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RESEARCH MEMORANDUM

SUMMARY OF TURBULENCE DATA OBTAINED DURING UNITED AIR LINES FLIGHT EVALUATION OF AN EXPERIMENTAL C BAND (5.5 CM) AIRBORNE WEATHER RADAR

By E. C. Coe and M. W. Fetner

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Langley Field, Va.

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RESEARCH MEMORANDUM

SUMMARY OF TURBULENCE DATA OBTAINED DURING UNITED AIR LINES FLIGHT EVALUATION OF AN EXPERIMENTAL C BAND (5.5 CM) AIRBORNE WEATHER RADAR

By E. C. Coe and M. W. Fetner

SUMMARY

Data on atmospheric turbulence in the vicinity of thunderstorms obtained during a flight evaluation of an experimental C band (5.5 cm) airborne radar are summarized. The turbulence data were obtained with an NACA VGH recorder installed in a United Air Lines DC-3 airplane.

INTRODUCTION

Several studies have been made in recent years on the use of airborne radar as a navigational aid for the pilot (see, for example, refs. 1 and 2). As a continuation of this work, United Air Lines, Inc., has recently completed a flight evaluation of an experimental C band (5.5 cm) airborne weather radar to determine its application in avoiding regions of severe turbulence in thunderstorm areas. Results from some phases of the work have been presented in reference 3. The NACA assisted in this work by providing an NACA VGH recorder (ref. 4) for obtaining information on the turbulence encountered on the flights and by evaluating the records for correlation with the radar indications. This report was prepared to summarize the gust-velocity data obtained from the VGH records.

SCOPE OF TESTS AND APPARATUS

A total of 40 flights was made by United Air Lines, Inc., with a Douglas DC-3 airplane between June and October 1953 in the vicinity of Denver, Colo. Of these flights, 12 were made for the technical evaluation and adjustment of the radar, and the remaining 28 flights were made in surveying thunderstorm areas to obtain radar and turbulence data. A total of approximately 80 hours of flight was made in the immediate vicinity of thunderstorms.

The NACA VGH recorder installed in the airplane to obtain gust data provides a continuous record of airspeed, pressure altitude, and normal acceleration. A detailed description of the instrument is given in reference 4. For use in the present tests, the pitot and static leads from the instrument were connected to the airplane service system and the accelerometer transmitter was mounted near the center of gravity of the airplane. The airspeed system was calibrated in flight by United Air Lines, Inc. In addition to 1-minute timing marks, a separate reference mark was impressed on the VGH record each time a photograph was taken of the radar scope in order to synchronize the turbulence and radar data.

EVALUATION AND PRESENTATION OF DATA

The evaluation of the VGH records consisted of reading the individual acceleration peaks and the associated airspeed and altitude to determine the derived gust velocities U_{de} above a threshold of 10 fps. The derived gust velocities are defined by equation (11) of reference 5. These velocities are about 50 to 70 percent larger than the velocities computed according to the gust-velocity scale used in past radar evaluations (ref. 1).

The values of the positive and negative gust velocities above a threshold of 10 fps derived from the VGH records are summarized by date and flight number in table I. The radar picture numbers in this table correspond to the United Air Lines numbering of their photographs of the radar scope. The photographs were taken at nonuniform time intervals and, in many cases, a number of gusts were encountered in the intervals between successive photographs. To assist in correlating the photographs with the gust data, each gust evaluated from the records has been identified in the table according to the 1/2-minute time interval that the gust was encountered after the time the photograph was taken. For additional information, the pressure altitude, airspeed, and acceleration read from the record are also noted in the table for each gust evaluated.

COMMENT

The values of gust velocity summarized in table I are in agreement with other gust measurements taken by the NACA for similar flights near or below thunderstorms. Since the present flights did not, in general,

penetrate the thunderstorms, the gust velocities are lower than might be expected within the more active portions of thunderstorms.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., June 2, 1954.

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2. Tolefson, H. B.: Some Possible Reductions in Gust Loads Through Use of Radar in Transport Airplanes. Bull. American Meteorol. Soc., vol. 34, no. 5, May 1953, pp. 187-191.

3. Harrison, Henry T., and Post, Edgar A.: Evaluation of C Band (5.5 Cm) Airborne Weather Radar. United Air Lines, Inc. (Denver, Colo.), Mar. 1, 1954.

