AD NUMBER
AD005017
CLASSIFICATION CHANGES
TO: unclassified
FROM: restricted
LIMITATION CHANGES
TO: Approved for public release, distribution unlimited
FROM: Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; 24 MAR 1953. Other requests shall be referred to National Aeronautics and Space Administration, Washington, DC.
AUTHORITY
NACA reclass list no. 56 dtd 13 Jan 1954; NASA TR Server website

AD-

5017

RESTRICTED

RESEARCH MEMORANDUM

SUMMARY OF PILOTS' REPORTS OF CLEAR-AIR TURBULENCE AT ALTITUDES ABOVE 10,000 FEET

By Harry Press, Martin H. Schindler, and James K. Thompson

Langley Aeronautical Laboratory
Langley Field, Va.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WASHINGTON

March 24, 1953

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

RESEARCH MEMORANDUM

SUMMARY OF PILOTS' REPORTS OF CLEAR-AIR TURBULENCE AT ALTITUDES ABOVE 10,000 FEET

By Harry Press, Martin H. Schindler, and James K. Thompson

SUMMARY

As part of a general investigation of the seriousness of the high-altitude clear-air turbulence problem, a program for the collection of pilots' reports of clear-air turbulence encountered in normal civil and military operations was undertaken in 1949. A simple postal-card questionnaire was distributed to groups of civil aircraft operators and selected military units. This paper presents a summary of the data obtained from this survey together with some additional reports from Air Weather Service reconnaissance flights. In a period of about two years, 443 cases of high-altitude encounters of clear-air turbulence were reported. Of these reports, two-thirds were concerned with turbulence of moderate and severe intensity. These reports indicated that the turbulent areas are patchy with more than half less than 50 miles in horizontal extent and 2,000 feet in vertical thickness. Although the frequency of occurrence of turbulence at high altitudes appears to be considerably less than at low altitudes, turbulence at high altitude still appears to occur with sufficient frequency to be a factor in the design and operation of aircraft.

INTRODUCTION

One of the problems associated with the design and operation of high-altitude aircraft is the frequency and severity of atmospheric turbulence at higher altitudes. Because of the scarcity of information on this subject, an extensive program for the investigation of high-altitude turbulence was undertaken by the National Advisory Committee for Aeronautics in order to establish the frequency, intensity, and other characteristics of this type of turbulence. This program, carried out in cooperation with the Air Transport Association of America, the Air Weather Service, the U. S. Weather Bureau, the U. S. Navy, and the U. S. Air Force, consisted of three phases: the collection of pilots' reports of clear-air turbulence the collection of airplane measurements of turbulence

from routine and special airplane operations, and atmospheric soundings with a specially developed balloon-borne turbulence telemeter instrument. This paper deals only with the phase of the program which involved the collecting and analyzing of pilots' reports of clear-air turbulence.

For the purpose of collecting pilots' reports of clear-air turbulence, a simple postal-card questionnaire form was distributed to civil and military authorities. In addition, pilots' reports of clear-air turbulence encounters were also obtained from weather reconnaissance airplanes of the Air Weather Service. The collection of these pilots' reports was an attempt for an early and qualitative assessment of the seriousness of the high-altitude clear-air turbulence problem. The collection of a set of documented cases of turbulence was also expected to be useful in the development of synoptic forecasting techniques. This second consideration is being explored by the U. S. Weather Bureau and early results have been reported (see ref. 1).

Since a large sample of pilots' reports is now available, a summary of the reports received to date has been prepared and is presented herein. Although many encounters of clear-air turbulence were probably not reported, the present reports indicate the scope of the problem. In this paper the available data are summarized and examined for their implications in regard to the frequency and intensity of high-altitude clear-air turbulence and the variation of these quantities with altitude and season of the year. In addition, the information obtained from these reports on the horizontal extent and vertical thickness of the turbulent areas is presented in order to provide a description of the physical dimensions of turbulent areas.

SCOPE OF DATA AND RESULTS

The basic data consist solely of pilots' reports of clear-air turbulence encounters at higher altitudes and were obtained primarily from three sources: Air Weather Service reconnaissance flights, routine military operations within continental United States (primarily fighter aircraft), and routine commercial transport. In addition, a small number of reports from NACA airplanes were received and were grouped with the reports from military operations. The latter two sources provide their data in the standard questionnaire developed for this program. A sample of a completed postal-card questionnaire is shown in figure 1. In all cases the same basic and simple turbulence scale defined in the following manner was used to classify the turbulence intensity:

Turbulence intensity:	Definition
Slight	Perceptible
Moderate	Difficulty walking
Severe	Objects thrown around cabin

The intensity of the reported turbulence is thus a rough qualitative measure and depends to some extent on the airplane characteristics, the pilot, and particularly on the flight speed of the airplane.

The total number of reports received from each of the data sources are summarized by turbulence intensity in the following table:

Turbulence intensity	Reconnaissance flights	Military	Civil transport
Slight	16	105	26
Moderate	15	193	45
Severe		36	7
Total	31	334	78

In a number of cases, the reports were incomplete, failing to specify such items as altitude, turbulence severity, or duration. These cases were used for the items available and, as a consequence, the total number of reports on a specific item will differ.

Because of general differences in airspeed range and pilot experience, the three sources of data (reconnaissance flights, military fighter operations, and civil transport operations), have been evaluated and presented separately as will be described.

