION
(30 ft. over water)
June 27, 1957

1100 CST

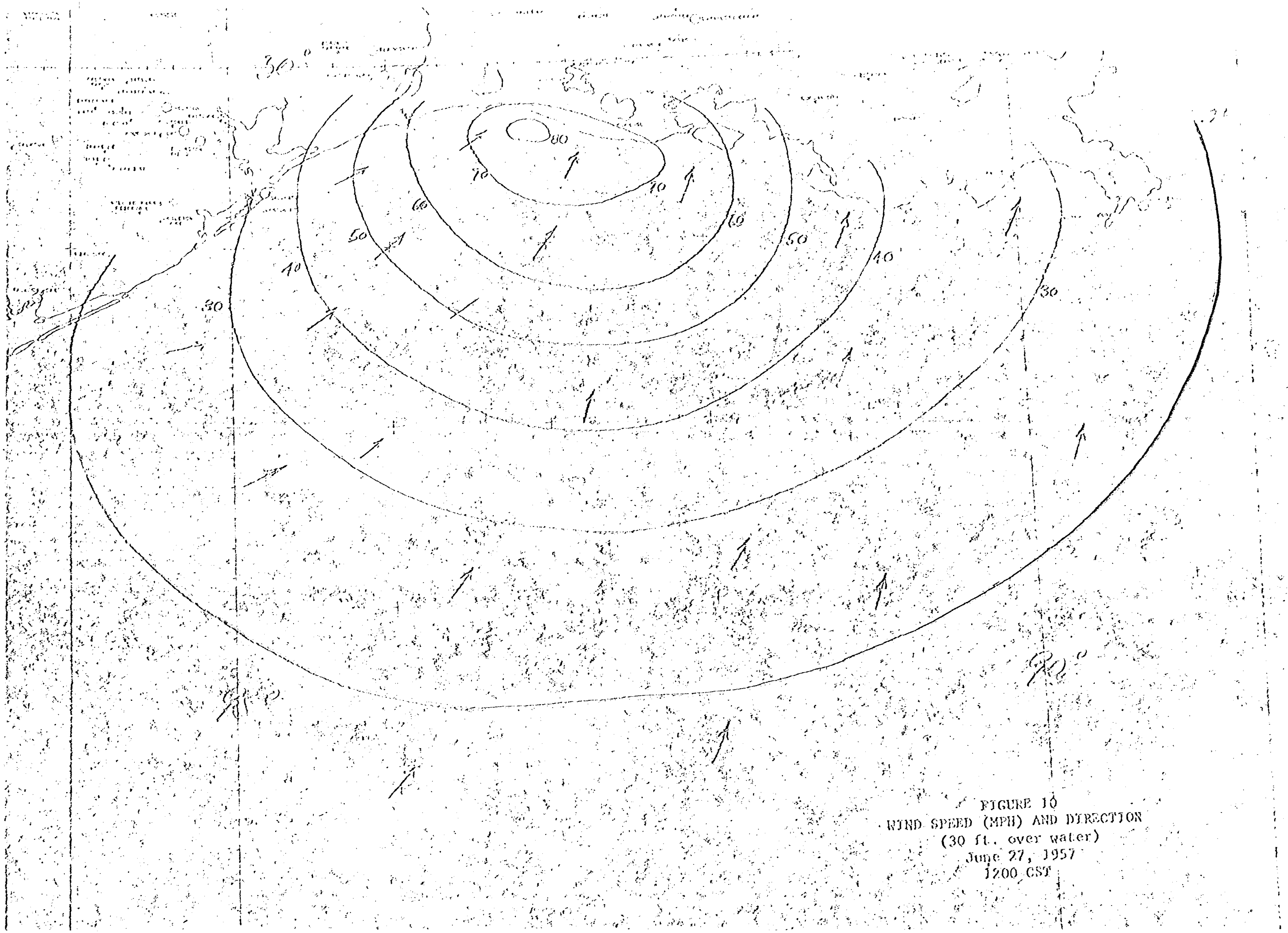



FIGURE 10
WIND SPEED (MPH) AND DIRECTION
(30 ft. over water)
June 27, 1957
1200 CST

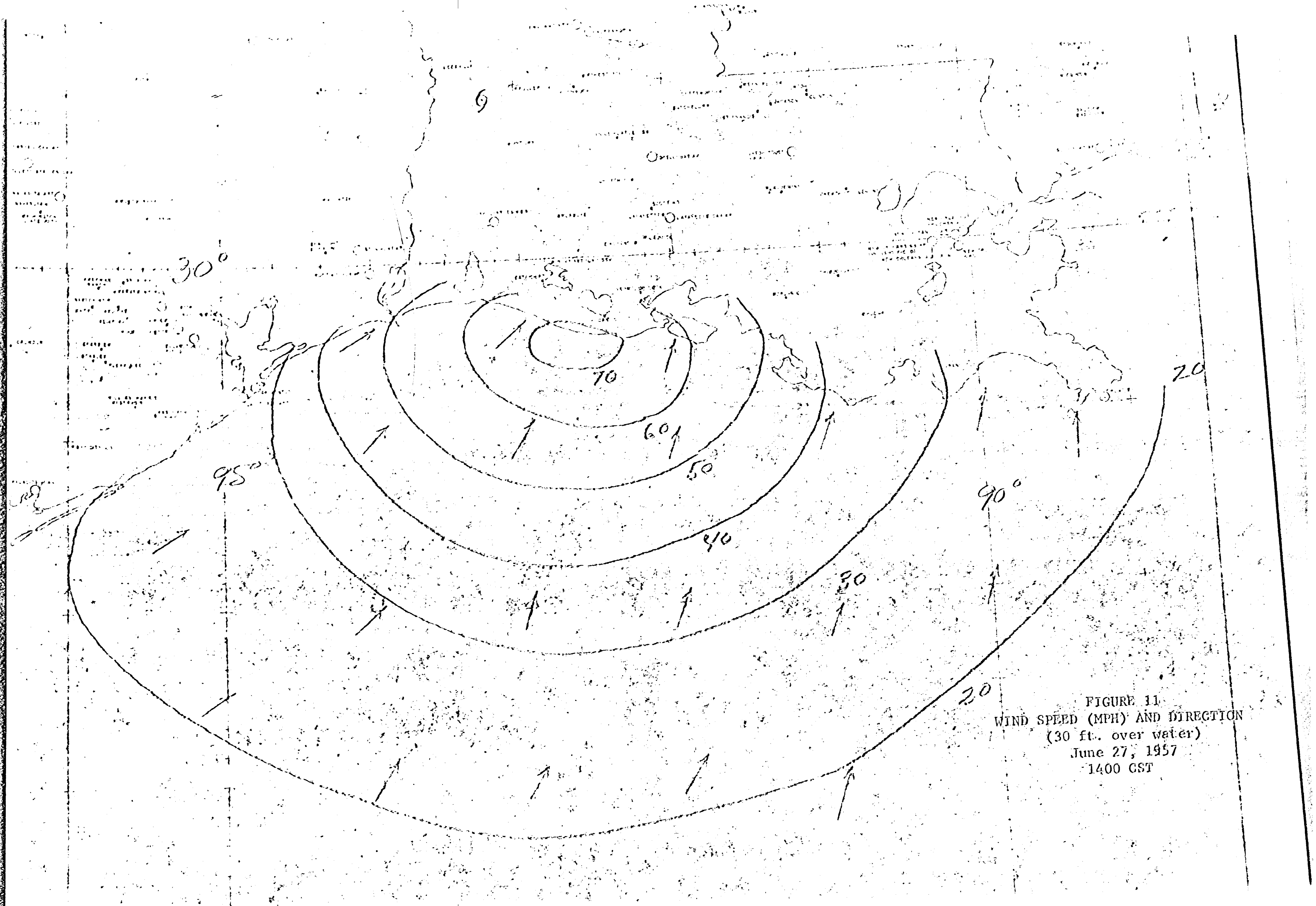



FIGURE 11
WIND SPEED (MPH) AND DIRECTION
(30 ft. over water)
June 27, 1957
1400 CST

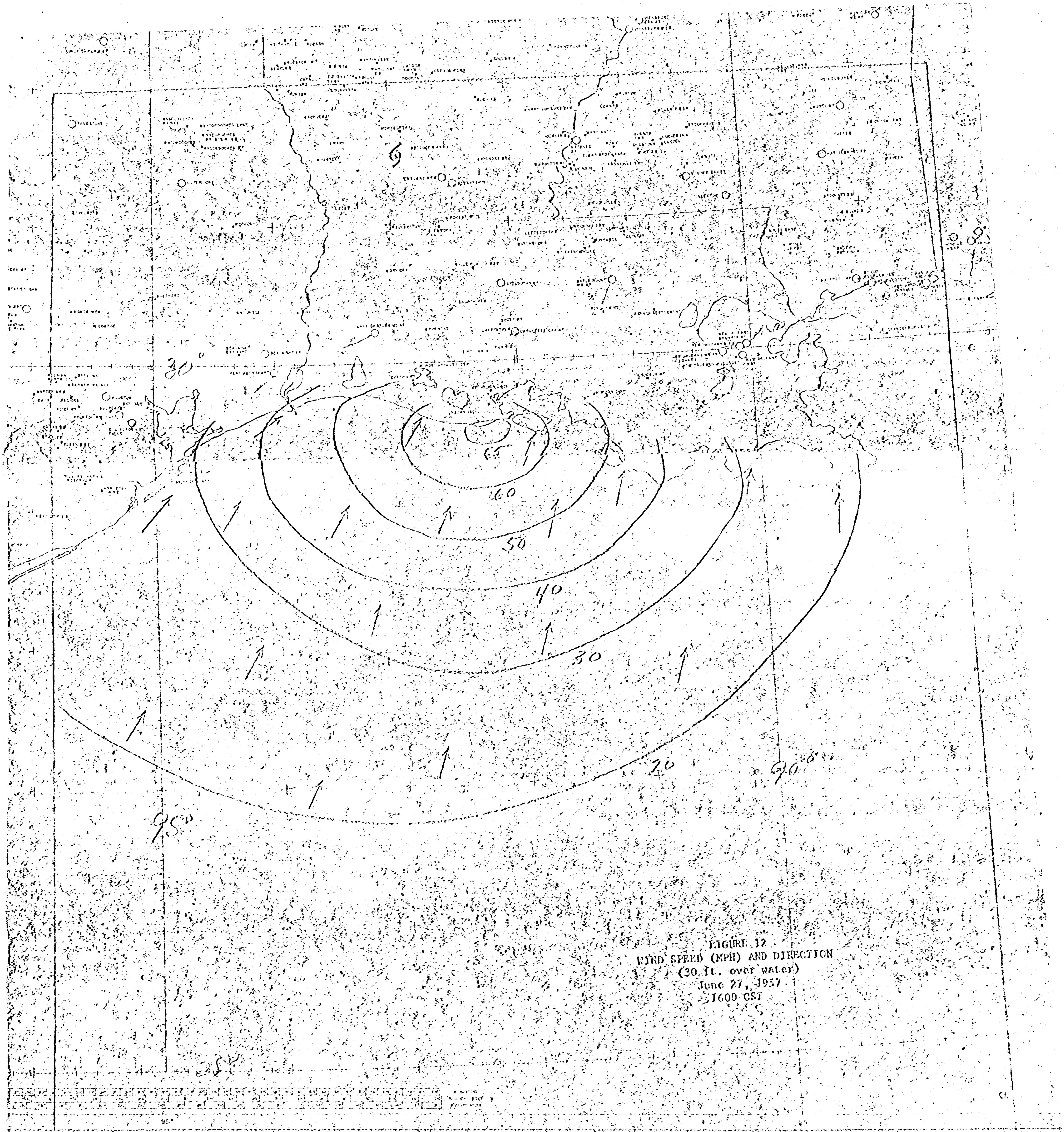



FIGURE 12
WIND SPEED (MPH) AND DIRECTION
(30 ft. over water)
June 27, 1957
1600 CST

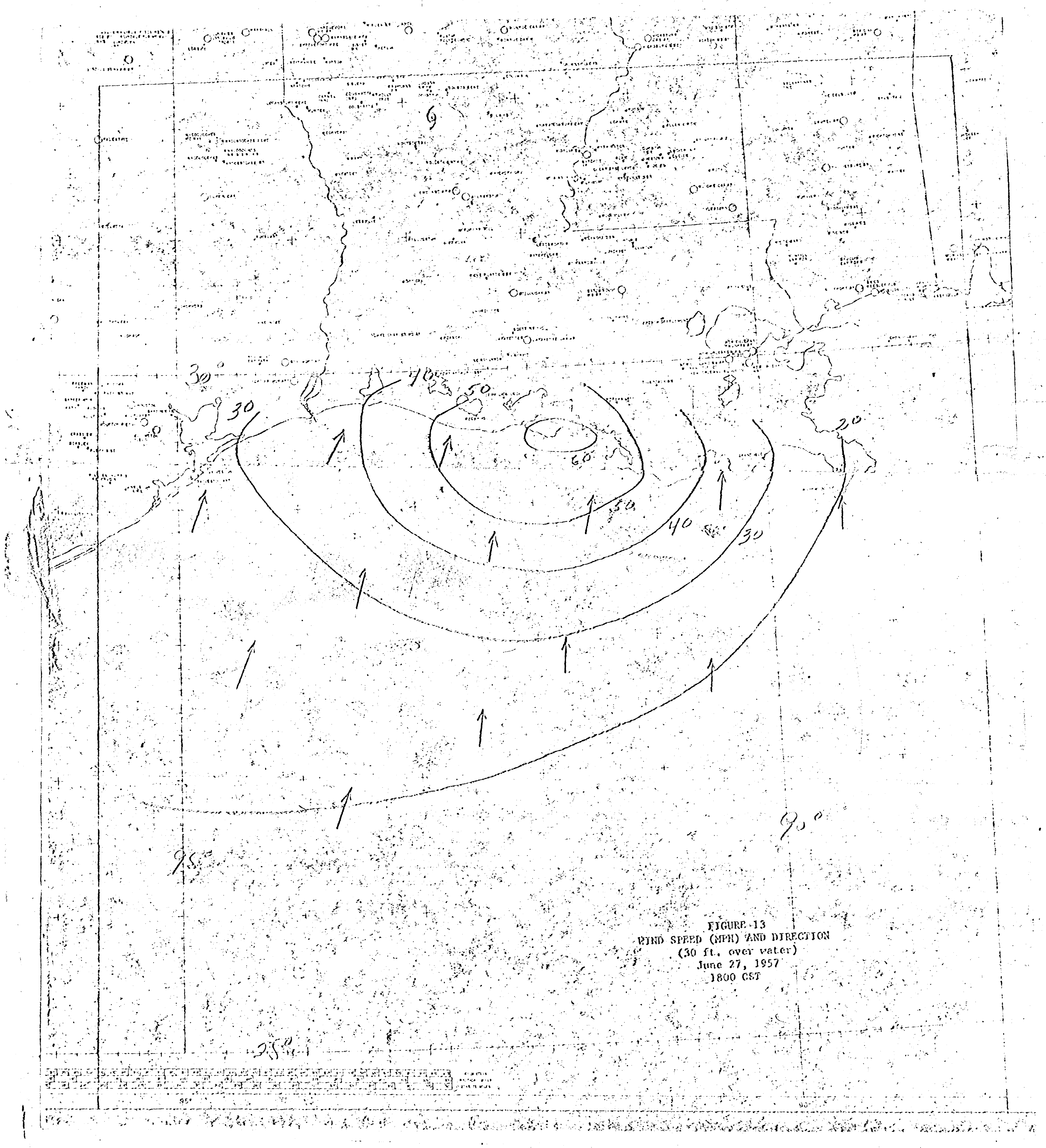



FIGURE 13
WIND SPEED (MPH) AND DIRECTION
(30 ft. over water)
June 27, 1957
1800 CST

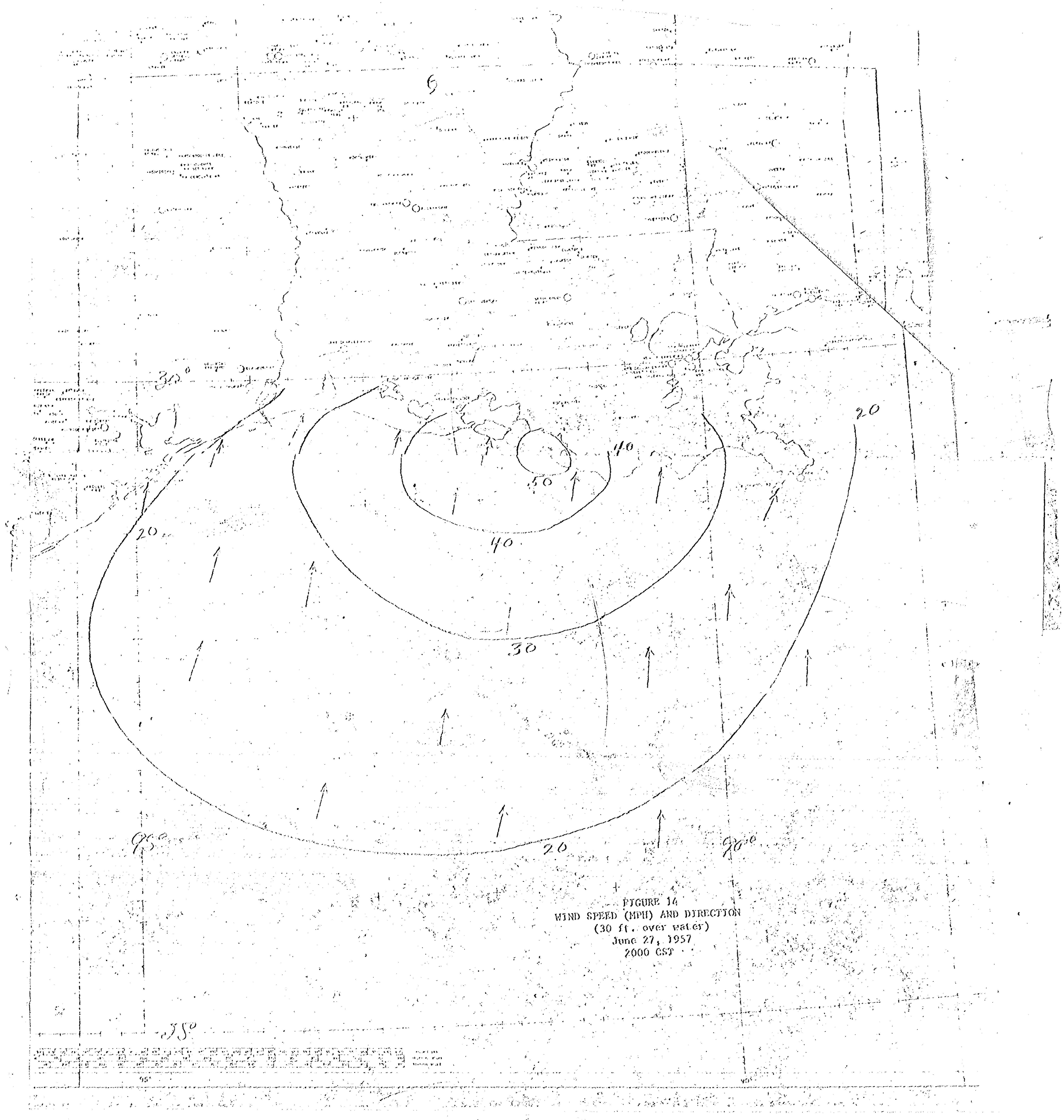



FIGURE 14
WIND SPEED (MPH) AND DIRECTION
(30 ft. over water)
June 27, 1957
2000 CST

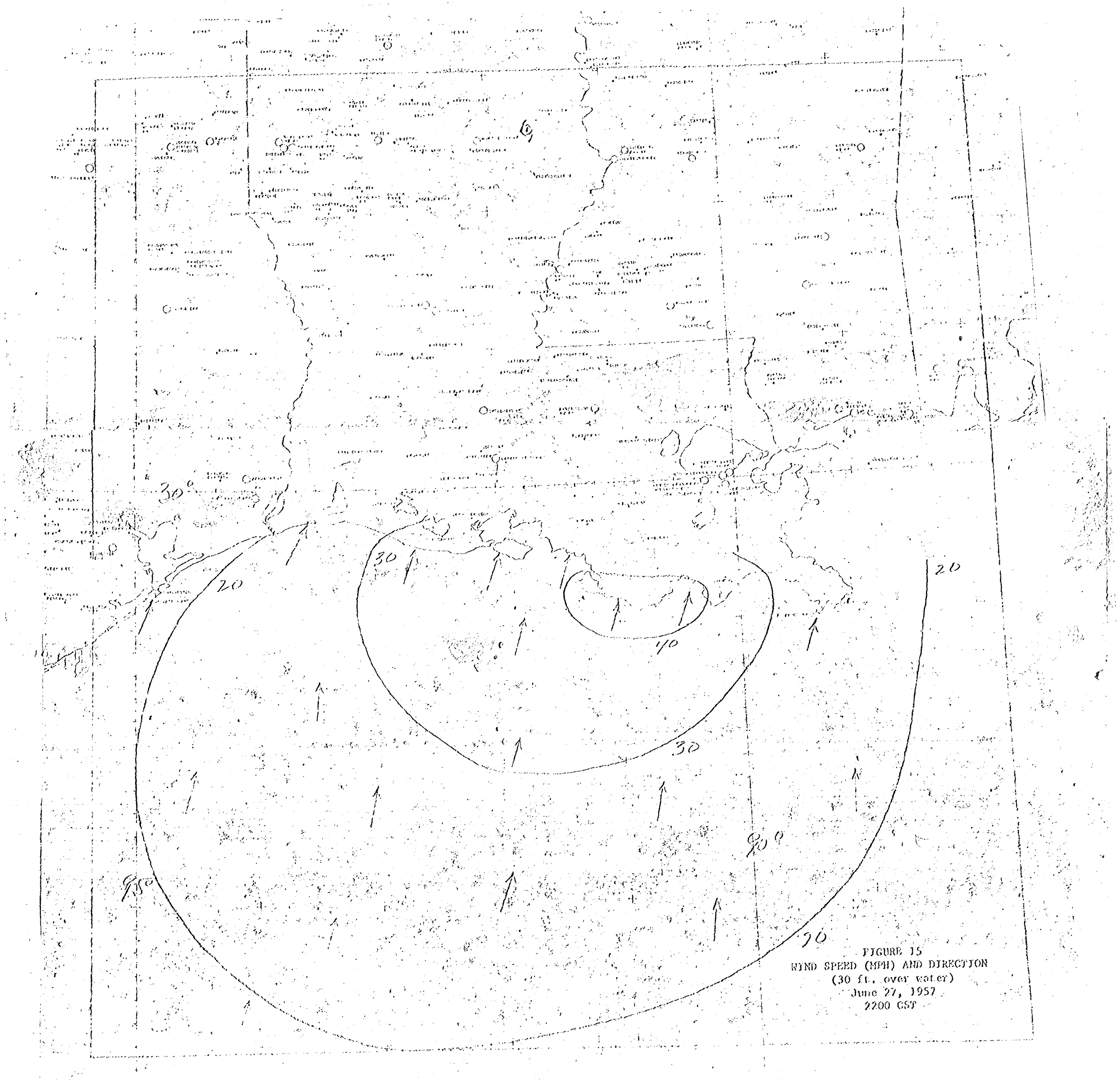



FIGURE 15
WIND SPEED (MPH) AND DIRECTION
(30 ft. over water)
June 27, 1957
2200 CST

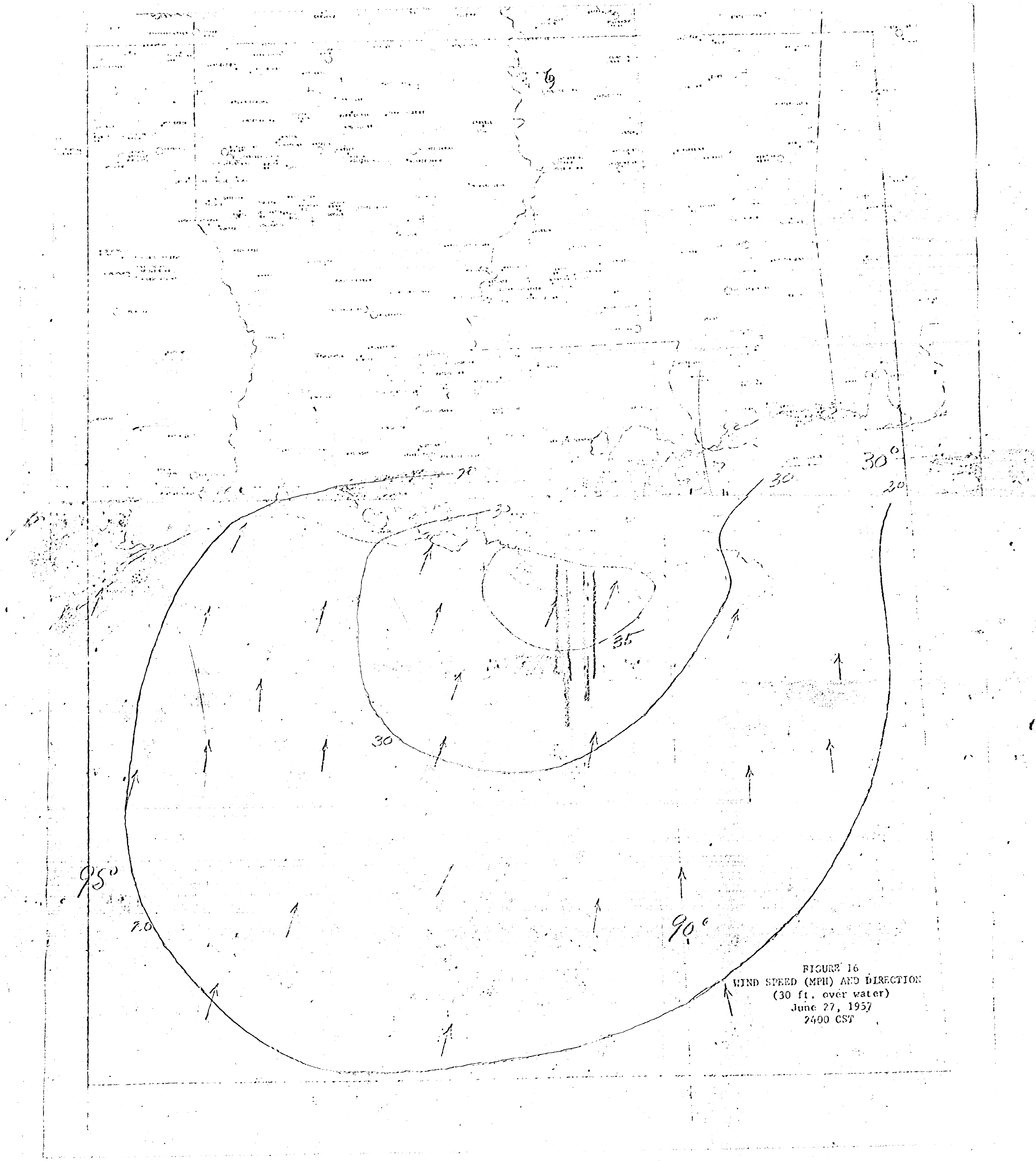



FIGURE 16
WIND SPEED (MPH) AND DIRECTION
(30 ft. over water)
June 27, 1957
2400 CST

UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
WASHINGTON

March 24, 1958

IN REPLY, PLEASE ADDRESS
CHIEF, U. S. WEATHER BUREAU
WASHINGTON 25, D. C.
AND REFER TO

0-6.12

MEMORANDUM TO THE CORPS OF ENGINEERS

HUR 7-51

FROM : Hydrometeorological Section

SUBJECT : Pressures, Wind Speeds and Directions in Hurricane Audrey near the Louisiana Coast, June 27, 1957

## Introduction

Hurricane Audrey of June 27, 1957, one of the most destructive June hurricanes of record, moved inland near the Texas-Louisiana border causing disastrous storm tides along the coast. Greatest destruction from tides and winds extended from Sabine Lake, Tex., to Cote Blanche Bay, La. The death toll in this area is estimated at about 400 and damage at $150,000,000*. As an aid in computing storm surge hydrographs, a detailed wind and pressure analysis of this storm has been made.

## Track

Hurricane Audrey was first reported as a tropical depression in the Bay of Campeche on June 24, 1957. The storm increased to hurricane intensity on the 25th and then moved northward, the center crossing the Louisiana coast at about 0830 CST June 27 midway between Sabine, Tex. and Cameron, La. The storm began recurvature to the northeast about the time it passed inland.

The smoothed track of the hurricane center is shown in figure 1. Over the Gulf of Mexico, hourly positions of the storm center along the track were determined largely from aircraft reconnaissance reports and land based radar reports. Over land, the hourly positions were determined from reports of calms and from radar reports. As the hurricane center crossed the coast, the radar eye was reported to be larger than the wind eye. However, the latter

---

* Weekly Weather and Crop Bulletin, U. S. Weather Bureau. Vol. XVII, No. 26a

Incl 11

was contained within the radar eye. Reports of minimum pressures and wind shifts were also used in positioning the track by applying methods described in Hydrometeorological Report No. 32, "Characteristics of United States Hurricanes Pertinent to Levee Design for Lake Okeechobee, Florida."

## Pressure

There was no observation of the minimum pressure in the hurricane at the time the center moved inland. An indication of the central pressure at the coast was obtained by constructing an average sea-level pressure profile for the hurricane (figure 2) by the method described in Hydrometeorological Report No. 32, using the equation

$$\frac{P - P_o}{P_n - P_o} = e^{-\frac{R}{r}}$$

where $P_o$ = central pressure, $P_n$ = asymptotic pressure, R = radius to area of maximum winds, and P = pressure at distance r.

In this method, which assumes a circular storm, an exponential profile defined by the above formula is fitted to a visually-drawn radial pressure profile of the storm most exactly for the inner portion and less exactly for the entire profile in order to minimize the error in $P_o$.

The lowest observed pressure in the hurricane, 28.30 in. at Hackberry, La., 12 nautical miles from the pressure center, was used as the innermost point of the visually-drawn profile when computing the exponential curve. The minimum observed pressure at Port Arthur, Tex., 28.52 in., 17 nautical miles from the pressure center, also fell on the exponential curve. Pressure distribution around Audrey as a whole was asymmetrical, but it was most nearly symmetrical within 60 nautical miles of the center. The exponential profile, shown as the heavy line in figure 2, was fitted to the visually-drawn profile of the symmetrical part of the hurricane. Beyond 60 nautical miles from the center, where the asymmetry was greater, the exponential curve departs from the visually-fitted curve.

A 70-percent confidence interval about the central pressure as extrapolated from the pressure observation nearest the pressure center can be read from figure 18, Hydrometeorological Report No. 32. This chart indicates that, assuming the observed pressure observations are placed the correct distance from the storm center, there is a 70-percent probability that the true central pressure in Hurricane Audrey lies between 27.15 in. and 28.35 in. This range is shown by the dashed lines in figure 2.

## Composite wind pattern

A composite over-water wind speed and direction pattern for the hurricane when it was off the Texas-Louisiana coast is shown in figure 4. The pattern was developed from ship reports, coastal observations and aircraft reconnaissance reports.

<u>Converting observations from time to space distribution</u>--To supplement the sparse offshore observations over the hurricane, wind observations from coastal stations adjusted to 30-ft over-water speeds were converted from a time to space distribution by plotting the data on a chart relative to the storm center and the direction of forward motion at the time of the observation (figure 3).

<u>Time periods for observations</u>--To construct the over-water wind speed pattern, ship observations of wind velocities for the period from 1500 CST June 26 to 1800 CST June 27 and wind velocities at coastal Weather Bureau stations at hourly intervals for the period from 1800 CST June 26 through 1800 CST June 27 were plotted on the composite observation chart (figure 3). These periods of time were selected in order to obtain observations in all quadrants of the hurricane as it passed over the coastal stations. Wind reports made by the U. S. Coast Guard Stations at Sabine, Tex. and Cameron, La. were also plotted on the chart. However, since the values plotted on the chart represented sustained wind speeds, the peak gusts reported by four Continental Oil Co. oil barge tenders adrift off the coast southeast of Cameron were not plotted on the composite observation chart.

<u>Adjustments for intensity changes off the coast</u>--In constructing the composite wind speed pattern, no adjustments were made to the wind speed for the effects of deepening or filling as the storm center approached the coast. When the hurricane was over the Gulf, the data near the center were too limited to indicate the details of any changes in the central pressure. Nor were there marked changes over the outer portion of the storm where data were available to serve as a guide to the time or amount of change of intensity of the storm.

<u>Adjustments for filling after landfall of center</u>--The wind speeds observed at the coastal stations after the storm center had been over land and filling had occurred were adjusted upward to assumed corresponding values before landfall. The adjustments were by the factors in the following table adapted from a study of average filling rates for 11 hurricanes.

Table 1

FACTORS FOR INCREASING HURRICANE WINDS OBSERVED AFTER LANDFALL TO COMPENSATE FOR FILLING OVER LAND

| Time (hours) | Adjustment Ratio for Wind Speed |
|---|---|
| T (at coast) | 1.00 |
| T + 1 | 1.08 |
| T + 2 | 1.14 |
| T + 3 | 1.18 |
| T + 4 | 1.22 |
| T + 5 | 1.25 |
| T + 6 | 1.28 |
| T + 7 | 1.32 |
| T + 8 | 1.35 |

The time selected for T (landfall of center) was 0900 CST June 27.

Analysis of observations--Independent analyses were made from the ship reports and from the adjusted land station reports. The two analyses agreed very well in most areas. The final analysis (figure 4) was made by combining the first two analyses and comparing the resulting isovel pattern with the distribution of wind speeds in the hurricane as reported by aircraft reconnaissance. The final composite pattern shows a wind-speed maximum of over 100 mph in the right sector.

Radius of maximum winds

A radius of maximum winds of nineteen nautical miles was computed using the exponential formula from the preceding section. This value is supported by observed data. Neither Lake Charles, La. nor Port Arthur, Tex., which lay approximately 19 nautical miles to the right and left of the track of the storm center, respectively, reported a lull in the wind as the center passed closest to the station. Their peak winds occurred about the time the center passed closest to the station (figure 3). This would indicate that they lay at or outside the radius of maximum winds. The wind eye at the coast was reported to be less than 15 miles in diameter.* The U. S. Coast Guard at Sabine, Tex., 15 nautical miles west of the track, reported a decrease in the winds as the center passed by, and at Cameron, about 20 nautical miles to the east of the track, the Coast Guard reported that there was no decrease in speed. Therefore it is reasonable to assume that the average radius of maximum winds was within the area defined by the minimum distance of Lake Charles

---

* Report to Chief of Weather Bureau from Director, National Hurricane Research Project, July 6, 1957.

and Port Arthur from the center and the limits of the wind eye.

Isovel charts for various hours

Isovel charts are shown in figure 5 for 0000 CST June 27 when the storm was still over the Gulf, in figure 6 for 0600 CST June 27 when the center was nearer the coast, in figure 7 for 0800 CST when the center was at the coast, and in figure 8 for 1300 CST June 27 when the center had moved inland. For the first three charts it was assumed that no appreciable filling or deepening occurred from 0000 CST June 27 until after the storm center crossed the coast. The composite wind-speed pattern (figure 4) was superimposed on charts of the Gulf with the front sector of the pattern aligned in the direction of forward motion. The isovels along the coast were adjusted to off-water and off-land speeds. To construct the isovels off the coast at 1300 CST, when the storm had been inland for several hours, a new composite wind-speed pattern was constructed for that portion of the storm remaining over water by the method described above under composite wind pattern using observations from 1300 CST to 1800 CST, unadjusted for the effects of filling.

Wind direction

Wind directions in the storm are shown by the short arrows on the composite wind-speed and direction pattern, figure 4. Since the hurricane was not symmetrical, a standard wind deflection angle across circles around the center as used for some other hurricanes was not appropriate. A composite pressure pattern for the storm at the coast (not shown) was drawn by adding the pressure values to wind observations in the composite plot of the coastal stations used for the wind-speed analysis and then drawing isobars to these pressure values. The majority of the ship reports showed good agreement with directional arrows drawn at 25° to the tangent to the isobars, so this deflection angle was used over the whole storm. By 1500 CST June 27, after the storm center had moved over land, the isobar pattern changed, becoming elongated to the west instead of to the south. This change, and the recurvature of the hurricane to the northeast, gives an apparent increase in the deflection angle across the isobars of the composite observation chart (figure 3) for those observations that were made in the left rear quadrant after 1200 CST June 27. However, ship observations of wind directions made at 1200 CST and later that were compared to pressure analyses of the storm made at these times indicate that the wind in the portion of the storm over water was still blowing across the isobars at a deflection angle of approximately 25°.

A comparison of peak gusts with sustained wind speeds

A comparison of peak gusts with sustained wind speeds was made in order to evaluate unusually high speeds reported from four oil barge tenders and to find an empirical relationship between sustained over-water speeds and over-water peak gust speeds. Four oil barge tenders adrift southeast of Cameron during hurricane Audrey logged wind speeds up to 150 mph which were reported to be peak gusts. A comparison of these reports was made with the average wind speed and peak gusts recorded in the same area by the oil drill barge, Vinegaroon, and with the wind speed profile from the right forward sector of the composite wind speed pattern, (figure 4). The wind speed profile in the right forward sector of the storm was selected for comparison because the Vinegaroon record and the majority of the gusts reported by the tenders occurred while the vessels were in that sector.

Observations--A chart showing the estimated courses and hourly positions of four Continental Oil Co. tenders, the Sharpe, Bates, Reading, and Craig, and extracts from the logs of the vessels was prepared by the Continental Oil Co. The extracts from the logs covered a period of time from 0230 CST to 1830 CST June 27. It was reported that the wind speeds logged by the tenders were peak gusts read from anemometer dial indicators. The tenders were equipped with Bendix-Friez selsyn type anemometers located 65 ft above the water. The oil drill barge, Vinegaroon, owned by the Zapata Off-Shore Co. was equipped with a Bendix Aerovane recording anemometer. A copy of the Vinegaroon wind speed record was obtained for the period from the early morning of June 26 to 0600 CST June 27 when the record ended. The barge was located at approximately 29°38'N latitude, 93°05'W longitude during this period. The average wind speed for 15-minute intervals and the peak gusts for each interval were read from the Vinegaroon trace in the course of this study from 2300 CST June 26 until the record ended at 0600 CST June 27.

Comparison of the data--The comparison of the over-water peak gusts with 15-minute average over-water wind speeds recorded in the right sector of the hurricane by the barge Vinegaroon and with the wind-speed profile from the right forward section of the composite over-water wind speed pattern (figure 4) is shown in figure 9. The wind speeds were plotted at the distance of the observation from the hurricane center. At the same distance from the storm center, the speeds reported by the tenders are compared with the peak gust speeds recorded by the Vinegaroon. For sustained winds of 50 mph or higher, the peak gusts near the center of the storm averaged 40 to 50 percent more than the sustained winds. Speeds reported from the oil barge tender are comparable to reported peak gusts on the Vinegaroon. It is confirmed that the tender's wind speeds were peak gust speeds.

## Hurricane parameters

Hurricane parameters observed or computed for hurricane Audrey by the methods described in Hydrometeorological Report No. 32 are listed below.

## Hurricane Parameters

| Central Pressure, $P_o$ (inches) | Asymptotic Pressure, $P_n$ (inches) Computed | Asymptotic Pressure, $P_n$ (inches) Observed |
|---|---|---|
| 27.95* | 29.70* | 29.75** |

| Radius of Maximum Wind, R. (nau. miles) Computed | Radius of Maximum Wind, R. (nau. miles) Observed | Average Maximum Gradient Wind, $V_{gx}$ ## (mph) |
|---|---|---|
| 19* | 16-19# | 95 |

| 4-Hour Average Forward Speed at the Coast, C (knots) |
|---|
| 14 |

| Lowest Observed Pressure On Land, $P_a$ | Station | Minimum Distance from Station Storm Track, $r_a$ (nau. miles) |
|---|---|---|
| 28.30 | U. S. Wildlife Service, Hackberry, La. | 12 |

* Computed with the exponential formula

** Observed on weather charts

\# Estimated from miscellaneous wind observations

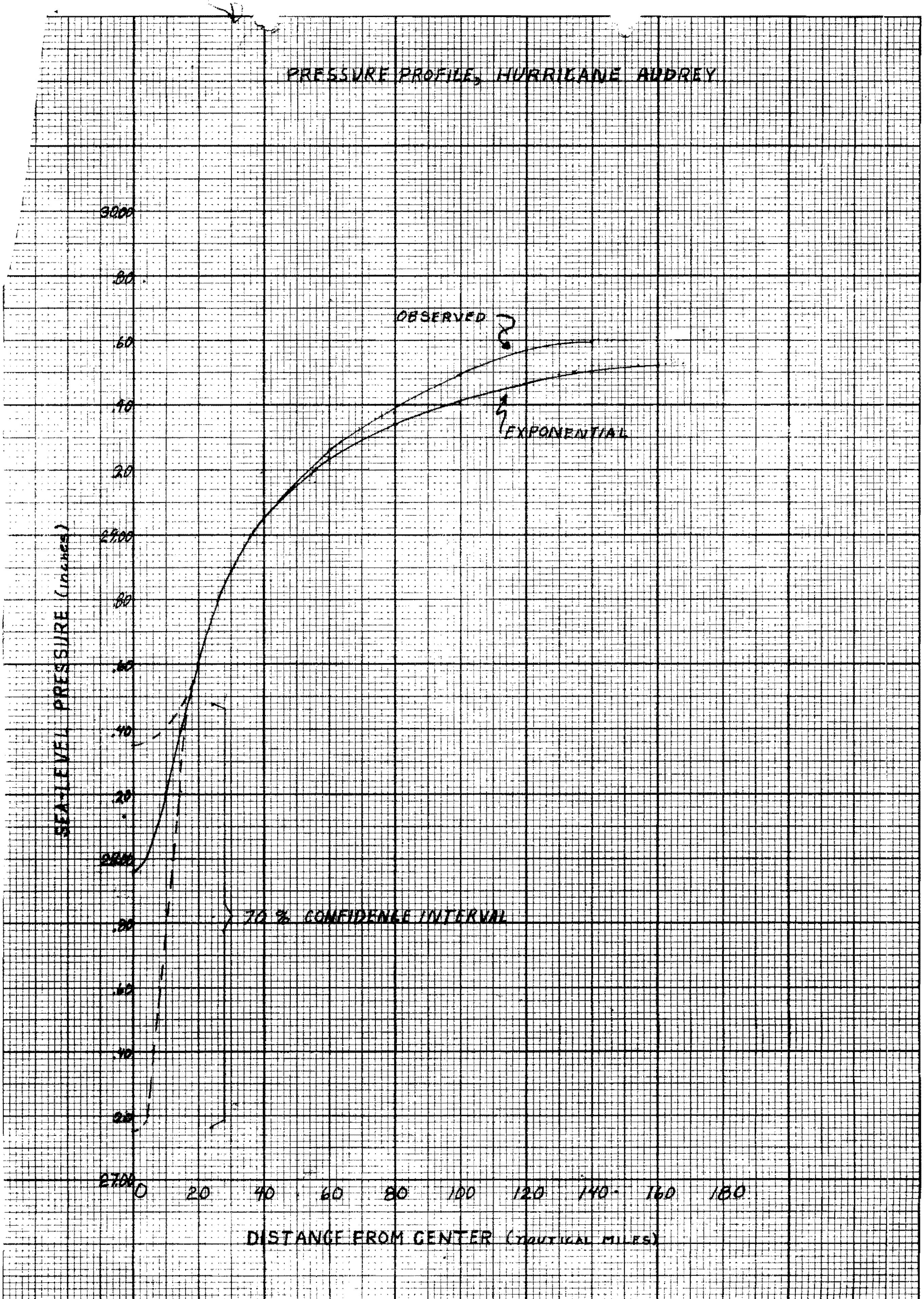
\## The computed maximum gradient wind represents an average speed at the radius of maximum wind. Because of the asymmetry of the pressure field of this hurricane the highest observed winds adjusted to 30-ft over-water winds are greater than the average maximum gradient wind. The average of the wind speeds read at eight points around the center at the radius of maximum winds (figure 2) is 82 mph. This value is equivalent to the average maximum gradient wind speed, 95 mph, reduced to 30-ft over-water speed using the factor of 86.5% taken from figure 26, Hydrometeorological Report No. 32.

