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REPORT OF TESTS CONDUCTED
with the
PAN-AMERICAN AIRWAYS DIRECTION FINDER AT ALAMEDA, CALIFORNIA

by
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REPORT OF TESTS CONDUCTED

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PAN-AMERICAN AIRWAYS DIRECTION FINDER AT ALAMEDA, CALIFORNIA

Introduction

This report describes a series of tests and observations on the Pan-American Airways ground direction finder which were recently concluded at Alameda, California. The investigation was conducted primarily for the purpose of determining whether similar equipment could be used to obtain bearings on domestic aircraft utilizing existing communication frequencies in the 3000 and 6000 kc bands. The operation of the direction finder in PAA service was also observed, since their practice involves features not contemplated for domestic operation.

Equipment

The direction finder installation at Alameda will now be described. It is believed typical of that adopted by the Pan-American Airways System for combined intermediate and high frequency service with the exception of the receiving equipment which is currently being modernized. Ground direction finders working on intermediate frequencies exclusively are also used by this company in foreign countries, but details are not available. The direction finder is located on a sandy beach surrounded on three sides by water. The operator and receiving equipment is housed in a wooden building about 10 feet high with a floor 8' x 10' which is situated near the center of the antenna system. This building, the antenna supports, and two floodlights mounted at the ground level, are the only structures appearing above ground within a radius of approximately 1000 feet. The floodlights are each about 300 feet from the center of the antenna system. The direction finder comprises two antenna systems, each composed of four vertical antennas disposed symmetrically around the periphery of a circle. These circles have radii of 40 feet and 100 feet and their centers are displaced about 3 feet. Diameters passing through diagonally opposite antennas of the inner and outer systems are separated 45 degrees. Each antenna element consists of 1" brass rod mounted on stand-off insulators. The supporting framework is formed by cross arms extending between two telephone-type poles set in concrete. The rod is in two sections with a small aluminum box housing coupling equipment inserted at the center. The overall length of each antenna is approximately 18 feet. Unshielded twisted-pair transmission lines run from the antenna coupling equipment to a pole situated at the center of the system and from that point are led into the house. The outer antenna system is intended for use at frequencies between 300 and 2000 kc and the inner for frequencies between 2000 and 6000 kc. The receiver used on the outer system is a PAA model DFR3 using a balanced tuned radio frequency amplifier stage and regenerative detector. On the inner system, an RCA AR-60S communication type receiver is used. Transmission lines from each system are brought to a goniometer, details of which are not available. In making a bearing observation, the receiver is placed in heterodyne operation, and the goniometer dial rotated to

obtain a minimum. The operator makes a number of trials over a period of 2 or 3 minutes, recording each of the goniometer readings at a point either side of the null or minimum where the beat note amplitude rises to a convenient level. The arithmetical average of these departures is taken as the representative goniometer reading. A correction in this result is then applied from a calibration curve, and the true line bearing is then available. The direction finder is calibrated by checking the goniometer setting against the actual position of a test transmitter on a large number of radials emanating from the direction finder. Curves available at Alameda were made at 1638, 2986, and 5165 kc. In addition, another check on the calibration is afforded by a fixed test transmitter situated in the administration building about 1 mile from the direction finder site.

Tests

The majority of the observations on domestic airline operation were made on 3147.5, 3182.5, 5122.5, and 5592.5 kc using both aircraft and ground stations. As pointed out above, considerable time is required to obtain the bearing, and it was usually impossible to do so in the time occupied by routine airline communications. Consequently, most of the results obtained in this phase of the work were on test transmissions lasting about one minute during which the carrier was left "on." This interval was not considered sufficient for greatest accuracy, but was the maximum permissible because of the demand for the channel by other stations. A log of the tests conducted is attached to this report. The error shown represents the difference between the bearing indicated by the direction finder and that determined from a Lambert conformal projection map. Figures 1, 2, and 3 show the relation between the bearing error and distance to the transmitting station in each observation. In cases where the bearing indication shifted during an observation, the points indicating the extent of the shift are joined by lines.

In observing results obtained by Pan-American Airways during a routine trans-Pacific flight, direction finder bearings and positions or "fixes" obtained by celestial observations were logged together with other pertinent information. A copy of the log of one clipper flight is attached to this report. So far as could be learned, transmission conditions as related to bearing results were representative of those encountered to date. Although three frequencies are available for direction finder work, 1638, 2986, and 5165 kc, only 1638 and 5165 were used on this flight. Since ground or surface "fix" points are not available, celestial navigation "fixes" were arbitrarily taken as reference points in determining the values of error shown on the log. Two aircraft antennas are mentioned in the log; the trailing antenna is of the quarter-wavelength retractable type, and the fixed antenna is the "L" type about 30 feet overall, with the horizontal portion accounting for approximately 20 feet.

Discussion

Essentially, this direction finder comprises the elements of the Adcock system. The only refinements added are the goniometer and the combination of two antenna arrays similar in design but differing in the spacing of the antenna elements. The use of a goniometer is essential if manual operation using aural indication is desired. Investigation has indicated that several frequencies, rather widely separated, must be available if dependable and reasonably accurate results are to be achieved. In this type of direction finder, an optimum value of antenna spacing obtains. For the frequencies selected for this system two arrays have been adopted.

Navigational requirements of Pan-American Airways differ considerably from those of domestic airlines. In contemplating adoption of this direction finder to airways serving domestic airlines, several improvements and additional features suggest themselves. First, it would seem desirable to obtain bearings which have no 180° ambiguity. Second, because of restrictions on time available for transmission, automatic bearing indication would be advisable. The problem of manning the direction finder would also require this feature, inasmuch as the direction finder is contemplated only as an auxiliary facility. The third point is that of improvement in the design of the existing equipment. It is believed that the horizontal component response is excessive and could be reduced by improving the transmission lines. Domestic airlines would not have available a frequency corresponding to the 1638 kc channel utilized by Pan-American Airways. Observations indicate that, lacking this frequency, an improvement in the performance on frequencies in the 3000 and 6000 kc bands would be necessary.