Air Weather Service Reconnaissance Flights

The pilots of the B-29 airplanes operated by the Air Weather Service over the northwest Pacific Ocean reported all clear turbulence encounters in their routine missions. The weather reconnaissance flights are such that practically all the flying is done over water at either about 10,000 feet or about 18,000 feet so that the turbulence reports are at those levels. These data cover 1 year of operations and represent close to 7,000,000 miles of flight. Summaries of these data are given in table I and include the number of occurrences of turbulence by severity, the total miles flown, and the miles of turbulent air encountered during each month.

Military Operations

These data represent reports from military operations from selected fighter-type training units in various parts of continental United States over a period of about 18 months. A few reports also included in this

group were, however, obtained from bomber-type airplanes and from operations at aeronautical research centers in various parts of the country. These data were intended to cover operations from an altitude of 25,000 feet to 45,000 feet; although contrary to the instructions on the postal cards, a few cases of turbulence below 25,000 feet were also reported. These cases were included in the present summary for completeness. Unfortunately, no data were available on the total amount of flying performed in the operations covered.

In order to determine whether these data indicated any trends in regard to variations of turbulence with season of the year and with altitude, the distributions of turbulence reports for the moderate and severe cases were determined by the month of the year (table II) and by altitude of flight (table III). For ease of interpretation, the primary results are summarized in figures 2 and 3, respectively, for the combined moderate and severe turbulence reports. The data for the light-turbulence cases were intentionally not used as these reports were felt to be seriously affected by the speed of the airplane and the pilots' discretion.

Civil Transports

Data are presented which cover a period of about 18 months in which the pilots of civil transports within the continental limits of the United States reported on clear-air turbulence which was encountered at altitudes above 10,000 feet and at least 5,000 feet above terrain. The reports were also made on postal-card questionnaires of the type shown in figure 1. In general, these flight operations did not include altitudes above 25,000 feet.

As with military operations, the distribution of reports by month and by altitude were determined separately for the moderate and severe turbulence cases and are given in tables II and III, respectively. The results obtained are also shown in figures 2 and 3 for the combined moderate and severe turbulence cases.

DISCUSSION

Frequency of Clear-Air Turbulence

Of the total 443 cases reported, 296 have been of moderate and severe intensity. Since this program covered perhaps as many as several million flight hours, the over-all incident rate of this type of turbulence appears lower than that normally associated with air operations at the lower altitudes (see, for example, ref. 2). It would thus appear that,

for operations at higher altitudes (above perhaps 35,000 feet) where turbulence may be expected to be primarily a clear-air phenomena, the over-all occurrence of turbulence would be substantially lower than for operations at the lower altitudes. This indication appears to be confirmed by other data recently obtained in flight-test investigations, reference 3.

In view of the evidence from the present data and other sources now available, it appears that the frequency of turbulence and particularly clear-air turbulence at higher altitudes is considerably less than that at low altitudes. Because of this reduction with altitude, it may be anticipated that high-altitude-operating airplanes will encounter substantially fewer gusts than low-altitude-operating airplanes. In view of the number of cases reported in the present survey, over 400, turbulence at high altitude still appears to occur with sufficient frequency to be a factor in the design and operation of aircraft. The fact that turbulence at the higher altitudes occurs predominately in clear air poses a special problem in that airplanes may be expected to run into turbulent areas without warning and at high speed.

Geography and Season

In order to determine whether the pilots' report data indicated any variations of turbulence with geography and season of the year, the available data were examined for geographical and seasonal variations. Clear-air turbulence was evidently reported in all parts of the United States with no readily apparent indications of geographical variations. The distribution of observations of the turbulence reports over the United States did not, therefore, appear to warrant further examination in detail. The distribution of pilots' reports by month and year shown in figure 2, however, appear to show a marked predominance of turbulence reports during the spring seasons of the year. Although the number of flights varied by season of the year due to weather and traffic considerations and were believed to be influenced by gasoline shortages during the period, it is believed that the indications of a predominance of clear-air turbulence reports during the spring may be real and warrants verification.

Distribution With Altitude

The distribution of turbulence reports with altitude shown in figure 3 unfortunately gives little indication of the variation of turbulence frequency with altitude, due to the lack of information on the flight times at the various altitudes. The lower altitudes of the reports from the civil transport operations principally reflect the altitude limitations of the present equipment in transport use which

preclude operations much above 25,000 feet. It is of interest to note that of the 229 military reports of high-altitude turbulence, 60 were at altitudes above 35,000 feet.

An inspection of the summary of the Air Weather Service reports in table I indicates that the portion of the flight miles in rough air was 0.00015 and 0.00050 for operations at 10,000 feet and 18,000 feet, respectively, and in no cases was heavy turbulence reported. It is obvious, therefore, that, at least for the region studied, the occurrence of clear-air turbulence at moderate altitudes over oceans is relatively rare and does not appear to be a serious problem. The increase in turbulence frequency with increasing altitude indicated by the data of table I appear contrary to what has been regarded as common experience. No explanation of this result appears evident although it may be associated with local variations in wind velocity with altitude.

Horizontal Extent of the Turbulent Areas

Most of the pilots' reports provided information on the horizontal extent of the turbulent areas, which, in miles, is summarized for both the military and civil operation reports of moderate and severe turbulence in table IV for encounters above and below 30,000 feet. This separation of the data into groups of above and below 30,000 feet was made in order to provide information on the possible variation with altitude of the turbulent-area dimensions. The over-all distribution of the horizontal extent of turbulent areas is shown separately in figure 4 for above and below 30,000 feet.

