

**TRIANGULATION TESTS AT THE
NEW YORK, PITTSBURGH AND WASHINGTON
DIRECTION FINDER STATIONS**

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TRIANGULATION TESTS AT THE
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DIRECTION FINDER STATIONS

INTRODUCTION

This note describes the triangulation tests which were conducted during the period of December 3 to 12, 1942, on three Civil Aeronautics Administration direction finders located at New York, N.Y., Pittsburgh, Pa., and Washington, D.C. The tests were conducted primarily to determine the limitations and accuracy of the equipment when used to establish the position of an airplane by triangulation methods.

EQUIPMENT

The ground equipment at each station consisted of a Western Electric Azimuth Indicating Radio Receiver with calibrating test oscillator and remote indicating unit supplied by the Graybar Electric Company.

The airplane used for flight testing was the CAA Boeing, NC-11. The transmitting equipment in the plane was a 50-watt commercial Type TA-26 Bendix transmitter.

METHOD OF TESTING

The method of testing consisted of taking simultaneous bearings at the three stations on transmissions from NC-11. The course of flight of the airplane was not known to the operators of the ground equipment. Transmissions were made over known points and lasted about 25 seconds with voice identification at the beginning and end of each transmission. In order that tests of several frequencies could be made during each flight, a time schedule was maintained as follows:

<u>Frequency</u>	<u>Airline Frequency</u>	<u>Time Minutes (any hour)</u>
4122.5 kc	EAL	00-06 and 30-36
4937.5 kc	TWA	06-12 and 36-42
5572.5 kc	UAL	12-18 and 42-48
5612.5 kc	AA	18-24 and 48-54
6210.0 kc	Itinerant	24-30 and 54-60

The information obtained and recorded at each station for each transmission received, included: time, frequency, class of bearing and observed bearing. The class of bearing indicates the amount of angular deviation in degrees that the bearing indication varied during the 25-second transmission. The following bearing classifications were used for these tests:

- Class A - Angular deviation of not more than $\pm 1^\circ$
- Class B - Angular deviation of not more than $\pm 5^\circ$
- Class C - Angular deviation of not more than $\pm 10^\circ$
- Class D - Angular deviation of more than $\pm 10^\circ$

The observed bearing in any class is the average of the indicated bearing plus the correction obtained from the station's calibration curve.

TESTS

Flight No. 1

This flight was made December 3, 1942, from Pittsburgh to New York via Harrisburg, Washington, Baltimore and Philadelphia. A total of 81 transmissions was made during the period 2:48 p.m. to 5:54 p.m. On this flight test the Pittsburgh equipment was inoperative on two frequencies and the New York station experienced high noise interference which greatly affected the bearing indications and made voice identification nearly unintelligible.

The data obtained on this flight are tabulated in table I.

Flight No. 2

This flight was made December 4, 1942, from New York City to Washington via the New Jersey coast to Cape May, N.J. A total of 59 transmissions was made during the period 3:45 p.m. to 6:01 p.m. On this flight test the Pittsburgh station was not in operation.

The data obtained on this flight are tabulated in table II.

Flight No. 3

This flight was made December 5, 1942, from Washington to Pittsburgh via Roanoke, Va. A total of 63 transmissions was made during the period 10:55 a.m. to 1:46 p.m. On this flight test the Pittsburgh station was not in operation.

The data obtained on this flight are tabulated in table III.

Flight No. 4

This flight was made December 12, 1942, from Pittsburgh, Pa., to Indianapolis, Ind., via Dunkirk, N.Y., Cleveland and Toledo, Ohio. A total of 95 transmissions was made during the period 11:01 a.m. to 3:22 p.m.

The data obtained on this flight are tabulated in table IV.

DISCUSSION

The method of obtaining bearings with this type direction finder equipment is to observe the position of a light spot on a cathode ray tube and obtain the azimuth angle in degrees from a scale located around the periphery of the tube's screen. Under favorable conditions of transmission, the light spot shows a steady deflection in both amplitude and azimuth angle. The bearings obtained under these conditions are considered as class "A" bearings. Under unfavorable conditions of transmission caused mainly by polarization changes, diversity effects, atmospheric disturbances and high noise levels, the light spot does not have a steady deflection but varies in both amplitude and direction. Bearings obtained under these conditions are classed "B", "C" or "D" depending on the degree of variation of the light spot deflection. The type of variation in the light spot deflection indicates when bearings are questionable.

In observing and recording bearings during these triangulation flight tests, all indicated bearings were recorded if it was possible to identify the transmission. No attempt was made to discard bearings which showed erratic behavior or gave only a small deflection of the light spot even though they were known to be bad bearings.

To assist in analyzing the results of these tests, the following curves have been plotted from the recorded data: average error, Flight No. 1, Washington and New York; average error, Flight No. 2, Washington and New York; average error, Flight No. 3, Washington and New York; average error, Flight No. 4, Washington, New York, and Pittsburgh; maximum and average error, Flight Nos. 1 and 4, Pittsburgh; maximum and average error, all flights, Washington; maximum and average error, all flights, New York; individual frequency error, Flight No. 4, Pittsburgh; individual frequency error, all flights, Washington; average error vs. distance, all flights, New York; average error vs. distance, all flights, Washington; average error vs. distance, Flight No. 4, Pittsburgh.

CONCLUSIONS

These tests which were conducted over land indicate that:

1. The direction finders give bearing accuracies which vary widely with distance. The average error which may be expected is as follows:

<u>Distance in Miles</u>	<u>Average Error</u>
0-75	$\pm 5^\circ$
75-300	$\pm 15^\circ$
300-600	$\pm 3^\circ$

2. The system does not show any pronounced difference in accuracy for different frequencies.
3. It will be necessary to reduce polarization errors and errors due to diversity effects in order to obtain more accurate aircraft position fixes.
4. The accuracy of determining the position of an aircraft by triangulation methods would be greatly improved by the use of a network of six or more direction finder facilities, inasmuch as bearings within the skip distance could be discarded.
5. Considerably different average error vs. distance curves were obtained from identical direction finders when installed at three different locations. This would indicate that it is essential to compare different types of direction finders at the same site in order to draw any definite conclusions as to their relative performance.

TABLE I

TRIANGULATION TESTS OF NC-11 BY WASHINGTON, NEW YORK, AND PITTSBURGH DIRECTION FINDERS

DECEMBER 3, 1942

POSITION NUMBER	1	2	3	4	5	6	7
TIME	2:48 P.M.	2:50 P.M.	2:51:30 P.M.	2:53 P.M.	2:57 P.M.	2:57:30 P.M.	3:02 P.M.
FREQUENCY KC	5572.5	5612.5	5612.5	5612.5	6210	6210	4122.5
LOCATION OF PLANE	McKeesport	Irwin	Jeanette	North of Greensburg	Latrobe	—	—
DISTANCE FROM PITTSBURGH IN MILES	4.5	12	17	21	30	31	44
TRUE BEARING FROM PITTSBURGH	70°	88°	90°	91.5°	92°	92°	90°
OBSERVED BEARING FROM PITTSBURGH	*	82°B	83°B	78°B	104°B	93°B	79°B
AZIMUTH ERROR FROM PITTSBURGH	—	- 6°	- 7°	- 3.5°	+ 12°	+ 1°	- 11°
DISTANCE FROM WASHINGTON IN MILES	192	185	181	182	170	168	159
TRUE BEARING FROM WASHINGTON	305.5°	306°	307°	307.5°	309°	309.5°	313°
OBSERVED BEARING FROM WASHINGTON	—	309°D	309°D	314°D	313°D	315°D	298°D
AZIMUTH ERROR FROM WASHINGTON	—	+ 3°	+ 2°	+ 6.5°	+ 4°	+ 5.5°	- 15°
DISTANCE FROM NEW YORK IN MILES	315	308	304	299	291	289	276
TRUE BEARING FROM NEW YORK	268.5°	268°	268°	268°	267.5°	267.5°	267.5°
OBSERVED BEARING FROM NEW YORK	—	—	—	—	279°B	279°C	—
AZIMUTH ERROR FROM NEW YORK	—	—	—	—	+ 11.5°	+ 11.5°	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "LG" BEARINGS MILES AND DIRECTION	—	—	—	—	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "WA" BEARINGS MILES AND DIRECTION	—	—	—	—	35 MI.S.E.	24 MI.E.	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "WA" & "LG" BEARINGS MILES AND DIRECTION	—	—	—	—	87 MI.N.W.	76 MI.N.W.	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING CENTER OF TRIANGLE MILES AND DIRECTION	—	—	—	—	—	—	—

* Pittsburgh Equipment not Operating on Frequencies 4937.5 and 5572.5 kc.

TABLE I

TRIANGULATION TESTS OF NC-11 BY WASHINGTON, NEW YORK, AND PITTSBURGH DIRECTION FINDERS

DECEMBER 3, 1942

POSITION NUMBER	8	9	10	11	12	13	14
TIME	3:04 P.M.	3:05:30 P.M.	3:07 P.M.	3:09:30 P.M.	3:14 P.M.	3:16:30 P.M.	3:18:30 P.M.
FREQUENCY KC	4122.5	4122.5	4937.5	4937.5	5572.5	5572.5	5572.5
LOCATION OF PLANE	Johnstown	—	—	—	—	—	—
DISTANCE FROM PITTSBURGH IN MILES	54	60	64	63	80	84	91
TRUE BEARING FROM PITTSBURGH	91°	90°	88°	90.5°	90°	90°	90°
OBSERVED BEARING FROM PITTSBURGH	—	91° C	*	*	*	*	*
AZIMUTH ERROR FROM PITTSBURGH	—	+ 1°	—	—	—	—	—
DISTANCE FROM WASHINGTON IN MILES	152	148	147	145	134	130	128
TRUE BEARING FROM WASHINGTON	315°	317°	318.5°	317.5°	323°	325°	327°
OBSERVED BEARING FROM WASHINGTON	309° D	300° D	317° D	315° D	320° D	317° D	—
AZIMUTH ERROR FROM WASHINGTON	- 6°	- 17°	- 1.5°	- 2.5°	- 3°	- 8°	—
DISTANCE FROM NEW YORK IN MILES	266	260	256	257	240	235	229
TRUE BEARING FROM NEW YORK	267°	267°	267.5°	267°	266.5°	266°	266°
OBSERVED BEARING FROM NEW YORK	—	—	N.E. Quad.	75° D	75° D	—	—
AZIMUTH ERROR FROM NEW YORK	—	—	—	+ 178°	+ 178.5°	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "LG" BEARINGS MILES AND DIRECTION	—	—	—	—	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "WA" BEARINGS MILES AND DIRECTION	—	—	—	—	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "WA" & "LG" BEARINGS MILES AND DIRECTION	—	—	—	—	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING CENTER OF TRIANGLE MILES AND DIRECTION	—	—	—	—	—	—	—

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TRIANGULATION TESTS OF NC-11 BY WASHINGTON, NEW YORK, AND PITTSBURGH DIRECTION FINDERS

DECEMBER 3, 1942

POSITION NUMBER	15	16	17	18	19	20	21
TIME	3:19:30 P.M.	3:21 P.M.	3:23 P.M.	3:25:30 P.M.	3:28 P.M.	3:34 P.M.	3:36 P.M.
FREQUENCY KC	5612.5	5612.5	5612.5	6210	6210	4122.5	4122.5
LOCATION OF PLANE	—	—	—	—	—	—	—
DISTANCE FROM PITTSBURGH IN MILES	94	101	101.5	106	119	130	135
TRUE BEARING FROM PITTSBURGH	90°	91°	90°	90°	90°	93°	93°
OBSERVED BEARING FROM PITTSBURGH	117°D	128°D	128°D	131°D	135°D	133°B	—
AZIMUTH ERROR FROM PITTSBURGH	+ 27°	+ 37°	+ 38°	+ 41°	+ 45°	+ 40°	—
DISTANCE FROM WASHINGTON IN MILES	126	121	122	120	114	104	101
TRUE BEARING FROM WASHINGTON	328°	330.5°	331°	333°	338°	343°	345°
OBSERVED BEARING FROM WASHINGTON	325°D	338°D	328°D	336°D	—	339°Int.	342°D
AZIMUTH ERROR FROM WASHINGTON	- 3°	+ 7.5°	- 3°	+ 3°	—	- 4°	- 3°
DISTANCE FROM NEW YORK IN MILES	226	220	219	215	202	192	187
TRUE BEARING FROM NEW YORK	266°	265.5°	265.5°	265.5°	265°	262.5°	262°
OBSERVED BEARING FROM NEW YORK	260-290°D	276°B	276°D	260-290°D	—	—	—
AZIMUTH ERROR FROM NEW YORK	+ 9°	+ 10.5°	+ 10.5°	+ 9.5°	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "LG" BEARINGS MILES AND DIRECTION	—	—	—	—	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "WA" BEARINGS MILES AND DIRECTION	87 MI.S.E.	—	—	—	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "WA" & "LG" BEARINGS MILES AND DIRECTION	50 MI.N.W.	41 MI.N.	53 MI.N.W.	37 MI.N.N.W.	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING CENTER OF TRIANGLE MILES AND DIRECTION	—	—	—	—	—	—	—

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DECEMBER 3, 1942

POSITION NUMBER	22	23	24	25	26	27	28
TIME	3:38 P.M.	3:40 P.M.	3:41:30 P.M.	3:43:30 P.M.	3:44:30 P.M.	3:48 P.M.	3:52 P.M.
FREQUENCY KC	4937.5	4937.5	4937.5	5572.5	5572.5	5572.5	5612.5
LOCATION OF PLANE	Plainfield	Carlisle	Wilson Airport	Mechanicsburg	—	—	Dover, Pa.
DISTANCE FROM PITTSBURGH IN MILES	140	145	151	155	158	159	165
TRUE BEARING FROM PITTSBURGH	93°	93°	92°	92°	92°	94°	97°
OBSERVED BEARING FROM PITTSBURGH	*	*	*	*	*	*	124° D
AZIMUTH ERROR FROM PITTSBURGH	—	—	—	—	—	—	+ 27°
DISTANCE FROM WASHINGTON IN MILES	100	99	101	99	99	94	84
TRUE BEARING FROM WASHINGTON	348°	351°	354.5°	356°	358°	359°	1.5°
OBSERVED BEARING FROM WASHINGTON	347° D	353° C	356° C	356° D	359° D	0° D	10° D
AZIMUTH ERROR FROM WASHINGTON	- 1°	+ 2°	+ 1.5°	0°	+ 1°	+ 1°	+ 8.5°
DISTANCE FROM NEW YORK IN MILES	182	177	171	167	164	164	163
TRUE BEARING FROM NEW YORK	262°	262°	262°	261.5°	261°	259°	255.5°
OBSERVED BEARING FROM NEW YORK	80-300° D	90-270° D	90-270° D	—	90-270° D	—	260° C
AZIMUTH ERROR FROM NEW YORK	—	—	—	—	—	—	+ 4.5°
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "LG" BEARINGS MILES AND DIRECTION	—	—	—	—	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "WA" BEARINGS MILES AND DIRECTION	—	—	—	—	—	—	113 MI. W.S.W.
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "WA" & "LG" BEARINGS MILES AND DIRECTION	—	—	23 MI. N.	—	26 MI. N.	—	22 MI. N.E.
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING CENTER OF TRIANGLE MILES AND DIRECTION	—	—	—	—	—	—	—

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TRIANGULATION TESTS OF NC-11 BY WASHINGTON, NEW YORK, AND PITTSBURGH DIRECTION FINDERS

