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MEMORANDUM HUR-2-120

Revised Standard Project Hurricane Criteria for the Atlantic and Gulf Coasts of the UNITED STATES

(DRAFT)

~~June 1972~~

MH December 1972

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20314

IN REPLY REFER TO
DAEN-CWE-Y

31 July 1972

SUBJECT: Memorandum HUR 7-120, Revised Standard Project Hurricane Criteria for the Atlantic and Gulf Coasts of the United States

District Engineer, New Orleans

Subject memorandum has been prepared by the Hydrometerological Branch, National Weather Service, in draft form and is being forwarded for interim use pending its final publication which will include data on the probable maximum hurricane. This report represents all the major changes in Standard Project Hurricane (SPH) criteria given in National Hurricane Research Project No. 33, which was distributed in November 1959. The purpose of the report is to incorporate all the various revisions, principally the changes in wind fields associated with well-developed hurricanes of recent years.

FOR THE CHIEF OF ENGINEERS:

1 Incl
as

for R. S. Thompson
JOSEPH M. CALDWELL
Chief, Engineering Division
Directorate of Civil Works

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Rec'd 12-14-72 aph

DRAFT

MEMORANDUM HUR 7-120

REVISED STANDARD PROJECT HURRICANE CRITERIA FOR THE ATLANTIC AND GULF COASTS OF THE UNITED STATES

Hydrometeorological Branch
Office of Hydrology
NOAA, National Weather Service
June 1972

I. Introduction

This memorandum covers revisions to Standard Project Hurricane (SPH) criteria given in National Hurricane Research Project Report No. 33 [1]. The need for these revisions was prompted by a comparison of the wind fields in well-developed hurricanes that occurred since 1956 with those used to develop the SPH in the original study. It is believed the wind fields or average radial storm winds of NHRP No. 33 should be stronger relative to the highest winds near the center of the storm. This is supported by the number of storms in recent years with winds that exceed those of NHRP No. 33. Figure 1 shows a comparison of the earlier radial wind profiles used in NHRP No. 33 with the profiles estimated in the more recent storms that bears out this contention. In this figure both velocity and distance are drawn on a relative basis, i.e., by ratios of actual wind to maximum wind and ratios of distance from the storm center to radius of maximum wind.

Memorandum HUR 7-84 [2] and several subsequent memoranda of that series provide revisions to NHRP No. 33 in zones B and C of the Gulf coast in order to better reflect the greater windspeeds of Hurricane Carla (1961) and others. Revisions of the present study are consistent with the revised values in zones B and C.

While the revision of the relative wind fields provide the main motivation for this work, other hurricane parameters were also updated, the most important being the Central Pressure Index (CPI). An important consideration in these revisions was to maintain consistency from zone to zone with a study giving meteorological characteristics of the probable maximum hurricane [3]. Criteria for the probable maximum hurricane (PMH) are the same meteorological parameters, some with the same values and similar developmental techniques, as those of the SPH criteria.

One reason why meteorological parameters, such as the CPI, need revision is that in the earlier storms the lowest pressure was seldom measured and therefore had to be estimated by indirect methods [4]. Exceptions were those storms where the center passed over a land station or a ship at sea. In recent storms much more reliable central pressures are often obtained through dropsondes from airplanes into the hurricane center.

The period of record for the revised SPH criteria includes all relevant storms in the 72-year period from 1900 through 1971.

Figure 2 shows revised values for maximum winds in the SPH along the Atlantic coast, with moderate forward speeds and mean radii of maximum winds, compared to the values previously published in NHRP No. 33. The increased winds up to about 35°N latitude are mainly due to lower CPI values in the revised analyses. The slightly lower winds farther north are due mainly to the adoption of a peripheral pressure that varies with latitude.

The present study is meant to be an interim report, giving the major changes in SPH criteria from that in NHRP No. 33. Many references are

made to that report. The planned publication of revised SPH criteria will contain the necessary information so that these references need not be made.

II. Interpretation of the SPH

The SPH is a hypothetical hurricane that is intended to represent the most severe combination of hurricane parameters that is "reasonably characteristic" of a specified geographic region, excluding extremely rare combinations. The SPH is intended as a practicable expression of the maximum ~~chance~~ DEGREE of protection that should be sought as a general rule in the planning and design of coastal structures for communities where protection of human life and destruction of property is involved. The height of the storm-generated surge is the critical factor. This is mainly dependent on the speed and direction of winds as a hurricane nears and enters the coast. Thus, the important product of the study is the hurricane wind field.

There have been numerous inquiries indicating there are some misunderstandings concerning what the SPH criteria represent. NHRP No. 33 and the present revision show frequency analyses of the CPI for large zones along the gulf and Atlantic coasts. The SPH uses the arbitrary 100-year return period of the CPI as a standard for comparison and consistency from zone to zone. However, use of 100-year return-period CPI values does not imply that the SPH has a 100-year return period for any place in a given zone, since other meteorological parameters are also important. Hence, the standard project hurricane has no frequency assigned to it. The angle of storm approach to the coastline, the rate of travel, and the radius of maximum wind are important meteorological considerations for determining the hurricane surge.

Although a CPI with a 100-year return period may be read from figures in this report for any point along the coast, it does not mean the value is expected to occur once in 100 years at that point. Because of the manner

in which the statistics of the CPI were developed (see pp. 3 and 4 in NHRP No. 33) the 100-year CPI at <u>any</u> point on the Atlantic coast, say x, must be interpreted as the CPI value which may be expected to occur once in 100 years, on the average, at <u>some</u> point in a 300 n. mi. zone centered at x. The smooth 100-year line which interpolates the CPI value from the mid-point of one zone to another is a convenience which insures a smooth regional progression of the CPI values.

Wind fields determined from NHRP No. 33 and this revision, represent 10-minute average speeds, standardized to a height of 30 feet above the surface. The 10-minute average was adopted as a standard sustained wind. Storm surges cannot be generated from wind gusts. The 30-ft height above the surface is used to standardize observations from instruments at differing heights.

III. SPH parameters

The independent parameters used to develop the SPH criteria are:

1. Central Pressure Index (CPI). This is the lowest pressure at the storm center. It is an independent variable for determination of the maximum gradient windspeed (V_{gx}).

2. Peripheral Pressure (p_n). This is the sea-level pressure at the outer limits of the hurricane wind circulation. It should not be confused with the assymptotic pressure discussed in [3]. Revised maximum wind (V_x) values for this report (see Part IV, F) where p_n depends on latitude are shown in figure 2.

3. Radius of maximum wind (R). This is the radial distance from the hurricane center to the location of highest winds which usually occurs just outward the hurricane eye-wall cloud.

4. Forward speed (T). This is the rate of translation of the hurricane center from one geographical point to another.

IV. Revisions to NHRP Report No. 33

A. Added storm data

Table A lists hurricanes with central pressures of less than 29.00 inches within each coastal zone for the 72-year period of record (1900-1971). There are 32 more storms than shown for a similar list in NHRP No. 33.

Table B lists all tropical storms which reached hurricane intensity at some time and moved through one or more of the zones during the 72-year period of record (1900-1971). There is an increase of 50 in the number of storms over those in NHRP No. 33.

B. Central Pressure Index (CPI) frequency analyses

New frequency analyses, figures 3-9, were made for each zone using central pressures (p_o) from table A. Changes in zone B were dictated primarily by Hurricane Camille (1969).

C. Coastal profile of CPI

The variation of CPI along the coast was obtained by fitting smooth curves to the frequency analyses of the CPI values plotted at the coastal center of each zone. Analysis of the discrete 100-year return-period CPI values resulted in smooth profiles along the Atlantic coast, figure 10, and Gulf coast, figure 11, and provides the necessary continuity and consistency between the Atlantic and Gulf coasts.

D. Nomogram for wind field profiles

The generalized SPH wind field is paracentric. However, since it is symmetrical, a radial wind profile taken along the line of maximum wind (line M) may be used to reconstruct the entire wind field. This is done by rotating the profile about the storm center, adjusting the windspeed according to a simple cosine function.

A wind profile nomogram, figure 12, was developed from hurricane wind patterns observed along the Atlantic and Gulf coasts through 1971. From the nomogram the radial wind profile for a given radius of maximum wind is defined by relative wind values read from isolines of radial distance (r in n. mi.) from the storm center. The relative wind (V/V_x) is the ratio of the wind (V) at a radial distance (r) to the maximum wind (V_x) along that radius. Profiles are defined for all radii of maximum wind from 4 to 50 n. mi. This covers the SPH range from small (RS) to large (RL) radius.

Relative wind (V/V_x) profiles of some storms exceed those of the nomogram (see fig. 1). The percent of storms undercut is uncertain, but it is probably in the range of 10-15 percent. For instance in the period 1957 through 1971, 4 or 5 out of 32 hurricanes in the Gulf and Atlantic coastal areas had some portion of their relative wind profile undercut. The storms that were partially undercut are: Carla (1961); Donna (1960); Ione (1955); Hazel (1954); Gracie (1959); and Camille (1969). This, however, does not mean that the actual SPH winds undercut all of these storms since the maximum wind (V_x) must also be considered.

Profiles from the nomogram, figure 12, provide higher windspeeds relative to the maximum wind (V_x) than did NHRP No. 33 over the entire wind field in all zones. This is shown in figure 13, for zone C where the average increase along the profile is about 10 percent. The figure also shows profiles used in two earlier SPH wind field revisions [2, 5]. The increase over NHRP No. 33 for other zones ranges to about 20 percent for mean (RM) and large (RL) radii of maximum winds.

E. Maximum gradient windspeed (V_{gx})

The maximum gradient windspeed equation

$$V_{gx} = K\sqrt{p_n - p_o} - R\,(0.575f) \qquad (1)$$

from [4], provides a means for computing the maximum windspeed in a SPH whose other parameters are known. V_{gx} is in mph when P_n and p_o are in inches, R is in n. mi. and f is in hr^{-1}. The coefficient (K) varies with latitude [3] in the revised SPH criteria as opposed to a constant value of 73.0 used in NHRP No. 33. The peripheral pressure (p_n) also varies with latitude. Figure 14 shows a plot of p_n versus latitude in storms and the adopted curve.

The central pressure (p_o), the radius of maximum wind (R), and storm speed (T) are given in table 1. The values of V_{gx} for mean (RM) and large (RL) radius of maximum wind were computed and also appear in table 1, after conversion to knots.

F. Maximum windspeed (V_x)

The maximum windspeed, in knots, adjusted to 30 feet above the water surface is defined by the equation:

$$V_x = 0.865\ V_{gx} + 0.5T \qquad (2)$$

0.885 USED FOR PMH (7-97)
ZONE B

where the gradient windspeed, V_{gx}, from equation (1) is in knots and the forward speed, T, is in knots. V_x was evaluated at 48 discrete geographical locations on the Atlantic and Gulf coasts using the two values of V_{gx} (for RM and RL) for slow (ST), moderate (MT), and fast (HT) forward speeds. These values are listed in table 1. The same overwater friction coefficient, 0.865, for reducing the gradient wind to 30 feet above the surface, was used in all zones.

G. Wind fields

Construction of isovel patterns involves rotation of the radial profile of windspeed about the hurricane center. If this is done by hand computation techniques, it is necessary to first sketch the wind profile along the radius of maximum wind, using figure 12. Under normal circumstances this radius, or line of maximum winds, extends to the right of the direction of motion vector of the storm, making an angle of 115° with the direction vector. To get the windspeed, V_{xp}, at any point x, a distance r from the center of the SPH, and that does not lie on line M, the expression

$$V_{xp} = V_x - \frac{T}{2}(1-\cos\theta) \qquad (3)$$

is used. V_x is the windspeed along the profile on M at a distance r from the center and θ is the angle between line M and radius vector through x.

Although an angle of 115° between line M and the direction of storm motion is preferred, this angle may be any value from 15° to 165°. This agrees with the limits of rotation given in NHRP No. 33.

The wind direction is defined as the angle of incurvature over the wind field. The angle of incurvature is the angle between the wind direction and a tangent to a circle centered over the storm, and is considered to be positive when the wind has a component directed toward the storm center. The angle of incurvature criteria, the same as that shown in NHRP No. 33, is as follows.

Radius	Angle of incurvature
1. Center out to region of maximum winds (R)	0°-10°
2. R out to 1.2 R	10°-25°
3. 1.2 R and outward	25°

Radial wind profiles for each zone from this study are compared with those in NHRP No. 33, in figures 15 through 21. The profile for zone C, figure 21, was used to construct a sample wind field, figure 22. This is for mile 360 with a moderate forward speed and mean radius.

H. Radius of maximum winds (R) and forward speed (T)

Some of the values of the CPI (p_o) were revised, and since R is somewhat dependent on p_o (see figure 7 and 17, NHRP No. 33) the values of the three categories of R (small, mean, and large) were accordingly revised. The new values in table 1 are only slightly different from those in table 1 of NHRP No. 33.

The values of the three categories of the forward speed (slow, moderate, and fast), read from figures 9 and 20, NHRP No. 33, resulted in slight differences from those originally published in table 1.

I. Frictional adjustment for windspeeds over land

In NHRP No. 33, a constant factor of 0.70 was used for reducing over-water winds to over-land. For the present revision, we recommend a variation in this reduction factor with the windspeed. The basis for this is shown in figure 30 of HMR #32 [4]. For windspeeds less than 10 knots, use 0.40, for speeds greater than 73 knots use 0.78. Interpolate linearly for intermediate speeds. These reduction factors for any over-water speed represent lower limiting values for the over-land windspeed at a point which is at least 10 miles inland along a trajectory starting at the coast. In other words, the reduction should be accomplished in about 10 miles over land. The speed-up when the trajectory leaves land to go back over water also occurs in about 10 miles.

V. Other SPH criteria, not revised

Other criteria for the SPH, such as adjustment for filling over land, and adjustment of windspeeds near shore, have not undergone revision.

VI. Isovel wind field construction

The procedure for constructing a revised SPH wind field is illustrated by the following example for a location along the Atlantic coast at 25.5°N. latitude. This example uses a mean radius of maximum wind (RM) and a moderate forward speed (MT).

1. From table 1, mean radius of maximum wind, (RM), for the location is 8 n. mi., maximum windspeed (V_x) is 109 knots, and moderate forward speed (MT) is 10 knots.

2. Using figure 12, read off relative windspeeds (V/V_x) at various distances from the center for RM of 8 n. mi. For this example, the following table gives the V/V_x and the actual wind, V, at the given distances.

Distance from center (n. mi.)	V/V_x	V (kts)
8	1.000	109
9	.995	108
12	.970	106
16	.916	100
20	.823	90
30	.698	76
40	.619	67
50	.559	61
60	.506	55
80	.431	47
100	.368	40
120	.317	35
150	.244	27
200	.158	17

3. For the values of V inside RM, read off relative distances from the center and relative windspeeds from figure 23. Construct table, as in step 2.

Relative distance from center (r/R)	Relative speed (V/V_x)	$V = V/V_x \times 109$ (knots)	$r = r/R \times 8$ (n. mi.)
.2	.025	3	1.6
.4	.117	13	3.2
.5	.227	25	4.0
.6	.450	49	4.8
.7	.735	80	5.6
.75	.835	91	6.0
.8	.900	98	6.4
.9	.970	106	7.2

4. Plot the values of steps 2 and 3, (V versus distance from center, r,) on graph paper, as in figures 24[1], upper right, and upper left. This gives the windspeed values for any point along the line of maximum winds.

5. On a large sheet (2'x2'), lay off a line (M), scaled with distance from a point designated as the center of the SPH. On this line, plot winds computed in steps 2 and 3 or interpolated from step 4. (See figure 24.)

6. To compute the windspeed V_{xp}, at any point x in the SPH wind field that does not lie on line M, use the following equation:

$$V_{xp} = V-T/2\ (1-\cos\theta),$$

where V is the windspeed along line M at the distance r from the center.

To show, in general, how the equation is used consider the point, x, 50 n. mi. from the storm center making an angle θ of 60° with line M.

[1]The plot, figure 24, should be on a reasonably large graph paper in order to obtain deatils on winds within RM. We suggest a sheet about 2½2'.

a. On figure 24 read V, along line M, of 61 knots at a distance of 50 n. mi. from the center.

b. Substituting in the equation gives

$$V_{xp} = 61 - \frac{10}{2}(1-.5) = 58.5 \text{ knots}$$

7. To determine a particular isovel, say for 40 knots, the following is suggested.

a. Mark the 40-knot point on line M, using figure 24, upper right, to get distance from the center.

b. Using the nomogram, figure 25, sketch in selected radial lines that indicate factors applied to forward speed (T) to find the 40-knot value at other points. These are tick marks .1, .2, etc., on figure 24, lower portion. Note that the 1.0 mark is diametrically opposite to line M.

c. To get the distance of the 40-knot value from the center along the radial tick mark 0.4, multiply 10 (the value of T) by 0.4 to get 4. Add 4 to 40 to get 44.

d. From upper right profile of figure 24, find the distance from center (along M), of the 44 knots and plot along line marked 0.4. This gives the location of the 40-knot wind on radial 0.4. Make similar computations for other radials to provide a smooth isovel around full circle of the pattern. Since the wind field is symmetrical about line M, half the pattern may be folded over to obtain the complete wind field.

e. For determining other isovels outside of R, follow the same procedure.

f. For isovels inside of R, use the same procedure, utilizing the wind profile in the upper left corner of figure 24.

A little experimenting will make the following evident. All isovels that have values larger than the differences between the maximum wind and the forward speed of the storm will be crescent or kidney-shaped. For the particular example above, where $V_x = 109$ and $T = 10$, all isovels with values between 99 and 109 are crescent-shaped. See example of the 100-knot isovel in figure 24. All other isovels are more or less circular.

<u>Alternate to detailed approach</u>. Without sacrificing much accuracy, all nearly circular isovels may be drawn as true circles, provided the forward speed, T, is relatively low, say, 12 knots or less. To do this for the 40-knot isovel as an example, perform step 7a above. To find the 40-knot point on the extension of M on the opposite side of the center use figure 24 again and find the distance from center to the 50 knot ($40 + T = 50$) value. Find the midpoint, on line M of the two points above, and using this as a center, draw a circle through the two points. This is the 40-knot isovel. Other isovels are determined in a similar manner.

REFERENCES

1. U. S. Weather Bureau, "Meteorological Considerations Pertinent to Standard Project Hurricane, Atlantic and Gulf Coasts of the United States," National Hurricane Research Project Report No. 33, 1958.

2. Memorandum HUR 7-84, Standard Project Hurricane Wind Field Patterns (revised) to replace existing patterns in NHRP Report No. 33, for Zones B & C, August 17, 1965.

3. Memoranda HUR 7-97 and HUR 7-97A, "Interim Report - Meteorological Characteristics of the Probable Maximum Hurricane, Atlantic and Gulf Coasts of the United States," May 7, 1968, along with "Peripheral Pressures for Probable Maximum Hurricanes," December 3, 1968.

