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EVALUATION
OF THE
RYAN WATERPROOF THERMOGRAPH (MODEL F-30)

By

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REVIEW NOTICE

FOREWORD

Men and his environment must be protected from the adverse effects of pesticides, radiation, noise and other forms of pollution, and the unwise management of solid waste. Efforts to protect the environment require a focus that recognizes the interplay between the components of our physical environment--air, water, and land. The National Environmental Research Centers provide this multidisciplinary focus through programs engaged in

- studies on the effects of environmental contaminants on man and the biosphere, and

- a search for ways to prevent contamination and to recycle valuable resources.

The Ryan Thermograph Temperature Recorder was evaluated at the request of the Cincinnati District, U. S. Corps of Engineers, in the Instrumentation Development Laboratory, AQCL, NERC-Cincinnati. This study included tests for accuracy, stability, linearity and response. Other pertinent characteristics are discussed.

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SYNOPSIS

The Ryan waterproof thermograph (Model F-30) was evaluated. The evaluation included tests for stability, linearity, response time, and accuracy. Recorder resolution, definition, and data pick-off capabilities were observed. The thermograph's construction, maintenance, and installation problems were discussed.

STABILITY OF THERMOGRAPH AT CONSTANT CONDITIONS

Stability tests were made at 35, 55, and 75F, respectively. First the thermograph was calibrated at the 35F condition; then it was fully immersed in a constant temperature bath under approximately 2 feet of water. A water pump provided thorough mixing throughout the bath. A precision thermometer was strapped directly to the thermograph's sensing bulb. The unit was left in the bath at each temperature condition for two or more days. (Table 1)

35F Condition - The true bath temperature varied from 35.3 to 35.6F (Range = 0.3F). The Ryan thermograph chart read from 35.5 to 36.0F (Range = 0.5F). It was impossible to read the Ryan instrument closer than 1/2F. The thermograph variation was not significantly greater than the variation of the bath. Therefore, stability at this condition was satisfactory.

55F Condition - The true bath temperature varied from 54.6 to 55.0F (Range = 0.4F). The thermograph chart read from 55.0 to 55.5F (Range = 0.5F). Since the thermograph variation was not significantly greater than the bath variation, stability at this condition was satisfactory.

75F Condition - The true bath temperature varied from 75.8 to 76.5F (Range = 0.7F). The thermograph varied from 77.0 to 77.5F (Range = 0.5F). The Ryan thermograph varied less than the bath and therefore stability at this condition was satisfactory.

LINEARITY

Temperature - Ryan temperature vs true temperature is plotted in Figure 1. These are average readings taken from Table 1. The graph indicates that Ryan temperature is linear with true temperature. The slope of the curve is slightly greater than 1. The calibration at 35F reflects the close agreement at this condition. The curve points out the desirability of calibrating the unit at mid-range. If this were done, better agreement would be obtained at the high end point.

Time - Figure 2 shows that the chart travel is linear with time. The initial step on the graph of 0.1 day for 0 inches of chart travel probably reflects the initial take-up of the chart on the spool (i.e., the chart did not move under the scriber until the slack was taken up).

RESPONSE

Response time tests were made from mid-range to the end points and vice versa. Results of these tests are given in Table 3. Response was fairly rapid until the scriber reached a point that was within 1 to 2F of the end point. At this point response became slow. The initial intention was to log the response time required for 98% of a step change. Sluggishness near the end points and the inability to read the chart to 2% of a 20F change made this extremely difficult. For these tests, response time was defined as the period from initial immersion into a bath set at 20F temperature differential, until noticeable movement of the scriber ceased. In Table 3, average response time ranged from 50.6 to 63.8 seconds.

The sluggishness made it desirable to perform additional tests which would indicate hysteresis and dead band. (Figure 3 and 4)

Hysteresis data were obtained when only the instrument's sensing bulb was in the constant temperature bath. The cover of the instrument was left off so that the strip chart could be read. The bath temperature was changed in 5F increments and the instrument was read only after the bath temperature peaked and remained constant for 5 minutes or more. The hysteresis curve is shown in Figure 3.