DECEMBER 3, 1942

POSITION NUMBER	29	30	31	32	33	34	35
TIME	3:53:30 P.M.	3:55 P.M.	3:57 P.M.	3:59 P.M.	4:03 P.M.	4:04 P.M.	4:05 P.M.
FREQUENCY KC	5612.5	6210	6210	6210	4122.5	4122.5	4122.5
LOCATION OF PLANE	Thomasville	Spring Grove	—	—	Silver Run	—	Westminster
DISTANCE FROM PITTSBURGH IN MILES	166	166	165	164	160	164	165
TRUE BEARING FROM PITTSBURGH	99°	100°	101.5°	103	105.5°	107°	108°
OBSERVED BEARING FROM PITTSBURGH	124°D	126°D	117°D	117°D	117°B	117°B	117°B
AZIMUTH ERROR FROM PITTSBURGH	+25°	+26°	+15.5°	+14°	+11.5°	+10°	+9°
DISTANCE FROM WASHINGTON IN MILES	78	75	71	69	61	57	54
TRUE BEARING FROM WASHINGTON	1.5°	1°	0°	359°	353°	355°	354°
OBSERVED BEARING FROM WASHINGTON	10°D	—	—	—	0°D	353°D	355°D
AZIMUTH ERROR FROM WASHINGTON	+8.5°	—	—	—	+7°	-2°	+1°
DISTANCE FROM NEW YORK IN MILES	165	167	169	172	180	180	181
TRUE BEARING FROM NEW YORK	254°	253°	252°	251°	249.5°	248°	247°
OBSERVED BEARING FROM NEW YORK	270°C	—	—	—	—	—	—
AZIMUTH ERROR FROM NEW YORK	+6°	—	—	—	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "LG" BEARINGS MILES AND DIRECTION	—	—	—	—	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "WA" BEARINGS MILES AND DIRECTION	51 MI. N.N.E.	—	—	—	42 MI. S.	36 MI. S.	32 MI. S.
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "WA" & "LG" BEARINGS MILES AND DIRECTION	—	—	—	—	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING CENTER OF TRIANGLE MILES AND DIRECTION	—	—	—	—	—	—	—

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TRIANGULATION TESTS OF NC-11 BY WASHINGTON, NEW YORK, AND PITTSBURGH DIRECTION FINDERS

DECEMBER 3, 1942

POSITION NUMBER	36	37	38	39	40	41	42
TIME	4:11 P.M.	4:12 P.M.	4:13 P.M.	4:17 P.M.	4:20:30 P.M.	4:22:30 P.M.	4:25 P.M.
FREQUENCY KC	4937.5	4937.5	5572.5	5572.5	5612.5	5612.5	6210
LOCATION OF PLANE	—	—	—	Sandy Spring	—	Garrett Park	—
DISTANCE FROM PITTSBURGH IN MILES	166	170	171	175	179	177	175
TRUE BEARING FROM PITTSBURGH	109°	113°	113°	117°	119°	120°	122°
OBSERVED BEARING FROM PITTSBURGH	*	*	*	*	129° C	124° C	143° D
AZIMUTH ERROR FROM PITTSBURGH	—	—	—	—	+ 11°	+ 4°	+ 21°
DISTANCE FROM WASHINGTON IN MILES	50	40	37	25	20	20	20
TRUE BEARING FROM WASHINGTON	355°	352°	352°	343°	340°	324°	314°
OBSERVED BEARING FROM WASHINGTON	—	355° B	352° B	348° A	340° A	326° B	310° A
AZIMUTH ERROR FROM WASHINGTON	—	+ 3°	0°	+ 5°	0°	+ 2°	- 4°
DISTANCE FROM NEW YORK IN MILES	182	188	189	197	200	205	209
TRUE BEARING FROM NEW YORK	246°	243°	242°	239.5°	238°	238°	238°
OBSERVED BEARING FROM NEW YORK	—	—	250° D	240° D	235° C	230° C	—
AZIMUTH ERROR FROM NEW YORK	—	—	+ 8°	+ 0.5°	- 3°	- 8°	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "LG" BEARINGS MILES AND DIRECTION	—	—	—	—	33 MI.S.W.	25 MI.S.E.	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "WA" BEARINGS MILES AND DIRECTION	—	—	—	—	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "WA" & "LG" BEARINGS MILES AND DIRECTION	—	—	26 MI.N.	3 MI.N.	11 MI.S.	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING CENTER OF TRIANGLE MILES AND DIRECTION	—	—	—	—	—	—	—

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TABLE I

TRIANGULATION TESTS OF NC-11 BY WASHINGTON, NEW YORK, AND PITTSBURGH DIRECTION FINDERS

DECEMBER 3, 1942

POSITION NUMBER	43	44	45	46	47	48	49
TIME	4:26 P.M.	4:28 P.M.	4:29 P.M.	4:31 P.M.	4:33 P.M.	4:35 P.M.	4:37 P.M.
FREQUENCY KC	6210	6210	6210	4122.5	4122.5	4122.5	4937.5
LOCATION OF PLANE	—	—	—	—	—	—	—
DISTANCE FROM PITTSBURGH IN MILES	176	179	179	179	185	190	192
TRUE BEARING FROM PITTSBURGH	123°	124°	124.5°	126°	127°	126°	125°
OBSERVED BEARING FROM PITTSBURGH	143° D	138° D	—	—	143° D	129° D	*
AZIMUTH ERROR FROM PITTSBURGH	+ 20.5°	+ 14°	—	—	+ 16°	+ 3°	—
DISTANCE FROM WASHINGTON IN MILES	19	16	17	20	18	13	10
TRUE BEARING FROM WASHINGTON	305°	290°	283°	265°	249°	238°	230°
OBSERVED BEARING FROM WASHINGTON	304° A	292° A	283° B	260° A	246° A	233° A	239° A
AZIMUTH ERROR FROM WASHINGTON	- 1°	+ 2°	0°	- 5°	- 3°	- 5°	+ 9°
DISTANCE FROM NEW YORK IN MILES	212	215	217	222	223	219	215
TRUE BEARING FROM NEW YORK	237.5°	236°	237°	235°	234°	233°	232°
OBSERVED BEARING FROM NEW YORK	—	—	—	238° C	—	—	—
AZIMUTH ERROR FROM NEW YORK	—	—	—	+ 4°	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "LQ" BEARINGS MILES AND DIRECTION	—	—	—	—	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "WA" BEARINGS MILES AND DIRECTION	171 MI.N.W.	96 MI.	—	—	52 MI.S.W.	10 MI.S.W.	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "WA" & "LQ" BEARINGS MILES AND DIRECTION	—	—	—	40 MI.W.S.W.	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING CENTER OF TRIANGLE MILES AND DIRECTION	—	—	—	—	—	—	—

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TABLE I

TRIANGULATION TESTS OF NC-11 BY WASHINGTON, NEW YORK, AND PITTSBURGH DIRECTION FINDERS

DECEMBER 3, 1942

POSITION NUMBER	50	51	52	53	54	55	56
TIME	4:41:30 P.M.	4:43 P.M.	4:45 P.M.	4:48 P.M.	4:50:30 P.M.	4:53 P.M.	4:56 P.M.
FREQUENCY KO	4937.5	5572.5	5572.5	5572.5	5612.5	5612.5	6210
LOCATION OF PLANE	—	Upper Marlboro	Leeland	Collington	Odenton	Linthicum Heights	—
DISTANCE FROM PITTSBURGH IN MILES	200	201	199	195	193	192	192
TRUE BEARING FROM PITTSBURGH	122°	121°	120°	118.5°	116°	113.5°	112.5°
OBSERVED BEARING FROM PITTSBURGH	*	*	*	*	131° D	117° C	131° D
AZIMUTH ERROR FROM PITTSBURGH	—	—	—	—	+15°	+3.5°	+18.5°
DISTANCE FROM WASHINGTON IN MILES	6	8	9	13	22	31	36
TRUE BEARING FROM WASHINGTON	115°	90°	63°	34°	27°	26°	25°
OBSERVED BEARING FROM WASHINGTON	137° A	86° B	58° A	30° A	28° A	22° B	25° C
AZIMUTH ERROR FROM WASHINGTON	+22°	-4°	-5°	-4°	+1°	-4°	0°
DISTANCE FROM NEW YORK IN MILES	204	200	197	193	186	178	173
TRUE BEARING FROM NEW YORK	231°	231°	232°	233.5°	235°	236.5°	238°
OBSERVED BEARING FROM NEW YORK	N.E. Quad.	230° D	230° D	—	230° D	N.W. Quad.	—
AZIMUTH ERROR FROM NEW YORK	—	-1°	-2°	—	-5°	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "LG" BEARINGS MILES AND DIRECTION	—	—	—	—	52 MI. S.W.	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "WA" BEARINGS MILES AND DIRECTION	—	—	—	—	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "WA" & "LG" BEARINGS MILES AND DIRECTION	—	10 MI. E.	46 MI. N.E.	—	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING CENTER OF TRIANGLE MILES AND DIRECTION	—	—	—	—	—	—	—

* Pittsburgh Equipment not Operating on Frequencies 4937.5 and 5572.5 kc.

TABLE I

TRIANGULATION TESTS OF NC-11 BY WASHINGTON, NEW YORK, AND PITTSBURGH DIRECTION FINDERS

DECEMBER 3, 1942

POSITION NUMBER	57	58	59	60	61	62	63
TIME	4:59 P.M.	5:02 P.M.	5:04 P.M.	5:06 P.M.	5:08 P.M.	5:11:30 P.M.	5:14 P.M.
FREQUENCY KC	6210	4122.5	4122.5	4122.5	4937.5	4937.5	5572.5
LOCATION OF PLANE	—	Kingsville	Bel Air	—	—	—	Cherryhill
DISTANCE FROM PITTSBURGH IN MILES	194	197	199	205	207	218	223
TRUE BEARING FROM PITTSBURGH	108°	107°	105°	103°	102°	102°	101°
OBSERVED BEARING FROM PITTSBURGH	131° D	117° D	113° C	113° C	*	*	*
AZIMUTH ERROR FROM PITTSBURGH	+ 23°	+ 10°	+ 8°	+ 10°	—	—	—
DISTANCE FROM WASHINGTON IN MILES	48	52	59	70	73	77	83
TRUE BEARING FROM WASHINGTON	27°	30°	30°	33°	34°	41°	43°
OBSERVED BEARING FROM WASHINGTON	26° D	33° D	34° D	31° D	32° D	38° D	38° D
AZIMUTH ERROR FROM WASHINGTON	- 1°	+ 3°	+ 4°	- 2°	- 2°	- 3°	- 5°
DISTANCE FROM NEW YORK IN MILES	162	158	152	141	137	130	124
TRUE BEARING FROM NEW YORK	239°	239°	240.5°	242°	241°	238°	238°
OBSERVED BEARING FROM NEW YORK	—	251° B	—	—	NE-SW D	NE-SW D	—
AZIMUTH ERROR FROM NEW YORK	—	+ 12°	—	—	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "LG" BEARINGS MILES AND DIRECTION	—	78 MI.W.	—	—	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "WA" BEARINGS MILES AND DIRECTION	—	34 MI.W.S.W.	28 MI.S.S.W.	39 MI.S.W.	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "WA" & "LG" BEARINGS MILES AND DIRECTION	—	6 MI.N.E.	—	—	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING CENTER OF TRIANGLE MILES AND DIRECTION	—	21 MI.S.W.	—	—	—	—	—

* Pittsburgh Equipment not Operating on Frequencies 4937.5 and 5572.5 kc.

TABLE I

TRIANGULATION TESTS OF NC-11 BY WASHINGTON, NEW YORK, AND PITTSBURGH DIRECTION FINDERS

DECEMBER 3, 1942

POSITION NUMBER	64	65	66	67	68	69	70
TIME	5:15 P.M.	5:17 P.M.	5:20 P.M.	5:21 P.M.	5:22 P.M.	5:24 P.M.	5:26 P.M.
FREQUENCY KC	5572.5	—	5612.5	5612.5	5612.5	5612.5	6210
LOCATION OF PLANE	Newark, Pa.	Marshalltown	—	Skycraft Airport	Claymont Airport	River-Chester, Pa.	Philadelphia R.R.
DISTANCE FROM PITTSBURGH IN MILES	227	232	237	238	243	245	248
TRUE BEARING FROM PITTSBURGH	100.5°	99°	98°	98°	97.5°	97°	96°
OBSERVED BEARING FROM PITTSBURGH	*	—	112° C	107° C	—	108° C	—
AZIMUTH ERROR FROM PITTSBURGH	—	—	+ 14°	+ 9°	—	+ 11°	—
DISTANCE FROM WASHINGTON IN MILES	87	95	99	102	107	110	115
TRUE BEARING FROM WASHINGTON	44°	45°	47°	47°	47.5°	48.5°	48.5°
OBSERVED BEARING FROM WASHINGTON	34° D	—	42° D	44° D	45° D	35° D	—
AZIMUTH ERROR FROM WASHINGTON	- 10°	—	- 5°	- 3°	- 2.5°	- 13.5°	—
DISTANCE FROM NEW YORK IN MILES	119	112	106	104	98	96	91
TRUE BEARING FROM NEW YORK	237°	236.5°	236°	236°	236°	235°	235°
OBSERVED BEARING FROM NEW YORK	SW	—	229° D	240° B	—	—	—
AZIMUTH ERROR FROM NEW YORK	—	—	- 7°	+ 4°	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "LG" BEARINGS MILES AND DIRECTION	—	—	57 MI.S.W.	56 MI.W.S.W.	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "WA" BEARINGS MILES AND DIRECTION	—	—	62 MI.S.W.	45 MI.S.W.	—	62 MI.S.W.	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "WA" & "LG" BEARINGS MILES AND DIRECTION	—	—	—	16 MI.N.E.	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING CENTER OF TRIANGLE MILES AND DIRECTION	—	—	—	41 MI.S.W.	—	—	—

* Pittsburgh Equipment not Operating on Frequencies 4937.5 and 5572.5 kc.

TABLE I

TRIANGULATION TESTS OF NC-11 BY WASHINGTON, NEW YORK, AND PITTSBURGH DIRECTION FINDERS

DECEMBER 3, 1942

POSITION NUMBER	71	72	73	74	75	76	77
TIME	5:28 P.M.	5:31 P.M.	5:32:30 P.M.	5:35 P.M.	5:38 P.M.	5:41:30 P.M.	5:44 P.M.
FREQUENCY KC	6210	4122.5	4122.5	4122.5	4937.5	4937.5	5572.5
LOCATION OF PLANE	Philadelphia City Hall	W. End of Palmyra B.	Across River Delanco	Bristol	Trenton	—	Monmouth Junction
DISTANCE FROM PITTSBURGH IN MILES	255	260	264	270	275	281	286
TRUE BEARING FROM PITTSBURGH	95°	93.5°	92.5°	92°	90°	88.5°	87.5°
OBSERVED BEARING FROM PITTSBURGH	109°D	103°B	91°B	89°B	*	*	*
AZIMUTH ERROR FROM PITTSBURGH	+ 14°	+ 9.5°	- 0.5°	- 3°	—	—	—
DISTANCE FROM WASHINGTON IN MILES	124	131	137	143	152	162	169
TRUE BEARING FROM WASHINGTON	48.5°	49°	49°	50°	49°	48°	48°
OBSERVED BEARING FROM WASHINGTON	—	38°D	38°D	36°D	35°D	38°D	39°D
AZIMUTH ERROR FROM WASHINGTON	—	- 11°	- 11°	- 14°	- 14°	- 10°	- 11°
DISTANCE FROM NEW YORK IN MILES	82	74	69	62	53	44	38
TRUE BEARING FROM NEW YORK	235°	235°	235.5°	235°	237.5°	241°	244.5°
OBSERVED BEARING FROM NEW YORK	—	235°B	235°B	235°B	235°B	237°B	250°A
AZIMUTH ERROR FROM NEW YORK	—	0°	- 0.5°	0°	- 2.5°	+ 6°	+ 5.5°
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "LG" BEARINGS MILES AND DIRECTION	—	55 MI.S.W.	13 MI.N.E.	20 MI.N.E.	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "WA" BEARINGS MILES AND DIRECTION	—	63 MI.S.W.	29 MI.W.N.W.	34 MI.N.W.	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "WA" & "LG" BEARINGS MILES AND DIRECTION	—	97 MI.S.W.	103 MI.S.W.	114 MI.S.W.	123 MI.S.W.	105 MI.S.W.	48 MI.W.S.W.
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING CENTER OF TRIANGLE MILES AND DIRECTION	—	65 MI.S.W.	25 MI.S.W.	28 MI.W.	—	—	—

* Pittsburgh Equipment not Operating on Frequencies 4937.5 and 5572.5 kc.