Charles S. Gilman

Charles S. Gilman, Chief
Hydrometeorological Section

Copies:
10 to OCE
1 to BEB

[redacted] [redacted]




(use observed)

PRESSURE PROFILE, HURRICANE AUDREY
JUNE 26-27, 1957

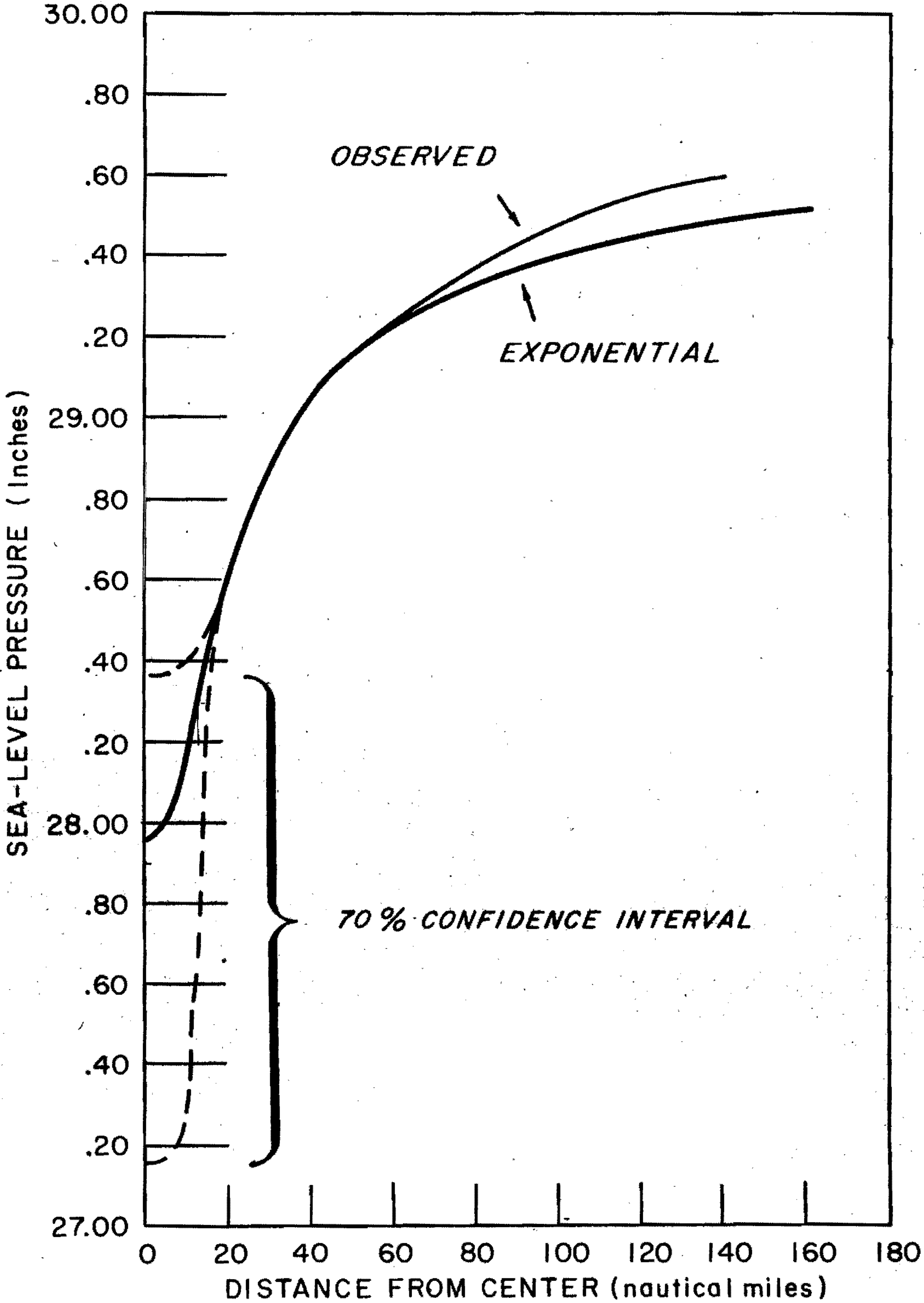



Figure 2

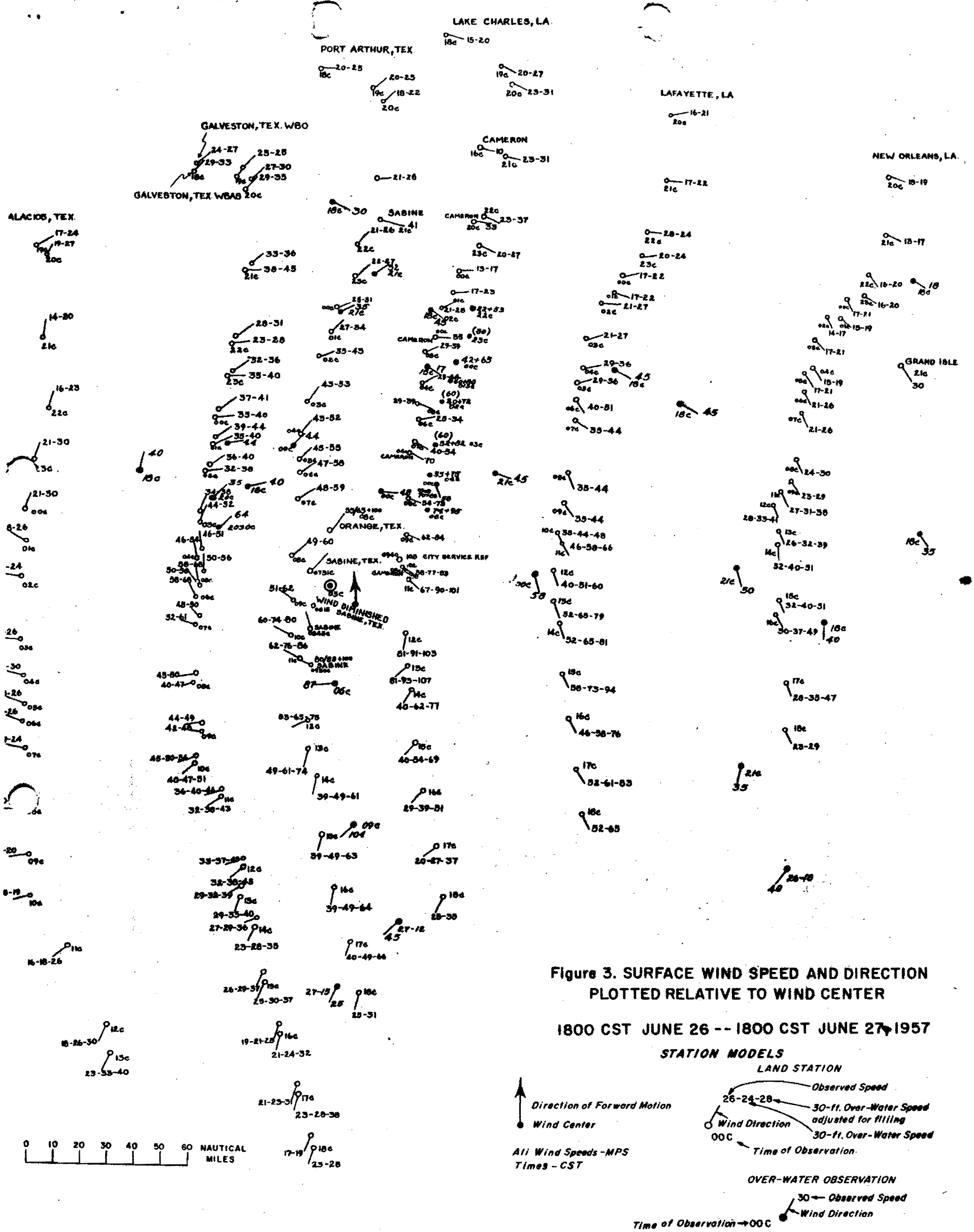



**Figure 3. SURFACE WIND SPEED AND DIRECTION PLOTTED RELATIVE TO WIND CENTER**

**1800 CST JUNE 26 -- 1800 CST JUNE 27, 1957**

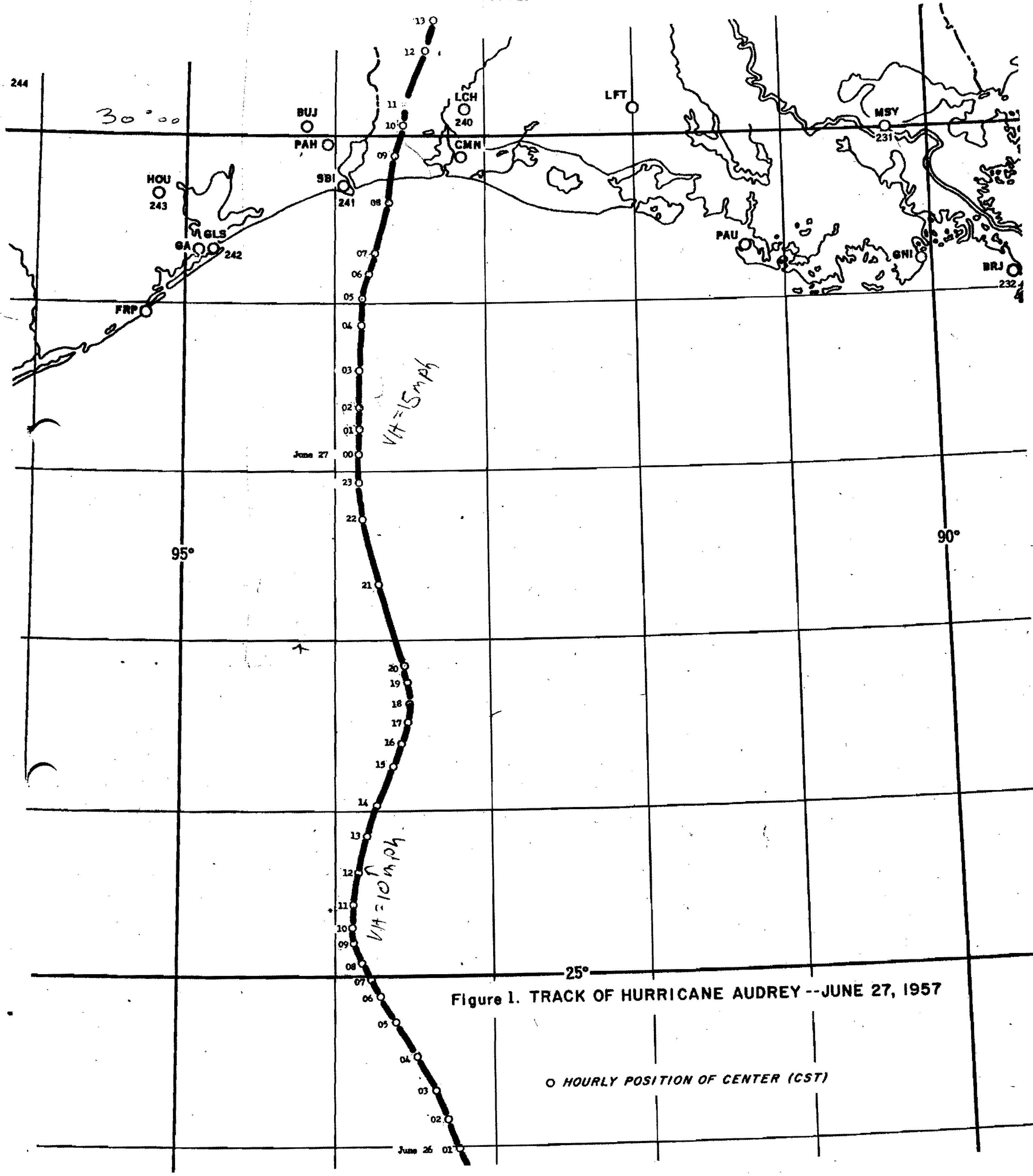


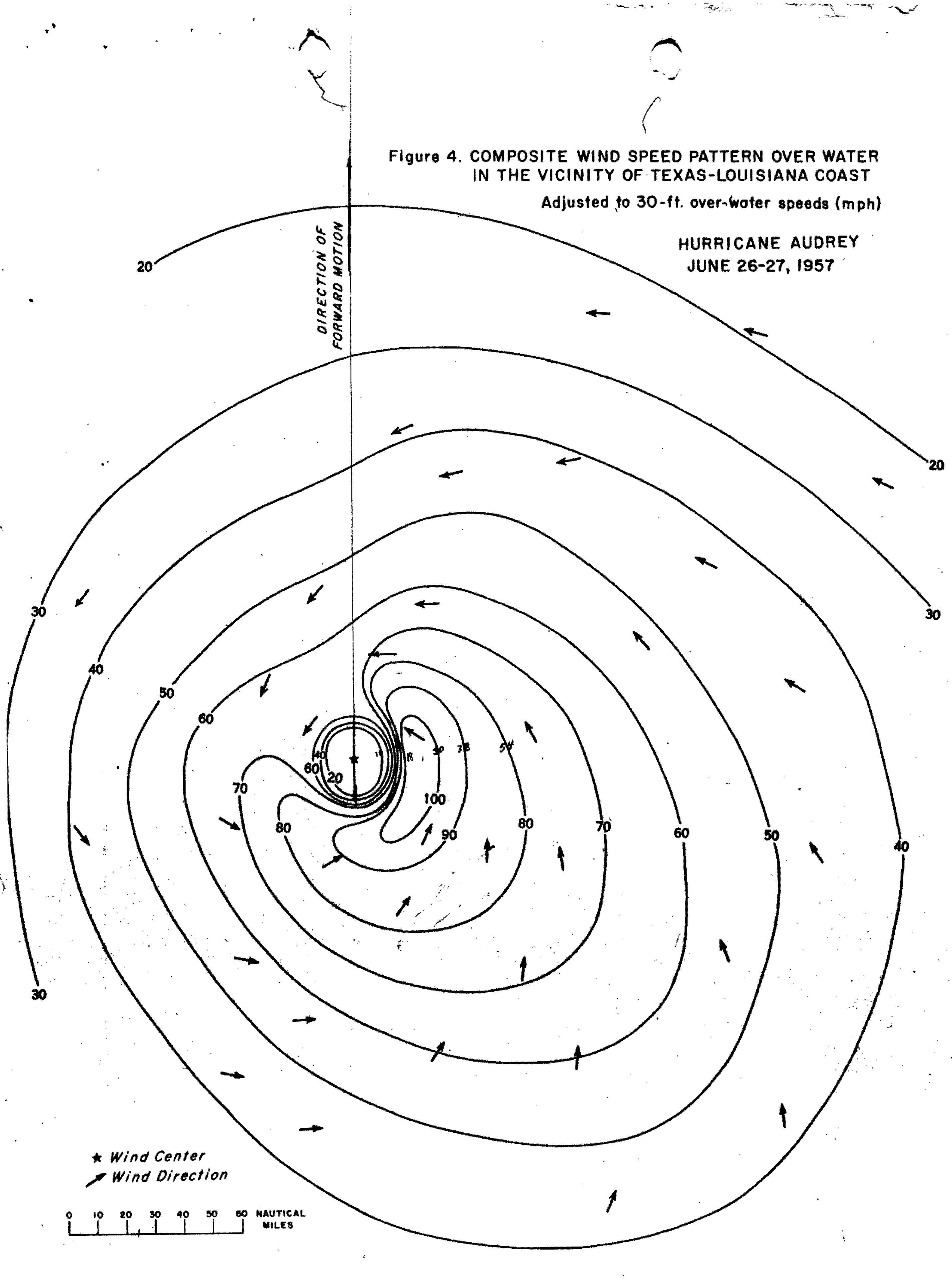

Figure 1. TRACK OF HURRICANE AUDREY --JUNE 27, 1957

o *HOURLY POSITION OF CENTER (CST)*

Figure 4. COMPOSITE WIND SPEED PATTERN OVER WATER IN THE VICINITY OF TEXAS-LOUISIANA COAST

Adjusted to 30-ft. over-water speeds (mph)

HURRICANE AUDREY
JUNE 26-27, 1957



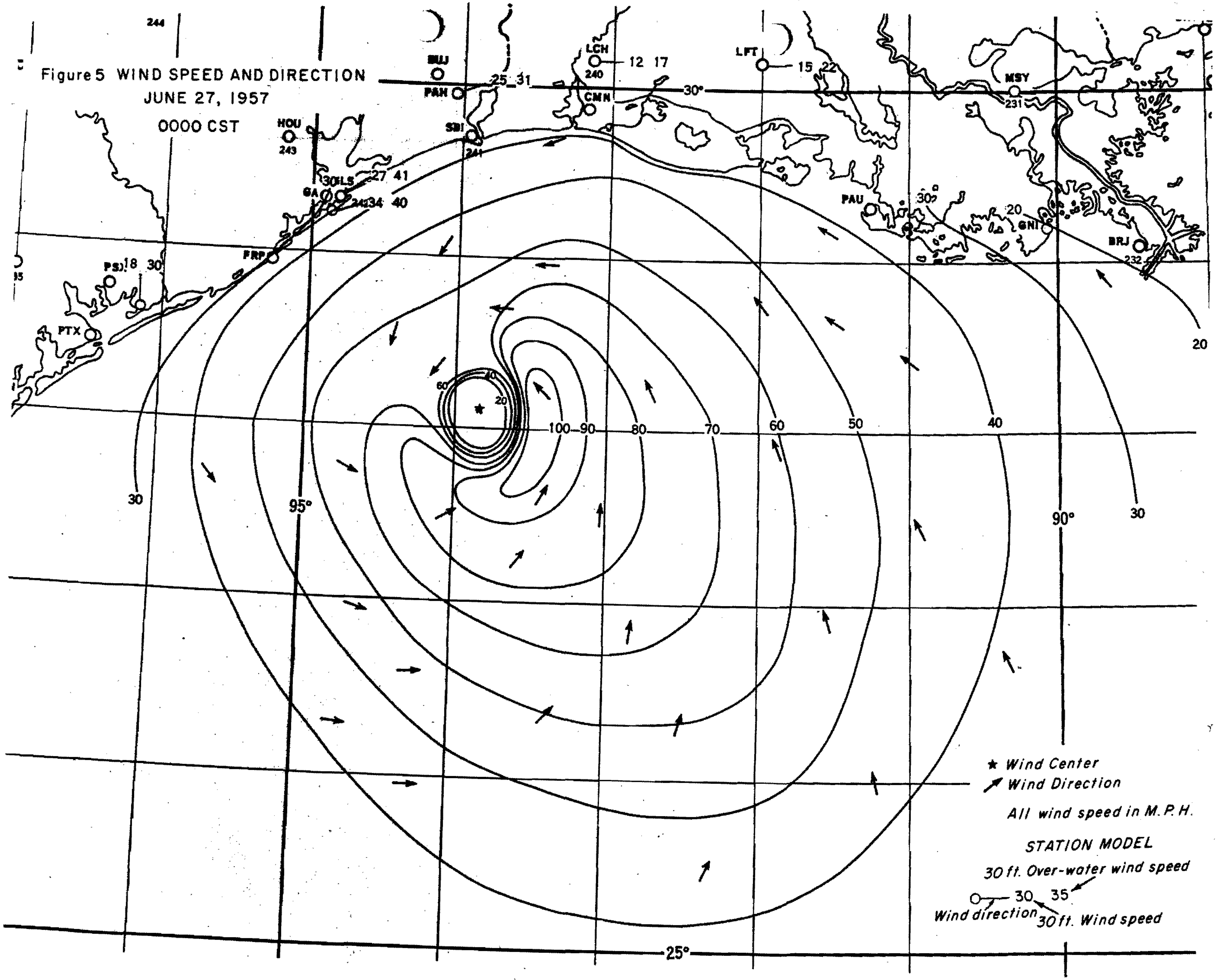



Figure 5 WIND SPEED AND DIRECTION
JUNE 27, 1957
0000 CST

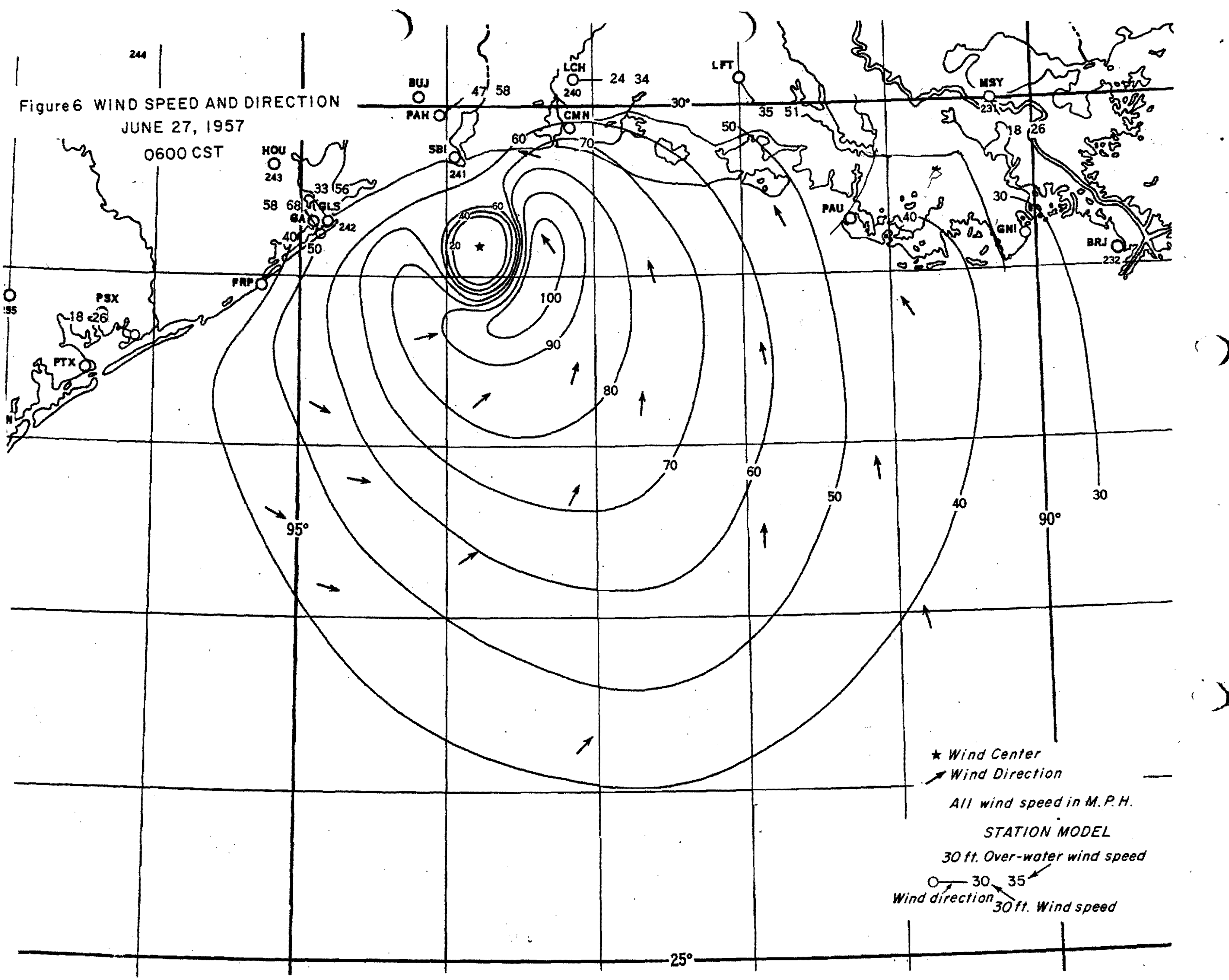



Figure 6 WIND SPEED AND DIRECTION
JUNE 27, 1957
0600 CST

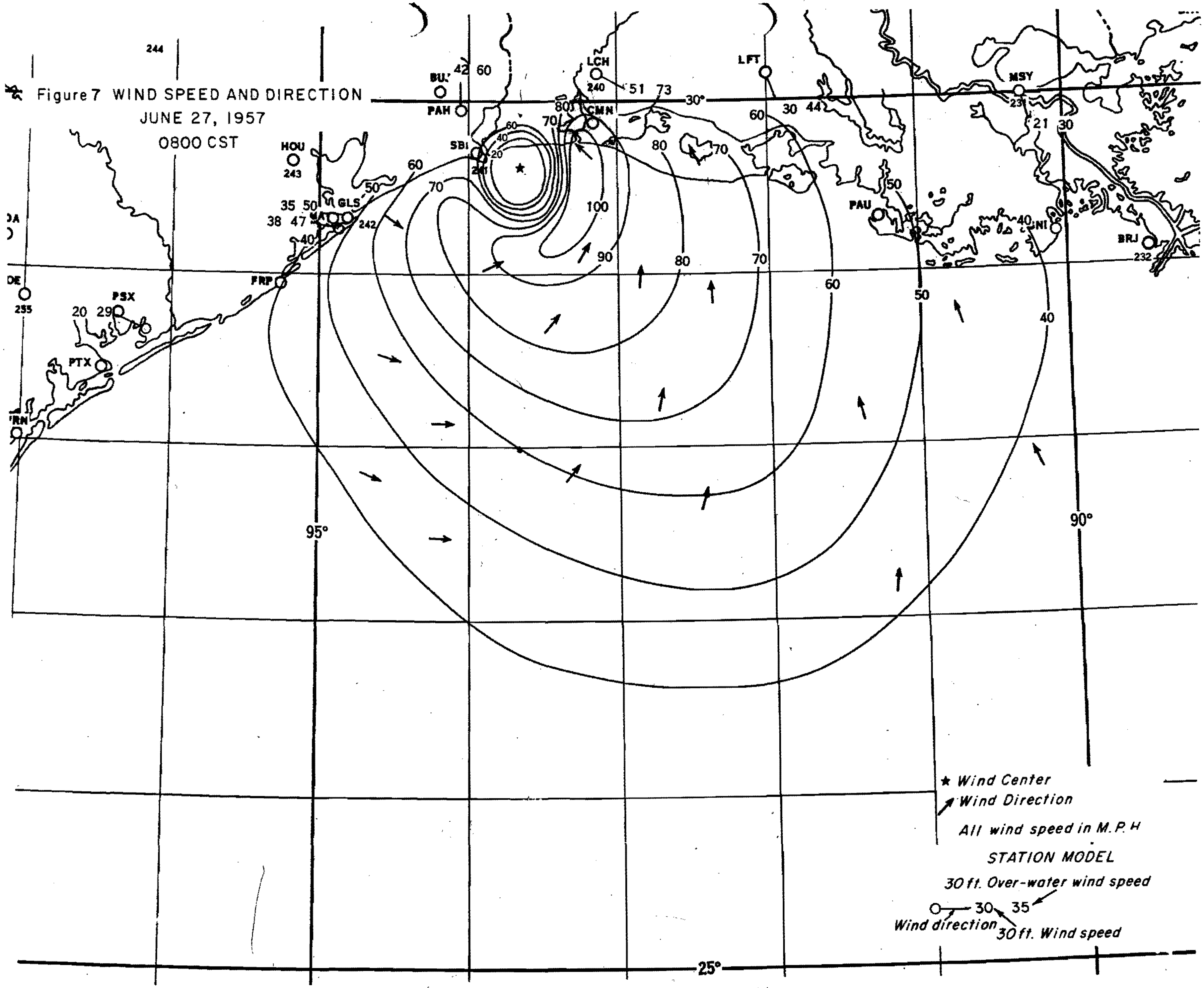



Figure 7 WIND SPEED AND DIRECTION
JUNE 27, 1957
0800 CST

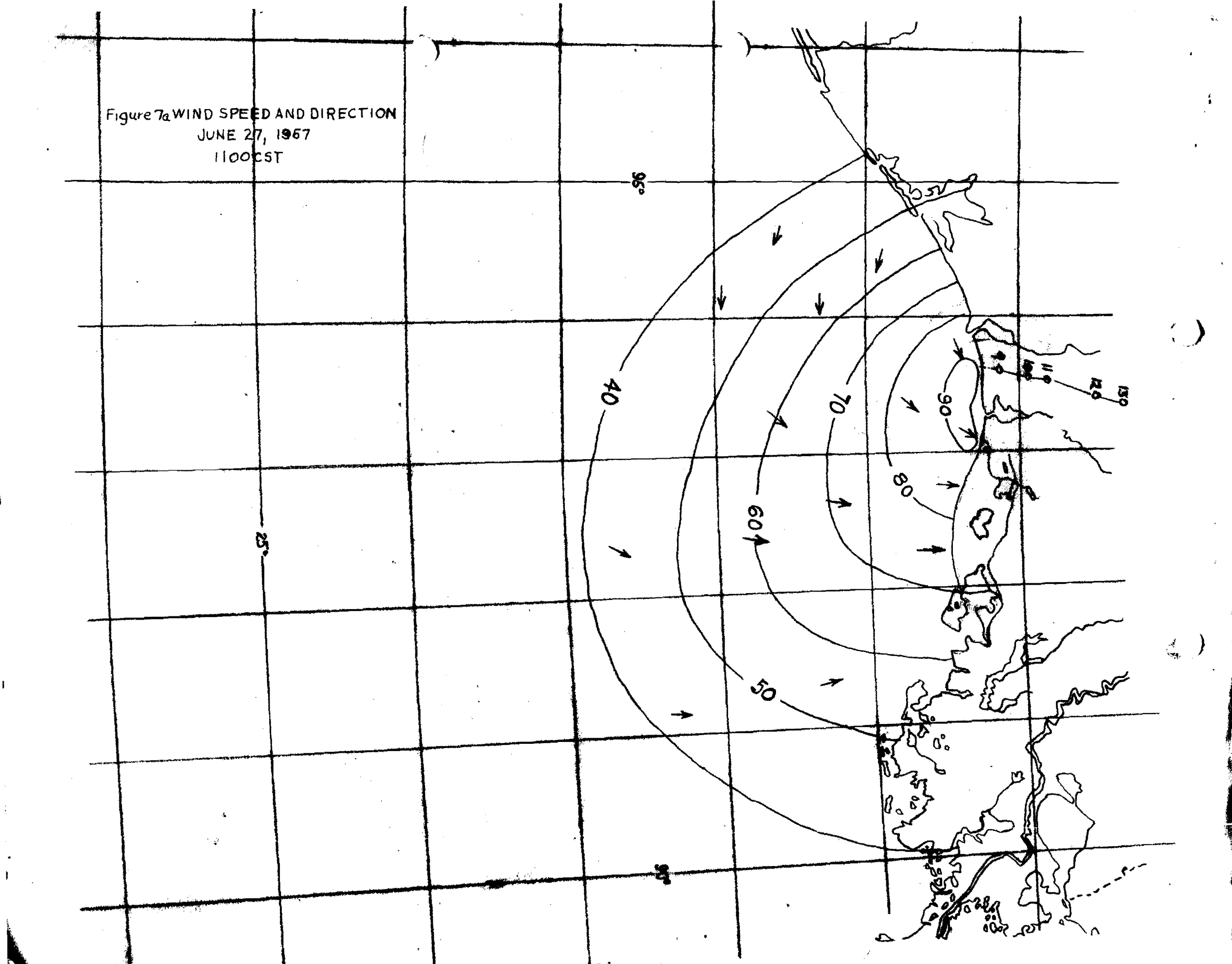



Figure 7a WIND SPEED AND DIRECTION
JUNE 27, 1967
1100 CST

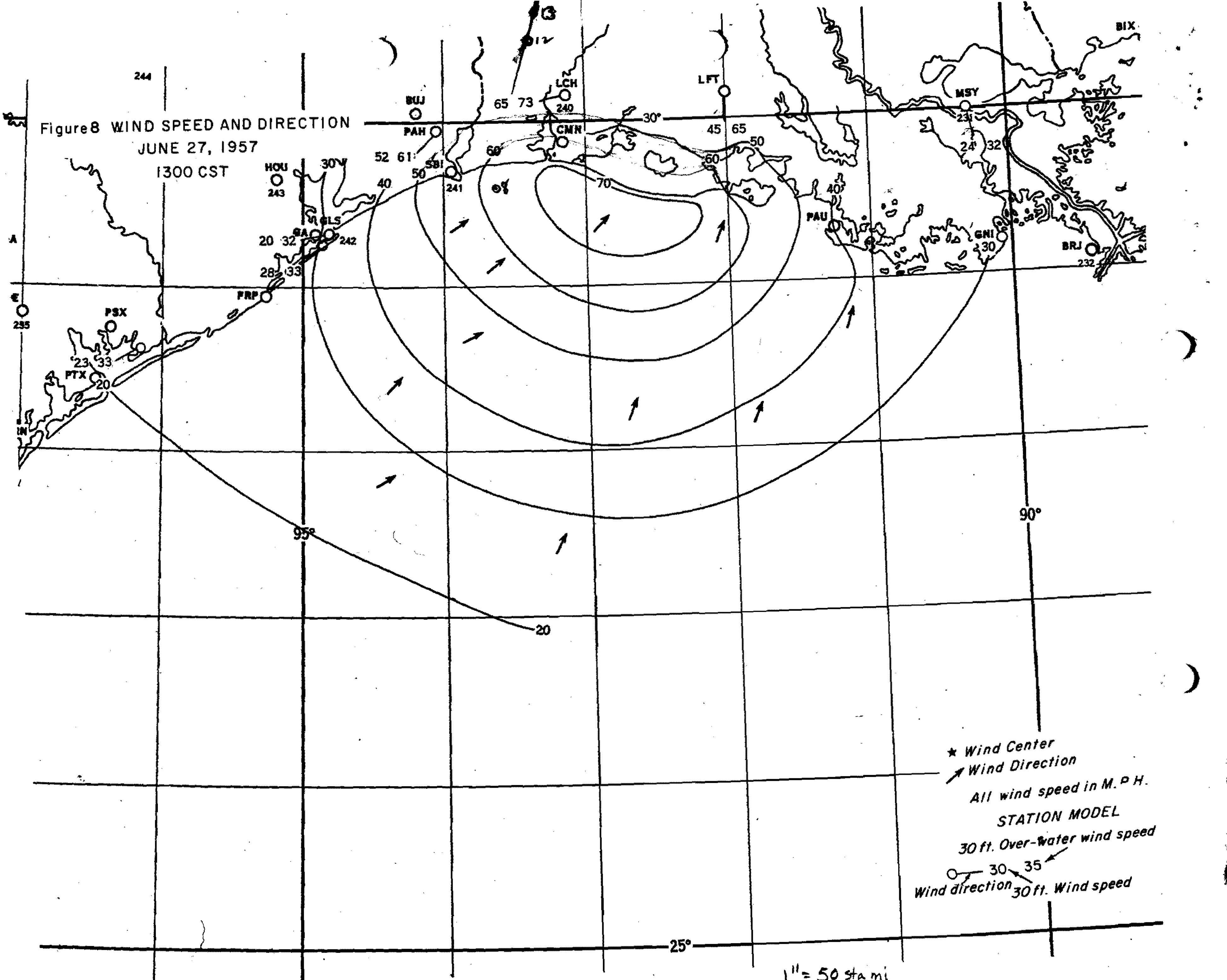



Figure 8 WIND SPEED AND DIRECTION
JUNE 27, 1957
1300 CST

COMPARISON OF PEAK GUSTS TO SUSTAINED WINDS
IN THE RIGHT SECTOR OF HURRICANE AUDREY, JUNE 27, 1957

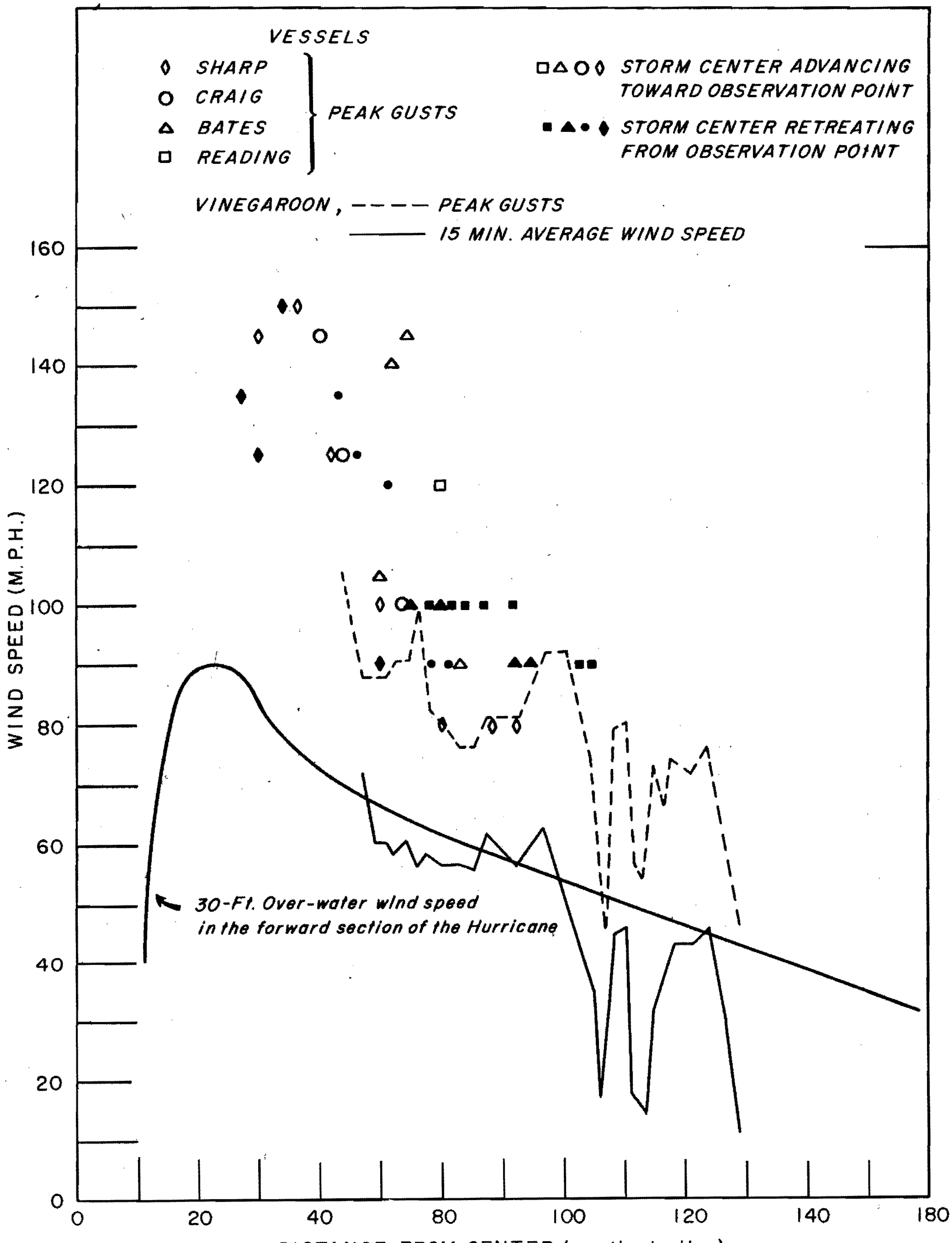



Figure 9

UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
WASHINGTON

December 6, 1957

IN REPLY PLEASE ADDRESS
CHIEF, U S WEATHER BUREAU
WASHINGTON 25, D. C.
AND REFER TO

0-6.12

MEMORANDUM TO CORPS OF ENGINEERS

HUR 7-45A

FROM : Hydrometeorological Section

SUBJECT: Standard Project Hurricane Isovels for a High Speed of Translation of the Hurricane Center, Gulf of Mexico Area, Zone C (Texas Coast)

References: (1) Telephone conversation, Messrs. Myers and Nunn, Nov. 1, 1957, regarding Standard Project Hurricane isovel patterns for a high rate of translation for Zones B and C (U.S. Gulf Coast)

(2) HUR 7-45, Standard Project Hurricane Parameters and Isovels, Gulf of Mexico Area, Zone C (Texas Coast)

This memorandum contains an isovel pattern for a Standard Project Hurricane in Zone C with a high speed of translation as requested in reference (1).

Isovel chart

A synthetically derived isovel chart for a Standard Project Hurricane with a central pressure of 27.42 in. and a high speed of translation has been developed for Zone C off the coast opposite Corpus Christi, Tex. This was done by imposing a degree of asymmetry to isotachs of gradient winds computed from pressure profile parameters and reduced to 30-ft. winds by empirical factors. The asymmetry factor, added to speeds on the right and subtracted from speeds on the left was $(0.5T)\cos a$ where $T$ was the representative high speed of translation of a Standard Project Hurricane in Zone C, 28 knots as shown in Table 1 reference (2), and $a$ the angle between the direction of forward motion and the wind direction.

A pattern showing the strongest winds in the right rear quadrant was selected as that most likely to occur by at least two authors. Isaac Cline in his book "Tropical Cyclones" states that "the wind velocities are much greater in the right half than in the left half of the cyclone

Incl #3

[redacted]

area, and the greatest sustained wind velocities occur as a rule in the right rear quadrant." L. A. Hughes has summarized a large number of reconnaissance flights ("On the Low-Level Structure of Tropical Storms," Journal of Meteorology, Dec. 1952) producing the best and most definitive composite low-level wind speed pattern yet available. The strongest winds are in the right rear quadrant in that pattern. Many variations may occur in the standard isovel pattern. To represent the many patterns that it would be reasonable to expect in Zone C, the isovels in the attached figure may be rotated with limits of 100° counterclockwise and 50° in a clockwise direction. The limits of rotation are indicated on the figure by dashed arrows extending outward from the wind center.

Variation of forward speed

The forward speed for a Standard Project Hurricane is chosen within or near the range of forward speeds shown in Table 1, reference (2). Forward speeds within these spans can be assumed to be independent of CPI and R. The attached isovel pattern computed for a forward speed of 28 knots is applicable for 20 knots to 40 knots although 28 knots is the fastest observed 4-hour average speed in the Gulf.

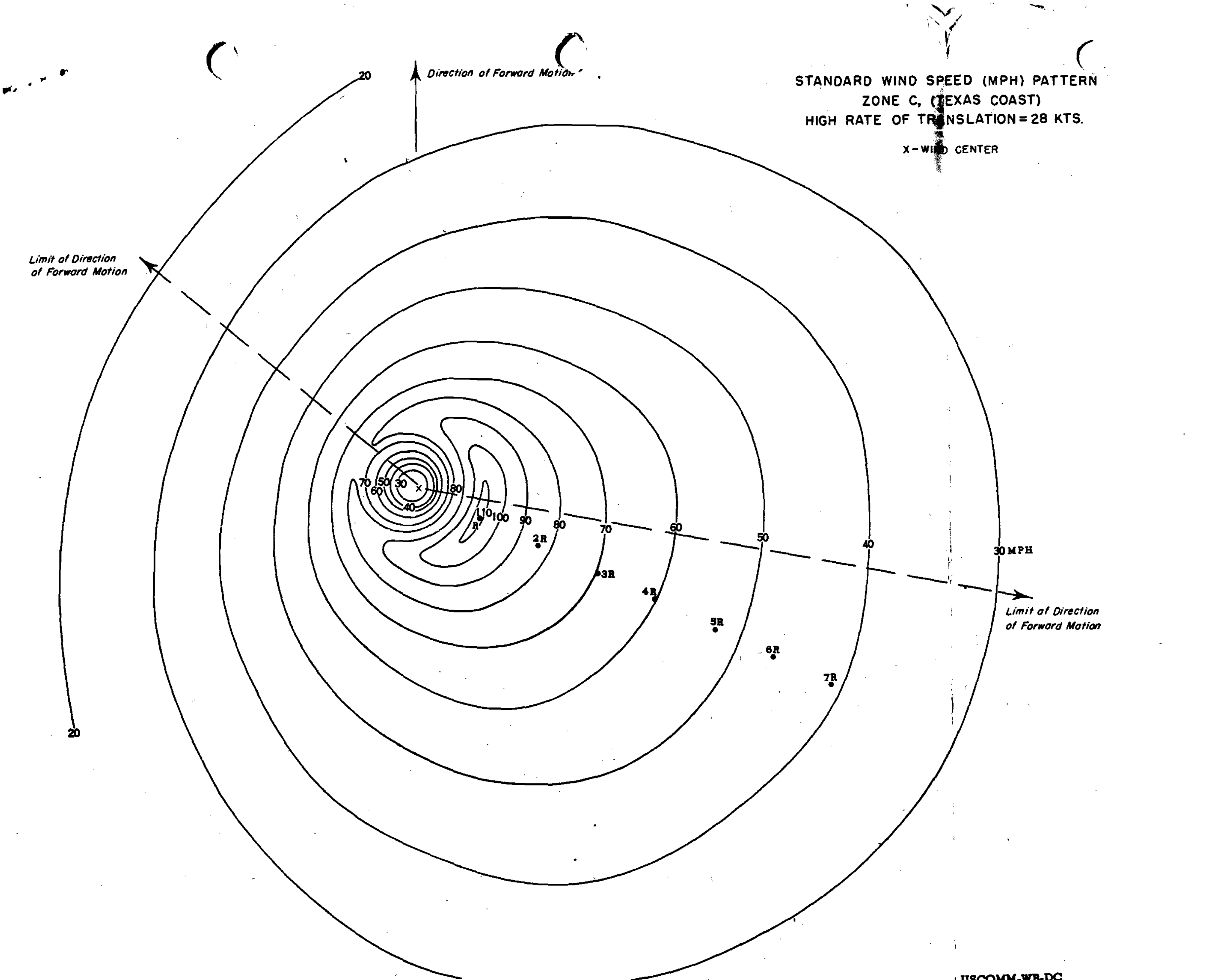
Other factors

Comments on variation in the radius of maximum wind, application to other Zone B locations, wind direction, the critical path, and adjustment for filling over land may be found in reference (2) to which this memorandum is supplementary.