4. U. S. Weather Bureau, "Characteristics of United States Hurricanes Pertinent to Levee Design for Lake Okeechobee, Florida," Hydrometeorological Report No. 32, 1954.

5. MEMORANDUM HUR 7-94, Surface Winds (30 ft.) in Standard Project Hurricane Critical to Espiritu Santo Bay (Matagorda Bay, Texas), for Large Radius of Maximum Winds and For Fast, Moderate and Slow Forward Speed.

TABLE 1. - STANDARD PROJECT HURRICANE INDEX CHARACTERISTICS

EAST COAST UNITED STATES

Coastal Location		CPI		Radius of Max. Wind (Nautical Miles)			Forward Speed (T) (Knots)			Representative Maximum Wind Speeds (Knots) Mean Radius of Max. Wind				Large Radius of Max. Wind			
Zone	Lat. (°N.)	(Inches	(mb)	RS	RM	RL	ST	MT	HT	V_{gx}(RM)	V_x(ST)	V_x(MT)	V_x(HT)	V_{gx}(RL)	V_x(ST)	V_x(MT)	V_x(HT)
1																	
	23	26.56	899.1	4	7	11	4	10	16	123	109	112	115	123	108	111	114
	24	26.61	901.1	4	8	11	4	10	16	122	108	111	114	122	108	111	114
	25	26.68	903.5	4	8	12	4	10	16	121	107	110	113	121	106	109	112
	25.5	26.73	905.2	4	8	13	4	10	17	120	106	109	112	119	105	108	112
	26	26.77	906.5	4	9	14	4	11	17	119	105	109	112	119	105	108	111
	27	26.88	914.0	5	10	17	4	11	18	117	103	107	110	116	102	106	109
2																	
	28	27.02	915.0	5	12	21	4	11	19	114	101	104	108	113	100	103	107
	29	27.21	921.4	6	14	27	4	11	20	110	97	101	105	108	96	99	104
	30	27.38	927.2	7	16	31	4	11	21	105	93	97	102	103	91	95	100
	30.5	27.43	928.9	7	16	32	4	11	22	104	92	95	101	102	90	94	99
	31	27.46	929.9	7	17	34	4	11	23	103	91	95	101	101	89	93	99
	32	27.49	930.9	7	16	32	4	12	26	102	90	94	101	99	88	92	99
3																	
	33	27.48	930.6	7	16	31	4	13	30	100	89	93	102	98	87	92	100
	34	27.46	929.9	6	15	30	5	15	34	100	89	94	103	97	87	92	101
	35	27.44	929.2	6	15	29	5	17	39	98	88	94	105	96	86	92	103
	35.5	27.44	929.2	6	15	29	5	18	41	98	87	93	105	95	85	92	103
	36	27.45	929.6	6	15	29	6	20	42	96	87	94	105	94	85	92	103
	37	27.49	930.9	7	16	31	8	23	45	94	85	93	104	91	83	91	102
4																	
	38	27.55	933.0	7	17	34	10	26	47	90	83	91	102	88	81	89	99
	39	27.63	935.7	7	18	38	12	29	49	87	81	90	100	84	78	87	97
	40	27.72	938.7	8	19	43	14	32	51	83	79	88	98	79	76	85	94
	40.5	27.77	940.4	8	20	46	15	34	51	81	78	87	96	77	74	83	92
	41	27.82	942.1	8	21	50	16	35	52	79	76	86	94	74	72	82	90
	42	27.92	945.5	9	23	56	17	36	53	75	73	83	91	69	68	78	86
	43	28.03	949.2	9	26	64	17	37	53	71	70	80	88	64	64	74	82
	44	28.15	953.3	10	28	72	17	38	53	67	66	77	84	59	59	70	77
	45	28.26	956.7	11	31	80	17	39	53	63	63	74	81	53	55	66	73

TABLE 1. - Continued

GULF COAST UNITED STATES

Coastal Location			Near City or	CPI		Radius of Max. Wind (Nautical Miles)			Forward Speed (T) (Knots)			Representative Maximum Wind Speeds (Knots) Mean Radius of Max. Wind				Large Radius of Max. Wind			
Zone	Mile	Lat (°N)	Other Landmark	(In)	(mb)	RS	RM	RL	ST	MT	HT	V_{gx}(RM)	V_x(ST)	V_x(MT)	V_x(HT)	V_{gx}(RL)	V_x(ST)	V_x(MT)	V_x(HT)
A																			
	1335	24		26.65	902.5	4	7	11	4	10	17	123	107	110	114	121	107	110	113
	1280	25		26.77	906.5	4	8	12	4	10	17	119	105	108	112	119	105	108	111
	1215	26	Marco, Fla.	26.91	911.3	4	9	14	4	11	17	117	103	106	109	116	102	106	109
	1150	27	Lemon Bay, Fla.	27.04	915.7	5	9	16	4	11	18	114	101	104	108	113	100	103	107
	1085	28	Dunedin, Fla.	27.16	919.7	5	10	18	4	11	19	111	98	102	106	110	98	101	105
	1025	29	Yankeetown, Fla.	27.24	922.5	5	11	19	4	11	20	110	97	100	105	109	96	99	104
	960	30	Carbur, Fla.	27.31	924.8	6	12	21	4	11	21	107	95	98	103	106	94	97	102
B																			
	900	29.7	Apalachicola, Fla.	27.34	925.8	6	12	22	4	11	28	107	94	98	106	106	93	97	105
	840	31.5	Grayton, Beach, Fla.	27.36	926.5	6	12	22	4	11	28	105	93	97	105	104	92	95	104
	780	31.6	Pensacola, Fla	27.36	926.5	6	12	22	4	11	28	105	93	97	105	104	92	95	104
	720	30.3	Mobile, Ala.	27.36	926.5	6	12	22	4	11	28	106	94	97	106	105	93	96	105
	660	29.1	New Orleans, La.	27.36	926.5	6	12	22	4	11	28	107	94	98	106	105	93	97	105
	600	29.3	Lake Barre, La.	27.36	926.5	6	12	22	4	11	28	107	94	98	106	105	93	97	105
	540	29.5	March Island, La.	27.36	926.5	6	12	22	4	11	28	106	94	98	106	105	93	97	105
	480	29.7	Grand Chenier, La.	27.34	925.8	6	12	22	4	11	28	107	94	98	106	106	93	97	105
C																			
	420	30	Port Arthur, Tex.	27.31	924.8	6	12	21	4	11	28	107	95	98	107	106	94	97	106
	360	29	Galveston, Tex.	27.28	923.8	6	11	20	4	11	28	109	96	100	108	108	95	99	107
	300	29	Bay City, Tex.	27.24	922.5	5	11	19	4	11	28	110	97	100	109	109	96	99	108
	240	28	San Antonio Vay, Tex.	27.21	921.4	5	11	19	4	11	28	110	97	101	109	109	97	100	109
	180	27	Sarita, Tex.	27.15	919.4	5	10	18	4	11	28	112	99	102	111	111	98	101	110
	120	26	Brownsville, Tex.	27.09	917.4	5	10	18	4	11	28	113	100	103	112	112	99	102	111

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 with P_n=29.92
V_x = estimated maximum 30-ft wind speed computed from V_x=0.865 V_{gx}+ 0.5T

TABLE A. - HURRICANES WITH CENTRAL PRESSURE INDEX LESS THAN 29.00 INCHES (1900-1967) RANKED BY CPI

EAST COAST UNITED STATES

Date	CPI (in.)	R (n.mi.)	V_{gx} (kts)	Lat. (deg. N.)	T (kts)	Max. 30-ft wind speed estimated from analyses of data (kts)
ZONE 1						
Sept. 2, 1935	26.35	6	119	24.8	9	
Sept. 9, 1919	27.44	15	94	24.8	8	
Oct. 20, 1926	27.52	21	85	24.6	16	
Sept. 10, 1960	27.55	22	-	24.5	9	
Sept. 18, 1926	27.59	24	96	25.8	17	
Sept. 16, 1928	27.62	53	102	26.7	13	
Sept. 17, 1947	27.76	34	89	26.2	10	
Sept. 4, 1933	27.98	29	88	26.9	11	
Sept. 15, 1945	28.09	24	86	25.5	10	
Sept. 8, 1965	28.11	22	-	25.2	11	
Sept. 28, 1929	28.15	28	85	24.9	10	
Aug. 26, 1949	28.16	23	86	26.7	14	78
Oct. 17, 1950	28.20	-	-	25.8	6	
Oct. 11, 1909	28.30	22	82	24.5	10	
July 28, 1926	28.34	14	77	28.0	-	
Sept. 22, 1948	28.41	16	74	26.8	11	
Sept. 27, 1964	28.57	-	-	25.5	9	
Nov. 4, 1935	28.73	-	69	-	-	
Oct. 20, 1924	28.83	25	54	25.8	6	
Sept. 11, 1903	28.84	43	66	25.8	8	
Oct. 18, 1906	28.84	35	58	26.9	6	
Oct. 5, 1948	28.85	31	58	25.8	13	
June 17, 1906	28.91	26	63	26.9	12	
ZONE 2						
Sept. 26, 1958	27.52	19	-	32.7	12	
Oct. 15, 1954	27.66	36	80	32.0	-	82
Sept. 29, 1959	28.05	10	-	32.0	12	100
July 28, 1926	28.34	14	77	28.4	8	
Aug. 30, 1954	28.35	-	-	-	-	
Aug. 12, 1955	28.40	45	63	32.5	7	
Oct. 19, 1968	28.47	-	-	31.0	17	
Sept. 10, 1960	28.47	33	-	32.9	26	
Sept. 19, 1955	28.51	50	68	32.8	10	
Sept. 9, 1964	27.82	20	-	29.1	7	100
Oct. 15, 1947	28.59	13	63	32.1	17	
Sept. 16, 1928	28.75	-	-	29.5	-	
Aug. 11, 1940	28.78	27	67	32.0	9	90
Oct. 25, 1921	28.91	-	-	29.0	10	
Sept. 15, 1945	28.91	-	-	29.0	-	
Aug. 28, 1911	28.92	27	63	32.1	8	
ZONE 3						
Sept. 27, 1958	27.66	25	91	34.0	18	
Oct. 15, 1954	27.66	36	80	33.0	26	82
Sept. 21, 1938	27.86	50	72	33.7	-	
Sept. 14, 1944	27.88	17	98	35.2	23	
Sept. 10, 1954	27.97	-	-	-	-	
Sept. 16, 1933	28.25	42	73	35.2	9	
Aug. 28, 1958	28.26	-	-	34.0	17	
Aug. 30, 1954	28.35	-	-	33.4	-	
Sept. 11, 1960	28.35	36	-	37.4	30	
Aug. 12, 1955	28.40	45	63	34.5	7	
Sept. 19, 1955	28.51	50	68	35.0	9	
Sept. 18, 1936	28.53	34	55	35.2	15	
Aug. 23, 1933	28.63	36	50	36.9	18	53
Aug. 25, 1924	28.70	34	68	35.2	22	
Sept. 3, 1913	28.81	41	63	35.8	16	
Aug. 24, 1949	28.86	24	70	33.5	22	
Dec. 2, 1925	28.95	54	54	34.2	14	
Sept. 16, 1967	28.97	-	-	36.6	9	
Sept. 17, 1906	28.98	61	63	34.0	16	
ZONE 4						
Sept. 21, 1938	27.86	50	72	41.8	47	83
Sept. 11, 1954	27.97	-	-	41.3	40	
Sept. 16, 1933	28.25	-	73	-	-	
Sept. 14, 1944	28.31	48	62	41.4	30	83
Sept. 11, 1960	28.35	-	-	38.0	32	
Aug. 31, 1954	28.38	22	-	41.8	33	
Sept. 18, 1936	28.53	34	55	38.0	-	
Aug. 26, 1924	28.70	66	51	41.3	29	
Aug. 29, 1958	28.73	-	-	39.0	21	
Aug. 15, 1971	28.88	-	-	42.5	11	75
Sept. 9, 1969	28.91	-	-	43.8	40	

TABLE A. - Continued

GULF COAST UNITED STATES

Date	CPI (in.)	R (n.mi.)	V_{gx} (kts)	T (kts)	Lat. (deg.N.)	Long. (deg.W.)
ZONE A						
Sept. 2, 1935	26.35	6	119	9	24.8	80.9
Sept. 9, 1919	27.44	15	94	8	24.6	82.9
Oct. 20, 1926	27.52	21	97	16	23.8	81.3
Sept. 10, 1960	27.55	20	-	9	25.5	81.5
Sept. 21, 1948	27.62	7	89	8	24.5	81.8
Oct. 17, 1910	27.80	16	73	11	24.5	82.5
Sept. 8, 1965	27.99	19	-	15	25.2	81.5
Oct. 18, 1944	28.02	27	81	13	24.6	82.8
Sept. 17, 1947	28.03	34	-	-	26.4	81.3
Sept. 18, 1926	28.05	24	-	17	26.5	81.0
Sept. 28, 1929	28.15	28	-	10	24.8	81.1
Oct. 25, 1921	28.29	18	70	10	28.1	82.8
Oct. 11, 1909	28.30	22	82	10	24.3	81.7
Sept. 16, 1928	28.30	53	-	-	27.7	81.4
Sept. 4, 1950	28.30	-	-	-	29.1	83.1
Aug. 26, 1949	28.37	23	-	14	27.2	81.2
Sept. 15, 1945	28.39	24	-	10	25.5	81.0
Oct. 6, 1964	28.47	-	-	15	24.0	83.0
Sept. 4, 1933	28.48	29	-	11	27.8	81.6
June 9, 1966	28.64	-	-	9	30.0	84.3
Oct. 18, 1968	28.70	-	-	10	29.3	82.2
Oct. 19, 1924	28.70	19	-	8	25.0	83.0
Nov. 4, 1935	28.73	-	69	-	25.0	81.0
Sept. 11, 1903	28.84	43	66	7	27.0	81.5
Oct. 18, 1906	28.84	35	58	6	25.0	81.0
Oct. 5, 1948	28.85	31	58	13	24.0	81.2
Oct. 18, 1950	28.88	-	-	-	28.0	81.6
June 17, 1906	28.91	26	63	-	25.1	80.9
Oct. 4, 1966	28.94	-	-	7	24.2	84.0
Oct. 7, 1941	28.98	18	68	11	29.8	84.7

Legend

CPI - central pressure index
R - radius of maximum winds
V_{gx} - maximum gradient wind speed
T - forward speed of the storm

Date	CPI (in.)	R (n.mi.)	V_{gx} (kts)	T (kts)	Lat. (deg.N.)	Long. (deg.W.)	Max. 30-ft wind speed estimates from analyses of data (kts)
ZONE B							
Aug. 17, 1969	26.61	15	111	-	28.6	88.5	130
Sept. 8, 1900	27.64	-	90	-	27.0	90.5	77
Sept. 10, 1965	27.79	32	-	17	28.9	89.8	
Sept. 29, 1915	27.70	29	92	10	29.9	90.1	74
June 27, 1957	27.95	19	95	14	29.8	93.6	91
Sept. 14, 1919	28.00	-	-	20	26.9	90.2	
Sept. 20, 1926	28.20	17	85	7	30.5	87.5	
July 21, 1909	28.31	19	86	-	26.8	91.0	
Aug. 25, 1926	28.31	27	87	10	29.6	90.7	
Oct. 3, 1964	28.33	21	-	7	29.0	91.4	
July 5, 1916	28.38	50	70	25	30.7	88.0	
July 31, 1936	28.46	19	70	9	30.5	86.5	
Sept. 28, 1917	28.48	33	70	13	30.4	87.2	
Sept. 27, 1906	28.50	73	72	16	30.6	88.5	
June 16, 1934	28.52	37	70	16	29.9	91.7	
Sept. 19, 1947	28.54	33	63	16	29.9	90.1	83
Aug. 14, 1901	28.72	33	72	14	29.9	90.1	
Oct. 18, 1916	28.76	19	70	21	30.4	87.2	
Aug. 7, 1940	28.76	11	62	8	29.0	92.8	
Sept. 23, 1956	28.76	22	64	10	30.0	86.5	71
July 27, 1943	28.78	16	68	8	28.2	92.0	
Sept. 30, 1929	28.80	65	61	6	30.1	85.7	
Aug. 30, 1950	28.92	21	56	23	30.2	88.0	
Sept. 21, 1920	28.93	28	58	28	29.6	90.7	
Sept. 20, 1909	28.94	88	63	11	29.9	90.1	
Oct. 7, 1941	28.98	18	68	11	29.9	84.7	
Sept. 15, 1960	28.98	-	-	10	28.1	89.0	
ZONE C							
Sept. 20, 1967	27.26	25	118	8	26.0	97.1	95
Sept. 11, 1961	27.64	20	-	6	27.2	94.9	
Sept. 8, 1900	27.64	14	90	10	29.2	95.9	77
Aug. 13, 1932	27.83	12	94	15	29.1	95.6	
Aug. 3, 1970	27.85	9	113	14	27.9	97.2	
June 27, 1957	27.95	19	83	14	29.2	93.8	
Aug. 18, 1916	28.00	35	101	11	27.5	97.5	
Sept. 14, 1919	28.00	-	-	20	27.7	97.5	
Sept. 5, 1933	28.02	20	91	8	25.9	97.5	
Aug. 30, 1942	28.07	18	77	14	28.5	96.7	
Aug. 16, 1915	28.14	32	72	11	29.8	95.0	63
June 22, 1921	28.17	17	84	11	29.7	95.4	
July 21, 1909	28.31	19	86	12	29.0	96.0	
Sept. 23, 1941	28.31	21	70	13	29.7	95.4	
Aug. 27, 1945	28.57	18	77	4	29.0	96.2	
June 28, 1929	28.62	13	71	15	28.5	96.5	
Sept. 11, 1970	28.73	-	-	11	23.9	96.3	
Aug. 7, 1940	28.76	11	62	8	29.9	93.9	
July 27, 1943	28.78	16	68	8	29.5	95.0	
Aug. 4, 1933	28.80	25	66	10	25.9	97.5	
Sept. 16, 1971	28.85	-	-	15	29.4	93.2	
Oct. 4, 1949	28.45	28	68	11	28.9	95.4	71
Sept. 10, 1971	28.91	-	-	5	28.5	96.0	80

TABLE B. - AVERAGE DIRECTION OF CENTER MOVEMENT OF ALL TROPICAL STORMS IN THE ZONE WHICH REACHED HURRICANE INTENSITY AT ANY TIME (1887-1956)
EAST COAST UNITED STATES

