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INTERIOR COMMUNICATIONS DIVISION  
I.C. SYSTEMS DEVELOPMENT SECTION

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Declassification Team

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Reviewer's name(s): H. DO, P. HANNA

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MANUAL, 11 DEC 2012, 03 SERIES

CONTRACT ACCEPTANCE TEST  
DRAFT GAGE SYSTEM  
FRIEZ INSTRUMENT DIVISION  
BENDIX AVIATION CORPORATION  
MANUFACTURER

FR-2751

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By W.E. Chadwick

- Report B-2751

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NRL Problem IC-1086

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Indicator Dial Diameter: Dial face to be 4 inches in diameter.	Complied,																		
Arc of Dial Graduations: Dial graduations to cover an arc of at least 315°.	Complied.																		
Width of Dial Graduations:	* Failed to comply. The five foot graduations are <u>not</u> wider than the one foot graduations.																		
Weights: Not specified.	Transmitter 31 lbs. 8 ozs. Indicator 6 $\frac{1}{2}$ lbs. 13 ozs. Above weights do not agree with estimated weights in reference (h).																		
Rate of response: Not specified.	Approximately 1.1 feet of indicated draft per second.																		
Electrical Characteristics: Not specified.	<table border="0"> <thead> <tr> <th></th> <th><u>Pointer at rest</u></th> <th><u>Pointer in motion</u></th> </tr> </thead> <tbody> <tr> <td>Volts</td> <td>115</td> <td>115</td> </tr> <tr> <td>Cycles</td> <td>60</td> <td>60</td> </tr> <tr> <td>Amps</td> <td>0.441</td> <td>0.443</td> </tr> <tr> <td>Watts</td> <td>4.45</td> <td>7.79</td> </tr> <tr> <td>P.F.</td> <td>0.087</td> <td>0.155</td> </tr> </tbody> </table>		<u>Pointer at rest</u>	<u>Pointer in motion</u>	Volts	115	115	Cycles	60	60	Amps	0.441	0.443	Watts	4.45	7.79	P.F.	0.087	0.155
	<u>Pointer at rest</u>	<u>Pointer in motion</u>																	
Volts	115	115																	
Cycles	60	60																	
Amps	0.441	0.443																	
Watts	4.45	7.79																	
P.F.	0.087	0.155																	
Mounting space: Not specified.	<u>Transmitter (Including shock mounts)</u> Height: 13 inches. Width: 11 inches. Depth: 11 inches. <u>Indicator</u> Height: 6 inches. Width: 6 inches. Depth: 5 inches.																		

Note: \* -- Indicates failure to comply with requirements.

#### Comments on Results of Tests

16. The preliminary accuracy test was made after the Transmitter had been calibrated to read correctly at 5 feet and at 45 feet, as recommended by the instruction book, reference (h). In this test and in all following tests the zero water level was maintained at the level of the cock, part 24, reference (i).

17. During the preliminary accuracy test, it was noticed that the follow-up pointer had a tendency to lag behind the motion of the true pointer from one to three inches of draft before it would move back into alignment with the true pointer.

18. It was noted, during the voltage and frequency variation tests that the follow-up pointer had a tendency to "hunt", that is, to oscillate back and forth on either side of the true pointer. This hunting was noticed in nearly all the remaining tests. At the 30 foot mark while the indicated draft was being increased,

19. In conducting the temperature tests, the case was closed at an ambient temperature of 75°F. and the temperature was then brought down to 40°F. After a six hour saturating period at 40°F. accuracy readings were taken. Upon completion of the tests at 40°F. the ambient temperature was allowed to return overnight to 75°F., and the temperature was then raised to 125°F. After a six hour saturating period at this temperature, accuracy readings were again taken.

20. Since the case of the transmitter had been closed at the start of the test with an ambient temperature of 75°F., it was decided upon completion of the normal tests to open the case and take readings, to determine (by contrast) the effect upon the accuracy due to increased pressure in the case of the transmitter when the ambient temperature was increased to 125°F. Although the accuracy of indications was greatly improved by opening the case, the errors permitted were still exceeded at several points. Upon allowing the temperature to return to 75°F., and with the case open the accuracy of indications was within the specified limits, except at one point, namely 5 foot with decreasing draft.

21. While shock testing the Draft Indicator, it was noted that on the third blow from the left, the Indicator would no longer follow the Transmitter correctly. Upon examination, it was found that the pointer set screws had loosened and the pointer was slipping on the hub. After tightening the screws the Indicator operated satisfactorily for the remainder of the tests.

22. While shock testing the Transmitter, it was noted that, after the fourth blow from the back, the follow-up pointer would follow the true pointer in the direction of increasing draft, but would not follow in the direction of decreasing draft. Upon examination it was found that, at each blow the true pointer shaft, which also carries the trip disc that operates the follow-up motor contacts would move slightly toward the front of the case. This slight movement was such that, even though the pin (which is attached to the moveable contact) was out of the slot in the trip disc, it was not sufficient to bring the moveable contact into contact with the stationary contact and consequently the follow-up motor could not run in the direction of decreasing draft. This trouble occurred on every blow and was temporarily corrected by opening the case after each blow and pushing the true pointer shaft back into its correct position.