4. Richardson, Norman R.: NACA VGH Recorder. NACA TN 2265, 1951.

5. Pratt, Kermit G.: A Revised Formula for the Calculation of Gust Loads. NACA TN 2964, 1953.

TABLE I.- SUMMARY OF TURBULENCE DATA

Radar picture no.	1/2-minute interval	Altitude, ft	Airspeed, V_e, mph	Acceleration increment, a_n, g	Gust velocity, U_{de}, fps
Flight 15, June 29, 1953					
072	1	12,000	127	0.32	10.3
073	1	11,200	124	.32	10.6
084	1	11,800	115	.33	12.0
085	1	11,600	117	.36	12.8
089	2	12,200	140	-.36	-10.6
100	1	12,000	132	.32	10.0
	1	12,000	124	-.31	-10.3
	1	11,900	123	.36	12.0
	1	11,900	127	.33	10.6
104	1	11,900	141	.38	11.1
112	4	12,100	151	.40	10.5
	6	12,300	158	-.40	-10.0
	7	11,900	151	.47	12.1
	8	11,600	108	.28	10.2
	8	11,600	132	-.36	-10.6
114	2	11,800	126	.51	15.9
128	1	9,700	128	-.33	-10.2
133	1	9,800	120	-.33	-10.8
135	1	9,900	117	.31	10.6
137	1	9,900	117	.32	10.7
	1	9,900	117	-.30	-10.2
147	1	9,400	118	.37	12.4
	1	9,100	110	.50	17.8
	2	9,000	113	.30	10.5
	2	8,700	131	.38	11.4
	2	8,700	131	-.50	-15.2
	2	8,800	122	.42	13.6
	2	8,800	123	-.35	-11.3
148	1	8,800	123	-.53	-17.3
149	1	8,600	117	-.40	-13.8
	1	8,500	114	-.31	-10.9
	1	7,900	122	.31	10.2
	1	7,900	124	.41	13.0
	1	7,900	116	.52	17.8
150	1	8,000	124	-.39	-12.7
	1	7,900	116	-.35	-12.2
	1	7,900	116	.32	11.0
	2	7,900	122	-.33	-10.7
153	1	7,500	118	.35	11.9
	1	7,600	115	.29	10.2
	1	7,700	113	-.30	-10.5
	1	7,700	118	.30	10.2
	1	7,700	116	-.34	-11.9
	1	7,600	118	.52	17.5
154	2	7,800	116	-.36	-12.5
	2	7,800	118	.41	14.1
	2	7,800	122	-.60	-19.6
	2	7,600	118	.37	12.5
	2	7,600	114	-.41	-14.2
	2	7,600	114	-.29	-10.0

TABLE I.- SUMMARY OF TURBULENCE DATA - Continued

Radar picture no.	1/2-minute interval	Altitude, ft	Airspeed, V_e, mph	Acceleration increment, a_n, g	Gust velocity, U_{de}, fps
Flight 15, June 29, 1953 - Concluded					
154	2	7,600	117	0.30	10.4
	2	7,500	122	.54	17.6
	2	7,500	116	.32	11.2
	2	7,500	115	.44	15.5
155	1	7,600	115	-.30	-10.6
	2	7,600	115	-.33	-11.6
156	1	7,800	118	.48	16.3
157	1	8,100	123	.45	14.5
	1	8,100	122	.53	17.4
	2	8,400	123	.33	10.8
	2	8,400	123	.31	10.2
	3	8,400	124	.32	10.4
	3	8,500	122	-.35	-11.5
	4	8,800	122	.38	12.7
	7	9,700	116	.32	10.7
	8	9,800	128	-.45	-13.8
159	1	9,900	131	-.35	-10.4
161	1	9,900	137	.40	11.5
174	1	9,900	117	.33	10.9
	1	10,000	115	.41	14.0
	1	10,000	115	-.33	-11.2
176	1	9,900	120	-.39	-12.6
178	2	10,100	138	.35	10.0
Flight 16, June 30, 1953					
210	1	10,700	134	0.35	10.7
212	1	11,000	137	.61	18.2
214	1	12,200	122	-.34	-11.1
	1	12,200	130	.33	10.2
216	1	12,400	136	.38	11.2
232	1	13,600	142	.38	10.6
235	1	12,800	112	.32	11.2
236	1	12,700	105	-.29	-11.0
	1	12,500	129	.33	10.2
	1	12,500	131	-.35	-10.5
237	1	12,500	132	-.41	-12.2
	1	12,400	130	-.49	-15.1
269	1	13,800	134	.34	10.0
278	1	13,200	109	-.52	-19.0
290	1	12,400	123	-.59	-19.2
	1	12,300	123	.33	10.7
330	1	5,100	137	.36	10.9
	1	5,200	123	-.34	-11.7
	1	5,100	123	.32	10.9
331	1	5,200	118	-.28	-10.0
335	1	5,900	134	.33	10.4
343	1	7,000	110	.45	16.1
346	1	7,300	118	-.32	-10.5
392	1	9,100	123	-.46	-15.3
393	1	8,800	112	-.32	-11.6