Conclusions

It is felt that the performance of the direction finder can be gauged quite closely from the results of the tests and observations already described. Observation of results obtained in Pan-American Airways service aided in formulating ideas relating to the feasibility of adopting the direction finder as an auxiliary aid on domestic routes. In presenting conclusions, the limitations mentioned in the discussion must be considered. Accordingly, the following assumptions will be made:

- (1) Remarks pertaining to bearing accuracy and stability are based on results obtainable from the Pan-American Airways system in its present state of development.
- (2) Operation would be confined to existing aeronautical frequencies in the so-called day and night frequency bands.
- (3) The system would be used only in emergencies.

There are, then, the following objections to adoption of the system:

- (1) Although the average error observed was of the order of 10 degrees, in several cases errors of the order of 50 degrees appear, and values of 20 degrees were common. These figures apply to airplane transmissions. Greater shifts in bearings on ground stations were observed.
- (2) During approximately 10 per cent of the time, no bearing indication could be obtained although the signal strength was satisfactory and no interference was noted.
- (3) An operator would be required at the direction finder when it was being used. Since the direction finder must be situated some distance from the operating headquarters at an airport, there would be a difficult personnel problem involved.
- (4) It would be necessary to calibrate each installation at intervals of about two months. This involves the services of two skilled men, mobile test equipment, and about two days' time. In the interval between calibrations, it would be difficult to apply correction for any error which may be observed or reported.
- (5) It would be necessary to confine the operation of the direction finder to emergencies, otherwise existing aircraft-to-ground communications would be disrupted.
- (6) Certain advantages would be lost in operating this direction finder intermittently. Continued use of the system in routine operation provides a closer check on the calibration.
- (7) Although not mandatory, it is felt that the process of determining the position of an aircraft could be materially facilitated if unilateral rather than line bearings were indicated by the direction finder.

It is conceivable that objections numbered (3), (4), and (5) might be circumvented, and those numbered (6) and (7) are not of major importance. However, the points numbered (1) and (2) are determining factors. Consequently in view of the findings as presented above, it is concluded that the Pan-American Airways system would be unsatisfactory for adoption by the Authority.

A. E. Harrison
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Goniometer Bearing (corrected)	Frequency	Time	Distance to Transmitting Station	True Bearing	Error	Description of Transmitting Station
121°	5592.5	3:15 p.m.	8	124°	-3°	Oakland (UAL)
	3147.5	9:30	387	56		@ 5 mi. west Carlin, Nev.
47		9:33	410	56½	-9½	— no minimum Elko, Nev.
139½	3182.5	9:38	333	137½	2	Burbank
133		9:40	360	137	-4	@ Santa Fe Springs, Calif.
60	3147.5	9:42	415	57½	2½	@ 5 mi. east Elko, Nev.
61		9:46	576	62½	-1½	@ over Promontory Point, Utah
338		9:55	321	355	-17	Medford, Oregon
55		10:14	486	62½	-7½	@ Wendover, Utah

@ denotes aircraft transmitter.

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Goniometer bearing (corrected)	Frequency	Time	Distance to transmitting station	True bearing	Error	Description of Transmitting station
3°	5122.5	9:30 am	321	355°	8°	Medford, Ore. (UAL)
85	4400	9:43	4			KLX - 5th harmonic
164	4760	10:02	17½	164	0	KPO - 7th harmonic
55½	5122.5	10:30	180	48½	7	Reno, Nev. (UAL)
50½		10:40	579	16½	34	Pendleton, Ore., (UAL)
18½		11:00	65	13½	5	@ Capay, Calif.
23	5122.5	3: pm	95	5	18	@ Williams, Calif.
49		3:20	180	48	1	Reno, Nev. (UAL)
82		3:22	67	42	40	Sacramento, Calif.
22		3:26	166	1	21	Red Bluff, Calif.
23		3:30	579	16½	6½	Pendleton, Ore.
		3:43	67	42		@ 1 mi. west Sacramento — no minimum
61		3:48	410	56½	4½	Elko, Nev.
51½		4:00	36	34	17½	@ Potrero Hills, Calif.
62		4:20	486	62½	½	@ Wendover, Utah

Goniometer bearing (corrected)	Frequency	Time	Distance to transmitting station	True bearing	Error	Description of Transmitting Station
	5122.5	4:45 pm	166	1°		Red Bluff, Calif — no minimum
21°		4:55	542	357	24°	Portland, Ore.
		5:00	67	42		Sacramento, Calif. — no minimum
6		5:02	683	0	6	Seattle, Wash.
		5:10	180	48		Reno, Nev. — No minimum
		5:11	166	1		Red Bluff, Calif — no minimum
7½		5:15	683	0	7½	Seattle, Wash.
3		5:16	542	357	6	Portland, Ore.
31		5:20	735	18½	12½	Spokane, Wash.
132	3182.5	8:45	156	117	15	Fresno, Calif.
133½		8:50	333	137½	-4	Burbank, Calif.
134		8:53	265	134	0	@ 20 mi. south Eakersfield
4½	3147.5	9:05	320	54½	-50	@ Buffalo Valley — minimum indef.
344		9:11	321	355	-11	Medford, Oregon
41		9:18	558	51	-10	@ Burley, Idaho