In testing for dead band, the unit was first taken from a bath at approximately 75F and placed in a bath that was held constant at 55.2F. The unit was left in this bath for 150 minutes. The procedure was repeated with the starting point set at approximately 35F. Figure 4 shows that when a central temperature (55.2F) was approached from two ends (75 and 35F), the differential was closed rapidly at first (to 2.5F in 1 to 2 minutes); it then took 150 minutes to close the differential to 1F. Hence the dead band was not greater than 1F.

CONSTRUCTION

The instrument is very sturdy and well built. It is enclosed inside a stainless steel shell and sealed in two places for protection from water leaks. One seal consists of an "O" ring that is compressed by a girth clamp. The other seal consists of an "O" ring with an application of a fine grade "O" ring lube. No leaks occur in 2 feet of water. It appears that the instrument could be submerged to much greater depths, as no large non-stainless steel areas are exposed to the water. The manufacturer specifies that the unit is waterproof to 1000 feet.

Complete construction details (including how it works) are given in the manufacturer's specifications. A visual inspection of the unit revealed these details.

RECORDING DEVICE

a. Resolution

The instrument uses chart paper that is 2 inches high and covers a temperature differential of 60F. Therefore, 1F represents .033 inch on the chart. The chart is graduated every 2 degrees. It is easy to read the chart to 1/2 of a graduation. Estimates can be made to 1/4 of a graduation or 0.5F.

The Model F-30* has a recorder chart speed of 5/8 inch/day. This is .026 inch/hour. Therefore, it is difficult to read this chart at a specific time.

b. Definition

The strip chart is pressure sensitive and the scriber makes a line that is clearly visible.

*Ryan thermograph Models F-8 and F-15 use chart speeds of 2-1/2 and 1-1/4 inch/day respectively.

c. Accuracy

The manufacturer indicates a temperature accuracy that is within 2%. Thus a full scale range of 60F is accurate within ±1.2F. (Refer to Table 2.) This table compares the average Ryan temperature with the average true bath temperature for each of the three conditions. The average differences between Ryan and true temperature were 0.2, 0.5, and 1.2F at the 35, 55, and 75F conditions, respectively. None of the averages differ from truth by more than 1.2F. Some of the individual readings at the 75F condition differed from truth by slightly more than 1.2F. If the unit was calibrated at mid-range instead of at the 35F condition, there would have been better agreementaat the high end point. Therefore, the thermograph is accurate within ±2% of full scale.

The manufacturer indicates a time accuracy of 2%. Figure 2 shows that the chart drive is linear with time. The chart is marked in increments of 2 days. These markings were checked and they are accurate with the recorder movement. The manufacturer indicates a 5/8 inch/day chart travel for the Model F-30. This was checked and found to be accurate within 2%.

d. Data Pick-off Capabilities

The chart for the Model F-30 can easily be read to 1F. It would be very difficult to read time in increments closer than 1 hour.

e. Other

The recorder mechanism, which is spring wound, ran continuously for a 30-day period and time vs chart travel was extremely linear throughout the period.

MAINTENANCE

The unit requires very little maintenance:

1. Change chart and rewind every 30 days.
2. Use "O" ring lube whenever cover is reinstalled.
3. Check calibration, at mid-range, before using the instrument and adjust scriber arm if necessary.

INSTALLATION PROBLEMS

a. Assembly

None

b. Field Installations

The instrument should include an eyebolt on top of the casing so that it may be positively secured with a line before it is lowered into the water.