TABLE I.- SUMMARY OF TURBULENCE DATA - Continued

Radar picture no.	1/2-minute interval	Altitude, ft	Airspeed, V_e, mph	Acceleration increment, a_n, g	Gust velocity, U_{de}, fps
Flight 16, June 30, 1953 - Concluded					
393	1	8,600	119	-0.53	-18.3
403	1	8,200	121	-.30	-10.0
406	1	7,800	126	.63	20.1
	1	7,700	132	-.43	-13.3
	1	7,700	127	.33	10.6
407	1	7,900	120	-.31	-10.5
414	1	8,000	134	.33	10.0
423	1	8,100	114	.40	14.1
442	1	11,600	122	-.31	-10.0
445	1	11,800	128	.78	23.9
	1	11,800	120	-.32	-10.4
447	1	11,800	116	-.30	-10.1
453	1	11,800	130	.36	10.8
469	1	11,500	109	-.46	-16.7
486	1	8,900	127	-.46	-14.2
490	1	7,500	134	.37	10.9
491	1	7,200	122	.34	11.2
493	1	6,900	119	.30	10.1
494	1	6,800	128	.36	11.4
	1	6,900	122	.50	16.8
	1	6,800	124	.31	10.0
495	1	6,900	123	-.32	-10.5
	1	6,800	120	-.48	-16.1
	1	6,800	128	.34	10.7
	1	6,900	129	-.33	-10.2
511	1	7,400	119	.35	12.1
Flight 17, July 1, 1953					
551	1	7,900	111	-0.27	-10.1
565	6	10,000	149	-.37	-10.0
	9	10,100	153	-.43	-11.5
	9	10,100	157	-.54	-14.1
572	2	10,000	116	-.30	-10.6
575	1	10,200	116	.31	10.8
578	1	10,100	126	.31	10.1
	1	10,100	125	.39	12.8
582	1	9,700	127	-.37	-11.8
583	1	9,600	118	-.34	-11.8
	1	9,500	119	.34	11.6
	1	9,500	112	-.39	-14.3
	1	9,500	109	.46	17.0
585	1	9,900	122	.44	14.8
	1	9,300	124	.34	11.1
586	1	9,300	128	-.44	-14.0
	1	9,300	118	-.32	-10.9
587	1	9,900	128	-.32	-10.2
	1	9,900	121	-.34	-11.5
588	1	10,100	126	-.32	-10.4
	7	9,700	127	.31	10.0
608	1	9,600	136	-.38	-11.3
609	1	9,700	137	.41	12.3
614	1	9,800	131	-.37	-11.3
	1	9,800	127	.37	11.8

TABLE I.- SUMMARY OF TURBULENCE DATA - Continued

Radar picture no.	1/2-minute interval	Altitude, ft	Airspeed, V_e, mph	Acceleration increment, a_n, g	Gust velocity, U_{de}, fps
Flight 17, July 1, 1953 - Concluded					
616	1	9,700	135	0.37	11.2
	1	9,600	118	.31	10.6
617	1	9,500	122	-.38	-12.8
	1	9,400	120	.36	12.2
618	1	10,100	131	.36	11.1
620	1	10,200	137	-.46	-13.8
621	1	10,000	121	-.33	-11.2
	1	9,700	130	.40	12.4
626	1	9,900	138	.38	11.1
	1	10,100	118	-.38	-12.9
	1	10,000	123	-.39	-13.0
627	1	9,900	117	-.36	-12.6
	2	9,600	127	.34	11.0
629	1	9,600	132	.37	11.3
	3	9,800	126	-.34	-11.1
630	1	9,700	125	-.34	-10.9
656	1	8,300	125	-.44	-14.0
657	1	7,900	119	.42	14.2
659	1	7,500	122	.32	10.6
	2	7,500	114	.29	10.2
660	1	7,600	120	-.38	-12.7
720	1	8,700	122	-.31	-10.1
724	1	8,900	128	-.32	-10.1
725	1	8,800	124	.38	12.2
733	1	8,500	149	.43	11.5
	2	8,600	152	.52	13.7
Flight 18, July 2, 1953					
768	1	9,200	145	0.50	14.4
769	1	9,100	133	-.46	-14.4
770	1	9,000	132	.35	11.0
	2	8,900	138	.37	11.2
771	2	8,800	123	.33	11.1
783	1	8,400	133	.39	12.1
797	1	8,700	120	-.31	-10.9
877	1	13,900	143	-.45	-12.4
	1	13,800	149	.58	15.2
	1	13,700	147	.40	10.7
	1	13,800	150	-.58	-15.2
	1	13,800	146	.41	11.0
882	1	12,900	134	.36	10.6
886	1	12,800	133	.37	11.0
888	1	12,300	121	-.36	-11.7
	2	12,300	126	.46	14.8
929	1	10,800	131	-.33	-10.2
Flight 19, July 9, 1953					
064	1	9,800	118	0.30	10.4
068	1	9,900	120	.30	10.6
099	1	9,700	112	.38	14.1
127	1	10,500	128	-.32	-10.0
128	1	10,700	132	-.38	-11.6
130	2	10,700	133	-.35	-10.6
131	1	10,500	128	.39	12.2
	2	10,600	127	.40	12.8
	2	10,600	130	-.50	-15.6
133	1	10,500	115	.29	10.1