Charles S. Gilman, Chief
Hydrometeorological Section

Attachments:

12 copies to OCE with attachments
1 to HEB with attachments


STANDARD WIND SPEED (MPH) PATTERN
ZONE C, (TEXAS COAST)
HIGH RATE OF TRANSLATION = 28 KTS.
X-WIND CENTER
Direction of Forward Motion
Limit of Direction of Forward Motion
Limit of Direction of Forward Motion
20
20
70
60
50
30
40
80
110
R
100
90
80
70
60
50
40
30 MPH
2R
3R
4R
5R
6R
7R

USCOMM-WB-DC

UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
WASHINGTON

October 16, 1957

IN REPLY, PLEASE ADDRESS
CHIEF, U. S. WEATHER BUREAU
WASHINGTON 25, D. C.
AND REFER TO

0-6.12

MEMORANDUM TO CORPS OF ENGINEERS

HUR 7-44

FROM : Hydrometeorological Section

SUBJECT: Standard Project Hurricane Isovel Patterns, Norfolk area

References: (1) Notes on conference on Hurricane Investigation Under P.L. 71, Downtown Norfolk area, Sept. 10 and 11, 1957
(2) HUR 2-1, Frequency of Central Pressure Indices along Atlantic Coast, June 18, 1957
(3) HUR 2-3, Hurricane Characteristics, Atlantic Coastal area, June 18, 1957
(4) HUR 7-43, Standard Project Hurricane Criteria and Isovel Patterns, East Coast U.S. Zone 3, in preparation

This memorandum shows isovel patterns for a Standard Project Hurricane (SPH) along a track critical for the Norfolk area.

## Track

The track, which is shown in figure 1, was proposed in conference (reference 1) and is critical for the Norfolk area. In all observed cases of wind-caused high water near Norfolk, the wind direction ranged generally from the northeast quarter. For an unusually high surge at Norfolk, the Hydrometeorological Section has been advised that strong winds must have a component down the Chesapeake Bay as well as into the mouth of the Bay from the Ocean. Moving the storm along the track shown in figure 1 meets these requirements.

## Wind Speed

### Derivation of isovel pattern

The basic synthetically derived isovel pattern for zone 3 is described in reference 4. In order to show the strongest winds from the critical direction, this basic isovel pattern (figure 3 of HUR 7-43) was turned 90° counterclockwise.

Incl 2

An isovel pattern showing the strongest winds in the right rear quadrant, as in reference 4, is believed to be the condition that most frequently occurs. That pattern is also an approximate mean of many possible variations. Figures 2 through 9 of this memorandum show one of the possible variations in individual tropical storms that is most critical for Norfolk. Further justification for placing the strongest winds to the northeast in the Norfolk SPH is that the maximum extent of strong winds is usually in the direction of the major anticyclone in the area. Such a track as shown in figure 1 would likely be associated with an anticyclone extending northeast of Norfolk, Va.

Parameters

The isovel charts were developed with the following characteristics.

Table 1

| Figure No. | $P_o$ | Radius to Region of Max. Winds (Nau. Mi.) | Forward Speed (mph) | 30-ft. over-water Max. Wind (mph) * |
|---|---|---|---|---|
| 2 | 27.55 | 34 | 23 | 104 |
| 3 | 27.55 | 34 | 23 | 104 |
| 4 | 27.55 | 34 | 23 | 104 |
| 5 | 27.55 | 34 | 23 | 104 |
| 6 | 27.55 | 34 | 23 | 104 |
| 7 | 28.07 | 34 | 23 | 97 |
| 8 | 28.27 | 34 | 23 | 92 |
| 9 | 28.44 | 34 | 23 | 88 |

*Based on formula, $V_{max} = 0.865\, V_{gx} + T/2$ where $V_{gx}$ = maximum gradient wind speed and T = forward speed of storm center in mph

Variation of forward speed

The wind speed patterns of figures 2-9 are empirical approximations and a high degree of refinement for forward speed is not warranted. The wind pattern was computed for a forward speed of 23 mph and can be used for forward speeds ranging from 12 to 50 mph.

Wind Direction

Wind directions at 30' are shown on the isovel charts by arrows. Because of the curving field, the direction is correct only at the arrow point. Wind directions may also be approximated from table 2.

Table 2

Wind Direction

| Radius | Deflection angle* |
|---|---|
| R to center | 20° |
| R to 1.2 R | Transition 20° to 25° |
| 1.2 R and beyond | 25° |

*Angle between true wind direction and a tangent to a circle with center at the wind center.

Vance A. Myers.
for Charles S. Gilman, Chief
Hydrometeorological Section

3 copies to OCE
1 copy to BEB

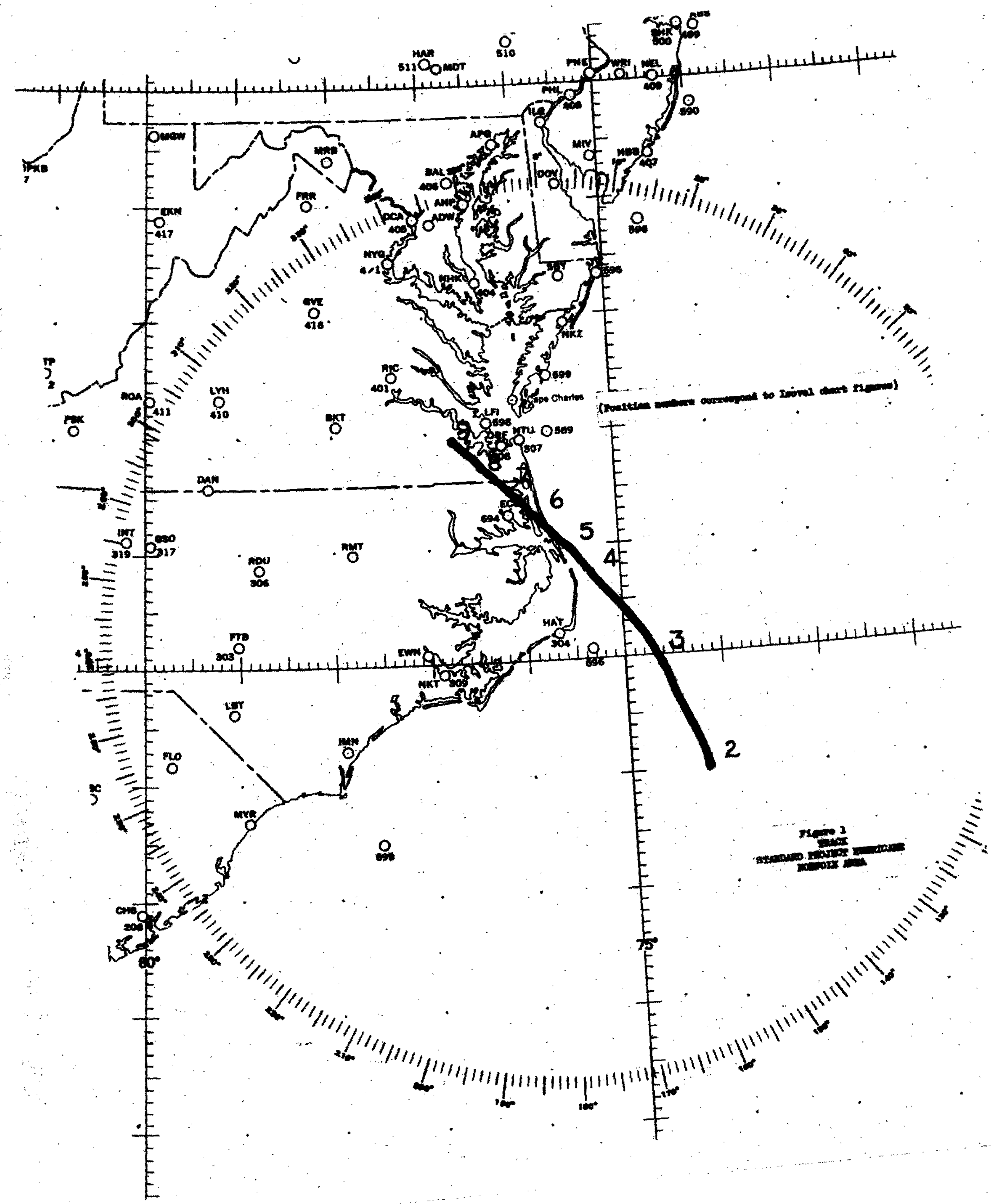



Figure 1
TRACK
STANDARD PROJECT HURRICANE
NORFOLK AREA

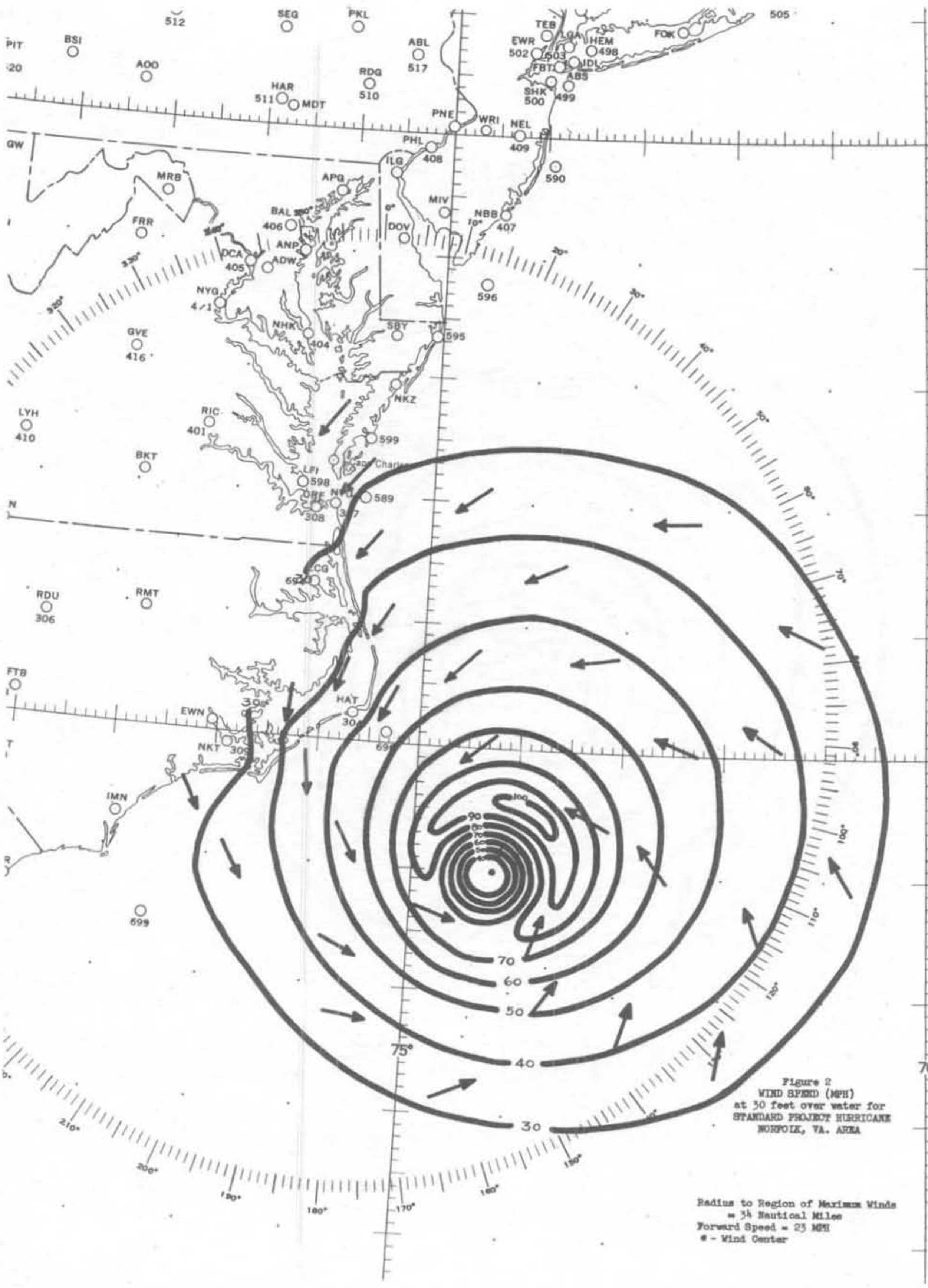



Figure 2
WIND SPEED (MPH)
at 30 feet over water for
STANDARD PROJECT HURRICANE
NORFOLK, VA. AREA

Radius to Region of Maximum Winds = 34 Nautical Miles
Forward Speed = 23 MPH
• - Wind Center

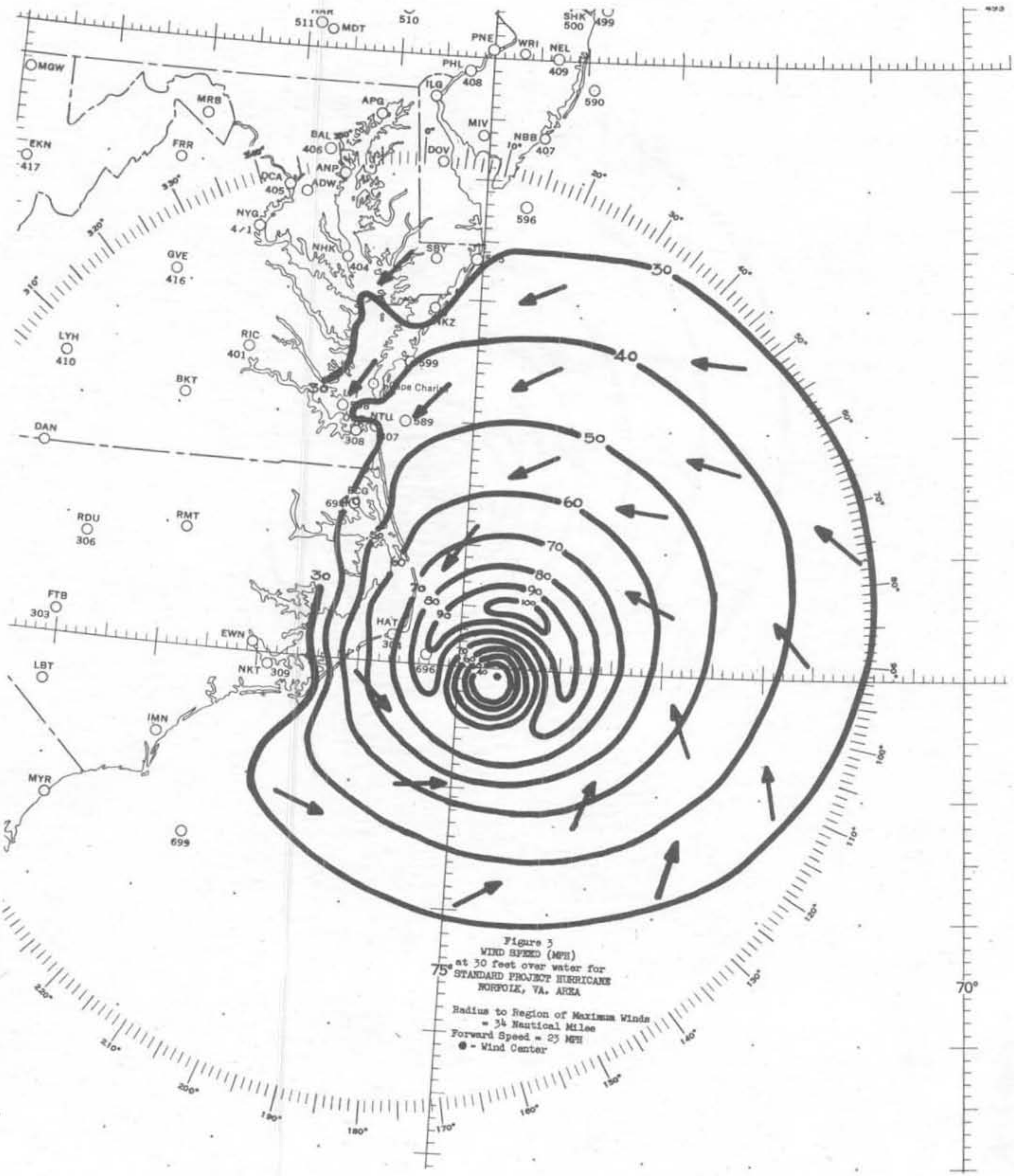



Figure 3
WIND SPEED (MPH)
at 30 feet over water for
STANDARD PROJECT HURRICANE
NORFOLK, VA. AREA

Radius to Region of Maximum Winds
= 34 Nautical Miles
Forward Speed = 23 MPH
● - Wind Center

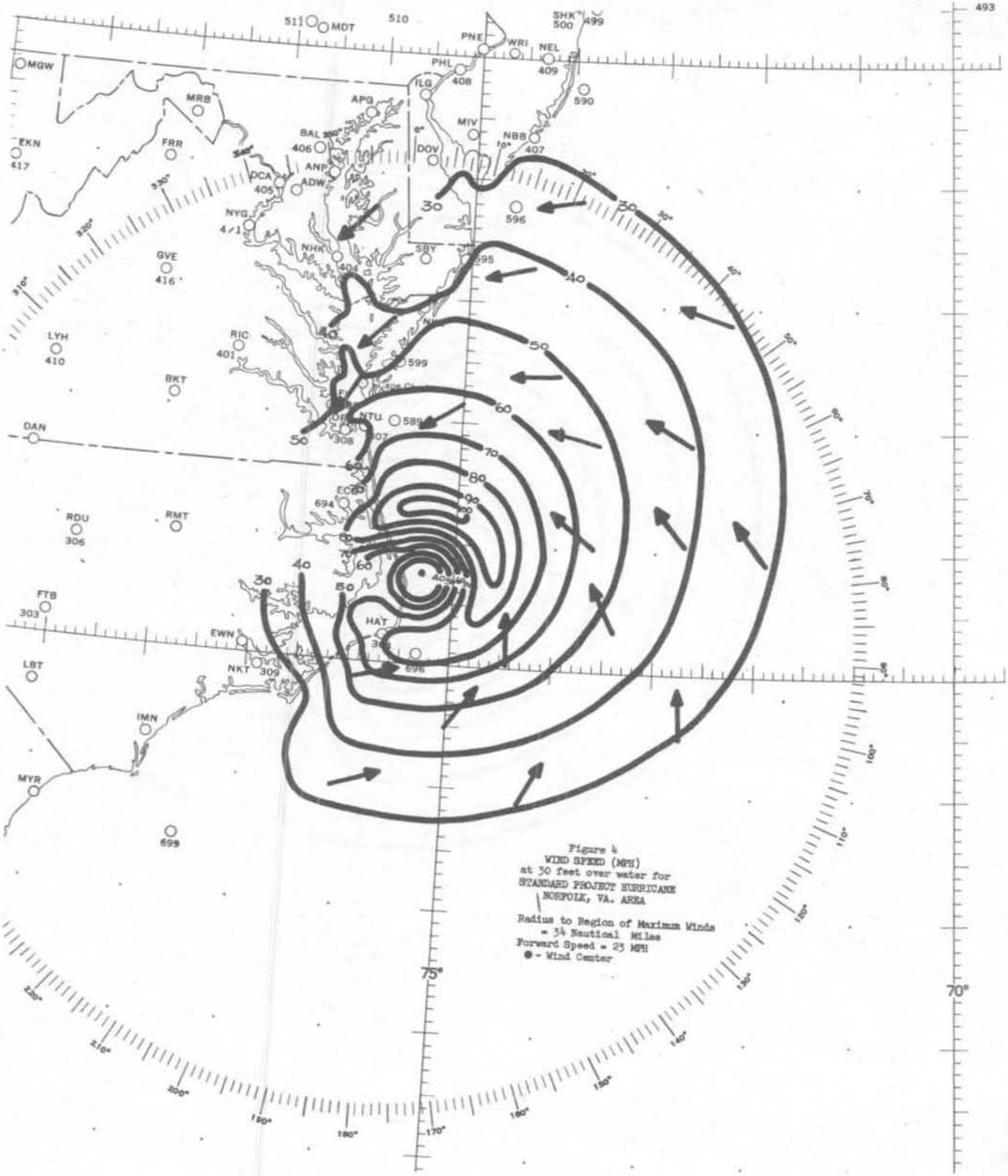



Figure 4
WIND SPEED (MPH)
at 30 feet over water for
STANDARD PROJECT HURRICANE
NORFOLK, VA. AREA

Radius to Region of Maximum Winds
= 34 Nautical Miles
Forward Speed = 23 MPH
● - Wind Center

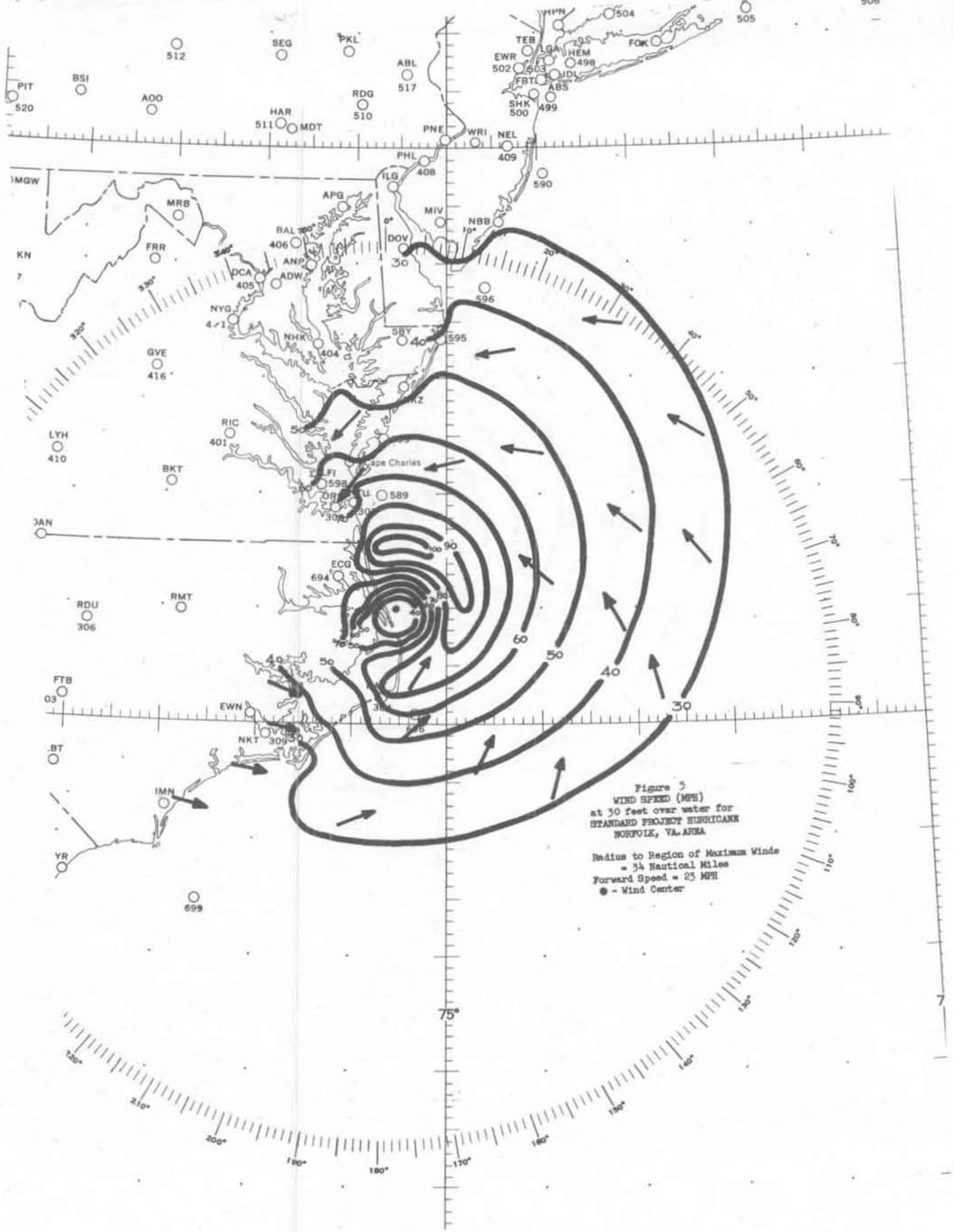



Figure 5
WIND SPEED (MPH)
at 30 feet over water for
STANDARD PROJECT HURRICANE
NORFOLK, VA. AREA

Radius to Region of Maximum Winds
= 34 Nautical Miles
Forward Speed = 23 MPH
● - Wind Center

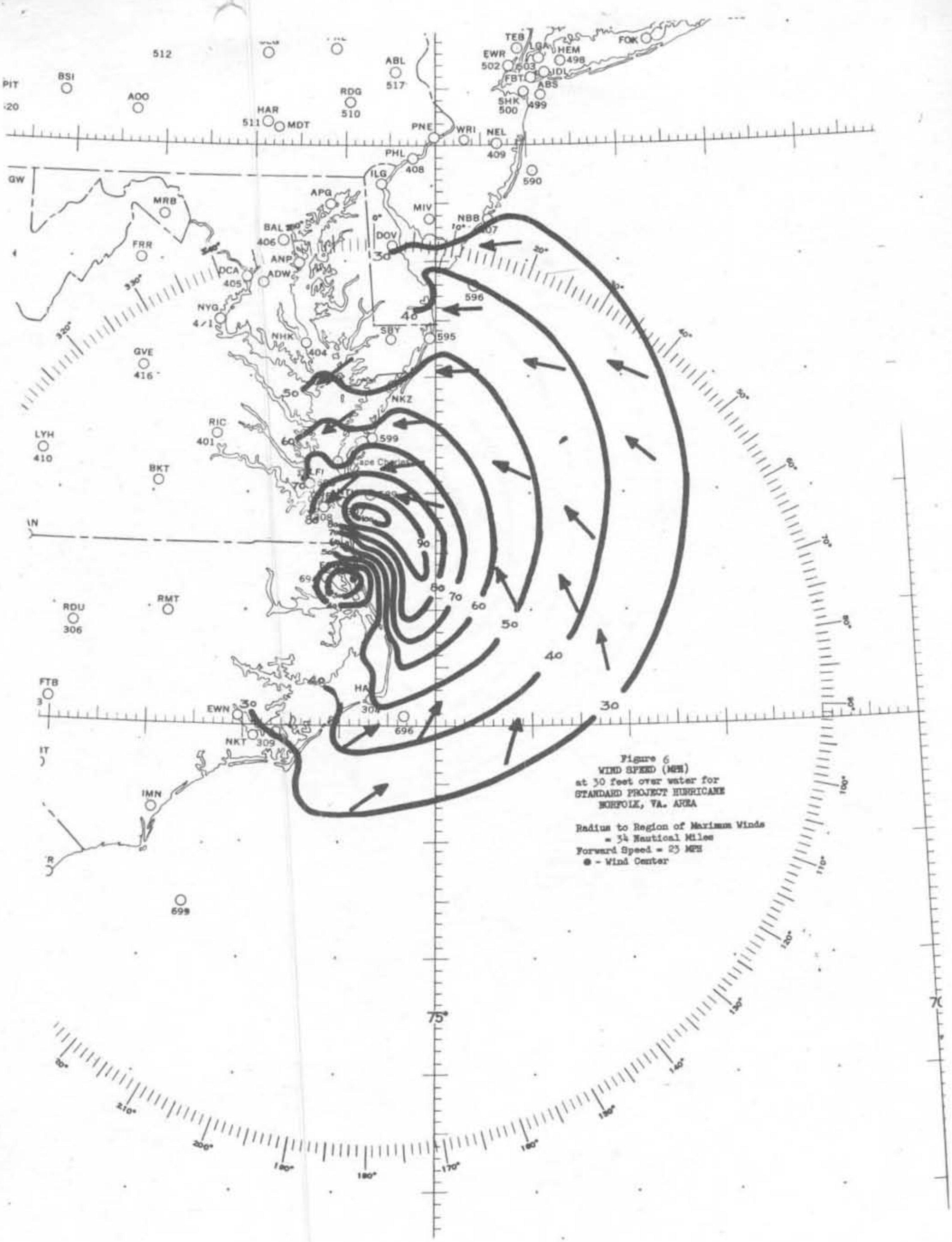



Figure 6
WIND SPEED (MPH)
at 30 feet over water for
STANDARD PROJECT HURRICANE
NORFOLK, VA. AREA

Radius to Region of Maximum Winds
= 34 Nautical Miles
Forward Speed = 23 MPH
● - Wind Center

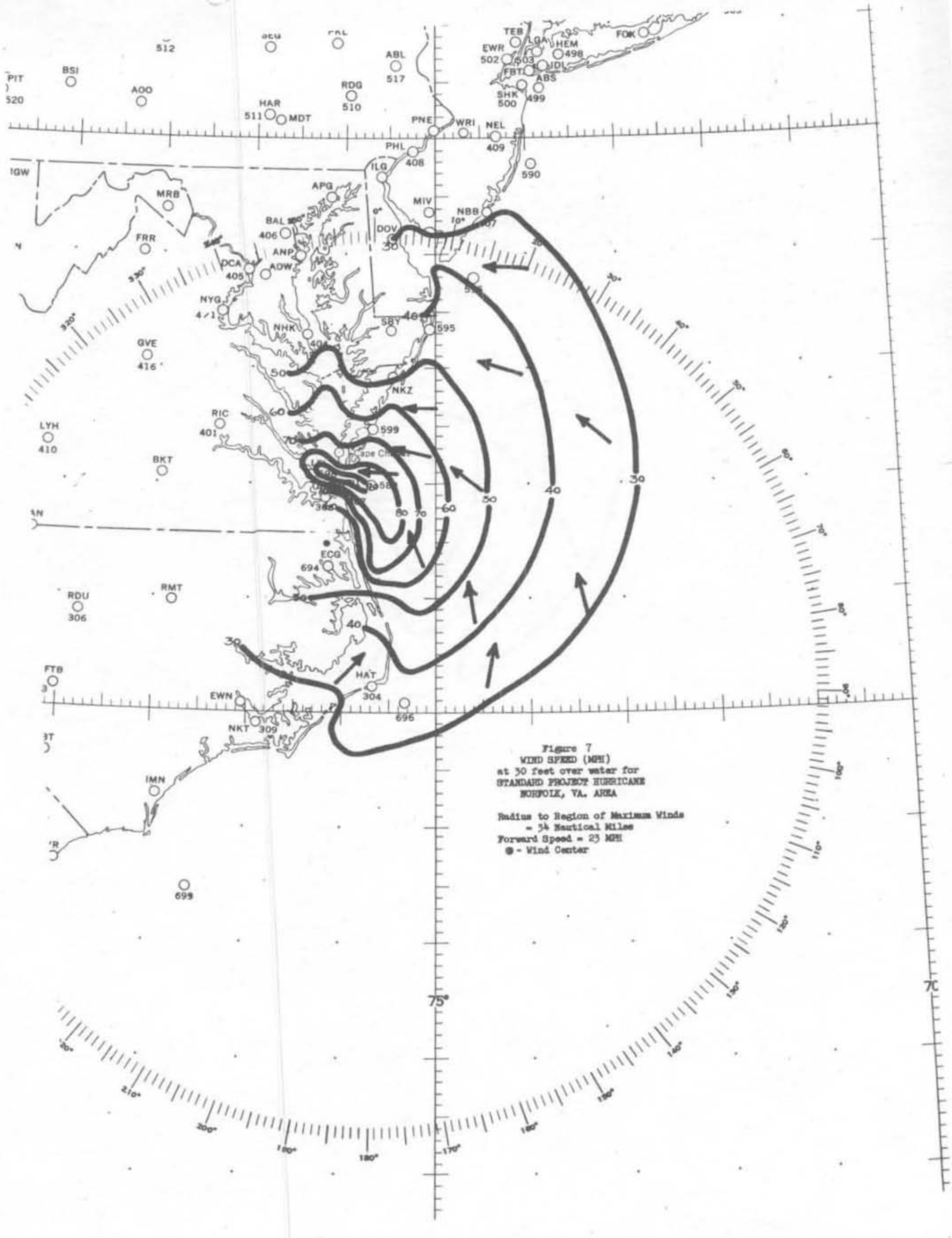



Figure 7
WIND SPEED (MPH)
at 30 feet over water for
STANDARD PROJECT HURRICANE
NORFOLK, VA. AREA

Radius to Region of Maximum Winds
= 34 Nautical Miles
Forward Speed = 23 MPH
● - Wind Center

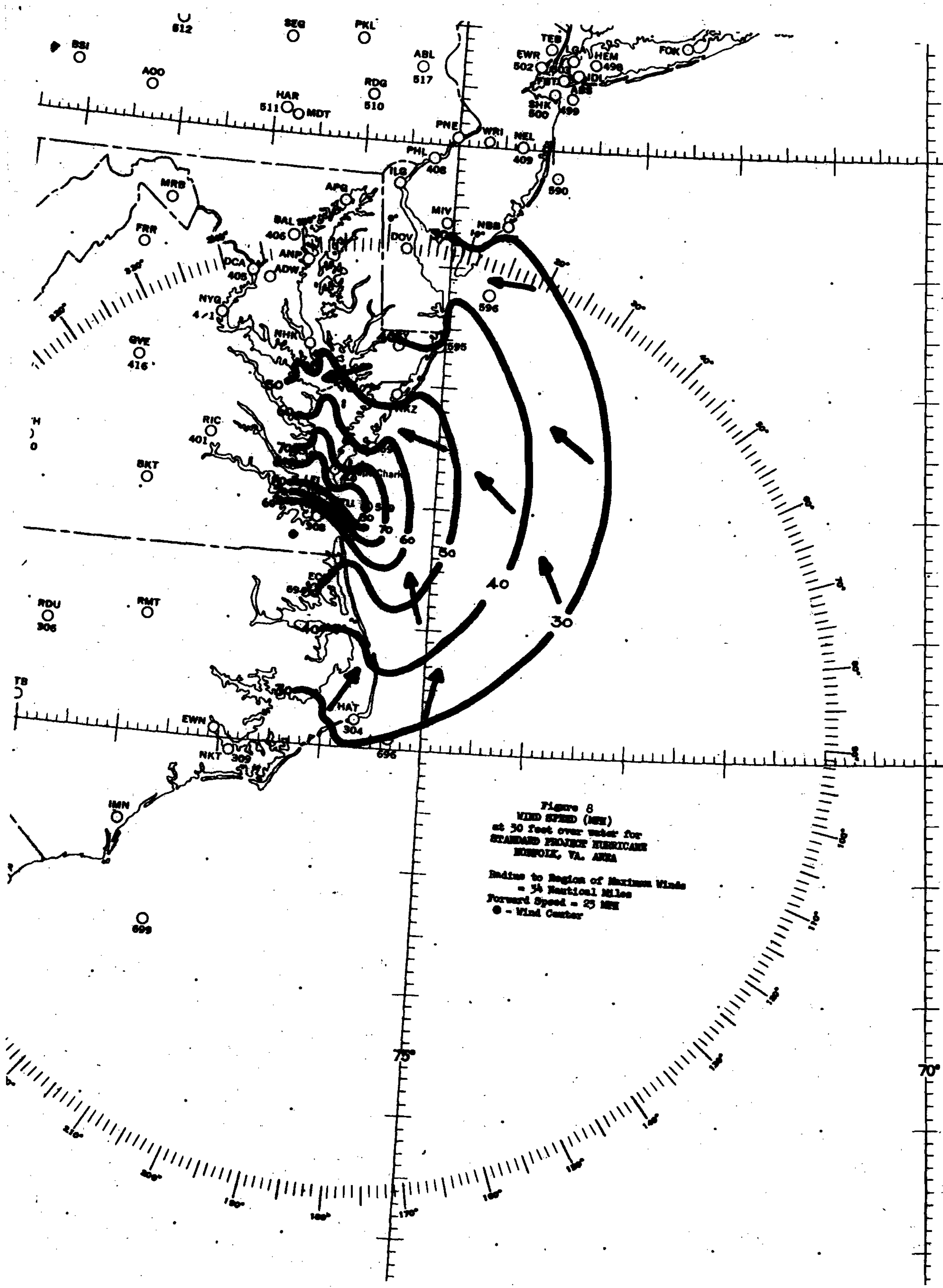



Figure 8
WIND SPEED (MPH)
at 30 feet over water for
STANDARD PROJECT HURRICANE
NORFOLK, VA. AREA

Radius to Region of Maximum Winds
= 34 Nautical Miles
Forward Speed = 25 MPH
● - Wind Center

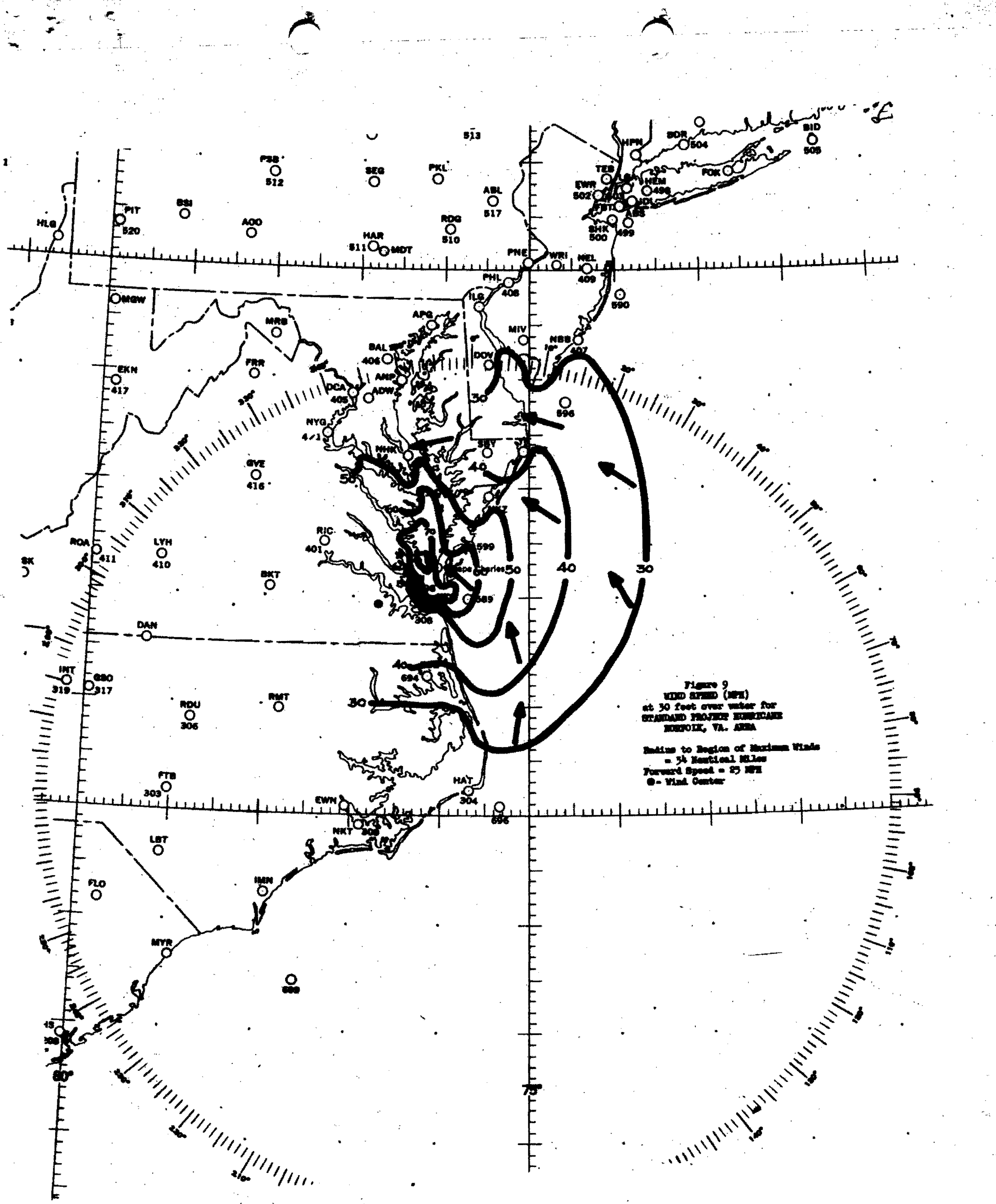



Figure 9
WIND SPEED (MPH)
at 30 feet over water for
STANDARD PROJECT HURRICANE
NORFOLK, VA. AREA

Radius to Region of Maximum Winds
= 34 Nautical Miles
Forward Speed = 25 MPH
⊙- Wind Center

UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
WASHINGTON

October 21, 1957

IN REPLY PLEASE ADDRESS
CHIEF, U. S. WEATHER BUREAU
WASHINGTON 25, D. C.
AND REFER TO

0-6.12

MEMORANDUM TO THE CORPS OF ENGINEERS
HUR 7-45

FROM ; Hydrometeorological Section

SUBJECT: Standard Project Hurricane Parameters and Isovels, Gulf of Mexico Area, Zone C (Texas Coast)

References: (1) OCE letter May 23, 1957, Hurricane Studies (P.L. 71) Galveston District
(2) HUR 2-4, Hurricane Frequency and Correlations of Hurricane Characteristics for the Gulf of Mexico Area P.L. 71, August 30, 1957

This memorandum lists parameters and contains a wind speed pattern for a severe hurricane in Zone C (figure 1) on the Gulf Coast of the United States as requested in reference (1). The purpose of this memorandum is analogous to MEMORANDUM HUR 7-33 for Zone 4 on the East Coast and MEMORANDUM HUR 7-42 for Zone B.

Hurricane parameters

Hurricane parameters and characteristics used in this memorandum are explained in detail in HUR 2-4. Characteristics of an extreme hurricane in various parts of Zone C are listed in Table 1 and are consistent meteorologically from point to point along the coast. The central pressure index (CPI) selected as representative of a Standard Project Hurricane and pertaining to each location along the coast were taken from figure 5 of reference 2 along the CPI curve indicating an average return period of one hundred years. These are consistent with the representative Standard Project Hurricanes for the East Coast, Lake Okeechobee, and Zone B (figure 1).

Isovel chart

A synthetically derived isovel chart has been developed for Zone C off the coast opposite Corpus Christi, Texas, which is near the center of the zone. This was accomplished by computing gradient winds from the pressure parameters, reducing them to 30-foot winds by empirical factors, and then imposing a small degree of asymmetry on the isovels. The asymmetry factor, added to speeds on the right and subtracted from speeds on the left, was (0.5T) cos a, where T was the forward motion of the storm in mph, and a the angle between direction of forward motion and wind direction. The curves of the highest value of the wind speed from these various steps are shown in figure 2. The resulting pattern for a CPI of 27.42 inches and a

Incl #2

[redacted]

Table 1

PARAMETERS OF SYNTHETIC HURRICANES IN ZONE C

| Zone | Location Mile (From fig.5 HUR 2-4) | Lat. at Coast (Deg.N) | Near City or other landmark | CPI (inches) | Radius of Max. Winds (Nau.miles) | | | Forward Speed (Knots) | | | Representative* Max.Wind Speed (mph) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | RS | RM | RL | ST | MT | HT | $V_{gx}$** | $V_x$ |
| C | 420 | 30 | Port Arthur, Tex. | 27.54 | 7 | 14 | 27 | 4 | 11 | 28 | 109 | 100 |
| | 360 | 29 | Galveston, Tex. | 27.52 | 7 | 14 | 26 | 4 | 11 | 28 | 109 | 101 |
| | 300 | 29 | Bay City, Tex. | 27.49 | 6 | 13 | 25 | 4 | 11 | 28 | 110 | 101 |
| | 240 | 28 | San Antonio Bay, Tex. | 27.45 | 6 | 13 | 24 | 4 | 11 | 28 | 111 | 102 |
| | 180 | 27 | Sarita, Tex. | 27.38 | 6 | 12 | 23 | 4 | 11 | 28 | 112 | 103 |
| | 120 | 26 | Brownsville, Tex. | 27.28 | 6 | 11 | 20 | 4 | 11 | 28 | 115 | 105 |

* For R = 24 nau. miles and forward speed of 10 knots (12 mph). Varies slightly with changes in these parameters

CPI Central pressure index

RS Representative small radius to region of maximum winds

RM Representative mean radius to region of maximum winds

RL Representative large radius to region of maximum winds

ST Representative slow speed of translation of hurricane center

MT Representative moderate speed of translation of hurricane center

HT Representative high speed of translation of hurricane center

**$V_{gx}$ Maximum theoretical gradient wind computed for each CPI by use of fig. 13, HUR 2-4, with $P_n$ = 29.92 in.

$V_x$ Estimated 30 ft speed in region of highest speeds, computed from $V_x = 0.865\, V_{gx} + 0.5T$ where T is forward speed in mph (T = 12 mph) forward speed of 10 knots is shown in figure 3.

Variation of R

The distance scale in figure 3 is in terms of radius of maximum winds (R). Any R listed in table 1 may be substituted as the distance scale.