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Goniometer bearing (corrected)	Frequency	Time	Distance to transmitting station	True bearing	Error	Description of Transmitting station
44°	5122.5	9:50 am	180	48°	-4°	Reno, Nevada
58		10:05	170	46	12	15 mi. west of Reno, Nev.
63		10:05	180	48	15	Reno, Nev. - indef. minimum
33	1760	10:25				KLX - Oakland 2nd harmonic
63	5122.5	10:30	180	48	15	Reno, Nevada
		10:35	66	42		Sacramento, Calif. - no minimum
56½		10:40	65	42	14½	@ over Sacramento
4		10:46	166	1	3	Red Bluff, Calif.
6		10:50	321	355	11	Medford, Ore.
4		11:05	321	355	9	Medford, Ore.
52		11:10	180	48	4	Reno, Nevada
54½		11:15	182	47	7½	@ 5 mi. north Reno, Nevada
108	5592.5	11:25	128	148	-40	@ King City, Calif.
121 - 132		11:30	245	133	-12 to -1	Bakersfield - bearing swinging
140½		11:30	333	137½	3	Burbank

Goniometer bearing (corrected)	Frequency	Time	Distance to transmitting station	True bearing	Error	Description of Transmitting station
151	5592.5	11:37 am	101	152	-1	@ over Gonzales, Calif.
145 - 146 $\frac{1}{2}$		11:57	278	146	-1 to $\frac{1}{2}$	@ 1 $\frac{1}{4}$ mi. SSE Santa Barbara
89 - 105 $\frac{1}{2}$		1:50 pm	156	117	-28 to -11 $\frac{1}{2}$	Fresno, Calif.
135		1:52	245	133	2	Bakersfield, Calif.
141 $\frac{1}{2}$ to 144		1:54	333	137 $\frac{1}{2}$	4 to 6 $\frac{1}{2}$	Burbank
132		1:55	142	147 $\frac{1}{2}$	-15 $\frac{1}{2}$	@ over SW leg Fresno range crossing highway 101
140		1:57	457	138 $\frac{1}{2}$	1 $\frac{1}{2}$	San Diego
144		2:05	107	142	2	@ 7 mi. NE Pinnacle National Monument
144	5592	2:15	110	137 $\frac{1}{2}$	6 $\frac{1}{2}$	@ 10 mi W Panoche, Calif.
143		2:16	83	142 $\frac{1}{2}$	$\frac{1}{2}$	@ Hollister, Calif.
15	5122.5	2:55	166	1	14	@ Red Bluff, Calif.
71 to 81		3:02	410	56 $\frac{1}{2}$	14 $\frac{1}{2}$ to 24 $\frac{1}{2}$	Elko, Nevada
27 to 31		3:05	579	16 $\frac{1}{2}$	10 $\frac{1}{2}$ to 14 $\frac{1}{2}$	Pendleton, Ore.
54		3:08	180	48	6	Reno, Nevada
60		3:10	517	34 $\frac{1}{2}$	25 $\frac{1}{2}$	Boise, Idaho

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Goniometer bearing (Corrected)	Frequency	Time	Distance to transmitting station	True Bearing	Error	Description of Transmitting Station
74	5122.5	3:12	590	$66\frac{1}{2}$	$7\frac{1}{2}$	Salt Lake City, Utah
7 to $13\frac{1}{2}$		3:15	542	357	10 to $16\frac{1}{2}$	Portland, Ore.
6 to 20		3:15	683	0	6 to 20	Seattle, Wash.
24 to $34\frac{1}{2}$		3:17	735	$18\frac{1}{2}$	$5\frac{1}{2}$ to 16	Spokane, Wash.
54		3:24	320	$54\frac{1}{2}$	$-\frac{1}{2}$	@ Buffalo Valley, Nev.
60		3:40	297	54	6	@ Needles Peak, Nev. (25 mi. west of Buffalo Valley)
44		3:55	517	$34\frac{1}{2}$	$9\frac{1}{2}$	Boise, Idaho
$2\frac{1}{2}$		3:56	321	355	$7\frac{1}{2}$	Medford, Ore.
45		4:00	517	$34\frac{1}{2}$	$10\frac{1}{2}$	Boise, Idaho
6		4:15	542	357	9	Portland — indefinite minimum
		4:15	166			Red Bluff — " "
71	3182.5	4:19	486	$62\frac{1}{2}$	$8\frac{1}{2}$	@ Wendover, Utah
$136\frac{1}{2}$ to 135		9:00	118	149	$-12\frac{1}{2}$ to -14	@ Greenfield, Calif.
$129\frac{1}{2}$		9:03	156	117	$12\frac{1}{2}$	Fresno, Calif.

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Goniometer Bearing (Corrected)	Frequency	Time	Distance to transmitting station	True bearing	Error	Description of Transmitting Station
133 $\frac{1}{2}$	3182.5	9:05 pm	455	138 $\frac{1}{2}$	-5	@ 1 mi N of San Diego
133		9:12	333	137 $\frac{1}{2}$	-4 $\frac{1}{2}$	Burbank
133		9:14	457	138 $\frac{1}{2}$	-5 $\frac{1}{2}$	San Diego - indefinite minimum
134 $\frac{1}{2}$		9:17	333	137 $\frac{1}{2}$	-3	Burbank
131 $\frac{1}{2}$		9:25	245	133	-1 $\frac{1}{2}$	Bakersfield
131 $\frac{1}{2}$		9:25	320	137	-5 $\frac{1}{2}$	@ Newhall, Calif.
320	3147.5	9:35	67	42	-82	Sacramento - indef. minimum
		9:49	180	48		Reno, Nevada - no minimum
		10:00	410	56 $\frac{1}{2}$		Elko, Nevada - no minimum
56		10:02	590	66 $\frac{1}{2}$	-10 $\frac{1}{2}$	Salt Lake City, Utah
2		10:05	542	357	5	Portland - fading badly
132		10:07	180	48	84	Reno, Nevada
		10:12	590	66 $\frac{1}{2}$		Salt Lake City - no minimum
145	3182.5	10:18	245	133	12	Bakersfield
136 $\frac{1}{2}$		10:23	333	134 $\frac{1}{2}$	2	Burbank, Calif. - fading