23. During the vibration test of the Draft Indicator, after several minutes of operation, it was noted that the Indicator pointer was not following the transmitter properly. Upon examination, it was found that the pointer hub set screw had loosened. The screw was tightened and the test resumed. At the completion of the test, it was found that the three screws, part 18, reference (j), which pass through the spider, part 20, and secure the dial mounting posts, part 25, had loosened and that one screw had fallen completely out. This allowed the dial to drop slightly and bind against the pointer hub, thus causing sluggish operation. Also, one of the nuts which secure the plugs of the separable connectors, had loosened and fallen off.

24. Examination of the Transmitter after the vibration test disclosed that one of the nuts, part 6, reference (i), had loosened and fallen off. Also, the same trouble that had been noted in the shock test (the lateral shift of

the true pointer shaft) had occurred and the follow-up motor would not run in the direction of decreasing draft until the true pointer shaft had been pushed back to its original position.

25. In order to complete the remaining 450 hour endurance test, it was decided to adjust the follow-up contacts so that the follow-up motor would operate regardless of any shift of the true pointer shaft. This was done but no attempt was made to re-calibrate the instrument to correct the errors which had occurred during the preceding tests.

26. During all tests (with the exception of the temperature test) the case of the Indicator-Transmitter was open and the Bourdon tube exposed to the atmosphere so that atmospheric pressure changes had no effect on the indications. However, during the temperature tests the case was sealed at 75°F. and the ambient temperature was brought down to 40°F. Readings were taken and the ambient temperature was then raised to 125°F. and readings again taken. These tests covered a period of several days, and some portion of the errors noted may have been caused by change in atmospheric pressure. Any atmospheric change would not affect the Bourdon tube (pressure in the case) due to the sealed case, but would directly affect the draft head on the instrument.

#### Conclusions

27. From the results of the accuracy tests taken during ambient temperatures of 40°F., and 125°F. (the case was closed at an ambient temperature of 75°F.) it appears that the readings of this instrument can not be relied upon if changes in the ambient temperature occur. If the case had been closed at a lower temperature it would appear that the errors at 125°F. would have been even greater. These errors are due mostly to increase in pressure within the case of the instrument as can be readily seen by comparing the results of the tests taken at 125°F. with the case closed and with the case open. Barometric pressures at the times of several test runs were not noted; they could have operated to accentuate or diminish the errors.

28. That this undesirable operation could be eliminated if some means were provided to automatically vent the case. Since the instrument was intended to operate even though completely submerged in a flooded compartment, the case is completely watertight and the only means of venting is to remove the cover. An automatic venting system that could be used, would be to provide a vent tube from the case of the instrument up to free atmosphere.

29. This, in conjunction with a ceramic disk (paragraph 5, Recommendations) would eliminate the errors due to increased case pressure caused by ambient <sup>temperature</sup> ~~pressure~~ changes and would in addition, eliminate the errors caused by barometric pressure variations. The ceramic disk would permit the equalization of pressures and, at the same time, prevent moisture from entering the case.

30. Since no means are provided of venting the pressure line of any accumulated air, errors will occur if air accumulates. This could be eliminated by providing a venting valve just below the cock, part 24, reference (i).

31. Regardless of whether the instrument is mounted upon a fore-and-aft bulkhead or an athwartship bulkhead, errors will be introduced by any roll or pitch of the ship. This could be compensated for, at least partially, by mounting the instrument on gimbals. This method however, would require more mounting space, and would not be entirely satisfactory.

32. The loosening of the screws and nuts which occurred during the shock and vibration tests may have been caused by insufficient tightening at assembly.

33. With the present amount of end play in the true pointer shaft, great care is necessary in adjusting the follow-up contacts in order to set the contacts sufficiently close to give reliable operation and yet not so close as to produce pointer hunting.

34. The errors noted following the endurance test were probably due to wear of various component parts. This occurrence, in actual ship-board operation, would necessitate a recalibration of the instrument and would require the simulating of pressures corresponding to 5 and 45 feet draft. How the manufacturer proposes that the two pressures necessary for calibration work could be reproduced accurately aboard a Naval vessel, is not known.

35. The flexible tubing furnished with the instrument, but not listed or shown in the instruction book or any of the drawings, is not satisfactory. Even though the equipment was received directly from the manufacturer, the tubing could not be used in any tests due to leakage at the flared tubing fitting. Since the design is such that these flared fittings cannot be remade or replaced, the tubing should be discarded and other means provided.

36. The dial face of the transmitter does not comply with the contract, being 1/8" smaller than specified.

37. The pointer of the Draft Indicator is not satisfactory as the pointer tip covers a space on the dial corresponding to approximately 4 inches of draft.

38. The tubing which connects the bracket end of the Bourdon tube to the pressure line is a potential source of trouble. Over a period of several years the coupling will have been taken apart a number of times and the flared tubing will become worn enough for leakage to occur. In its present form, the tubing is extremely difficult to replace due to the soldered connection at the bracket end of the Bourdon tube. If the soldered connection were replaced by a flared tubing fitting, tube replacement could be made quickly and easily.

39. On page 7, line 34, Section V, Adjustments, of the Instruction Book, the instructions read, "Turning the screw clockwise will cause the pointer to rotate counter-clockwise". This statement is incorrect inasmuch as, turning the screw clockwise actually causes the pointer to also rotate clockwise.

40. Further, on page 9, line 6, Section V, Adjustments, the Instruction Book states that, "If it is out of tolerance, loosen capstan screw (142) slightly and push the pivot toward the center if the reading is too

high or out if it is too low". This statement is also incorrect because, if the reading is too high, pushing the pivot toward the center will cause the reading to become still higher.