SUMMARY

a. Stability

Satisfactory.

b. Linearity (temperature and time)

Satisfactory.

c. Response Time

Approximately 57.5 seconds for completion of 90% of a 20F step change. Some hysteresis and dead band were noted.

d. Construction

Sturdy, corrosion resistant.

e. Resolution

Satisfactory for temperature. Difficult to read chart at specific time.

f. Definition

Satisfactory.

g. Accuracy

±2% of full scale on temperature when properly calibrated. Calibration is a tedious process. Chart travel is linear and the 2 day time markings are accurate but the (Model F-30) chart would be difficult to read in time increments that are closer than 1 hour.

h. Data Pick-off Capability

Temperature (to 1F). Time (no closer than 1 hour for the Model F-30).

i. Maintenance

Very little required.

g. Installation Problems

1. Assembly - none.
2. Field - provision should be made to enable one to secure the instrument to a line.

CONCLUSIONS

Average instrument accuracy was within ±2% of full scale when calibrated properly. Accurate calibration is a tedious process. Some hysteresis, dead band, and sluggishness near the end point of a step response was noted. This is shown in the report and should be carefully scrutinized by one contemplating purchase of the instrument. Resolution is satisfactory for temperature, but it is difficult to read the chart at a specific time. When properly calibrated, the instrument is a useful tool for collecting temperature data with reasonable accuracy in remote stream locations for unattended periods up to 30 days. Pinpoint accuracy, as required of a precision thermometer, should not be expected.

Table 1. STABILITY

35 F Condition				55 F Condition				75 F Condition			
Date 1969	Time	Temp. F (true)	Temp. F (Ryan)	Date 1969	Time	Temp. F (true)	Temp F (Ryan)	Date 1969	Time	Temp. F (true)	Temp. F (Ryan)
1/22	4:50	35.5	36.0	1/24	4:20	54.8	55.0	1/30	5:10	76.5	77.5
1/23	8:05	35.6	36.0	1/27	8:20	54.8	55.0	1/31	8:25	76.0	77.5
	12:20	35.4	36.0		9:20	54.8	55.0		9:10	75.9	77.0
	4:00	35.6	36.0		4:10	54.8	55.0		11:00	75.8	77.0
	4:35	35.4	36.0		4:45	54.9	55.0		1:20	75.8	77.0
1/24	8:15	35.4	35.5	1/29	10:40	55.0	55.5		2:35	76.0	77.0
	9:15	35.4	35.5	1/30	8:30	55.0	55.5		3:45	76.0	77.0
	10:40	35.6	35.5		10:45	54.8	55.5		4:40	76.0	77.0
	11:30	35.4	35.5		12:45	54.8	55.5	2/3	8:25	76.0	77.5
	12:25	35.3	35.5		1:30	54.8	55.5		9:15	76.0	77.5
	1:30	35.4	35.5		2:50	54.8	55.5				
					4:20	54.6	55.5	Avg.=		76.0	77.2
Avg.=		35.5	35.7								
				Avg.=		54.8	55.3				

Table 2. ACCURACY

Condition F	Temp. F (true) avg.	Temp. F (Ryan) avg.	Difference Ryan—true	No. of readings
35	35.5	35.7	0.2	11
55	54.8	55.3	0.5	12
75	76.0	77.2	1.2	10

Table 3. RESPONSE TIME TESTS (12/27/68)

	Bath temperature Low F		Bath temperature High F
	35		54.6

	Ryan temperature Low F		High F	Time (secs.)
	35	←	54	50
	35	←	54	60
	35	←	54	55
	35	←	54	58
	35	←	54	30
Avg. =	35		54	50.6
	35	→	52	54
	35	→	52	70
	35	→	52	60
	35	→	52	75
	35	→	52	60
Avg. =	35		52	63.8

Note: Response from 52F to 54F on rising temperature was very slow.

	Bath temperature Low F		Bath temperature High F
	55.2		74.6

	Ryan temperature Low F		High F	Time (secs.)
	56	←	74	60
	56	←	73	60
	56	←	73	60
	56	←	73	55
	56	←	73	60
Avg. =	56		73.2	59.0
	56	→	73	65
	56	→	73	55
	56	→	73	53
	56	→	73	55
	56	→	73	55
Avg. =	56		73	56.6