Variation of CPI

The isovel pattern, figure 3, was constructed for a CPI value in the middle of Zone C. There is an intrazonal variation in wind speed in Zone C because of the variation of CPI. The isovels in figure 3 can be adjusted to other CPI's by multiplying them by the factors listed in table 2.

Table 2

RATIOS FOR ADJUSTMENT OF ISOVELS TO VARIOUS CPI'S

| CPI (inches) | Ratios* |
|---|---|
| 27.55 | 0.97 |
| 27.50 | 0.98 |
| 27.45 | 0.99 |
| 27.40 | 1.00 |
| 27.35 | 1.01 |
| 27.30 | 1.02 |
| 27.25 | 1.03 |

* Ratios for (T) Forward speed of 10 Knots, Fig. 2

Variation of forward speed

The forward speed for a project hurricane is chosen within or near the range of forward speeds shown in table 1. Forward speeds within this span can be assumed to be independent of CPI and R. Fast-moving hurricanes are believed to have a greater asymmetry of their wind-speed fields than slow-moving storms. The highest speeds are most generally found somewhere in the right half of the storm. These two conditions have been conformed to in developing the pattern of figure 3 by adding the forward speed factor described under "isovel chart." This is an empirical approximation and a high degree of refinement of adjusting wind patterns to forward speed is not required; figure 3 computed for a forward speed of 10 knots or approximately the average forward speed of Zone C can be applied to storms with 1/2 to twice this forward speed.

An investigation of forward speed in relation to latitude in the Gulf Coast area showed no significant relationship in contrast to the latitudinal variation found along the Atlantic Coast.

Wind direction

The wind direction for use in conjunction with the wind speed pattern of figure 3 may be approximated from table 3. These directions are shown by arrows on the chart.

Table 3

WIND DIRECTION

| Radius | *Deflection Angle |
|---|---|
| Radius R to center | 20° |
| R to 1.2R | Transition 20° to 25° |
| 1.2R and beyond | 25° |

*Angle between true wind direction and a tangent to a circle with center at the storm center.

Critical path

The path for a project hurricane is selected on the basis of the configuration of the coast or inlet concerned within the span of directions that are shown to be common on the azimuth chart of past hurricane paths in the zone, figure 4 (from HUR 2-4). Most hurricanes pass through Zone C from the east and southeast and a smaller number from the south. Hurricanes have moved through the zone from bearings of 30° to 210°. There is no evidence of a correlation between hurricane intensity and path.

Comparison of synthetic isovels with past storms

Four of the most severe storms of record to pass through Zone C were the hurricanes of September 8, 1900, August 13, 1932, August 18, 1916 and September 5, 1933. The hurricane parameters of these storms are listed in table 4 and may be compared with the parameters of synthetic hurricanes in table 1.

Table 4

PARAMETERS OF SEVERE HURRICANES PASSING THROUGH ZONE C

| Date | CPI (inches) | R (nau.mi.) | Forward Speed (knots) | Max. 30-ft Wind (mph) |
|---|---|---|---|---|
| Sept. 8, 1900 | 27.64 | 14 | 10 | 88 (estimate HUR 7-36) |
| Aug. 13, 1932 | 27.83 | 12 | 15 | 93* |
| Aug. 18, 1916 | 28.00 | 35 | 11 | 100* |
| Sept. 5, 1933 | 28.02 | 20 | 8 | 91* |

*Estimated from computed gradient winds listed in table 3-1, National Hurricane Research Project Report No. 5. Maximum 30-ft wind = 0.865 $V_{gx}$ where $V_{gx}$ is the maximum gradient wind.

Adjustment for filling overland

The critical path may pass partly overland. The normal weakening of a hurricane over land can be approximated by reducing the open sea wind speed values by the following factors, taken from Table 4, HUR 7-43, which are based on the time elapsed since the storm center crossed the coast.

Table 5

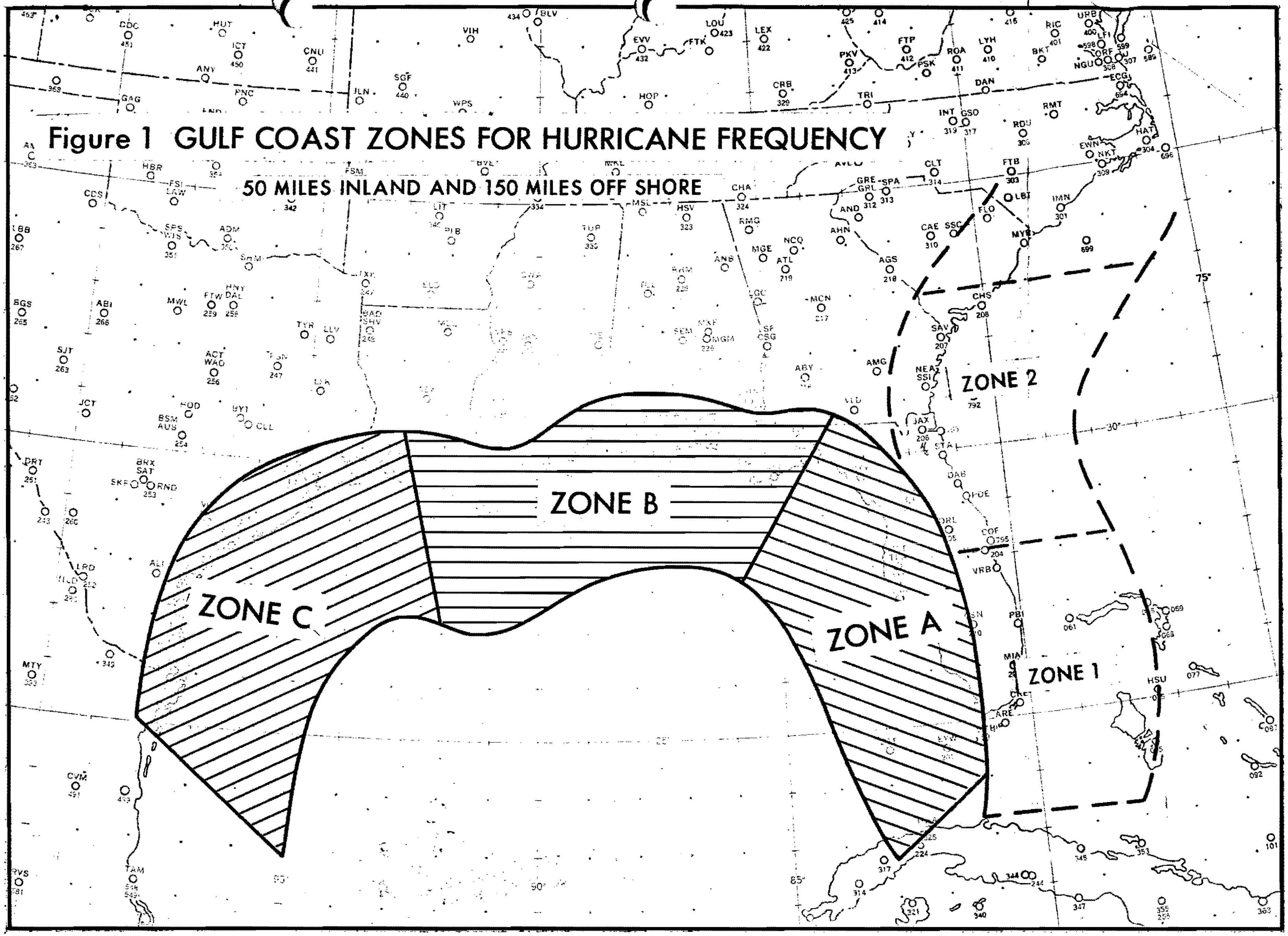
FACTORS FOR REDUCING HURRICANES FOR FILLING OVER LAND

| Time (hours) | Adjustment ratio for wind speed |
|---|---|
| T (at coast) | 1.00 |
| T + 1 | 0.93 |
| T + 2 | 0.88 |
| T + 3 | 0.85 |
| T + 4 | 0.82 |
| T + 5 | 0.80 |
| T + 6 | 0.78 |
| T + 7 | 0.76 |
| T + 8 | 0.74 |

The factors in Table 5 will yield speeds for portions of the storm that are still over water. Further reductions would be required to obtain the speeds over land.

Vance A. Myers
for Charles S. Gilman, Chief
Hydrometeorological Section

8 copies to OCE
1 copy to BEB




# Figure 1 GULF COAST ZONES FOR HURRICANE FREQUENCY

50 MILES INLAND AND 150 MILES OFF SHORE

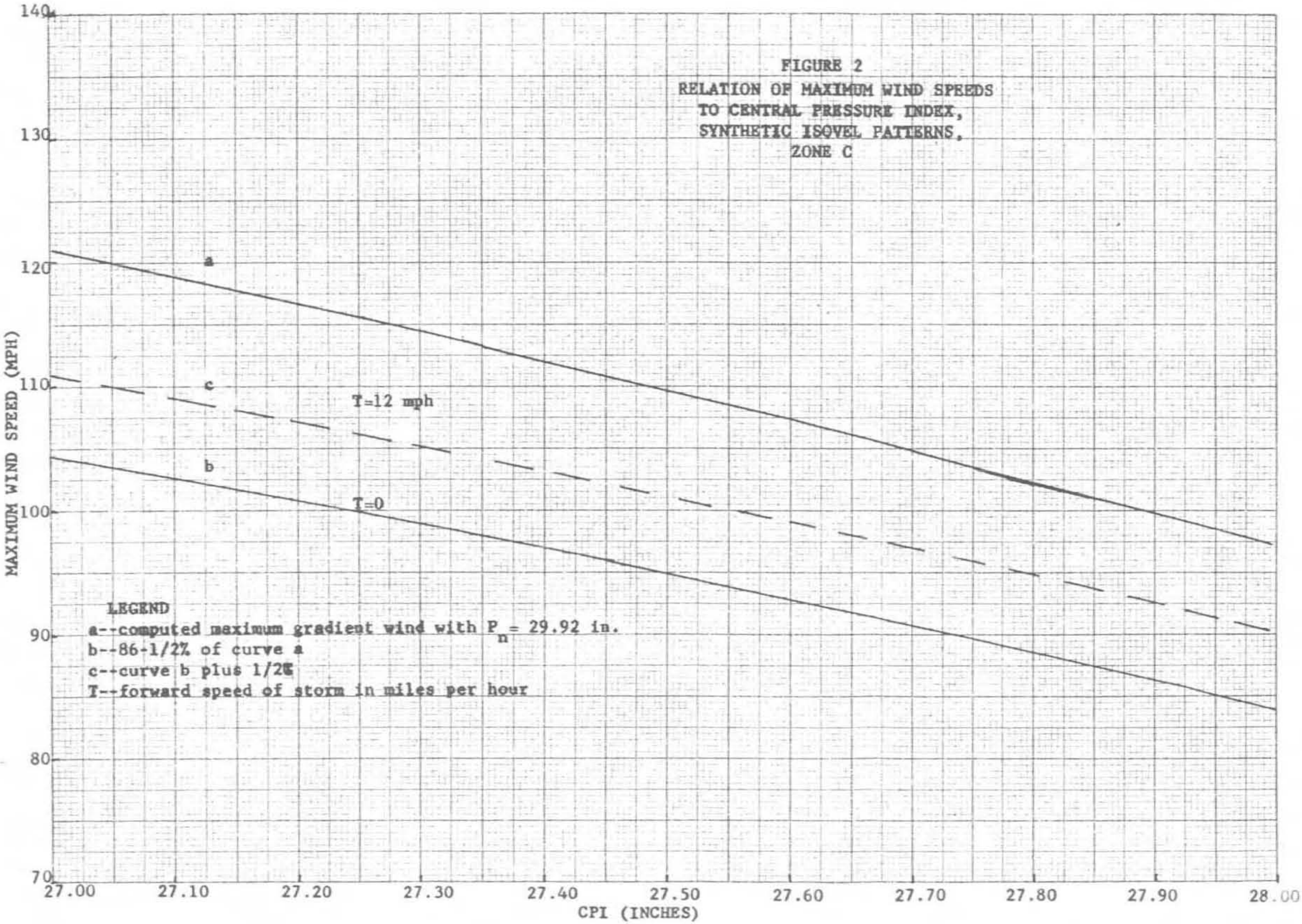



FIGURE 2
RELATION OF MAXIMUM WIND SPEEDS
TO CENTRAL PRESSURE INDEX,
SYNTHETIC ISOVEL PATTERNS,
ZONE C

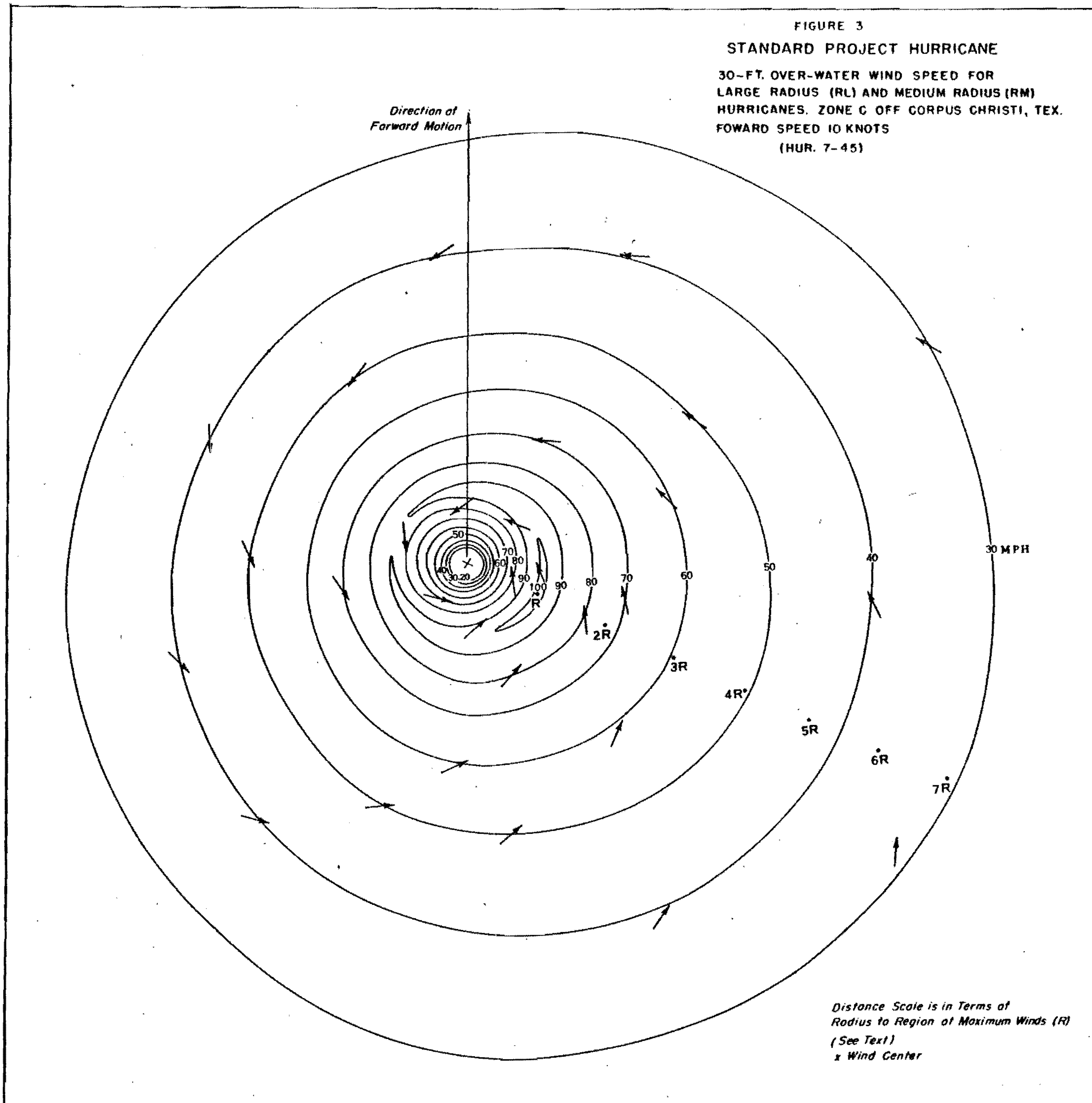



FIGURE 3

STANDARD PROJECT HURRICANE

30-FT. OVER-WATER WIND SPEED FOR LARGE RADIUS (RL) AND MEDIUM RADIUS (RM) HURRICANES. ZONE C OFF CORPUS CHRISTI, TEX. FOWARD SPEED 10 KNOTS

(HUR. 7-45)

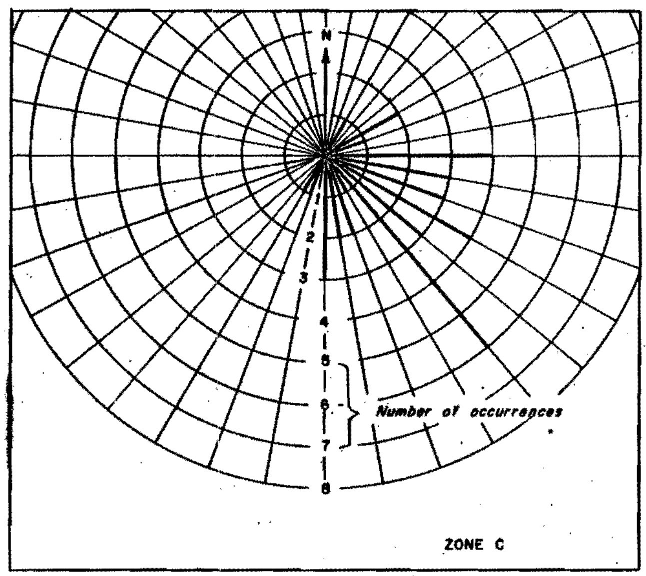



Fig. 4. AZIMUTH DISTRIBUTION OF HURRICANE PATHS IN ZONE
1900–1956

LMVD
22743

UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
WASHINGTON

October 21, 1957

IN REPLY PLEASE ADDRESS
CHIEF, U. S. WEATHER BUREAU
WASHINGTON 25, D. C.
AND REFER TO

0-6.12

MEMORANDUM TO CORPS OF ENGINEERS
HUR 7-43
FROM : Hydrometeorological Section

SUBJECT: Standard Project Hurricane Criteria and Isovel Patterns, East Coast U. S., Zone 3

References:
1. OCE letter of June 6, 1957, "Standard Project Hurricane Isovels for Zone 3 Atlantic Coast" and telephone communications
2. HUR 2-1, Frequency of Central Pressure Indices Along Atlantic Coast, June 18, 1957
3. HUR 2-3, Hurricane Characteristics, Atlantic Coastal Area, June 18, 1957
4. HUR 7-33, Hurricane Criteria for East Coast of United States Comparable to Lake Okeechobee Standard Project Hurricane and Isovel Patterns, June 20, 1957
5. Partial Definite Project Report, Central and Southern Florida Project, Part IV, Supplement 2, Section 2, Design Memorandum, Hurricane Winds Over Lake Okeechobee, Jacksonville District Engineer, Dec. 31, 1953

This memorandum lists parameters of a severe hurricane for zone 3 (figure 1), and contains wind speed patterns for moderate and high speed rate of translation.

Hurricane parameters

Characteristics of extreme hurricanes consistent on meteorological grounds from point to point along the Atlantic Coast were explained and specified in reference 4. These characteristics pertinent to zone 3 are listed in table 1.

Incl 1

Table 1

STANDARD PROJECT HURRICANE CHARACTERISTICS, ZONE 3, EAST COAST U. S.

| Location (Zone) | Latitude (deg. N.) | CPI (Inches) | Radius of Max. Winds (naut.miles) RS | RM | RL | Forward Speed (kts) ST | MT | HT | Representative Max. Wind Speed (mph) $V_{gx}$ | $V_x$ T=17kts | T=35kts |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 33 | 27.65 | 7 | 18 | 40 | 4 | 13 | 30 | 104 | 100 | 110 |
| | 34 | 27.60 | 7 | 17 | 37 | 5 | 15 | 34 | 105 | 101 | 111 |
| | 35 | 27.56 | 7 | 17 | 35 | 5 | 17 | 38 | 107 | 103 | 112 |
| | 35.5 | 27.55 | 7 | 17 | 34 | 5 | 18 | 40 | 107 | 103 | 112 |
| | 36 | 27.55 | 7 | 17 | 34 | 6 | 20 | 42 | 107 | 103 | 112 |
| | 37 | 27.57 | 7 | 17 | 35 | 7 | 22 | 45 | 106 | 102 | 112 |

CPI Central pressure index, estimated minimum pressure
RS Representative small radius to region of maximum winds
RM Representative mean radius to region of maximum winds
RL Representative large radius to region of maximum winds
ST Representative slow speed of translation of hurricane center
MT Representative moderate speed of translation of hurricane center
HT Representative high speed of translation of hurricane center
T Speed of translation of hurricane center
$V_{gx}$ Maximum theoretical gradient wind computed for each CPI by use of figure 7, HUR 2-3, with $P_n = 29.92$ inches
$V_x$ Estimated maximum 30 ft wind speed. Computed from $V_x = 0.865\ V_{gx} + 0.5T$, (T in mph)

## Isovel charts

Synthetically derived isovel charts have been developed for the middle of zone 3 at 35.5°N. This was accomplished by computing gradient winds from the pressure parameters, reducing to 30 ft. winds by empirical factors, and finally imposing a moderate degree of asymmetry on the isovels. The asymmetry factor, added to speeds on the right and subtracted on the left, was (0.5T) cos a, where a was the angle between direction of forward motion and wind direction, and T the forward speed in mph. The curves of highest value of the wind speed from these various steps are shown in figure 2. The resulting patterns for a CPI of 27.55 inches and forward speeds respectively of 17 knots (20 mph) and 35 knots (40 mph) are shown in figures 3 and 4.

A pattern showing the strongest winds in the right rear quadrant was selected as that most likely to occur, according to at least two authors. Isaac Cline in his book "Tropical Cyclones" states that, "the wind velocities are much greater in the right half than in the left half of the cyclone area, and the greatest sustained wind velocities occur as a rule in the right rear quadrant." L. A. Hughes has summarized a large number of reconnaissance flights ("On the Low-Level Structure of Tropical Storms," Journal of Meteorology, December 1952) producing the best and mose definitive composite low-level wind speed pattern yet available. The strongest winds are in the right rear quadrant in that pattern. Many variations may occur in the standard isovel pattern of figures 3 and 4. To represent the many patterns that would be reasonable to expect in zone 3, figures 3 and 4 may be rotated with limits of 100° counterclockwise and 50° in a clockwise direction.

Variation of R

The distance scales of figures 3 and 4 are in terms of radius of maximum winds (R). Any R listed in the RM or RL columns of table 1 may be substituted as the distance scale.

Variation of CPI

The isovel patterns of figures 3 and 4 are constructed for a CPI of 27.55 inches. They can be adjusted to other CPI's by multiplying all speeds by factors in table 2.

Table 2

RATIOS FOR ADJUSTMENT OF ISOVELS TO VARIOUS CPI's

| CPI inches | Ratio |
|---|---|
| 27.50 | 1.01 |
| 27.55 | 1.00 |
| 27.60 | 0.99 |
| 27.65 | 0.98 |

Variation of forward speed

The forward speed for a project hurricane is chosen within or near the range of forward speeds shown in table 1. Forward speed within these spans can be assumed to be independent of CPI and R. Fast-moving hurricanes are believed to have a greater asymmetry of their wind-speed fields than slow moving storms. The highest speeds are most generally found somewhere in the right half of the storm. These two conditions have been conformed to in developing the patterns of figures 3 and 4 by adding the forward speed factor described above. This is an empirical approximation and a high degree of refinement of adjusting wind patterns to forward speed is not required; figures 3 and 4 computed respectively for forward speeds of 17 knots (20 mph) and 35 knots (40 mph) can be applied directly to all forward speeds in their respective MT and HT columns of table 1.

Wind direction

The wind direction at 30' for use in conjunction with the speeds of figures 3 and 4 may be approximated from table 3. These directions are shown by arrows on the charts.

Table 3

WIND DIRECTION

| Radius | Deflection angle* |
|---|---|
| Radius R to center | 20° |
| R to 1.2 R | Transition 20° to 25° |
| 1.2 R and beyond | 25° |

*Angle between true wind direction and a tangent to a circle with center at the storm center.

Critical path

The path for a project hurricane is selected on the basis of the configuration of the coast or inlet concerned, within the span of directions that are shown to be common on the azimuth chart of past hurricane paths in the zone, figure 5 (reproduced from figure 10, HUR 2-3).

Severe hurricanes have been observed to move from bearings of 90° through 210° within the zone, Weaker tropical storms have traveled over a greater range of bearings. Any MT or HT forward speed in table 1 may be combined with any path bearing between 120° and 210°. Combination of HT forward speeds with more easterly bearings would require further study.

Adjustment for filling over land

The critical path may pass partly over land. This would hold for Chesapeake Bay, and other places. The normal weakening of a hurricane over land may be approximated by reducing the open-sea wind speed values by the following factors; based on the time elapsed since the storm center crossed the coast:

Table 4

FACTORS FOR REDUCING HURRICANES FOR FILLING OVER LAND

| Time (hours) | Adjustment ratio for wind speeds |
|---|---|
| T (at coast) | 1.00 |
| T plus 1 | .93 |
| T plus 2 | .88 |
| T plus 3 | .85 |
| T plus 4 | .82 |
| T plus 5 | .80 |
| T plus 6 | .78 |
| T plus 7 | .76 |
| T plus 8 | .74 |

The above will yield over-water speeds in portions of the storm that are still over water. Further reductions would be required to obtain the speeds over land.

Adjustment of wind speeds near shore

If speeds over the water near the shore line are critical, the reduction of speeds at the 30-ft level by friction may be approximated as follows: reduce on-shore winds at the shore to 0.89 of the over-water value; accomplish this reduction over a transition zone of two or three miles. For off-shore winds, at the shore reduce to 0.70 of the over-water value, with a "speed-up" to over-water value in about ten miles.

Comparison of synthetic isovels with past storms

The most severe storm of record to pass close to the coast at Cape Hatteras was the hurricane of September 14, 1944. Hurricane Hazel of 1954 was the most severe hurricane to strike the Carolina coast in the southern part of the zone. Parameters for these two are listed in table 5 and may be compared with the parameters of synthetic hurricanes in table 1.

The hurricane of September 1938 and Edna of 1954 passed sufficiently far off shore at the latitude of zone 3 that parameters are not well established. The hurricane of 1938 may have been of equal severity with the 1944 hurricane and Edna was also a severe storm at that latitude.

Table 5

PARAMETERS OF SEVERE HURRICANES PASSING THROUGH ZONE 3

| Date | Latitude (deg. N) | CPI (Inches) | R (naut.mi.) | Forward Speed (knots) | Max. 30' Wind (mph) |
|---|---|---|---|---|---|
| Sept. 14, 1944 | 35 | 27.88 | 49 | 23 | 107* |
| Oct. 15, 1954 | 34 | 27.66 | 14 | 26 | 90* |

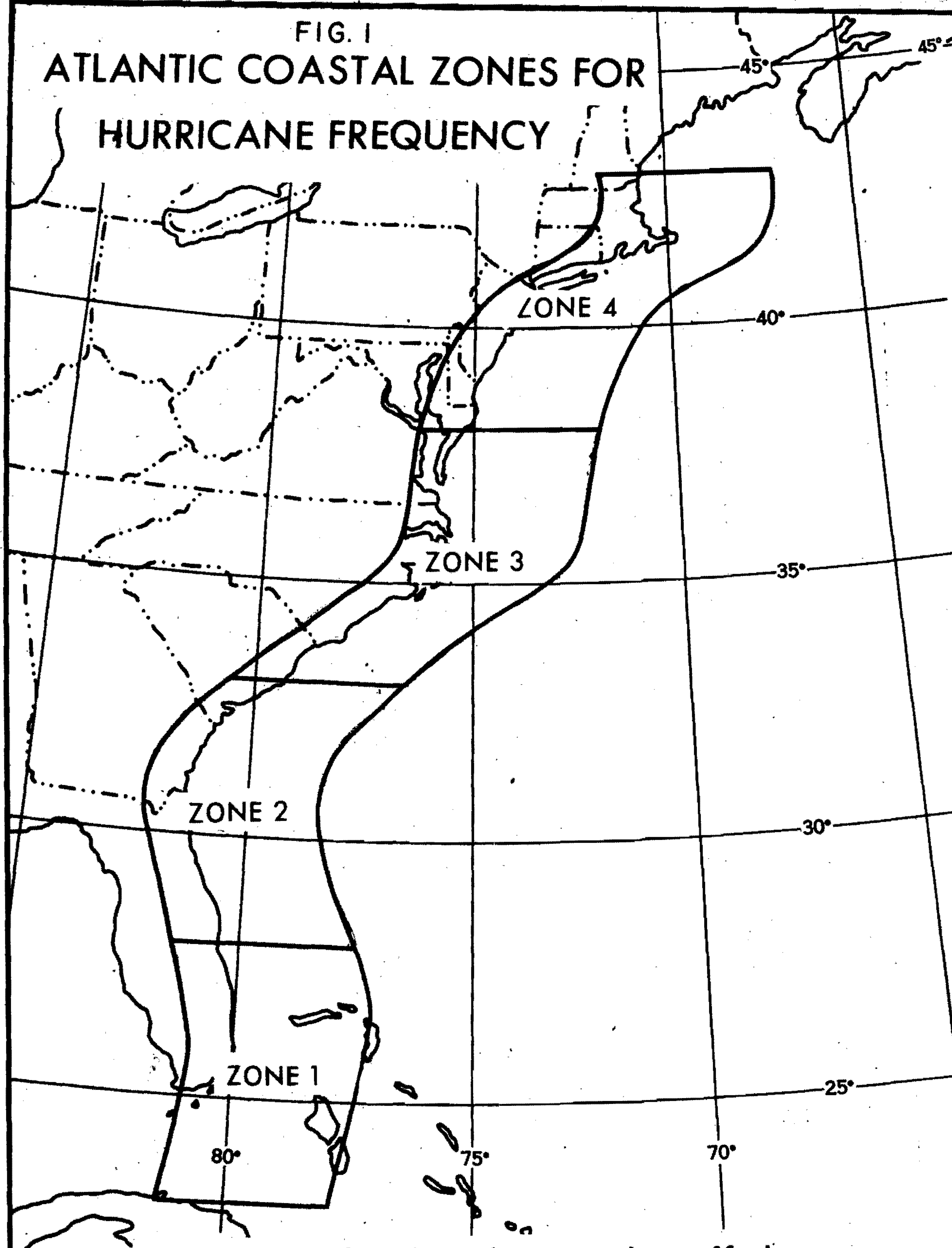
*estimated from pressures distribution.

for Charles S. Gilman, Chief
Hydrometeorological Section

cc: 15 to OCE
1 to BEB

FIG. I

# ATLANTIC COASTAL ZONES FOR HURRICANE FREQUENCY




50 miles inland and 150 miles off shore.

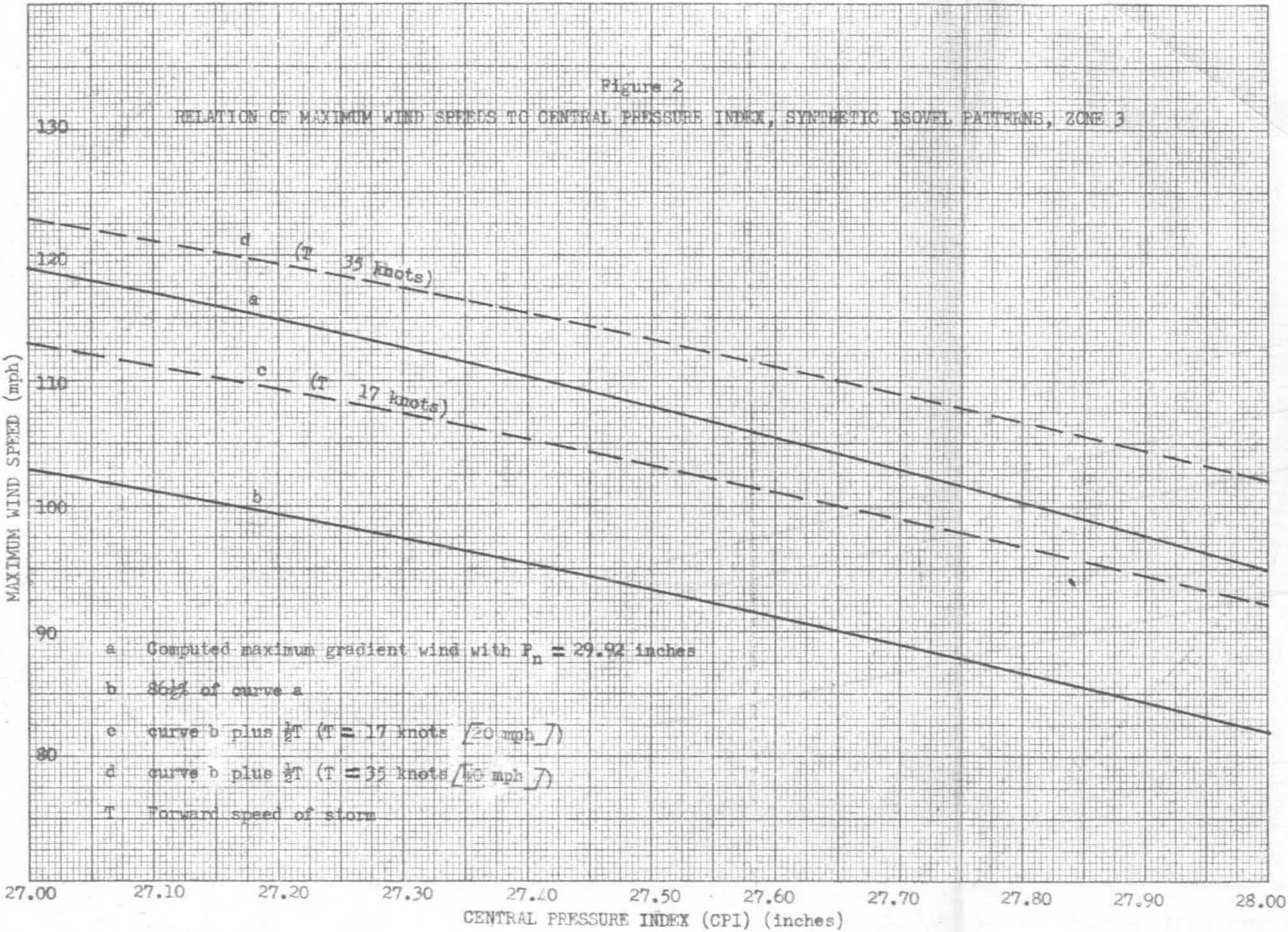



Figure 2

RELATION OF MAXIMUM WIND SPEEDS TO CENTRAL PRESSURE INDEX, SYNTHETIC ISOVEL PATTERNS, ZONE 3

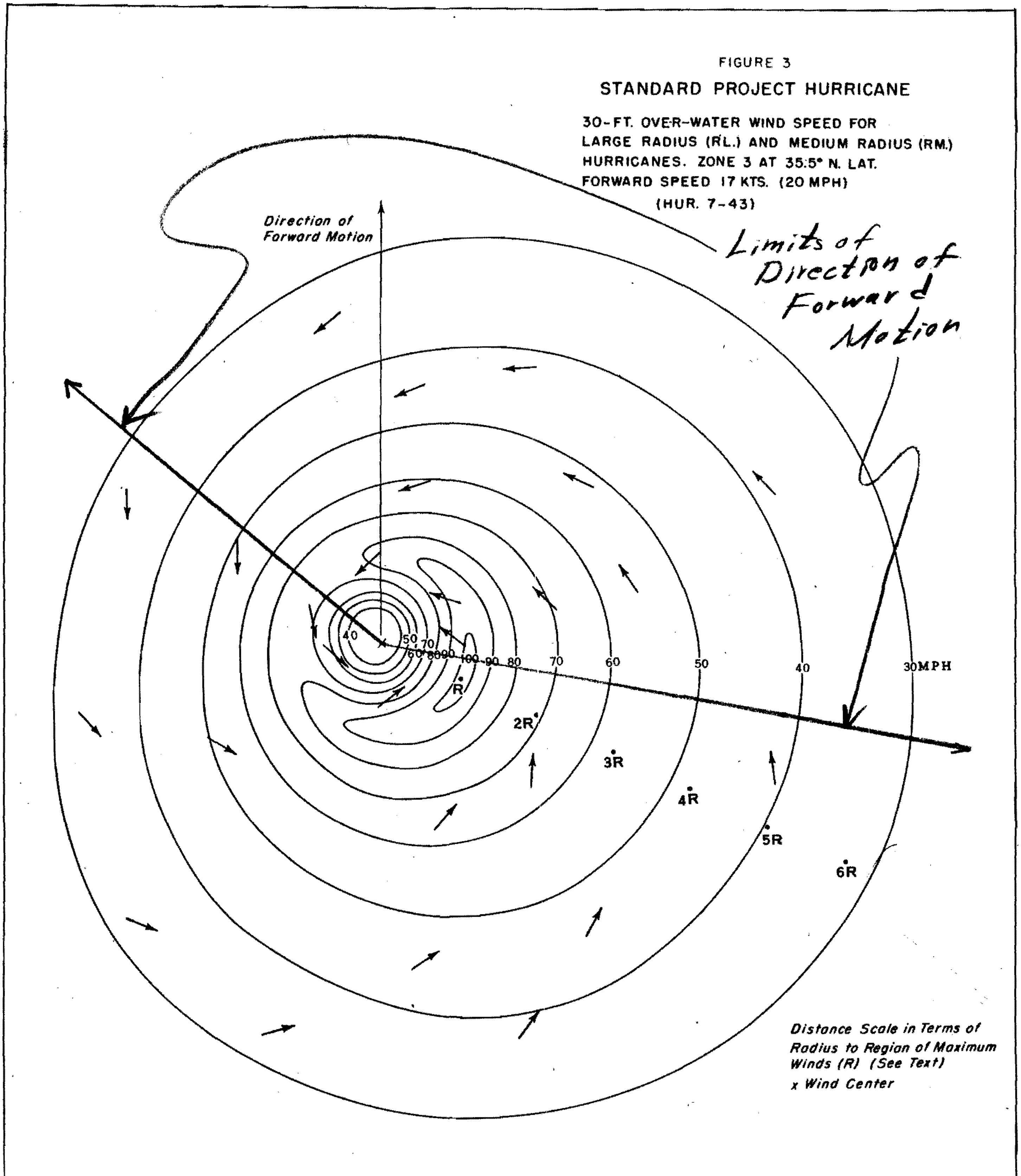



FIGURE 3

STANDARD PROJECT HURRICANE

30-FT. OVER-WATER WIND SPEED FOR LARGE RADIUS (RL.) AND MEDIUM RADIUS (RM.) HURRICANES. ZONE 3 AT 35.5° N. LAT. FORWARD SPEED 17 KTS. (20 MPH)

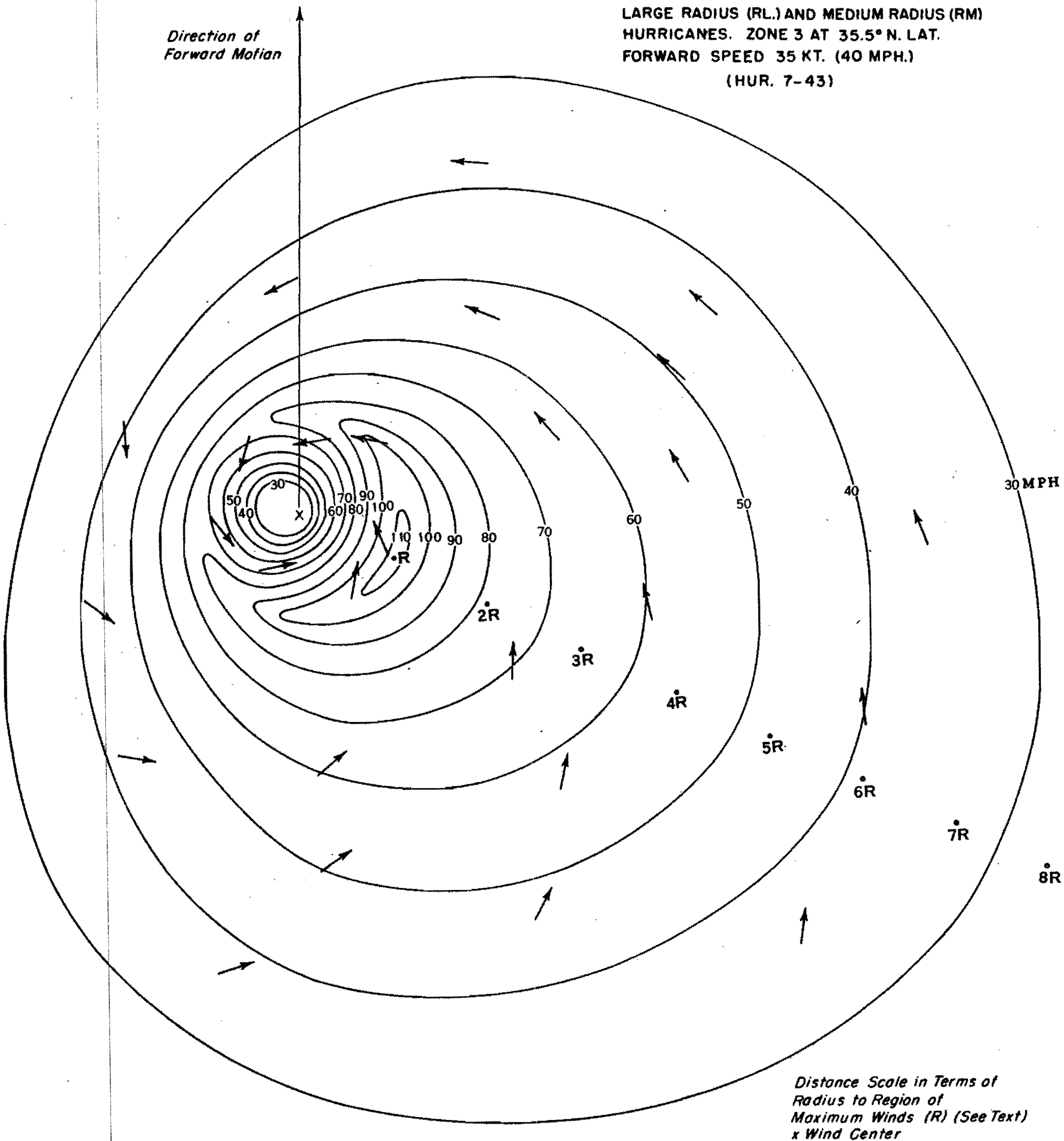
(HUR. 7-43)

Figure 4

STANDARD PROJECT HURRICANE

30-FT. OVER-WATER WIND SPEED FOR LARGE RADIUS (RL.) AND MEDIUM RADIUS (RM) HURRICANES. ZONE 3 AT 35.5° N. LAT. FORWARD SPEED 35 KT. (40 MPH.)