Inspection of figure 4 indicates that most of the turbulent areas were of relatively small spatial extent with more than half the cases reported having horizontal extents less than 50 miles. A few cases were reported, however, in which the turbulent areas were widespread and extended over 500 miles. From figure 4 and the average values given in table IV, it appears that the turbulent areas have about the same horizontal dimensions above and below an altitude of 30,000 feet. A separate examination of the severe and moderate turbulence occurrences, table IV, gives some indication that the areas of severe turbulence were larger than the dimensions for moderate occurrence.

Vertical Thickness of Turbulent Areas

Since the vertical thickness could be determined only if the airplane encountered the turbulent areas during climbing or descending, only a part of the reports, roughly, one-third, contained information of the vertical thickness of the turbulent areas. The available data on turbulent-area vertical thickness are summarized in table V and show

the distribution of layer thickness for the encounters above and below 30,000 feet. As in the case of the horizontal extent of the turbulent areas, these data cover both the military and civil operations for moderate and severe turbulence. The over-all distribution of vertical thickness is shown separately in figure 5 for above and below 30,000 feet.

Inspection of figure 5 indicates that the turbulent areas were generally thin with more than half the cases reported having a vertical thickness below 2,000 feet. One case was reported to be 14,000 feet thick and occurred above 30,000 feet.

Figure 5 and table V also indicate that a slight variation of thickness with altitude may exist with the average layer thicker below 30,000 feet. There is also an indication from table V that the areas of severe turbulence were of larger vertical thickness. The average thickness was about 3,000 feet for the moderate cases and almost 4,000 feet for the severe cases. The relatively small vertical extent of the turbulent areas as compared with the horizontal extent indicates that a change of airplane altitude offers the best operating practice for getting out of turbulent areas.

SUMMARY OF RESULTS

A two-year survey of high-altitude aircraft encounters of clear-air turbulence based on pilots' reports from selected military and civil operations has indicated the following results:

1. A total of 443 cases of high-altitude clear-air turbulence were reported of which more than two-thirds represented occurrences of moderate and severe turbulence.

2. Although the amount of flying covered in the survey is not known, a rough estimation suggests that this program covered as many as several million flight hours. It thus appears that the over-all frequency of encountering turbulence at the higher altitudes, above 25,000 feet, is small and is substantially lower than for normal operations at lower altitudes.

3. The data indicated more turbulence at the higher altitudes during the spring season than during other seasons of the year.

4. The horizontal dimensions of the turbulent areas varied from a few miles to, in a few cases, many hundreds of miles although more than half the cases reported had dimensions of less than 50 miles.

5. The vertical extent of the turbulent areas varied over a range of several hundred feet to roughly 10,000 feet with more than half the cases reported having thicknesses of less than 2,000 feet.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va.

REFERENCES

1. Mook, Conrad P.: A Meteorological Analysis of Reports of Turbulence Encountered by Aircraft in Clear Air. Aero. Eng. Rev., vol. 11, no. 9, Sept. 1952, pp 22-27.

2. Press, Harry, and McDougal, Robert L.: The Gust and Gust-Load Experience of a Twin-Engine Low-Altitude Transport Airplane in Operation on a Northern Transcontinental Route. NACA TN 2663, 1952.

3. Steiner, Roy, and Persh, Doris A.: Normal Accelerations and Associated Operating Conditions on Four Types of Commerical Transport Airplanes From VGH Data Available as of September 1951. NACA RM L52A28, 1952.

TABLE I.- SUMMARY OF CLEAR-AIR TURBULENCE REPORTS BY AIR WEATHER SERVICE RECONNAISSANCE AIRPLANES OPERATING OVER NORTHWEST PACIFIC OCEAN

Month	10,000-foot altitudes					18,000-foot altitudes				
	Number of occurrences			Miles in turbulence	Total miles flown	Number of occurrences			Miles in turbulence	Total miles flown
	a_L	b_M	c_H			a_L	b_M	c_H		
1951										
April		1		20	232,500	2	2		45	470,000
May					218,300	3	1		200	441,400
June					140,200					290,500
July		1		unknown	164,000	1			100	330,000
August					201,500	1	1		100	405,000
September	3			273	190,400		1		22	383,600
October		1		36	232,000	1	2		120	467,000
November					182,600					369,500
December					186,000	2	2		556	375,000
1952										
January					187,500		1		104	379,000
February					191,500	2	2		470	387,000
March					184,000		1		120	375,000
Total	3	3	0	329	2,310,500	12	13	0	1837	4,673,000

^{a}L Light turbulence (perceptible).

^{b}M Moderate turbulence (difficulty walking).

^{c}H Heavy turbulence (objects thrown about cabin).