TABLE I.- SUMMARY OF TURBULENCE DATA - Continued

Radar picture no.	1/2-minute interval	Altitude, ft	Airspeed, V_e, mph	Acceleration increment, a_n, g	Gust velocity, U_{de}, fps
Flight 19, July 9, 1953 - Concluded					
135	1	10,600	132	-.39	-12.0
	1	10,700	127	-.33	-10.6
136	1	10,300	122	.31	10.4
139	1	10,200	122	-.39	-12.9
	1	10,200	128	.33	10.4
	1	10,200	125	.32	10.3
	1	10,100	124	.35	11.4
	1	10,100	120	.35	12.0
140	1	9,800	116	.34	12.0
	1	10,000	112	.31	11.1
	1	9,900	112	.28	10.2
	1	9,900	118	-.32	-11.0
	1	9,900	128	.43	13.7
	1	10,100	130	-.39	-12.3
	1	10,100	123	-.44	-14.4
144	1	10,200	124	.32	10.4
	1	10,300	126	-.39	-12.6
	2	10,600	129	-.37	-11.8
146	1	10,500	142	.35	10.1
	1	10,400	154	-.54	-14.1
148	1	10,200	147	.41	11.3
153	2	10,500	117	-.31	-10.9
	2	10,500	117	-.29	-10.0
165	1	10,100	151	.46	12.2
190	1	8,200	142	.38	10.9
	1	8,200	146	-.36	-10.0
206	1	8,800	131	.34	10.6
	1	8,800	130	.34	10.6
	1	8,800	124	-.32	-10.5
	1	8,700	120	-.31	-10.5
	1	8,900	122	-.32	-10.7
208	1	8,800	118	-.39	-13.5
212	1	8,800	122	-.33	-10.9
	1	8,700	120	-.29	-10.0
254	1	9,300	132	-.45	-13.8
	1	9,300	130	.55	17.0
	1	9,300	135	.38	11.2
255	1	9,300	129	.38	11.8
261	1	9,400	120	.50	16.9
265	1	9,900	111	.37	13.2
275	1	8,600	130	-.40	-12.2
282	1	8,900	115	-.32	-11.3
283	1	8,700	112	.35	12.7
284	1	8,700	126	.36	11.6
	1	8,700	123	.48	15.7
296	1	8,600	129	-.37	-11.4
297	1	8,500	126	.32	10.1
	1	8,600	125	-.34	-10.9
298	1	8,500	118	-.32	-10.9
300	1	8,300	117	.30	10.2
316	2	8,800	136	-.36	-10.7
	2	8,900	127	-.49	-15.4

TABLE I.- SUMMARY OF TURBULENCE DATA - Continued

Radar picture no.	1/2-minute interval	Altitude, ft	Airspeed, V_e, mph	Acceleration increment, a_n, g	Gust velocity, U_{de}, fps
Flight 20, July 10, 1953					
436	5	9,600	134	0.49	15.1
447	1	12,800	147	.43	11.7
449	1	12,800	147	-.43	-11.6
458	3	12,700	143	-.36	-10.1
	3	12,700	143	.43	12.1
466	3	10,400	171	.46	10.8
	4	10,200	169	.43	10.2
	5	10,000	163	.42	10.4
504	1	10,400	128	-.38	-11.6
518	1	9,600	135	-.39	-11.6
Flight 21, July 15, 1953					
566	1	9,600	125	0.48	16.1
595	1	9,500	124	.30	10.1
623	1	9,500	124	.51	17.2
662	1	9,100	115	.30	10.8
	1	9,100	113	.29	10.5
663	1	9,200	108	-.27	-10.3
	1	9,200	107	-.29	-11.0
667	1	9,400	132	-.33	-10.2
	1	9,300	132	.42	13.0
668	1	9,200	124	.31	10.3
	1	9,200	122	.54	18.4
671	1	9,200	111	.37	13.7
677	1	9,300	128	.34	11.0
	2	9,400	131	.38	12.0
681	1	9,400	137	.42	12.6
685	1	9,400	126	-.43	-14.2
692	1	9,400	120	-.32	-11.0
699	1	9,300	109	-.30	-11.3
	1	9,300	114	.37	13.4
	1	9,200	110	-.27	-10.1
703	1	8,700	113	.50	18.4
	1	8,900	123	.34	11.5
	1	8,900	122	-.30	-10.1
745	3	10,200	130	-.36	-11.5
	7	10,200	132	-.33	-10.0
809	1	12,200	130	-.38	-11.8
813	1	12,000	144	.39	10.9
873	1	11,100	117	.30	10.3
877	1	11,300	118	-.35	-11.9
	1	11,300	118	.35	11.9
878	1	11,400	128	.42	13.2
880	1	11,400	117	-.36	-12.3
882	1	11,200	116	.35	12.1
909	1	11,200	122	.45	14.6
	1	11,200	122	.37	12.1
914	1	11,000	130	.34	10.3
	1	11,000	133	.34	10.3
920	1	10,800	116	.30	10.5
	1	10,800	113	.34	12.0
939	1	10,500	121	.40	13.1
	1	10,600	122	.38	12.3
944	1	10,700	121	.32	10.4
	1	10,700	126	-.33	-10.4
976	2	10,000	141	.37	10.4
986	1	9,900	116	.29	10.0