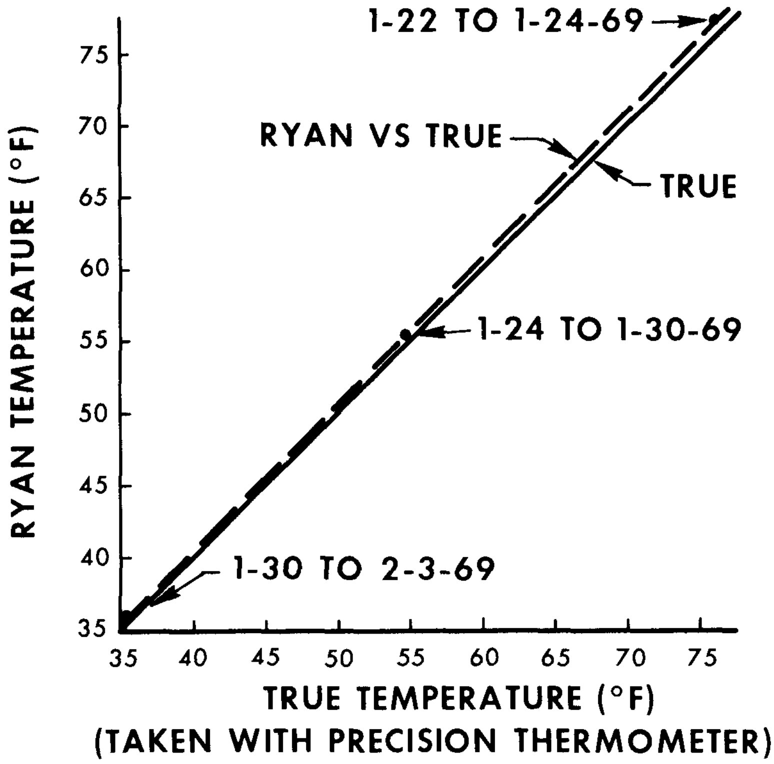
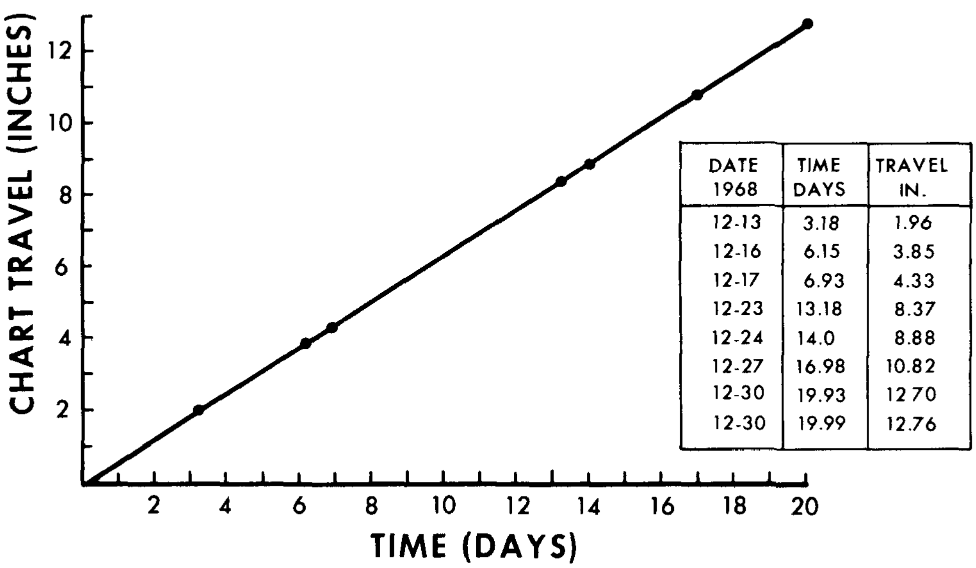


FIGURE 1 TEMPERATURE LINEARITY



DATE 1968	TIME DAYS	TRAVEL IN.
12-13	3.18	1.96
12-16	6.15	3.85
12-17	6.93	4.33
12-23	13.18	8.37
12-24	14.0	8.88
12-27	16.98	10.82
12-30	19.93	12 70
12-30	19.99	12.76