TABLE I

TRIANGULATION TESTS OF NC-11 BY WASHINGTON, NEW YORK, AND PITTSBURGH DIRECTION FINDERS

DECEMBER 3, 1942

POSITION NUMBER	78	79	80	81
TIME	5:46 P.M.	5:49 P.M.	5:51 P.M.	5:54:30 P.M.
FREQUENCY KC	5572.5	5612.5	5612.5	6210
LOCATION OF PLANE	—	Metuchen	Center of Railway	—
DISTANCE FROM PITTSBURGH IN MILES	286	295	300	304
TRUE BEARING FROM PITTSBURGH	87°	85°	84.5°	85°
OBSERVED BEARING FROM PITTSBURGH	*	—	—	—
AZIMUTH ERROR FROM PITTSBURGH	—	—	—	—
DISTANCE FROM WASHINGTON IN MILES	170	183	189	192
TRUE BEARING FROM WASHINGTON	47°	47°	47°	48°
OBSERVED BEARING FROM WASHINGTON	46°D	46°D	42°D	45°D
AZIMUTH ERROR FROM WASHINGTON	- 1°	- 1°	- 5°	- 3°
DISTANCE FROM NEW YORK IN MILES	37	26	20	16
TRUE BEARING FROM NEW YORK	250°	259°	269°	268°
OBSERVED BEARING FROM NEW YORK	258°A	260°A	270°A	260°A
AZIMUTH ERROR FROM NEW YORK	+ 8°	+ 1°	+ 1°	- 8°
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "LG" BEARINGS MILES AND DIRECTION	—	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "WA" BEARINGS MILES AND DIRECTION	—	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "WA" & "LG" BEARINGS MILES AND DIRECTION	8 MI.N.E.	3 MI.W.	21 MI.W.	18 MI.S.W.
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING CENTER OF TRIANGLE MILES AND DIRECTION	—	—	—	—

* Pittsburgh Equipment not Operating on Frequencies 4937.5 and 5572.5 kc.

TABLE II
TRIANGULATION TESTS OF NC-11 BY WASHINGTON AND NEW YORK DIRECTION FINDERS

DECEMBER 4, 1942

POS. NO.	TIME P.M.	FREQ. KC	LOCATION OF PLANE	WASHINGTON				NEW YORK				INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "WA" & "NY" BEARINGS MILES AND DIRECTION
				DIST. IN MILES	TRUE BEARING	OBSER. BEARING (CORR.)	ERROR	DIST. IN MILES	TRUE BEARING	OBSER. BEARING (CORR.)	ERROR	
1	3:45:30	5572.5	George Washington Bridge	214	46.5°	46° B	- 0.5°	17	352.5°	350° A	- 2.5°	1.5 N.W.
2	—	5572.5	Bendix Airport	209	45.5	—	—	19	333	—	—	—
3	3:55:00	6210	Newark Airport	197	46.5	—	—	16	295.5	297 A	+ 1.5	—
4	3:58:00	6210	Miller Field	194	49	—	—	12	256	256 A	0	—
5	4:02:15	4122.5	Atlantic Highlands	191	52.5	46 B	- 6.5	16	207	210 A	+ 3	—
6	4:04:45	4122.5	N. Tip of L. Branch	190	54	48 C	- 6	20	192.5	199 A	+ 6.5	—
7	4:07:25	4937.5	N. Tip Asbury Park	185	56	51 D	- 5	27	192	195 A	+ 3	22 N.
8	4:09:00	4937.5	Inlet at Belmar	182	57	55 D	- 2	31	192	195 A	+ 3	6.5 N.
9	4:11:00	4937.5	Inlet at Manasquan	179	58	46 D	-12	37	192	194 A	+ 2	—
10	—	5572.5	Inlet at Laureleton	177	59	—	—	40	191	—	—	—
11	4:16:30	5572.5	Highway at Toms River	169	60.5	50 D	-10.5	49	194	190 A	- 4	—
12	—	5612.5	Inlet at Lenoka Harbor	165	62	—	—	55	199	—	—	—
13	4:21:00	5612.5	Inlet 2 Mi. N. of Waretown	162	63	46 D	-17	59	195.5	194 A	- 1.5	—
14	4:22:30	5612.5	Inlet opposite Barnegat	158	64	60 D	- 4	64	196	193 A	- 3	19 N.N.E.
15	4:25:17	6210	Highway at Manahawkin	155	65	—	—	68	196.5	191 A	- 5.5	—
16	4:27:00	6210	1 Mile East of Tuckertown	149	67	—	—	76	197.5	191 B	- 6.5	—
17	4:30:00	6210	South Edge of Great Bay	144	69	—	—	83	198	187 B	- 11	—
18	4:33:00	4122.5	Oceanville	140	70	—	—	87	199.5	203 B	+ 3.5	—
19	4:34:30	4122.5	Absecon	137	70.5	—	—	90	200.5	202 B	+ 1.5	—
20	4:35:30	4122.5	Pleasantville	135	71	—	—	93	201	202 A	+ 1	—
21	4:38:30	4937.5	Highway to Longport	130	73	64 D	- 9	98	202	205 B	+ 3	18 N.N.E.
22	4:40:30	4937.5	Highway Marked on Map	126	74	55 D	-24	104	202.5	204 B	+ 1.5	73.5 N.N.E.
23	—	4937.5	Railroad Marked on Map	124	75	—	—	106	203	204 B	+ 1	—
24	4:45:00	5572.5	Highway to Sea Island City	120	77	64 D	-13	111	203.5	203 B	- 0.5	42 N.N.E.
25	4:47:00	5572.5	Highway on Map	118	78	70 D	- 8	115	204	195 D	- 9	37 N.E.
26	4:48:00	5572.5	R.R. Highway to Stone Harbor	115	79.5	70 D	- 9.5	119	204.5	150-215	—	55 N.E.
27	4:50:00	5612.5	Highway to Wildwood	113	81	75 D	- 6	122	204.5	200 D	- 4.5	22 N.E.
28	4:53:30	5612.5	Cape May	108	84	70 D	-14	131	205	—	—	—
29	4:57:30	6210	Light Ship N. of Cape Henlopen	101	89	70 D	-19	141	206	205 D	- 1	47 N.N.E.
30	5:00:00	6210	Lewes	98	91.5	75 D	-16.5	145	206.5	210 D	+ 3.5	31 N.
31	5:01:30	4122.5	Highway at Rehoboth	97	93	80 D	-13	149	206	—	—	—
32	5:02:45	4122.5	Inlet at Rehoboth	98	96	86 D	-10	154	205.5	—	—	—
33	5:04:15	4122.5	S. Shore Oak Orchard Inlet	98	98	88 D	-10	158	205	—	—	—
34	5:06:00	4122.5	Clarksville Highway	97	100.5	86 D	-14.5	161	205	—	—	—
35	5:08:00	4937.5	Highway Marked on Map	99	104	91 D	-13	167	204	45 D	-159	—
36	5:10:50	4937.5	Highway Junction - Showell	96	106.5	94 D	-12.5	171	205	160 D	- 45	127 E.
37	—	4937.5	Whalesville	92	108	—	—	175	206	—	—	—
38	5:14:20	5572.5	Willards	90	109	103 D	- 6	176	207	—	—	—
39	5:15:50	5572.5	Pittesville	87	110	103 B	- 6	178	207.5	180 D	- 27.5	84 E.
40	5:17:10	5572.5	Parsonsburg	84	111.5	106 D	- 5.5	180	208	—	—	—
41	5:20:45	5612.5	Salisbury River	78	114	109 D	- 5	185	210	190 D	- 20	65 E.
42	5:23:25	5612.5	Hebron	71	112.5	104 D	- 8.5	183	212.5	180 D	- 32.5	100 E.
43	5:27:30	6210	Nanticoke River	64	115	103 D	-12	187	214.5	—	—	—
44	—	—	Highway Marked on Map	61	116.5	—	—	188	215	—	—	—
45	—	—	Rivers Junction	57	118	—	—	191	216.5	—	—	—
46	5:33:40	4122.5	Highway Marked on Map	53	120.5	117 D	- 3.5	193	218	—	—	—
47	5:35:30	4122.5	Highway Marked on Map	49	122	118 B	- 4	195	219	—	—	—
48	5:38:30	4937.5	Highway - Taylors Island	43	126	127 D	+ 1	198	221	45 D	-176	—
49	5:41:00	4937.5	James Island Tip	40	128.5	132 B	+ 3.5	200	221.5	40 D	-178.5	—
50	5:45:30	5572.5	W. Edge Chesapeake Bay	31	136	140 C	+ 4	205	224	180 D	- 44	—
51	5:47:15	5572.5	1 Mile N. Prince Frederick	26	138	140 A	+ 2	206	225	—	—	—
52	—	—	E. Edge Patuxent River	24	147.5	—	—	209	226	—	—	—
53	5:51:20	5612.5	Highway Intersection	21	156.5	156 A	- 0.5	212	227	—	—	—
54	5:52:50	5612.5	R. R. Cross-Over on Map	20	164	162 A	- 2	214	228	180 D	- 48	—
55	—	—	Bryantown	19	170	—	—	215	228.5	—	—	—
56	5:56:00	6210	Railroad & Highway Crossing	17	189.5	188 A	- 1.5	218	229.5	—	—	—
57	5:58:40	6210	Highway N. of Poutret	17	200.5	204 A	+ 3.5	220	230.5	214 B	- 16.5	—
58	6:00:00	6210	Pocomokey	18	212	216 A	+ 4	222	231	—	—	—
59	6:01:30	4122.5	West Shore of Potomac River	18	226	226 A	0	223	232	—	—	—

TABLE III
TRIANGULATION TESTS OF NC-11 BY WASHINGTON AND NEW YORK DIRECTION FINDERS

DECEMBER 5, 1942

POS. NO.	TIME P.M.	FREQ. KC	LOCATION OF PLANE		WASHINGTON				NEW YORK				INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "WA" & "NY" BEARINGS MILES AND DIRECTION
					DISTANCE IN MILES	TRUE BEARING	OBSERVED BEARING (CORREC.)	ERROR	DISTANCE IN MILES	TRUE BEARING	OBSERVED BEARING (CORREC.)	ERROR	
1	10:55:00	6210	38°41'30"	77°05'30"	9.5	228°	237° A	+ 9°	218	232°	210°	- 22°	---
2	58:00	6210	38 38 30	77 05 00	16	220	226 A	+ 6	221	231.5	205 B	- 26.5	---
3	11:00:35	4122.5	38 35 40	77 07 30	20.5	216	217 A	+ 1	225	231	---	---	---
4	03:45	4122.5	38 31 30	77 13 30	28	220	220 A	0	232	231	---	---	---
5	05:40	4122.5	38 29 40	77 18 10	32	224	223 A	- 1	237	231.5	---	---	---
6	08:35	4937.5	38 27 20	77 24 10	38	227	222 A	- 5	242.5	232	60	-172	---
7	---	---	38 23 00	77 32 30	47	228.5	---	---	251.5	232	210 C	- 22	---
8	---	---	38 21 10	77 36 00	51	229	---	---	255	232.5	210 C	- 22.5	---
9	---	---	38 19 40	77 41 30	54	230	---	---	259	232.5	200 C	- 32.5	---
10	19:35	5612.5	38 16 20	77 47 40	62.5	231	234 C	+ 3	267	232.5	220 C	- 12.5	---
11	21:10	5612.5	38 13 40	77 52 00	68	231.5	235 B	+ 3.5	272	232.5	222 C	- 10.5	---
12	23:45	5612.5	38 11 30	77 58 00	74	233	236 C	+ 3	277	233	228 C	- 5	---
13	29:15	6210	38 06 30	78 08 00	84	233.5	238 D	+ 4.5	288.5	233.5	235 C	+ 1.5	34 S.W.
14	30:30	4122.5	38 05 30	78 10 30	86.5	234	228 D	- 6	291	233.5	---	---	---
15	32:25	4122.5	38 04 00	78 13 40	90	234	226 C	- 8	295	233.5	---	---	---
16	34:30	4122.5	38 01 00	78 19 00	96	234	224 C	-10	300	233.5	---	---	---
17	37:50	4937.5	38 01 00	78 25 00	100	236	228 C	- 8	304	234	---	---	---
18	---	---	37 58 30	78 27 00	104	235	---	---	308	233.5	70	-163.5	---
19	---	---	37 55 30	78 33 00	110.5	235	---	---	315	234	232	- 2	---
20	---	---	37 54 30	78 38 00	114.5	236	---	---	318.5	234.5	230	- 4.5	---
21	---	---	37 52 00	78 42 00	119	236	---	---	323	234.5	---	---	---
22	52:10	5612.5	37 50 20	78 48 10	125	236.5	230 D	- 6.5	329	235	235 B	0	---
23	57:20	6210	37 42 30	78 49 30	131	234	236 D	- 8	336	234	235 C	+ 1	33 S.W.
24	59:40	6210	37 36 00	78 58 00	142	233	237 D	+ 4	347	233.5	230 C	- 3.5	---
25	12:03:55	4122.5	37 31 00	79 07 00	152.5	233	224 D	- 9	357.5	233.5	---	---	---
26	---	---	37 26 10	79 09 00	157	232	---	---	362	233	---	---	---
27	---	---	37 22 20	79 13 40	164	232	---	---	353	233	---	---	---
28	---	---	37 21 30	79 16 30	166.5	232	---	---	371	233	---	---	---
29	07:50	4937.5	37 21 10	79 22 30	171	233	228 D	- 5	376	233.5	---	---	---
30	10:15	4937.5	37 20 00	79 31 30	178	234.5	226 D	- 8.5	383	234	210 D	- 24	---
31	12:45	5572.5	37 20 40	79 37 00	182	236	228 D	- 8	386	235	---	---	---
32	15:55	5572.5	37 22 30	79 44 00	185	237.5	230 D	- 7.5	389.5	236	230 D	- 6	---
33	17:25	5572.5	37 22 00	79 48 00	189.5	238	236 D	- 2	394	236.5	230 D	- 6.5	---
34	19:45	5612.5	37 20 10	79 52 30	193.5	238	236 D	- 2	398	236.5	237 B	+ 0.5	---
35	21:55	5612.5	37 19 00	79 58 00	199	239	242 D	+ 3	404	236.5	237 B	+ 0.5	65 N.E.
36	26:40	6210	37 21 00	79 57 00	196.5	239	248 D	+ 9	401	237	238 B	+ 1	105 N.E.
37	35:00	4122.5	37 49 00	79 50 00	175	247	236 D	-11	377	240	---	---	---
38	38:35	4937.5	37 56 30	79 49 30	172	249.5	232 D	-17.5	372	241	238 B	- 3	---
39	40:35	4937.5	38 00 30	79 49 30	169.5	251	236 D	-15	369	241.5	---	---	---
40	45:50	5572.5	38 10 40	79 49 30	165.5	255	245 D	-10	362	243.5	240 B	- 3.5	48 S.W.
41	47:50	5572.5	38 17 30	79 49 00	163	257.5	245 D	-12.5	357.5	244.5	---	---	---
42	52:25	5612.5	38 25 00	79 50 00	161.5	260.5	246 D	-14.5	354	246	---	---	---
43	55:30	6210	38 32 40	79 48 00	158	263.5	247 D	-16.5	349	247	247 B	0	---
44	1:00:45	4122.5	38 42 30	79 49 30	159	267.5	242 D	-25.5	344.5	249	---	---	---
45	---	---	38 50 30	79 52 30	160	271	---	---	343	250	---	---	---
46	---	---	38 52 30	79 51 30	159.5	274	---	---	339	251	---	---	---
47	13:50	5572.5	39 05 00	79 53 00	161.5	277	268 D	- 9	337	253	---	---	---
48	---	---	39 10 30	79 54 00	163	279.5	---	---	336	254	---	---	---
49	---	---	39 17 10	79 54 00	164.5	282	---	---	333	255	---	---	---
50	18:50	5612.5	39 20 00	79 54 00	165	283	268 D	-15	332	256	255 D	- 1	160 S.W.
51	21:00	5612.5	39 23 10	79 54 00	166	285	273 D	-12	331	256.5	255 D	- 1.5	72 S.W.
52	---	---	39 27 30	79 54 00	167	286	---	---	330	257	255 B	- 2	---
53	27:15	6210	39 35 30	79 54 00	170	289	280 D	- 9	327	259	270 D	+ 11	---
54	29:00	6210	39 38 30	79 53 00	170	290.5	283 D	- 7.5	325	259.5	---	---	---
55	---	---	39 40 40	79 53 00	171	291.5	---	---	324.5	260	---	---	---
56	---	---	39 47 00	79 54 10	175	293.5	---	---	324	261	---	---	---
57	35:30	4122.5	39 50 30	79 54 00	176	295	288 D	- 7	323	262	---	---	---
58	37:15	4937.5	39 52 00	79 55 00	178	295.5	293 D	- 2.5	323.5	262.5	---	---	---
59	38:30	4937.5	39 54 20	79 54 30	178	296	293 D	- 3	322	263	---	---	---
60	40:30	4937.5	40 01 30	79 54 30	182	298.5	293 D	- 5.5	320.5	264	---	---	---
61	---	---	40 04 40	79 55 00	184	299	---	---	321	265	---	---	---
62	43:40	5572.5	40 08 30	79 56 00	187	300.5	301 D	+ 0.5	321	266	---	---	---
63	46:00	5572.5	40 11 30	79 56 30	189	301.5	300 D	- 0.5	321	266.5	---	---	---