41. Due to the fact that only one Indicator was furnished for test, the suitability of the electrical transmission system could not be determined by testing of the actual instruments. However, it has been determined from previous tests reference k, of type "N" self-synchronous motors, that when using a type "N" synchro as a generator, it can position only two type "N" synchros and maintain the specified degree of accuracy of  $\pm 1.5^\circ$ . Since three inches of draft on the dial of the Draft Indicator covers a space of  $1.55^\circ$ , it may be assumed that if more than two Indicators are positioned by a Transmitter, the (additional) error in the electrical transmission system will exceed the allowable error at the subject equipment (0 - 30 feet,  $\pm 3$  inches). This defect in the system could readily be improved by replacing the Type N self-synchronous motor used as a generator in the Transmitter with a type A self-synchronous generator.

#### Recommendations

42. That the subject Friez Draft Indicating Equipment be approved for use aboard Naval vessels, subject to modifications to prevent errors in accuracy of indications due to shock, vibration, inclination, temperature changes barometric pressure changes and continued operation, as noted in comments and conclusions.

43. That the flexible tubing now supplied with the instrument be not approved for Naval use and that ordinary rubber hose be used in its place for connecting the Transmitter to the permanent pressure tubing.

44. That some means of calibrating the instrument be furnished by the manufacturer in the spare parts box. A possible means of calibration would be either to furnish a Bourdon tube type pressure gage tester with special weights corresponding to the pressures of 5 and 45 foot heads of sea water, or to furnish such special weights for the gage testers now supplied Naval vessels.

45. That the errors noted in the instruction book under comments and conclusions be corrected.

46. That tests be made upon a ceramic disk, developed by Bell Laboratories and used by the U. S. Marine Corps in "lip" microphones, to determine its suitability for use as a means of venting instrument cases. It is claimed that this disk will pass air but exclude water. If proven satisfactory, this disk would not only be applicable in connection with a means of venting the case of the subject equipment, but might also provide a direct means of venting other I. C. equipment.

47. That the transmitter be equipped with plug and jack connectors for quick and easy removal of the instrument from the case during routine maintenance and repair.

48. That in order to allow for future additions of Indicators to the system, the type N self-synchronous motor, used as a generator, in the transmitter be replaced by a Type A self-synchronous generator.

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49. That complete tests be conducted on the subject equipment after modifications to correct the defects noted herein have been completed.

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REFERENCES

- (a) BuShips ltr. S24-7(335c) of September 27, 1945 to Director, NRL.
- (b) Contract NObs-17602.
- (c) Navy Department Specification 18-G-3b of July 1, 1944.
- (d) Supplementary General Specifications for Machinery SGS(65)-151(a) of 1 February 1937 with Amendments.
- (e) BuShips ltr. NObs-17602(665b3) of 14 April 1945 to Friez Instrument Division.
- (f) BuShips ltr. NObs-17602(1772b) of 27 March 1945 to Bendix Aviation Corporation.
- (g) BuShips ltr. NObs-17602(1772b) of 3 February 1945 to Bendix Aviation Corporation.
- (h) Friez Instruction Book No. 122.
- (i) Friez Instrument Division Drawing No. AV-500144 - BuShips Plan No. S6505-607345 - Draft Gage Transmitter - Sheets 1 and 2.
- (j) Friez Instrument Division Drawing No. AV-500145 - BuShips Plan No. S6505-607346 - Draft Gage Indicator - Sheets 1 and 2.
- (k) NRL Test Report No. 584 (No. 1 Supplement) of 20 July 1945.

Table No. 1

Results of Accuracy Tests-Draft Indicating System

True Draft in Feet	Indicated Error in Feet											
	Preliminary Accuracy			103.5 v - 57 cycles			103.5 v - 60 cycles			103.5 v - 63 cycles		
	Pointers			Pointers			Pointers			Pointers		
	True	Follow-up	Repeater	True	Follow-up	Repeater	True	Follow-up	Repeater	True	Follow-up	Repeater
5	0	0	0	-0.1	-0.1	0	0	0	0	0	-0.1	0
10	0	0	0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0	0	0
15	0	0	0	-0.1	-0.2	-0.2	0	-0.1	-0.1	-0.1	-0.1	-0.1
20	-0.1	-0.1	-0.1	0	0	0	-0.1	-0.25	-0.25	-0.2	-0.25	-0.25
25	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.25	-0.1	-0.1	-0.1	-0.1	-0.1
30	0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.25	0	0	0
35	-0.1	-0.2	-0.25	-0.2	-0.3	-0.3	-0.2	-0.1	-0.1	-0.2	-0.25	-0.25
40	0	0	-0.2	-0.2	-0.2	-0.4	-0.1	-0.2	-0.2	-0.4	-0.5	-0.5
45	-0.1	-0.2	-0.25	0	-0.1	-0.1	0	0	0	0	0	0
50	0	0	0	0	-0.1	-0.2	0	0	-0.1	0	-0.1	-0.1
45	-0.1	-0.2	-0.2	0	0	0	0	0	0	0	0	0
40	0	+0.1	+0.1	0	0	0	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2
35	-0.2	-0.2	-0.2	-0.1	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	-0.1	-0.2	-0.2	0	-0.1	-0.1
25	0	+0.1	+0.1	0	+0.1	+0.1	0	0	0	-0.1	-0.1	-0.1
20	0	+0.1	+0.1	0	0	0	0	+0.2	+0.2	0	0	0
15	0	+0.25	+0.25	0	0	+0.1	0	0	0	0	-0.1	-0.1
10	0	+0.25	+0.25	-0.1	+0.1	+0.1	0	+0.2	+0.2	0	0	0
5	0	0	0	0	0	+0.1	0	+0.25	+0.25	0	+0.2	+0.2