Date	Avg. Direction of movement within zone (degrees to)	Date	Avg. direction of movement within zone (degrees to)	Date	Avg. direction of movement within zone (degrees to)	Date	Avg. direction of movement within zone (degrees to)
	ZONE 1				ZONE 2		
Aug. 18, 1887	306	Aug. 6, 1928	318	Aug. 20, 1887	018	July 21, 1934	215
Aug. 15, 1888	302	Sept. 15, 1928	303	Aug. 22, 1887	353	Aug. 10, 1940	304
Sept. 3, 1888	182	Sept. 25, 1929	235	Oct. 10, 1888	052	Aug. 2, 1940	234
Sept. 7, 1888	272	Aug. 28, 1932	297	Sept. 9, 1888	031	Sept. 18, 1941	029
Aug. 23, 1891	289	Sept. 5, 1932	348	Oct. 12, 1893	355	Oct. 8, 1941	107
Oct. 11, 1893	318	Oct. 4, 1933	056	Aug. 26, 1893	346	Oct. 19, 1944	016
Aug. 26, 1893	323	Aug. 31, 1933	286	Sept. 25, 1894	011	Aug. 1, 1944	350
Sept. 25, 1894	005	Sept. 2, 1933	299	Oct. 8, 1894	050	June 24, 1945	040
Oct. 20, 1895	030	July 29, 1933	293	Oct. 9, 1896	043	Sept. 16, 1945	016
Sept. 4, 1896	047	Sept. 6, 1934	328	Aug. 30, 1898	332	July 5, 1946	354
Oct. 8, 1896	049	Aug. 31, 1935	287	Oct. 1, 1898	300	Oct. 14, 1947	274
Aug. 1, 1898	290	Sept. 28, 1935	037	Oct. 30, 1899	000	Sept. 22, 1948	058
Oct. 28, 1899	021	Nov. 3, 1935	237	Aug. 13, 1899	017	Sept. 5, 1950	345
Aug. 11, 1899	324	July 27, 1936	287	Oct. 20, 1904	318	May 16, 1951	019
Aug. 9, 1901	296	Oct. 5, 1941	287	Sept. 13, 1904	307	Oct. 2, 1951	302
Aug. 10, 1903	291	Sept. 17, 1941	003	Oct. 19, 1906	213	Aug. 29, 1952	322
Sept. 11, 1903	293	Sept. 14, 1945	306	June 17, 1906	302	Sept. 27, 1953	068
Oct. 15, 1904	010	Sept. 12, 1946	025	July 28, 1908	001	Oct. 14, 1954	094
June 16, 1906	032	Oct. 11, 1947	051	Oct. 18, 1910	015	Aug. 29, 1954	021
Oct. 17, 1906	036	Sept. 16, 1947	241	Aug. 26, 1911	295	Aug. 16, 1955	318
Sept. 30, 1908	002	Sept. 21, 1948	051	July 13, 1916	326	Aug. 11, 1955	348
July 27, 1908	336	Oct. 5, 1948	044	Oct. 25, 1921	075	Sept. 19, 1955	349
Oct. 11, 1909	052	Aug. 25, 1949	299	Sept. 29, 1920	043	Sept. 26, 1958	325
Nov. 21, 1912	034	Oct. 17, 1950	339	Sept. 22, 1920	314	Sept. 10, 1960	030
Nov. 15, 1916	062	Oct. 2, 1951	053	Sept. 16, 1924	060	Sept. 24, 1963	040
Sept. 7, 1919	270	May 17, 1951	125	Nov. 30, 1925	035	Sept. 9, 1964	218
Oct. 20, 1924	076	Oct. 24, 1952	052	July 26, 1926	335	June 5, 1968	343
Oct. 20, 1926	056	Sept. 10, 1960	315	Sept. 17, 1928	022	June 19, 1968	060
July 26, 1926	324	Aug. 27, 1964	345	Sept. 9, 1930	047	Aug. 10, 1968	034
Sept. 17, 1926	305	Sept. 8, 1965	270	Sept. 6, 1934	005	Oct. 19, 1968	043
Aug. 12, 1928	309	June 17, 1968	333			Aug. 8, 1969	033
		Aug. 9, 1968	315				

4/13/72

TABLE B. - Continued

EAST COAST UNITED STATES

Date	Avg. direction of movement within zone (degrees to)	Date	Avg. direction of movement within zone (degrees to)	Date	Avg. direction of movement within zone (degrees to)	Date	Avg. direction of movement within zone (degrees to)
ZONE 3				ZONE 4			
Aug. 20, 1887	047	July 21, 1934	247	Oct. 20, 1887	017	Sept. 16, 1933	044
Oct. 20, 1887	035	Sept. 7, 1934	023	Aug. 21, 1888	068	Sept. 8, 1934	017
Oct. 11, 1888	038	Sept. 5, 1935	066	Sept. 10, 1888	044	June 19, 1934	057
Nov. 25, 1888	024	Sept. 17, 1936	339	Oct. 11, 1888	045	Sept. 6, 1935	069
Sept. 24, 1889	057	Sept. 20, 1938	273	Nov. 26, 1888	034	Sept. 18, 1936	046
Sept. 11, 1889	314	Aug. 31, 1940	025	Sept. 10, 1889	278	Sept. 24, 1936	015
July 8, 1891	069	Aug. 16, 1940	037	Sept. 24, 1889	045	Sept. 21, 1938	007
Oct. 11, 1891	015	Sept. 22, 1941	029	Oct. 12, 1891	040	Sept. 1, 1940	027
Aug. 23, 1893	358	Oct. 8, 1941	108	July 8, 1891	066	Oct. 17, 1943	007
Oct. 4, 1893	104	Oct. 19, 1944	022	Aug. 23, 1893	003	Oct. 20, 1944	047
Oct. 13, 1893	006	Aug. 1, 1944	358	Oct. 9, 1894	032	Aug. 2, 1944	061
Sept. 26, 1894	043	Sept. 13, 1944	008	Sept. 9, 1896	357	Sept. 14, 1944	033
Oct. 9, 1894	041	June 25, 1945	038	Aug. 19, 1899	064	June 26, 1945	046
Oct. 30, 1899	004	Sept. 17, 1945	015	June 29, 1902	098	Sept. 11, 1950	042
Aug. 15, 1899	034	July 5, 1946	045	Oct. 12, 1902	066	Aug. 14, 1953	046
July 10, 1901	256	Oct. 9, 1946	086	Sept. 15, 1903	332	Sept. 6, 1953	019
Oct. 10, 1903	022	Aug. 23, 1949	035	Oct. 11, 1903	059	Aug. 30, 1954	015
Sept. 15, 1903	347	Aug. 19, 1950	033	Sept. 14, 1904	039	Sept. 10, 1954	030
Sept. 14, 1904	329	Oct. 3, 1951	040	Sept. 15, 1912	078	Aug. 18, 1955	074
Sept 16, 1906	292	May 20, 1951	025	July 20, 1916	028	Sept. 27, 1956	055
July 30, 1908	036	Aug. 13, 1953	013	Sept. 6, 1918	020	Aug. 29, 1958	045
Oct. 19, 1910	058	Sept. 27, 1953	058	Sept. 30, 1920	022	Sept. 11, 1960	028
Oct. 5, 1912	241	Oct. 15, 1954	002	Aug. 25, 1924	028	Sept. 28, 1962	040
Sept. 1, 1913	315	Aug. 30, 1954	029	Dec. 3, 1925	068	Oct. 21, 1968	032
July 19, 1916	012	Sept. 10, 1954	024	Aug. 23, 1927	034	Sept. 9, 1969	030
July 13, 1916	320	Aug. 11, 1955	012			Aug. 12, 1969	050
Sept. 22, 1920	315	Sept. 18, 1955	015			Aug. 15, 1971	033
Sept. 30, 1920	025	Aug. 16, 1955	324				
Oct. 23, 1923	348	Sept. 27, 1956	050				
Sept. 16, 1924	313	Aug. 28, 1958	045				
Aug. 25, 1924	284	Sept. 27, 1958	010				
Dec. 1, 1925	284	Sept. 11, 1960	028				
Aug. 23, 1927	003	Sept. 28, 1962	036				
Sept. 17, 1928	306	Sept. 20, 1963	320				
Sept. 11, 1930	304	Sept. 16, 1967	018				
Aug. 22, 1933	322	Aug. 11, 1968	067				
Sept. 15, 1933	016	Oct. 20, 1968	043				
		Sept. 9, 1969	040				
		Sept. 30, 1971	315				

TABLE B. - Continued

GULF COAST UNITED STATES

Date	Avg. direction of movement within zone (degrees to)	Date	Avg. direction of movement within zone (degrees to)
ZONE A			
Sept. 5, 1900	217	Sept. 2, 1935	335
Aug. 10, 1901	290	Nov. 4, 1935	270
Sept. 11, 1903	292	Nov. 7, 1935	084
Sept. 17, 1904	185	July 28, 1936	303
June 16, 1906	350	Aug. 2, 1938	250
Oct. 16, 1906	038	Sept. 16, 1941	272
Oct. 10, 1909	020	Oct. 6, 1941	320
Oct. 17, 1910	002	Oct. 18, 1944	010
Aug. 9, 1911	325	June 23, 1945	059
Sept. 11, 1912	294	Sept. 15, 1945	000
Sept. 2, 1915	327	Oct. 7, 1946	010
Nov. 15, 1916	055	Sept. 17, 1947	289
Nov. 9, 1919	275	Aug. 18, 1947	276
Sept. 29, 1920	065	Oct. 11, 1947	038
Oct. 24, 1921	050	Oct. 4, 1948	040
Oct. 19, 1924	060	Sept. 20, 1948	010
Nov. 30, 1925	041	Aug. 26, 1949	325
July 28, 1926	311	Oct. 20, 1950	030
Sept. 18, 1926	300	Sept. 2, 1950	018
Sept. 16, 1928	330	Oct. 18, 1950	338
Aug. 8, 1928	310	Oct. 1, 1951	090
Aug. 12, 1928	321	Sept. 10, 1960	330
Sept. 27, 1929	315	Oct. 14, 1964	040
Sept. 7, 1930	047	Sept. 8, 1965	280
Aug. 29, 1932	296	June 9, 1966	346
July 30, 1933	270	Oct. 4, 1966	080
Sept. 1, 1933	284	June 4, 1968	030
Oct. 4, 1933	028	Oct. 18, 1968	053
Sept. 3, 1933	325	May 24, 1970	018
July 22, 1934	247		

Date	Avg. direction of movement within zone (degrees to)	Date	Avg. direction of movement within zone (degrees to)
ZONE B			
Sept. 7, 1900	292	Sept. 29, 1929	000
Aug. 12, 1901	325	Aug. 31, 1932	315
Oct. 9, 1902	020	Aug. 2, 1933	269
Sept. 12, 1903	350	July 23, 1934	270
Sept. 26, 1906	332	June 15, 1934	359
Aug. 10, 1911	318	Aug. 26, 1934	295
Sept. 11, 1912	315	Sept. 4, 1935	000
June 12, 1912	050	Nov. 7, 1935	075
Sept. 3, 1915	000	July 30, 1936	327
Sept. 28, 1915	355	Aug. 4, 1938	296
Oct. 17, 1916	005	Oct. 6, 1941	000
July 4, 1916	350	Aug. 18, 1942	304
Sept. 27, 1917	025	July 25, 1943	273
Aug. 6, 1918	328	Sept. 19, 1943	32
Nov. 12, 1919	280	Sept. 18, 1947	303
Sept. 21, 1920	350	Aug. 22, 1947	315
Sept. 29, 1920	060	Sept. 3, 1948	020
Oct. 15, 1923	010	Oct. 18, 1950	211
Sept. 13, 1924	035	Aug. 29, 1950	005
Sept. 19, 1926	308	Sept. 25, 1953	041
Aug. 24, 1926	000	Sept. 15, 1960	000
Aug. 9, 1928	310	Oct. 3, 1964	355
Aug. 13, 1928	344	Sept. 10, 1965	315
		Aug. 17, 1969	340
ZONE C			
Sept. 7, 1900	305	Aug. 17, 1936	236
June 24, 1902	005	June 26, 1936	318
July 20, 1909	276	Aug. 14, 1938	340
Aug. 27, 1909	292	Aug. 27, 1938	270
Sept. 13, 1910	000	Aug. 6, 1938	307
June 11, 1912	018	Sept. 22, 1941	346
Oct. 15, 1912	319	Aug. 20, 1942	299
June 27, 1913	295	Aug. 29, 1942	313
Aug. 16, 1915	345	July 26, 1943	302
Aug. 18, 1916	290	Sept. 15, 1943	025
Aug. 6, 1918	325	Aug. 24, 1945	000
Nov. 13, 1919	270	Oct. 22, 1947	308
Sept. 6, 1921	320	Oct. 3, 1949	000
June 20, 1921	346	June 24, 1954	316
June 15, 1922	305	Sept. 4, 1955	280
June 28, 1929	320	June 27, 1957	003
Aug. 12, 1932	329	Sept. 11, 1961	330
Aug. 3, 1933	255	Sept. 20, 1967	332
July 6, 1933	240	Aug. 3, 1970	295
Sept. 3, 1933	278	Sept. 11, 1970	270
July 24, 1934	270	Sept. 16, 1971	037
Aug. 26, 1934	212	Sept. 10, 1971	260

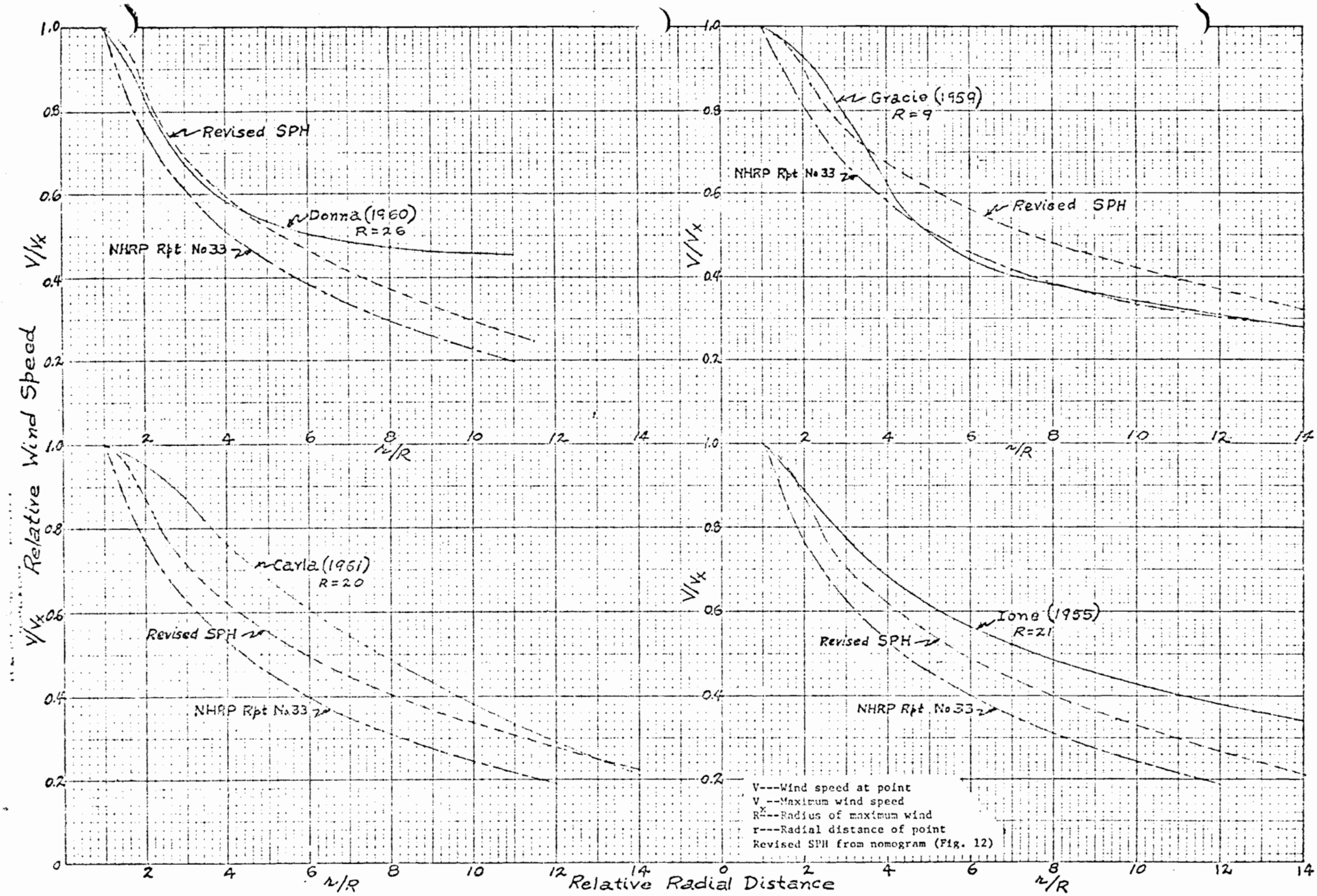


Fig. 1. COMPARISON OF WIND PROFILES IN HURRICANES

10 X 10 TO THE ½ INCH 359-11G
KEUFFEL & ESSER CO. MADE IN U.S.A.

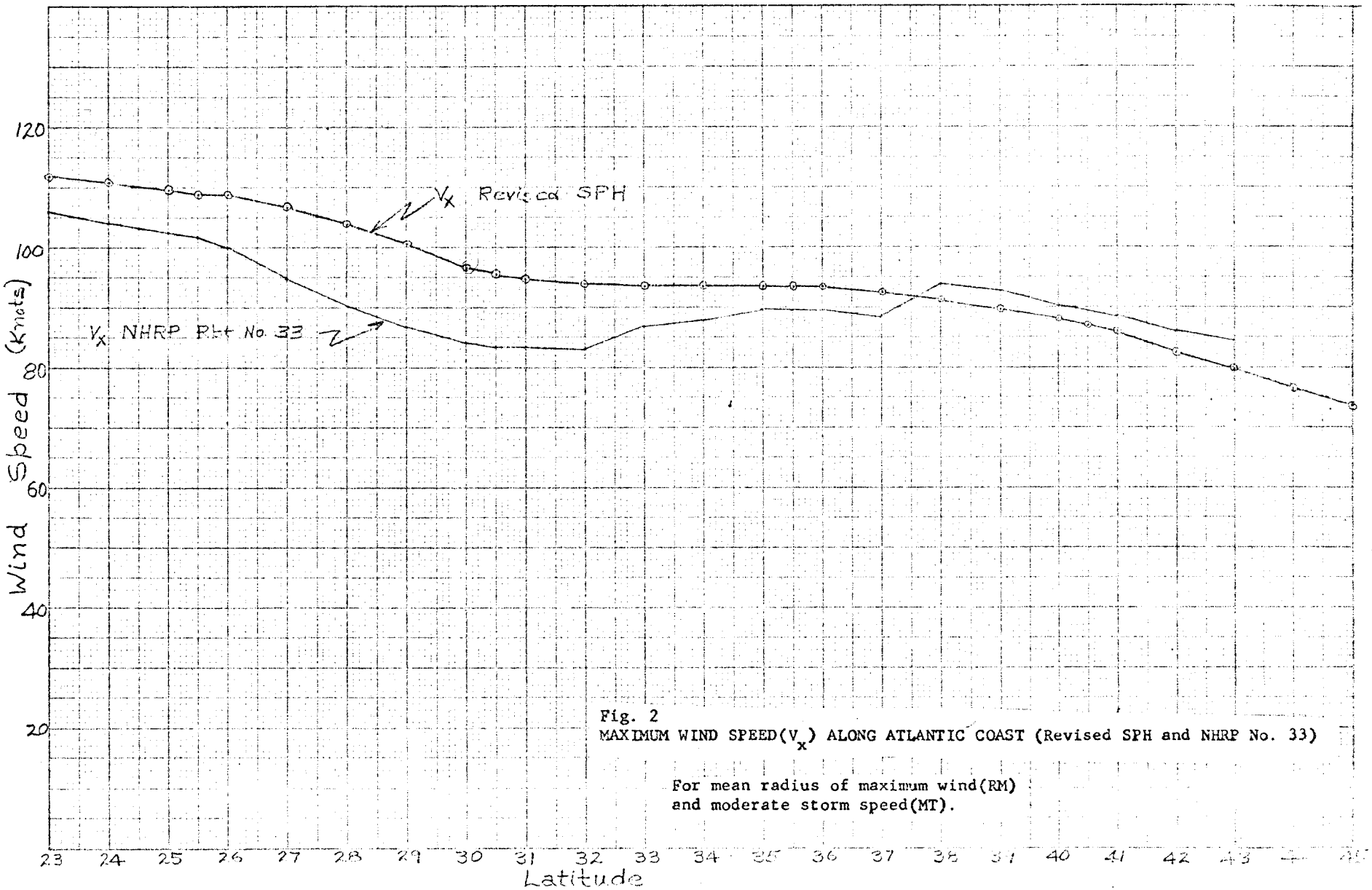


Fig. 2
MAXIMUM WIND SPEED(V_x) ALONG ATLANTIC COAST (Revised SPH and NHRP No. 33)

For mean radius of maximum wind(RM)
and moderate storm speed(MT).