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Goniometer bearing (Corrected)	Frequency	Time	Distance to transmitting station	True Bearing	Error	Description of Transmitting Station
71	3147.5	10:28 pm	590	$66\frac{1}{2}$	$4\frac{1}{2}$	Salt Lake City, Utah
$286\frac{1}{2}$	2776	10:30	22	291	$-4\frac{1}{2}$	KRR, RCA - Bolinas, Calif.
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$52\frac{1}{2}$ to $59\frac{1}{2}$	3147.5	10:30 am	44	34	$10\frac{1}{2}$ to $25\frac{1}{2}$	@ 8 mi NNE Potrero Hills - Bearings shifted
92	3182.5	10:40	83	$105\frac{1}{2}$	$-13\frac{1}{2}$	@ Turlock, Calif.
$155\frac{1}{2}$		10:43	101	153	$2\frac{1}{2}$	@ 5 mi W Gonzales, Calif.
			225	149		@ 8 mi NNE Santa Maria, Calif. - unreadable
$19\frac{1}{2}$	3147.5	11:32	180	48	$-28\frac{1}{2}$	Reno, Nevada
318		11:34	66	42	-84	Sacramento, Calif.
359		11:35	166	1	-2	Red Bluff, Calif.
$358\frac{1}{2}$		11:39	321	355	$3\frac{1}{2}$	Medford, Ore. - weak signal
40	3182.5	11:50	156	117	-77	Fresno, Calif. " "
164		12:08 pm	79	$153\frac{1}{2}$	$10\frac{1}{2}$	@ 7 mi. SSE Watsonville, Calif.
125		12:10	156	117	8	Fresno - weak signal

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Goniometer bearing (Corrected)	Frequency	Time	Distance to transmitting station	True Bearing	Error	Description of Transmitting Station
125	3182.5	12:10 pm	156	117	8	Fresno - weak signal
		12:12	333	137 $\frac{1}{2}$		Burbank, Calif. - signal too weak for bearing.
127		2:05	156	117	10	Fresno
132 $\frac{1}{2}$		2:08	333	137 $\frac{1}{2}$	-5	Burbank
144 to 145		2:09	110	142	2 to 3	@ 25 mi. SE Hollister
146 $\frac{1}{2}$ to 145		2:14	88	142	4 $\frac{1}{2}$ to 3	@ Tres Pinos, Calif.
36		2:21	180	48	-12	Reno, Nevada
51 $\frac{1}{2}$	3182.5	2:22	25	50	1 $\frac{1}{2}$	@ 2 mi. W Pittsburgh, Calif.
350 $\frac{1}{2}$		2:28	166	1	-10 $\frac{1}{2}$	Red Bluff
	5592.5	2:46	233	135		@ 6 mi. SW Button Willow— no minimum, signal fading badly
133		2:48	333	137 $\frac{1}{2}$	-4 $\frac{1}{2}$	Burbank
119 $\frac{1}{2}$		2:56	305	136	-16 $\frac{1}{2}$	@ 3 mi E Reservoir Summit, Calif.
96 $\frac{1}{2}$		3:00	156	117	-20 $\frac{1}{2}$	Fresno, Calif.
25	5122.5	3:24	191	1/2	24 $\frac{1}{2}$	@ 25 mi N Red Bluff

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Goniometer bearing (Corrected)	Frequency	Time	Distance to transmitting station	True Bearing	Error	Description of Transmitting Station
47	5122.5	3:37 pm	486	$62\frac{1}{2}$	$-15\frac{1}{2}$	@ Wendover, Utah
60		3:40	367	56	4	@ Beowawe, Nevada
$56\frac{1}{2}$		3:53	180	48	$8\frac{1}{2}$	Reno - Signal fading badly
$7\frac{1}{2}$		3:56	321	355	$12\frac{1}{2}$	Medford, Oregon
47		4:00	67	42	5	Sacramento - indefinite minimum - signal fading
40 to 43		4:10	320	$54\frac{1}{2}$	$-14\frac{1}{2}$ to $-11\frac{1}{2}$	@ Buffalo Valley, Nev. - poor minimum
74		4:11	410	$56\frac{1}{2}$	$17\frac{1}{2}$	Elko, Nev.
74		4:20	590	$66\frac{1}{2}$	$7\frac{1}{2}$	Salt Lake City
60		4:22	180	48	12	Reno, Nevada
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$131\frac{1}{2}$	5592.5	2:00 pm	156	$117\frac{1}{2}$	14	Fresno - indef. minimum
133 to 133		2:01	245	133	0	Bakersfield - bearing swinging
139 to 136		2:02	333	$137\frac{1}{2}$	$1\frac{1}{2}$ to $-1\frac{1}{2}$	Burbank
136		2:05	146	151	-15	@ SW leg Fresno range at Lockwood, Calif.