TABLE II.- DISTRIBUTION OF TURBULENCE REPORTS

BY MONTH AND YEAR

Month	Military airplanes			Civil airplanes			Military and civil airplanes		
	Frequency			Frequency			Frequency		
	Moderate	Severe	Total	Moderate	Severe	Total	Moderate	Severe	Total
1950									
January									
February									
March	4		4				4		4
April	3		3				3		3
May	2		2				2		2
June	4	1	5				4	1	5
July									
August									
September									
October									
November									
December	1		1				1		1
1951									
January	3		3				3		3
February									
March		2	2					2	2
April	17	5	22	4	1	5	21	6	27
May	25	1	26	13	2	15	38	3	41
June	10	1	11	7		7	17	1	18
July	9		9	1		1	10		10
August	11	1	12	2		2	13	1	14
September	3	1	4	2		2	5	1	6
October	5	3	8	2		2	7	3	10
November	4	1	5	1		1	5	1	6
December	3	1	4	1	1	2	4	2	6
1952									
January	11	3	14	3		3	14	3	17
February	15	8	23	5	1	6	20	9	29
March	24	4	28	4	1	5	28	5	33
April	25	1	26				25	1	26
May	5	1	6		1	1	5	2	7
June	4		4				4		4
July	3	2	5				3	2	5
August	1		1				1		1
September	1		1				1		1
October									
November									
December									
Totals	193	36	229	45	7	52	238	43	281

TABLE III.- FREQUENCY DISTRIBUTION OF TURBULENCE REPORTS BY ALTITUDE

Altitude, ft	Military airplanes			Civil airplanes			Total
	Moderate	Severe	Total	Moderate	Severe	Total	
10,000 to 15,000	5		5	12	1	13	18
15,000 to 20,000	13	7	20	28	4	32	52
20,000 to 25,000	28	10	38	5	2	7	45
25,000 to 30,000	45	7	52				52
30,000 to 35,000	45	4	49				49
35,000 to 40,000	40	7	47				47
40,000 to 45,000	10		10				10
45,000 to 50,000		1	1				1
Total	186	36	222	45	7	52	274
Mean altitude	29,800	27,200	29,400	16,700	18,200	16,900	27,000

TABLE IV.- FREQUENCY DISTRIBUTION OF HORIZONTAL EXTENT OF TURBULENCE AREAS

Horizontal extent, miles	Frequency distribution								
	Below 30,000 ft			Above 30,000 ft			All altitudes		
	Severe	Moderate	Both	Severe	Moderate	Both	Severe	Moderate	Both
0 to 25	9	35	44		25	25	9	60	69
25 to 50	5	31	36	1	22	23	6	53	59
50 to 75	4	11	15	2	6	8	6	17	23
75 to 100	1	8	9	2	5	7	3	13	16
100 to 125	1	9	10	1	5	6	2	14	16
125 to 150	2	2	4	1	4	5	3	6	9
150 to 175		2	2		2	2		4	4
175 to 200		2	2		4	4		6	6
200 to 225	1	7	8		2	2	1	9	10
225 to 250	1		1		2	2	1	2	3
250 to 275					1	1		1	1
275 to 300					2	2		2	2
300 to 325		2	2		1	1		3	3
325 to 350									
350 to 375									
375 to 400		1	1	1	1	2	1	2	3
400 to 425		1	1					1	1
425 to 450	1	2	3				1	2	3
450 to 475					1	1		1	1
475 to 500									
500 to 525					1	1		1	1
525 to 550	1		1				1		1
550 to 575									
575 to 600									
600 to 625									
625 to 650									
650 to 675		1	1					1	1
675 to 700									
700 to 725									
725 to 750									
750 to 775									
775 to 800									
800 to 825									
825 to 850									
850 to 875									
875 to 900									
900 to 925									
925 to 950	1		1				1		1
Total	27	114	141	8	84	92	35	198	233
Mean horizontal extent	125	83	91	122	90	93	125	86	92

TABLE V.- FREQUENCY DISTRIBUTION OF VERTICAL THICKNESS OF TURBULENCE

Thickness, ft	Frequency distribution								
	Below 30,000 feet			Above 30,000 feet			All altitudes		
	Severe	Moderate	Both	Severe	Moderate	Both	Severe	Moderate	Both
>250	1	1	2				1	1	2
250 to 750	1	3	4		7	7	1	10	11
750 to 1,250	1	4	5		4	4	1	8	9
1,250 to 1,750		2	2		2	2		4	4
1,750 to 2,250	3	12	15		19	19	3	31	34
2,250 to 2,750	1	1	2		1	1	1	2	3
2,750 to 3,250		6	6	2	6	8	2	12	14
3,250 to 3,750				2		2	2		2
3,750 to 4,250	1	2	3		1	1	1	3	4
4,250 to 4,750	1		1				1		1
4,750 to 5,250	3	4	7		2	2	3	6	9
5,250 to 5,750	1		1				1		1
5,750 to 6,250		3	3		1	1		4	4
6,250 to 6,750									
6,750 to 7,250	1	2	3				1	2	3
7,250 to 7,750					1	1		1	1
7,750 to 8,250					1	1		1	1
8,250 to 8,750		1	1					1	1
8,750 to 9,250		1	1					1	1
9,250 to 9,750									
9,750 to 10,250	1	1	2	1		1	2	1	3
10,250 to 10,750									
10,750 to 11,250		1	1					1	1
13,750 to 14,250					1	1		1	1
Total	15	44	59	5	46	51	20	90	110
Mean thickness	3,700	3,400	3,500	4,600	2,600	2,800	4,000	3,000	3.200

NACA - U. S. Weather Bureau

CLEAR AIR TURBULENCE REPORT

Form Approved Budget Bureau No. 41-R1327

WB 611-1

Purpose: To collect information on the frequency and severity of turbulence in clear air at high altitudes so that safer airplanes can be designed and means of predicting and avoiding such turbulence can be developed.