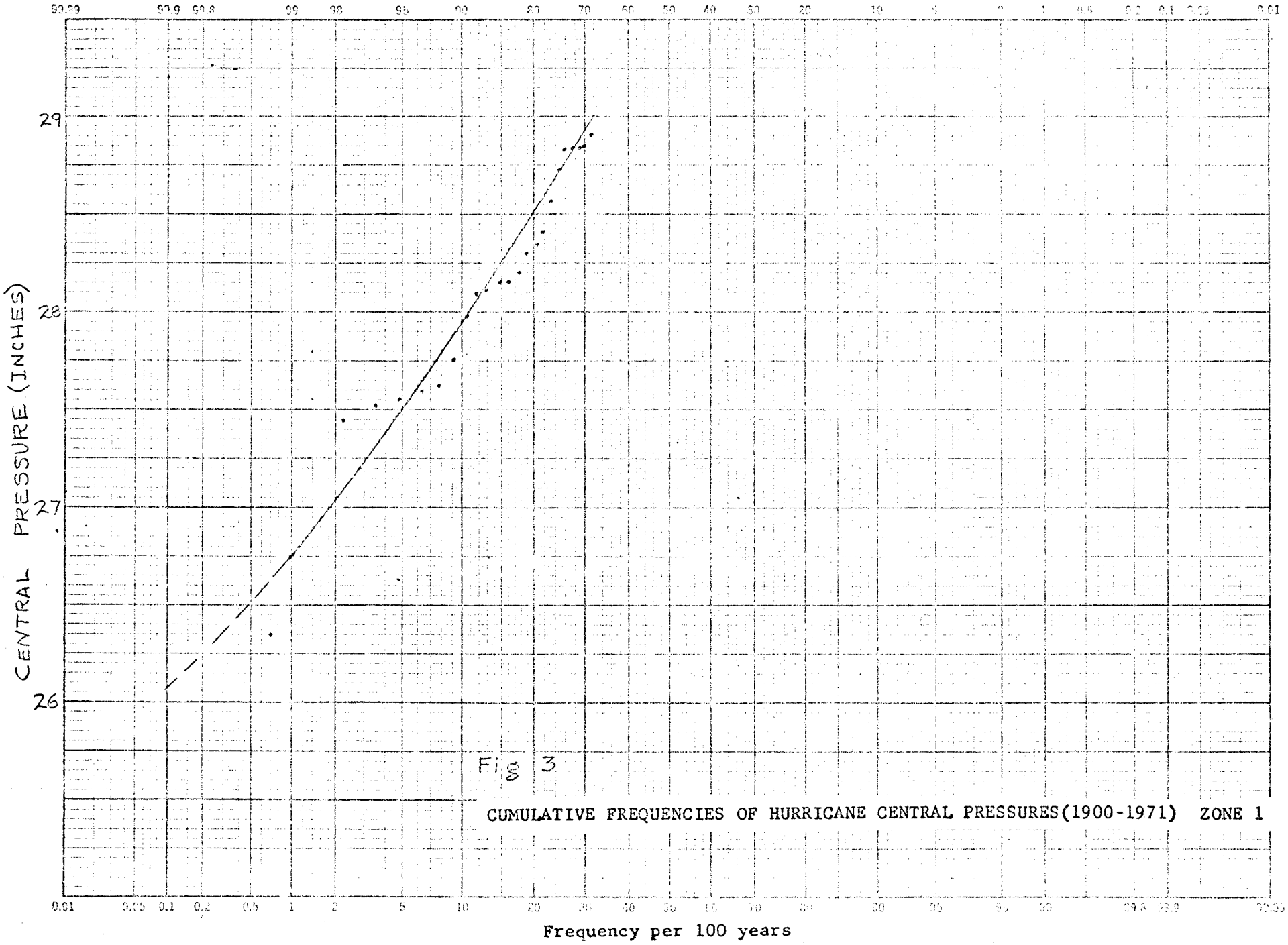


Fig 3

CUMULATIVE FREQUENCIES OF HURRICANE CENTRAL PRESSURES(1900-1971) ZONE 1

PROBABILITY 46 8000
X 90 DIVISIONS
KEUFFEL & ESSER CO.

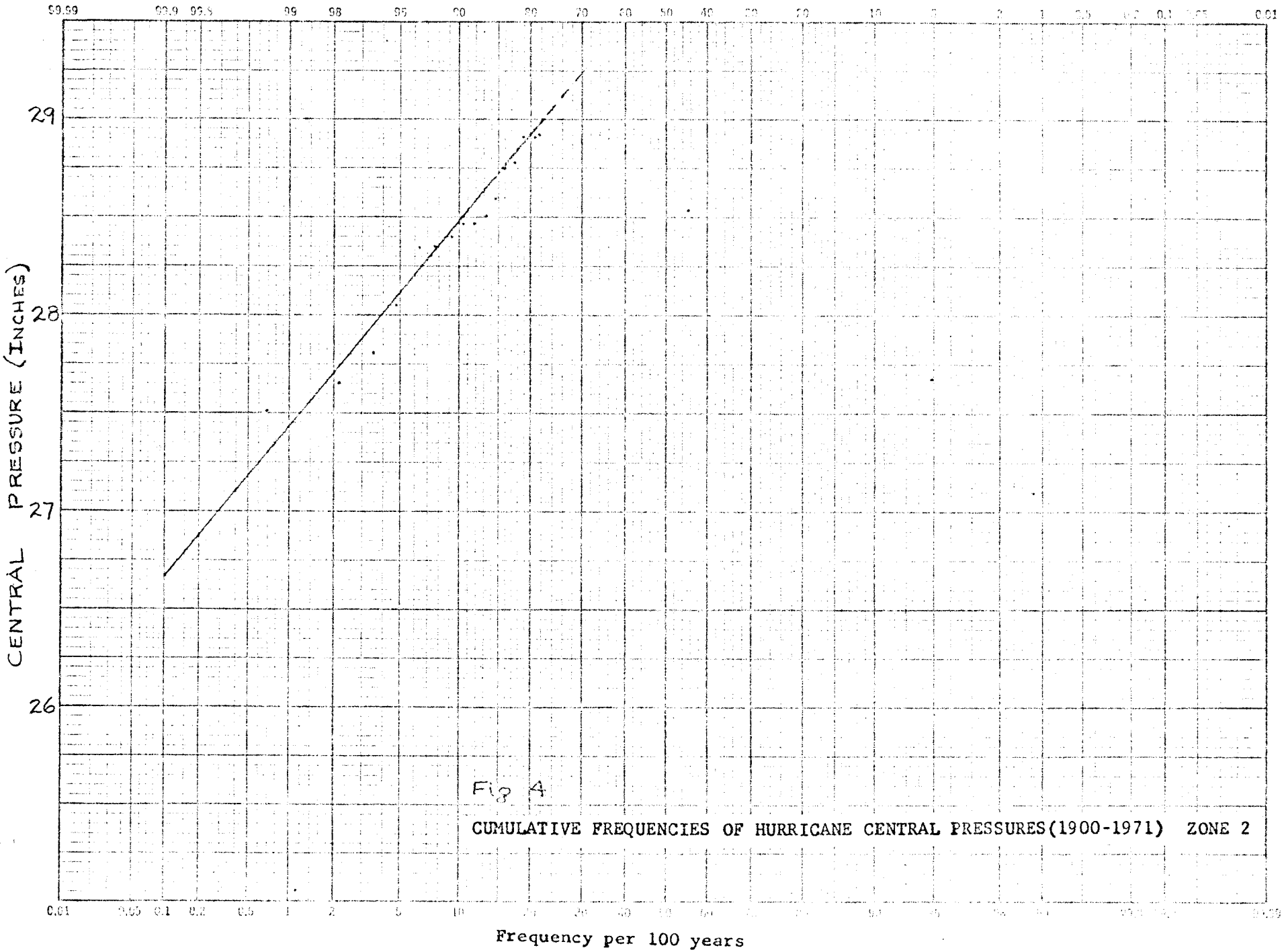


Fig 4

CUMULATIVE FREQUENCIES OF HURRICANE CENTRAL PRESSURES(1900-1971) ZONE 2

PROBABILITY 46 3000
X 90 DIVISIONS
KEUFFEL & ESSER CO.