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Table No. 2

Results of Accuracy Tests - Draft Indicating System

True Draft in Feet	Indicated Error in Feet											
	126.5 v - 63 cycles			126.5 v - 60 cycles			126.5 v - 57 cycles			40°F. Ambient		
	Pointers			Pointers			Pointers			Pointers		
	True	Follow-up	Repeater	True	Follow-up	Repeater	True	Follow-up	Repeater	True	Follow-up	Repeater
5	0	0	0	0	0	0	0	-0.2	-0.2	+0.2	+0.2	+0.25
10	0	0	0	-0.1	0	0	0	0	0	+0.2	**+0.4	**+0.4
15	0	0	0	-0.1	-0.25	-0.25	-0.1	-0.1	-0.1	+0.1	0	0
20	-0.1	-0.1	-0.1	-0.1	-0.25	-0.25	-0.1	-0.1	-0.1	0	-0.1	-0.1
25	0	-0.1	-0.1	0	-0.2	-0.2	0	-0.2	-0.25	0	-0.2	-0.2
30	0	-0.1	-0.1	0	-0.2	-0.2	0	-0.2	-0.2	0	-0.25	-0.25
35	-0.1	-0.2	-0.25	-0.2	-0.4	-0.4	0	-0.25	-0.3	-0.2	-0.3	-0.4
40	-0.2	-0.5	-0.5	-0.25	-0.5	-0.5	-0.1	-0.3	-0.3	-0.4	-0.5	-0.5
45	0	-0.3	-0.3	0	0	0	0	-0.1	-0.2	-0.2	-0.2	-0.2
50	0	0	-0.1	0	0	0	0	0	-0.1	-0.2	-0.2	-0.2
45	-0.1	-0.1	-0.1	0	0	0	0	0	0	-0.2	0	0
40	-0.2	-0.2	-0.2	0	-0.2	-0.2	-0.1	0	0	-0.1	-0.1	-0.1
35	-0.2	-0.2	-0.25	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0	0
30	0	-0.1	-0.1	0	-0.2	-0.2	+0.2	+0.2	+0.2	0	0	0
25	0	-0.1	-0.1	0	0	0	0	+0.1	+0.1	0	+0.2	+0.2
20	-0.1	-0.1	-0.1	0	0	0	0	+0.1	+0.1	0	+0.1	+0.1
15	0	0	0	0	0	+0.1	0	+0.1	+0.2	+0.1	+0.25	+0.25
10	0	0	0	0	+0.1	+0.1	0	+0.2	+0.2	+0.1	+0.25	+0.25
5	0	0	0	0	+0.1	+0.1	0	+0.2	+0.2	+0.2	**+0.4	**+0.5

Note: \* -- Denotes non-compliance.

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Table No. 3

Results of Accuracy Tests - Draft Indicating System

True Draft in Feet	Indicated Error in Feet											
	125°F. Ambient			125°F. - case open			75°F. Ambient			Inclined 25° backward		
	Pointers			Pointers			Pointers			Pointers		
	True	Follow-up	Repeater	True	Follow-up	Repeater	True	Follow-up	Repeater	True	Follow-up	Repeater
5	*-1.0	*-1.0	*-0.9	*+0.3	*+0.3	*+0.4	+0.2	+0.2	+0.2	+0.2	-0.2	0
0	*-1.5	*-1.5	*-1.5	0	0	0	+0.1	+0.1	+0.1	0	*-0.4	*-0.4
5	*-1.4	*-1.5	*-1.5	0	0	0	0	+0.1	+0.1	-0.1	*-0.4	*-0.4
0	*-1.4	*-1.5	*-1.5	0	0	0	0	0	0	-0.1	*-0.4	*-0.4
5	*-1.2	*-1.2	*-1.2	0	-0.1	-0.1	0	0	0	0	*-0.4	*-0.4
0	*-1.1	*-1.25	*-1.25	0	0	-0.1	+0.1	+0.1	+0.1	+0.1	*-0.3	*-0.3
5	*-1.2	*-1.4	*-1.5	0	0	-0.2	-0.25	-0.4	-0.5	0	-0.5	-0.5
0	*-1.2	*-1.2	*-1.2	+0.1	+0.1	-0.1	-0.3	-0.4	-0.4	+0.1	-0.25	-0.25
5	*-1.25	*-1.3	*-1.5	+0.2	+0.1	0	-0.1	-0.3	-0.4	0	-0.4	-0.5
0	*-1.25	*-1.25	*-1.4	+0.2	+0.25	+0.2	-0.1	-0.3	-0.4	0	-0.2	-0.3
5	*-0.8	*-0.8	*-0.8	+0.4	+0.5	+0.5	0	+0.1	+0.1	+0.25	0	0
0	*-0.8	*-0.9	*-0.9	+0.4	+0.4	+0.4	0	0	0	+0.2	-0.2	-0.2
5	*-0.9	*-0.75	*-0.75	+0.25	+0.4	+0.4	0	+0.2	+0.2	+0.3	0	0
0	*-0.75	*-0.7	*-0.6	*+0.4	*+0.5	*+0.5	+0.2	+0.2	+0.2	*+0.4	+0.2	+0.2
5	*-0.7	*-0.7	*-0.75	+0.25	*+0.5	*+0.5	+0.1	0	0	*+0.3	+0.2	+0.2
0	*-0.8	*-0.6	*-0.5	+0.2	*+0.2	*+0.5	+0.1	+0.25	+0.25	+0.25	+0.2	+0.2
5	*-0.8	*-0.6	*-0.5	+0.25	*+0.5	*+0.5	+0.1	+0.1	+0.2	*+0.4	+0.2	+0.25
0	*-1.0	*-0.75	*-0.75	+0.2	*+0.5	*+0.5	+0.2	+0.25	+0.25	+0.2	0	0
5	*-0.5	-0.25	-0.1	*+0.6	*+0.9	*+1.0	*+0.4	*+0.7	*+0.7	*+0.7	*+0.7	*+0.7

Note: \* -- Denotes non-compliance.