(HUR. 7-43)



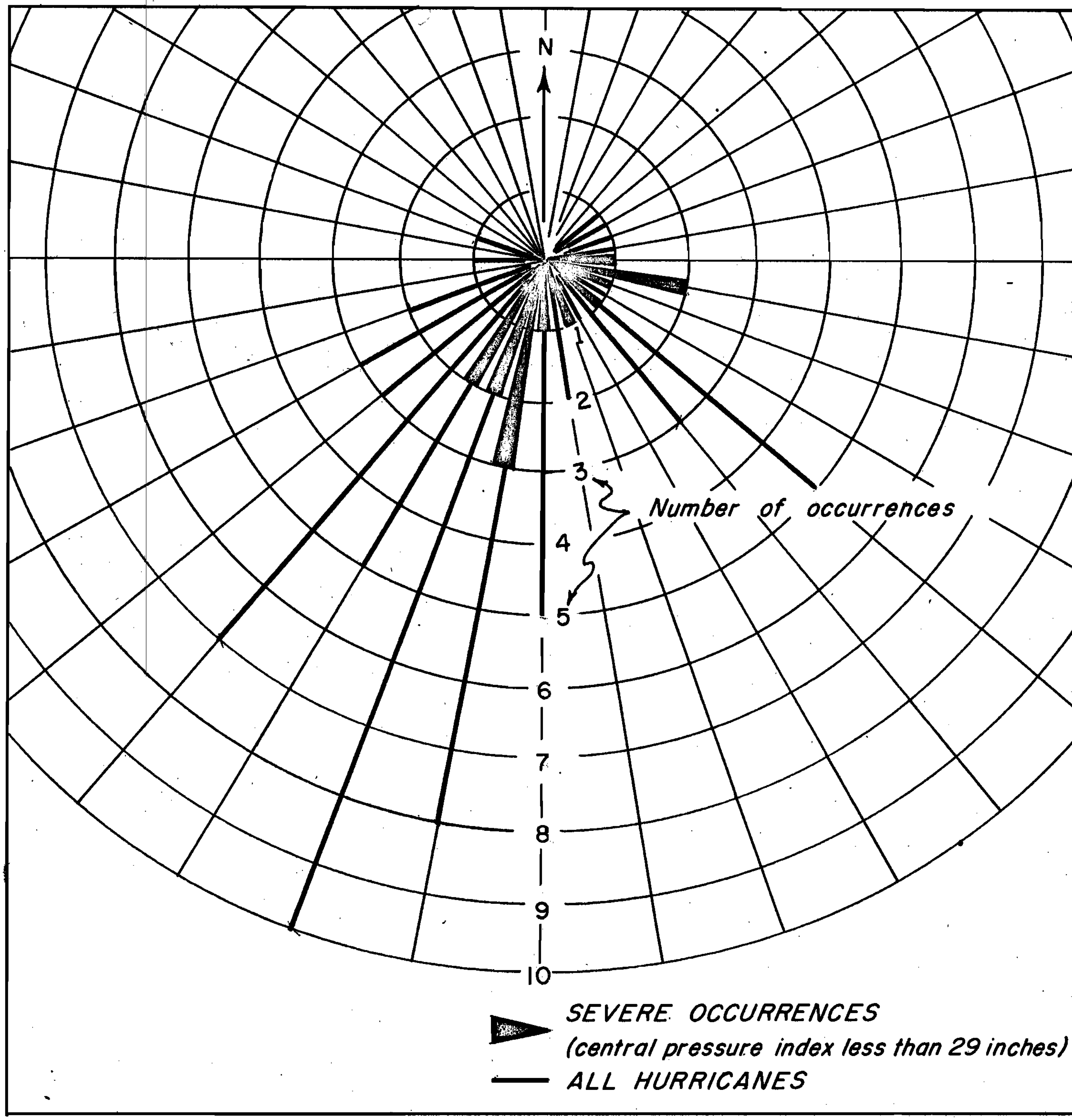



Fig. 5. AZIMUTH DISTRIBUTION OF PATHS FOLLOWED BY HURRICANES IN ZONE 3 (1887-1956)

UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
WASHINGTON

October 11, 1957

IN REPLY, PLEASE ADDRESS
CHIEF, U. S. WEATHER BUREAU
WASHINGTON 25, D. C.

TO : Mr. A. L. Cochran, Civil Works
Office of Chief of Engineers
Corps of Engineers

FROM : Hydrometeorological Section

SUBJECT: MEMORANDUM HUR 7-42

MEMORANDUM HUR 7-42, "Standard Project Hurricane Parameters and Isovels, Mid-Gulf Coast U. S. Zone B, and Standard Project Hurricane Lake Pontchartrain, La." is herewith transmitted. This was assigned in paragraph 11b(4) and 11b(5) of notes on conference held in New Orleans, La., June 13-14, 1957, on hurricane studies (P.L. 71).

It will be noted in Table 3, Parameters of Severe Storms Passing through Zone B, that the maximum 30-ft. wind speed for the September 29, 1915 hurricane is listed as 99 mph while the maximum value developed for this storm in MEMORANDUM HUR 7-39 was 105 mph. The lower value used in Table 3 was arrived at by using one-half the speed ot translation in the asymmetry factor of the storm instead of the total speed of translation that was used in HUR 7-39. This wind speed value is comparable with the 30-ft. wind speed values in Table 1 which were arrived at by the same method but would make no appreciable difference in the surges computed for Lake Pontchartrain.

Charles S, Gilman, Chief
Hydrometeorological Section

Attachments
12 copies to OCE with attachments

UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
WASHINGTON

October 11, 1957

IN REPLY PLEASE ADDRESS
CHIEF, U. S. WEATHER BUREAU
WASHINGTON 25, D. C.
AND REFER TO

0-6.12

MEMORANDUM HUR 7-42 TO CORPS OF ENGINEERS

FROM : Hydrometeorological Section

SUBJECT: Standard Project Hurricane Parameters and Isovels, Mid-Gulf Coast U. S., Zone B, and Standard Project Hurricane, Lake Pontchartrain

References:
(1) Notes on conference held in New Orleans, La., June 13-14, 1957, re hurricane studies (P.L. 71) paragraphs 11b(4) and 11b(5).
(2) MEMORANDUM HUR 2-4, Hurricane Frequency and Correlation of Hurricane Characteristics for the Gulf of Mexico Area, P.L. 71.
(3) MEMORANDUM HUR 7-40, Louisiana Hurricane of September 29, 1915, transposed to a Critical Track.
(4) Notes on conference between Representatives of OCE and USWB, January 4, 1957 re hurricane studies under P.L. 71.

This memorandum lists parameters and contains a wind speed pattern for a severe hurricane in Zone B (figure 1) on the Gulf Coast of the U. S. and a description of the Standard Project Hurricane for Lake Pontchartrain as requested in reference (1). The purposes of this memorandum, prepared by the Hydrometeorological Section in close consultation with the OCE, are analogous to Memorandum HUR 7-33 for Zone 4 on the East Coast and HUR 7-43 for Zone 3.

STANDARD PROJECT HURRICANE FOR ZONE B

Hurricane parameters

Hurricane parameters and characteristics used in this memorandum are explained in detail in HUR 2-4. Characteristics of an extreme hurricane in various parts of Zone B are listed in Table 1 and are consistent on meteorological grounds from point to point along the coast. The central pressure index (CPI) selected as representative of a Standard Project Hurricane and pertaining to each location along the coast was taken from figure 5 of reference 2 along the CPI curve indicating an average return

Table 1

PARAMETERS OF SEVERE SYNTHETIC HURRICANES IN ZONE B

| Zone | Location Mile (From Fig.5 HUR 2-4) | Near City or other landmark | CPI (inches) | Radius of Maximum Winds (nau.miles) RS | RM | RL | Forward Speed (knots) ST | MT | HT | Representative* Max. Wind Speed (mph) **$V_{gx}$ | $V_x$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| B | 900 | Apalachicola, Fla. | 27.55 | 7 | 14 | 27 | 4 | 11 | 28 | 108 | 102 |
| | 840 | Grayton Beach, Fla. | 27.58 | 7 | 14 | 28 | 4 | 11 | 28 | 108 | 101 |
| | 780 | Pensacola, Fla. | 27.59 | 7 | 14 | 29 | 4 | 11 | 28 | 108 | 101 |
| | 720 | Mobile, Ala. | 27.60 | 7 | 14 | 30 | 4 | 11 | 28 | 107 | 101 |
| | 660 | New Orleans, La. | 27.60 | 7 | 14 | 30 | 4 | 11 | 28 | 107 | 101 |
| | 600 | Lake Barre, La. | 27.59 | 7 | 14 | 29 | 4 | 11 | 28 | 108 | 101 |
| | 540 | Marsh Island, La. | 27.58 | 7 | 14 | 29 | 4 | 11 | 28 | 108 | 101 |
| | 480 | Grand Chenier, La. | 27.56 | 7 | 14 | 28 | 4 | 11 | 28 | 108 | 102 |

*For R = 30 nau. mi. and forward speed of 10 knots (12 mph). Varies slightly with changes in these parameters

CPI Central pressure index
RS Representative small radius to region of maximum winds
RM Representative mean radius to region of maximum winds
RL Representative large radius to region of maximum winds
ST Representative slow speed of translation of hurricane center
MT Representative moderate speed of translation of hurricane center
HT Representative high speed of translation of hurricane center
**$V_{gx}$ Maximum theoretical gradient wind computed for each CPI by use of fig. 13, HUR 2-4, with $P_n$ = 29.92 in.
$V_x$ Estimated 30-ft speed in region of highest speeds. Computed from $V_x = 0.885 V_{gx} + 0.5T$, where T is forward speed in mph.
For discussion of the empirical reduction factor of 0.885 see p. 3, HUR 7-39, "Revised wind fields vicinity of Lake Pontchartrain, Hurricane of September 29, 1915," Aug. 16, 1957.

period of one hundred years. These are consistent with the representative Standard Project Hurricanes for the East Coast and Lake Okeechobee.

For the small radius (RS), medium radius (RM), and large radius (RL) corresponding to the CPI, figure 8 of HUR 2-4 was used as a guide, while the characteristic slow (ST) moderate (MT), and high forward speeds (HT) are from figure 11.

Isovel chart

A synthetically derived isovel chart has been developed for Zone B off the coast south of New Orleans, La. near the center of the zone. This was accomplished by computing gradient winds from the pressure parameters, reducing them to 30-ft. winds by empirical factors and imposing a degree of asymmetry on the isovels. The asymmetry factor, added to speeds on the right and subtracted on the left, was (0.5T)cos a, where T was the forward motion of the storm and a the angle between direction of forward motion and wind direction. The curves of highest value of the wind speed from these various steps are shown in figure 2. The resulting pattern for a CPI of 27.60 inches and a forward speed of 10 knots is shown in figure 3.

Variation R

The distance scale of figure 3 is in terms of R. Any R listed in table 1 may be substituted as the distance scale.

Application to other Zone B locations

The maximum CPI variation in table 1 for Zone B is only 0.05 inches. The wind speed difference due to varying the CPI over this range is about 1%. Therefore the wind speed pattern shown in figure 3 can be employed anywhere in Zone B.

Variation of forward speed

The forward speed for a project hurricane is chosen within or near the range of forward speeds shown in table 1. Forward speed within these spans can be assumed to be independent of CPI and R. Fast moving hurricanes are generally believed to have a greater asymmetry of their wind speed fields than slow-moving storms. The highest speeds are generally found somewhere in the right half of the storm. These two conditions have been conformed to in developing the pattern of figure 3 by adding the forward speed factor described under "isovel chart." This is an empirical approximation and a high degree of refinement of adjusting wind patterns to forward speed is not required; figure 3, computed for a forward speed of 10 knots or approximately the average forward speed of the zone, is applicable for 1/2 to twice this forward speed.

An investigation of forward speed in relation to latitude in the Gulf Coast area showed no significant relationship in contrast to the latitudinal variation found along the Atlantic Coast.

Wind direction

The wind direction for use in conjunction with the isovel pattern of figure 3 may be approximated from table 2 factors. These directions are shown by arrows on the chart.

Table 2

WIND DIRECTION

| Radius | Deflection Angle* |
|---|---|
| Radius R to center | 20° |
| R to 1.2 R | Transition 20° to 25° |
| 1.2 R and beyond | 25° |

*Angle between true wind direction and a tangent to a circle with center of the storm at the center.

Critical path

The path for a project hurricane is selected on the basis of the configuration of the coast or inlet concerned, within the span of directions that are shown to be common on the azimuth chart of past hurricane paths in the zone, figure 4. Most hurricanes pass through Zone B from the south and southeast, a smaller number from the southwest. There is no evidence of a correlation between hurricane intensity and path.

Comparison of synthetic isovels with past storms

Four of the most severe storms of record to pass through Zone B were the hurricanes of October 1, 1893; September 29, 1915; September 19, 1947; and September 8, 1900. The hurricane parameters for these storms are listed in Table 3 and may be compared with the parameters of synthetic hurricanes in Table 1. The hurricane of September 8, 1900 passed sufficiently far offshore that its parameters were not determined in the zone. The parameters listed for this last hurricane are near Galveston.

Table 3
PARAMETERS OF SEVERE STORMS PASSING THROUGH ZONE B

| Date | CPI (inches) | R (nau.mi.) | Forward speed (knots) | Maximum wind at 30 ft. (mph) |
|---|---|---|---|---|
| Oct. 1, 1893 | 28.22 | 17 | 7 | 81 (estimate-HUR 7-17) |
| Sept. 8, 1900 | 27.64 | 14 | 10 | 88 (estimate-HUR 7-36) |
| Sept. 29, 1915 | 27.70 | 26 | 10 | 99 (estimate from $V_x = .885\ V_{gx} + 0.5T$) |
| Sept. 19, 1947 | 28.53 | 28 | 17 | 89 (estimate-HUR 7-37) |
| Sept. 29, 1915 transposed to critical track (HUR 7-40) | 27.70 | 26 | 4-12 | 99 (HUR 7-40) |

Adjustment for filling overland

The critical path may pass partly overland. The normal weakening of a hurricane over land can be approximated by reducing the open sea wind speed values by the following factors, taken ffom Table 4, HUR 7-43 which are based on the time elasped since the storm center crossed the coast.

Table 4
FACTORS FOR REDUCING HURRICANES FOR FILLING OVER LAND

| Time (hours) | Adjustment ratio for wind speed |
|---|---|
| T (at coast) | 1.00 |
| T + 1 | 0.93 |
| T + 2 | 0.88 |
| T + 3 | 0.85 |
| T + 4 | 0.82 |
| T + 5 | 0.80 |
| T + 6 | 0.78 |
| T + 7 | 0.76 |
| T + 8 | 0.74 |

Storms moving inland over flooded areas or over marshy land and lakes will fill at a lesser rate, comparable to the rate of filling that occurred in the September 29, 1915 hurricane. The factors to reduce the open-sea wind speed values in these cases are given in Table 5, taken from Table 1, HUR 7-40.

Table 5
FACTORS FOR REDUCING HURRICANES FOR FILLING
OVER FLOODED OR MARSHY LAND AREAS

| Time (hours) | Adjustment ratio for wind speed |
|---|---|
| T (at coast) | 1.00 |
| T + 1 | 0.99 |
| T + 2 | 0.99 |
| T + 3 | 0.98 |
| T + 4 | 0.97 |

The factors in Tables 4 and 5 will yield speeds for portions of the storm that are still over water. Further reductions would be required to obtain the speeds over land.

STANDARD PROJECT HURRICANE FOR LAKE PONTCHARTRAIN, LA.

The isovel pattern of the Standard Project Hurricane for Zone B, figure 3, is nearly identical with the isovel pattern for the September 29, 1915 hurricane transposed to a critical track for Lake Pontchartrain (HUR 7-40) except that the values of the isovels in figure 3 are 2 percent higher than those in the 1915 hurricane transposed. The Standard Project Hurricane pattern applicable to Lake Pontchartrain with a forward speed and track as shown in HUR 7-40 can be obtained by increasing the isovel values of the 1915 hurricane transposed by 2 percent.

To adjust these isovels to a high forward speed, in excess of 20 knots, add the following factor to speeds on the right and subtract for speeds on the left: $(0.5T - 6) \cos a$, where T is the forward speed in m.p.h. and a is defined on page 2.

Charles S. Gilman, Chief
Hydrometeorological Section

attachments
12 to OCE with attachments

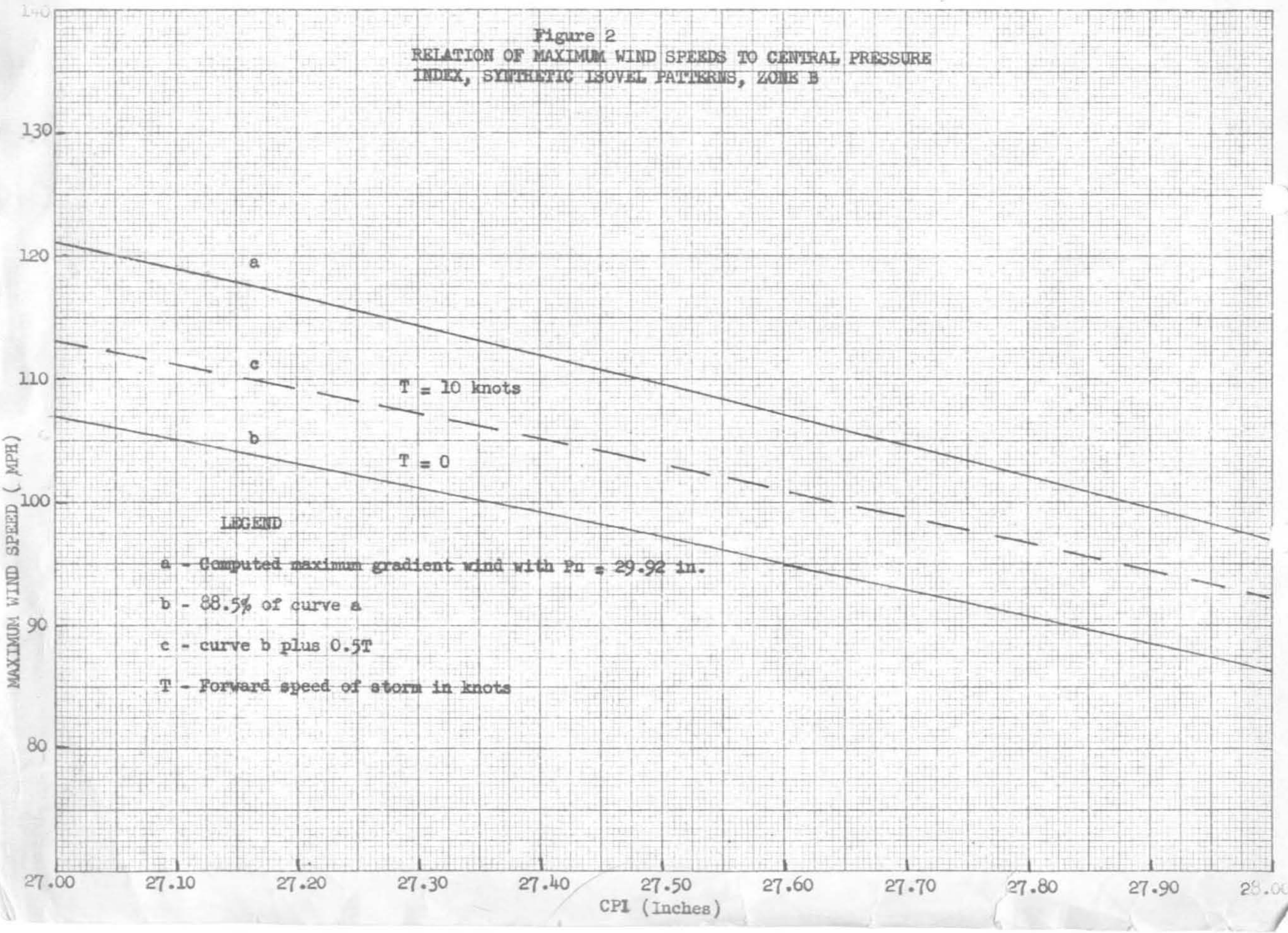



Figure 2
RELATION OF MAXIMUM WIND SPEEDS TO CENTRAL PRESSURE INDEX, SYNTHETIC ISOVEL PATTERNS, ZONE B

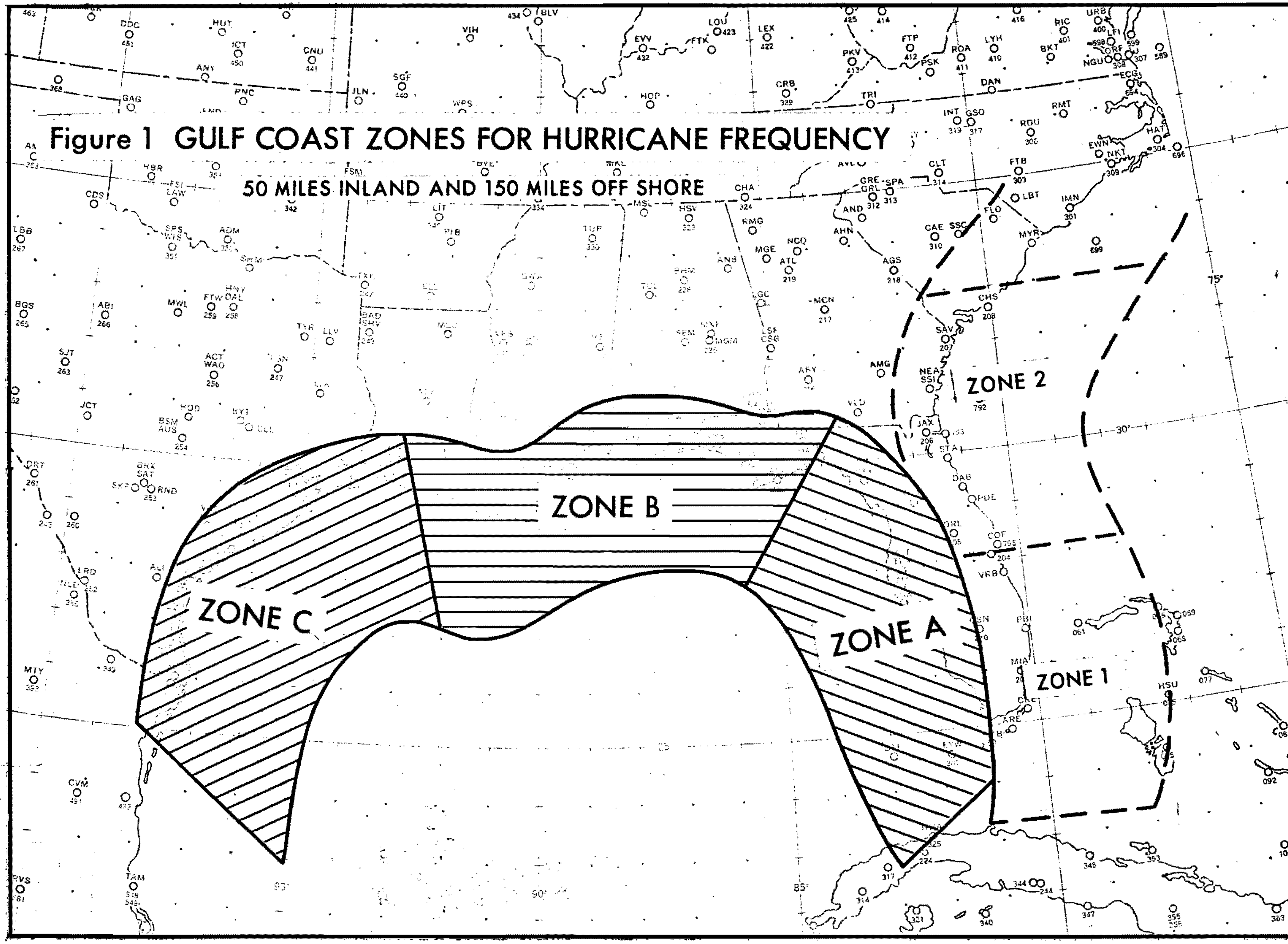
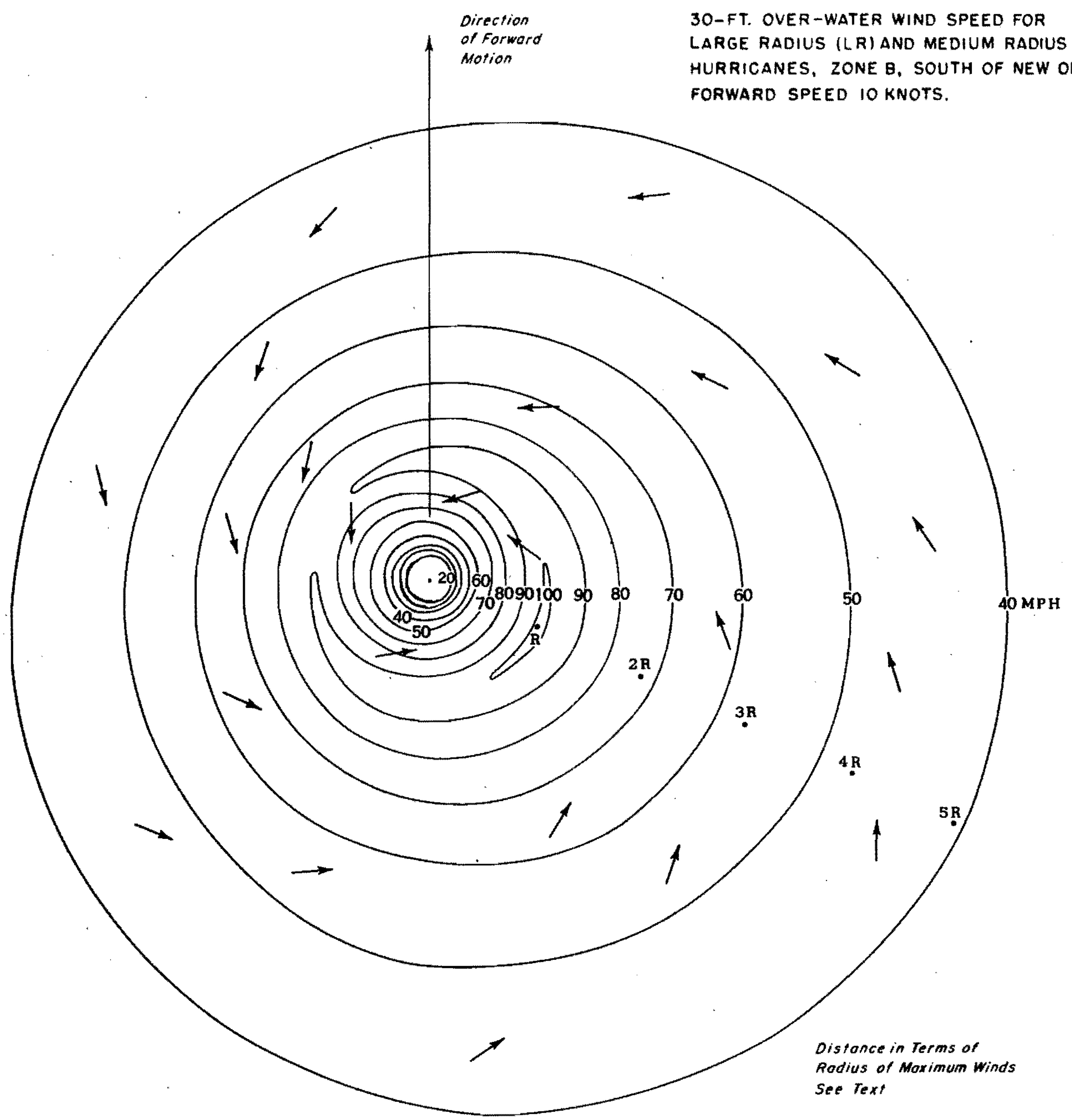



Figure 1 GULF COAST ZONES FOR HURRICANE FREQUENCY

50 MILES INLAND AND 150 MILES OFF SHORE

FIGURE 3

30-FT. OVER-WATER WIND SPEED FOR LARGE RADIUS (LR) AND MEDIUM RADIUS (MR) HURRICANES, ZONE B, SOUTH OF NEW ORLEANS, L.A. FORWARD SPEED 10 KNOTS.



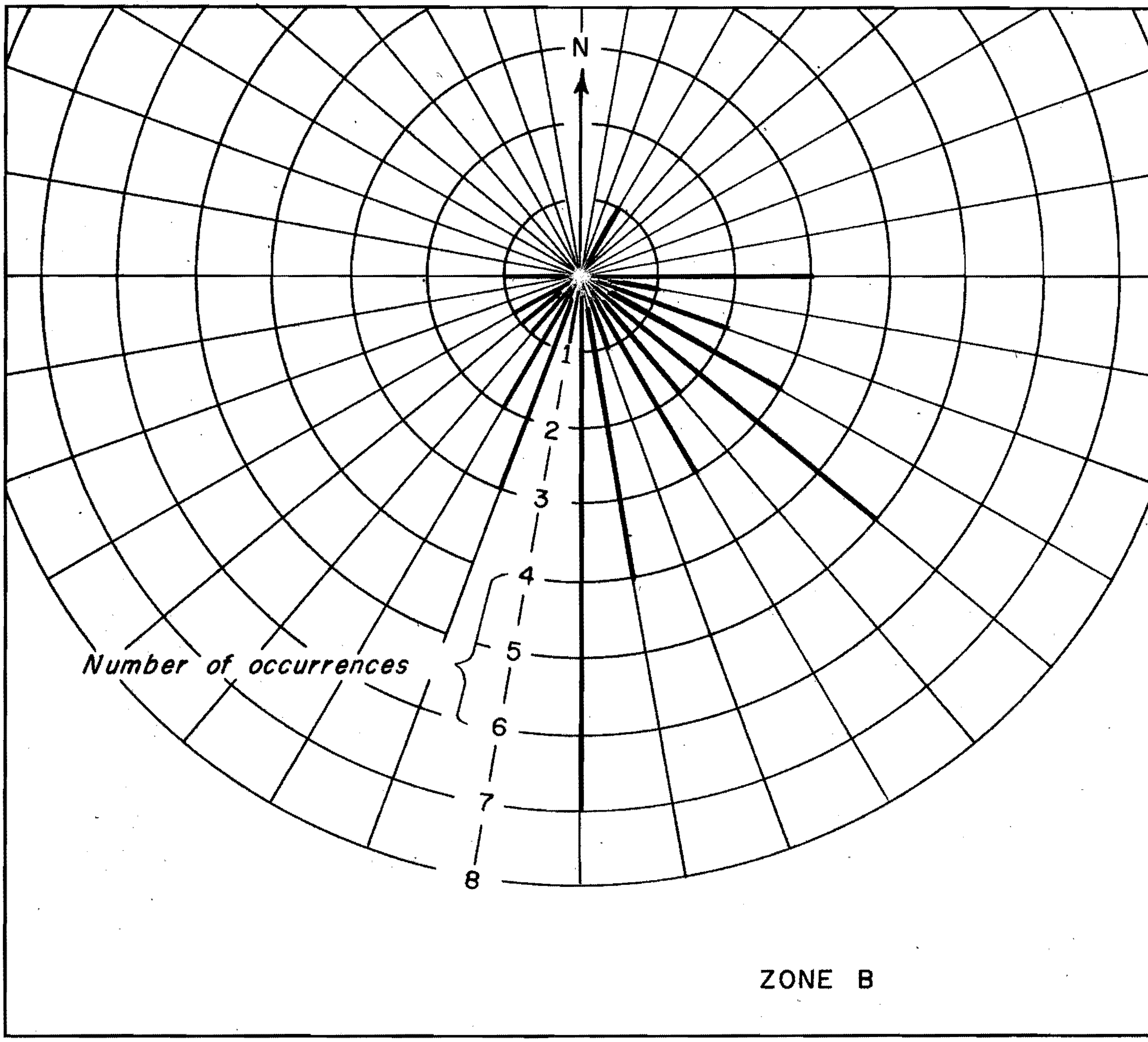



Fig. 4 AZIMUTH DISTRIBUTION OF HURRICANE PATHS IN ZONE
1900–1956

UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
WASHINGTON 25

September 6, 1957

IN REPLY, PLEASE ADDRESS
CHIEF OF BUREAU
AND REFER TO

0-6.12

TO : Mr. A. L. Cochran, Civil Works
Office of Chief of Engineers
Corps of Engineers

FROM : Hydrometeorological Section

SUBJECT: MEMORANDUM HUR 7-40, Louisiana hurricane of September 29, 1915, transposed to a critical track

Reference: Notes dated 17 June 1957 on conference held in New Orleans, La., 13-14 June 1957 on hurricane studies (P.L. 71)

In compliance with paragraph 11 b (b) of the above referenced notes, herewith are charts (with explanatory notes) depicting hypothetical wind fields at selected times for the hurricane of September 29, 1915, transposed to a critical track.

Charles S. Gilman, Chief
Hydrometeorological Section

Attachments
cc: 2 to OCE with attachments
1 to BEB with attachments

1 to New Orleans WBO with attachments

UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
WASHINGTON 25

September 6, 1957

IN REPLY, PLEASE ADDRESS
CHIEF OF BUREAU
AND REFER TO

0-6.12

MEMORANDUM HUR 7-40

FROM : Hydrometeorological Section

SUBJECT : Louisiana Hurricane of September 29, 1915, transposed to a critical track

References: HUR 7-39, August 16, 1957
Notes dated 17 June 1957 on conference held in New Orleans, La. 13-14 June 1957, on hurricane studies (P.L. 71)

Movement along critical track

The hurricane of September 29, 1915, has been transposed to the critical path shown in figure 1, as adopted at the referenced conference. This track was quite similar to the one worked up by the New Orleans Weather Bureau Office at the request of the Hydrometeorological Section. The hypothetical speed of the center along the track was reduced to 4 knots during a one-hour period at the point of recurvature. Such a speed was about the slowest observed at recurvature in an examination of many storm tracks in the vicinity of Lake Pontchartrain (HUR 7-38, table 1). The speed of the storm was decelerated while approaching the point of recurvature by a factor of .95 per hour and accelerated after recurvature by a factor of 1.1 per hour. The application of these factors gave a movement of approximately 150 nautical miles during the 24-hour period encompassing recurvature, which was approximately equal to the respective minimum movement measured along 29 storm tracks in the vicinity, as shown in Tracks of Tropical Storms, 1887-1956 (HUR 1-1).

Variation of central pressure along critical track

The variation of central pressure with time along the critical track was chosen midway between the average variation found in 3 Florida storms and the mean observed in several storms moving over land but toward water. This choice was influenced by the fact that the critical track of figure 1 is roughly parallel to the coastline. The resultant variation in $P_o$ for the transposed storm is shown in figure 2. The pressure profile of figure 2b, HUR 7-39, is applicable to the transposed storm at the time of landfall of the center.

Adjustments to the mean over-water wind-speed profile

The average over-water wind-speed profile evolved in HUR 7-39 for the storm as it occurred was applicable to the transposed case at landfall, without alteration. Adjustment factors for the speed profiles at other selected times prior to and succeeding landfall were calculated according to the procedures used in HUR 7-39. The new adjustment factors are listed in table 1.

A constant speed of 6 knots for the storm center (rather than the exact speeds from figure 1) was used in calculating the contribution of storm movement to the actual wind speeds. Otherwise, the various adjustments and corrections applied in HUR 7-39 were repeated without alteration.

Final wind fields

The resultant wind fields in final form have been reproduced in figures 3 through 12, inclusive.

Charles S. Gilman, Chief
Hydrometeorological Section

Attachments
CC: 2 to OCE with attachments
1 to BEB with attachments

1 to New Orleans WBO with attachments

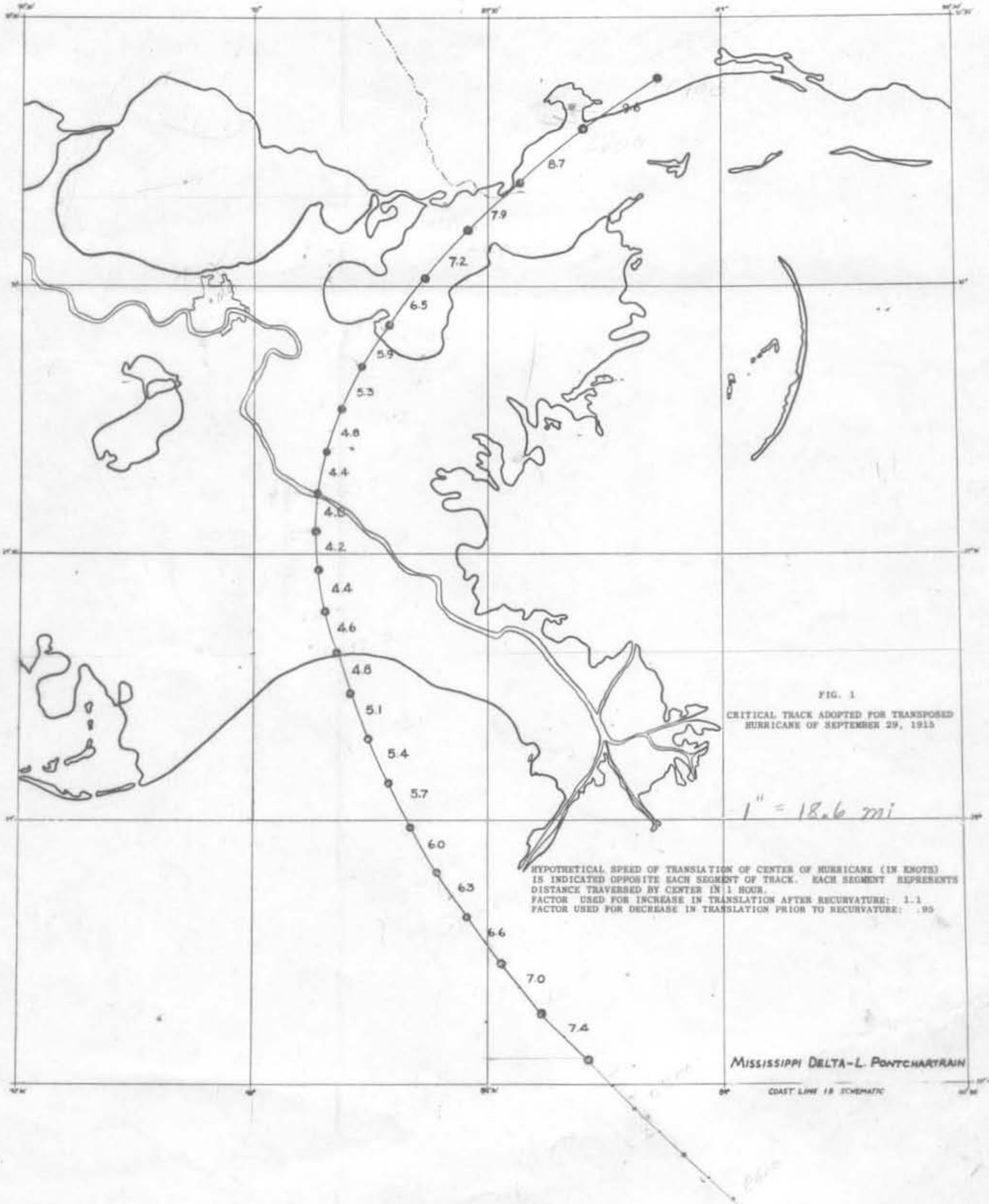



FIG. 1

CRITICAL TRACK ADOPTED FOR TRANSPOSED HURRICANE OF SEPTEMBER 29, 1915

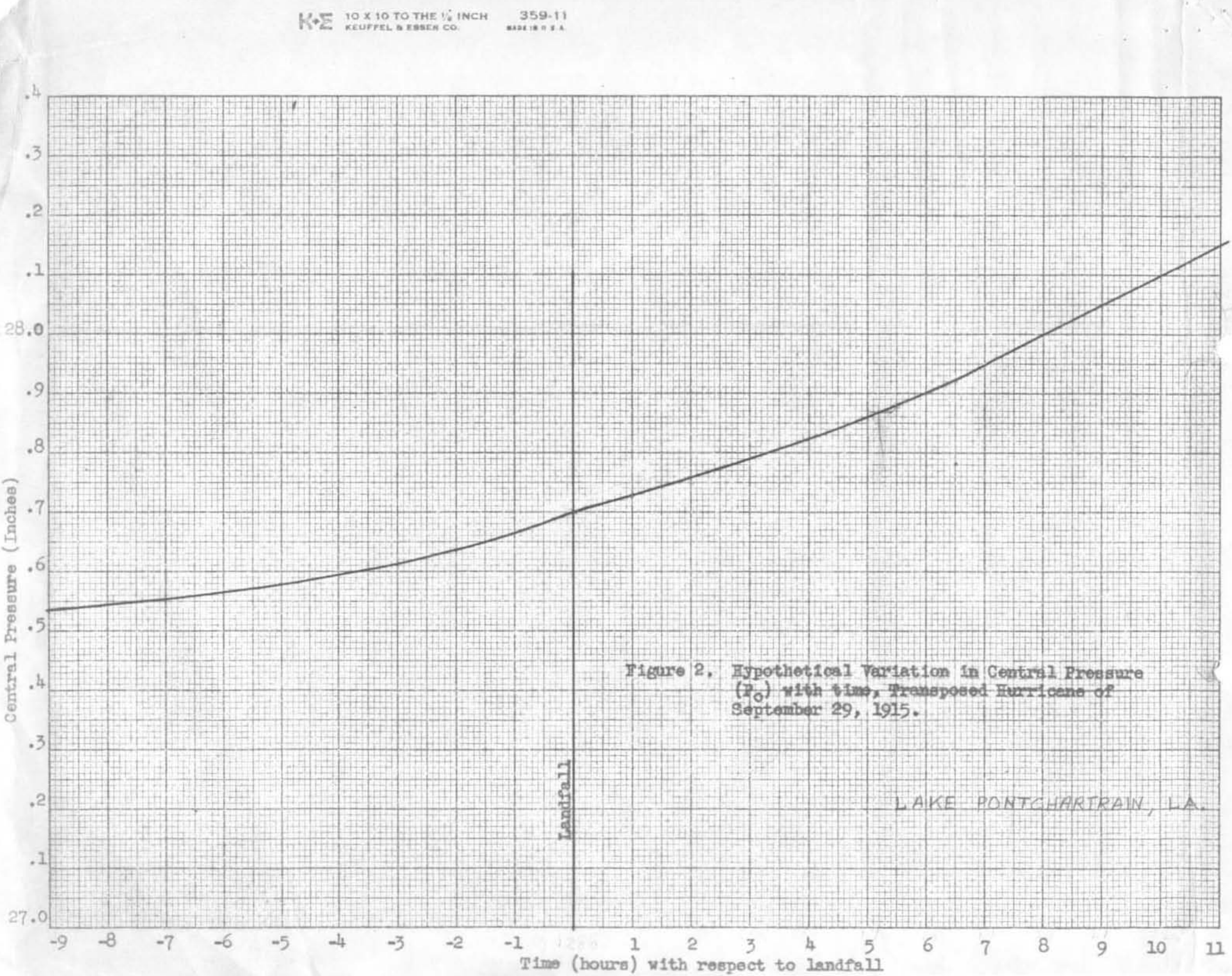



Figure 2. Hypothetical Variation in Central Pressure ($P_o$) with time, Transposed Hurricane of September 29, 1915.