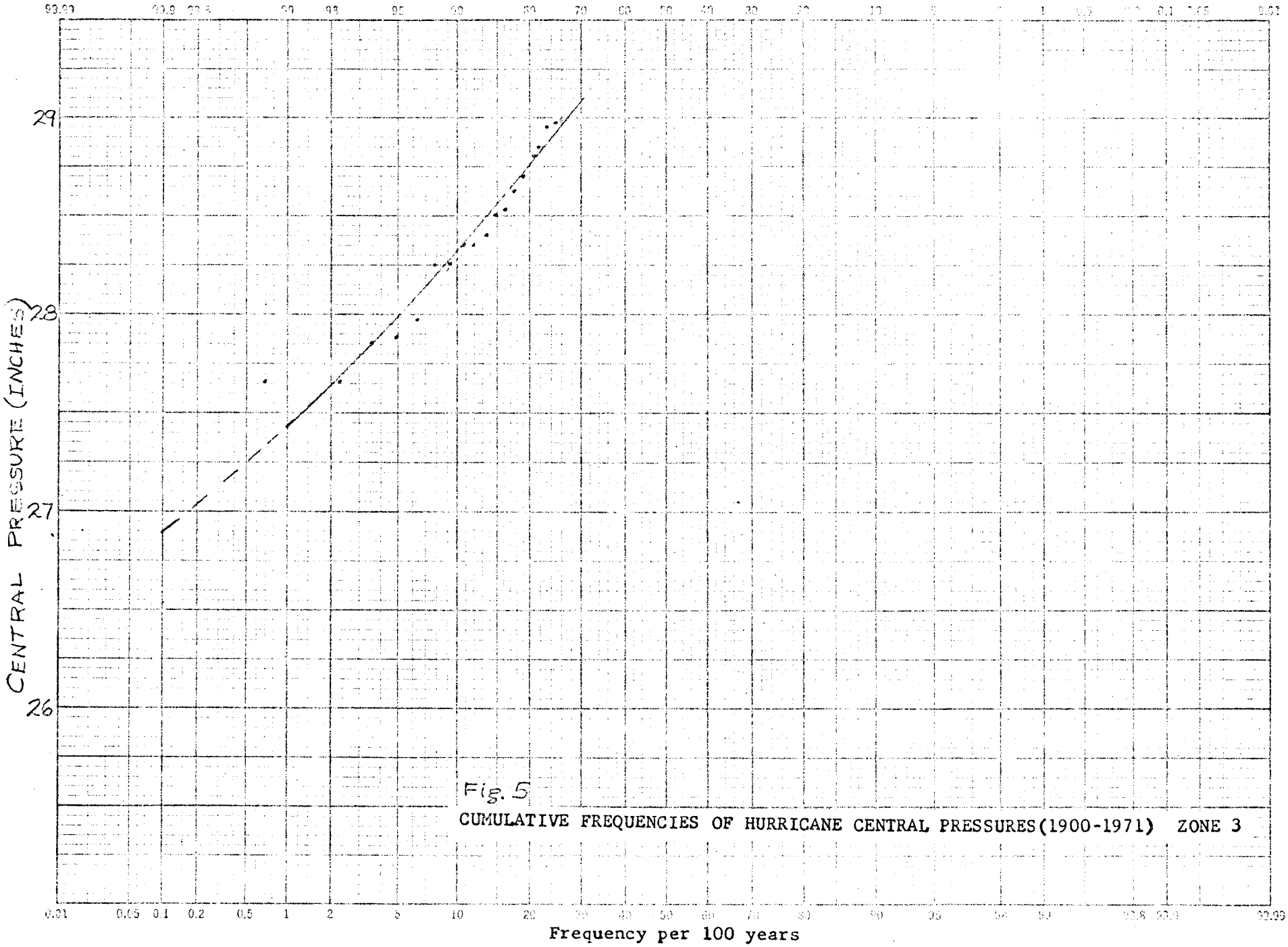


Fig. 5

CUMULATIVE FREQUENCIES OF HURRICANE CENTRAL PRESSURES (1900-1971) ZONE 3

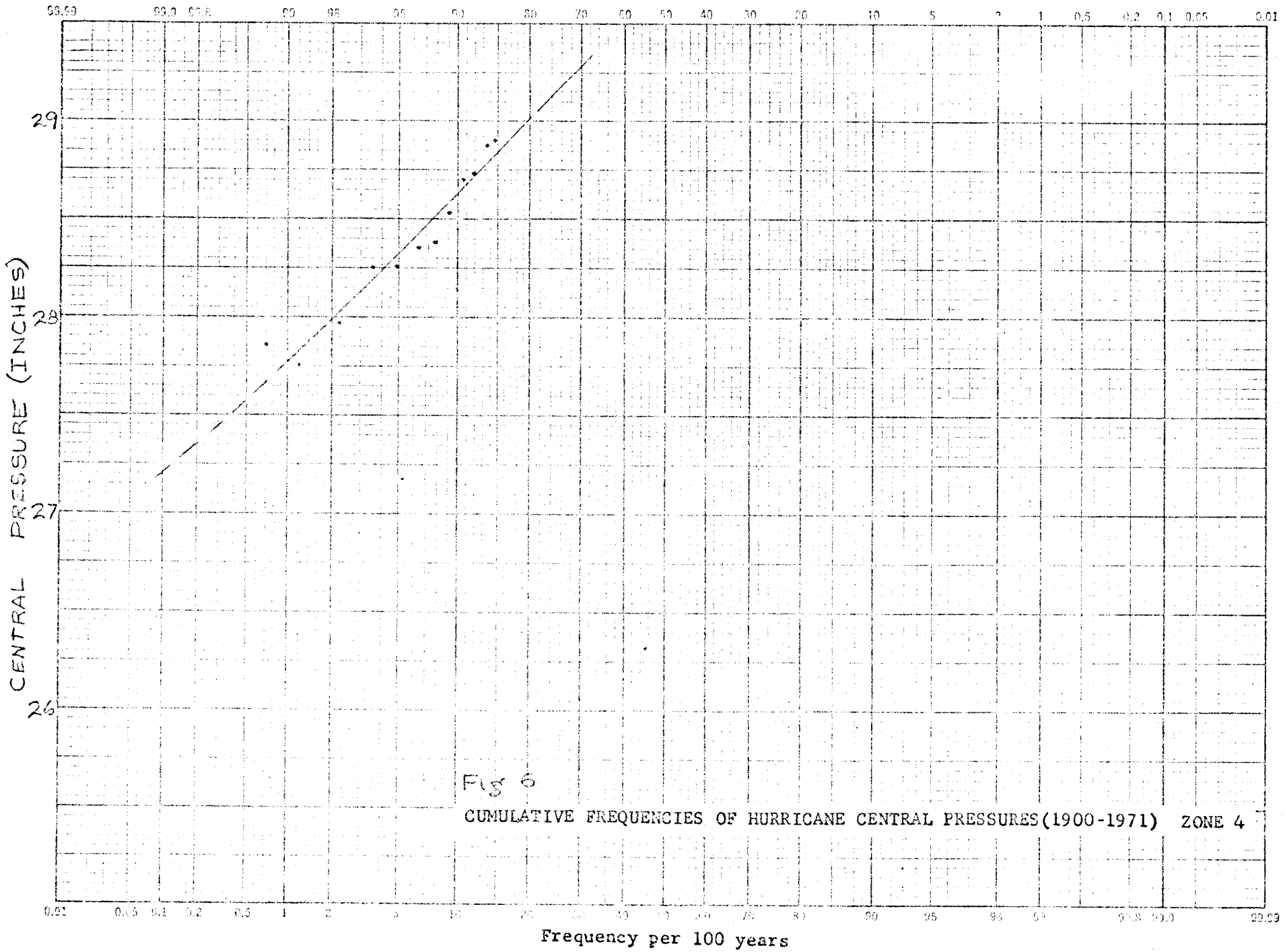


Fig 6

CUMULATIVE FREQUENCIES OF HURRICANE CENTRAL PRESSURES(1900-1971) ZONE 4

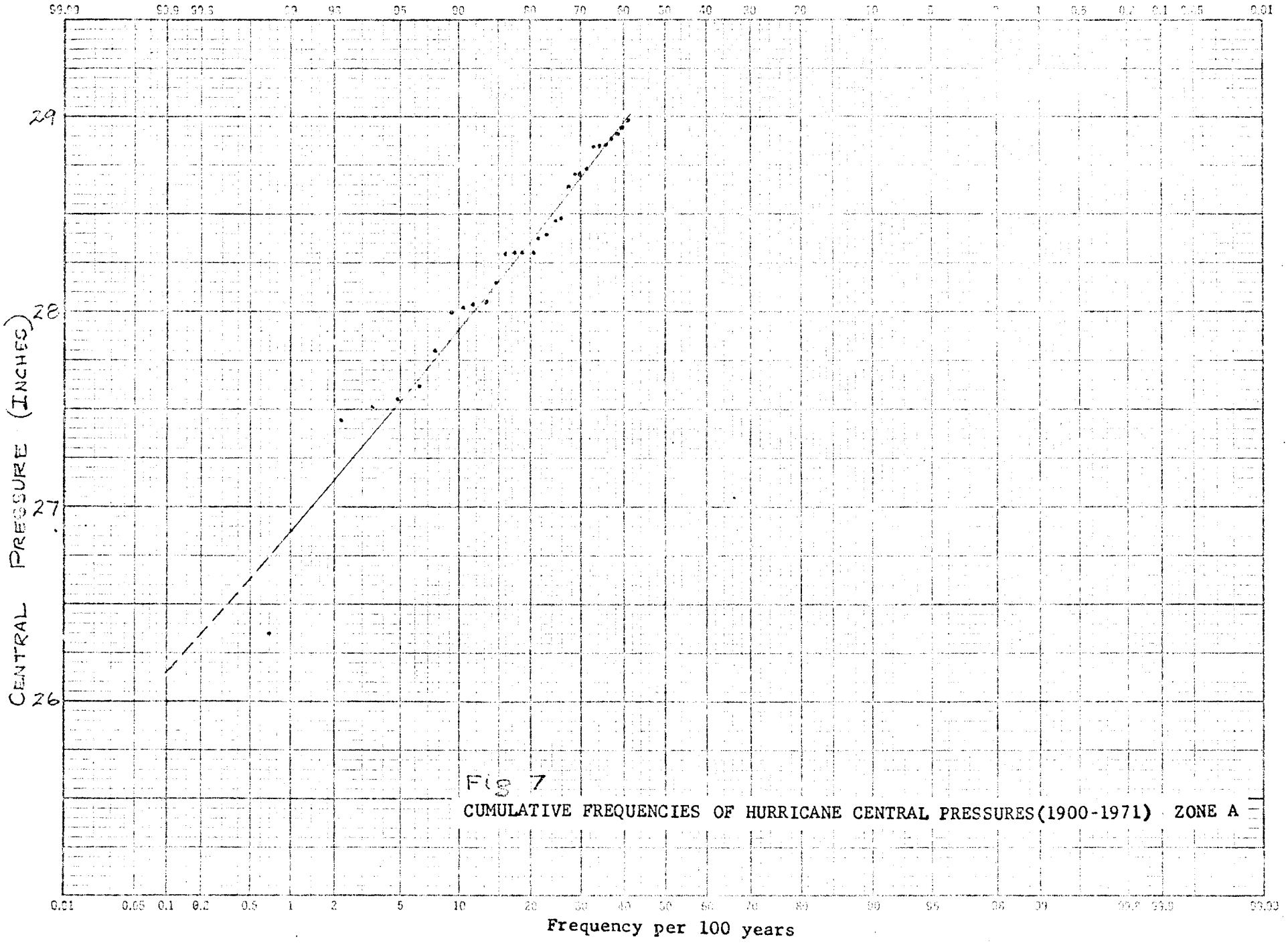


FIG 7

CUMULATIVE FREQUENCIES OF HURRICANE CENTRAL PRESSURES (1900-1971) ZONE A

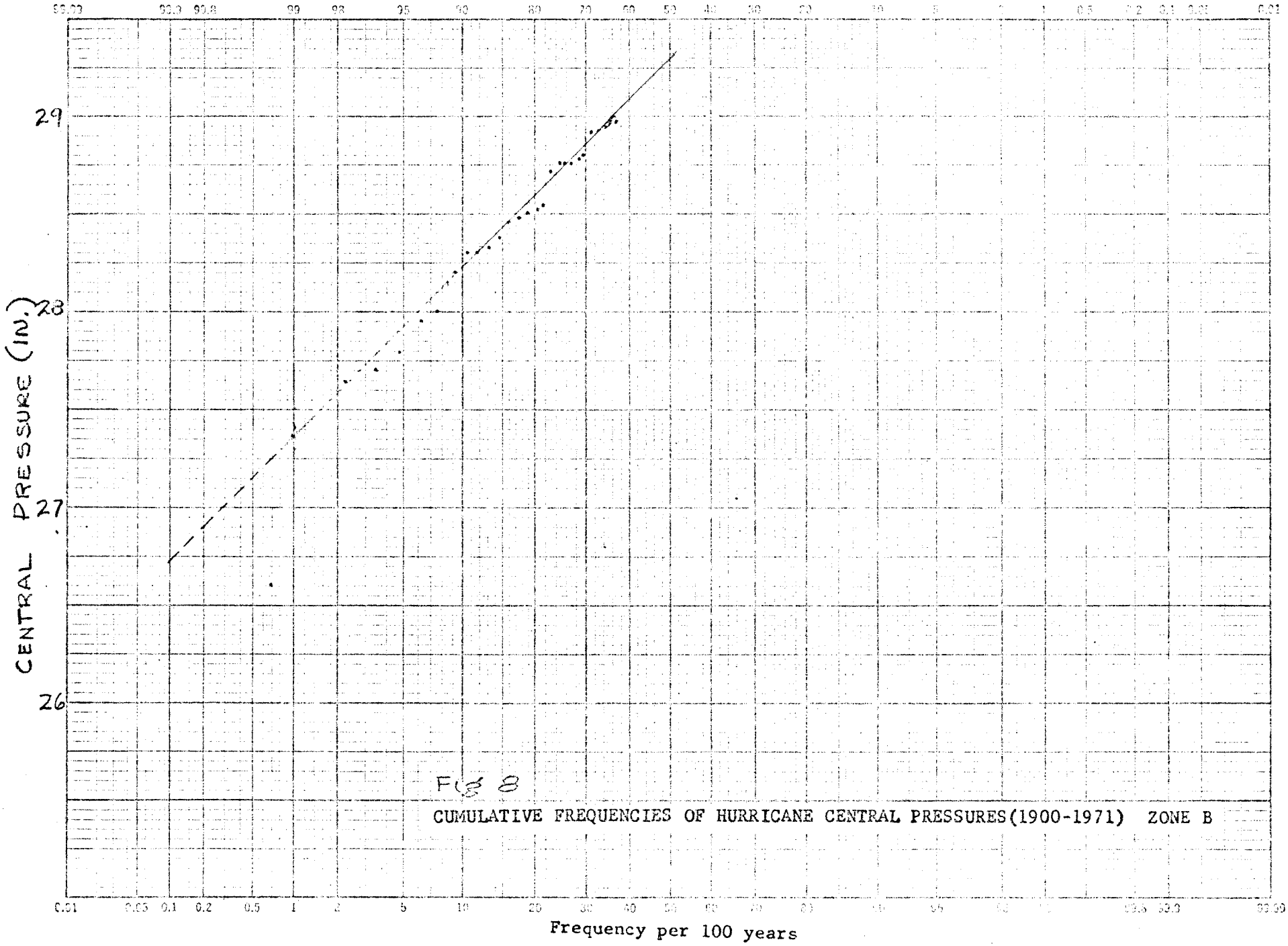


FIG 8

CUMULATIVE FREQUENCIES OF HURRICANE CENTRAL PRESSURES(1900-1971) ZONE B

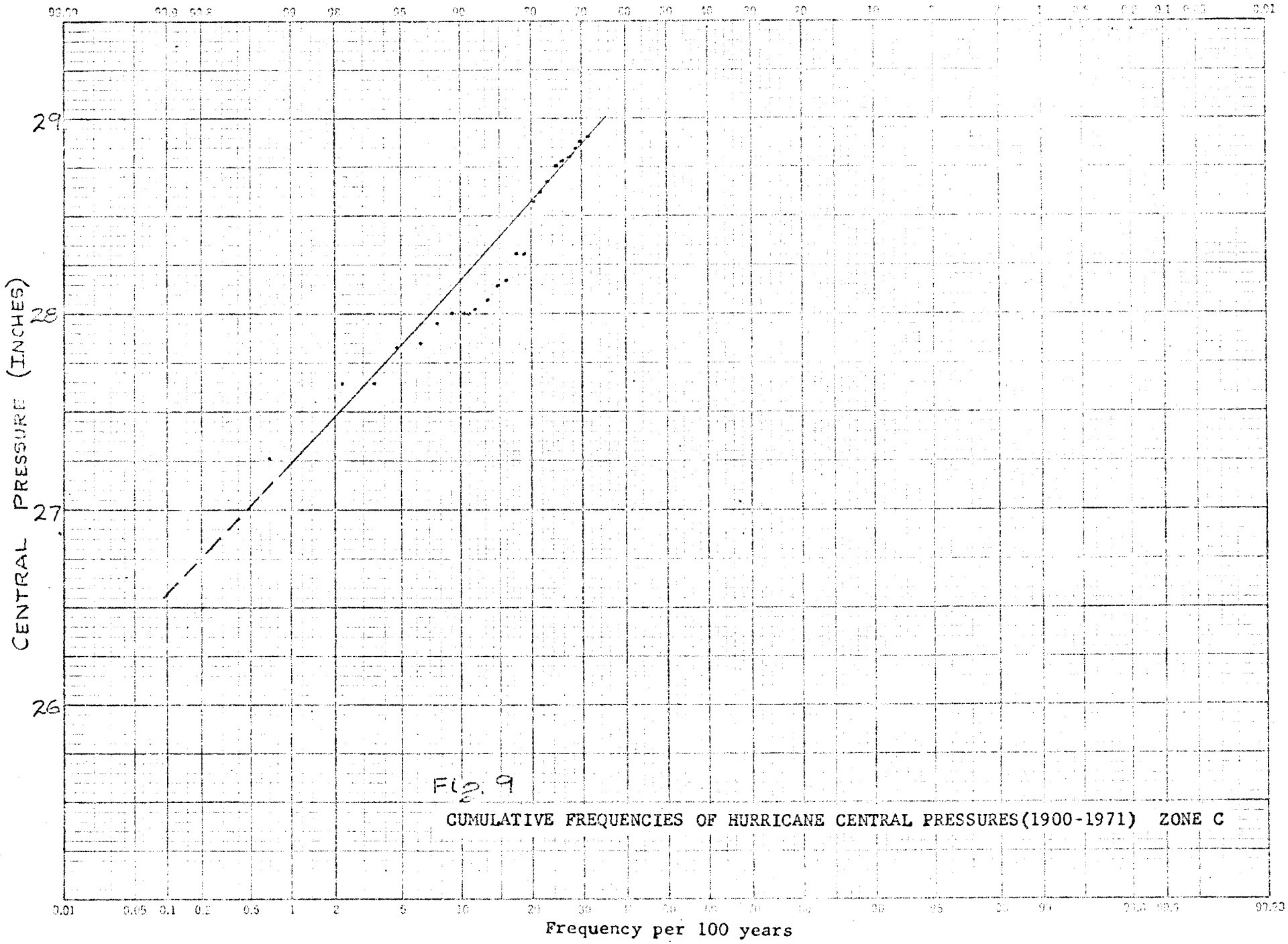


Fig. 9

CUMULATIVE FREQUENCIES OF HURRICANE CENTRAL PRESSURES (1900-1971) ZONE C

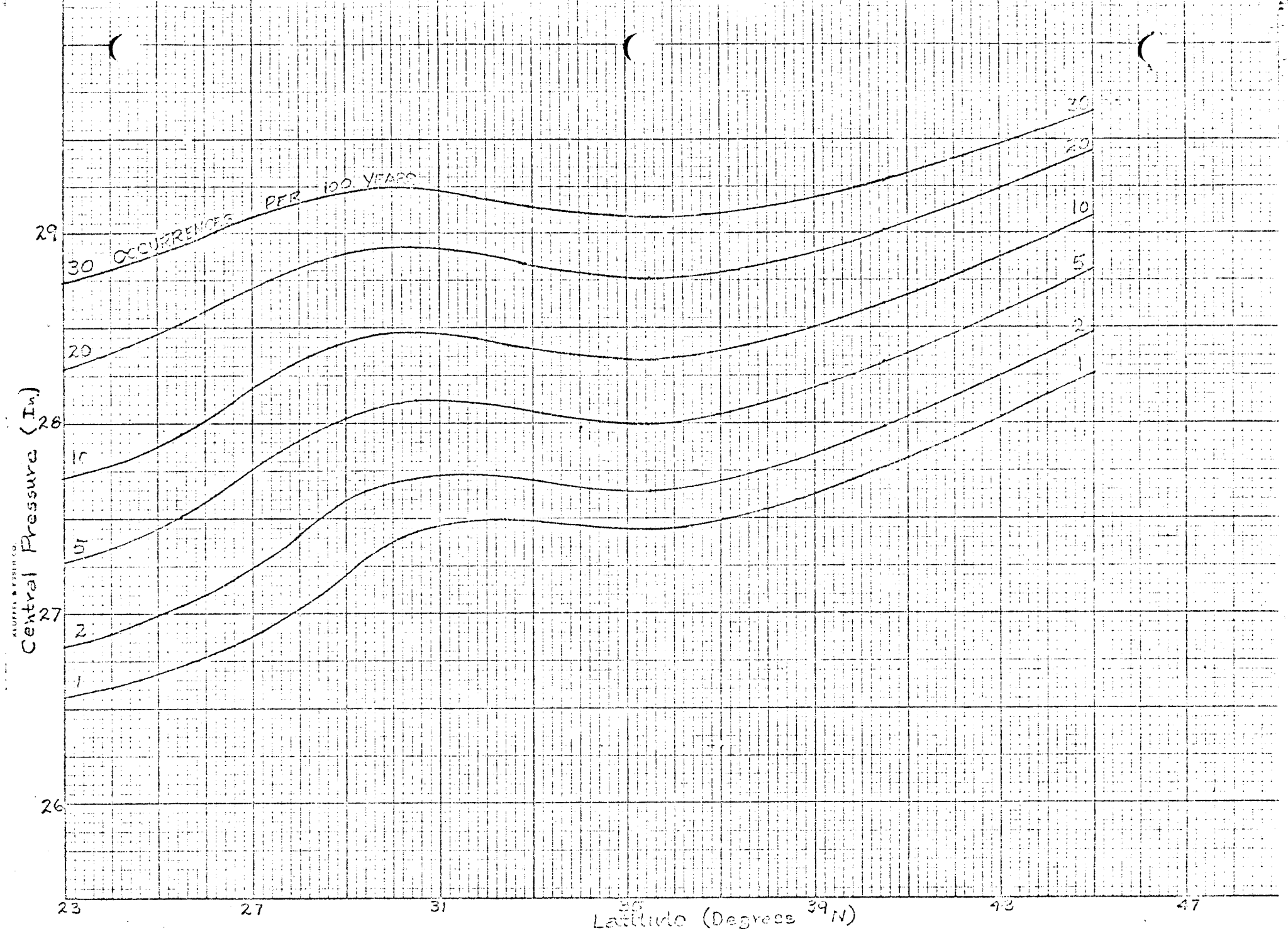


Fig. 10. LATITUDINAL VARIATION OF AVERAGE FREQUENCY PER 100 YEARS OF CPI, ATLANTIC COAST ZONES