Instructions: Complete this report for encounters with turbulence ONLY IN CLEAR AIR at altitudes above 10,000 feet (for the civil airlines) and 25,000 feet (for the Military Services). In mountainous areas, however, turbulence at less than 5,000 feet above the mountains within a 20-mile radius need not be reported.

C-82

① Date 30 April 1951

② Airplane Type BOEING B-377

③ Time occurred 510 p.m. local standard time

④ Location 85 miles in E direction from BOSTON (landmark)

or _____ lat. _____ long.

⑤ Indicated altitude: 19000 ft.

altimeter setting 3004 inches Hg.

⑥ Indicated airspeed: 174 mph knots

⑦ Estimate of maximum intensity (check one):

- ☐ slight (perceptible)
- ☑ moderate (difficulty walking)
- ☐ severe (objects thrown around cabin)

⑧ Length of time in turbulence: 25 min.

⑨ If climbing or descending, Vertical extent of turbulence _____ ft.

Remarks: (Describe characteristics of turbulence--choppy, hard jolts, heavy drafts, continuous or intermittent, etc.; describe airplane reactions--wallowing, uncontrolled roll, momentary upsets, etc.; describe evasive action--changes in altitude, direction and airspeed, etc.; if there are any clouds in vicinity, note types and estimated distance.)

CHARACTERISTS OF TURB.:
CHOPPY - CONTINUOUS
AIRPLANE REACTIONS:
WALLOWING
NO EVASIVE ACTION
NO CLOUDS IN VIC.

NACA

(Over)

Figure 1.- Sample of completed turbulence questionnaire report.

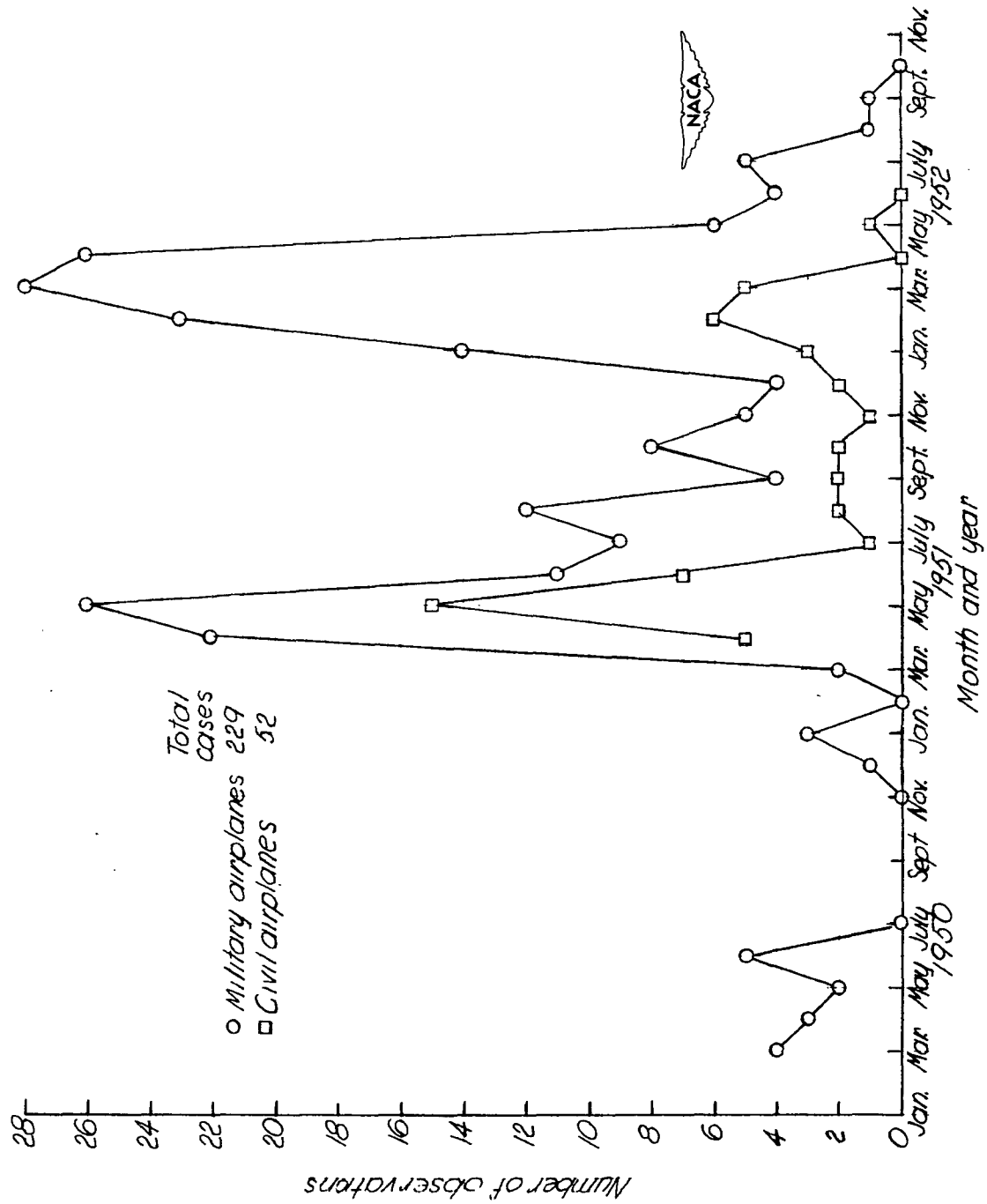

Figure 2.- Number of pilot's reports of turbulence by month and year.