TABLE IV

TRIANGULATION TESTS OF NC-11 BY WASHINGTON, NEW YORK, AND PITTSBURGH DIRECTION FINDERS

DECEMBER 12, 1942

POSITION NUMBER	1	2	3	4	5	6	7
TIME	11:01:45 A.M.	11:03:30 A.M.	11:06:00 A.M.	11:08:00 A.M.	11:10:00 A.M.	11:11:30 A.M.	11:13:30 A.M.
FREQUENCY KC	4122.5	4122.5	4122.5	4937.5	4937.5	4937.5	5572.5
LOCATION OF PLANE	—	—	—	State Dick	—	—	—
DISTANCE FROM PITTSBURGH IN MILES	16	20	24.5	34	41	43.5	48
TRUE BEARING FROM PITTSBURGH	12°	15°	17°	26°	24°	24°	24.5°
OBSERVED BEARING FROM PITTSBURGH	21° A	24° A	27° A	—	—	—	23 B
AZIMUTH ERROR FROM PITTSBURGH	+9°	+9°	+10°	—	—	—	- 1.5°
DISTANCE FROM WASHINGTON IN MILES	200	201	201.5	201	204	205	206
TRUE BEARING FROM WASHINGTON	309°	310°	311°	314°	316°	316.5°	317.5°
OBSERVED BEARING FROM WASHINGTON	—	—	309° B	311° C	315° C	317° B	338° C
AZIMUTH ERROR FROM WASHINGTON	—	—	- 2°	- 3°	- 1°	+ 0.5°	+ 20.5°
DISTANCE FROM NEW YORK IN MILES	315	312	310.5	302.5	301	300	298
TRUE BEARING FROM NEW YORK	271.5°	272°	273°	274°	275°	276°	276.5°
OBSERVED BEARING FROM NEW YORK	—	275°	272°	272° D	270° D	270° D	282° B
AZIMUTH ERROR FROM NEW YORK	—	+3°	- 1°	- 2°	- 5°	- 6°	+ 5.5°
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "LG" BEARINGS MILES AND DIRECTION	—	4 MI.E.	5 MI.S.E.	—	—	—	30 MI.S.
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "WA" BEARINGS MILES AND DIRECTION	—	—	9 MI.S.	—	—	—	101 MI.S.
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "WA" & "LG" BEARINGS MILES AND DIRECTION	—	—	9 MI.S.W.	12 MI.S.W.	34 MI. S.E.	40 MI.S.E.	71 MI.S.W.
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING CENTER OF TRIANGLE MILES AND DIRECTION	—	—	6 MI.S.	—	—	—	62 MI.S.W.

TABLE IV

TRIANGULATION TESTS OF NO-11 BY WASHINGTON, NEW YORK, AND PITTSBURGH DIRECTION FINDERS

DECEMBER 12, 1942

POSITION NUMBER	8	9	10	11	12	13	14
TIME	11:15:45 A.M.	11:17:30 A.M.	11:20:00 A.M.	11:22:00 A.M.	11:24:00 A.M.	11:26:00 A.M.	11:29:30 A.M.
FREQUENCY KC	5572.5	5572.5	5612.5	5612.5	5612.5	6210	6210
LOCATION OF PLANE	Rimersburg	Sligs	—	—	Lucinda	Lickinsville	Endeavor
DISTANCE FROM PITTSBURGH IN MILES	55.5	60	66	70	75.5	80	93.5
TRUE BEARING FROM PITTSBURGH	23.5°	23°	23°	22.5°	22.5°	21°	22°
OBSERVED BEARING FROM PITTSBURGH	23° B	23° B	23° B	24° B	24° B	19 C	21° C
AZIMUTH ERROR FROM PITTSBURGH	- 0.5°	0°	0°	+ 1.5°	+ 1.5°	- 2°	- 1°
DISTANCE FROM WASHINGTON IN MILES	210	213	215	217.5	221	224.5	236.5
TRUE BEARING FROM WASHINGTON	319.5°	320.5°	322°	323°	324°	325°	328°
OBSERVED BEARING FROM WASHINGTON	329° D	338° D	338° D	327° D	—	313° D	317° D
AZIMUTH ERROR FROM WASHINGTON	+ 9.5°	+ 17.5°	+ 16°	+ 4°	—	- 12°	- 11°
DISTANCE FROM NEW YORK IN MILES	296	295.5	293	292.5	291.5	292	295.5
TRUE BEARING FROM NEW YORK	278°	278.5°	280°	280.5°	281.5°	282.5°	285°
OBSERVED BEARING FROM NEW YORK	281° B	285° B	279°	279° B	279° B	282° A	—
AZIMUTH ERROR FROM NEW YORK	+ 3°	+ 6.5°	- 1°	- 1.5°	+ 2.5°	- 0.5°	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "LG" BEARINGS MILES AND DIRECTION	16 MI.S.S.W.	34 MI.S.S.W.	5 MI.S.	7.5 MI.S.	14 MI.S.S.W.	5 MI.W.S.W.	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "WA" BEARINGS MILES AND DIRECTION	41 MI.S.S.W.	88 MI.S.S.W.	81 MI.S.	17 MI.S.S.W.	—	29.5 MI.S.S.W.	48 MI. S.S.W.
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "WA" & "LG" BEARINGS MILES AND DIRECTION	35 MI.S.W.	64 MI.S.W.	69 MI.W.	28 MI.S.E.	—	42 MI.W.	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING CENTER OF TRIANGLE MILES AND DIRECTION	29 MI.S.S.W.	59 MI.S.S.W.	40 MI.S.W.	12 MI.W.	—	19 MI.S.W.	—

TABLE IV

TRIANGULATION TESTS OF MC-11 BY WASHINGTON, NEW YORK, AND PITTSBURGH DIRECTION FINDERS

DECEMBER 12, 1942

POSITION NUMBER	15	16	17	18	19	20	21
TIME	11:31:30 A.M.	11:35:30 A.M.	11:39:00 A.M.	11:41:00 A.M.	11:43:00 A.M.	11:46:00 A.M.	11:50:00 A.M.
FREQUENCY KC	4122.5	4122.5	4937.5	4937.5	5572.5	5572.5	5612.5
LOCATION OF PLANE	Tidoute	—	—	—	—	—	—
DISTANCE FROM PITTSBURGH IN MILES	100	112.5	135.5	141	149	155	157
TRUE BEARING FROM PITTSBURGH	23.5°	21°	22.5°	23°	22°	22°	22°
OBSERVED BEARING FROM PITTSBURGH	27° C	27° 0	—	—	—	—	32° D
AZIMUTH ERROR FROM PITTSBURGH	+3.5°	+6°	—	—	—	—	+10°
DISTANCE FROM WASHINGTON IN MILES	242	251	263	267.5	272	277	279.5
TRUE BEARING FROM WASHINGTON	330°	332°	335°	336°	338°	339°	339.5°
OBSERVED BEARING FROM WASHINGTON	322° D	326° A	328° C	329° C	340° D	—	—
AZIMUTH ERROR FROM WASHINGTON	- 8°	- 6°	- 7°	- 7°	+ 2°	—	—
DISTANCE FROM NEW YORK IN MILES	297.5	297	293	293.5	293	294	296
TRUE BEARING FROM NEW YORK	286.5°	289.5°	292.5°	293.5°	296°	297°	297.5°
OBSERVED BEARING FROM NEW YORK	282° B	282° B	297° D	297° D	289° C	293° B	294° B
AZIMUTH ERROR FROM NEW YORK	- 4.5°	- 7.5°	+4.5°	+3.5°	- 7°	- 4°	- 3.5°
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "LG" BEARINGS MILES AND DIRECTION	22 MI.S.	37 MI.S.	—	—	—	—	31 MI.S.E.
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "WA" BEARINGS MILES AND DIRECTION	39.5 MI.S.	37 MI.S.	—	—	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "WA" & "LG" BEARINGS MILES AND DIRECTION	32 MI.S.W.	37 MI.S.	94 MI.N.W.	87 MI.N.W.	50 MI.S.E.	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING CENTER OF TRIANGLE MILES AND DIRECTION	29.5 MI.S.	37 MI.S.	—	—	—	—	—

TABLE IV

TRIANGULATION TESTS OF NC-11 BY WASHINGTON, NEW YORK, AND PITTSBURGH DIRECTION FINDERS

DECEMBER 12, 1942

POSITION NUMBER	22	23	24	25	26	27	28
TIME	11:57:00 A.M.	12:04:00 P.M.	12:09:00 P.M.	12:10:00 P.M.	12:14:30 P.M.	12:17:00 P.M.	12:19:00 P.M.
FREQUENCY KC	6210	4122.5	4937.5	4937.5	5572.5	5572.5	5612.5
LOCATION OF PLANE	Springville	—	Irving	Silver Creek	Dunkirk	—	Brocton
DISTANCE FROM PITTSBURGH IN MILES	167	163	163	161	157	151	148
TRUE BEARING FROM PITTSBURGH	22.5°	18.5°	15°	14°	12°	11°	10°
OBSERVED BEARING FROM PITTSBURGH	33°D	25°C	—	—	30°D	29°D	—
AZIMUTH ERROR FROM PITTSBURGH	+10.5°	+6.5°	—	—	+18°	+18°	—
DISTANCE FROM WASHINGTON IN MILES	277	282	289.5	289	289.5	287	286
TRUE BEARING FROM WASHINGTON	340.5°	338.5°	337°	336.5°	335°	333.5°	333°
OBSERVED BEARING FROM WASHINGTON	—	—	—	—	333°B	328°B	333°B
AZIMUTH ERROR FROM WASHINGTON	—	—	—	—	-2°	-5.5°	0°
DISTANCE FROM NEW YORK IN MILES	282	293.5	304	305.5	310	313.5	314.5
TRUE BEARING FROM NEW YORK	299.5°	298.5°	298°	297.5°	297°	296°	295°
OBSERVED BEARING FROM NEW YORK	304°B	303°A	—	—	304°C	304°B	304°B
AZIMUTH ERROR FROM NEW YORK	+4.5°	+4.5°	—	—	+7°	+8°	+9°
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "LG" BEARINGS MILES AND DIRECTION	38 MI.E.	28 MI.S.W.	—	—	59 MI.E.	62 MI.E.N.E.	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "WA" BEARINGS MILES AND DIRECTION	—	—	—	—	62 MI.S.S.E.	74 MI.S.S.E.	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "WA" & "LG" BEARINGS MILES AND DIRECTION	—	—	—	—	80 MI.S.E.	130 MI.N.W.	83 MI.S.S.E.
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING CENTER OF TRIANGLE MILES AND DIRECTION	—	—	—	—	12 MI.E.	10 MI.W.	—

TABLE IV

TRIANGULATION TESTS OF NO-11 BY WASHINGTON, NEW YORK, AND PITTSBURGH DIRECTION FINDERS

DECEMBER 12, 1942

POSITION NUMBER	29	30	31	32	33	34	35
TIME	12:23:00 P.M.	12:25:30 P.M.	12:26:45 P.M.	12:28:30 P.M.	12:31:00 P.M.	12:33:30 P.M.	12:35:00 P.M.
FREQUENCY KC	5612.5	6210	6210	6210	4122.5	4122.5	4122.5
LOCATION OF PLANE	Westfield	—	Ripley	—	North East	—	—
DISTANCE FROM PITTSBURGH IN MILES	142.5	139.5	138	134.5	133	130	128
TRUE BEARING FROM PITTSBURGH	7.5°	6°	5°	3°	2°	0°	358°
OBSERVED BEARING FROM PITTSBURGH	—	—	—	—	10° C	5° 0	8° C
AZIMUTH ERROR FROM PITTSBURGH	—	—	—	—	+ 8°	+ 5°	+ 10°
DISTANCE FROM WASHINGTON IN MILES	285.5	285.5	285.5	286	286	286	287
TRUE BEARING FROM WASHINGTON	331°	330°	329.5°	328.5°	328°	327°	326°
OBSERVED BEARING FROM WASHINGTON	328° 0	328° D	327° C	330° D	325° B	323° A	322° B
AZIMUTH ERROR FROM WASHINGTON	- 3°	- 2°	- 2.5°	+ 1.5	- 3°	- 4°	- 4°
DISTANCE FROM NEW YORK IN MILES	320	323	325	328	330	334	337
TRUE BEARING FROM NEW YORK	294°	293.5°	293°	292.5°	292°	291°	291°
OBSERVED BEARING FROM NEW YORK	294° A	290° B	294° C	296° B	—	304° B	298° B
AZIMUTH ERROR FROM NEW YORK	0°	- 3.5°	+ 1°	+ 3.5°	—	+ 13°	+ 7°
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "LO" BEARINGS MILES AND DIRECTION	—	—	—	—	—	83 MI. S. S. W.	44 MI. S. W.
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "WA" BEARINGS MILES AND DIRECTION	—	—	—	—	43 MI. S. S. E.	43 MI. S.	54 MI. S. S. E.
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "WA" & "LO" BEARINGS MILES AND DIRECTION	25 MI. E. S. E.	24 MI. S.	31 MI. S. E.	27 MI. W. N. W.	—	187 MI. N. W.	134 MI. S. E.
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING CENTER OF TRIANGLE MILES AND DIRECTION	—	—	—	—	—	60 MI. S. E.	18 MI. S. S. E.