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Goniometer bearing (Corrected)	Frequency	Time	Distance to transmitting station	True bearing	Error	Description of transmitting station
134 to 132 $\frac{1}{2}$	5592.5	2:06 pm	83	142 $\frac{1}{2}$	-8 $\frac{1}{2}$ to -10	@ Hollister, Calif.
138		2:10	333	137 $\frac{1}{2}$	1/2	Burbank, Calif.
146 $\frac{1}{2}$		2:29	83	142 $\frac{1}{2}$	4	@ Hollister, Calif. Note: this bearing taken on modulation.,
85 $\frac{1}{2}$ to 80	5122.5	2:36	66	42	43 $\frac{1}{2}$ to 38	Sacramento, Calif.
45 $\frac{1}{2}$		2:39	180	48	-2 $\frac{1}{2}$	Reno, Nevada
11 to 9 $\frac{1}{2}$		2:55	126	3	8 to 6 $\frac{1}{2}$	@ 25 mi S Red Bluff, near Willows, Calif.
13 $\frac{1}{2}$		3:04	73	15	-1 $\frac{1}{2}$	@ 12 mi. NW Woodland, Calif.
74		3:11	66	42	32	Sacramento - poor minimum
4 $\frac{1}{2}$ to 14		3:15	166	1	3 $\frac{1}{2}$ to 13	Red Bluff
3 $\frac{1}{2}$		3:16	321	355	8 $\frac{1}{2}$	Medford, Ore - Signal fading
61 $\frac{1}{2}$ to 54 $\frac{1}{2}$		3:19	320	54 $\frac{1}{2}$	7 to 0	@ Buffalo Valley, Nevada
59		3:28	338	56	3	@ 2 mi W Betty O'Neil, Nevada
122 $\frac{1}{2}$	5592.5 5122.5	3:30	8	124	-1 $\frac{1}{2}$	Oakland, (UAL)
131	5122.5	4:30	156	117 $\frac{1}{2}$	23 $\frac{1}{2}$	Fresno, Calif.

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Goniometer bearing (Corrected)	Frequency	Time	Distance to transmitting station	True bearing	Error	Description of transmitting station
136 to 143	5122.5	4:31 pm		137 $\frac{1}{2}$	-1 $\frac{1}{2}$ to 5 $\frac{1}{2}$	Burbank -- bearing swinging
126	3182.5	4:47	113	109	17	@ 6 mi. SE Merced, Calif.
122 $\frac{1}{2}$		4:50	156	117 $\frac{1}{2}$	5	Fresno, Calif.
135		4:55	245	133	2	Bakersfield, Calif.
122 to 125		5:15	17 $\frac{1}{2}$	127 $\frac{1}{2}$	-5 $\frac{1}{2}$ to -2 $\frac{1}{2}$	@ 3 mi. S of Hayward, Calif. bearing swinging
139		5:15	296	135 $\frac{1}{2}$	3 $\frac{1}{2}$	@ 3 mi. SE Sandburg, Calif.
135		5:22	333	137 $\frac{1}{2}$	-2 $\frac{1}{2}$	Brubank
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318	3147.5	9:44 am	66	42	-84	Sacramento, Calif.
2		10:03	321	355	7	Medford, Ore. - weak signal
39		10:51	180	48	-9	Reno, Nev. - weak signal - minimum disappeared intermittently.
		10:52	410	56 $\frac{1}{2}$		Elko, Nevada - signal unheard
		10:59	590	66 $\frac{1}{2}$		Salt Lake City - signal unheard
		11:01	166	1	-2 $\frac{1}{2}$	Red Bluff - signal very weak
	3182.5	11:12	176	148 $\frac{1}{2}$		@ Paso Robles, Calif. - signal unheard

Goniometer bearing (Correction)	Frequency	Time	Distance to transmitting station	True bearing	Error	Description of transmitting station
147	5592.5	11:30 am	106	152	-5	@ 6 mi. S Gonzales, Calif.
151		11:33	246	150	1	@ 8 mi NW Santa Inez, Calif. -- signal very weak
		11:35	156	117 $\frac{1}{2}$		Fresno -- no minimum -- signal weak
138 $\frac{1}{2}$		11:37	245	133	5 $\frac{1}{2}$	Bakersfield, Calif.
138 $\frac{1}{2}$		11:39	333	137 $\frac{1}{2}$	1	Durbank, Calif.
17 to 7 $\frac{1}{2}$	5122.5	11:44	321	355	+12 $\frac{1}{2}$ to +22	Medford -- null disappeared intermittently.
9 to 15		11:45	166	1	8 to 14	Red Bluff
		11:48	66	42		Sacramento -- unable obtain bearing on account of interference
45		11:50	180	48	-3	Reno, Nevada
		11:52	410	56 $\frac{1}{2}$		Elko, Nevada -- unheard
		11:54	590	66 $\frac{1}{2}$		Salt Lake City -- unheard
November 14, 1938						
80 $\frac{1}{2}$ to 72	8390	4:30 pm				WSL CW also assigned WSC located at Tuckerton, N. J. bearing swinging
	9450	4:40				WES -- no minimum -- Rocky Point, N.Y.

P.A.A.

Alameda d/f log
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Goniometer bearing (Corrected)	Frequency	Time	Distance to transmitting station	True bearing	Error	Description of transmitting station
	8450	9:10 am				KMI - voice - signal strong no minimum
	8660	9:15				JKS - CW Otchishi, Japan - no minimum
78	7500	9:21				W4FIV - CW
183 $\frac{1}{2}$	6500	9:25		164	19 $\frac{1}{2}$	KPO - distinct null
261 $\frac{1}{2}$	1638	10:51		260 $\frac{1}{2}$	1 $\frac{1}{2}$	@ PAA Commodore - directly over Farrallane Islands
161 $\frac{1}{2}$	5000 (approx)	3:25 pm	17	164	-2 $\frac{1}{2}$	KPO
33	1700 (approx)	3:35				KSW - good minimum on outer system
33	1550 (approx)	3:40	67	42	-9	KFBK Sacramento - good null outer system
81 $\frac{1}{2}$	1500 (approx)	3:45				KSAN - good null - outer system
169	1750 (approx)	3:50				W6MDF - outer system
302	1450	4:00	231	336	-34	KIEM Eureka, Calif - outer system
92 $\frac{1}{2}$ to 99	6000 (approx)	4:46				Broadcast Station, Venezuela

P.A.A.