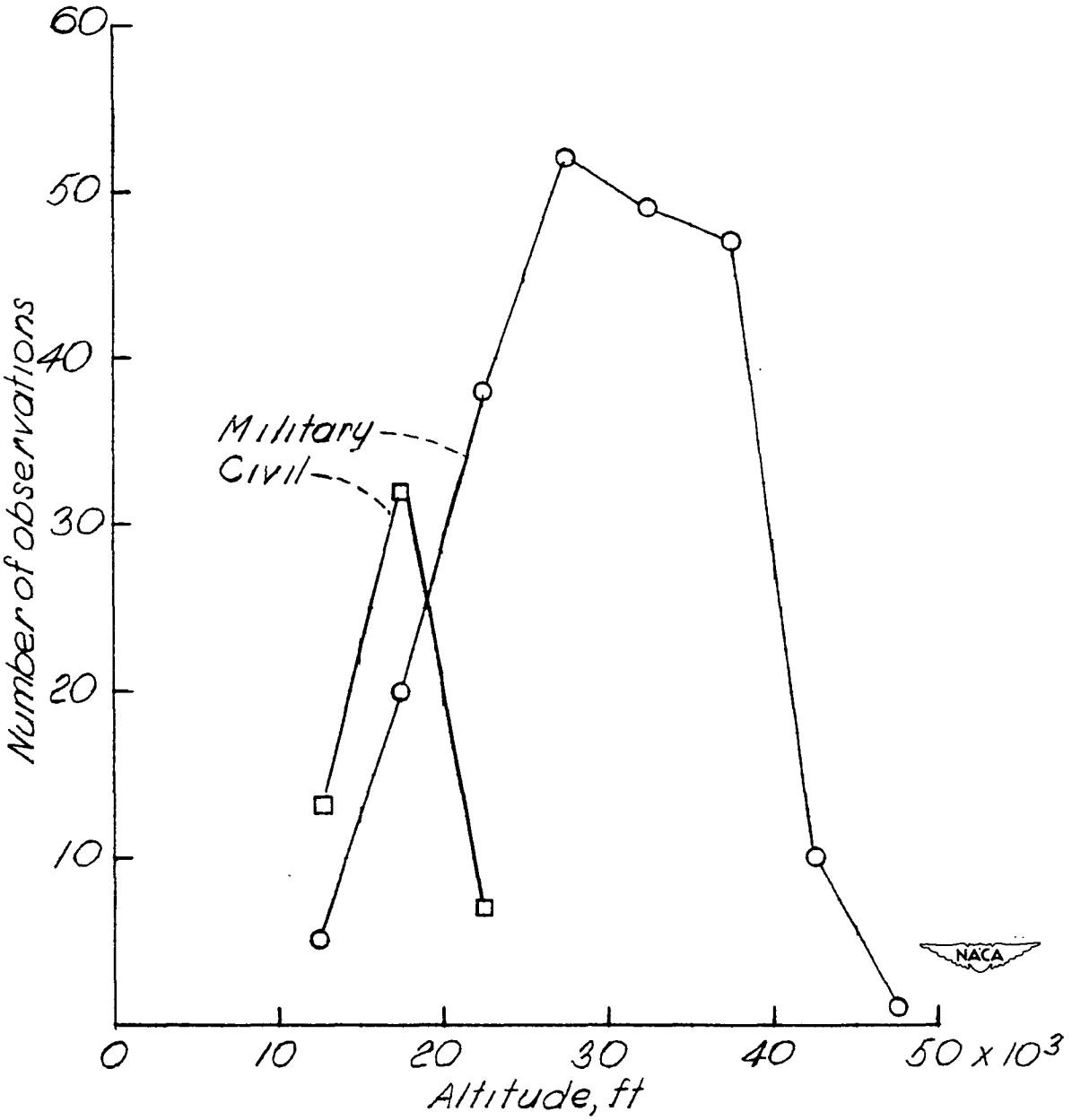

Figure 3.- Frequency distribution of turbulence reports with altitude.