FIGURE 2 TIME LINEARITY

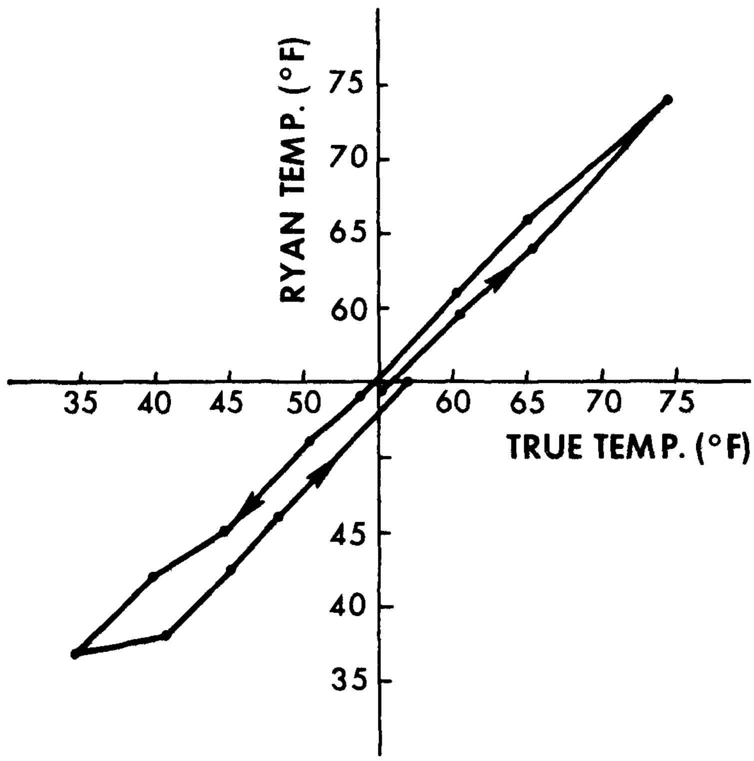


FIGURE 3 HYSTERESIS

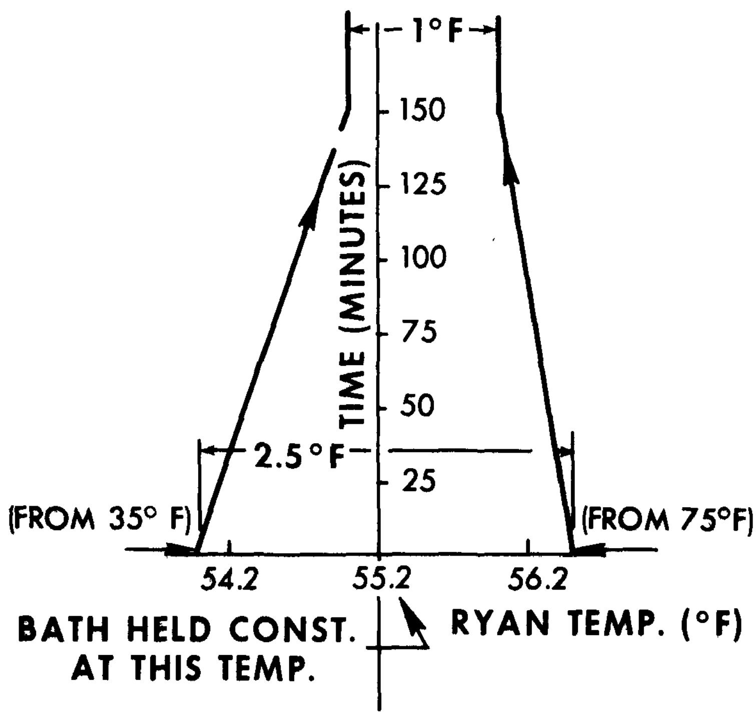