Alameda d/f log
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Goniometer bearing (Corrected)	Frequency	Time	Distance to transmitting station	True bearing	Error	Description of transmitting station
161 $\frac{1}{2}$		10:20 am		164	-2 $\frac{1}{2}$	KPO
192 $\frac{1}{2}$	4947.5	11:00		198 $\frac{1}{2}$	-6	San Francisco, TMA
108 to 114 $\frac{1}{2}$		11:01	156	117	-2 $\frac{1}{2}$ to -9	Fresno, Calif.
98 to 102		11:03	419	103	-1 to -4 $\frac{1}{2}$	Las Vegas, Nevada
November 17, 1938						
99 $\frac{1}{2}$	4947.5	9:55 am	431	105	-5 $\frac{1}{2}$	Boulder City, Nevada
134 $\frac{1}{2}$		10:18	333	137 $\frac{1}{2}$	-3	Burbank, Calif.
52 (Uncorrected)		1:40 pm		42	10	Sacramento radio range - outer system
129 (Uncorrected)	344	1:45		117	12	Fresno radio range - outer system
47 $\frac{1}{2}$ (Uncorrected)		9:30		42	5 $\frac{1}{2}$	Sacramento, Calif. - radio range - outer system
60 (Uncorrected)	391	9:35		56 $\frac{1}{2}$	3 $\frac{1}{2}$	Elko radio range - outer system
120 (Uncorrected)		9:43		117	3	Fresno radio range - outer system

November 17, 1938

Goniometer bearing (Corrected)	Frequency	Time	Distance to transmitting station	True bearing	Error	Description of transmitting station
121	3182.5	10:14 pm		124	-3	Oakland (UAL)
133 $\frac{1}{2}$	3280.0	10:28	378	138	-4 $\frac{1}{2}$	KLKF - indefinite minimum loud signal - Huntington Beach, Calif.
132	3088	10:35	333	137 $\frac{1}{2}$	-5 $\frac{1}{2}$	Burbank, Calif.
November 18, 1938						
48 (Uncorrected)	3088	9:17 am		42	6	Sacramento, Calif.
260 (Uncorrected)		9:26	39	260	0	R Farrallane Islands, Lighthouse Service
280 (Uncorrected)		9:27				J Lighthouse Service
260 (Uncorrected)		9:28		262	-2	M San Francisco, Calif.
97 $\frac{1}{2}$	4947.5	10:02	431	108 $\frac{1}{2}$	-11	Boulder City, TWA
162	5315	10:15	28	153 $\frac{1}{2}$	8 $\frac{1}{2}$	KNA - QSA5 - Palo Alto, Calif.
86 $\frac{1}{2}$	5692.5	2:22 pm	419	106	-19 $\frac{1}{2}$	Las Vegas
59		2:30	625	52	7	Pocatello, Idaho
74		2:42	590	66 $\frac{1}{2}$	7 $\frac{1}{2}$	Salt Lake City, Utah
67 $\frac{1}{2}$		2:56	590	66 $\frac{1}{2}$	1	Salt Lake City, Utah

Goniometer bearing (Corrected)	Frequency	Time	Distance to transmitting station	True bearing	Error	Description of transmitting station
91	5692.5	3:13 pm	419	106	-15	Las Vegas
135		3:13	333	137 $\frac{1}{2}$	-2 $\frac{1}{2}$	Burbank, Calif.
80		3:38	470	88 $\frac{1}{2}$	-8 $\frac{1}{2}$	@ Enterprise, Utah
119 $\frac{1}{2}$		3:41	360	124	-4 $\frac{1}{2}$	@ Daggett, Calif.
80 to 86		4:04	506	82 $\frac{1}{2}$	-2 $\frac{1}{2}$ to 3 $\frac{1}{2}$	@ Milford, Utah
41		4:20	762	38	3	Butte, Mont. Strong signal minimum indefinite
105 $\frac{1}{2}$	5592.5	4:22	156	117	11 $\frac{1}{2}$	Fresno, Calif.
67 $\frac{1}{2}$	5692.5	4:26	590	66 $\frac{1}{2}$	1	Salt Lake City, Utah
99	4947.5	4:40	431	108 $\frac{1}{2}$	-9 $\frac{1}{2}$	Boulder City, Nevada
November 19, 1938						
335	3105	10:58 am	20	332 $\frac{1}{2}$	2 $\frac{1}{2}$	@ Army ship over Hamilton Field, Calif.
6	8960	11:50	678	0	6	KLWA, Seattle, Wash.
174 $\frac{1}{2}$	8905	11:55	28	154	20 $\frac{1}{2}$	KJJ - broad minimum - Palo Alto, Calif. 37 26 44 N 122 06 40 W

Goniometer bearing (Corrected)	Frequency	Time	Distance to transmitting station	True bearing	Error	Description of transmitting station
42 $\frac{1}{2}$	5122.5	9:30 am	180	48	-4 $\frac{1}{2}$	Reno - indefinite minimum
30		9:41	579	17 $\frac{1}{2}$	12 $\frac{1}{2}$	Pendleton, Oregon
41		9:42	67	42	-1	@ Sacramento, Calif.
6		9:50	683	0	6	Seattle, Wash.
357 $\frac{1}{2}$		10:05	321	355	2 $\frac{1}{2}$	Medford, Oregon
25		10:11	550	5 $\frac{1}{2}$	19 $\frac{1}{2}$	@ North Dalles
357		10:22	542	357	0	Portland, Oregon
357		11:03	542	357	0	Portland, Oregon
71		11:16	486	62 $\frac{1}{2}$	8 $\frac{1}{2}$	@ Wendover, Utah
2		11:25	166	1	1	Red Bluff - indefinite minimum
357	3147.5	7:04 pm	542	357	0	Portland, Ore. - indef. minimum
19		7:10	579	16 $\frac{1}{2}$	2 $\frac{1}{2}$	Pendleton, Ore. - " "
350 $\frac{1}{2}$		7:16	683	0	-9 $\frac{1}{2}$	Seattle, Washington
		7:50	517	34 $\frac{1}{2}$		Boise - no minimum - strong signal

@ denotes aircraft transmitter

Log of ground radio direction finder bearings
 supplied Phillipine Clipper, trip 249, west-
 bound Alameda to Honolulu, November 16, 1938.