Table 1

TIME ADJUSTMENT FACTORS

| Hour (with respect to landfall) | Factor (ratio of speeds at respective hours to speeds at landfall) |
|---|---|
| -6 | 1.03 |
| -5 | 1.03 |
| -4 | 1.02 |
| -3 | 1.02 |
| -2 | 1.01 |
| -1 | 1.01 |
| Landfall | 1.00 |
| +1 | .99 |
| +2 | .99 |
| +3 | .98 |
| +4 | .97 |
| +5 | .97 |
| +6 | .95 |
| +7 | .94 |
| +8 | .93 |
| +9 | .92 |
| +10 | .91 |
| +11 | .89 |
| +12 | .88 |
| +13 | .87 |
| +14 | .85 |

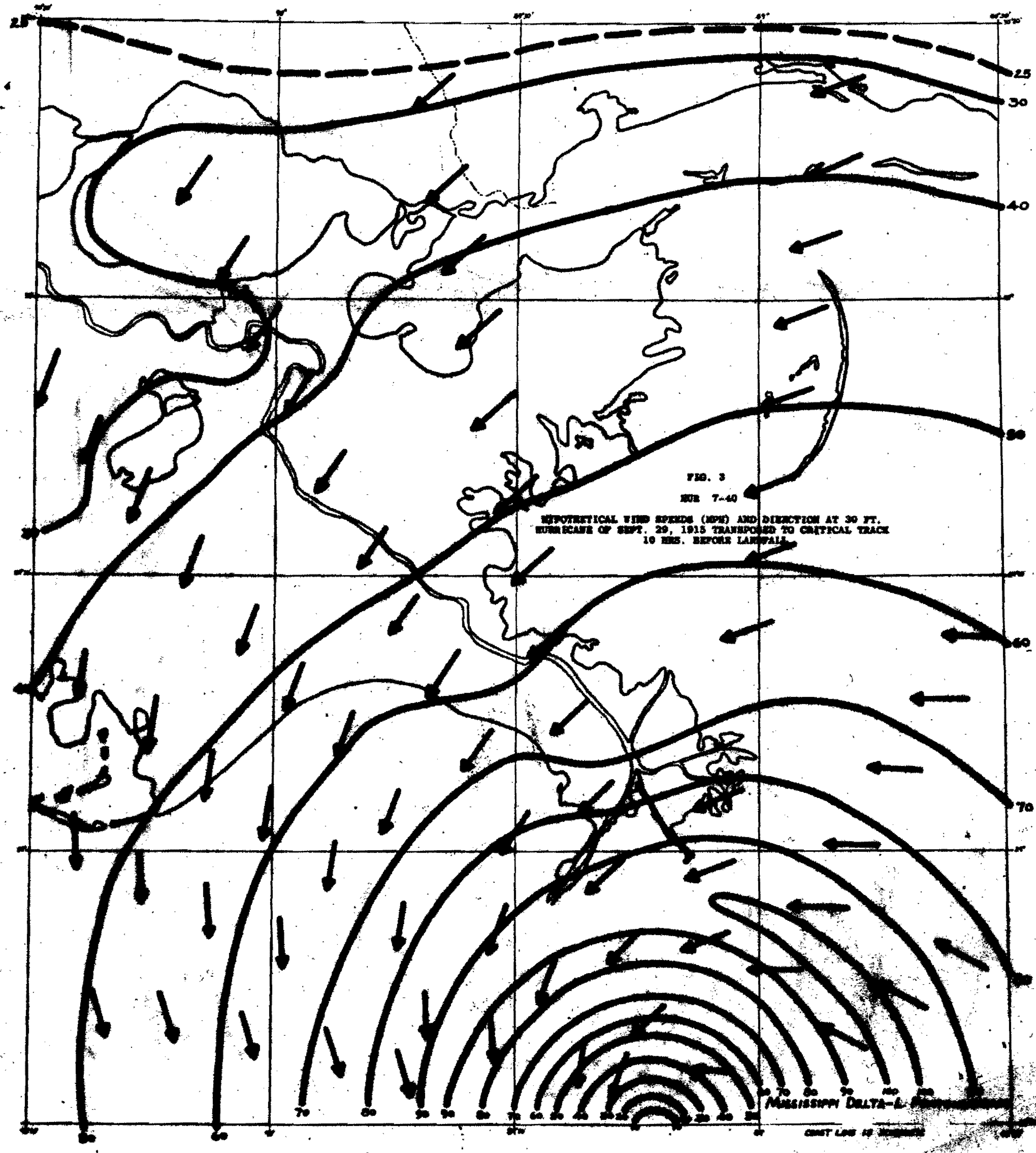



FIG. 3

HUR 7-40

HYPOTHETICAL WIND SPEEDS (MPH) AND DIRECTION AT 30 FT.
HURRICANE OF SEPT. 29, 1915 TRANSPOSED TO CRITICAL TRACK
10 HRS. BEFORE LANDFALL

1915 Transposed
0200
10 hrs Before Landfall

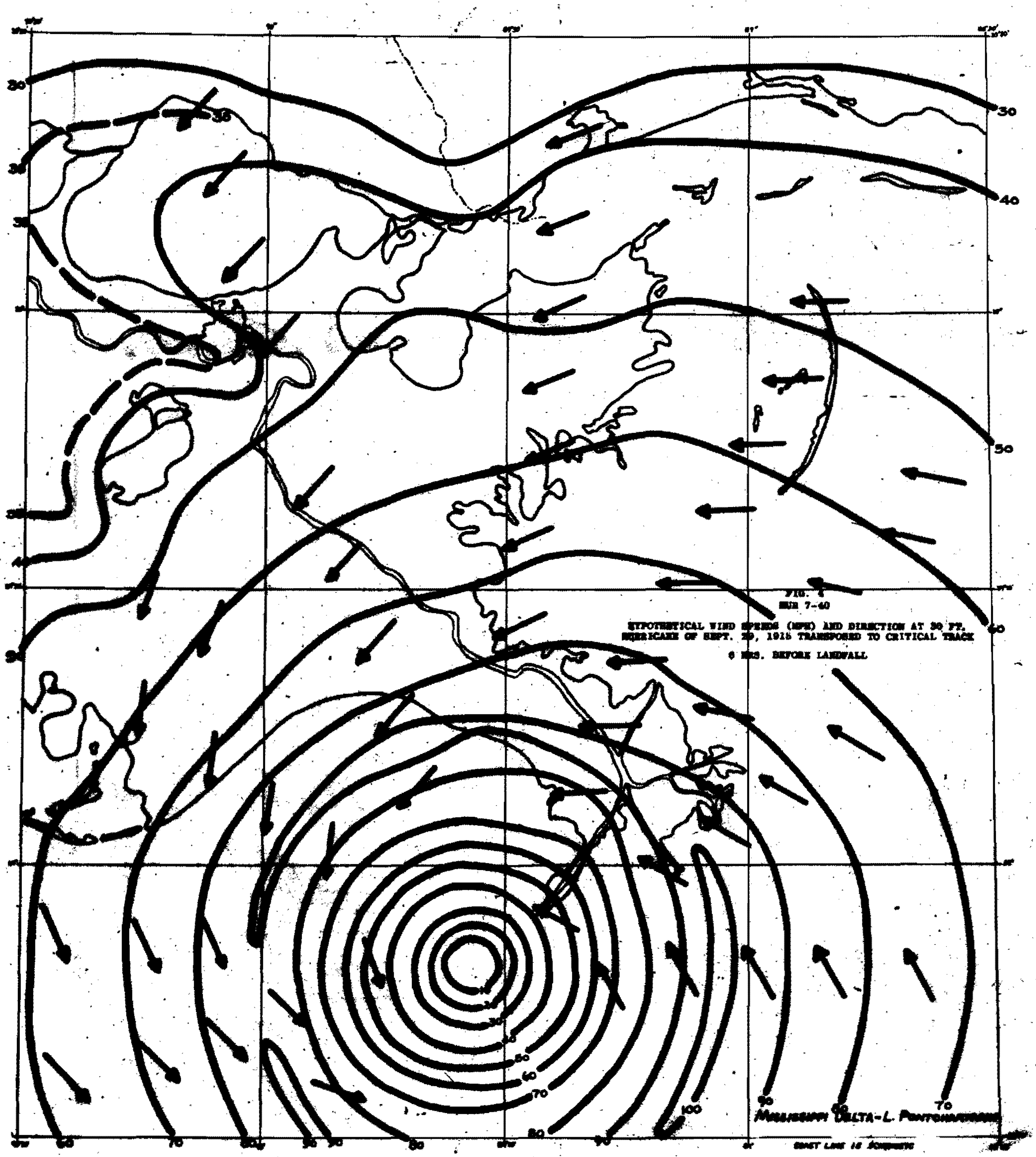



FIG. [illegible]
HUR 7-40

HYPOTHETICAL WIND SPEEDS (MPH) AND DIRECTION AT 30 FT.
HURRICANE OF SEPT. 29, 1915 TRANSPOSED TO CRITICAL TRACK

6 HRS. BEFORE LANDFALL

1915 Transposed
0600
6 hrs B.L.

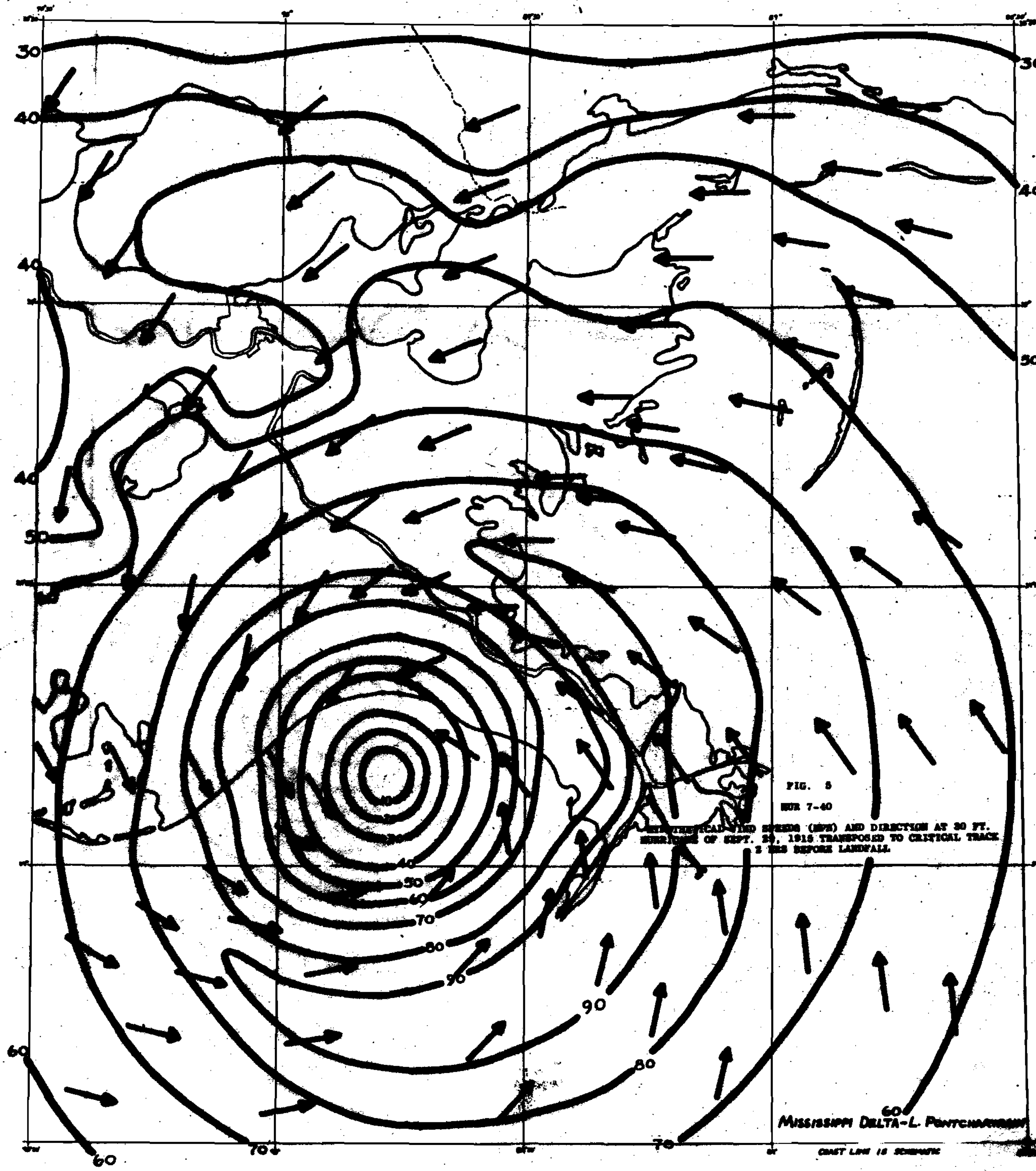



FIG. 5

HUR 7-40

HYPOTHETICAL WIND SPEEDS (MPH) AND DIRECTION AT 30 FT.
HURRICANE OF SEPT. 29, 1915 TRANSPOSED TO CRITICAL TRACK
2 HRS BEFORE LANDFALL

1000

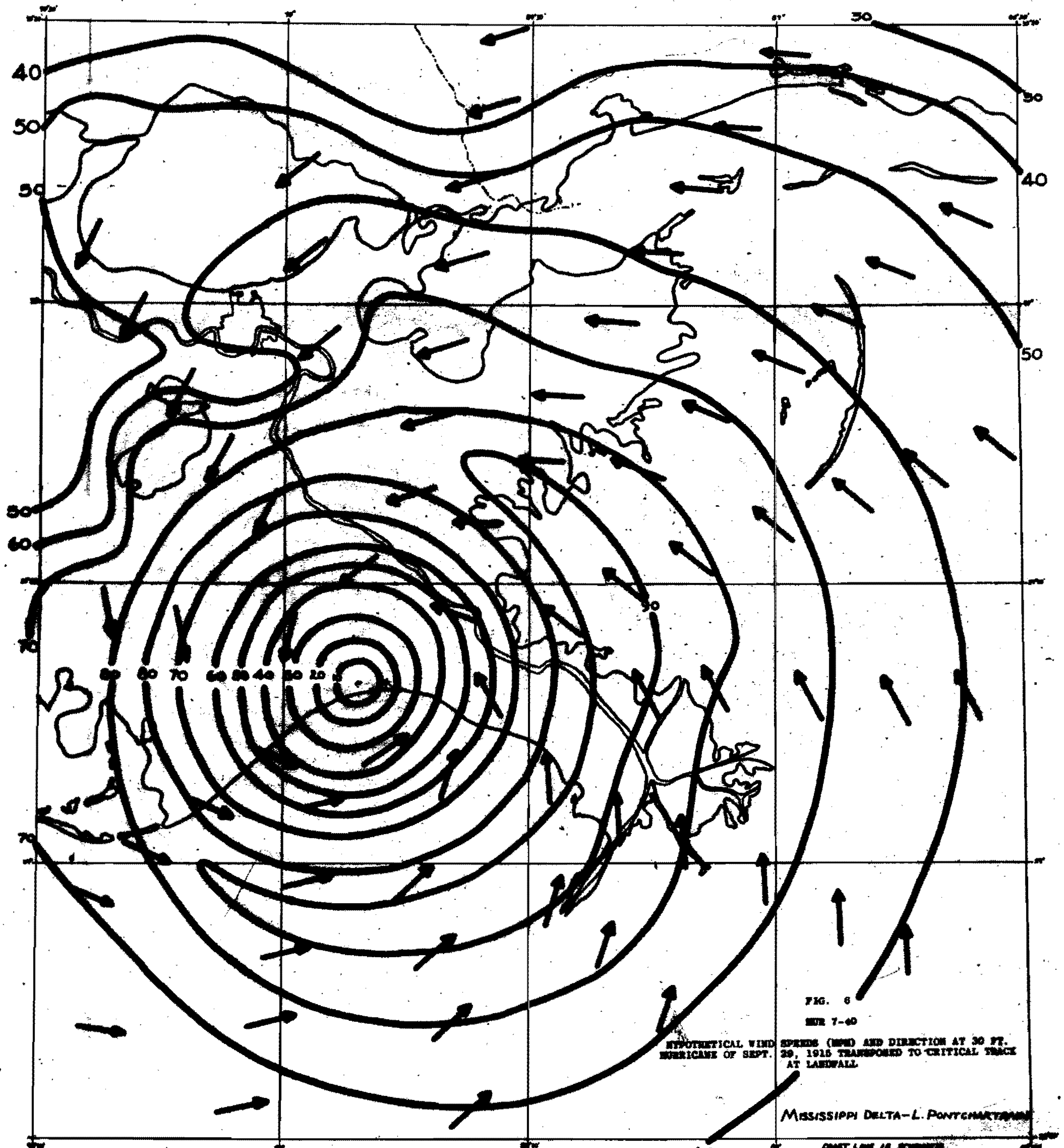



FIG. 6

HUR 7-40

HYPOTHETICAL WIND SPEEDS (MPH) AND DIRECTION AT 30 FT.
HURRICANE OF SEPT. 29, 1915 TRANSPOSED TO CRITICAL TRACK
AT LANDFALL

1200

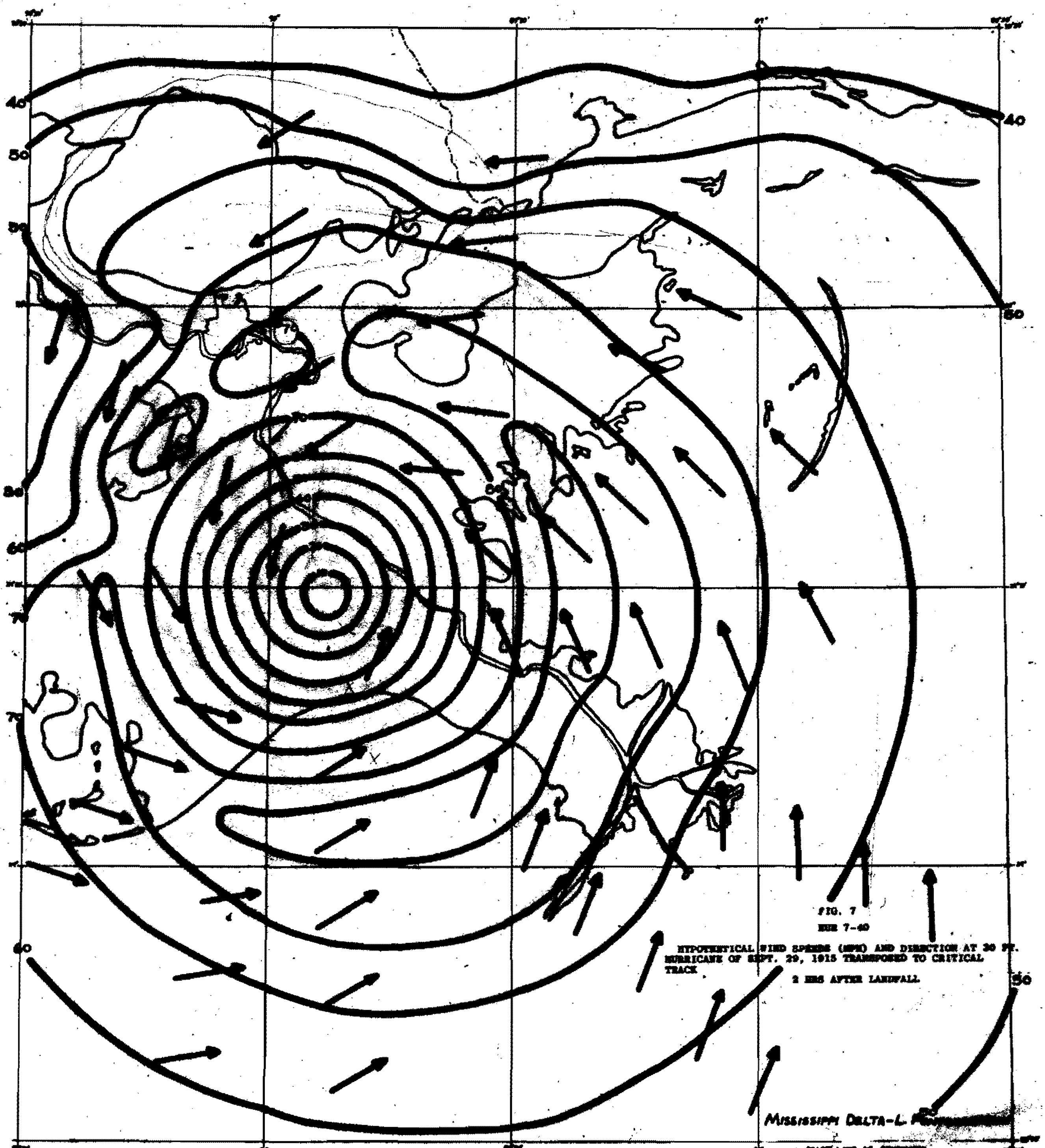



FIG. 7
HUR 7-40

HYPOTHETICAL WIND SPEEDS (MPH) AND DIRECTION AT 30 FT.
HURRICANE OF SEPT. 29, 1915 TRANSPOSED TO CRITICAL
TRACK

2 HRS AFTER LANDFALL

1400

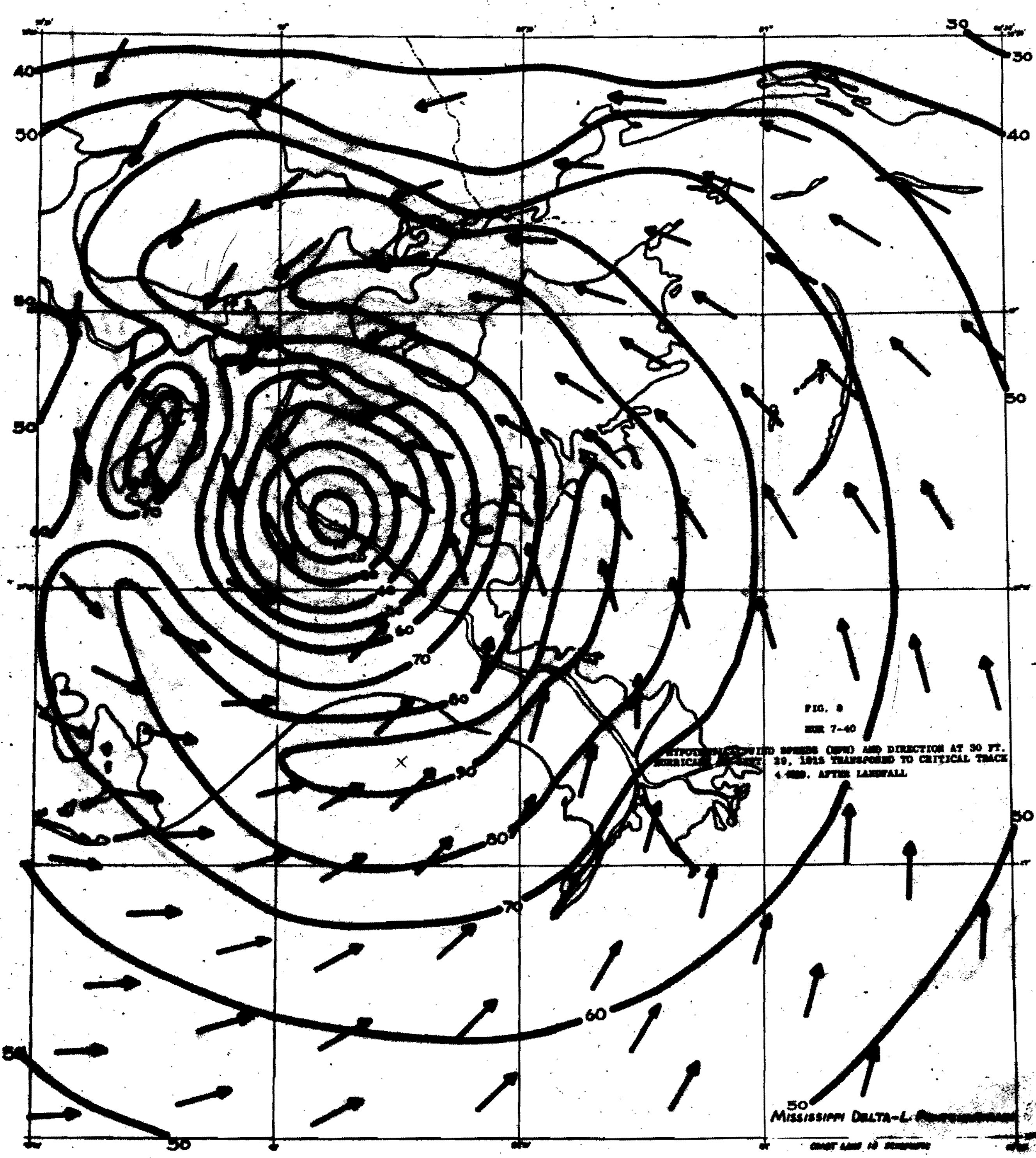



FIG. 8

HUR 7-40

[illegible] WIND SPEEDS (MPH) AND DIRECTION AT 30 FT.
HURRICANE [illegible] 29, 1915 TRANSPOSED TO CRITICAL TRACK
4 HRS. AFTER LANDFALL

1600

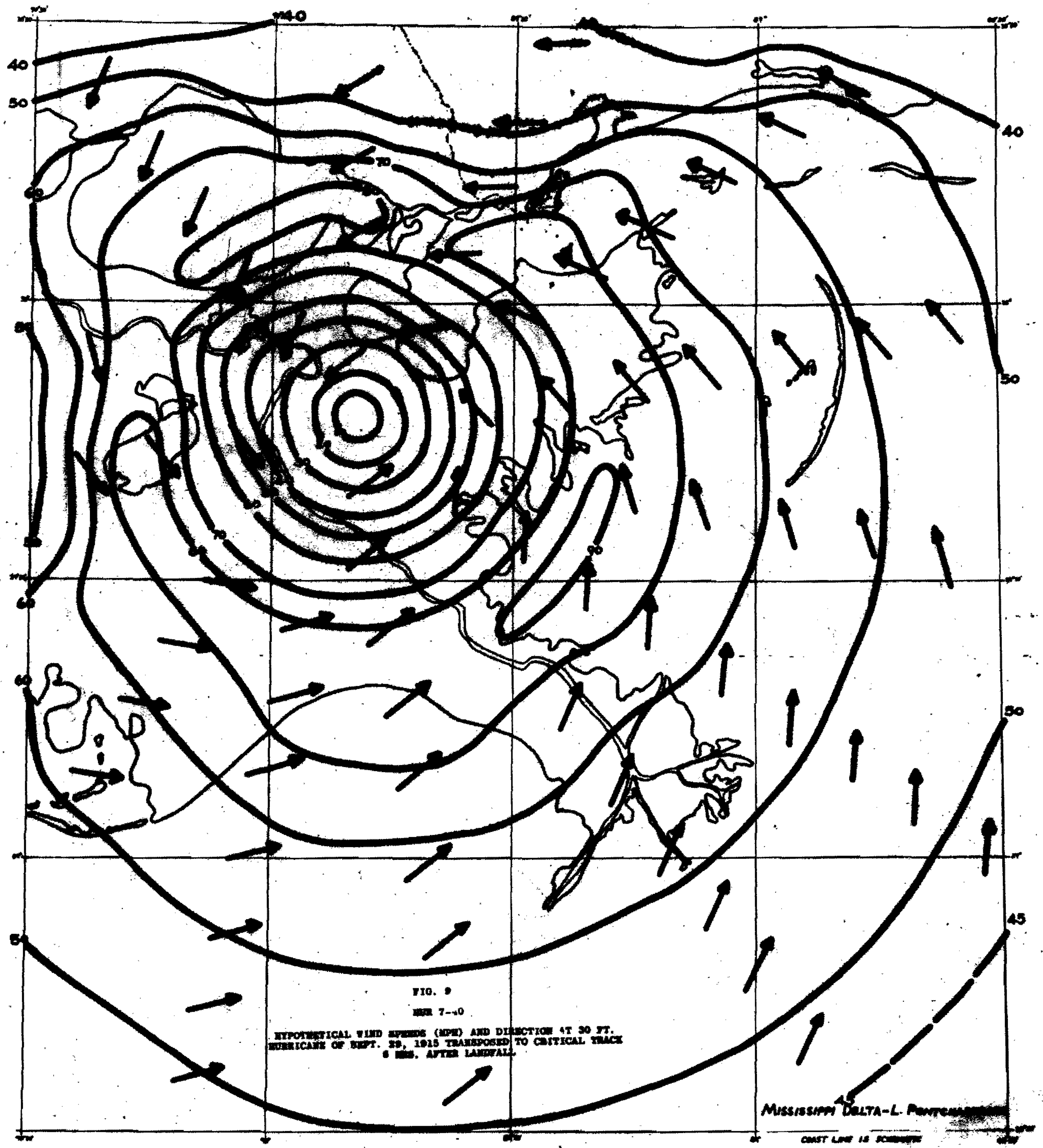
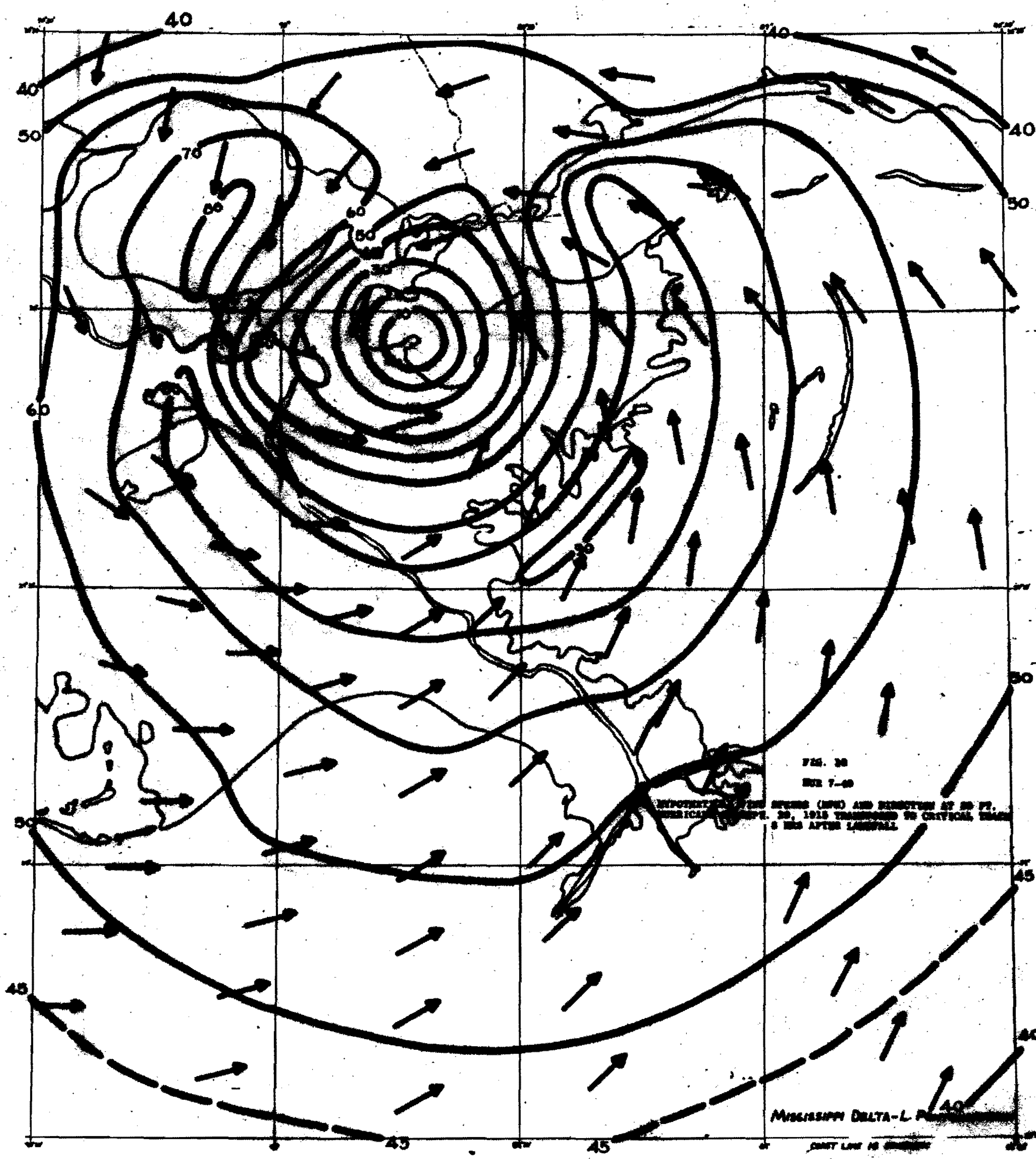



FIG. 9

HUR 7-40

HYPOTHETICAL WIND SPEEDS (MPH) AND DIRECTION AT 30 FT.
HURRICANE OF SEPT. 29, 1915 TRANSPOSED TO CRITICAL TRACK
6 HRS. AFTER LANDFALL.

1800



40
50
60
70
80
45
Mississippi Delta-L

5

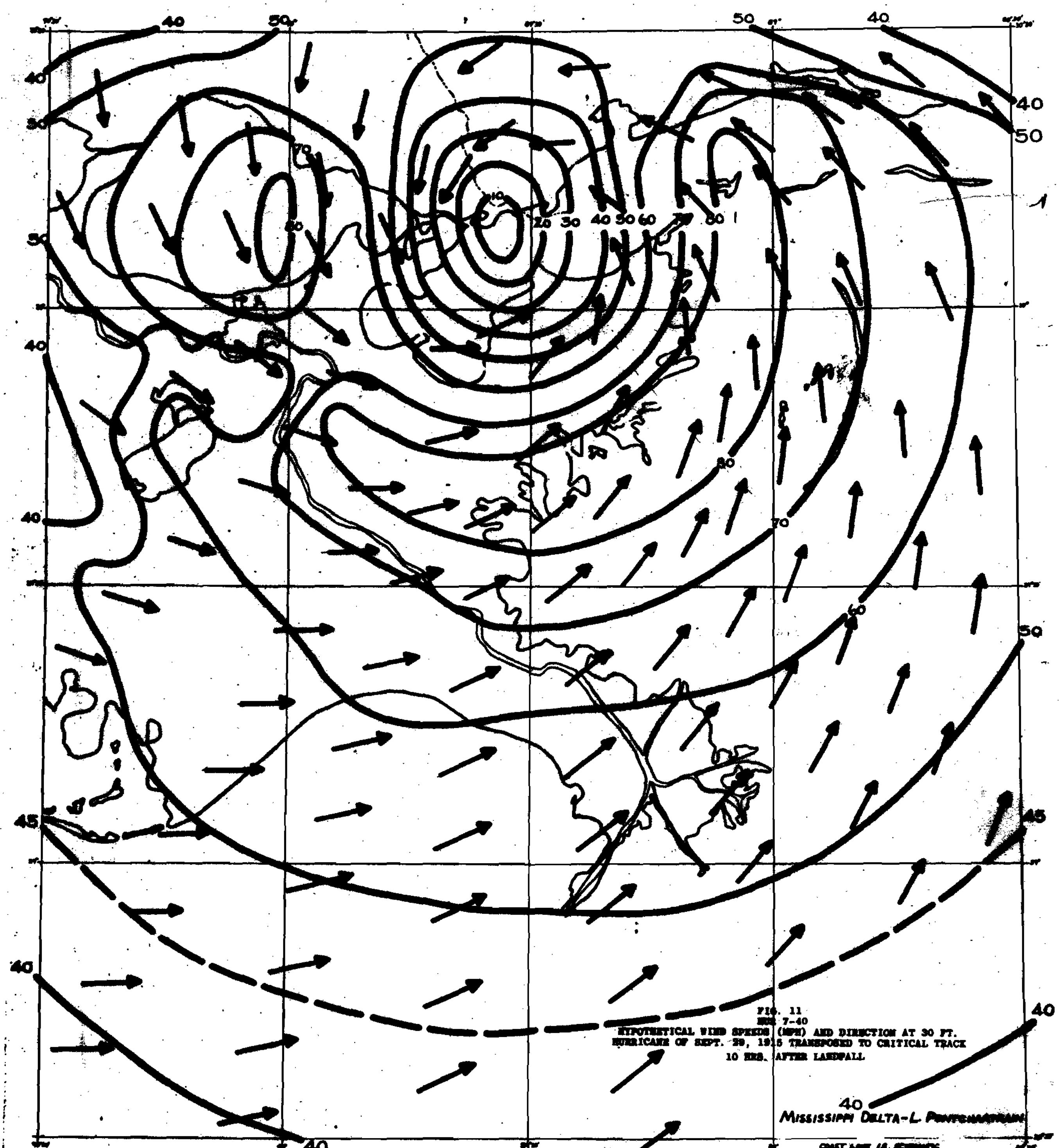



FIG. 11
HUR 7-40
HYPOTHETICAL WIND SPEEDS (MPH) AND DIRECTION AT 30 FT.
HURRICANE OF SEPT. 29, 1915 TRANSPOSED TO CRITICAL TRACK
10 HRS. AFTER LANDFALL

2200

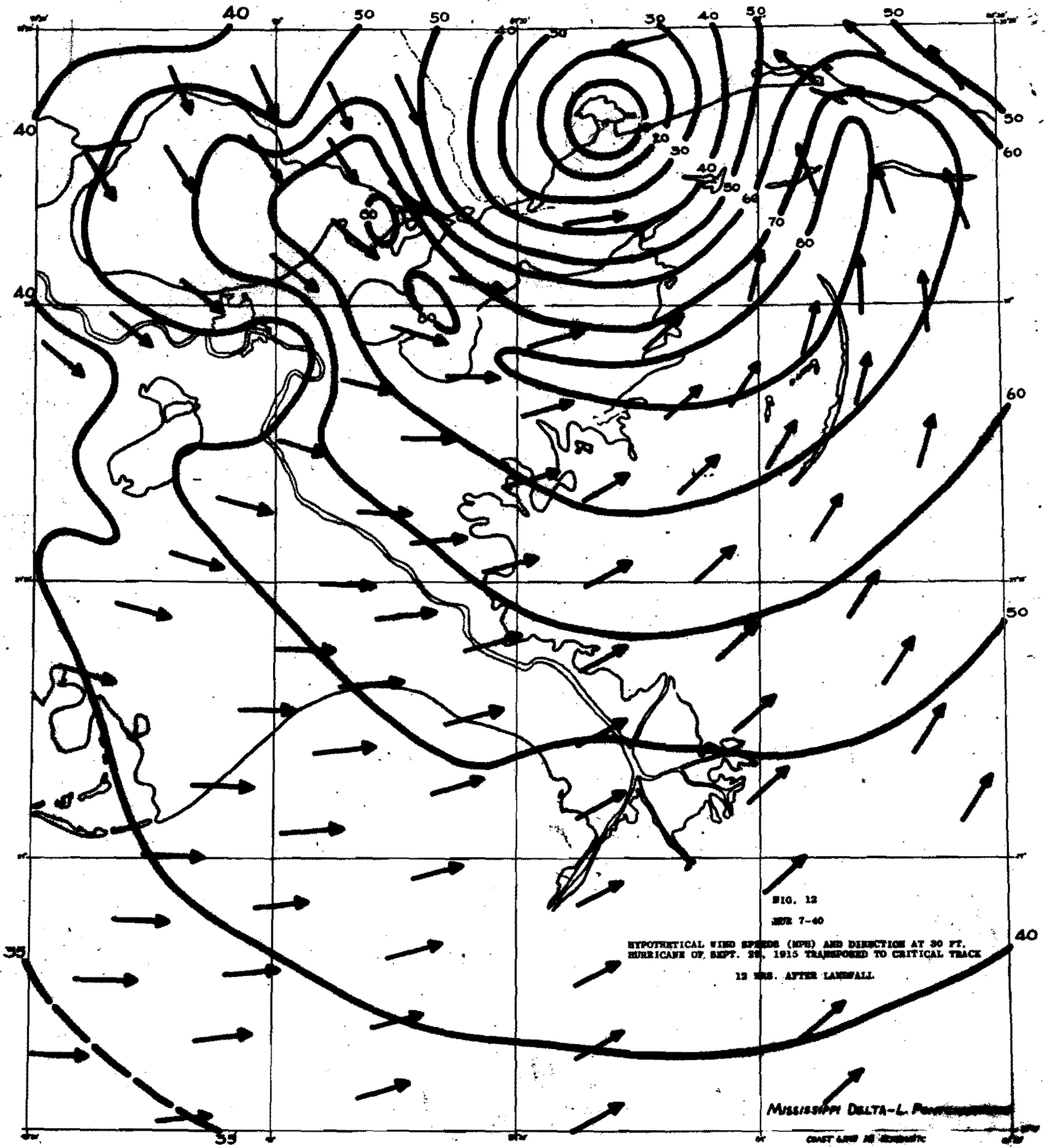



FIG. 12

HUR 7-40

HYPOTHETICAL WIND SPEEDS (MPH) AND DIRECTION AT 30 FT.
HURRICANE OF SEPT. 29, 1915 TRANSPOSED TO CRITICAL TRACK

12 HRS. AFTER LANDFALL.

2000

2300

UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
WASHINGTON 25

IN REPLY, PLEASE ADDRESS
CHIEF OF BUREAU
AND REFER TO

October 19, 1956

0-6.12

MEMORANDUM: HUR 7-17

FROM; Hydrometeorological Section

SUBJECT: Hurricane of September-October 1893 in Louisiana

The subject hurricane produced one of the severest hurricane inundations in the history of Louisiana. Enclosed for the information of the New Orleans District and other offices concerned is the study of this hurricane we carried out in connection with our New-Orleans-Lake Pontchartrain assignment (memo from OCE July 13, 1956). The study was directed at determining parameters for the storm ($P_o$, R, etc.) and the severity of the wind circulation as compared with more recent hurricanes. The data are inadequate for positive conclusions on the severity. However the weight of the evidence is that the hurricane of 1893 at the time it inundated Grand Isle and crossed the Mississippi Delta was no more severe than the greatest hurricane since that time (September 29, 1915).

Charles S. Gilman, Chief
Hydrometeorological Section

Enclosures
cc: 2 with enclosures to OCE
1 with enclosure to BEB

THE LOUISIANA HURRICANE OF 1893
Hydrometeorological Section
September 1956

## INTRODUCTION

The hurricane of September 27-October 5, 1893, caused one of the greatest hurricane disasters in the history of Louisiana. Few weather records are available for the period from stations that were within the path of the storm. Nevertheless, the path of the storm was reconstructed using the sparse data, and values for the central pressures, gradient winds, and winds at anemometer level over water were calculated for several times in order to show the intensity of the factors which caused this disaster.

The hurricane formed in the Caribbean Sea then moved northward across the center of the Gulf of Mexico (figure 1). It approached the Louisiana coast unexpectedly, on Sunday, October 1, 1893, (1) and crossed the Mississippi River Delta near Bastian Bay, La., between 2300-0100E, October 1-2. The hurricane then moved northeastward up the coast of eastern Louisiana through Breton and Chandeleur Sounds and passed inland between Biloxi and Pascagoula, Miss. at about 1000E on October 2. An intense storm of less than average diameter, the hurricane caused 2000 deaths along the Louisiana coastal areas and along the Mississippi and Alabama coasts. As the hurricane passed through Plaquemines Parish, La., Mr. Kerkam, Secretary of the Louisiana State Weather Service, estimated the winds to be as high as 100mph. (1)

Destruction from the wind was great; houses were smashed, people were killed by flying debris as they rushed into the night to escape from their collapsing flooded homes, the orange and sugar crops were ruined, rice in the fields was battered as though threshed, harvested rice stored along the levees was blown into the river. Nothing was left standing on Grand

Isle and no house in Plaquemines Parish was undamaged. Although the destruction from the wind was great, flooding and sea surges caused even greater damage and loss of life. (2)

The greatest loss of life occurred at Cheniere Caminada, a fishing village on a low-lying spit of land just west of Grande Isle on Caminada Bay. 1650 persons out of a population of 1800 perished there. A strong south wind had blown throughout the day on October 1, backing up the Gulf waters into Caminada Bay and the adjoining bays and bayous, flooding the marsh lands and nearby prairies. The water rose to five feet above its usual level in the bays and when it was at that height the wind changed to the northeast. "...This blew the water from the Gulf through Caminada Pass. Here the outgoing rush of water was met by the sea. The meeting of waters caused a perfect wall of water to be raised. The waters rose to a height of twenty feet and swept everything before them." (3)

South of New Orleans in the vicinity of ~~Porte~~ Pointe-a-la-Hache shortly after midnight on October 1, the winds blew so violently out of the east-northeast that in some places the waters of the Mississippi rose 9 feet and poured over the levees. After a calm the hurricane winds blew from the west and, according to newspaper accounts, the water from the Gulf and its bays rose fifteen feet and swept away the fishing hamlets along the coast and poured over the levee into the river. It inundated the highest orange groves and the railroad to a depth of four feet. (2, 4)

The storm moved up the eastern Louisiana shore the morning of October 2, inundating the Chandeleur Islands and the islands along the Mississippi coast and causing great damage to coastal shipping. It was estimated that at least 350 craft were wrecked. (5) Waves washed away sections of the beach, undermined the L & N track and destroyed sixty sections of the railroad bridge over Biloxi Bay. In Mobile Bay where the water rose rapid- to eight feet above tide (as much as 2 feet in 1/2 hour) the flood was the worst experienced there up to that time. The extreme speed of the wind at Mobile was reported to be 80 mph. The marshes around Mobile were flooded and all the houses in them destroyed. Seven persons lost their lives. (6)

The storm struck Pensacola, Fla., at about 4:45 a.m. on October 2, with the wind reaching its maximum velocity, 66 mph from the Southwest, at 3:45 p.m.

OBSERVATIONS

Port Eads, La.

Since many recording instruments in the path of the hurricane were blown down as it passed, no complete history of the winds and pressures is available. The instruments at Port Eads were destroyed and no observations were recorded for the storm period after the 8 p.m. observation on October 1. The station pressure at that time was 29.65 in. and the wind 24 mph from the Southeast. The hurricane was centered west-southwest of the station.

New Orleans, La.

A fairly symmetrical trace was made by the recording barograph at New Orleans as the center of the storm passed within 45 miles of the city at about 0345E on October 2. (figure 2) The pressure had fallen steadily to a low of 29.32 in. MSL by that time from a pressure of 29.81 in. at noon of the previous day. The instruments recording wind speeds became inoperative at 20.52E on October 1. The wind at that time was 30 mph from the Northeast with gusts to 35 mph recorded on the triple register. West End, north of the city on Lake Pontchartrain, registered winds of 65 mph (uncorrected) before the instrument became inoperative. (1) The 10-minute-average wind speeds for New Orleans are shown in figure 7.

Moss Point, Miss.

A pressure fall from 29.70 in. at 0600E on October 2 to 28.65 in. at

1030E (1.10 inch in 4-1/2 hours) was reported by the captain of a schooner lying at anchor at Moss Point, Miss., close to the storm track. The captain reported that the wind blew strongly from the east-southeast and east until 1030E when it gradually veered to south, southwest, and then strongly from the west-southwest and west at 1200E. The wind did not veer north of west until sometime during the night. It cleared after 1600E and by 2100E the wind was nearly calm. (1) Table 1 shows the values reported by the ship.

Table 1

SHIP OBSERVATION AT MOSS POINT, MISS.--Oct. 2, 1893

| Time (EST) | Pressure (Inches) | Remarks* |
|---|---|---|
| 06 | 29.70 | "Blowing heavy from ESE" |
| 07 | 29.30 | "Wind SE by E" |
| 08 | 29.00 | "No change in the wind" |
| 09 | 28.85 | "Heavier and heavier" |
| 1030 | 28.65 | "Wind abated nearly to calm and gradually went around by south to southwest" |
| 12 | | "Came out heavy from west-southwest and west" |
| 16 | | "Cleared away" |
| 21 | | "Nearly calm" |

*Quoted from the description of the storm by Henry M. Daview, Captain of the Schooner B. Frank Neally.(1)

Mobile, Ala.

The cutter Forward anchored in Mobile Bay about 35 miles northeast of Moss Point reported that "the barometer fell 71 points in five hours from seven o'clock in the morning until noon." (7)

At Mobile the storm was reported to have begun without warning at about 0400E on October 2 and ended at 1800E. (8) A southeast gale was reported by 0830E with a maximum wind of 72 mph (uncorrected) from the southeast. The 10-minute-average wind speeds for Mobile on October 2 are shown in figure 7. The lowest pressure observed at Mobile during the storm, 2916 in. MSL, occurred at 1500E (figure 2). After that the pressure began to rise rapidly and by 2000E it was 29.53 in. The wind had shifted to the west at that time.