TABLE IV

TRIANGULATION TESTS OF NO-11 BY WASHINGTON, NEW YORK, AND PITTSBURGH DIRECTION FINDERS

DECEMBER 12, 1942

POSITION NUMBER	36	37	38	39	40	41	42
TIME	12:37:40 P.M.	12:45:00 P.M.	12:47:30 P.M.	12:50:30 P.M.	12:52:30 P.M.	12:55:00 P.M.	12:57:30 P.M.
FREQUENCY KC	4937.5	5572.5	5572.5	5612.5	5612.5	6210	6210
LOCATION OF PLANE	—	N. Girard	—	Connesant	—	—	—
DISTANCE FROM PITTSBURGH IN MILES	127	121.5	120.5	120	119.5	119	118
TRUE BEARING FROM PITTSBURGH	357°	350°	348°	344°	342.5°	341°	338°
OBSERVED BEARING FROM PITTSBURGH	—	—	135°	120°	343° D	340° D	338° D
AZIMUTH ERROR FROM PITTSBURGH	—	—	+147°	+136°	+0.5°	- 1°	0°
DISTANCE FROM WASHINGTON IN MILES	287.5	291.5	292	295	296	296.5	298.5
TRUE BEARING FROM WASHINGTON	325.5°	322.5°	321.5°	320°	319.5°	319°	317.5°
OBSERVED BEARING FROM WASHINGTON	322° B	314° B	317° C	317° C	314°	315°	317° 0
AZIMUTH ERROR FROM WASHINGTON	- 3.5°	- 8.5°	- 4.5°	- 3°	- 5.5°	- 4°	- 0.5°
DISTANCE FROM NEW YORK IN MILES	339.5	352	355	361	364	367	372.5
TRUE BEARING FROM NEW YORK	290.5°	289°	288.5°	287.5°	287.5°	287°	286.5°
OBSERVED BEARING FROM NEW YORK	304° B	284° B	287° B	288° A	284°	288°	290° B
AZIMUTH ERROR FROM NEW YORK	+13.5°	- 5°	- 1.5°	+0.5°	- 3.5°	+1°	+3.5°
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "LG" BEARINGS MILES AND DIRECTION	—	—	—	—	23 MI. S.S.E.	11 MI. S.S.E.	31 MI. N.W.
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "WA" BEARINGS MILES AND DIRECTION	—	—	—	—	53 MI. S.S.E.	40 MI. S.S.E.	7 MI. S.S.E.
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "WA" & "LG" BEARINGS MILES AND DIRECTION	193 MI. N.W.	43.5 MI. N.E.	31 MI. E.	36 MI. E.S.E.	26 MI. N.E.	54 MI. E.S.E.	56 MI. E.W.
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING CENTER OF TRIANGLE MILES AND DIRECTION	—	—	—	—	30 MI. S.S.W.	16 MI. E.	29 MI. N.W.

TABLE IV

TRIANGULATION TESTS OF NO-11 BY WASHINGTON, NEW YORK, AND PITTSBURGH DIRECTION FINDERS

DECEMBER 12, 1942

POSITION NUMBER	43	44	45	46	47	48	49
TIME	12:59:30 P.M.	1:02:00 P.M.	1:04:30 P.M.	1:07:00 P.M.	1:09:30 P.M.	1:11:30 P.M.	1:13:00 P.M.
FREQUENCY KC	6210	4122.5	4122.5	4937.5	4937.5	4937.5	5572.5
LOCATION OF PLANE	—	Geneva	Madison	—	Painesville	—	—
DISTANCE FROM PITTSBURGH IN MILES	117	117	117.5	118.5	120	120	120.5
TRUE BEARING FROM PITTSBURGH	335°	333°	330.5°	328°	326°	324°	322.5°
OBSERVED BEARING FROM PITTSBURGH	343° D	335° C	327° D	—	—	—	—
AZIMUTH ERROR FROM PITTSBURGH	+ 8°	+ 2°	- 3.5°	—	—	—	—
DISTANCE FROM WASHINGTON IN MILES	299.5	303	304	305	309	308.5	309.5
TRUE BEARING FROM WASHINGTON	316.5°	316°	315°	314°	313°	312.5°	312°
OBSERVED BEARING FROM WASHINGTON	313°	314° B	310° B	311° C	309° C	310° C	307° B
AZIMUTH ERROR FROM WASHINGTON	- 3.5°	- 2°	- 5°	- 3°	- 4°	- 2.5°	- 5°
DISTANCE FROM NEW YORK IN MILES	375	379	383.5	388	393	395	397.5
TRUE BEARING FROM NEW YORK	285.5°	285.5°	285°	284°	284°	283.5°	283°
OBSERVED BEARING FROM NEW YORK	290° B	285° D	—	281° C	279° B	282° B	279° B
AZIMUTH ERROR FROM NEW YORK	+ 4.5°	- 0.5°	—	- 3°	- 5°	- 1.5°	- 4°
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "LG" BEARING MILES AND DIRECTION	26 MI.S.W.	7 MI.S.E.	—	—	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "WA" BEARINGS MILES AND DIRECTION	65 MI.S.E.	32 MI.S.S.E.	60 MI.S.S.E.	—	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "WA" & "LG" BEARINGS MILES AND DIRECTION	102 MI.W.S.W.	13 MI.E.	—	22 MI.S.	36 MI.S.S.E.	12 MI.N.E.	28.5 MI.S.S.W.
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING CENTER OF TRIANGLE MILES AND DIRECTION	8 MI.S.E.	10 MI.S.S.E.	—	—	—	—	—

TABLE IV

TRIANGULATION TESTS OF NC-11 BY WASHINGTON, NEW YORK, AND PITTSBURGH DIRECTION FINDERS

DECEMBER 12, 1942

POSITION NUMBER	50	51	52	53	54	55	56
TIME	1:14:30 P.M.	1:17:30 P.M.	1:19:00 P.M.	1:23:00 P.M.	1:25:30 P.M.	1:33:00 P.M.	1:34:30 P.M.
FREQUENCY KC	5572.5	5572.5	5612.5	5612.5	6210	4122.5	4122.5
LOCATION OF PLANE	—	—	—	N.E. Cleveland	W. End of Cleveland	—	Lorraine Airport
DISTANCE FROM PITTSBURGH IN MILES	121	121.5	121	121.5	123	139	140
TRUE BEARING FROM PITTSBURGH	321°	319°	316.5°	314.5°	312°	304°	304°
OBSERVED BEARING FROM PITTSBURGH	—	—	—	—	—	315° C	299° C
AZIMUTH ERROR FROM PITTSBURGH	—	—	—	—	—	+ 11°	- 5°
DISTANCE FROM WASHINGTON IN MILES	311	312	312.5	314	315.5	332	334
TRUE BEARING FROM WASHINGTON	311.5°	310.5°	310°	310°	306°	303°	303°
OBSERVED BEARING FROM WASHINGTON	307° B	306° B	309° B	307° B	303°	—	296° C
AZIMUTH ERROR FROM WASHINGTON	- 4.5°	- 4.5°	- 1°	- 3°	- 3°	—	- 7°
DISTANCE FROM NEW YORK IN MILES	400	404	406.5	410	413.5	434	437
TRUE BEARING FROM NEW YORK	283°	282.5°	282°	281.5°	281	279°	279°
OBSERVED BEARING FROM NEW YORK	281° A	282° B	279° B	279° B	281° B	—	—
AZIMUTH ERROR FROM NEW YORK	- 2°	- 0.5°	- 3°	- 2.5°	+ 0.5°	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "LG" BEARINGS MILES AND DIRECTION	—	—	—	—	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "WA" BEARINGS MILES AND DIRECTION	—	—	—	—	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "WA" & "LG" BEARINGS MILES AND DIRECTION	37 MI. N.E.	53 MI. W.S.W.	34 MI. S.E.	24 MI. S.S.E.	64 MI. W.N.W.	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING CENTER OF TRIANGLE MILES AND DIRECTION	—	—	—	—	—	—	—

TABLE IV

TRIANGULATION TESTS OF NC-11 BY WASHINGTON, NEW YORK, AND PITTSBURGH DIRECTION FINDERS

DECEMBER 12, 1942

POSITION NUMBER	57	58	59	60	61	62	63
TIME	1:37:30 P.M.	1:38:30 P.M.	1:40:30 P.M.	1:42:00 P.M.	1:43:30 P.M.	1:46:00 P.M.	1:47:00 P.M.
FREQUENCY KC	4937.5	4937.5	4937.5	4937.5	5572.5	5572.5	5572.5
LOCATION OF PLANE	—	—	Vermillion	—	Buron	Sandusky	—
DISTANCE FROM PITTSBURGH IN MILES	143	146	149	152	157	163	165
TRUE BEARING FROM PITTSBURGH	302°	301°	302°	299°	300°	299°	298°
OBSERVED BEARING FROM PITTSBURGH	—	—	—	—	286° C	—	110°
AZIMUTH ERROR FROM PITTSBURGH	—	—	—	—	- 14°	—	+ 172°
DISTANCE FROM WASHINGTON IN MILES	337	339	342	347	350	357	359
TRUE BEARING FROM WASHINGTON	302°	302°	301°	301°	301°	300°	300°
OBSERVED BEARING FROM WASHINGTON	298° B	296° C	296° B	297° B	301° B	304° B	303° B
AZIMUTH ERROR FROM WASHINGTON	- 4°	- 6°	- 5°	- 4°	0°	+ 4°	+ 3°
DISTANCE FROM NEW YORK IN MILES	441	444	446	453	457	463	465
TRUE BEARING FROM NEW YORK	278°	278°	278°	278°	279°	279°	279°
OBSERVED BEARING FROM NEW YORK	276° B	276° C	—	—	276° B	284°	277° C
AZIMUTH ERROR FROM NEW YORK	- 2°	- 2°	—	—	- 3°	+ 5°	- 2°
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "LG" BEARINGS MILES AND DIRECTION	—	—	—	—	53 MI.S.W.	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "WA" BEARINGS MILES AND DIRECTION	—	—	—	—	118 MI.S.E.	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "WA" & "LG" BEARINGS MILES AND DIRECTION	100 MI.W.S.W.	134 MI.W.S.W.	—	—	42 MI.S.E.	48 MI.S.E.	19 MI.S.E.
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING CENTER OF TRIANGLE MILES AND DIRECTION	—	—	—	—	47 MI.S.E.	—	—

TABLE IV

TRIANGULATION TESTS OF NC-11 BY WASHINGTON, NEW YORK, AND PITTSBURGH DIRECTION FINDERS

DECEMBER 12, 1942

POSITION NUMBER	64	65	66	67	68	69	70
TIME	1:49:45 P.M.	1:52:00 P.M.	1:54:00 P.M.	1:57:45 P.M.	2:00:00 P.M.	2:01:15 P.M.	2:02:40 P.M.
FREQUENCY KC	5612.5	5612.5	6210	6210	6210	4122.5	4122.5
LOCATION OF PLANE	—	Vickory Airport	—	—	—	Elmore	—
DISTANCE FROM PITTSBURGH IN MILES	170	175	179	184	192	194	198
TRUE BEARING FROM PITTSBURGH	297°	297°	295°	295°	296°	295°	295°
OBSERVED BEARING FROM PITTSBURGH	286° D	286° D	—	—	—	297° A	294° B
AZIMUTH ERROR FROM PITTSBURGH	-11°	-11°	—	—	—	+2°	-1°
DISTANCE FROM WASHINGTON IN MILES	363	368	373	379	386	388	392
TRUE BEARING FROM WASHINGTON	300°	299°	299°	299°	299°	299°	298°
OBSERVED BEARING FROM WASHINGTON	303° C	299° B	—	—	—	294° C	294° C
AZIMUTH ERROR FROM WASHINGTON	+3	0°	—	—	—	-5°	-4°
DISTANCE FROM NEW YORK IN MILES	470	477	481	487	493	497	500
TRUE BEARING FROM NEW YORK	279°	279°	278°	278°	279°	279°	279°
OBSERVED BEARING FROM NEW YORK	278°	279°	—	277°	277°	—	—
AZIMUTH ERROR FROM NEW YORK	-1°	0°	—	-1°	-2°	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "LG" BEARINGS MILES AND DIRECTION	117 M1.W.	204 M1.W.	—	—	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "WA" BEARINGS MILES AND DIRECTION	160 M1.S.E.	88 M1.S.E.	—	—	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "WA" & "LG" BEARINGS MILES AND DIRECTION	5 M1.W.S.W.	45 M1.W.	—	—	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING CENTER OF TRIANGLE MILES AND DIRECTION	22 M1.N.E.	50 M1.W.S.W.	—	—	—	—	—

TABLE IV

TRIANGULATION TESTS OF MC-11 BY WASHINGTON, NEW YORK, AND PITTSBURGH DIRECTION FINDERS

DECEMBER 12, 1942

POSITION NUMBER	71	72	73	74	75	76	77
TIME	2:03:40 P.M.	2:12:00 P.M.	2:14:00 P.M.	2:17:00 P.M.	2:20:30 P.M.	2:23:30 P.M.	2:26:45 P.M.
FREQUENCY MC	4122.5	4937.5	5572.5	5572.5	5612.5	5612.5	6210
LOCATION OF PLANE	—	Tontogany	—	—	—	—	—
DISTANCE FROM PITTSBURGH IN MILES	203	212	214	218	223	227	231
TRUE BEARING FROM PITTSBURGH	295°	292°	290°	288°	287°	285°	284°
OBSERVED BEARING FROM PITTSBURGH	294°B	—	—	291°B	282°C	278°C	286°D
AZIMUTH ERROR FROM PITTSBURGH	- 1°	—	—	+ 3°	- 5°	- 7°	+ 2°
DISTANCE FROM WASHINGTON IN MILES	395	405	407	411	414	418	421
TRUE BEARING FROM WASHINGTON	298°	297°	296°	295°	294°	293°	293°
OBSERVED BEARING FROM WASHINGTON	293°C	293°C	295°B	294°B	294°C	294°C	294°C
AZIMUTH ERROR FROM WASHINGTON	- 5°	- 4°	+ 1°	- 1°	- 0°	+ 1°	+ 1°
DISTANCE FROM NEW YORK IN MILES	504	516	520	525	530	536	539
TRUE BEARING FROM NEW YORK	279°	278°	278°	277°	277°	276°	276°
OBSERVED BEARING FROM NEW YORK	—	—	278°C	277°	279°C	279°C	—
AZIMUTH ERROR FROM NEW YORK	—	—	- 8°	0°	+ 2°	+ 3°	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "LG" BEARINGS MILES AND DIRECTION	—	—	—	29 MI.E.	26 MI.N.N.W.	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "WA" BEARINGS MILES AND DIRECTION	—	—	—	—	—	71 MI.N.W.	350 MI.N.W.
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "WA" & "LG" BEARINGS MILES AND DIRECTION	—	—	106 MI.S.E.	93 MI.E.	130 MI.W.N.W.	140 MI.W.N.W.	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING CENTER OF TRIANGLE MILES AND DIRECTION	—	—	—	—	—	—	—

TABLE IV

TRIANGULATION TESTS OF NC-11 BY WASHINGTON, NEW YORK, AND PITTSBURGH DIRECTION FINDERS

DECEMBER 12, 1942

POSITION NUMBER	78	79	80	81	82	83	84
TIME	2:28:30 P.M.	2:31:00 P.M.	2:33:30 P.M.	2:36:00 P.M.	2:40:00 P.M.	2:41:30 P.M.	2:46:00 P.M.
FREQUENCY KC	6210	4122.5	4122.5	4122.5	4937.5	4937.5	5572.5
LOCATION OF PLANE	—	—	—	Van Wert	—	—	—
DISTANCE FROM PITTSBURGH IN MILES	234	238	241	247	252	255	261
TRUE BEARING FROM PITTSBURGH	283°	282°	281°	280°	278°	277°	276°
OBSERVED BEARING FROM PITTSBURGH	280° D	278° B	279° B	—	—	—	278° D
AZIMUTH ERROR FROM PITTSBURGH	- 3°	- 4°	- 2°	—	—	—	+ 2°
DISTANCE FROM WASHINGTON IN MILES	424	427	430	433	437	440	444
TRUE BEARING FROM WASHINGTON	292°	291°	291°	290°	289°	289°	288°
OBSERVED BEARING FROM WASHINGTON	293° C	291° B	286° C	284° B	283° B	284° B	287° C
AZIMUTH ERROR FROM WASHINGTON	+ 1°	0°	- 5°	0°	- 6°	- 5°	- 1°
DISTANCE FROM NEW YORK IN MILES	546	550	554	560	566	570	578
TRUE BEARING FROM NEW YORK	275°	275°	275°	274°	274°	273°	273°
OBSERVED BEARING FROM NEW YORK	—	—	—	—	—	—	270°
AZIMUTH ERROR FROM NEW YORK	—	—	—	—	—	—	- 3°
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "LG" BEARINGS MILES AND DIRECTION	—	—	—	—	—	—	24 MI. S.W.
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "WA" BEARINGS MILES AND DIRECTION	37 MI. E.	111 MI. W.	—	—	—	—	435 MI. W.
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "WA" & "LG" BEARINGS MILES AND DIRECTION	—	—	—	—	—	—	124 MI. W.
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING CENTER OF TRIANGLE MILES AND DIRECTION	—	—	—	—	—	—	68 MI. W.