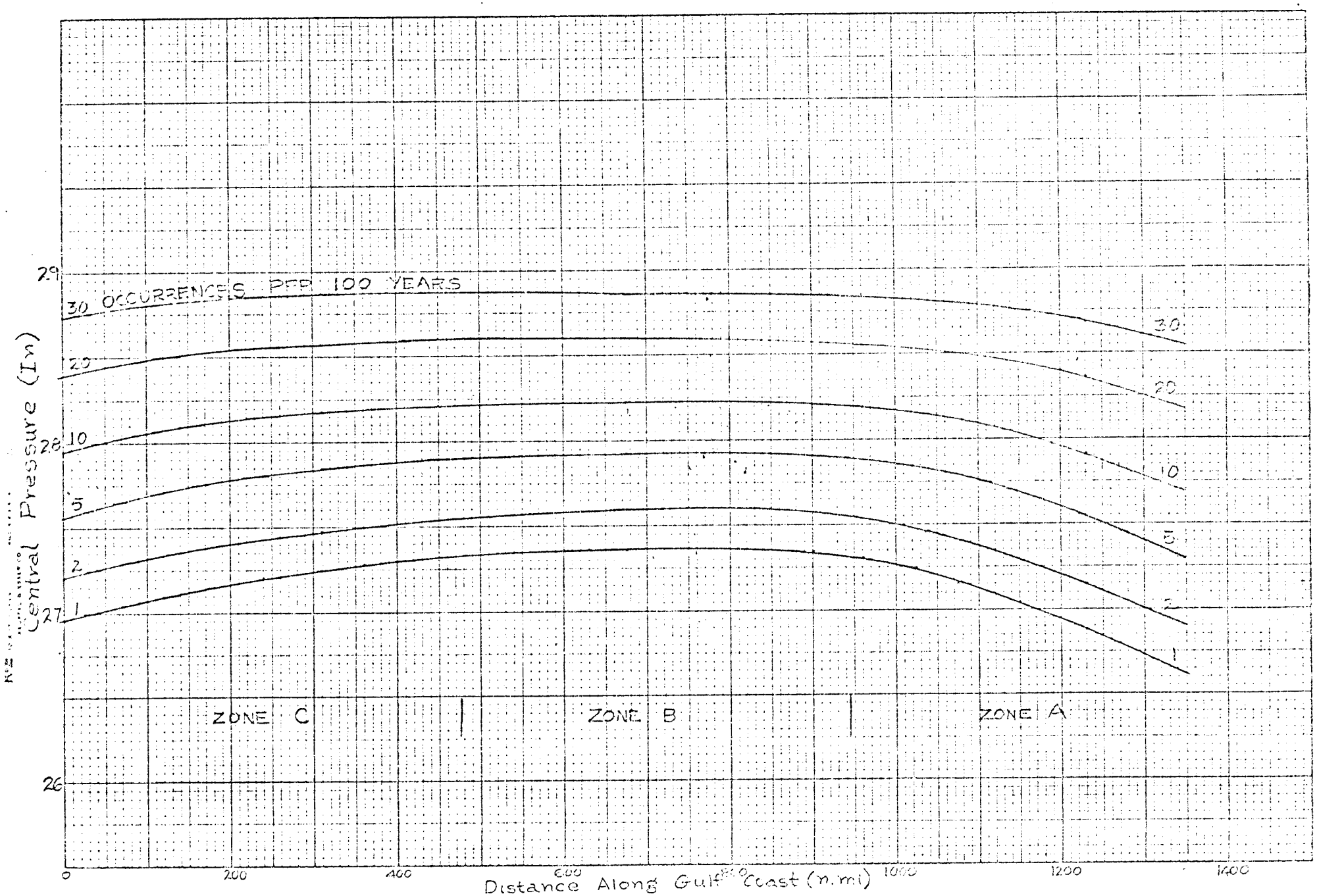


Fig. 11. GEOGRAPHICAL VARIATION OF AVERAGE FREQUENCY PER 100 YEARS OF CPI, GULF COAST ZONES

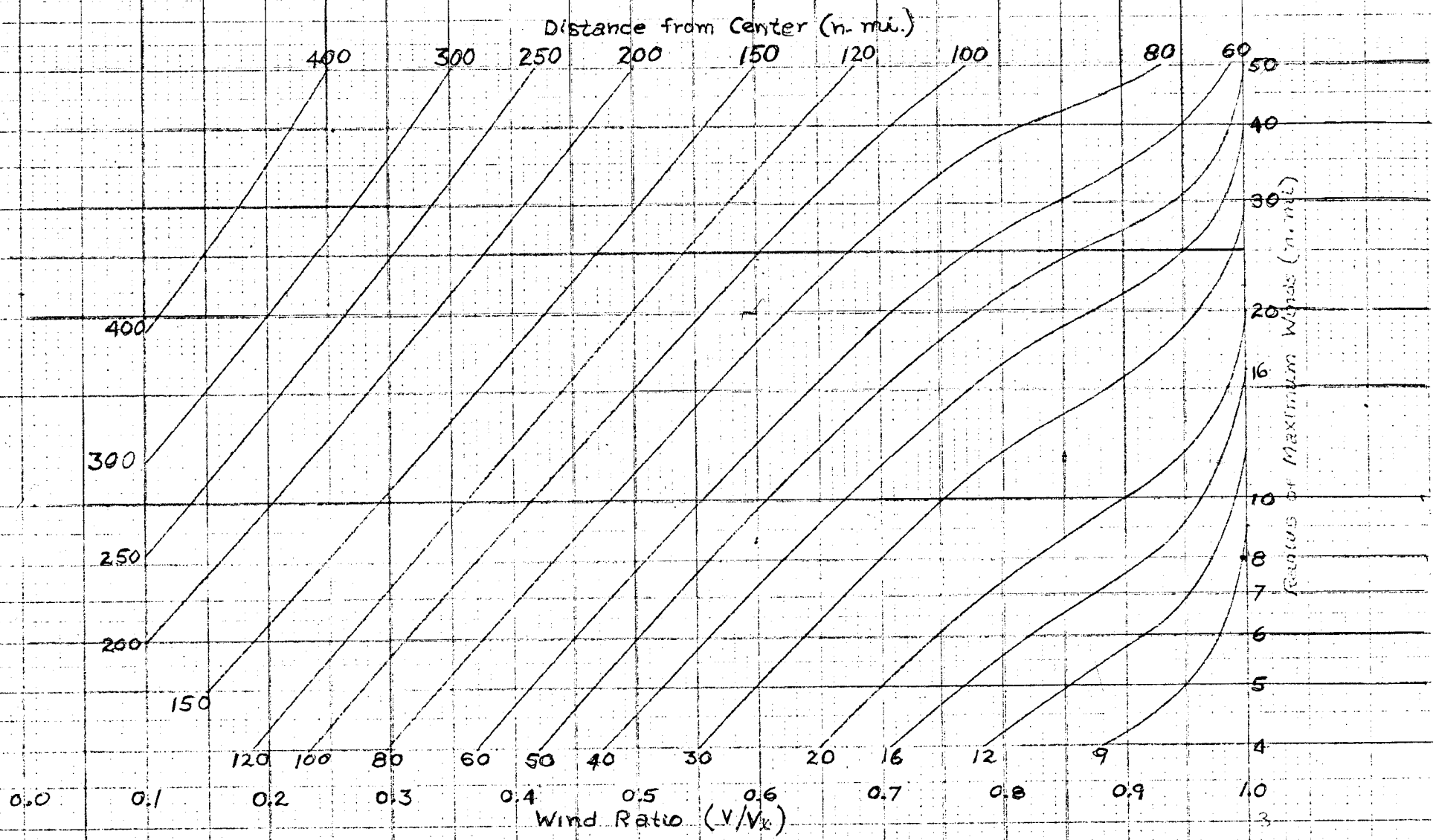


Fig. 12

NOMOGRAM FOR DETERMINING WIND PROFILE

10 X 10 TO THE ½ INCH 359-11G
KEUFFEL & ESSER CO. MADE IN U.S.A.

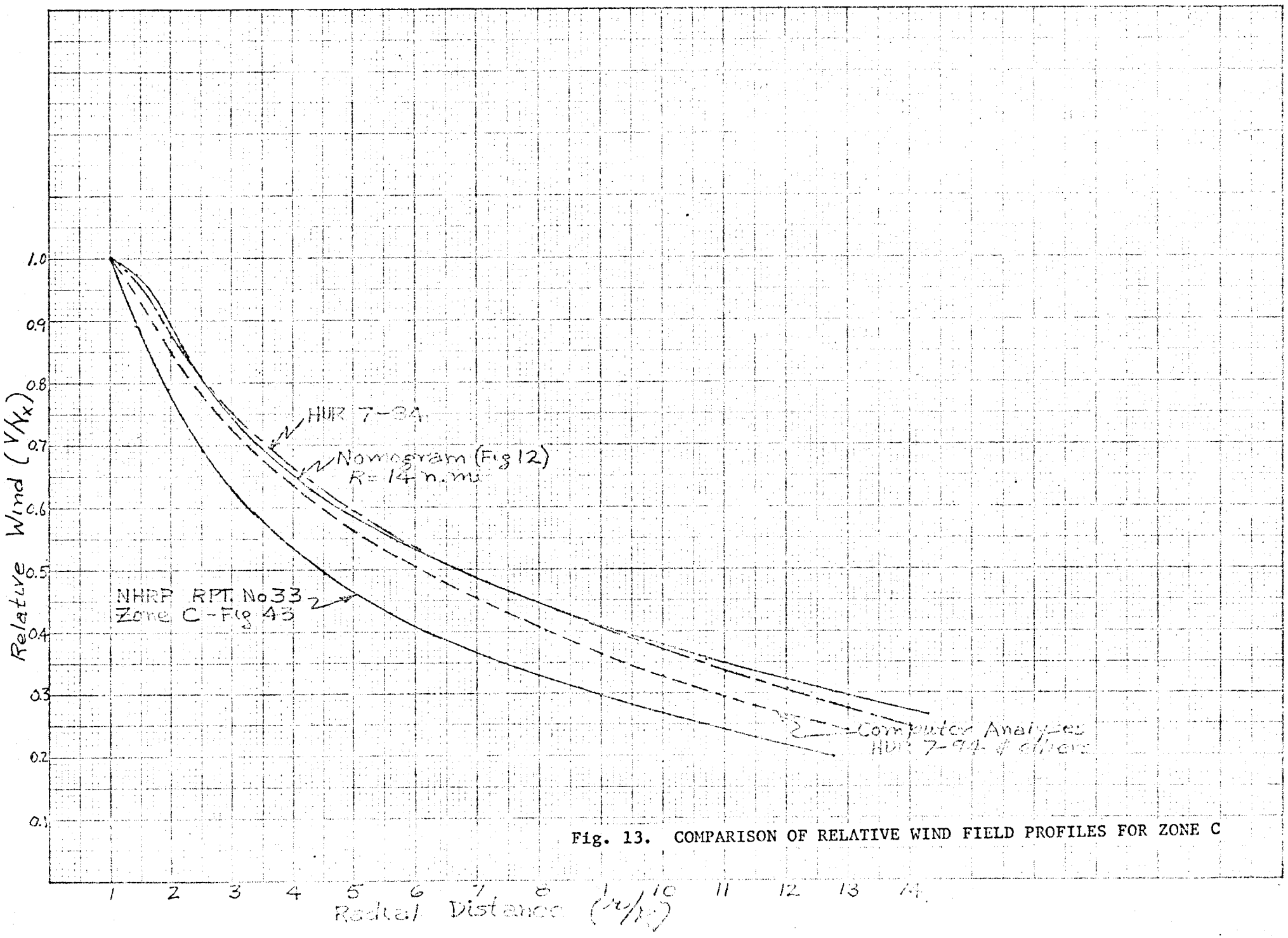


Fig. 13. COMPARISON OF RELATIVE WIND FIELD PROFILES FOR ZONE C

10 X 10 TO THE INCH 46 0730
7 X 10 INCHES
KEUFFEL & ESSER CO.

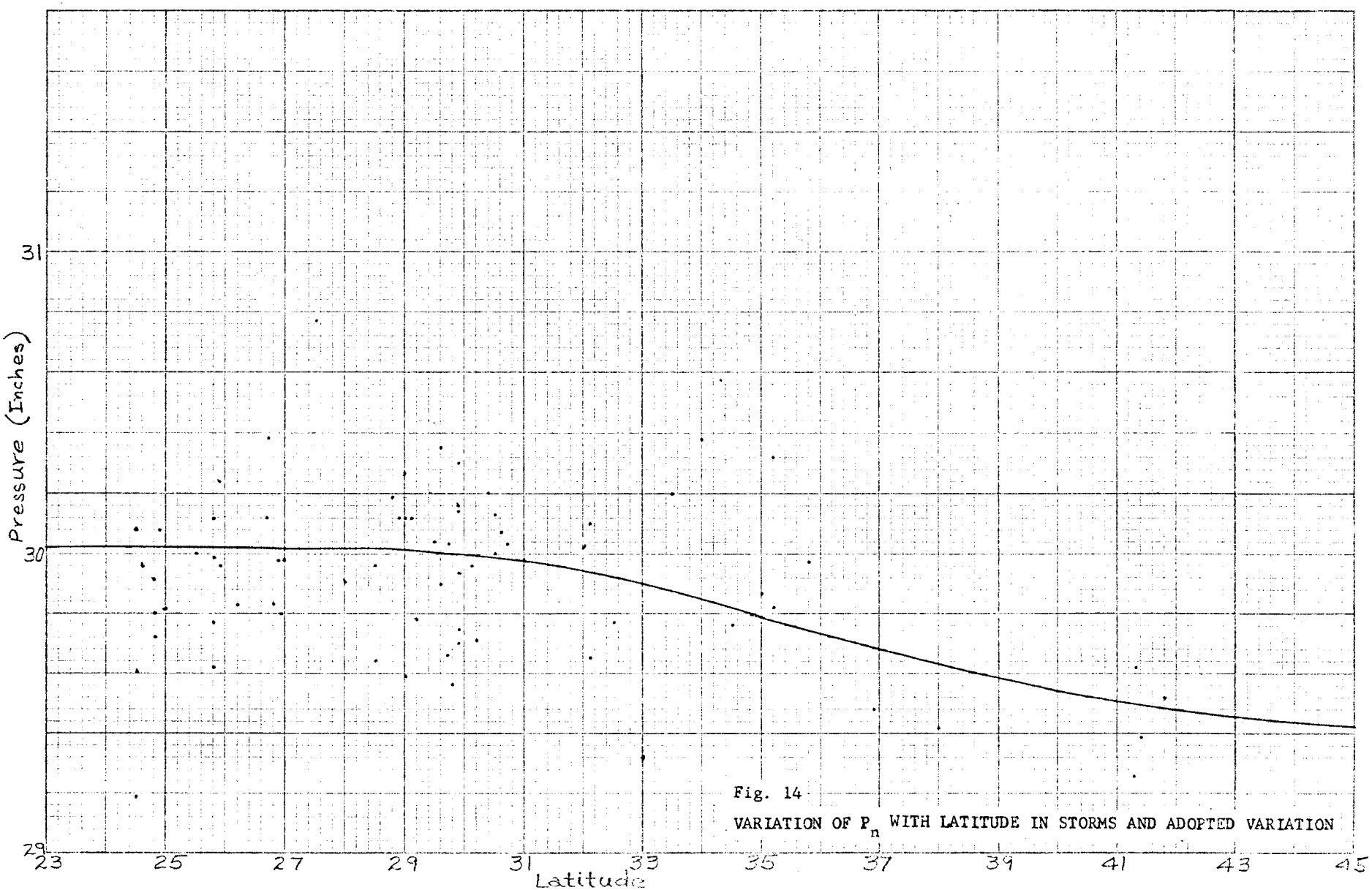
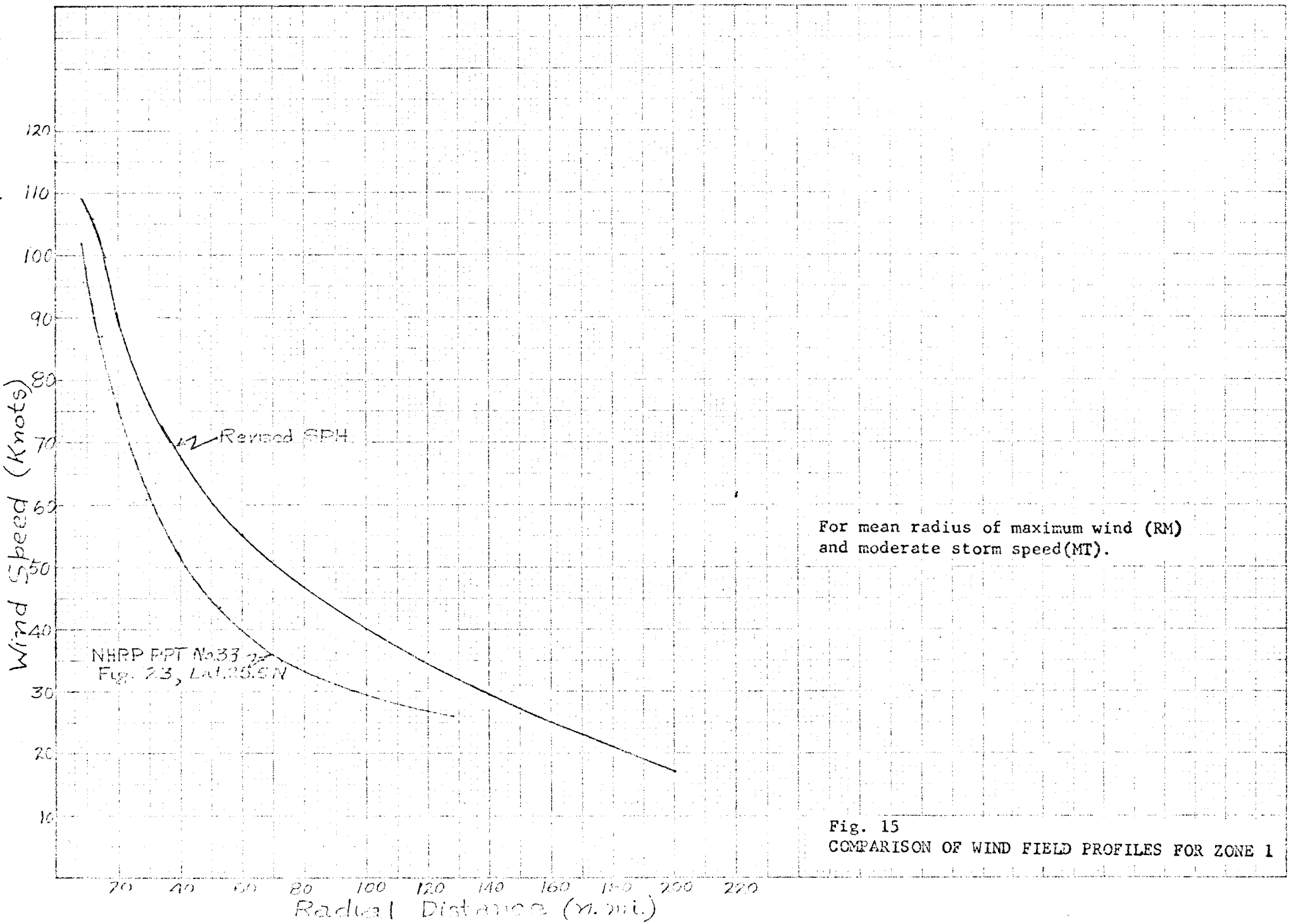


Fig. 14

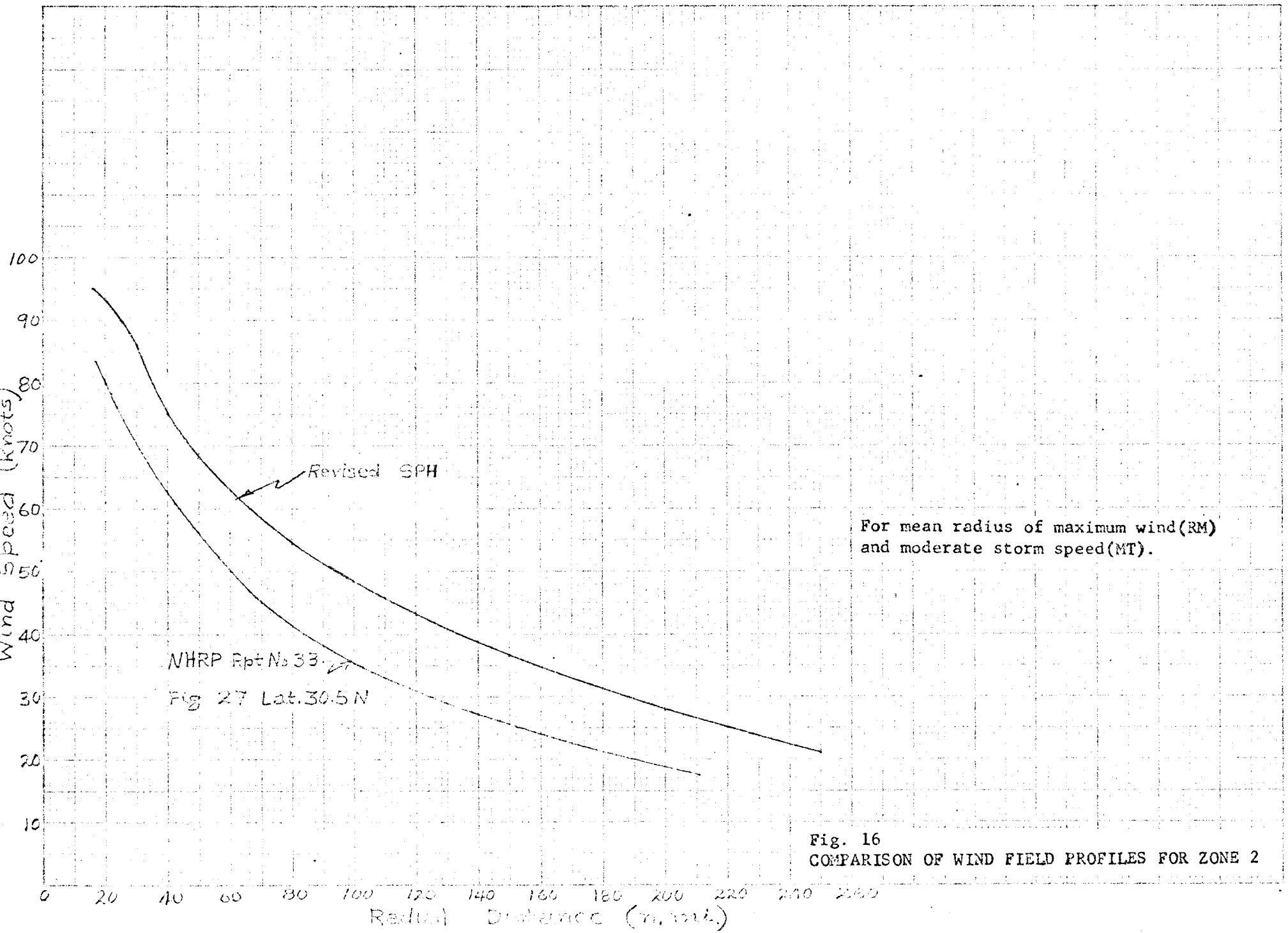
VARIATION OF P_n WITH LATITUDE IN STORMS AND ADOPTED VARIATION



For mean radius of maximum wind (RM) and moderate storm speed(MT).