Pensacola, Fla.

At Pensacola, Fla., the storm struck at about 0445E on October 2. Wind throughout the morning was from the south at 34 to 40 mph; the maximum velocity observed at Pensacola was 66 mph from the southwest at 1545E. (1) The lowest pressure observed here, 29.47 in., occurred at 1645E (figure 2), at which time the hurricane had moved inland to a point about 65 miles northwest of Pensacola (figure 5).

Once inland, the hurricane moved slowly northeastward over Georgia to Cape Hatteras.

## RECONSTRUCTING THE TRACK

The track of the storm for the period 2000E October 1 to 1700E October 2 was reconstructed, using the limited data available from stations within 100 miles of the path of the storm as it moved inland, descriptions of the storm and of the storm damage as reported in the Monthly Weather Review and newspaper accounts of the times, and using the procedures described in Chapter I, Hydrometeorological Report No. 32, (9). Gradient wind speeds and the speed of the wind at anemometer level over water were computed using the reconstructed track.

Sea-level pressures

A graph of the sea-level pressures for stations within 100 miles of the path of the storm as it moved across Louisiana and into Alabama was drawn using a common time scale (figure 2). A barograph trace was available for New Orleans, but pressures for Port Eads, La.; Mobile, Ala.; Pensacola, Fla.; and Meridian, Miss., were taken from W. B. Form 1001. The ship report of barometer readings at Moss Point, Miss. was also included.

Lines of position from pressure

The times of intersection of any two pressure traces on the Sea-level Pressure Graph (figure 2) and the time of minimum pressure for each station were noted. Perpendicular bisectors of chords drawn between stations whose pressure traces intersected were used as lines of position of the track. The assumption that the hurricane is circular requires that the center of the storm lie on the bisectors at the designated times. Perpendicular lines from each station, labeled with the time of the station minimum pressure, were drawn to the track and adjusted as the track was laid out. If the hurricane were circular the center of the storm would lie at the end point of these lines at the time of minimum pressure.

Wind shift analysis

Further adjustments to the path were made using distances from a station at hourly intervals taken from a wind-direction graph (figure 3) drawn from data taken from autographic wind-direction records. (New Orleans was the only station considered in this study that had autographic records of both wind speed and wind direction.) Hourly position checks were laid out on the path and a vector was drawn for that section of the path that covered the period during which a wind shift occurred at New Orleans. The hourly positions were marked on the vector. This vector was traced on a polar diagram whose center represented the station in such a way that the time checks fell on the polar azimuth lines corresponding to the direction of the wind at New Orleans at the check times. Distances from the center of the polar diagram to the hourly positions were scaled off, laid out on the graph, and used to check the distance of the storm center from New Orleans at those times.

Preliminary track

Hourly positions of the hurricane center were plotted on a map using the pressure and wind-derived lines of position and giving weight to material on the storm in the Monthly Weather Review for October 1893 and descriptions of the storm in the Mobile Daily Register and New Orleans Times-Democrat of that time.

First approximation of pressure profiles

Distances from the pressure-reporting stations to the hourly positions of the track were scaled off. Hourly and minimum pressures for each station read from the pressure-time graph were plotted on a graph against the distance of the station from the hurricane center. Pressure profiles for 0000E, 0400E, 1000E, and 1400E were drawn to these curves.

Final track

Using the pressure profiles, the distance from the station to the storm center at hourly intervals was read from the graph for each station. Arcs were then drawn along the hurricane track with these distances as radii and the stations as centers. The intersection of the arcs for each hour were considered in the final adjustment of the track.

The final revised track differed from the track shown in the October 1893 Monthly Weather Review in that it entered the southeastern Louisiana coast from the south instead of the southwest and a few miles further east (figure 5). After crossing the peninsula and following the Louisiana coastline northeastward, the final hurricane track entered the mainland about 13 miles west of the track shown in the Monthly Weather Review.

Final pressure profile

In fitting the first pressure profile to the station traces it was difficult to reconcile the pressure trace at Moss Point with that at Mobile. Because of this, the track was redrawn to show the center of the hurricane passing inland 13 miles west of Moss Point instead of at Moss Point. Hourly distances of the stations from the track were rescaled and a final pressure profile was drawn (figure 6).

Exponential pressure profile

An exponential pressure profile derived from the equation

$$\frac{P - P_o}{P_n - P_o} = e^{-R/r}$$

where P = pressure at radius r
R = radius of maximum winds
$P_o$= pressure at the center
$P_n$= assymptotic pressure

was drawn for 1000E and 1400E October 2 (figure 7). The value of $P_o$ at 1000E on the exponential curve was 28.22 in. and at 1400E increased to 29.17 in.

Gradient wind

The speed of the gradient wind was computed for 1000E and 1400E October 2 and the gradient-wind profile was plotted and compared with the 10-minute-average winds observed at anemometer level at New Orleans and Mobile. In order to obtain a better fit to the plot of the Mobile wind, R was made smaller, and a new curve was plotted for the gradient wind at 1400E.

Over-water wind at anemometer level

The values of the ratio of the average 10-minute over-water wind to gradient wind were obtained from figure 26, Hydrometeorological Report No. 32, and used to compute the over-water wind at anemometer level from the gradient wind. Figure 7 compares these values with the average 10-minute wind speeds at anemometer level at Mobile and New Orleans.

Radius of maximum wind

For 1000E October 2, these curves (figure 7) plotted against distance from the center of the storm, give a value of 80 mph for the maximum over-water wind speed at anemometer level. This value, $V_o$, is 86% of the value of the maximum gradient wind, $V_g$, computed from the pressure profile in figure 6. The radius of the maximum wind, R, computed from the pressure field, at 1000E extended 20 miles from the storm center. The 1400E $V_o$-curve shows that at that time the winds had decreased and R had increased. The maximum over-water wind at anemometer level on the 1400E $V_o$-curve had decreased to 47 mph. A band of wind above 50 mph extended from 10 miles of the center to 52 miles of the center at 1000E October 2. At 1400E winds of 40 mph or greater extended from 18 to 36 miles of the center.

## CONCLUSION

If the hurricane was of the same intensity as it approached Moss Point as it was when it crossed the Mississippi Delta, and if the pressure values reported by the ship at Moss Point were correct, the central pressure during that period is computed as 28.22 in. as shown by the exponential pressure profile in figure 6. The possibility also exists that filling occurred as the storm moved across the Delta to Moss Point and that its central pressure had been even lower as it approached the Louisiana coast. Lack of sufficient wind and pressure data has prevented the computation of wind-field patterns for this storm offshore south of the Mississippi Delta. Pressure and wind profiles constructed for this hurricane from the data available show that the radius of maximum winds at 1000E October 2 was 20 miles with a maximum wind speed over water at anemometer level of 80 mph (figure 7). Winds of hurricane force (75 mph) prevailed in a band 10 miles wide. Filling occurred after the hurricane moved inland, and the pressure and wind profiles show that by 1400E October 2 the central pressure had risen to 29.17 in. (figure 6) The radius of maximum wind had increased to 27 miles and the maximum wind at anemometer level over water had decreased to 49 mph.

The wind distribution shown in figure 7 agrees with statements that the violent winds in the storm covered a limited area. Although the storm center passed within 45 miles of New Orleans, winds of hurricane force were not reported in the city.

From this analysis it can be inferred that this hurricane was one of the three most intense to pass over the eastern Louisiana coast in the last 65 years. Table I, Hydrometeorological Report 32, gives a lower central pressure for the other two, the hurricanes of September 29, 1915, and September 20, 1926.

Table II below compares values computed for these storms of September 1915 and September 1926 with values computed for the hurricane of October 1893.

Table II

| Hurricane | $P_o$ In. | $P_n - P_o$ In. | $V_{gx}$ MPH | $V_{ox}$ MPH | R Nav. Mi. |
|---|---|---|---|---|---|
| Oct. 1893 (Miss. coast) | 28.22 | 1.77 | 94 | 80 | 17 |
| Sept.1915 | 27.87 | 2.27 | 106 | 91 | 29 |
| Sept.1926 (Ala. coast) | 28.20 | 1.93 | 98 | 84 | 24 |

Figures

References

1. U. S. Weather Bureau, "Monthly Weather Review", October 1893, Vol. XXI, No. 10, p. 272.
2. "New Orleans Times-Democrat", October 5, 1893.
3. "New Orleans Times-Democrat", October 7, 1893.
4. "New Orleans Times-Democrat", October 6, 1893.
5. Daily Register, Mobile, Ala., October 7, 1893.
6. Daily Register, Mobile, Ala., October 3, 1893.
7. Daily Register, Mobile, Ala., October 4, 1893.
8. Weather Bureau Form 1001, Original Monthly Record of Observations at Mobile, Ala., October 1893.
9. Vance A. Myers, Hydrometeorological Section, U. S. Weather Bureau, "Characteristics of United States Hurricanes Pertinent to Levee Design for Lake Okeechobee, Florida," Hydrometeorological Report No. 32, March 1954.

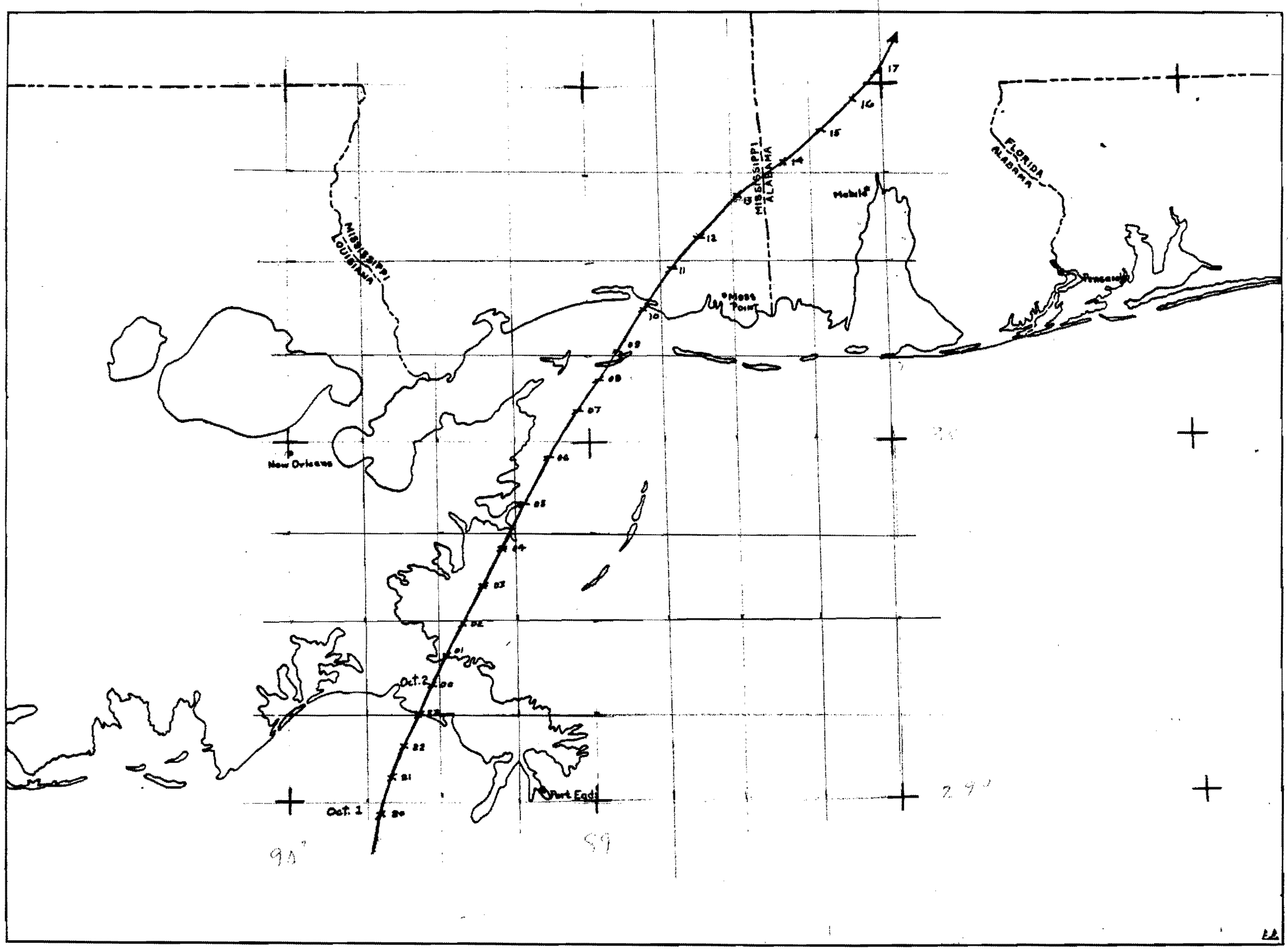



Fig. 5 FINAL TRACK -- Hourly Positions E.S.T. -- Hurricane of Oct. 1-5, 1893

OBSERVED 10-MINUTE AVERAGE WIND SPEEDS AND COMPUTED WIND SPEEDS AT ANEMOMETER LEVEL OVER WATER -- OCT. 1-2, 1893

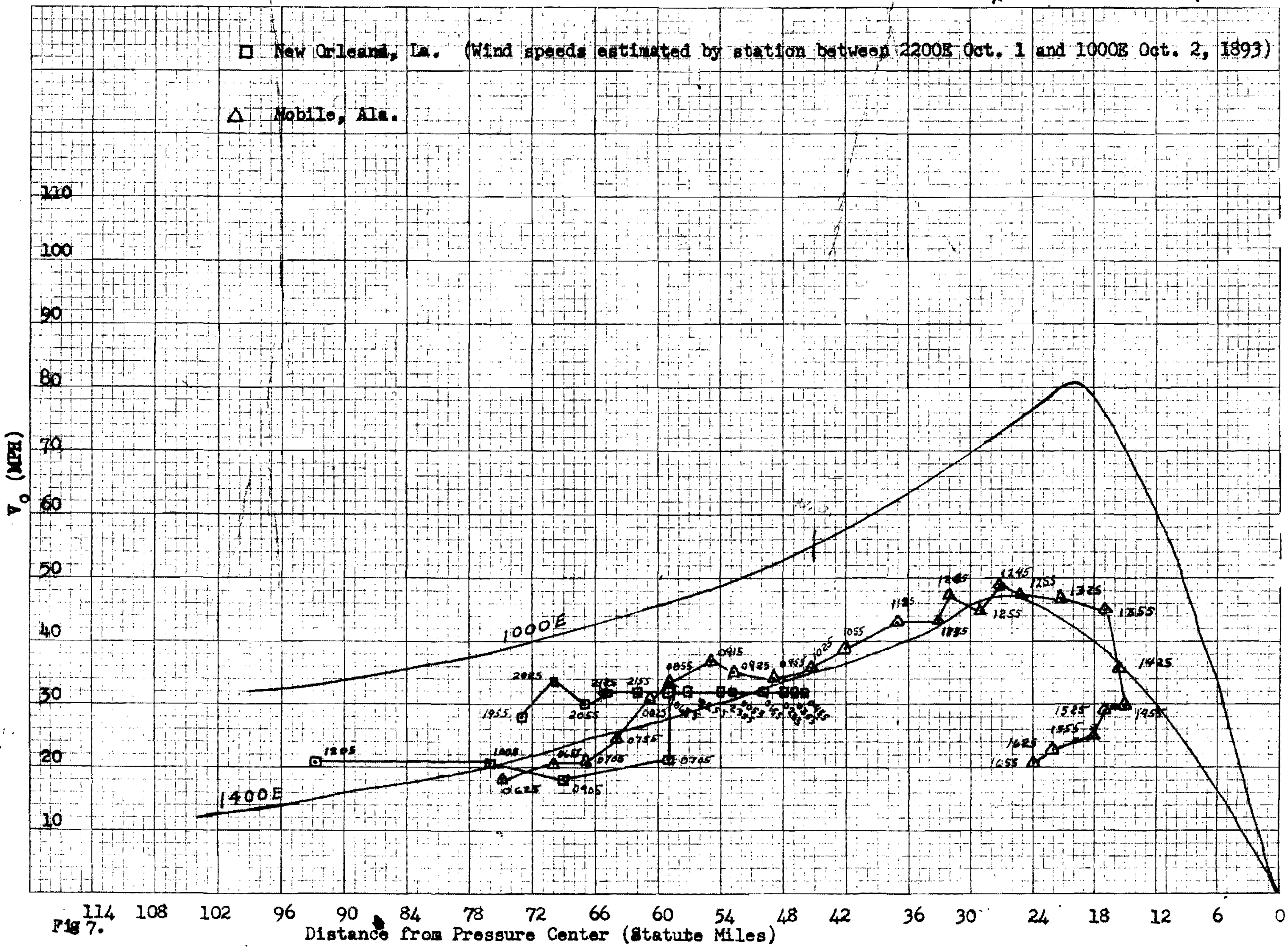



Fig 7.

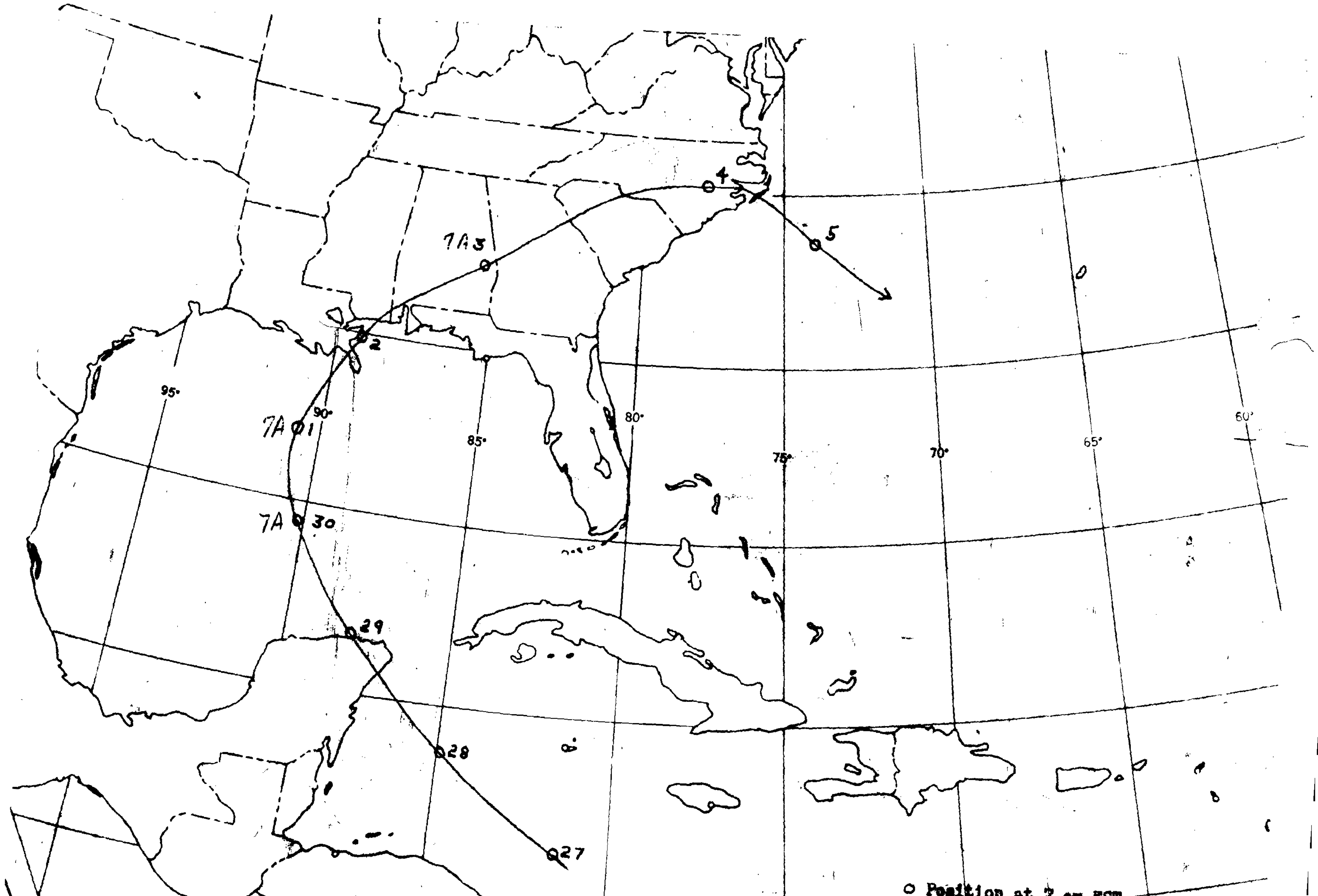
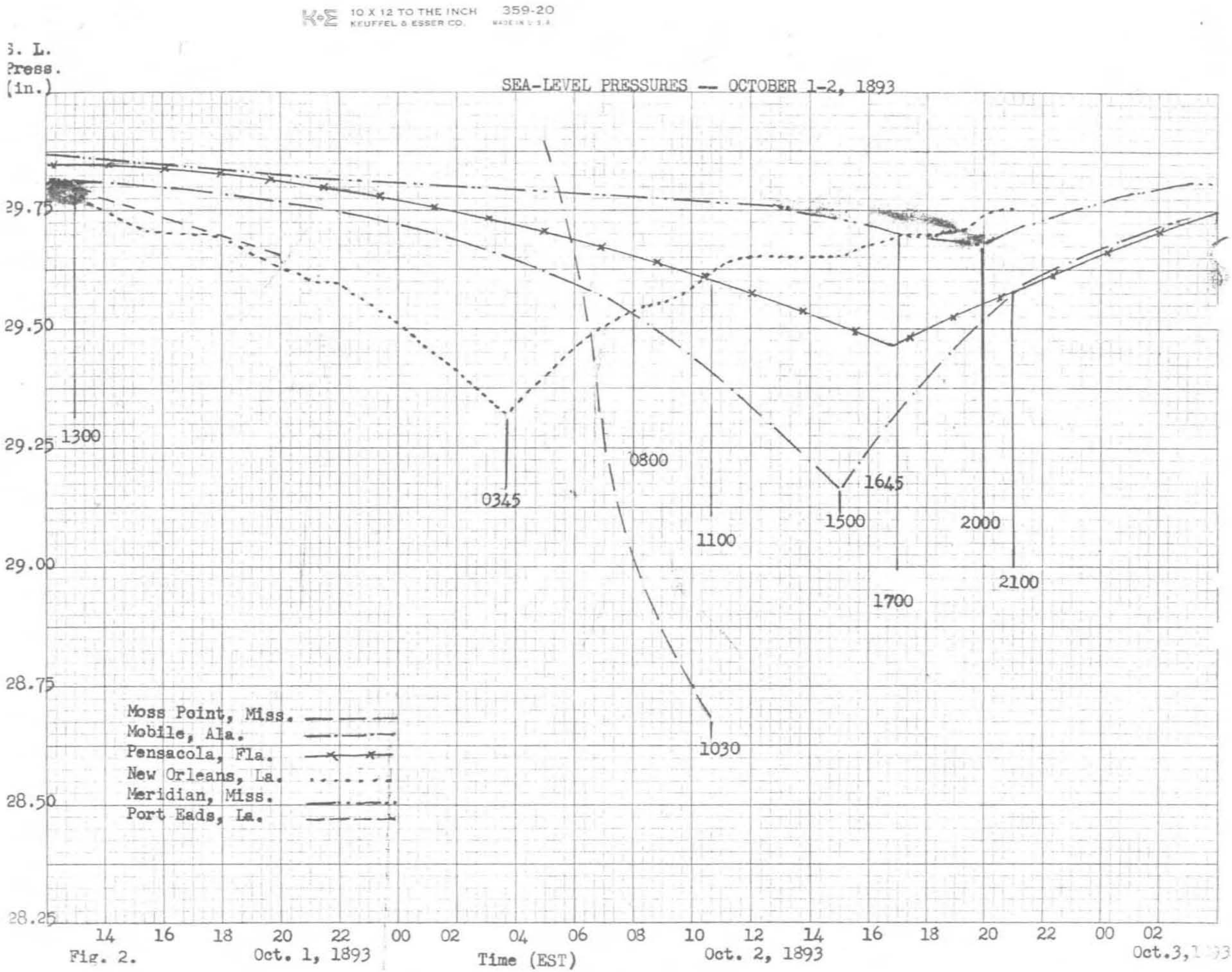



Fig. 1.

Track of the Hurricane of September 27 - October 5, 1893
(Track south of Latitude 29 and east of Latitude 85 taken from the Office of Climatology track of the storm.)



K+E 10 X 12 TO THE INCH 359-20
KEUFFEL & ESSER CO.
S. L.
Press.
(in.)
SEA-LEVEL PRESSURES -- OCTOBER 1-2, 1893
29.75
29.50
29.25
29.00
28.75
28.50
28.25
1300
0345
0800
1030
1100
1500
1645
1700
2000
2100
Moss Point, Miss.
Mobile, Ala.
Pensacola, Fla.
New Orleans, La.
Meridian, Miss.
Port Eads, La.
14
16
18
20
22
00
02
04
06
08
10
12
14
16
18
20
22
00
02
Oct. 1, 1893
Time (EST)
Oct. 2, 1893


Fig. 2.

GRAPH OF AVERAGE 10 MINUTE WIND DIRECTIONS RECORDED AT NEW ORLEANS, LA. OCT. 1-2, 1893

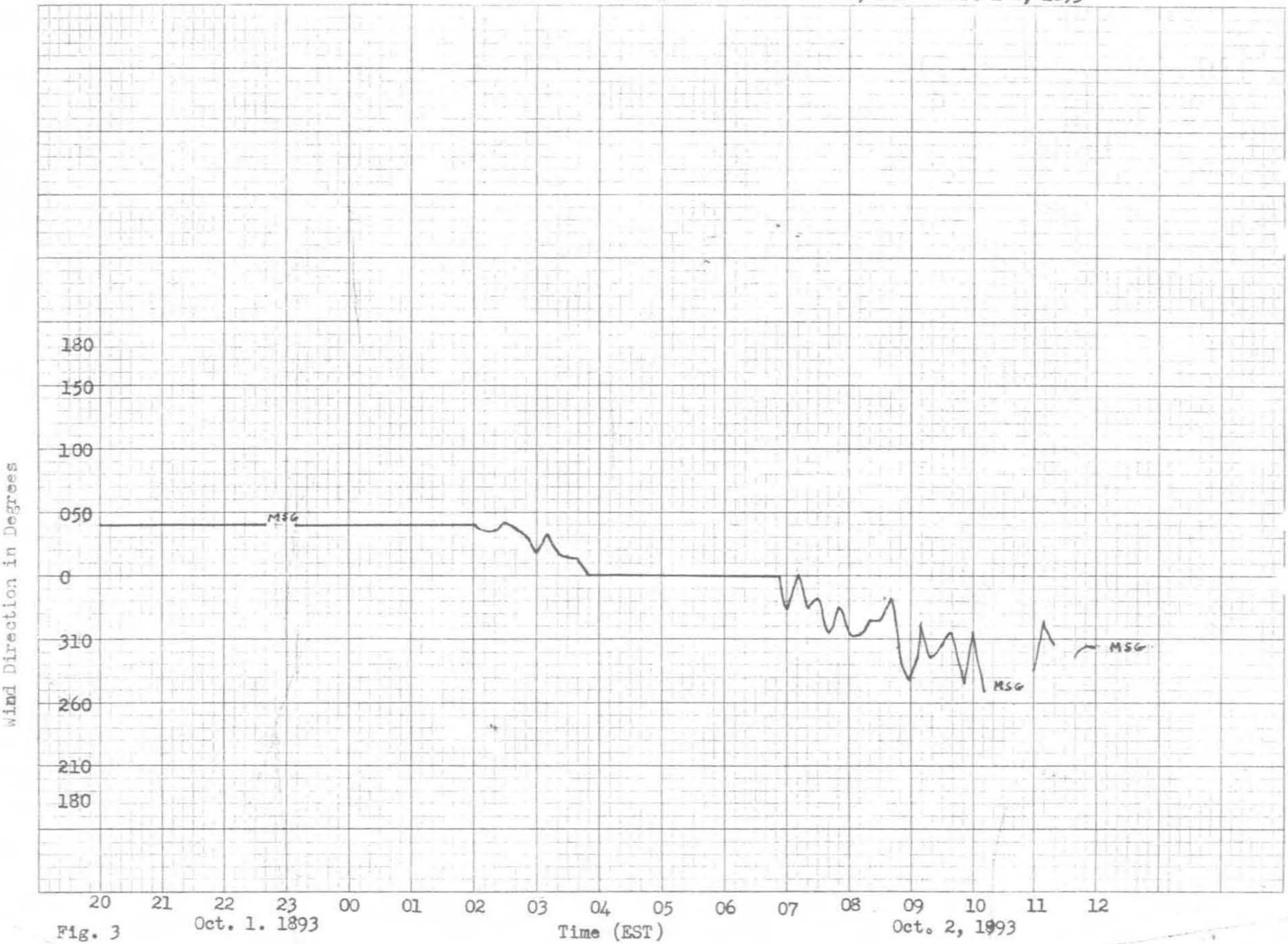



Fig. 3

FINAL PRESSURE PROFILES —OCT. 1-2, 1893 (EST)

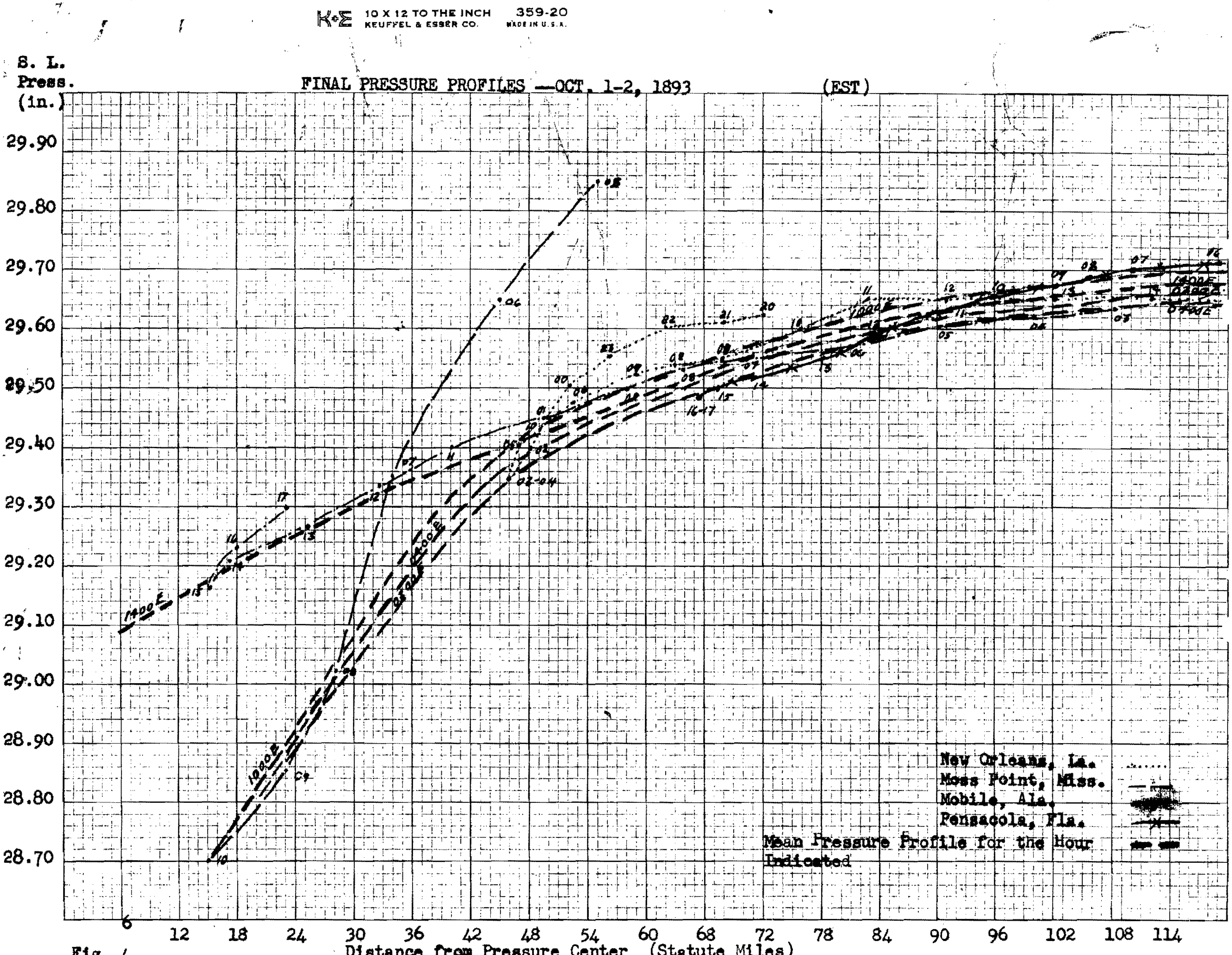
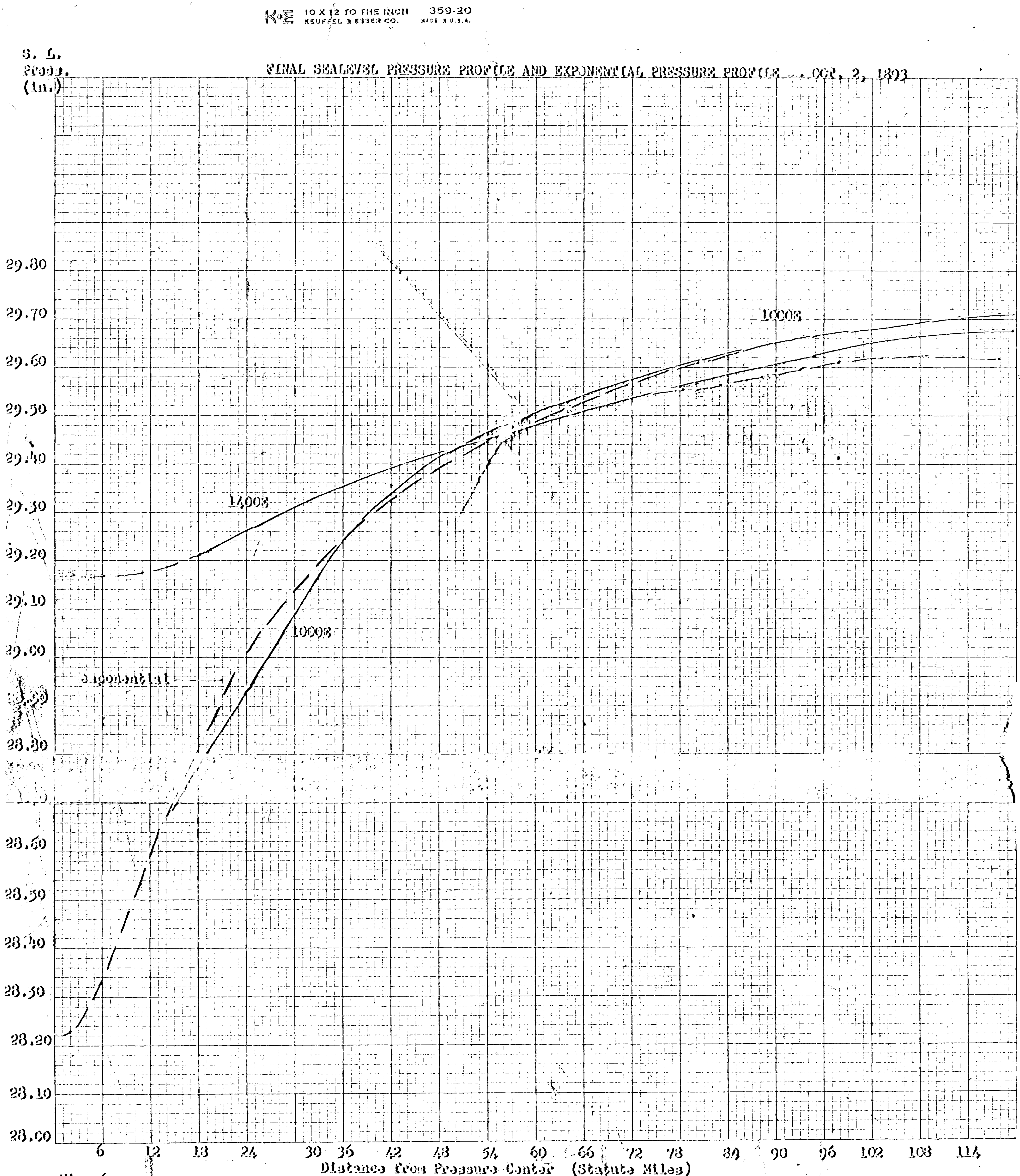



Fig. 4.


K+E 10 X 12 TO THE INCH 359-20
KEUFFEL & ESSER CO. MADE IN U.S.A.
S. L.
Pres.
(in.)
FINAL SEALEVEL PRESSURE PROFILE AND EXPONENTIAL PRESSURE PROFILE — OCT. 2, 1893
29.80
29.70
29.60
29.50
29.40
29.30
29.20
29.10
29.00
28.80
28.60
28.50
28.40
28.30
28.20
28.10
28.00
1000Z
1400Z
1000Z
Exponential
6
12
18
24
30
36
42
48
54
60
66
72
78
84
90
96
102
108
114
Distance from Pressure Center (Statute Miles)
Fig. 6.

UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
WASHINGTON

December 6, 1957

IN REPLY PLEASE ADDRESS
CHIEF, U. S. WEATHER BUREAU
WASHINGTON 25, D. C.
AND REFER TO

0-6.12

**MEMORANDUM TO CORPS OF ENGINEERS**

HUR 7-42A

FROM : Hydrometeorological Section

SUBJECT : Standard Project Hurricane Isovels for a High Speed of Translation of the Hurricane Center Mid-Gulf Coast, U. S., Zone B.

References: (1) Telephone conversation, Messrs. Myers and Nunn, Nov. 1, 1957, regarding Standard Project Hurricane isovel patterns for a high rate of translation for Zone B and C. (U.S. Gulf Coast).

(2) HUR 7-42, Standard Project Hurricane Parameters and Isovels Mid-Gulf Coast, U. S. Zone B and Standard Project Hurricane, Lake Pontchartrain.

This memorandum contains an isovel pattern for a Standard Project Hurricane in Zone B with a high speed of translation as requested in reference (1).

Isovel chart

A synthetically derived isovel chart for a Standard Project Hurricane with a CPI of 27.60 in. and a high speed of translation has been developed for Zone B off the coast south of New Orleans, La. This was done by imposing a degree of asymmetry to isotachs of gradient winds computed from pressure parameters and reduced to 30-ft. winds by empirical factors. The asymmetry factor, added to speeds on the right and subtracted from speeds on the left, was $(0.5T)\cos a$ where T was the representative high speed of translation of a Standard Project Hurricane in Zone B, 28 kts. as shown in Table 1, reference (2), and a the angle between the direction of forward motion and the wind direction. Maximum wind at R is 111 mph.

A pattern showing the strongest winds in the right rear quadrant was selected as that most likely to occur by at least two authors. Isaac Cline in his book "Tropical Cyclones" states that "the wind velocities are much greater in the right half than in the left half of the cyclone area, and the greatest sustained wind velocities occur as a rule in the right rear quadrant." L. A. Hughes has summarized a large number of reconnaissance flights ("On the Lower-Level Structure of Tropical Storms", Journal of Meteorology, Dec. 1952) producing the best and most definitive composite low-level wind speed pattern yet available. The strongest winds are in the right rear quadrant in that pattern. Many variations may occur in the standard isovel pattern. To represent the many patterns that it would be reasonable to expect in Zone B, the isovels in the attached figure may be rotated with limits of 100° counter clockwise and 50° in a clockwise

Incl #1

[redacted]

direction. The limits of rotation are indicated on the figure by dashed arrows extending outward from the wind center.

Variation of forward speed

The forward speed for a Standard Project Hurricane is chosen within or near the range of forward speeds shown in Table 1, reference (2). Forward speeds within these spans can be assumed to be independent of CPI and R. The attached isovel pattern computed for a forward speed of 28 knts. is the fastest observed 4-hour average speed in the Gulf.

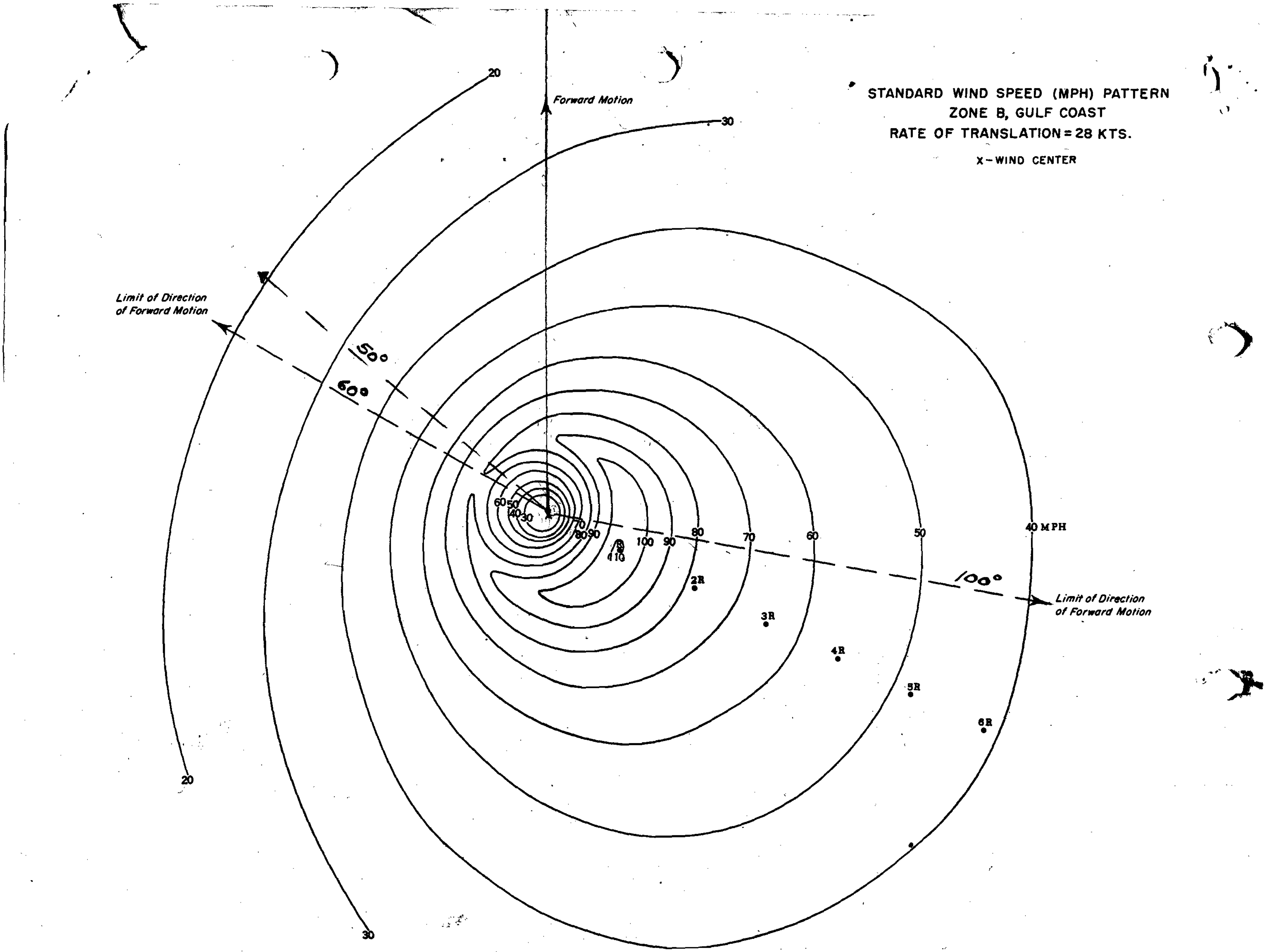
Other factors

Comments on variation in the radius of maximum wind, application to other Zone B locations, wind direction, the critical path, and adjustment for filling over land may be found in reference (2) to which this memorandum is supplementary.

Charles S. Gilman, Chief
Hydrometeorological Section

Attachment

cc: 12 to OCE with attachments
1 to BEB with attachments



STANDARD WIND SPEED (MPH) PATTERN
ZONE B, GULF COAST
RATE OF TRANSLATION = 28 KTS.
X-WIND CENTER
Forward Motion
Limit of Direction of Forward Motion
50°
60°
100°
Limit of Direction of Forward Motion
20
30
40 MPH
50
60
70
80
90
100
110
2R
3R
4R
5R
6R


USCOMM-WB-DC

UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
WASHINGTON 25
August 15, 1957

IN REPLY, PLEASE ADDRESS
CHIEF OF BUREAU
AND REFER TO

0-6.12

TO : Mr. A. L. Cochran, Civil Works
Office of Chief of Engineers
Corps of Engineers

FROM : Hydrometeorological Section

SUBJECT: MEMORANDUM HUR 7-39, Revised Wind Fields Vicinity of Lake Pontchartrain, Hurricane of September 29, 1915

Transmitted herewith is the Subject Memorandum which includes revised isotachs for the Louisiana Hurricane of 1915 for the information of the New Orleans District. This memorandum supersedes Memoranda HUR 7-15 and 7-28.