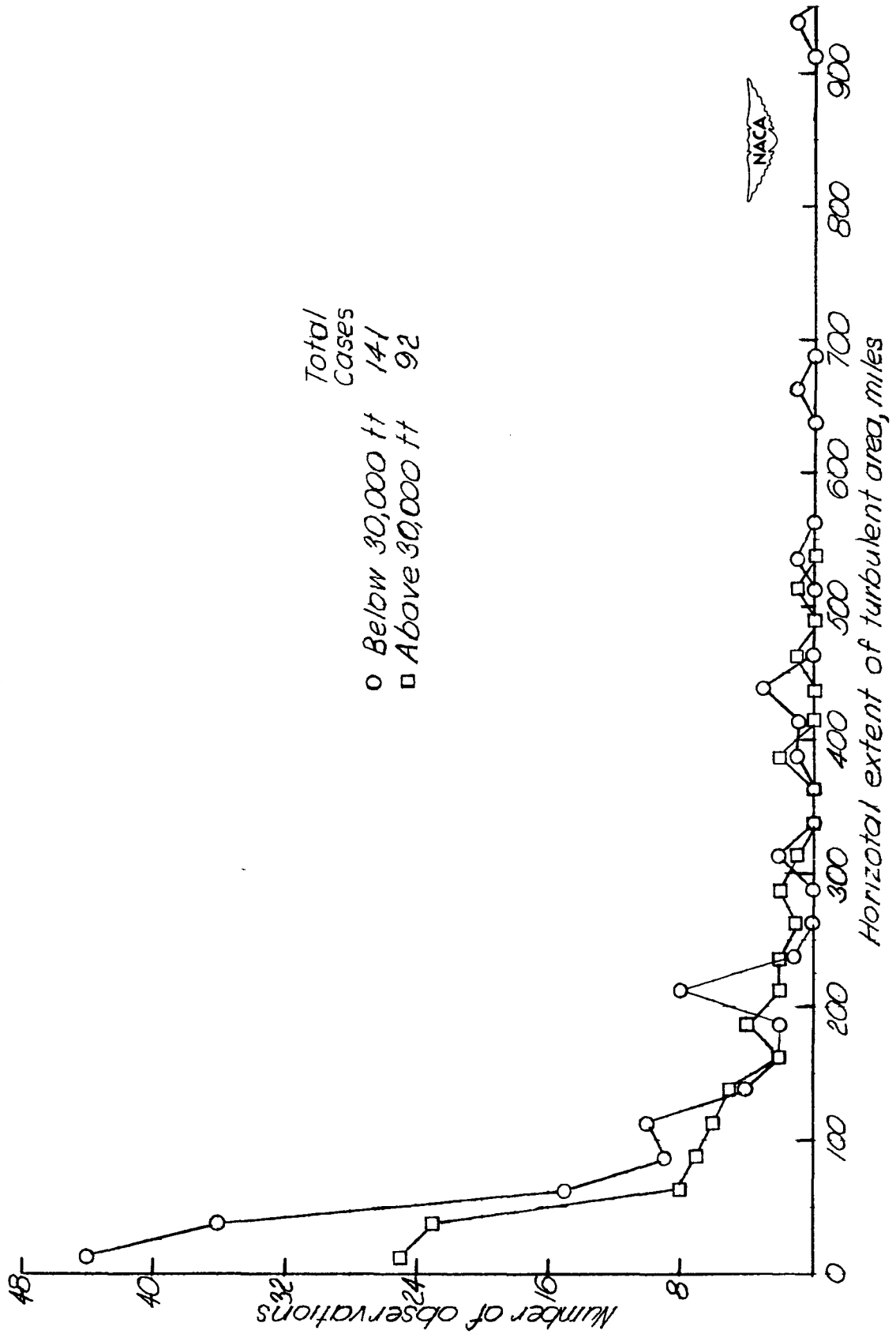

Figure 4.- Frequency distribution of horizontal extent of turbulent area.