TABLE I.- SUMMARY OF TURBULENCE DATA - Continued

Radar picture no.	1/2-minute interval	Altitude, ft	Airspeed, V_e, mph	Acceleration increment, a_n, g	Gust velocity, U_{de}, fps
Flight 21, July 15, 1953 - Concluded					
986	1	9,800	119	-0.32	-10.7
	1	9,900	120	-.31	-10.4
	1	9,900	122	-.39	-12.7
	1	9,900	122	.33	10.9
987	1	9,900	121	-.36	-11.9
005	2	9,100	157	.40	10.1
	2	9,100	154	-.44	-11.5
	2	9,000	145	.61	16.6
	2	9,000	146	.43	11.7
Flight 22, July 16, 1953					
145	1	7,300	129	0.32	10.3
146	1	7,300	133	.43	13.6
147	1	7,300	137	.34	10.2
	1	7,300	136	-.33	-10.2
152	2	7,700	134	-.32	-10.0
176	1	6,200	119	-.38	-13.2
	2	6,200	121	-.30	-10.4
283	1	6,400	138	.34	10.0
322	2	5,800	138	.52	15.4
	2	5,900	136	-.35	-10.5
Flight 23, July 17, 1953					
443	1	12,800	120	0.33	11.0
Flight 24, July 22, 1953					
561	1	9,600	134	-0.33	-10.4
	1	9,600	133	.32	10.0
579	1	8,300	120	.31	10.6
	1	8,300	122	.30	10.2
580	1	8,300	118	.32	11.2
581	1	8,200	116	.33	11.8
582	1	8,200	114	.38	13.9
589	1	8,000	124	-.34	-11.3
591	1	7,900	122	-.42	-14.4
593	2	8,000	119	-.30	-10.4
	2	8,000	126	.32	10.6
603	1	7,900	142	.37	10.8
604	2	8,000	140	.35	10.4
607	1	7,700	137	.50	15.2
608	2	7,500	140	-.54	-16.1
609	5	7,500	132	.34	10.7
616	1	7,900	127	.38	12.3
617	1	8,000	128	.37	11.9
618	1	8,000	118	.31	10.9
620	1	8,100	116	.29	10.2
622	1	8,200	122	.30	10.1
	1	8,300	123	.30	10.1
	1	8,200	119	-.37	-12.8
	1	8,300	124	-.32	-10.8
	1	8,400	124	.31	10.4
	1	8,500	111	-.29	-10.7
623	1	8,400	117	.32	11.3
625	1	7,400	107	-.34	-13.0
	1	7,500	108	.27	10.4
	1	7,400	106	.32	12.2

TABLE I.- SUMMARY OF TURBULENCE DATA - Continued

Radar picture no.	1/2-minute interval	Altitude, ft	Airspeed, V_e, mph	Acceleration increment, a_n, g	Gust velocity, U_{de}, fps
Flight 24, July 22, 1953 - Concluded					
626	1	7,600	105	0.36	14.1
	1	7,500	111	.30	11.2
	1	7,500	106	.30	11.8
	1	7,900	111	-.36	-13.3
	1	7,800	106	.28	10.8
627	1	7,900	111	-.31	-11.6
	1	7,800	111	.39	14.3
	1	7,900	110	-.29	-10.9
638	17	8,700	126	.38	12.4
	17	8,800	131	.34	10.6
	18	8,600	141	.40	11.5
639	1	8,600	131	.37	11.5
643	1	7,100	118	.30	10.3
651	1	6,600	127	.34	11.0
662	1	6,400	122	-.36	-12.0
	1	6,500	127	.32	10.4
696	2	9,500	113	-.32	-11.3
722	1	9,600	105	.29	10.8
	1	9,600	112	-.34	-12.1
724	1	9,900	107	-.37	-13.8
Flight 26, July 27, 1953					
768	2	6,000	124	0.31	10.4
	3	6,000	126	-.35	-11.8
	4	6,000	117	.33	11.8
	4	6,100	116	.43	15.7
	5	6,200	127	-.30	-10.0
	6	6,300	119	-.43	-15.3
	6	6,300	118	-.31	-11.1
	6	6,300	120	.34	12.1
	6	6,400	127	-.44	-14.6
	6	6,300	128	.35	11.4
	9	6,900	124	.46	15.4
769	1	7,100	119	-.52	-18.4
	2	7,600	125	.35	11.9
	2	7,700	124	-.37	-12.4
	3	7,700	120	.57	19.9
	3	7,700	118	-.38	-13.6
	3	7,800	120	-.37	-12.9
	3	7,700	119	.42	14.8
	3	7,600	112	-.67	-25.2
	3	7,500	118	.32	11.5
	3	7,500	119	.40	14.1
	4	7,600	119	-.32	-11.2
	4	7,500	116	-.46	-16.5
	4	7,600	116	.30	11.1
	4	7,800	125	-.54	-18.2
771	1	7,800	117	.29	10.4
	1	7,800	120	-.33	-11.5
773	1	8,200	119	.40	14.1
	1	8,300	119	-.31	-11.0
	1	8,300	120	.41	14.3
	1	8,400	119	.30	10.7
	1	8,400	125	-.31	-10.5
791	1	9,800	129	-.60	-19.3
	1	9,900	122	-.58	-19.7
	1	9,900	132	.45	14.1