Bearing indicated by Direction Finder	Bearing obtained by Celestial observation	Error	Frequency - kc	Time G. C. T.	Direction finder station	Approx. distance from Alameda, Calif.	Remarks
255.5°	251.5°	4°	1638	2330	Ala- meda	80	Fixed antenna
249.5	"	-2	5165	2335	"	80	
253.0	"	1.5	1638	2345	"	140	Fixed antenna
247.0	"	-4.5	5165	2350	"	140	
252	"	.5	1638	0020	"	190	
---	"	--	5165	0025	"	190	No minimum; strong signal
245.5	"	-6	1638	0050	"	230	Bearing reported as approx. account indefinite minimum
---	"	--	5165	0055	"	230	No minimum - Good signal
246.5	251	-4.5	1638	0130	"	290	Clipper reported sunset
---	"	--	5165	0135	"	290	No minimum - Good signal
249	250	-1	1638	0150	"	350	
---	"	--	5165	0155	"	350	No minimum - Good signal
250	"	0	1638	0230	"	470	
---	"	--	5165	0235	"	470	No minimum - Good signal
248.5	"	-1.5	1638	0250	"	550	
---	"	--	5165	0255	"	550	No minimum - Good signal
250.5	250.5	0	1638	0315	"	710	
---	"	--	5165	0320	"	710	No minimum - Good signal

Bearing indicated by Direction Finder	Bearing obtained by Celestial observation	Error	Frequency - kc	Time G. C. T.	Direction finder station	Approx. distance from Alameda, Calif.	Remarks
248.50	252°	-3.5	1638	0355	Ala- meda	800	
---	252	--	5165	0400	"	800	No Minimum - Fair Signal
250	252.5	-2.5	1638	0425	"	890	Signal weak
---	"	--	5165	0430	"	890	No Minimum - Fair Signal
252	"	-.5	5165	--	Hono.	890	
253.5	"	1	1638	0455	Ala.	940	Signal weak
---	"	--	5165	0500	"	940	No Minimum - Signal readable
254.5	"	2	1638	0530	Hono.	940	
251.5	"	-1	1638	0550	Ala.	1090	Signal weak
254	"	1.5	1638	0600	Hono.	1090	
243.5	"	-9	5165	0743	Ala.	1230	
245	"	-7.5	5165	0746	Ala.	1230	Trailing antenna
247	"	-5.5	1638	0750	Ala.	1320	Signal weak
249	252	-3	1638	0817	Ala.	1390	Signal weak
249	"	-3	1638	0851	Ala.	1480	Signal barely readable. At this time, bearing ob- servations discontinued at Alameda.

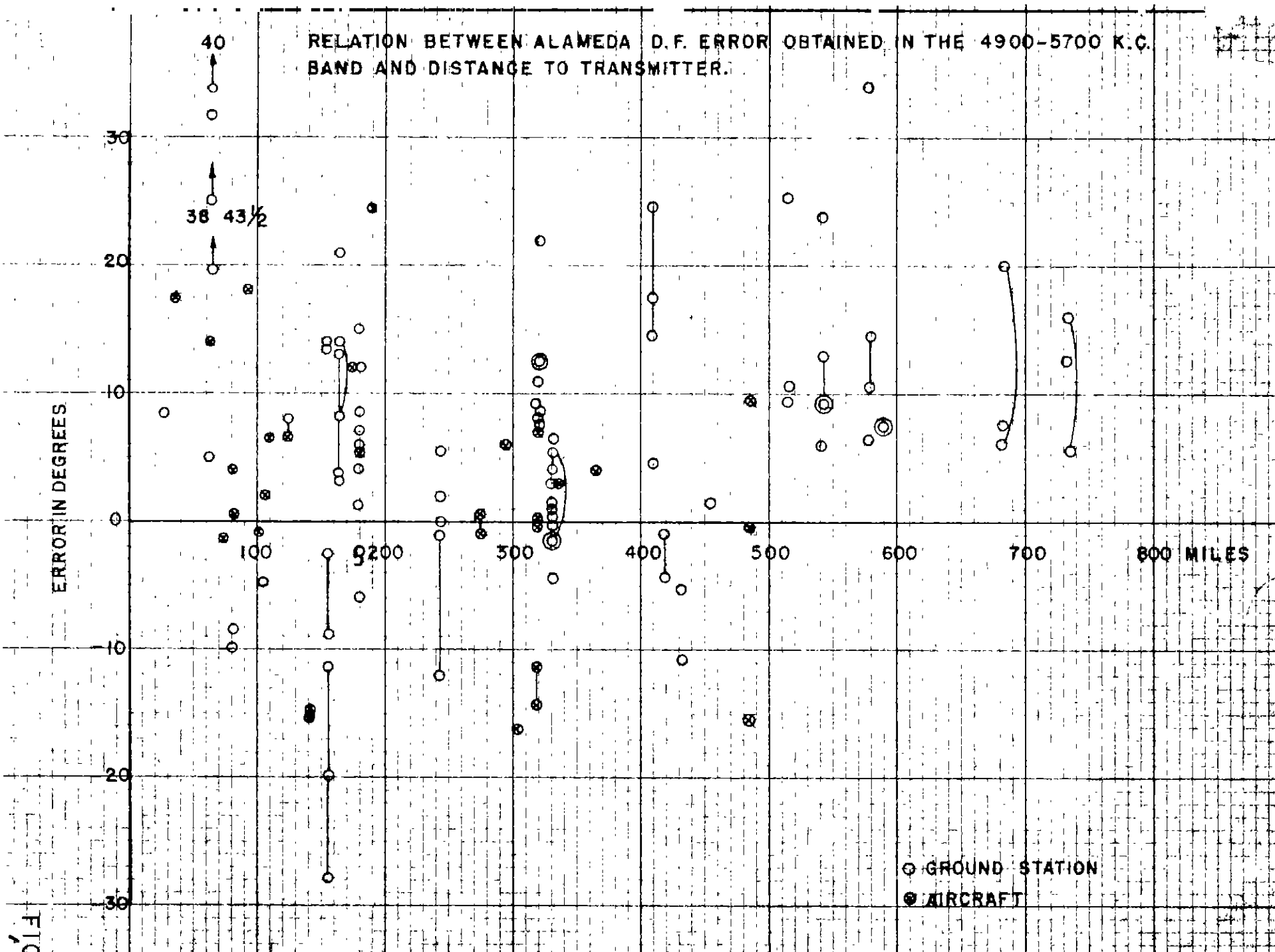
NOTE: 5165 kc transmissions on fixed antenna, and 1638 kc transmissions on trailing antenna except where otherwise noted.