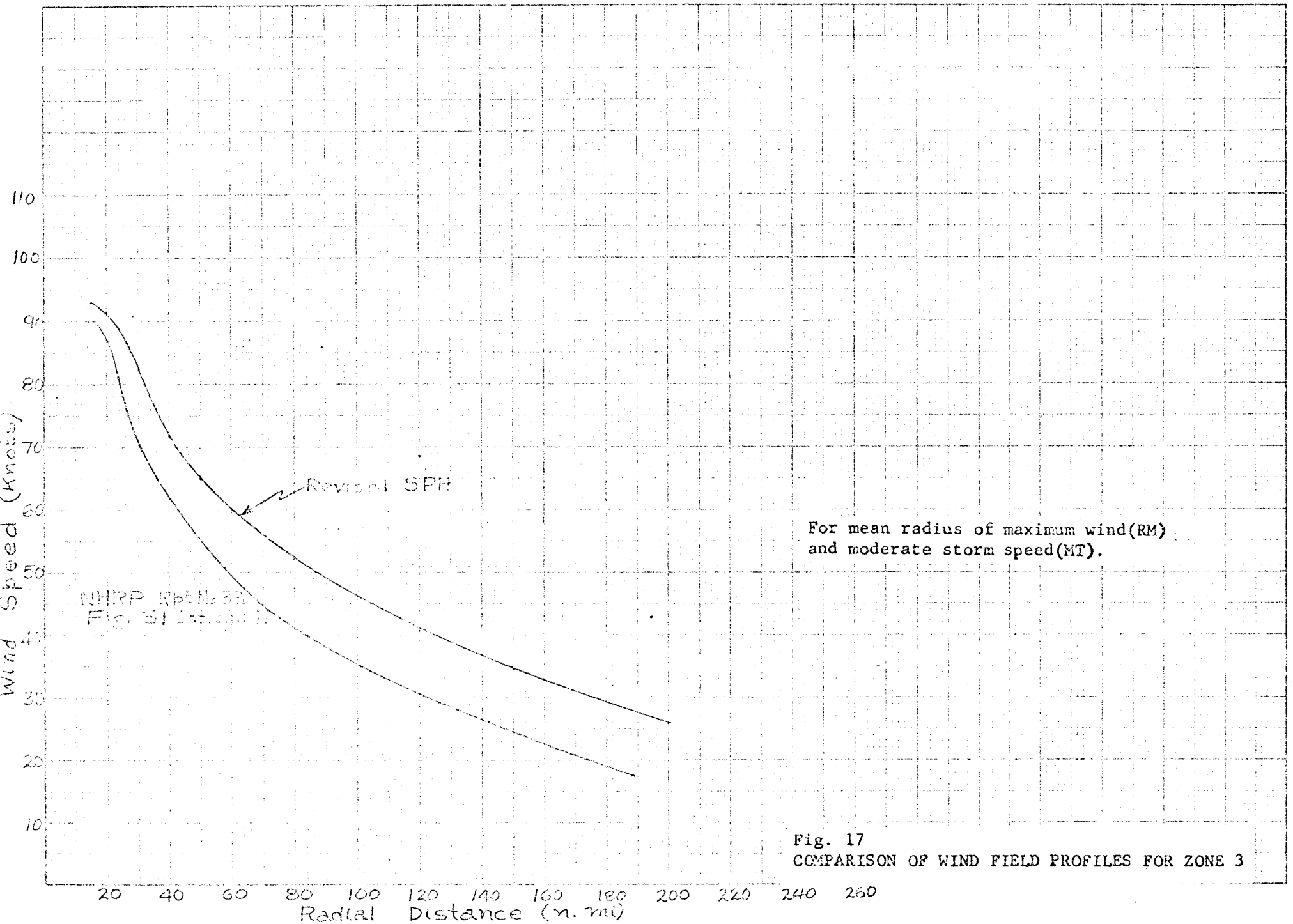
Fig. 15
COMPARISON OF WIND FIELD PROFILES FOR ZONE 1

10 X 10 TO 1/2 INCH 46 1320



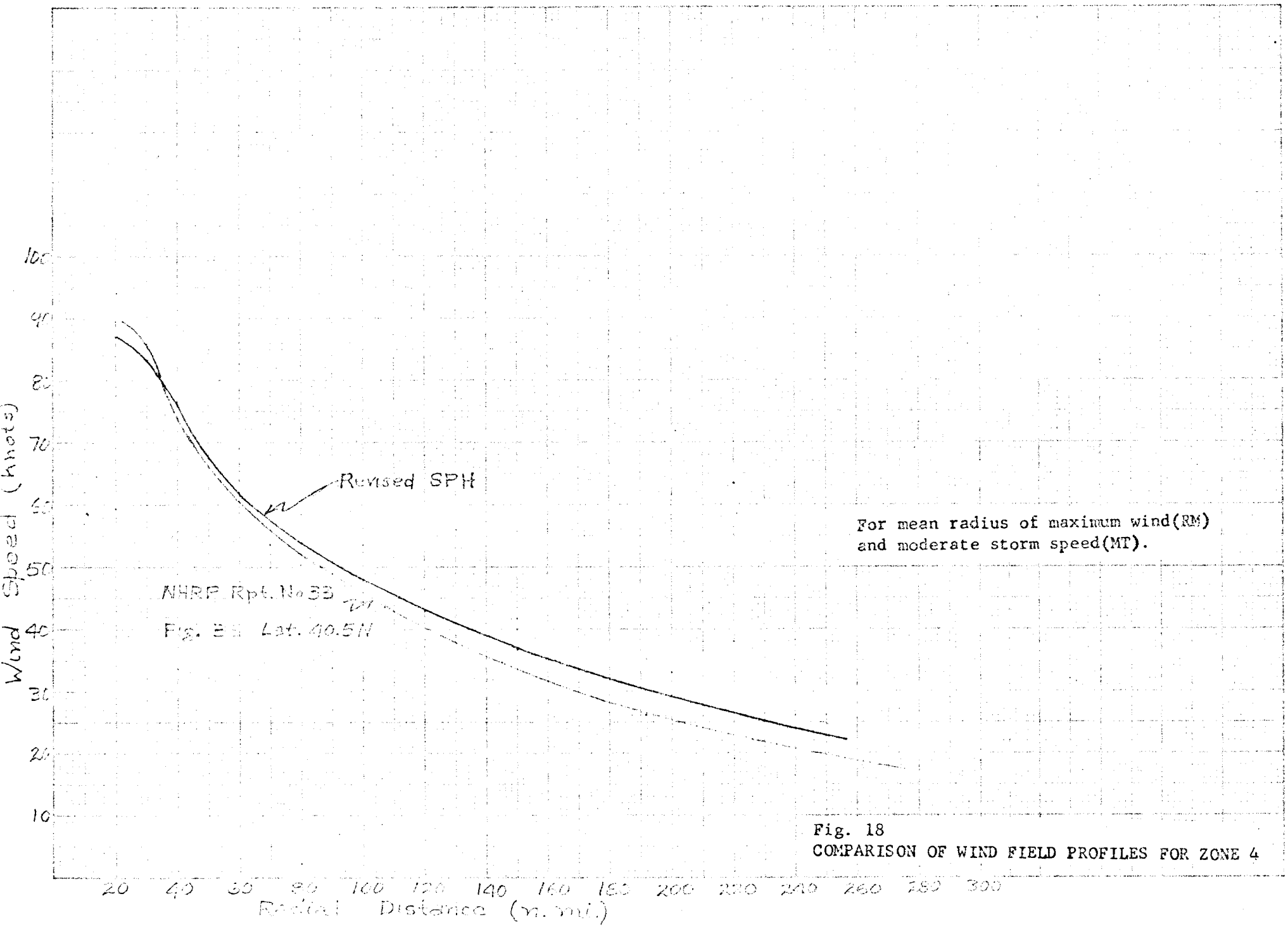
For mean radius of maximum wind(RM) and moderate storm speed(MT).

Fig. 16
COMPARISON OF WIND FIELD PROFILES FOR ZONE 2



For mean radius of maximum wind(RM) and moderate storm speed(MT).

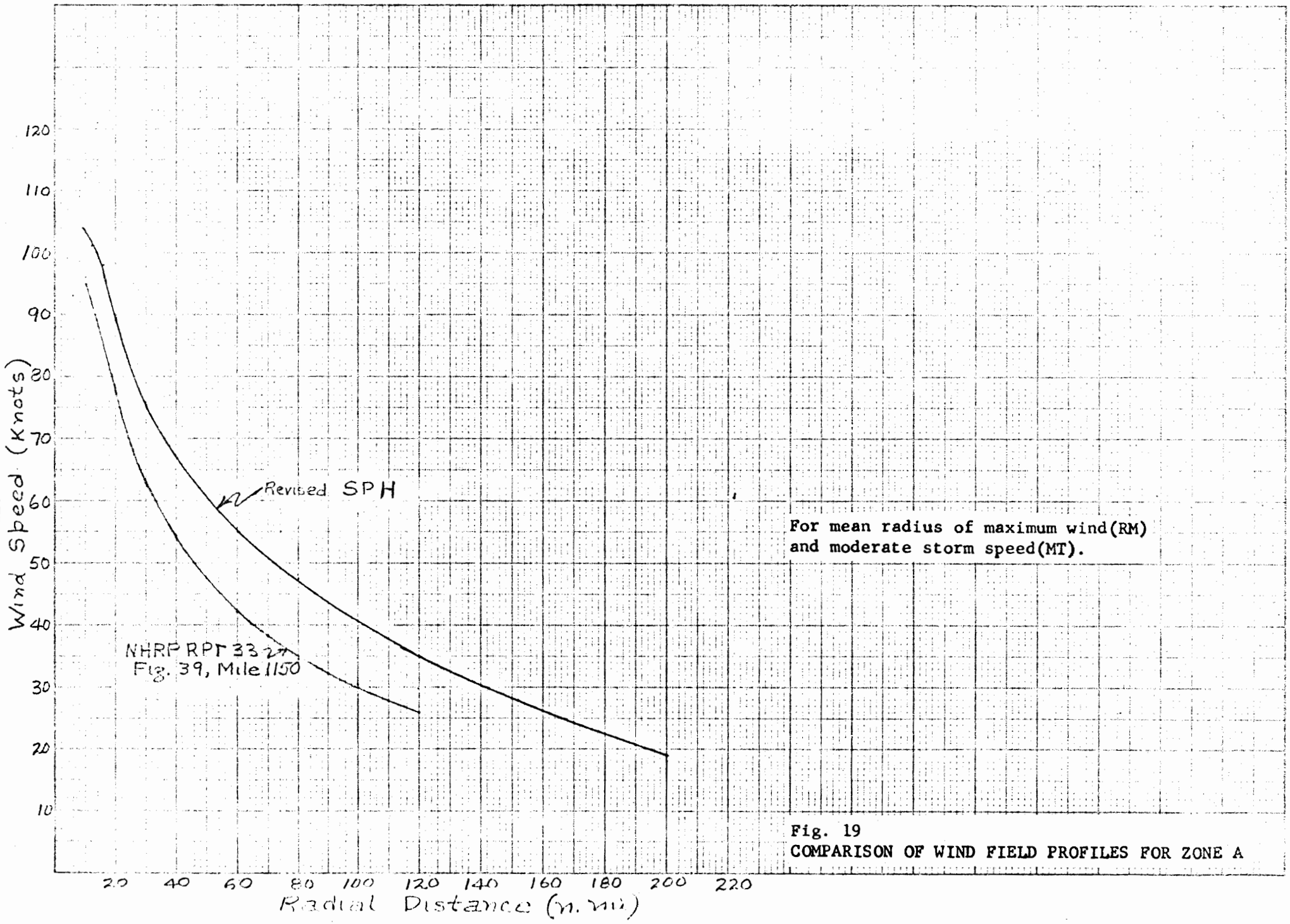
Fig. 17
COMPARISON OF WIND FIELD PROFILES FOR ZONE 3



For mean radius of maximum wind(RM) and moderate storm speed(MT).

Fig. 18
COMPARISON OF WIND FIELD PROFILES FOR ZONE 4

K&E 10 X 10 TO ½ INCH 46 1320
KEUFFEL & ESSER CO.



For mean radius of maximum wind(RM) and moderate storm speed(MT).

Fig. 19
COMPARISON OF WIND FIELD PROFILES FOR ZONE A

10 X 10 TO ½ INCH 46 1320
KEUFFEL & ESSER CO.

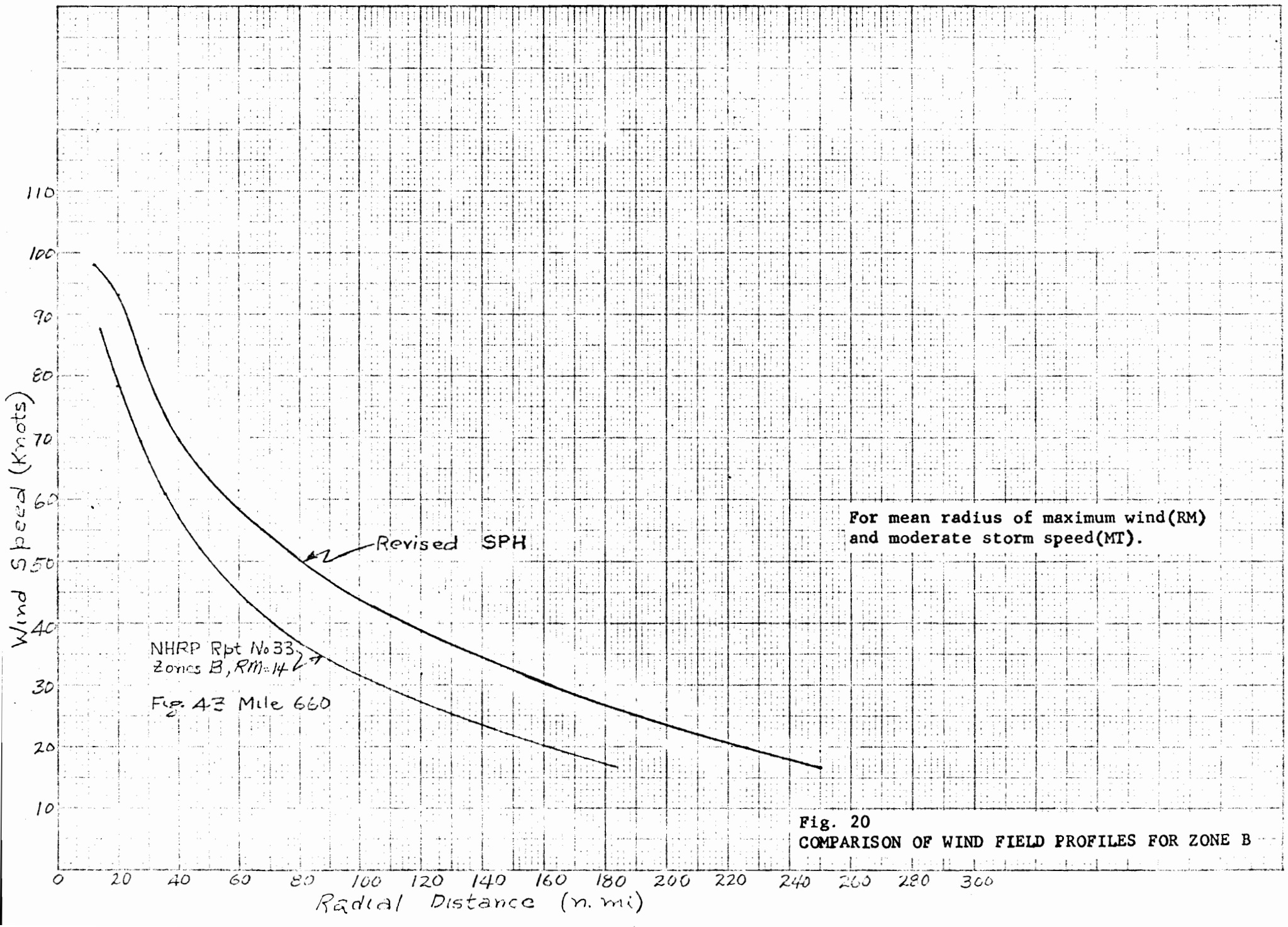
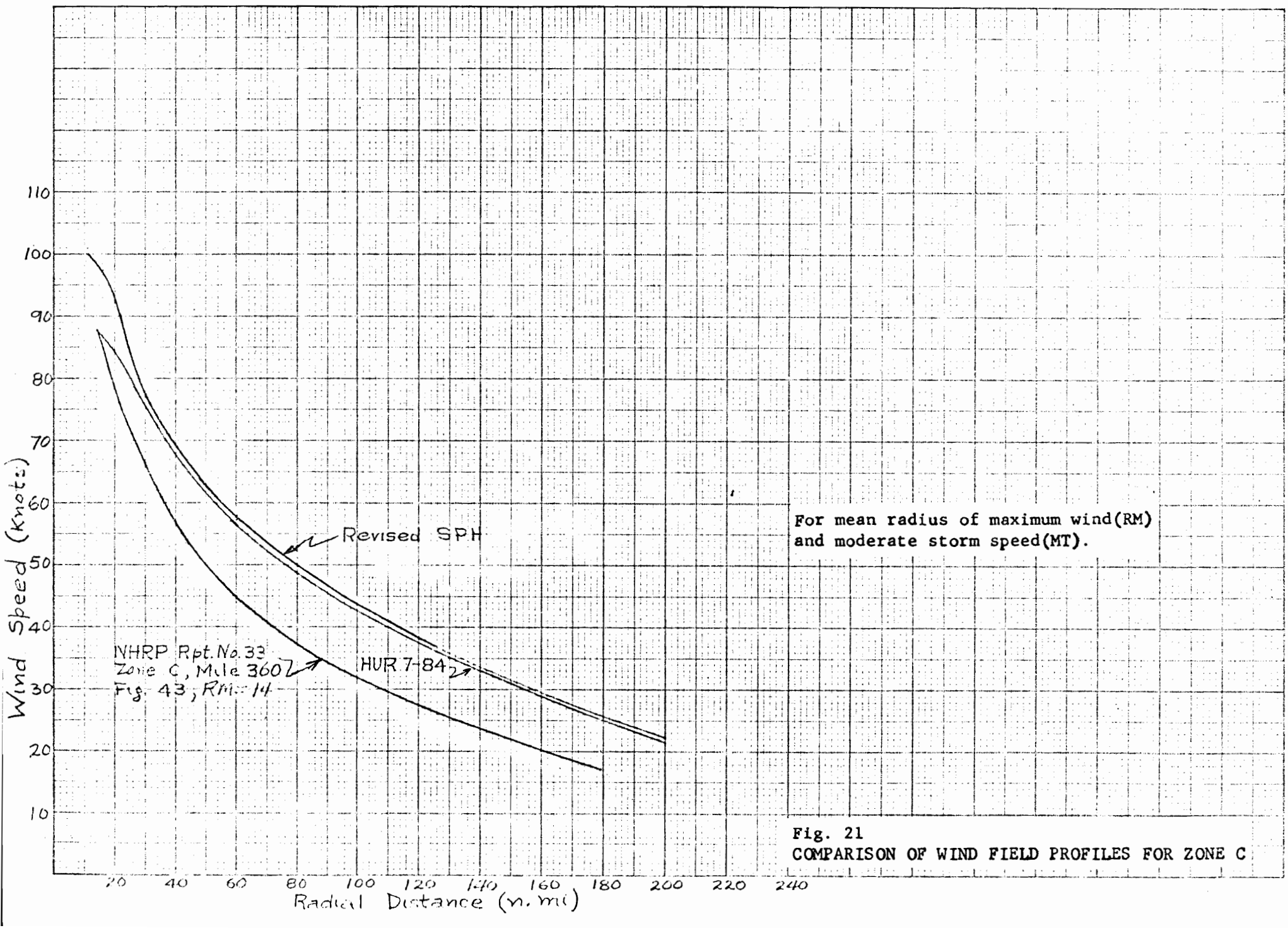


Fig. 20
COMPARISON OF WIND FIELD PROFILES FOR ZONE B

K&E 10 X 10 TO ½ INCH 46 1320
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.