TABLE I.- SUMMARY OF TURBULENCE DATA - Continued

Radar picture no.	1/2-minute interval	Altitude, ft	Airspeed, V_e, mph	Acceleration increment, a_n, g	Gust velocity, U_{de}, fps
Flight 26, July 27, 1953 - Concluded					
791	1	9,900	130	0.32	10.2
	1	9,900	126	.49	16.0
	1	9,900	136	-.35	-10.7
839	1	9,600	125	.31	10.1
860	1	9,900	144	-.40	-11.3
861	1	9,900	136	-.39	-11.9
863	1	9,700	134	.35	10.7
866	1	9,700	124	-.36	-11.8
Flight 27, July 28, 1953					
929	1	9,700	130	0.41	12.8
930	1	9,700	130	.38	12.0
932	1	9,900	146	.38	10.6
947	1	9,900	123	-.36	-12.1
031	1	10,100	128	-.35	-11.3
	1	9,900	132	.32	10.0
	1	9,900	119	-.43	-14.9
	1	9,900	125	.50	16.3
037	1	10,200	122	-.50	-16.9
206	1	6,300	116	.33	11.4
227	2	7,100	138	.38	11.4
	3	7,000	138	.37	10.9
229	1	6,500	114	.57	20.4
	1	6,700	112	-.29	-10.6
	1	6,600	117	.55	19.0
	1	6,600	118	-.47	-16.1
	1	6,700	115	.33	11.7
	2	6,600	120	-.38	-12.8
	2	6,700	127	.36	11.4
	2	6,600	130	.43	13.6
	2	6,800	132	.33	10.1
252	2	9,100	138	.43	12.1
Flight 28, August 5, 1953					
423	1	6,100	147	-0.37	-10.4
	1	6,000	140	.48	14.2
425	4	6,200	117	-.29	-10.3
451	1	5,900	124	.33	11.2
	2	5,900	123	-.38	-13.1
456	2	6,100	123	.34	11.6
	2	6,100	127	-.48	-15.6
	2	6,100	123	.37	12.4
457	1	6,100	115	-.29	-10.4
	1	6,000	120	.32	11.2
	1	6,000	116	.48	17.2
460	2	6,100	117	.36	12.9
461	1	6,300	112	.30	11.4
	2	6,200	109	.28	10.9
	2	6,200	117	.28	10.1
463	1	6,300	123	-.41	-14.1
	1	6,300	114	.39	14.1
	2	6,400	116	-.29	-10.3
	2	6,100	115	.40	14.6
	2	6,100	102	-.30	-12.4

TABLE I.- SUMMARY OF TURBULENCE DATA - Continued

Radar pictures no.	1/2-minute interval	Altitude, ft	Airspeed, V_e, mph	Acceleration increment, a_n, g	Gust velocity, U_{de}, fps
Flight 28, August 5, 1953 - Continued					
463	2	6,000	99	0.30	12.9
	2	6,000	108	.38	14.6
	2	5,900	110	.34	13.0
	3	5,900	112	.38	14.3
464	1	5,900	113	-.28	-10.3
	1	5,900	118	.37	13.0
474	2	5,800	120	.32	11.0
484	1	6,600	117	.45	15.9
	1	6,800	118	.31	11.1
485	1	6,900	108	-.35	-13.5
	1	6,600	112	.37	13.6
488	1	6,600	121	.32	10.9
	1	6,500	120	.32	11.1
	1	6,700	118	-.42	-14.7
	1	6,700	115	-.35	-12.9
	1	6,700	112	.36	13.5
	1	6,600	123	.37	12.4
	1	6,600	126	.60	20.0
489	1	6,600	125	-.40	-13.2
	1	6,400	108	.27	10.6
	1	6,400	106	-.34	-13.2
490	2	5,900	105	-.25	-10.0
	3	5,900	109	.26	10.0
494	1	6,000	111	-.31	-11.7
497	2	6,000	115	-.32	-11.6
	2	6,000	112	-.34	-12.5
	2	5,900	116	.30	10.8
	3	6,000	109	.27	10.5
	3	6,000	107	-.36	-13.9
498	1	5,900	111	-.30	-11.5
	1	6,000	111	-.46	-17.4
	2	5,900	109	.28	10.8
	2	6,000	111	.34	12.6
	2	6,100	107	.34	13.4
	2	6,000	107	-.26	-10.2
499	1	6,100	109	-.33	-12.6
	1	6,200	107	-.35	-13.7
	1	6,000	107	.27	10.4
	1	6,000	110	.32	12.2
	2	6,000	104	.42	16.7
	2	6,000	111	.30	11.5
	2	6,200	110	-.36	-13.8
	3	6,200	103	-.30	-12.2
	3	6,200	117	.48	17.2
	3	6,300	120	-.97	-33.7
	3	6,300	115	-.33	-11.8
	3	6,200	113	-.40	-14.7
	3	6,200	110	-.30	-11.2
500	1	6,300	114	-.29	-10.7
	1	6,300	120	-.32	-11.0
501	1	6,200	112	-.35	-13.2
	1	6,100	117	.31	11.0
504	1	6,400	121	-.30	-10.4
508	2	6,800	130	.34	10.8
	2	7,000	118	-.42	-14.6