TABLE IV

TRIANGULATION TESTS OF NO-11 BY WASHINGTON, NEW YORK, AND PITTSBURGH DIRECTION FINDERS

DECEMBER 12, 1942

POSITION NUMBER	85	86	87	88	89	90	91
TIME	2:47:30 P.M.	2:50:40 P.M.	2:52:30 P.M.	2:56:50 P.M.	2:59:20 P.M.	3:02:30 P.M.	3:05:30 P.M.
FREQUENCY KC	5572.5	5612.5	5612.5	6210	6210	4122.5	4122.5
LOCATION OF PLANE	—	—	Pennville	—	Eaton	—	Gilman
DISTANCE FROM PITTSBURGH IN MILES	264	269	275	282	285	292	298
TRUE BEARING FROM PITTSBURGH	273°	274°	273°	272°	271°	270°	270°
OBSERVED BEARING FROM PITTSBURGH	274° C	274° C	270° C	268° C	266° D	267° C	267° C
AZIMUTH ERROR FROM PITTSBURGH	- 1°	0°	- 3°	- 4°	- 5°	- 3°	- 3°
DISTANCE FROM WASHINGTON IN MILES	447	451	455	460	463	469	475
TRUE BEARING FROM WASHINGTON	287°	286°	286°	285°	284°	284°	283°
OBSERVED BEARING FROM WASHINGTON	289° B	285° B	285° B	285°	284° C	284° C	275° B
AZIMUTH ERROR FROM WASHINGTON	+ 2°	- 1°	- 1°	0°	0°	0°	- 8°
DISTANCE FROM NEW YORK IN MILES	581	587	591	598	603	609	615
TRUE BEARING FROM NEW YORK	272°	272°	272°	271°	271°	270°	270°
OBSERVED BEARING FROM NEW YORK	270°	270°	268°	268°	—	—	—
AZIMUTH ERROR FROM NEW YORK	- 2°	- 2°	- 4°	- 3°	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "LQ" BEARINGS MILES AND DIRECTION	123 MI.E.	124 MI.E.	—	—	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "WA" BEARINGS MILES AND DIRECTION	42 MI.W.	42 MI.W.	102 MI.W.	—	62 MI.E.S.E.	53 MI.N.E.	453 MI.W.
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "WA" & "LQ" BEARINGS MILES AND DIRECTION	36 MI.S.E.	37 MI.S.E.	82 MI.S.E.	—	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING CENTER OF TRIANGLE MILES AND DIRECTION	31 MI.E.S.E.	35 MI.E.S.E.	—	—	—	—	—

TABLE IV

TRIANGULATION TESTS OF MC-11 BY WASHINGTON, NEW YORK, AND PITTSBURGH DIRECTION FINDERS

DECEMBER 12, 1942

POSITION NUMBER	92	93	94	95
TIME	3:08:30 P.M.	3:14:00 P.M.	3:19:30 P.M.	3:22:30 P.M.
FREQUENCY KC	4937.5	5572.5	5572.5	5612.5
LOCATION OF PLANE	Anderson	—	—	N. Indianapolis
DISTANCE FROM PITTSBURGH IN MILES	304	312	318	327
TRUE BEARING FROM PITTSBURGH	268°	267°	266°	265°
OBSERVED BEARING FROM PITTSBURGH	—	267°C	265°C	262°C
AZIMUTH ERROR FROM PITTSBURGH	—	0°	- 1°	- 3°
DISTANCE FROM WASHINGTON IN MILES	479	486	490	498
TRUE BEARING FROM WASHINGTON	282°	281°	280°	279°
OBSERVED BEARING FROM WASHINGTON	276° A	277° B	—	278° C
AZIMUTH ERROR FROM WASHINGTON	- 6°	- 4°	—	- 1°
DISTANCE FROM NEW YORK IN MILES	622	631	638	647
TRUE BEARING FROM NEW YORK	269°	269°	268°	268°
OBSERVED BEARING FROM NEW YORK	—	260°	—	262° B
AZIMUTH ERROR FROM NEW YORK	—	- 9°	—	- 6°
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "LG" BEARINGS MILES AND DIRECTION	—	—	—	—
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "PT" & "WA" BEARINGS MILES AND DIRECTION	—	—	—	30 MI. S.S.W.
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING "WA" & "LG" BEARINGS MILES AND DIRECTION	—	140 MI. S. E.	—	182 MI. S. E.
INDICATED POSITION WITH RESPECT TO TRUE POSITION USING CENTER OF TRIANGLE MILES AND DIRECTION	—	—	—	—

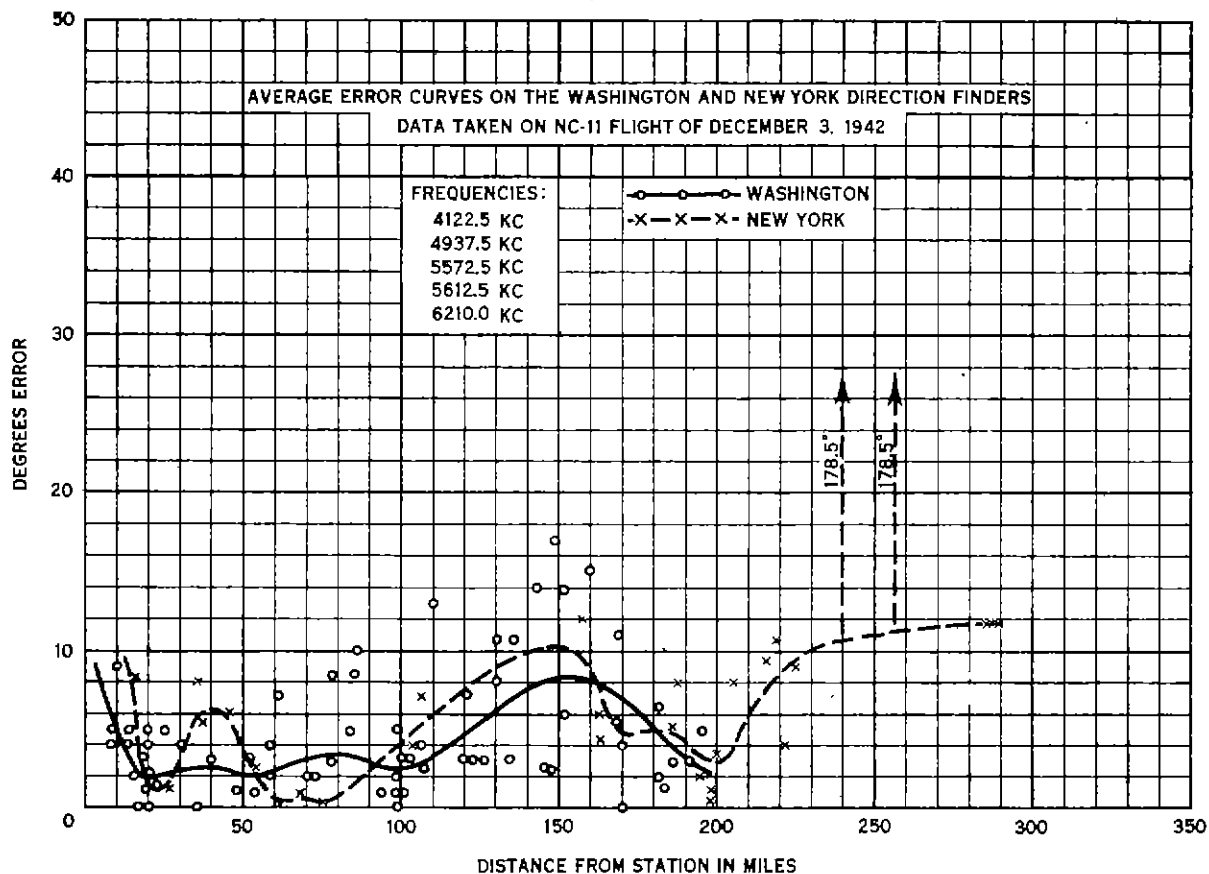


Figure 1. Average Error, Flight No. 1, Washington and New York

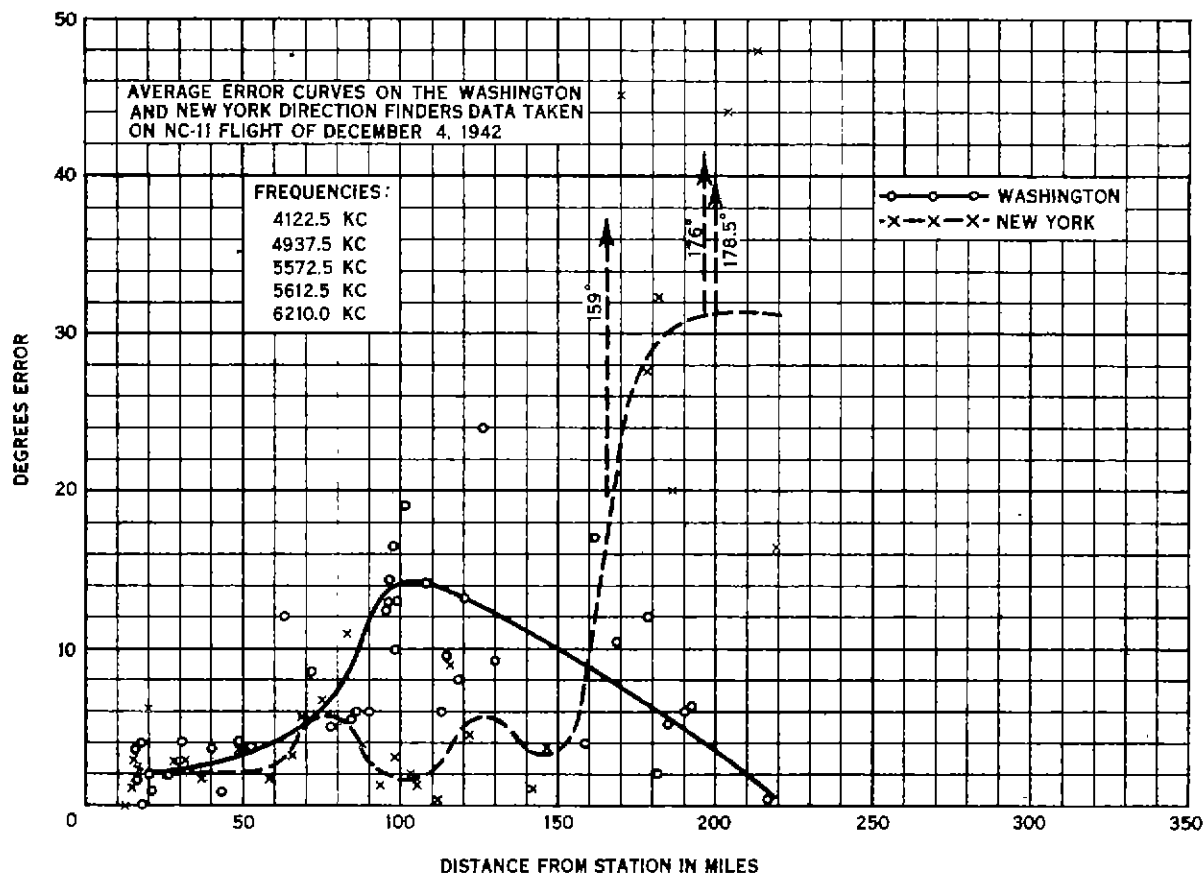


Figure 2. Average Error, Flight No. 2, Washington and New York

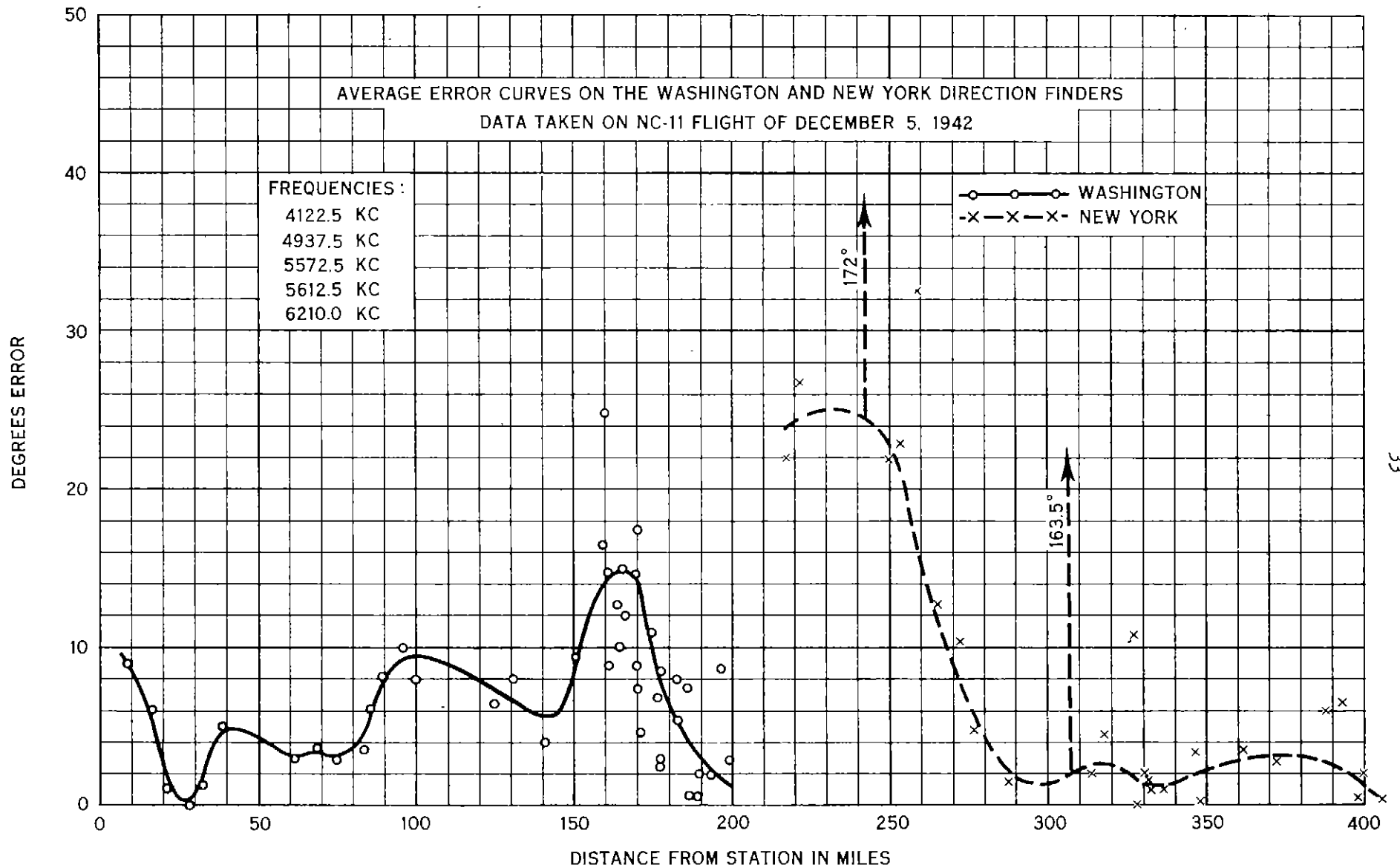


Figure 3. Average Error, Flight No. 3, Washington and New York.