FIGURE 4 DEAD BAND

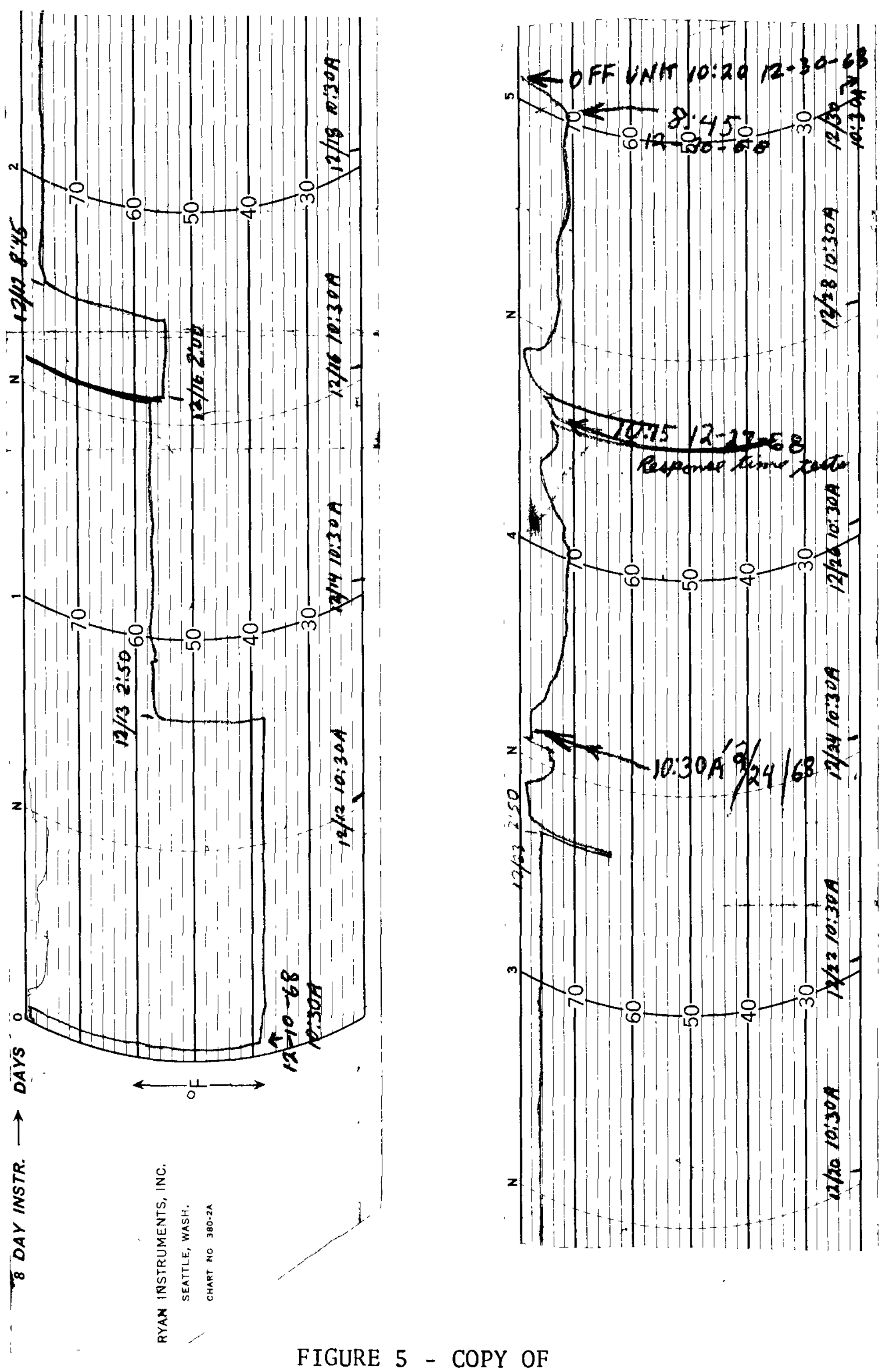


FIGURE 5 - COPY OF
ORIGINAL STRIP CHART
(TIME LINEARITY, RESPONSE)