Charles S. Gilman, Chief
Hydrometeorological Section

Attachments
cc: 3 with attachments to OCE
1 with attachments to OCE

UNITES STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
Washington
August 16, 1957

In reply. Please address
CHIEF, U.S. WEATHER BUREAU
Washington 25, D. C.
and refer to

0-6.12

MEMORANDUM HUR 7-39

FROM :Hydrometeorological Section

SUBJECT: Revised wind fields vicinity of Lake Pontchartrain, Hurricane of September 29, 1915

Introduction

This memorandum presents charts of reconstructed wind speeds and directions in the hurricane of September 29, 1915 over Lake Pontchartrain and adjacent waters of the Gulf of Mexico. These charts are revisions of those furnished in Memoranda HUR 7-15 and 7-28. The wind speeds have been revised from the previous charts, mostly to higher values, from the following considerations:

a. The central pressure of the storm was well established close to New Orleans but was not observed near the coast. A revised coastal central pressure was obtained by extrapolation from the New Orleans value. A faster rate of filling was assumed between the coast and New Orleans (lower central pressure at the coast) in the present analysis on the basis of a recently completed empirical study of rates of filling in hurricanes over land.

b. Further study was made of the ratio of observed wind speeds at the New Orleans Weather Bureau Office to probable over-water wind speeds. Comparison of observed speeds at the New Orleans WBO in the 1947 hurricane with better exposed stations in the same storm led to larger adjustment factors than previously employed.

c. Reconsideration indicated that the water surface, which reduces the wind speed less than a land surface, extended beyond the normal boundaries of the Lake and the Gulf during the hurricane. This effect, while slight, was also in the direction of higher wind speeds.

d. The winds over the water surfaces in the storm are of necessity estimated indirectly from pressure and wind data over land, to the extent that such data are available. Another indirect index of the winds is the behavior of water levels. The meteorological data determine the over-water wind speeds only within a certain range; the resulting values are not exact.

Considering the observed water levels qualitatively, the analysts were influenced toward slightly higher wind speeds within the range dictated by the meteorological data.

Track

The track of the storm center (center of lowest pressure) is depicted in figure 1. The center of wind rotation is several miles to the left of the pressure center.

Central pressure

The known information on the central pressure of the hurricane is depicted on a time scale in figure 2a. This includes the minimum observed pressures at the New Orleans Weather Bureau Office and the Ship Ceiba in dock at New Orleans. Another ship in the Gulf, which experienced some of the conditions of the eye of the storm, was at an unknown distance from the point of minimum pressure. Also shown in figure 2a are average rates of filling for hurricanes moving inland over extensive land masses, over the Florida Peninsula, and over a land area but with movement back toward a body of water, each of the three curves being projected from New Orleans back to the coast. Several possible variations with time of central pressure are shown by the heavy curves a, b and c. Curve b was considered the most probable and was selected for further computations. An average radial pressure profile for 1200 CST (about the time of landfall) is shown in figure 2b.

Comparison New Orleans WBO wind speeds with other sites

The winds at the New Orleans Weather Bureau Office were appreciably reduced by the friction of the surrounding city. A study was made of the magnitude of this effect, by comparing the New Orleans Weather Bureau Office wind speeds (site had not changed) with wind speeds from nearby stations in other years. Mean daily wind speeds at the New Orleans WBO were compared with the mean daily speeds at the better exposed airport station at Moisant Airport, for all days on which the speeds were 15 mph or higher at the airport for the years 1950-1954. The mean values are plotted as "x's" in figure 4 for northeast winds (the principal high-speed wind direction of the 1947 hurricane), for south-southeast (southeast was the principal high-speed direction in the 1915 hurricane), and for all directions combined. It can be noted that there is no significant directional difference.

For data on high speeds the New Orleans WBO speeds were plotted against speeds at the Weather Bureau Airport Station at Moisant Airport, the Naval Air Station, and the Huey P. Long Bridge in the 1947 hurricane (figure 4). The fact that the stations would be in different parts of the hurricane at a particular time was taken into account by constructing profiles of speed against distance from storm center in the hurricane, and plotting speeds against each other corresponding to equal distances from the storm center. The Huey Long Bridge anemometer is at 165'. The winds here are perhaps 5%

in excess of equivalent speeds at 30' over Lake Pontchartrain. The Naval Air Station speeds were from an off-lake direction in this comparison and are comparable to over-water speeds. The Moisant Airport site requires an adjustment upward of perhaps 5 or 10% to over-water speeds. The comparison of Huey Long Bridge with the WBO is given the most weight, as only these stations had automatic wind registering equipment. The mean ratio of Bridge speeds to WBO in the 1947 hurricane is 1.97 to 1 (by eye in figure 4).

A check was made on changes in the environmental conditions at the New Orleans Weather Bureau Office between 1915 and more recent years. The accumulated mean annual wind speeds at New Orleans are shown plotted against the same variable for Meridian, Miss., in figure 7. It appears that there was a change in environmental conditions associated with moving of the New Orleans station in March 1915, but that there has been no appreciable change since that time. The anemometer height had only been changed one foot at Meridian and moved less than one block prior to 1948, when the Meridian station was moved to the Airport.

Radius of maximum winds

Computation of the radius of maximum winds from the pressure field in the hurricane at various times gave values averaging slightly over 36 statute miles. The apparent radius of maximum winds as determined from the wind speed records at New Orleans offices was 26 statute miles. An average value of 30 statute miles was used in developing the reconstructed wind patterns.

Computed wind fields

A theoretical wind speed called the gradient wind speed may be computed by formulas from the pressures. The maximum value of this theoretical wind speed may be computed from the difference between the central pressure in a hurricane and the pressure near the "outskirts" of the storm. The upper curve of figure 3 depicts the time variation of the maximum gradient speed that was derived from the central pressure variation of curve b, figure 2a, and an outside pressure, $p_n$, held at the average value of 29.92 inches. In the formulas used the maximum wind speed is proportional to the square root of the difference between outside pressure and central pressure.

Empirical studies have indicated that the maximum 30-foot over-water wind speed is about 86% of the maximum theoretical gradient speed (Lake Okeechobee hurricane 1949) in many instances, but may range from about 70% to 100% of this theoretical value in various hurricanes (Hydrometeorological Report No. 32, page 46).

After weighting all the pertinent data, a reduction factor of 88.5% was tentatively selected for the 1915 hurricane, and is depicted by curve b of figure 3.

The first approximation to a computed 30' over-water wind field was obtained by taking the maximum speeds from the curve b of figure 3 for various times at a radius of 30 statute miles from the center, and determining winds at other distances from the center in proportion to the variation of the wind speed inside and outside the radius of maximum winds observed in the Lake Okeechobee hurricane of 1949 (qualitatively confirmed in many other hurricanes). From such profiles a computed speed could be obtained at any point and at any hour in the range of the hurricane, by adding a component for the forward motion of the storm. Such computed speeds are plotted against observed New Orleans speeds in figure 5. The average ratio of computed 30' over water wind to observed is about 1.83 to 1.0, which has the proper relationship to the WBO-Huey Long Bridge factor of 1.97 to 1. At the only other observing station, Burrwood, La., a comparison of computed with observed wind speeds is depicted in figure 6. Only qualitative correspondence was expected on this diagram because of the unusual nature of the wind speed variation at Burrwood. The large surge of high speed between 1500 and 1700 CST at about 70 nautical miles from the center of the storm was not thought to be representative of the speed distribution in other quardants of the storm or at other times.

## Wind speed charts

Applying all the foregoing considerations the standard wind profile at the coast shown in figure 8 is derived. Variations in the profile for other times are also shown on the figure. This is the average wind profile in all directions from the storm center. The dashed curves show the respective limiting profiles.

Wind speed charts were constructed by applying the profile of figure 8 plus an adjustment for forward motion of the storm plus frictional reduction in the vicinity of shore-lines: a slight decrease on-shore, a slower speed-up for off-shore winds. Attempts were made to estimate where the shoreline was at the various hours, from a chart of maximum flooding during the hurricane. The final wind fields are depicted in figures 9a through 9h inclusive.

## Wind directions

A deflection angle of 30° toward low pressure was adopted as a reasonable compromise among the distribution of fluctuations noted in the wind direction at New Orleans. The deflection angle was kept constant at 30° regardless of radial distance or bearing from the center.

Charles S. Gilman, Chief
Hydrometeorological Section

Attachments
3 with attachments to OCE
1 with attachments to BEB

1.14

29.92
28.30
1.62 in x1.14 =

29.92
29.35
.57

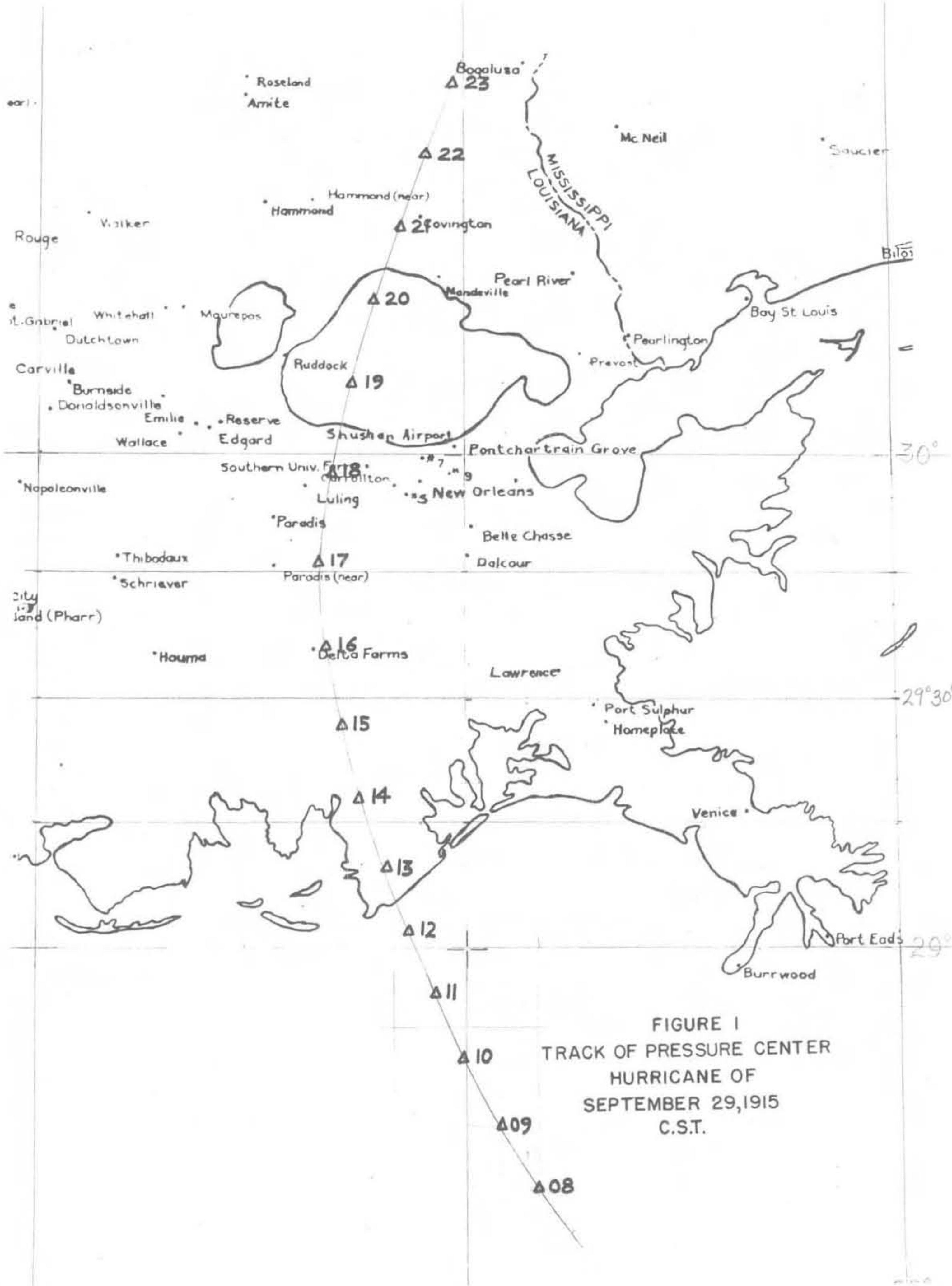



FIGURE I
TRACK OF PRESSURE CENTER
HURRICANE OF
SEPTEMBER 29, 1915
C.S.T.

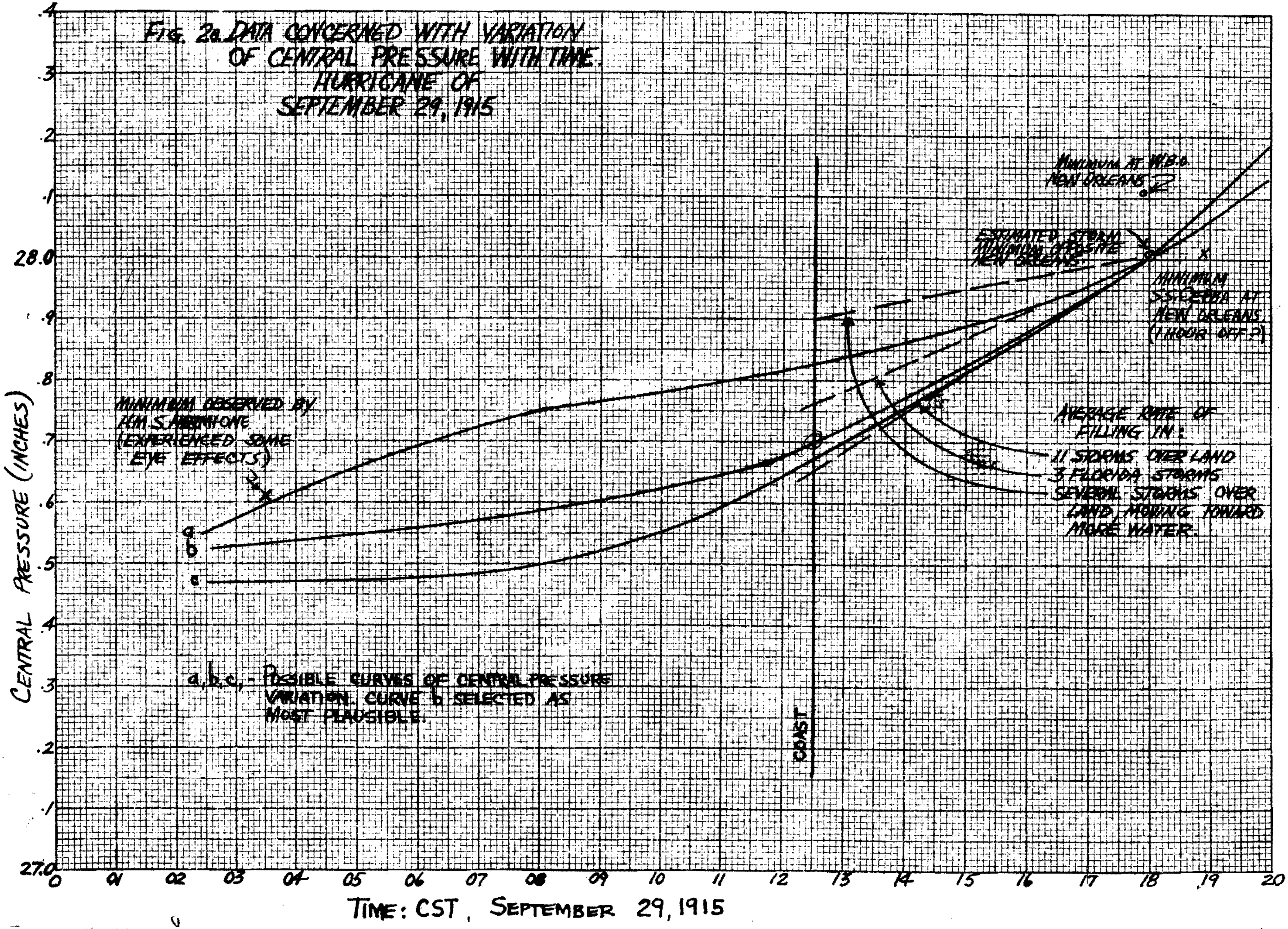
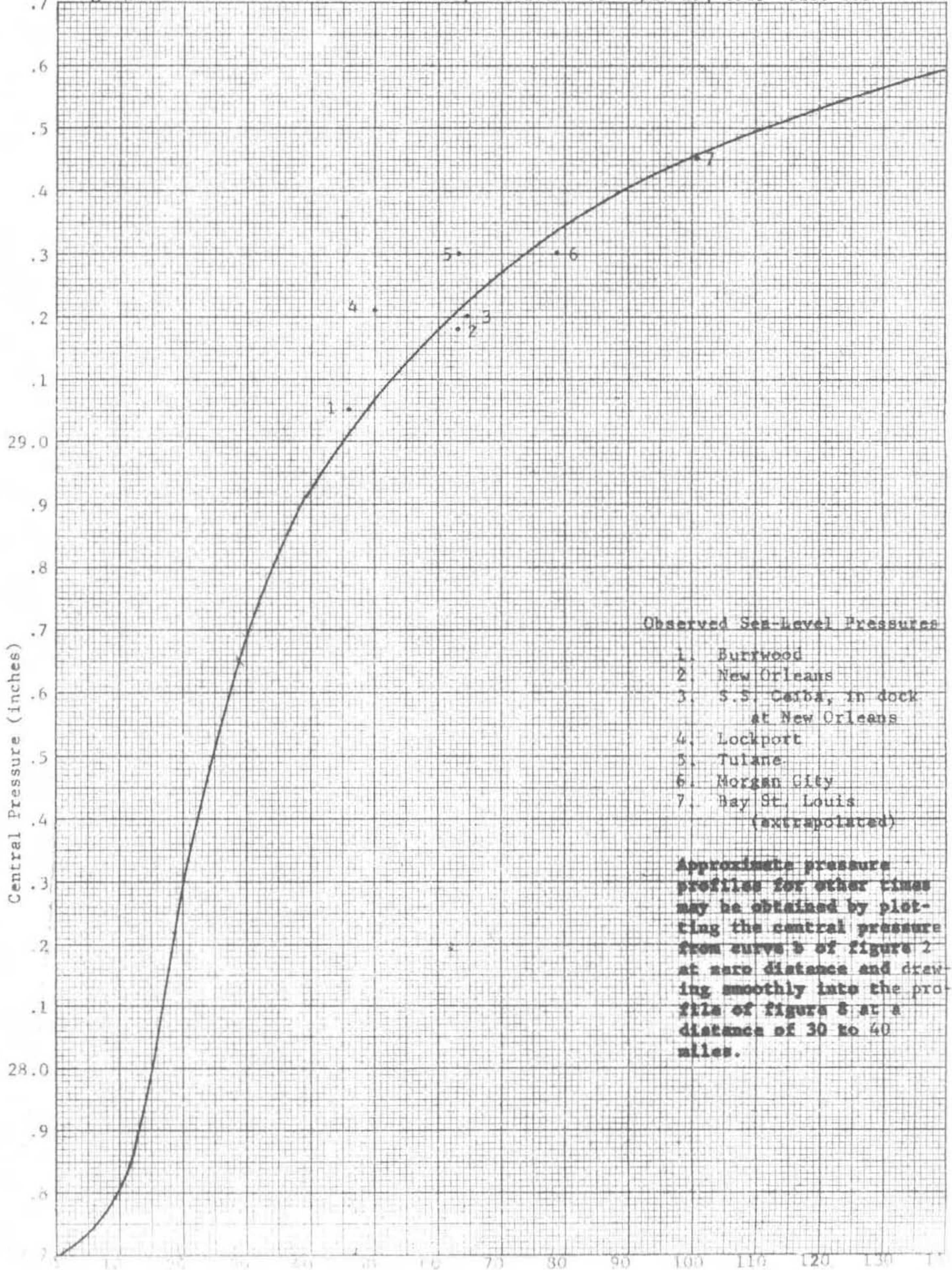


FIG. 2a DATA CONCERNED WITH VARIATION
OF CENTRAL PRESSURE WITH TIME.
HURRICANE OF
SEPTEMBER 29, 1915
MINIMUM AT W.B.O.
NEW ORLEANS
ESTIMATED STORM
MINIMUM OPPOSITE
NEW ORLEANS
MINIMUM
S.S. CEIBA AT
NEW ORLEANS
(1 HOUR OFF ?)
MINIMUM OBSERVED BY
H.M.S. HERMIONE
(EXPERIENCED SOME
EYE EFFECTS)
AVERAGE RATE OF
FILLING IN:
11 STORMS OVER LAND
3 FLORIDA STORMS
SEVERAL STORMS OVER
LAND, MOVING TOWARD
MORE WATER.
a
b
c
a, b, c, - POSSIBLE CURVES OF CENTRAL PRESSURE
VARIATION. CURVE b SELECTED AS
MOST PLAUSIBLE.
COAST
CENTRAL PRESSURE (INCHES)
.4
.3
.2
.1
28.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
27.0
0
01
02
03
04
05
06
07
08
09
10
11
12
13
14
15
16
17
18
19
20
TIME: CST, SEPTEMBER 29, 1915

Fig. 2b. Reconstructed Pressure Profile, Hurricane of Sept. 29, 1915 1200 CST



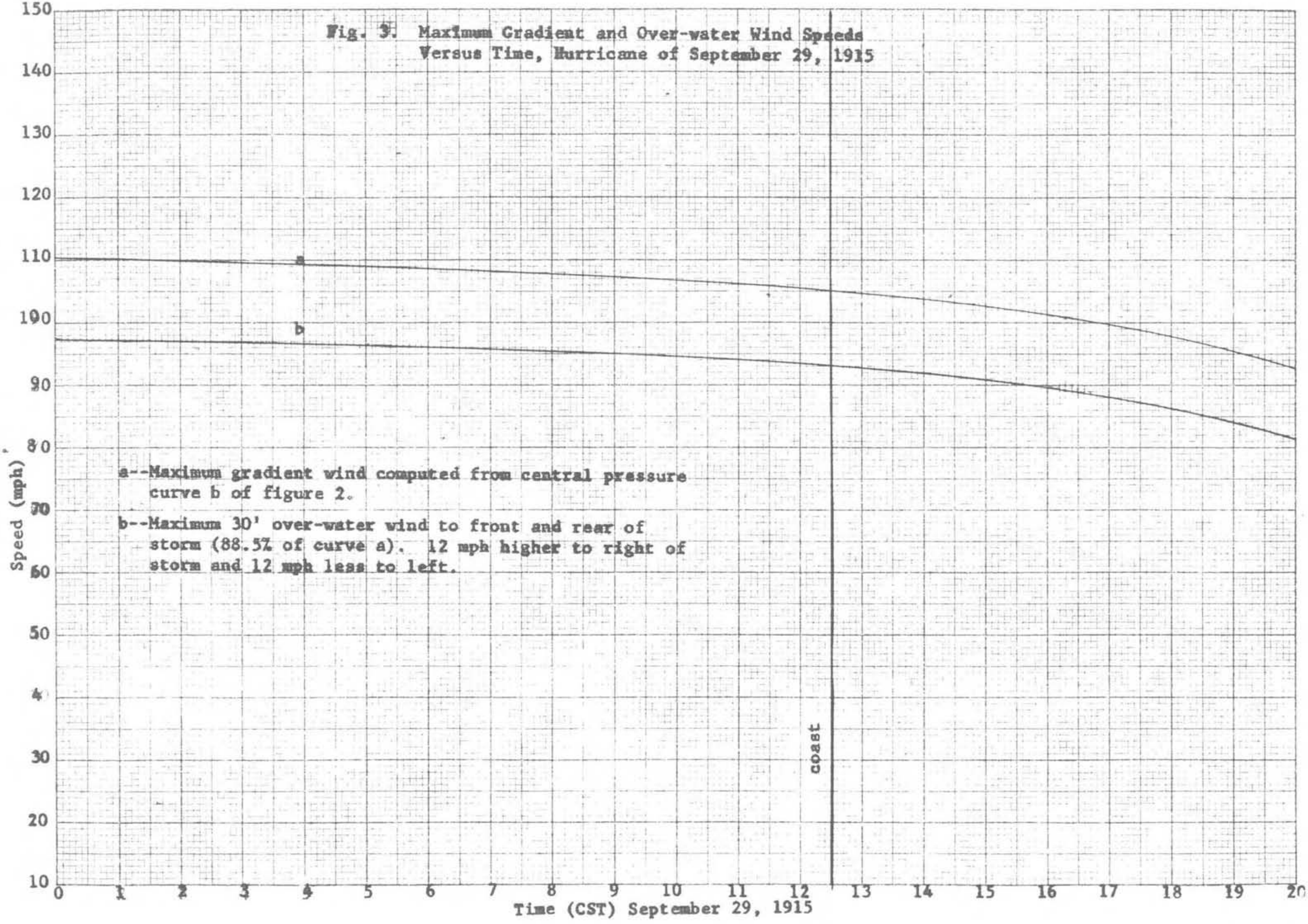


Fig. 3. Maximum Gradient and Over-water Wind Speeds Versus Time, Hurricane of September 29, 1915

Fig. 4. Comparison of Observed Speeds at WBO New Orleans with Other Nearby Stations

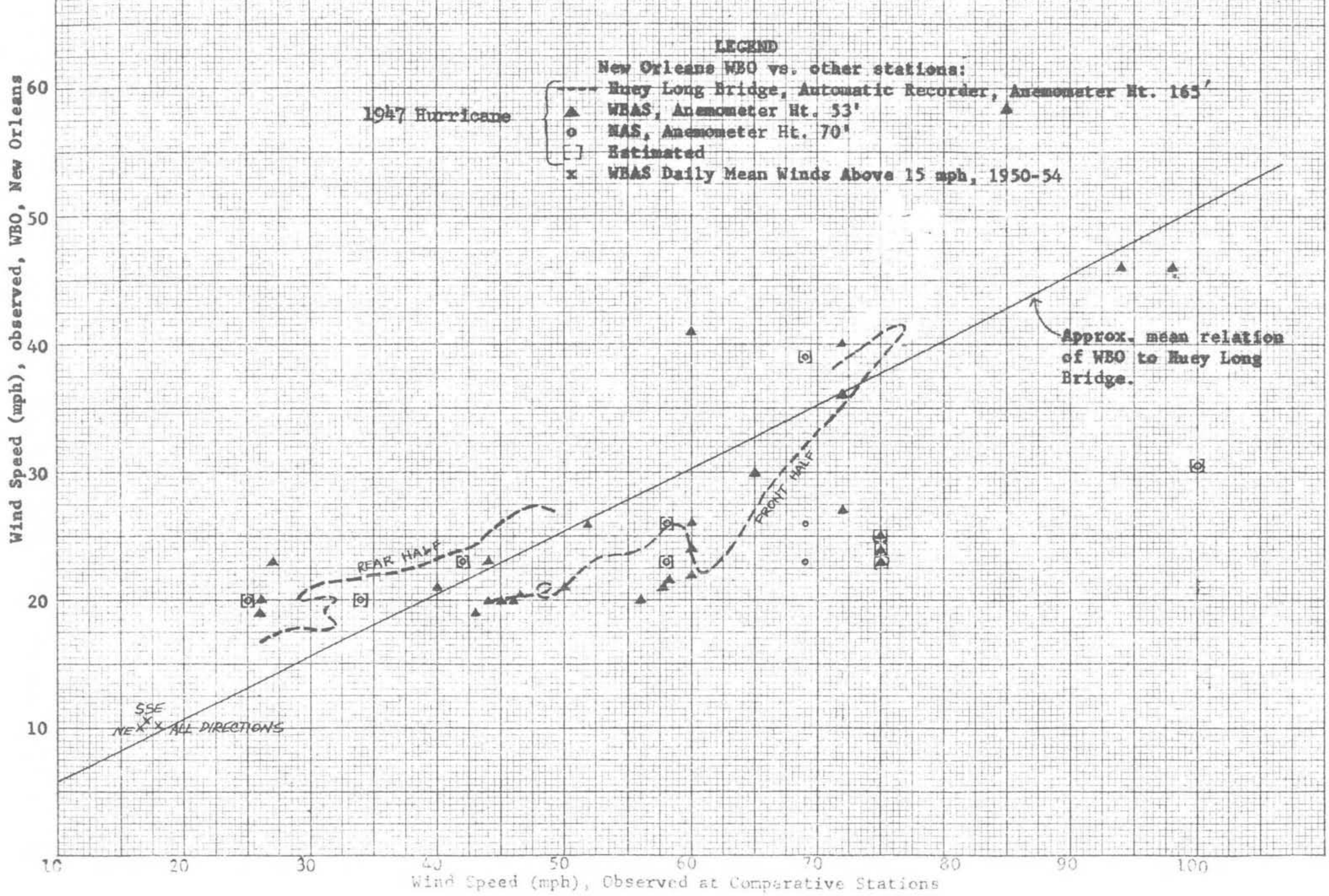


Fig. 5. Observed vs. Computed Over-Water Wind Speeds, WBO, New Orleans

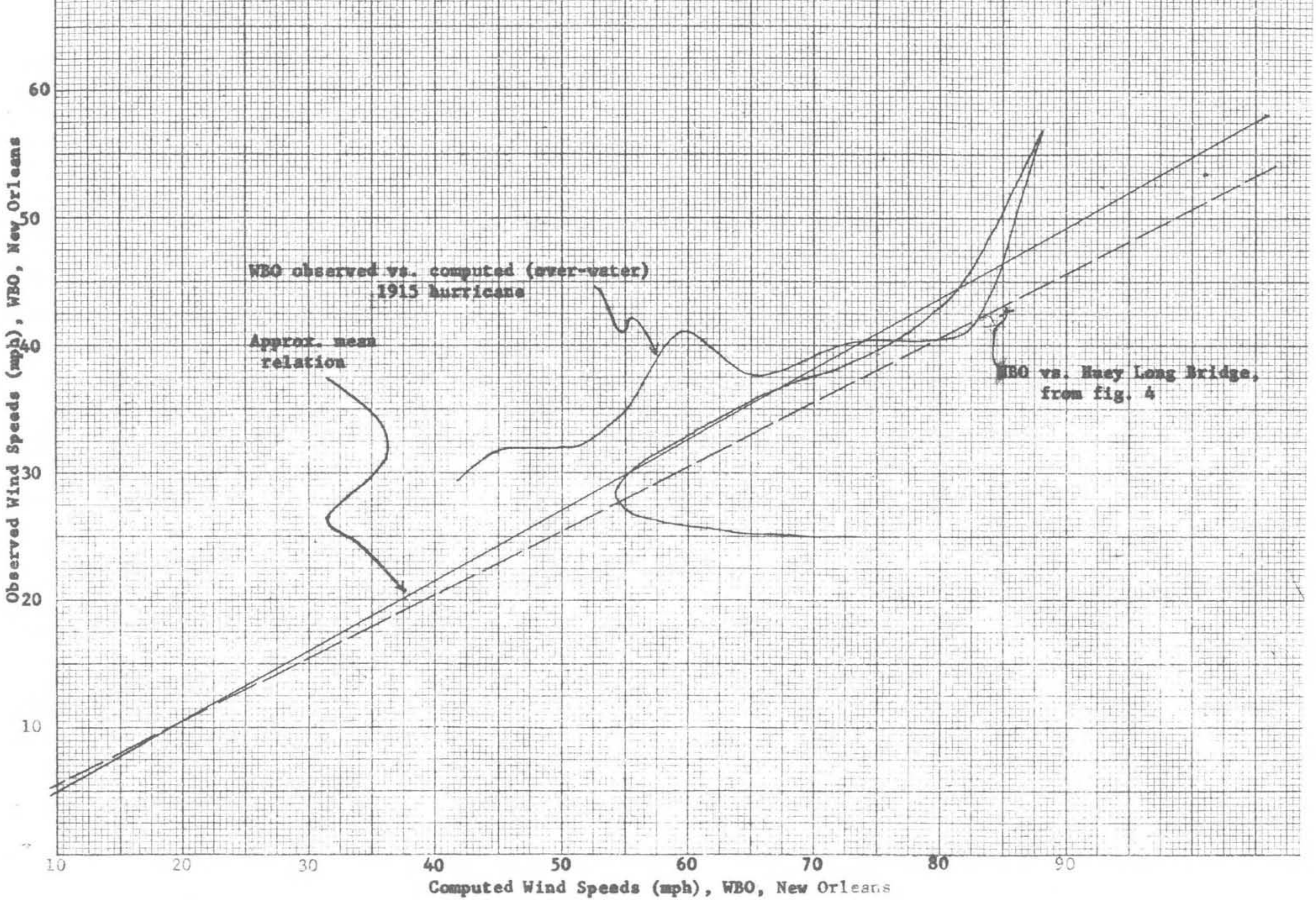
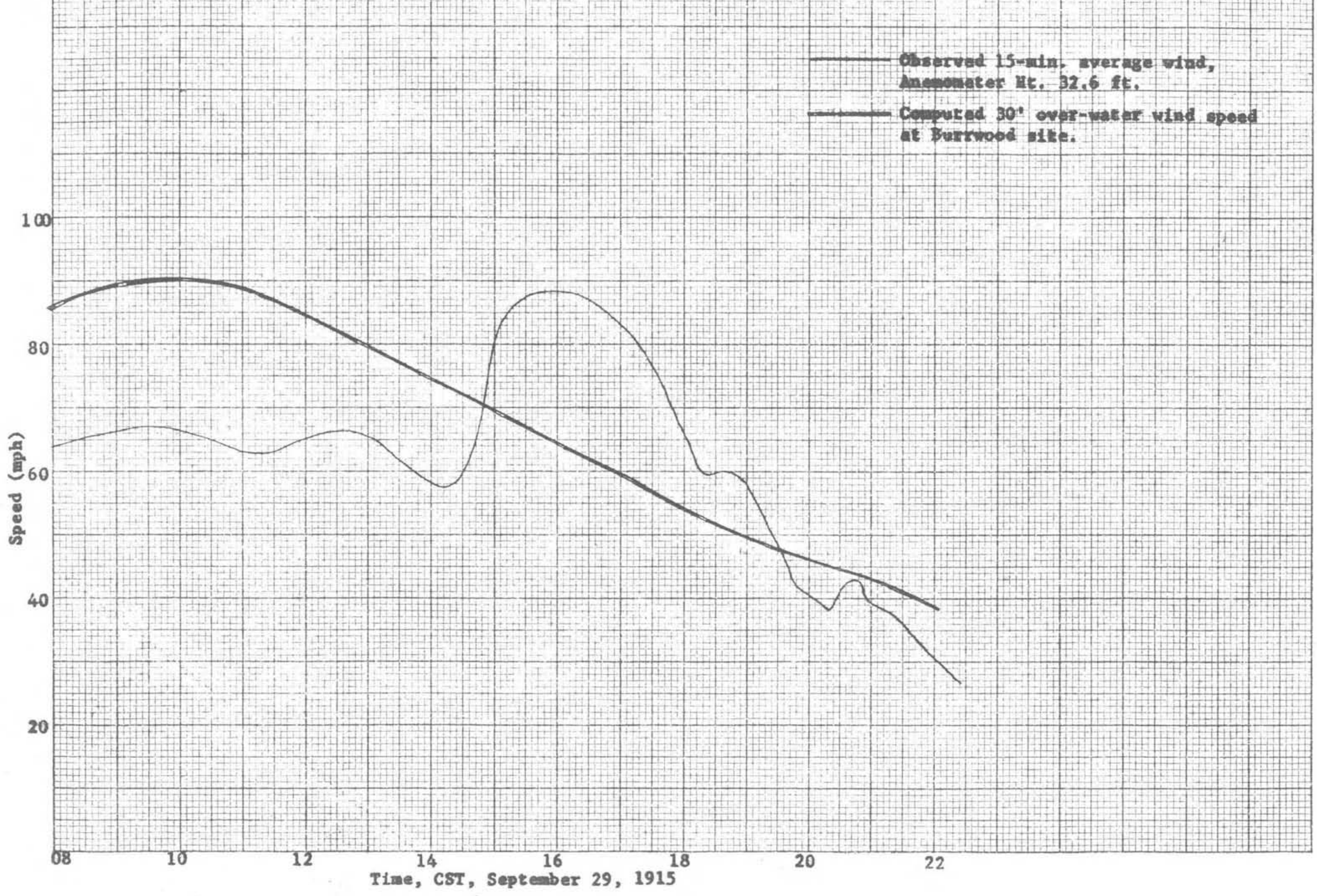


Fig. 6. Comparison of Observed with Computed Wind Speeds at Burrwood, La., September 29, 1915.



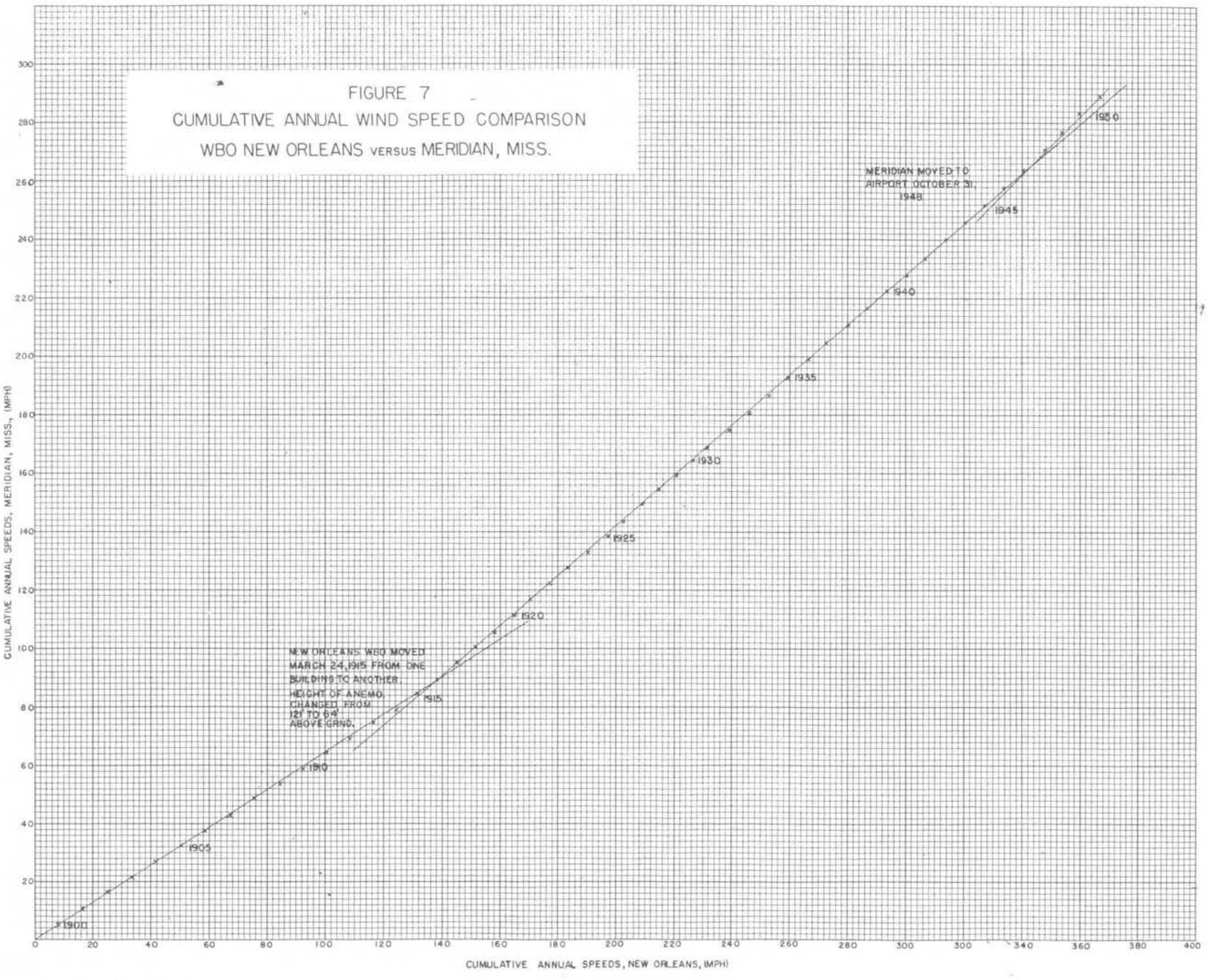
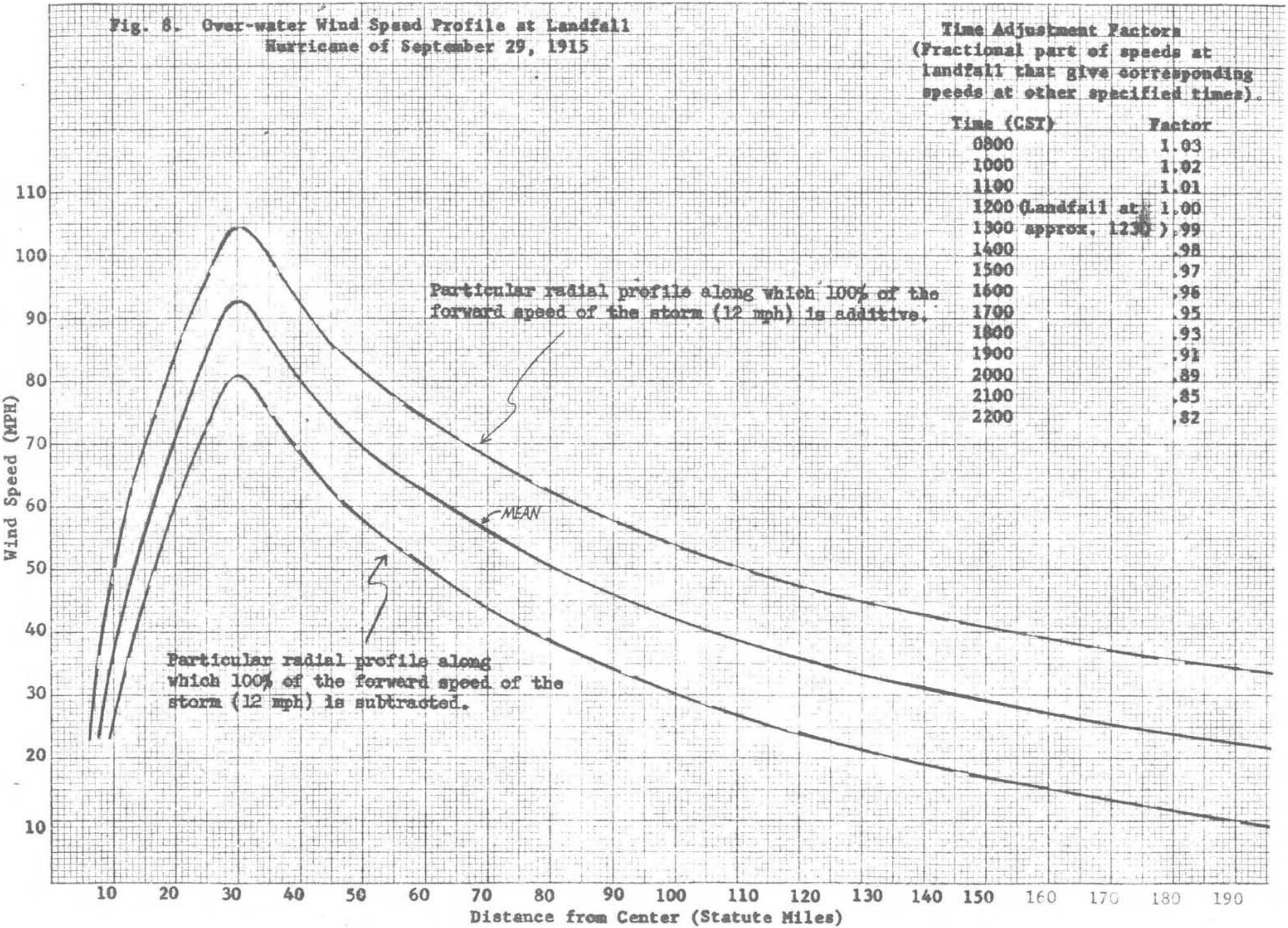



FIGURE 7
CUMULATIVE ANNUAL WIND SPEED COMPARISON
WBO NEW ORLEANS versus MERIDIAN, MISS.

Fig. 8. Over-water Wind Speed Profile at Landfall
Hurricane of September 29, 1915




Time Adjustment Factors
(Fractional part of speeds at landfall that give corresponding speeds at other specified times).

| Time (CST) | | Factor |
|---|---|---|
| 0800 | | 1.03 |
| 1000 | | 1.02 |
| 1100 | | 1.01 |
| 1200 | (Landfall at | 1.00 |
| 1300 | approx. 1230) | .99 |
| 1400 | | .98 |
| 1500 | | .97 |
| 1600 | | .96 |
| 1700 | | .95 |
| 1800 | | .93 |
| 1900 | | .91 |
| 2000 | | .89 |
| 2100 | | .85 |
| 2200 | | .82 |