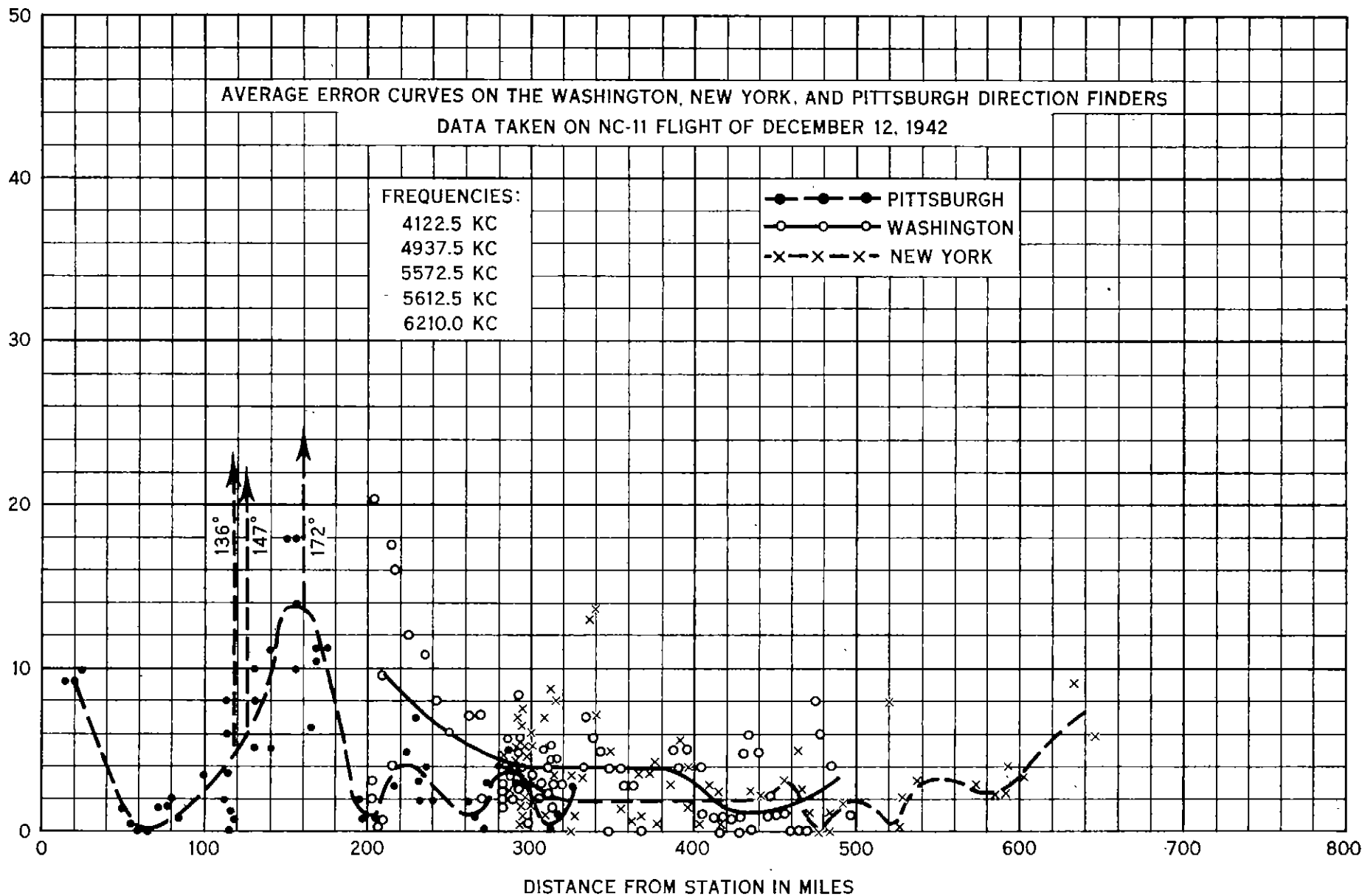


Figure 4. Average Error, Flight No. 4, Washington, New York, and Pittsburgh.

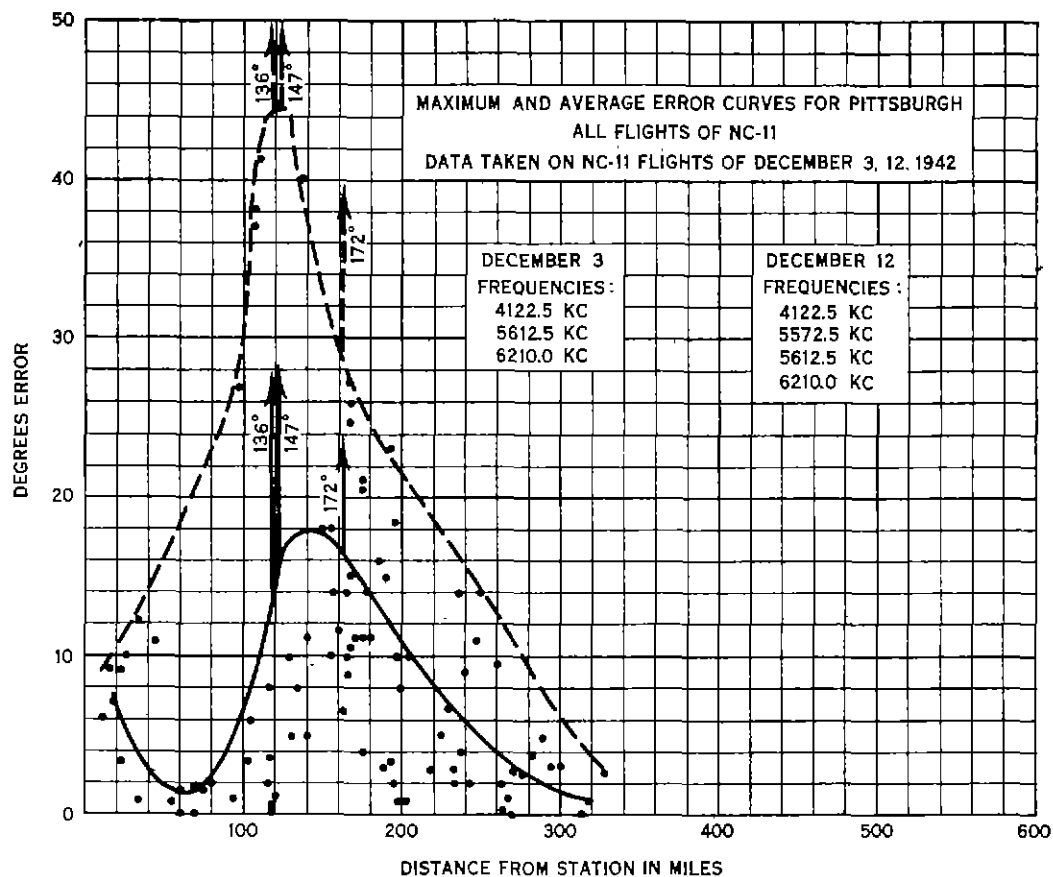


Figure 5. Maximum and Average Error, Flights Nos. 1 and 4, Pittsburgh.

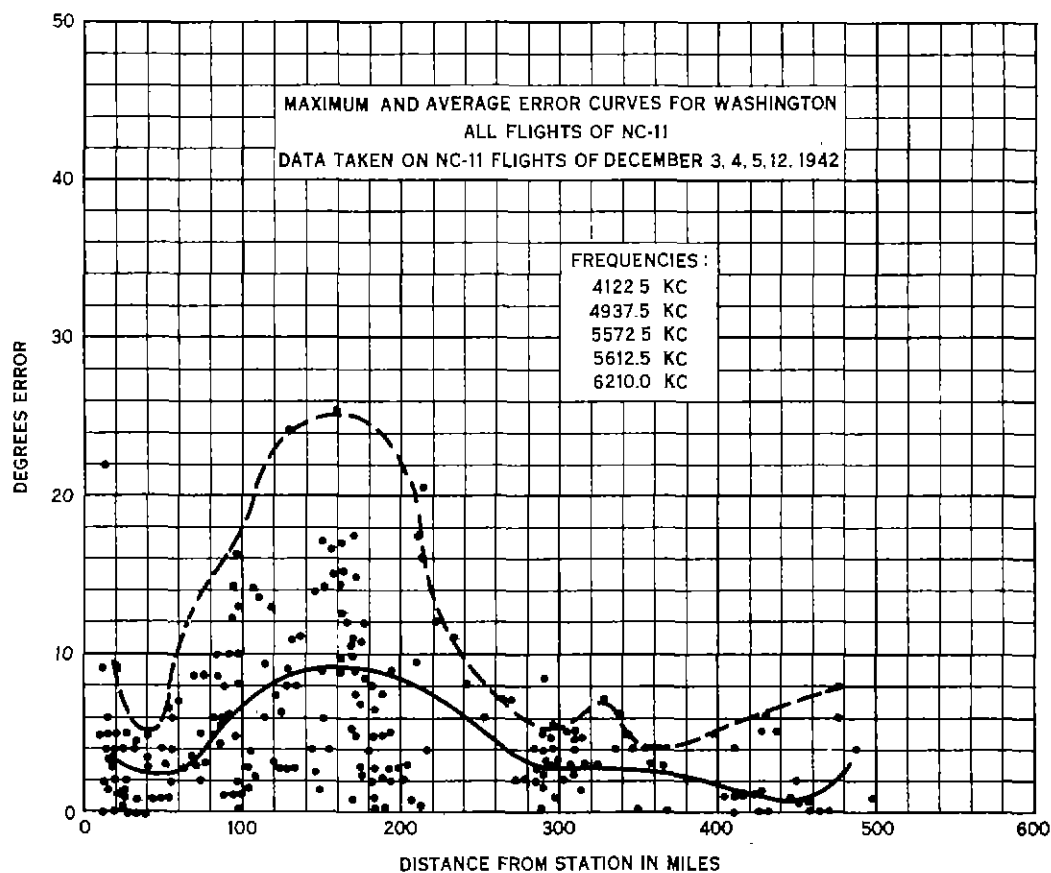


Figure 6. Maximum and Average Error, All Flights, Washington.

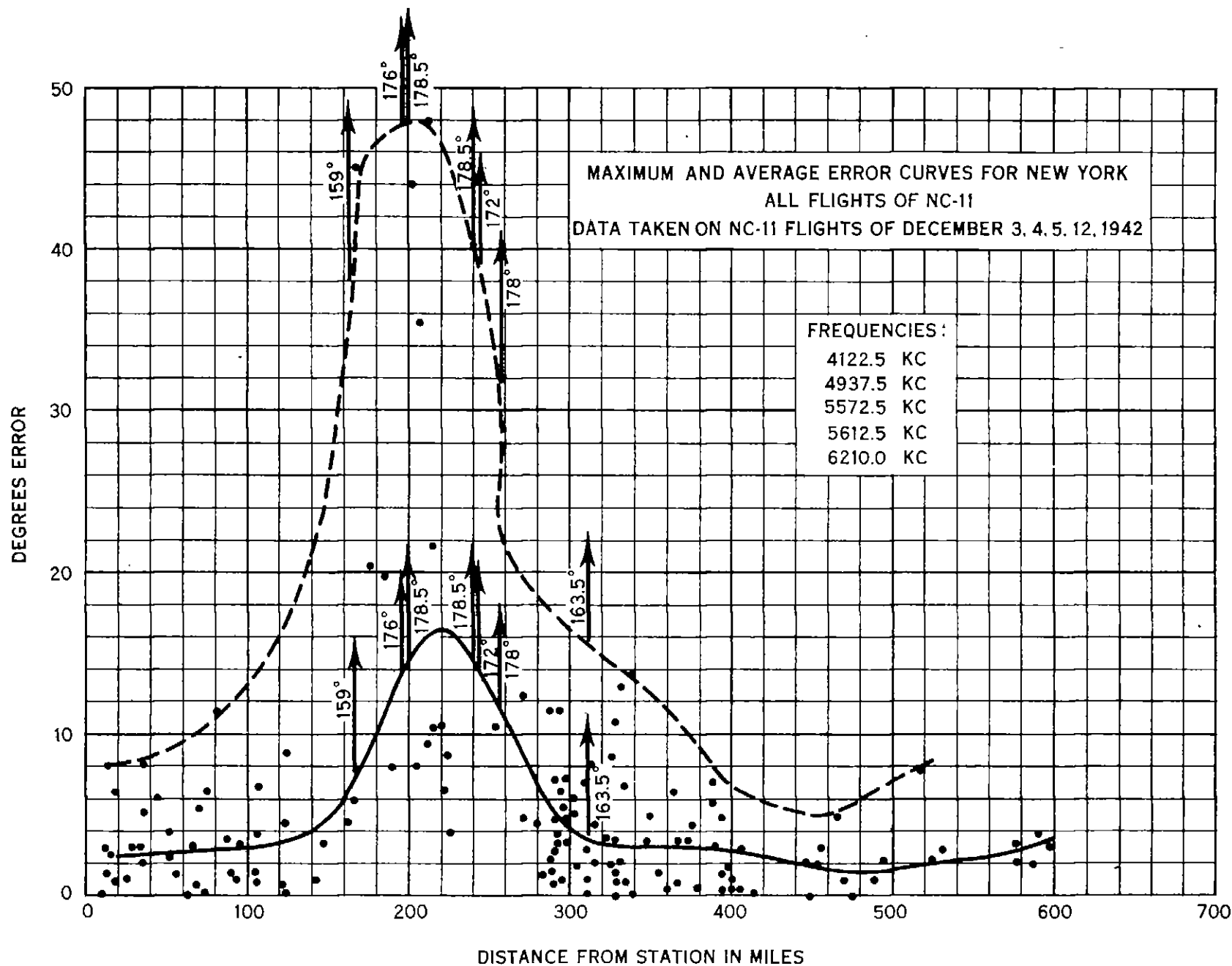


Figure 7. Maximum and Average Error, All Flights, New York.

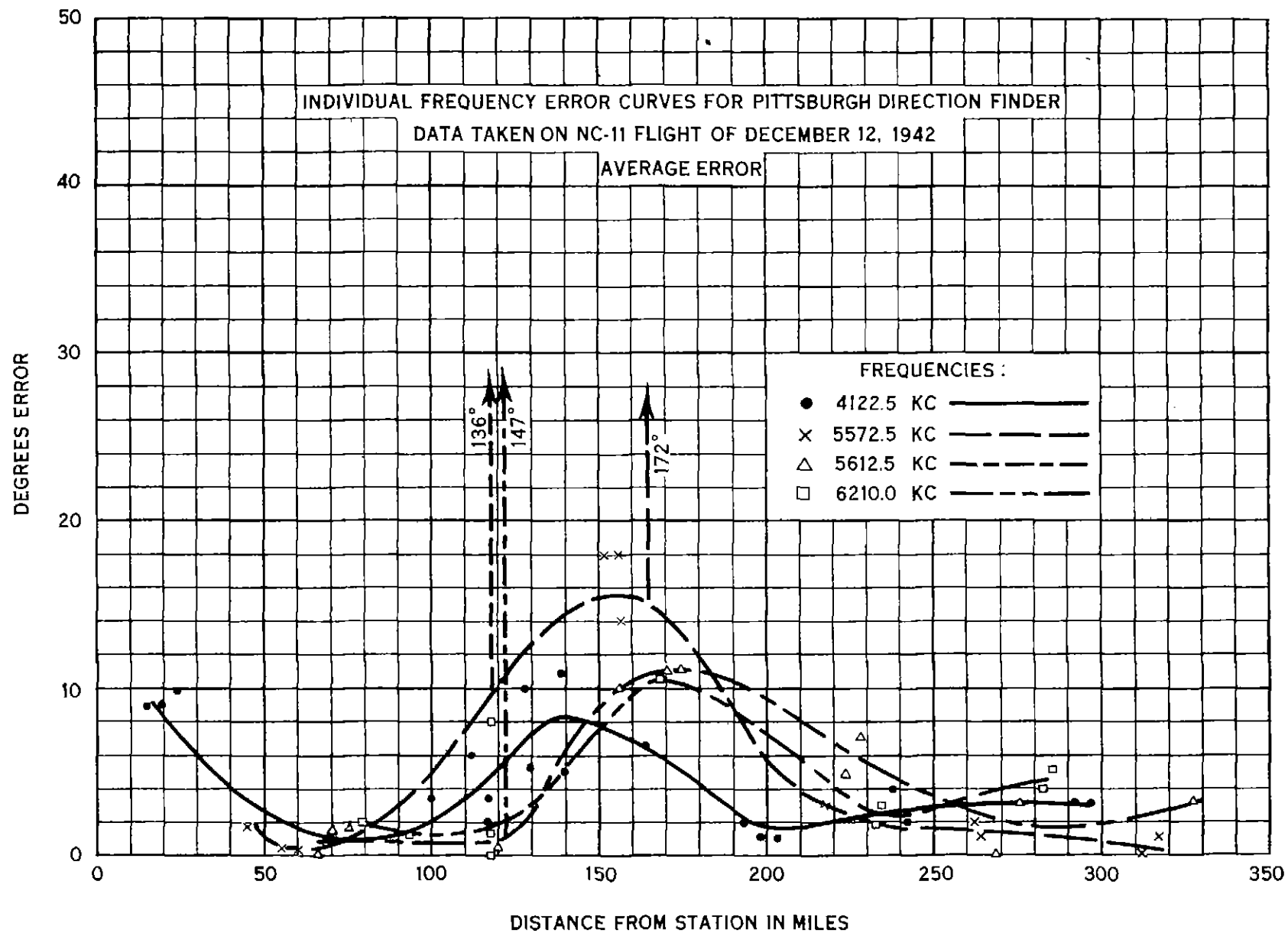


Figure 8. Individual Frequency Error, Flight No. 4, Pittsburgh.