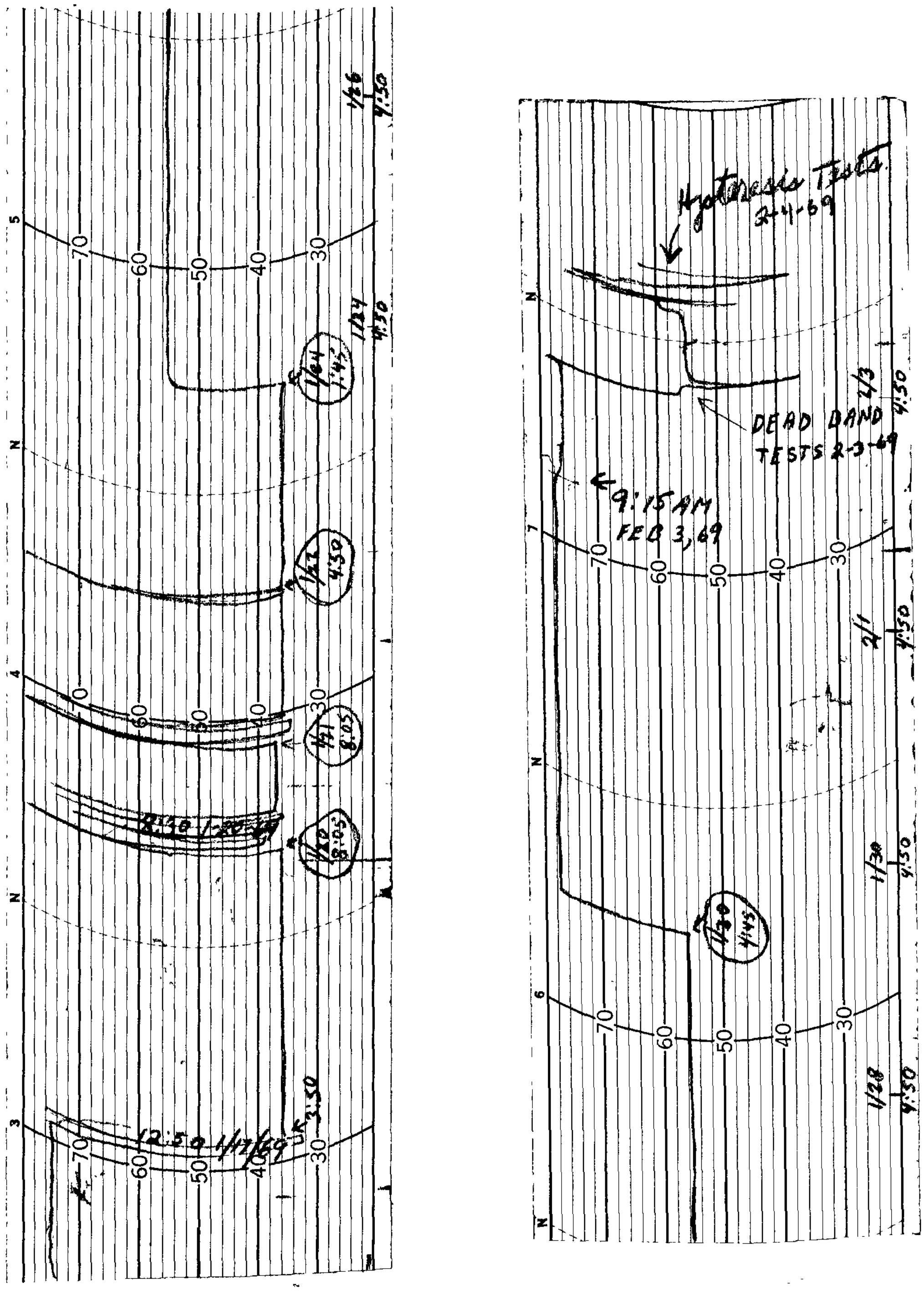


FIGURE 6 - COPY OF
ORIGINAL STRIP CHART
(STABILITY, ACCURACY, TEMPERATURE LINEARITY,
HYSTERESIS, DEAD BAND)

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

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15. SUPPLEMENTARY NOTES

16. ABSTRACT

The Ryan waterproof thermograph (Model F-30) was evaluated. The evaluation included tests for stability, linearity, response time, and accuracy. Recorder resolution, definition, and data pick-off capabilities were observed. The thermograph's construction, maintenance, and installation problems were discussed.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Temperature measuring instruments, Thermal measurements.	Thermograph evaluation, Temperature instrumentation, Thermograph performance, Thermographs.	13B

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