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Table No. 4

Results of Accuracy Tests - Draft Indicating System

True Draft in Feet	Indicated Error in Feet											
	Inclined 25° forward			Inclined 10° right			Inclined 10° left			Inclined 25° left		
	Pointers			Pointers			Pointers			Pointers		
	True	Follow-up	Repeater	True	Follow-up	Repeater	True	Follow-up	Repeater	True	Follow-up	Repeater
	+0.25	+0.25	+0.25	+0.2	+0.25	+0.25	+0.2	**+0.3	**+0.3	+0.1	+0.2	+0.2
1	+0.2	**+0.5	**+0.5	+0.2	**+0.3	**+0.3	+0.1	+0.1	+0.1	+0.1	+0.2	+0.2
1	+0.25	+0.2	+0.2	+0.25	**+0.3	**+0.3	0	0	0	+0.1	+0.1	+0.1
2	+0.25	-0.2	-0.2	0	+0.1	+0.1	0	-0.1	-0.1	-0.1	-0.1	-0.1
2	+0.25	0	0	0	0	0	0	0	0	0	-0.1	-0.1
3	**+0.4	**+0.4	**+0.4	+0.2	+0.2	+0.2	+0.1	-0.1	-0.1	0	-0.1	-0.1
3	+0.2	0	-0.1	0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2
4	+0.25	+0.25	+0.1	+0.1	0	0	0	-0.1	-0.1	-0.2	-0.3	-0.3
4	+0.2	+0.2	0	+0.2	+0.2	+0.1	0	0	-0.1	0	-0.2	-0.3
5	+0.3	+0.4	+0.3	+0.1	+0.2	+0.1	0	0	0	+0.2	+0.3	+0.3
4	+0.5	**+0.6	**+0.6	+0.25	+0.2	+0.2	0	0	0	+0.2	+0.25	+0.25
4	+0.4	+0.4	+0.4	+0.3	+0.25	+0.25	+0.1	+0.3	+0.3	+0.1	+0.1	+0.1
3	+0.25	+0.25	+0.25	+0.2	+0.2	+0.2	+0.1	+0.3	+0.3	0	0	0
3	**+0.4	**+0.4	**+0.4	+0.2	+0.25	+0.25	+0.2	+0.1	+0.1	+0.2	+0.2	+0.2
2	**+0.5	**+0.5	**+0.5	+0.2	+0.2	+0.2	+0.1	+0.1	+0.1	+0.2	+0.2	+0.2
2	**+0.4	**+0.5	**+0.5	+0.2	**+0.4	**+0.4	+0.2	**+0.4	**+0.4	+0.2	**+0.3	**+0.3
1	**+0.5	**+0.5	**+0.5	+0.25	**+0.6	**+0.6	+0.2	**+0.4	**+0.4	+0.2	**+0.4	**+0.4
1	**+0.5	**+0.6	**+0.6	+0.25	**+0.4	**+0.4	+0.2	**+0.4	**+0.4	+0.2	**+0.3	**+0.3
	**+0.7	**+0.8	**+0.9	**+0.5	**+0.7	**+0.8	**+0.4	**+0.7	**+0.7	+0.25	**+0.6	**+0.6

Note: \* -- Denotes non-compliance.