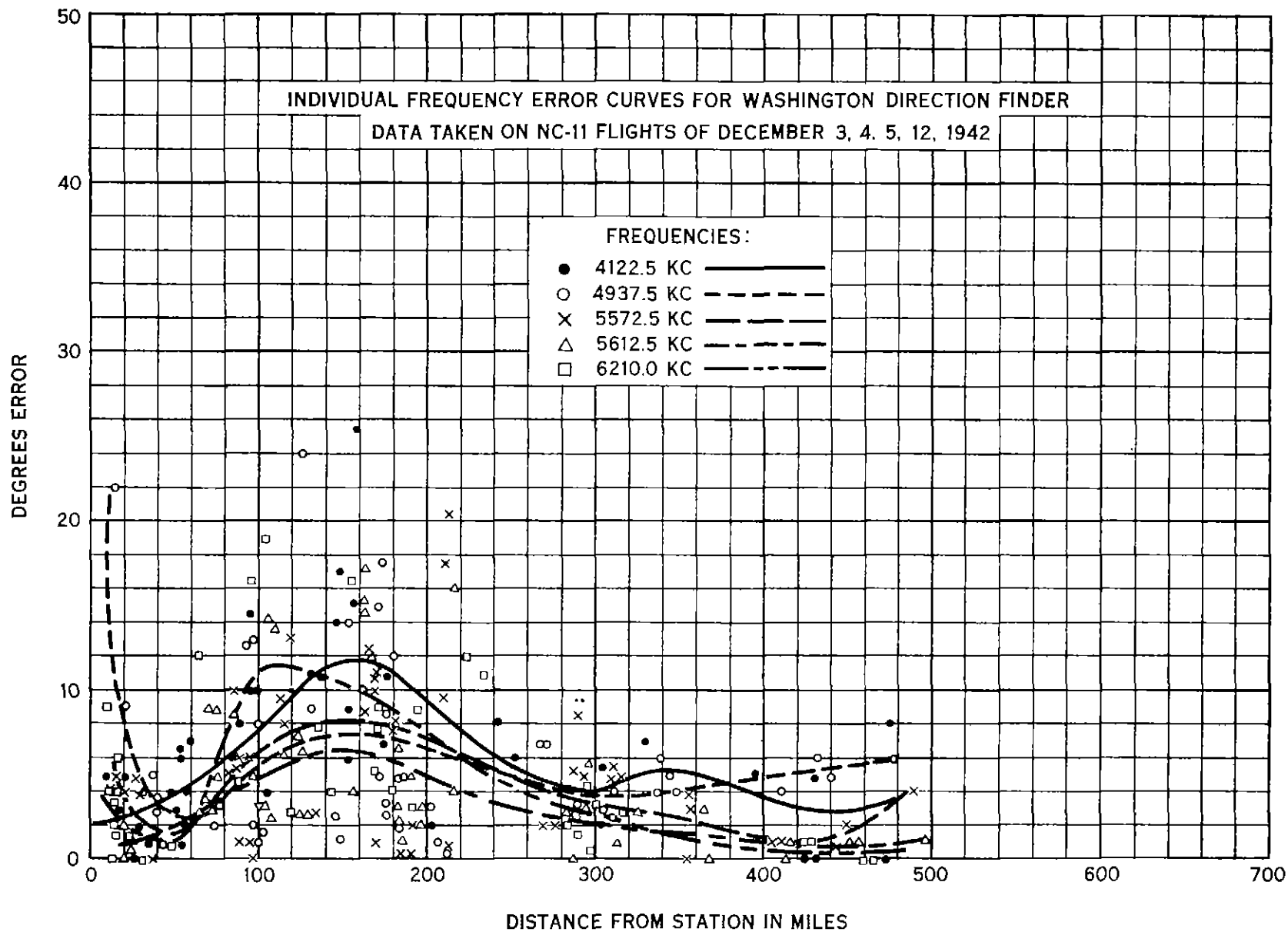


Figure 9. Individual Frequency Error, All Flights, Washington.

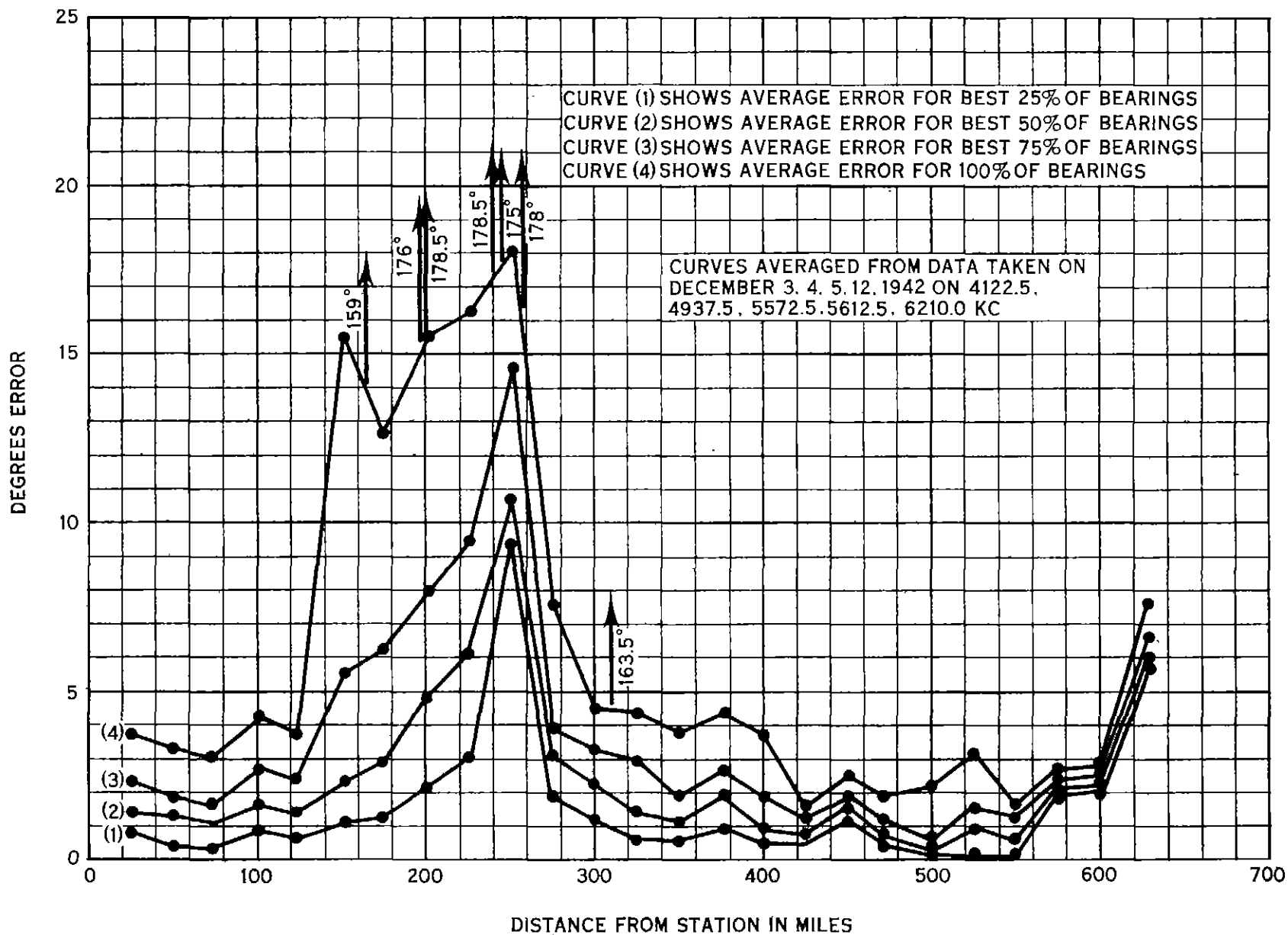


Figure 10. Average Error vs. Distance, All Flights, New York.

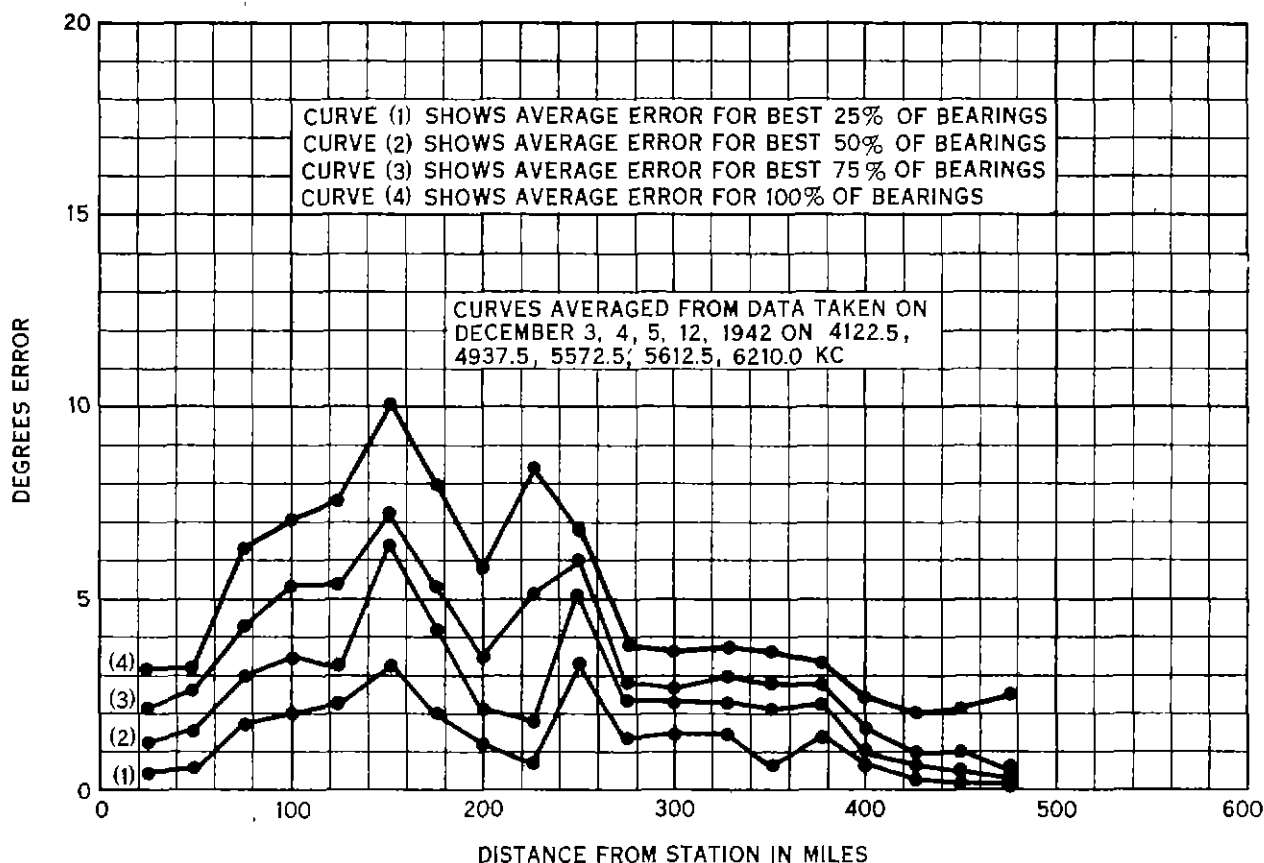


Figure 11. Average Error vs. Distance, All Flights, Washington

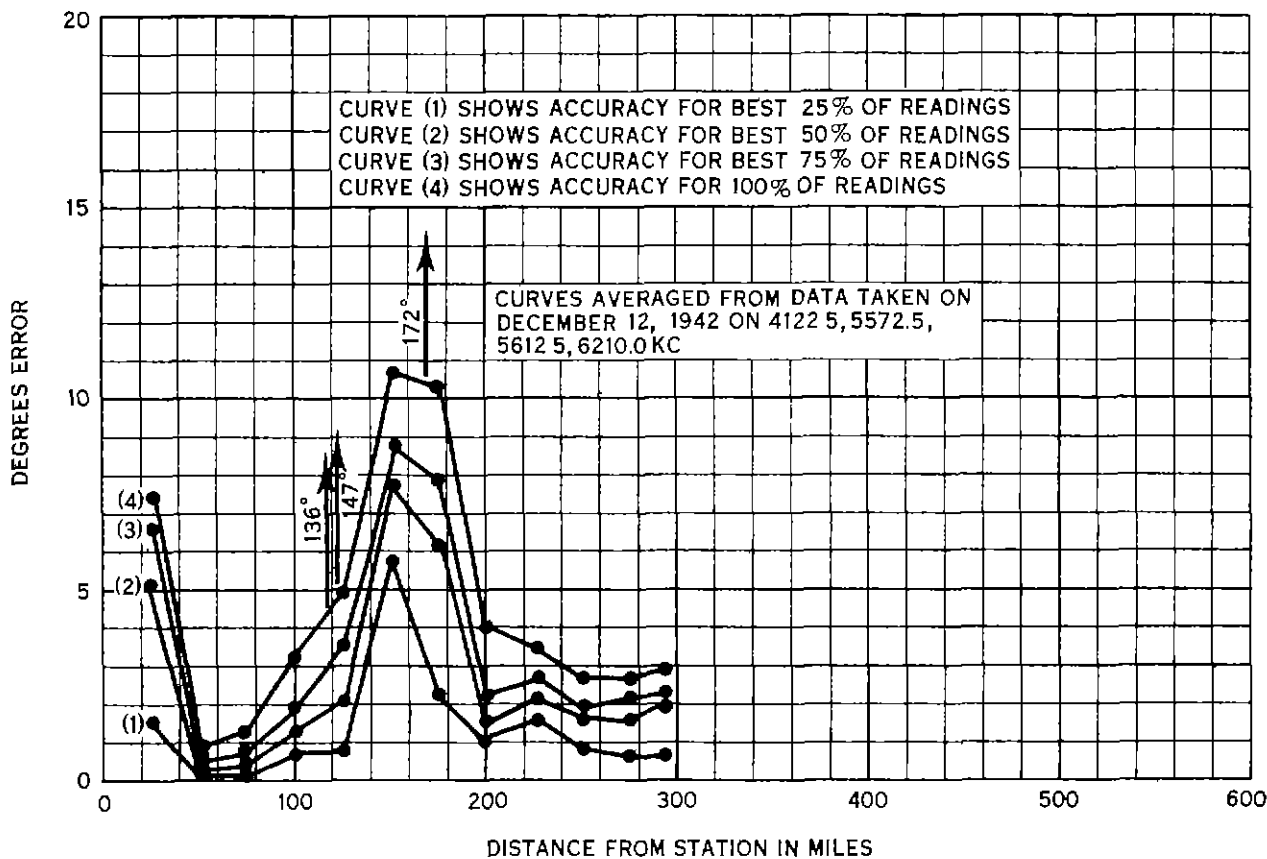


Figure 12. Average Error vs. Distance, Flight No. 4, P