TABLE I.- SUMMARY OF TURBULENCE DATA - Continued

Radar picture no.	1/2-minute interval	Altitude, ft	Airspeed, V_e, mph	Acceleration increment, cm, g	Gust velocity, U_{de}, fps
Flight 28, August 5, 1953 - Concluded					
508	2	6,900	125	0.35	11.8
	2	7,000	120	.34	11.7
	2	7,000	120	.32	11.3
	2	7,000	116	-.31	-11.3
	2	7,000	113	-.31	-11.6
	2	7,000	116	-.29	-10.3
511	2	7,000	116	-.29	-10.4
Flight 29, August 10, 1953					
684	1	7,500	130	0.32	10.1
715	1	7,000	105	-.29	-11.3
720	1	7,400	141	.40	11.6
722	1	7,800	143	-.35	-10.2
	1	7,900	144	.36	10.3
723	1	7,900	143	.46	13.3
760	1	7,400	121	.38	12.8
	1	7,400	112	.32	11.8
762	4	7,200	125	.39	12.8
774	1	7,400	121	.30	10.3
	1	7,400	108	-.43	-16.2
Flight 30, August 17, 1953					
850	1	8,200	154	0.40	10.9
862	1	8,100	123	-.37	-12.6
863	1	8,100	124	-.39	-13.3
882	1	8,200	122	-.34	-11.7
883	1	8,000	116	.30	11.1
890	1	8,100	132	.31	10.0
895	1	7,900	123	-.29	-10.0
899	1	7,900	131	-.31	-10.1
	1	7,800	126	.44	14.9
904	1	8,400	134	.35	11.0
910	1	8,600	135	.39	12.2
911	2	8,300	142	.52	15.3
	3	7,900	150	.44	12.3
978	1	8,600	118	.39	13.8
979	1	8,600	127	.38	12.4
	1	8,600	126	.63	20.9
	1	8,600	121	.31	10.9
	2	8,500	123	.34	11.7
Flight 31, August 18, 1953					
120	1	7,900	132	-0.34	-11.0
	1	7,800	131	-.34	-10.7
	1	8,400	126	-.30	-10.0
123	1	8,500	140	-.37	-11.1
151	1	8,600	125	.44	14.5
	1	8,600	120	-.32	-11.1
154	1	8,500	124	.40	13.5
	1	8,700	126	-.31	-10.3
155	1	8,700	135	-.66	-20.2
	1	8,800	129	.39	12.7
156	1	8,700	127	-.32	-10.6
	1	8,600	129	.44	14.3
	1	8,700	138	.41	12.5
	1	8,700	135	.61	18.9
171	1	8,400	148	-.52	-14.5

TABLE I.- SUMMARY OF TURBULENCE DATA - Continued

Radar picture no.	1/2-minute interval	Altitude, ft	Airspeed, V_e, mph	Acceleration increment, a_n, g	Gust velocity, U_{de}, fps
Flight 31, August 18, 1953 - Concluded					
171	1	8,400	140	0.40	11.9
227	1	8,100	118	-.31	-11.0
228	1	9,900	121	.36	12.5
	1	8,100	119	.44	15.5
	1	8,100	115	.30	10.9
232	1	8,200	129	-.31	-10.1
233	1	8,200	122	-.30	-10.3
	1	8,200	118	.31	11.2
	1	8,200	120	-.48	-16.7
	1	8,200	121	-.49	-17.0
279	1	7,600	116	-.28	-10.2
281	1	7,600	113	-.28	-10.3
330	5	7,600	121	.35	12.1
331	1	7,700	148	.39	11.0
	1	7,800	138	.50	15.1
332	4	7,600	154	-.39	-10.5
	4	7,500	148	.53	14.9
	4	7,600	155	-.41	-11.0
	4	7,600	156	.50	13.4
	5	7,500	148	.47	13.3
Flight 32, August 19, 1953					
357	2	8,400	155	-0.44	-12.0
358	1	8,400	147	-.42	-12.0
	1	8,400	146	-.53	-15.2
367	6	8,500	145	.35	10.2
	6	8,600	143	.38	11.1
368	1	8,600	156	.56	14.8
	1	8,700	147	-.44	-12.6
	1	8,700	159	-.41	-10.7
370	3	8,400	162	-.42	-10.8
	3	8,500	162	-.39	-10.0
381	3	8,400	167	.65	16.0
	3	8,500	169	.46	11.1
382	1	8,500	172	-.47	-11.3
	1	8,500	164	-.85	-21.4
	1	8,300	166	.65	16.1
383	2	8,400	164	.59	15.0
	2	8,500	167	.62	15.2
	2	8,300	155	.48	12.7
	3	8,300	173	.52	12.4
	3	8,400	164	-.42	-10.5
	3	8,300	154	.44	11.7
	3	8,400	158	-.46	-12.1
	4	8,400	173	-.52	-12.5
	4	8,400	163	-.48	-12.1
	4	8,400	160	.63	16.3
	4	8,300	164	-.58	-14.7
	4	8,300	153	.53	14.2
	4	8,300	165	.42	10.4
384	1	8,200	168	.44	10.9
	1	8,300	162	-.53	-13.6