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Table No. 5

## Results of Accuracy Tests - Draft Indicating System

True Draft in Feet	Indicated Error in Feet											
	Inclined 25° Right			After 50 Hours Endurance			After Shock Test			After Vibration Test		
	Pointers			Pointers			Pointers			Pointers		
	True	Follow-up	Repeater	True	Follow-up	Repeater	True	Follow-up	Repeater	True	Follow-up	Repeater
5	**+0.4	**+0.5	**+0.5	**+0.7	**+0.8	**+0.9	**+0.4	**+0.4	**+0.4	**+0.8	**+0.8	**+0.8
10	**+0.4	**+0.4	**+0.4	+0.1	+0.1	+0.2	**+0.4	**+0.4	**+0.4	+0.25	+0.2	+0.1
15	**+0.3	**+0.3	**+0.3	0	0	0	+0.2	**+0.3	**+0.3	**+0.3	**+0.3	**+0.3
20	+0.2	**+0.3	**+0.3	0	0	0	+0.2	+0.2	+0.2	**+0.3	**+0.4	**+0.4
25	+0.2	+0.1	+0.1	+0.1	+0.2	+0.1	0	+0.2	+0.2	**+0.4	**+0.4	**+0.4
30	**+0.4	**+0.4	**+0.4	+0.2	+0.2	+0.2	**+0.3	**+0.3	**+0.3	+0.25	+0.25	+0.2
35	+0.25	0	0	0	0	-0.1	+0.1	0	0	+0.2	+0.2	0
40	+0.25	+0.1	+0.1	-0.1	-0.2	-0.25	+0.1	+0.2	+0.2	+0.2	+0.25	+0.2
45	+0.4	+0.25	+0.25	0	0	-0.1	+0.2	+0.2	+0.2	+0.2	+0.2	+0.1
50	+0.4	+0.4	+0.4	+0.2	+0.3	+0.2	+0.3	+0.4	+0.4	+0.25	+0.25	+0.25
45	+0.5	+0.5	+0.5	+0.1	+0.2	+0.3	+0.5	+0.5	+0.5	**+0.6	**+0.7	**+0.7
40	+0.3	+0.3	+0.3	+0.2	+0.2	+0.2	+0.25	+0.25	**+0.25	**+0.6	**+0.6	+0.4
35	+0.3	+0.3	+0.3	+0.1	+0.1	+0.1	+0.2	+0.2	+0.2	+0.4	+0.4	+0.4
30	**+0.4	**+0.4	**+0.4	+0.25	+0.25	+0.25	**+0.4	**+0.4	**+0.4	**+0.75	**+0.8	**+0.7
25	**+0.3	**+0.3	**+0.3	+0.25	+0.25	+0.25	**+0.4	**+0.4	**+0.4	**+0.6	**+0.6	**+0.6
20	+0.25	**+0.5	**+0.5	+0.2	+0.2	+0.2	**+0.4	**+0.6	**+0.6	**+0.5	**+0.6	**+0.6
15	**+0.4	**+0.6	**+0.6	+0.1	**+0.3	**+0.5	+0.25	+0.2	**+0.3	**+0.5	**+0.5	**+0.5
10	**+0.3	**+0.6	**+0.6	+0.2	**+0.5	**+0.6	**+0.5	**+0.6	**+0.7	**+0.5	**+0.5	**+0.5
5	**+0.9	**+1.2	**+1.2	**+0.7	**+0.8	**+1.0	**+1.0	**+1.2	**+1.3	**+1.1	**+1.3	**+1.3

Note: \* -- Denotes non-compliance.