For mean radius of maximum wind(RM) and moderate storm speed(MT).

Fig. 21
COMPARISON OF WIND FIELD PROFILES FOR ZONE C

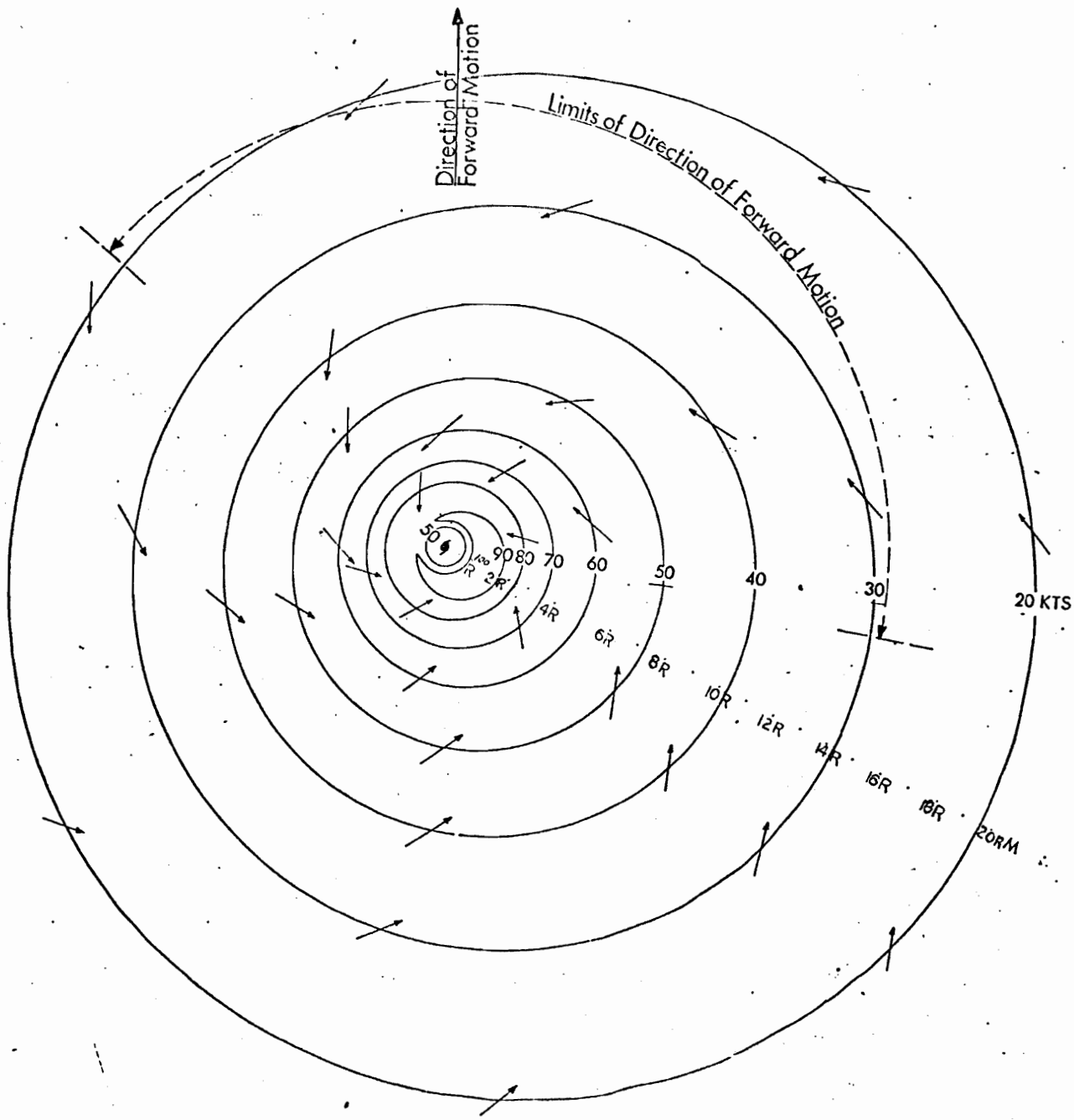


Fig. 22

EXAMPLE OF REVISED SPH WIND FIELD, ZONE C

Mean radius of maximum wind and moderate storm speed.

6-16-72

K+E 10 X 10 TO THE ½ INCH 359-11G
KEUFFEL & ESSER CO. MADE IN U.S.A.

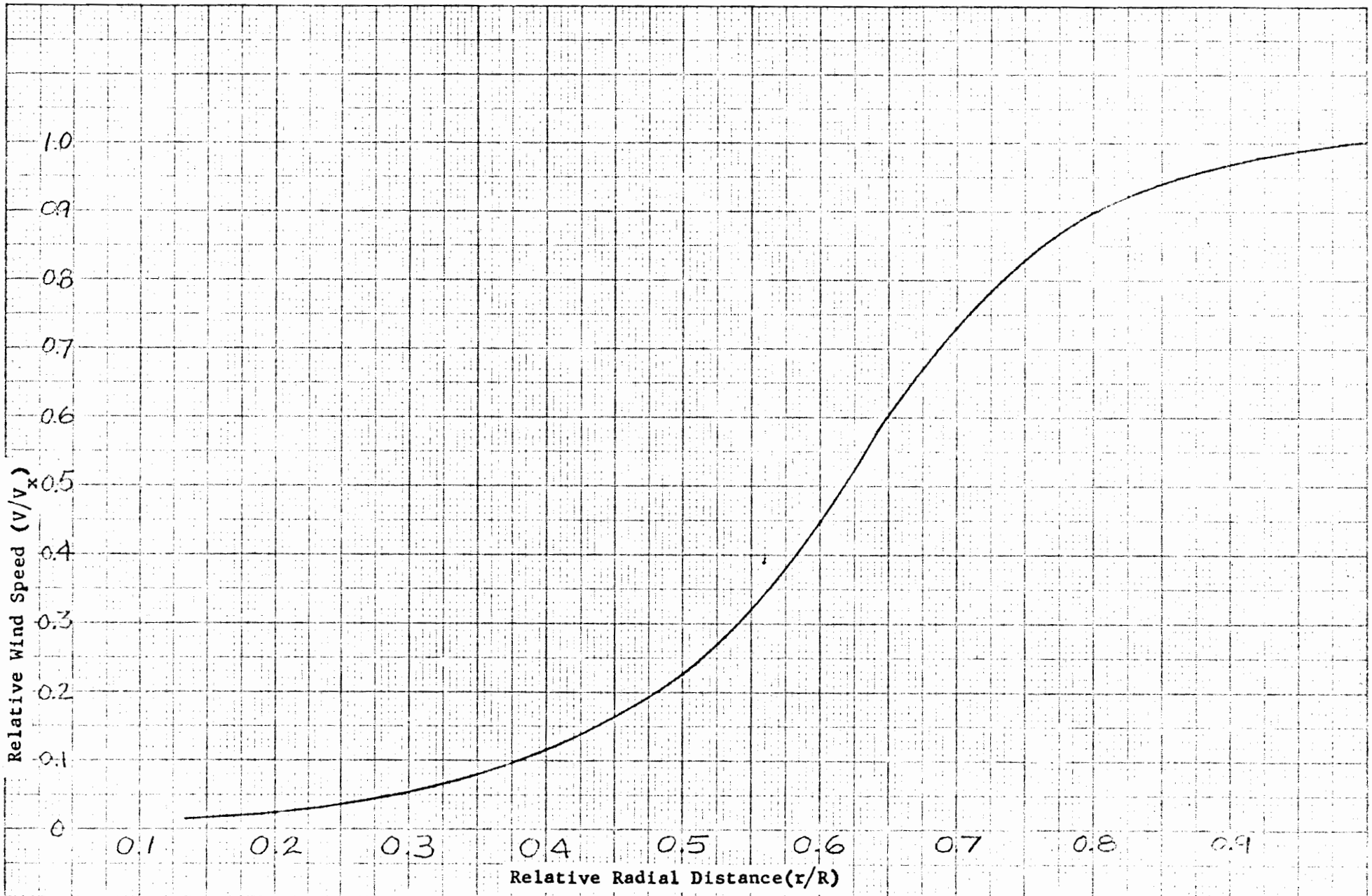


Fig. 23. VARIATION OF WINDSPEED (V/V_x) WITH RADIAL DISTANCE (r/R) WITHIN THE RADIUS OF MAXIMUM WIND

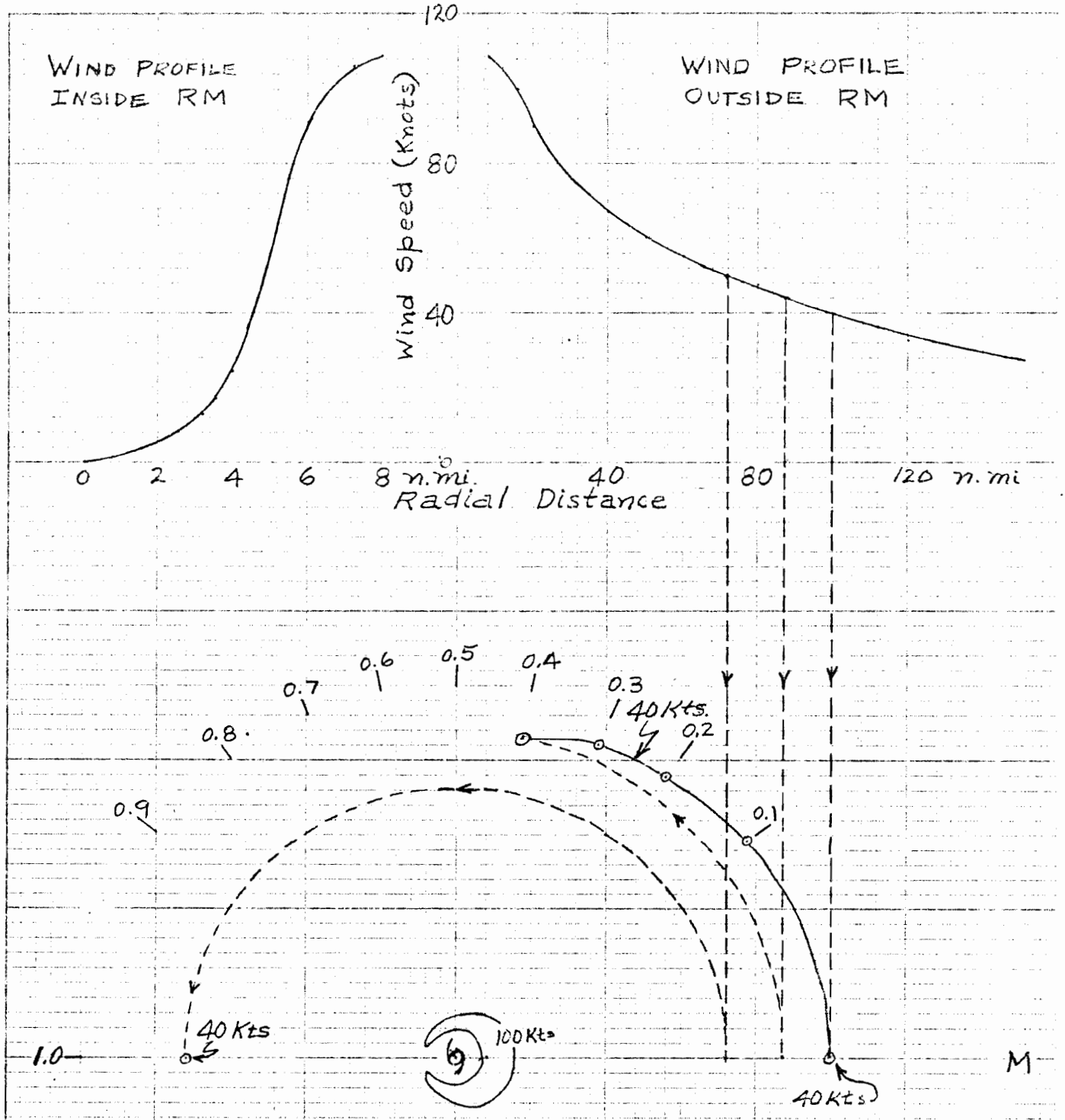


Fig 24
EXAMPLE OF WIND FIELD CONSTRUCTION

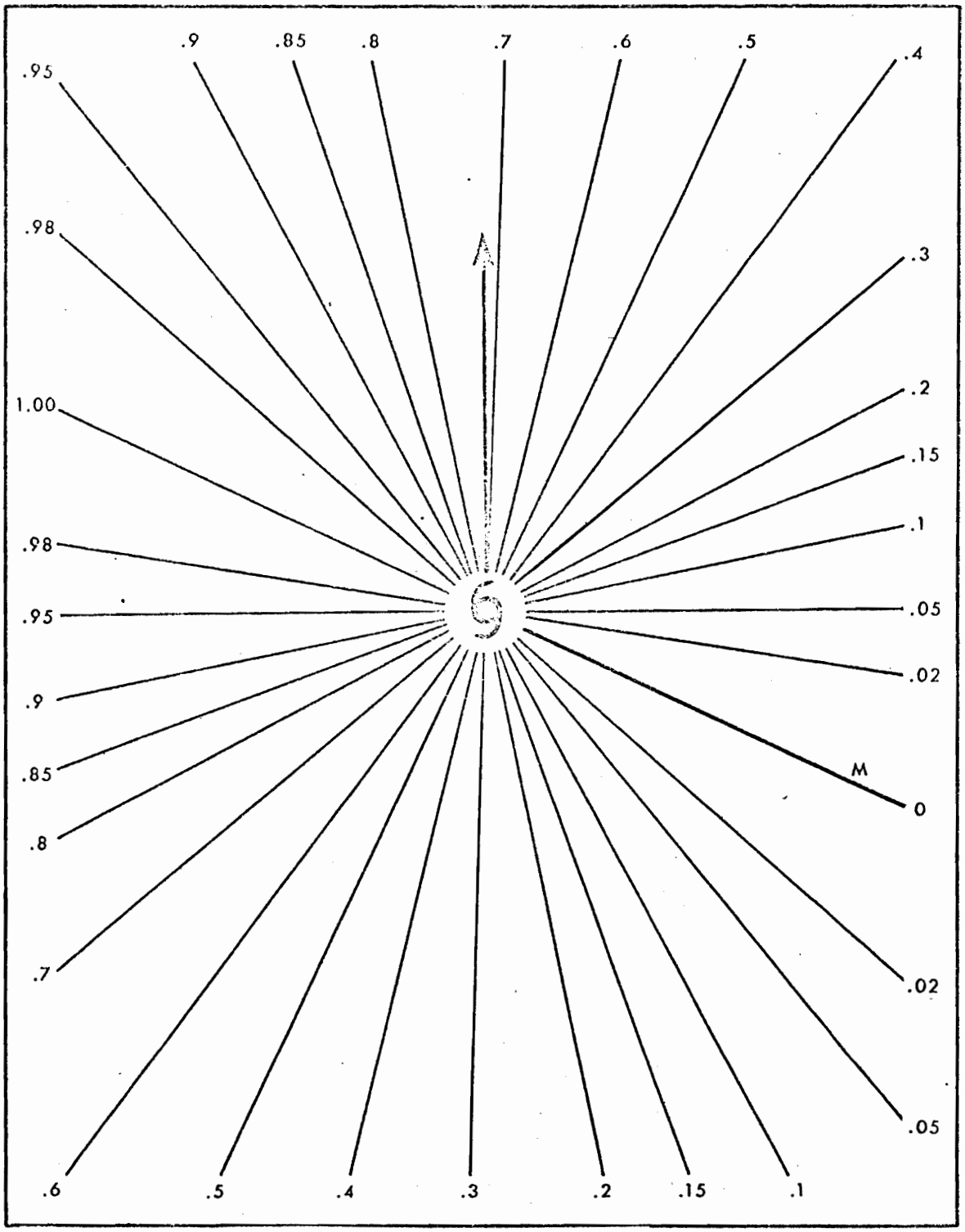


Fig. 25
NOMOGRAM FOR WIND FIELD ASSYMETRY FACTOR

Values are ratio of storm speed(T) to be subtracted from maximum wind profile.