TABLE I.- SUMMARY OF TURBULENCE DATA - Continued

Radar picture no.	1/2-minute interval	Altitude, ft	Airspeed, V_e, mph	Acceleration increment, a_n, g	Gust velocity, U_{de}, fps
Flight 32, August 19, 1953 - Concluded					
384	1	8,200	163	0.40	10.1
	1	8,200	162	.70	17.7
	1	8,200	169	.48	11.7
	1	8,200	158	-.43	-11.3
	2	8,200	157	.41	10.9
	2	8,200	153	-.40	-10.8
385	1	8,200	145	.52	14.8
	1	8,200	156	.50	13.2
	1	8,200	164	-.65	-16.3
	1	8,200	152	-.53	-14.5
	1	8,100	151	-.42	-11.3
	1	8,100	160	.43	11.1
	1	8,000	157	.46	12.0
	2	8,000	156	.56	14.9
	2	8,000	162	.53	13.5
	2	8,100	164	-.42	-10.6
	2	8,000	160	.46	12.0
	3	8,000	157	.39	10.3
	4	8,000	168	.43	10.6
	4	8,000	165	.45	11.3
386	3	8,000	155	.39	10.4
	4	8,100	141	-.61	-17.9
	4	8,100	147	.36	10.0
389	2	7,600	144	.44	12.7
393	5	8,600	145	.39	11.1
	6	8,500	155	.50	13.4
	7	8,400	155	.38	10.1
394	3	8,200	153	.38	10.2
	6	8,200	137	-.39	-11.9
	6	8,200	137	.34	10.1
395	2	8,300	137	.43	13.0
397	2	8,300	146	.37	10.3
399	2	8,500	160	-.39	-10.2
401	17	10,900	130	.35	11.1
409	17	7,800	137	-.37	-11.0
413					
	6	8,200	135	-.39	-11.9
	14	8,200	154	-.38	-10.1
	20	8,300	154	.41	10.8
	22	8,300	146	-.36	-10.2
414	2	8,200	151	.38	10.4
	21	8,200	153	.46	12.3
Flight 36, September 8, 1953					
758	1	2,800	172	0.42	10.4
760	2	1,900	130	.35	11.6
	2	1,900	131	-.31	-10.0
	5	1,500	124	-.34	-11.6
761	5	800	96	.26	11.7
	5	800	91	.39	18.4
	5	800	91	.27	12.5
Flight 38, September 17-18, 1953					
803	1	7,200	136	-0.33	-10.1
	1	7,200	132	-.35	-11.0
804	1	7,200	138	.36	10.9
	1	7,200	141	-.49	-14.4
	2	7,100	137	-.34	-10.5

TABLE I.- SUMMARY OF TURBULENCE DATA - Concluded

Radar picture no.	1/2-minute interval	Altitude, ft	Airspeed, V_e, mph	Acceleration increment, a_n, g	Gust velocity, U_{de}, fps
Flight 38, September 17-18, 1953 - Concluded					
804	3	7,000	140	-0.39	-11.6
805	1	7,100	128	-.37	-12.1
	1	7,100	141	.36	10.7
	2	7,200	140	.39	11.6
806	1	7,300	138	.35	10.5
808	2	7,300	151	.41	11.3
	3	7,200	139	.33	10.0
	3	7,200	139	-.50	-15.0
	3	7,200	142	.44	13.0
	3	7,200	127	-.32	-10.6
	3	7,100	130	.35	11.3
	4	7,300	126	-.55	-18.5
	4	7,200	133	.38	11.8
	4	7,300	129	-.45	-14.6
809	2	7,400	143	.39	11.4
811	1	7,500	141	-.34	-10.0
812	1	7,300	142	.34	10.0
817	1	7,600	137	-.45	-13.6
818	1	7,600	132	.38	12.1
819	1	7,500	142	.50	14.7
823	2	7,200	131	.49	15.6
	2	7,200	131	-.34	-10.9
824	1	7,300	134	.37	11.4
833	42	7,200	147	.39	10.8
834	1	7,100	146	-.48	-13.5
835	1	7,000	129	-.58	-18.6
837	1	7,100	122	.32	10.8
841	1	7,100	127	-.31	-10.0
857	1	5,300	130	-.35	-11.1
860	1	5,300	122	-.42	-14.0
862	2	5,500	127	.47	15.3
864	1	5,600	136	.52	15.7
877	1	5,500	156	-.41	-10.7
880	1	5,500	162	-.42	-10.7
881	1	5,400	140	.59	17.4
	1	5,300	140	-.74	-21.7
	1	5,300	142	.43	12.4
	1	5,300	144	-.40	-11.4
	1	5,300	147	-.40	-11.3
881	2	4,900	152	.59	16.1
	2	4,800	147	.42	11.9
	3	4,500	159	.63	16.6
	3	4,500	157	.38	10.0
	3	4,500	150	.38	10.6
	3	4,600	157	-.42	-11.2
	3	4,600	150	-.37	-10.3
	3	4,500	144	-.37	-10.8
	3	4,600	144	.45	12.9
	3	4,600	145	-.52	-15.0
882	1	4,500	137	.39	12.0
	1	4,500	137	-.42	-12.6
	2	4,500	140	-.38	-11.3
	2	4,400	135	.38	11.7
	2	4,100	139	.36	10.7
884	1	3,300	133	-.40	-12.7
Flight 39, September 18, 1953					
900	3	7,800	147	0.36	11.2
	3	7,900	135	.31	10.6
901	1	7,800	147	.35	10.8
	1	7,700	145	.42	13.1
	2	7,800	146	.32	10.0
904	1	7,900	136	-.30	-10.0
	1	7,900	136	-.34	-11.5
	1	7,900	133	.30	10.4
	1	7,800	130	.32	11.3
	1	7,900	133	-.30	-10.2
	2	7,800	133	-.37	-12.6
905	1	7,800	135	.30	10.3

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