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Table No. 6

Results of Accuracy Tests - Draft Indicating System

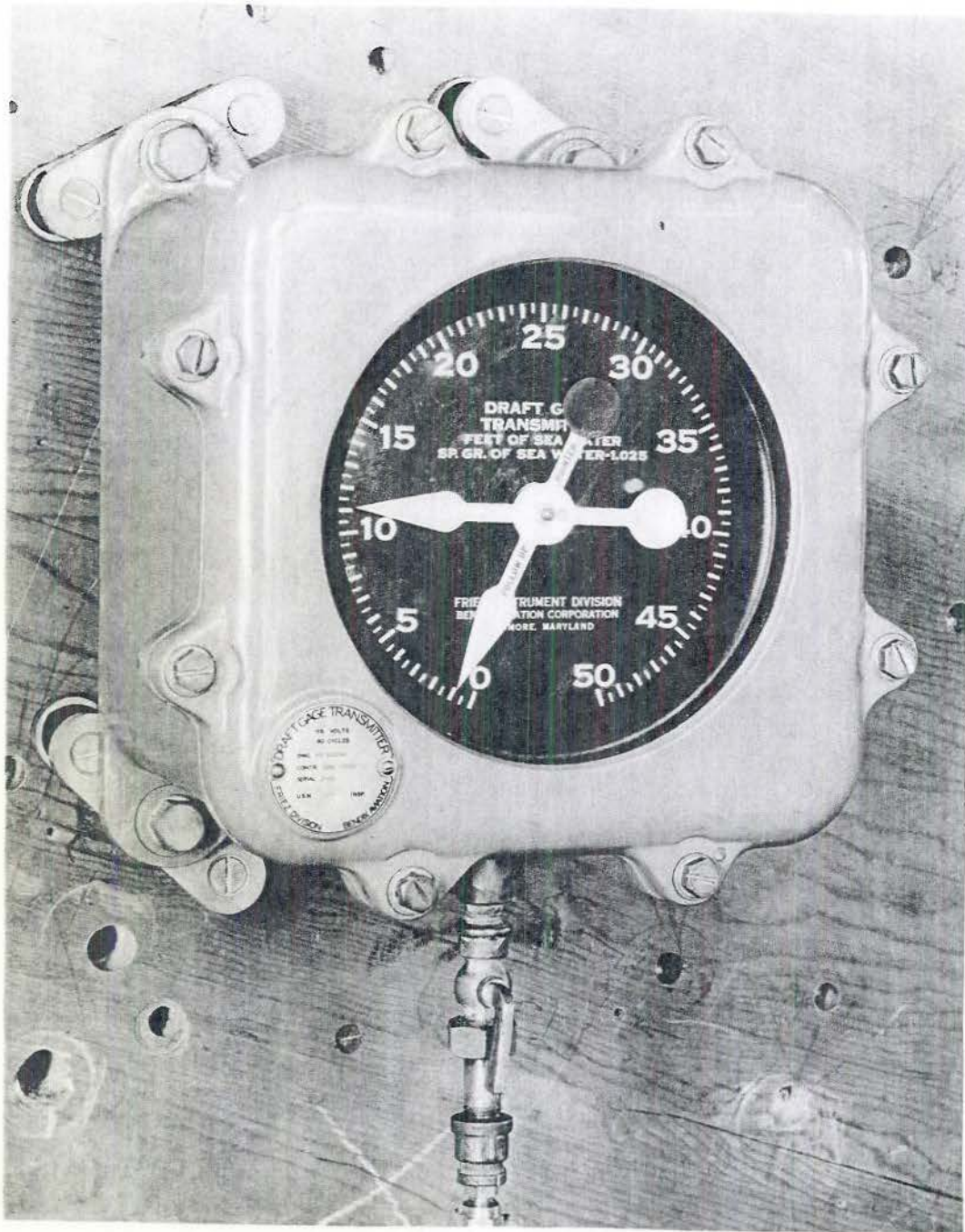
True Draft in Feet	Indicated Error in Feet								
	After adjusting follow-up contacts			After 500 hours endurance			After 25% overpressure		
	Pointers			Pointers			Pointers		
	True	Follow-up	Repeater	True	Follow-up	Repeater	True	Follow-up	Repeater
5	**+0.5	**+0.7	**+0.7	**+0.5	**+0.6	**+0.6	**+0.8	**+0.9	**+0.9
10	**+0.4	**+0.6	**+0.6	**+0.4	**+0.6	**+0.6	**+0.6	**+0.8	**+0.8
15	**+0.3	**+0.3	**+0.3	**+0.4	**+0.4	**+0.3	**+0.4	**+0.3	**+0.3
20	+0.2	**+0.3	**+0.3	**+0.5	**+0.7	**+0.6	**+0.4	**+0.4	**+0.3
25	+0.25	+0.25	+0.25	**+0.5	**+0.5	**+0.5	**+0.5	**+0.5	**+0.5
30	+0.25	+0.1	+0.1	**+0.6	**+0.6	**+0.5	**+0.5	**+0.5	**+0.4
35	+0.2	+0.25	+0.2	+0.4	+0.4	+0.3	+0.3	+0.4	+0.3
40	+0.25	+0.1	0	**+0.6	**+0.6	+0.5	+0.4	+0.4	+0.3
45	+0.25	+0.2	+0.1	+0.25	+0.25	+0.2	+0.3	+0.2	+0.1
50	+0.4	+0.5	+0.5	**+0.7	**+0.7	**+0.6	**+0.6	**+0.6	+0.5
45	**+0.6	**+0.7	**+0.7	**+0.8	**+0.9	**+0.8	**+0.8	**+0.8	**+0.75
40	+0.5	+0.5	+0.5	**+0.7	**+0.8	**+0.7	**+0.75	**+0.75	**+0.6
35	+0.5	**+0.6	**+0.6	+0.5	+0.5	+0.4	+0.4	+0.4	+0.3
30	**+0.7	**+0.7	**+0.7	**+0.6	**+0.75	**+0.7	**+0.6	**+0.7	**+0.6
25	**+0.6	**+0.6	**+0.6	**+0.6	**+0.6	**+0.6	**+0.7	**+0.75	**+0.75
20	**+0.6	**+0.6	**+0.6	**+0.7	**+0.75	**+0.7	**+0.6	**+0.8	**+0.8
15	**+0.6	**+0.8	**+0.8	**+0.6	**+0.6	**+0.6	**+0.75	**+1.0	**+1.0
10	**+0.6	**+0.9	**+0.9	**+0.6	**+0.75	**+0.8	**+0.7	**+0.9	**+1.0
5	**+0.75	**+1.0	**+1.0	**+0.7	**+1.0	**+1.0	**+0.75	**+1.0	**+1.0

Note: \* -- Denotes non-compliance.

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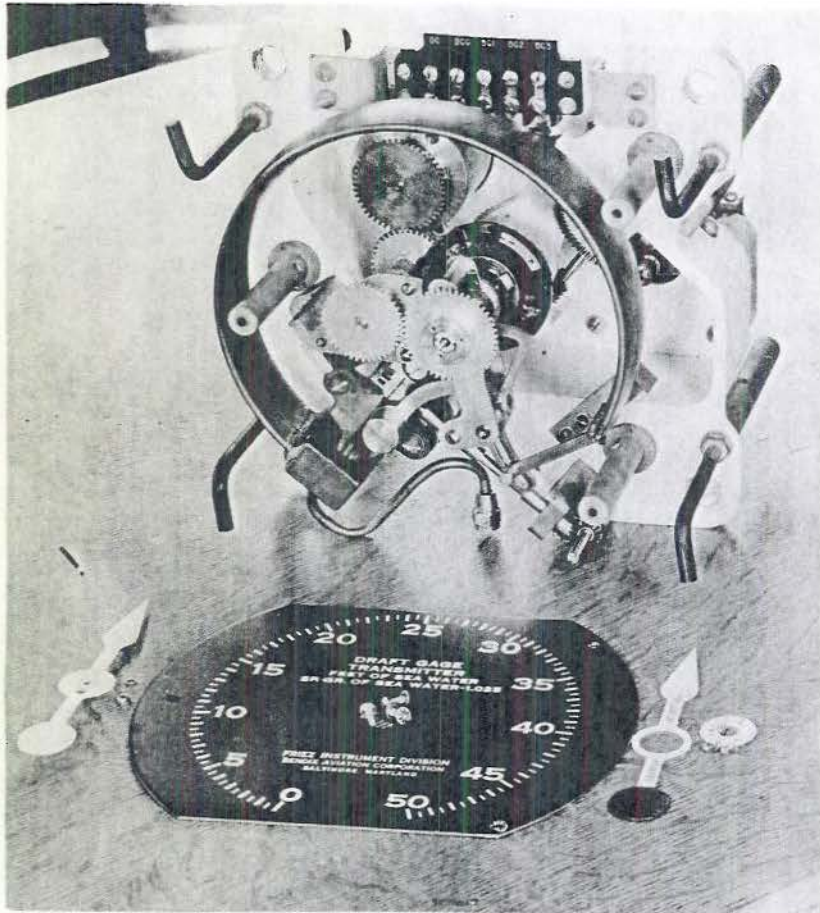