RELATION BETWEEN ALAMEDA D.F. ERROR OBTAINED IN THE 4900-5700 K.C. BAND AND DISTANCE TO TRANSMITTER.

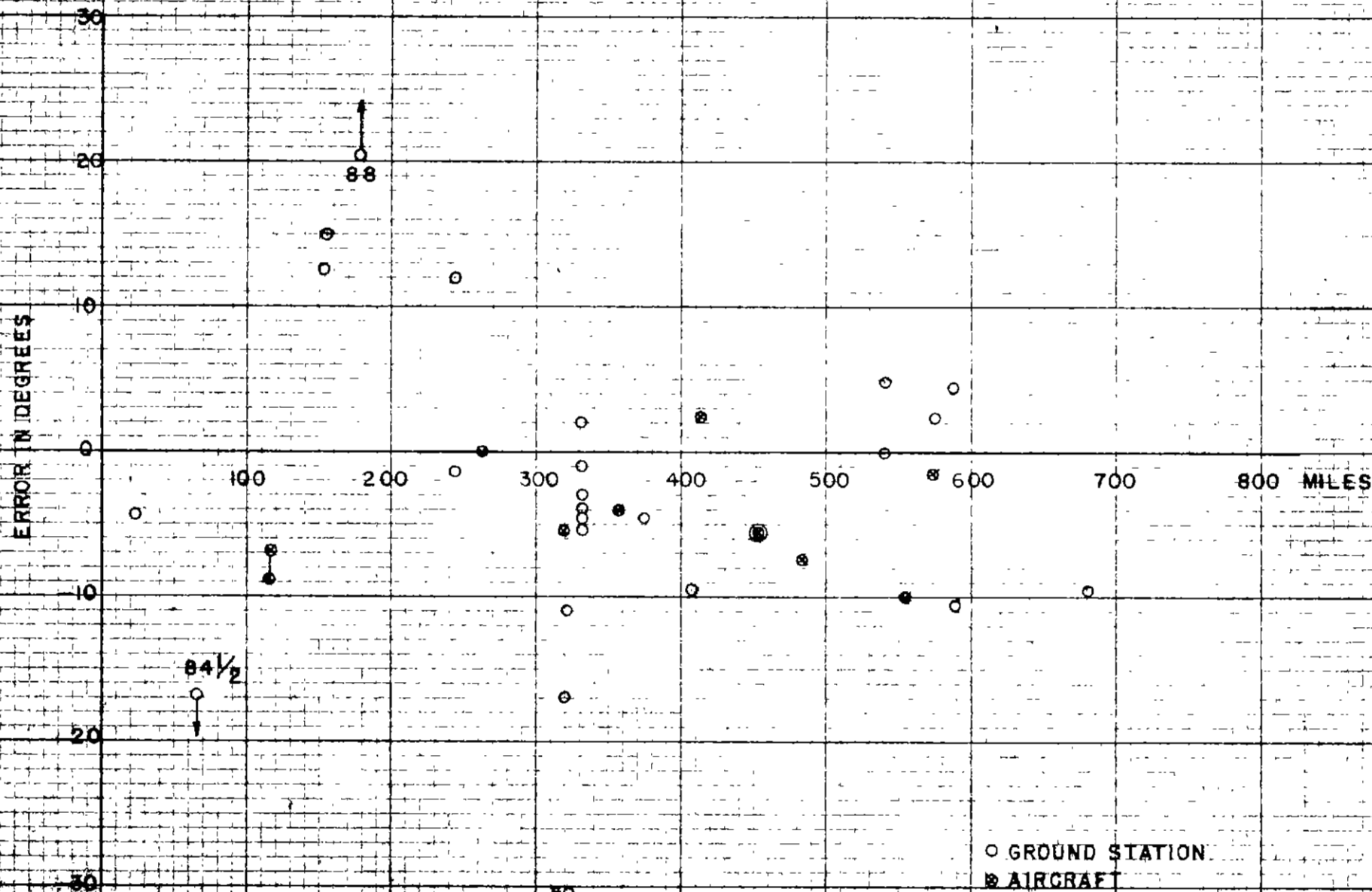
ERROR IN DEGREES

MILES

○ GROUND STATION
● AIRCRAFT



RELATION BETWEEN ALAMEDA D. F. ERROR OBTAINED AT NIGHT IN THE 3000-3200 KC.
BAND AND DISTANCE TO TRANSMITTER



RELATION BETWEEN ALAMEDA D.F. ERROR OBTAINED DURING DAY IN THE 3000-3200 KC.
AND DISTANCE TO TRANSMITTER.