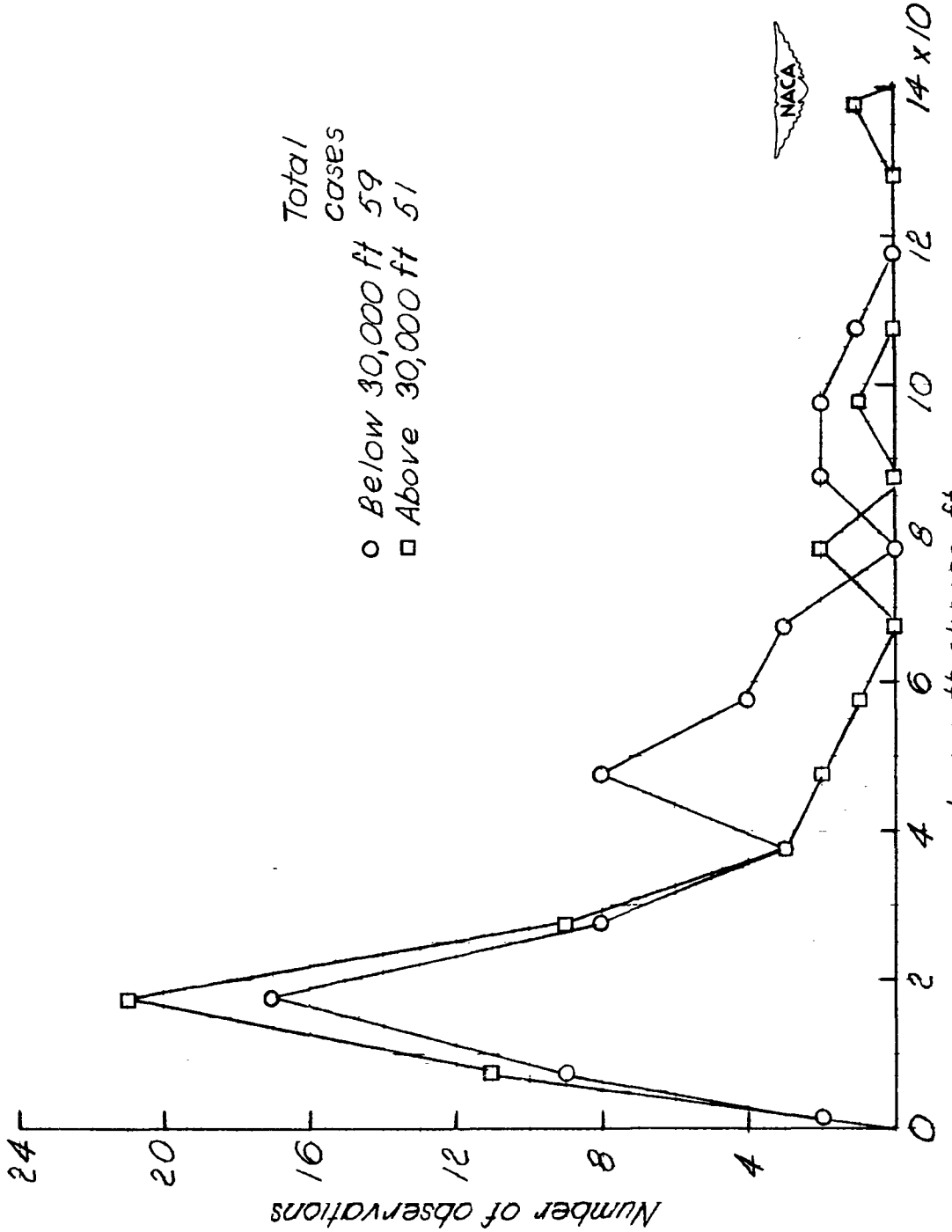

Figure 5.- Frequency distribution of vertical thickness of turbulent areas.

NACA-Langley - 3-24-53 - 400

NACA RM L52L30a
National Advisory Committee for Aeronautics.
SUMMARY OF PILOTS' REPORTS OF CLEAR-AIR TURBULENCE AT ALTITUDES ABOVE 10,000 FEET. Harry Press, Martin H. Schindler and James K. Thompson. March 1953. 18p. diagrs., 5 tabs. (NACA RM L52L30a) RESTRICTED

A cooperative program for the collection of pilots' reports of clear-air turbulence encountered at high altitudes in normal civil and military operations was undertaken in 1949. A simple postal-card questionnaire was distributed to groups of civil aircraft operators and selected military units, and a summary of the data obtained from this survey is presented together with some additional reports from Air Weather Service reconnaissance flights.

Copies obtainable from NACA, Washington

RESTRICTED
SECURITY INFORMATION

1. Loads, Gust - Wings (4.1.1.1.3)
2. Gusts, Frequency (6.1.2.2)

I. Press, Harry
II. Schindler, Martin H.
III. Thompson, James K.
IV. NACA RM L52L30a

NACA

RESTRICTED

NACA RM L52L30a
National Advisory Committee for Aeronautics.
SUMMARY OF PILOTS' REPORTS OF CLEAR-AIR TURBULENCE AT ALTITUDES ABOVE 10,000 FEET. Harry Press, Martin H. Schindler and James K. Thompson. March 1953. 18p. diagrs., 5 tabs. (NACA RM L52L30a) RESTRICTED

A cooperative program for the collection of pilots' reports of clear-air turbulence encountered at high altitudes in normal civil and military operations was undertaken in 1949. A simple postal-card questionnaire was distributed to groups of civil aircraft operators and selected military units, and a summary of the data obtained from this survey is presented together with some additional reports from Air Weather Service reconnaissance flights.

Copies obtainable from NACA, Washington

RESTRICTED
SECURITY INFORMATION

1. Loads, Gust - Wings (4.1.1.1.3)
2. Gusts, Frequency (6.1.2.2)

I. Press, Harry
II. Schindler, Martin H.
III. Thompson, James K.
IV. NACA RM L52L30a

NACA

RESTRICTED

NACA RM L52L30a
National Advisory Committee for Aeronautics.
SUMMARY OF PILOTS' REPORTS OF CLEAR-AIR TURBULENCE AT ALTITUDES ABOVE 10,000 FEET. Harry Press, Martin H. Schindler and James K. Thompson. March 1953. 18p. diagrs., 5 tabs. (NACA RM L52L30a) RESTRICTED

A cooperative program for the collection of pilots' reports of clear-air turbulence encountered at high altitudes in normal civil and military operations was undertaken in 1949. A simple postal-card questionnaire was distributed to groups of civil aircraft operators and selected military units, and a summary of the data obtained from this survey is presented together with some additional reports from Air Weather Service reconnaissance flights.

Copies obtainable from NACA, Washington

RESTRICTED
SECURITY INFORMATION

1. Loads, Gust - Wings (4.1.1.1.3)
2. Gusts, Frequency (6.1.2.2)

I. Press, Harry
II. Schindler, Martin H.
III. Thompson, James K.
IV. NACA RM L52L30a

NACA

RESTRICTED

NACA RM L52L30a
National Advisory Committee for Aeronautics.
SUMMARY OF PILOTS' REPORTS OF CLEAR-AIR TURBULENCE AT ALTITUDES ABOVE 10,000 FEET. Harry Press, Martin H. Schindler and James K. Thompson. March 1953. 18p. diagrs., 5 tabs. (NACA RM L52L30a) RESTRICTED

A cooperative program for the collection of pilots' reports of clear-air turbulence encountered at high altitudes in normal civil and military operations was undertaken in 1949. A simple postal-card questionnaire was distributed to groups of civil aircraft operators and selected military units, and a summary of the data obtained from this survey is presented together with some additional reports from Air Weather Service reconnaissance flights.

Copies obtainable from NACA, Washington

RESTRICTED
SECURITY INFORMATION

1. Loads, Gust - Wings (4.1.1.1.3)
2. Gusts, Frequency (6.1.2.2)

I. Press, Harry
II. Schindler, Martin H.
III. Thompson, James K.
IV. NACA RM L52L30a

NACA

RESTRICTED