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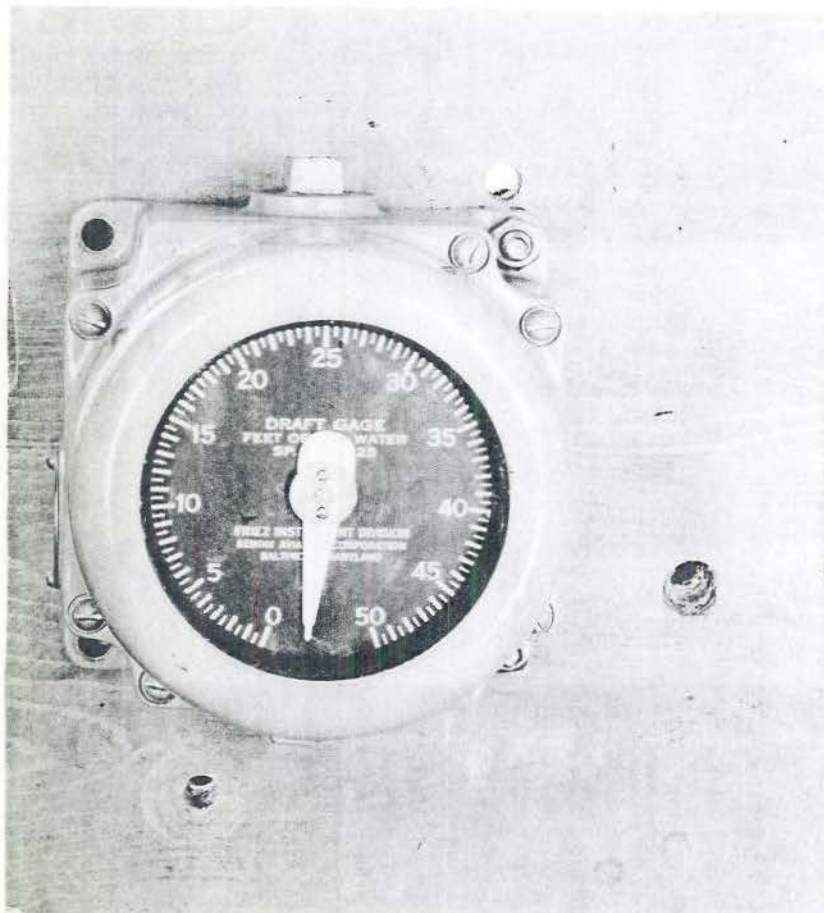
PLATE I

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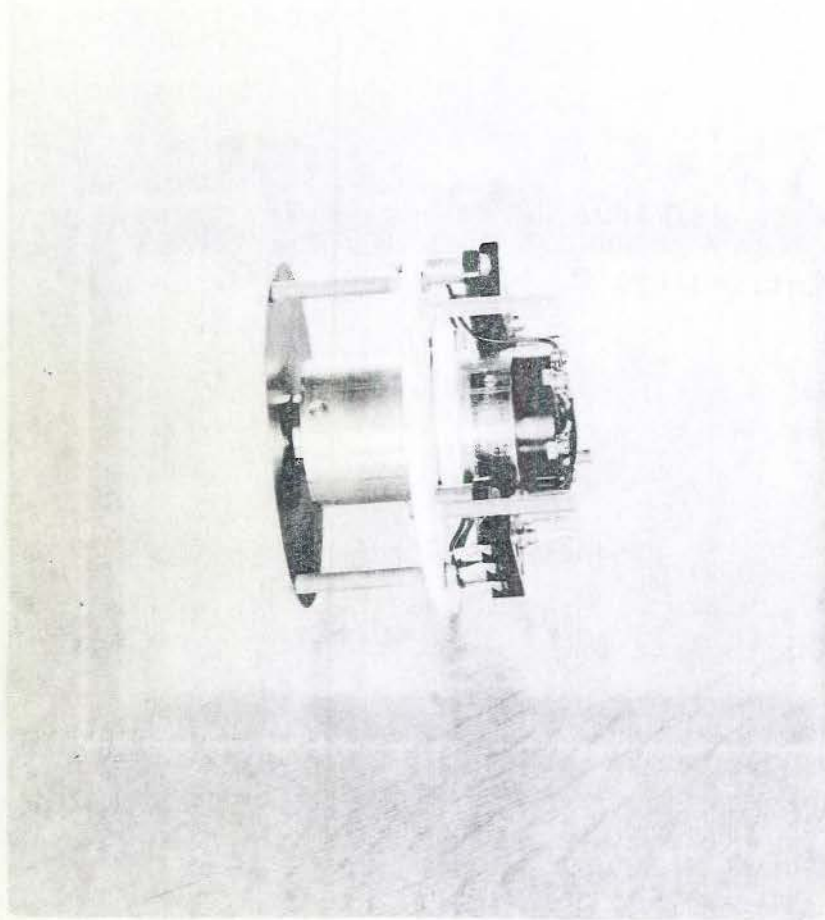
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