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SUBJECT: Dowtherm "A" Journal Bearing Test

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Abstract

The bearing housing of an overhung vertical shaft centrifugal pump, consisting of a plain journal bearing, one double row ball bearing and two mechanical shaft face seals to contain the lubricant (Dowtherm "A"), was operated for a total of 3206 hours at 2600 rpm, pumping molten salt #30 at a temperature of 1200°F.

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DOWTHERM "A" JOURNAL BEARING TEST

Purpose

The purpose of these tests was to demonstrate by an extended or durability type of dynamic testing that a relatively high radiation resistant organic fluid which does not possess the property of "oiliness" can be used as a lubricant for properly designed journal and antifriction bearings. Furthermore, that this fluid can be satisfactorily isolated using the mechanical rotary face type seal under the operating conditions described below, and that the selected organic fluid (Dotherm "A") is compatible with some typical materials of construction used in reactor pumps, e.g., inconel, stainless steel, mild steel, etc.

Test Equipment

The test bearings, consisting of an inconel journal (3.4002" outside diameter), an aluminum alloy 750T bearing (3.4036" inside diameter and 2-1/2" long), and a double row MRC 5309 ball bearing, were installed in an MF sump type rotary pump (UCNC Drawing F-2-02-054-650), using an MF-2 impeller (D-2-02-054-648), a pressure breakdown plug (B-2-02-054-2390), and an MF-2 shaft (D-2-02-054-639). The bearings were loaded to an unknown amount by the hydraulic unbalance on the impeller while circulating fuel composition #30 in a short circuit hot loop (F-2-02-054-2174), see Fig. 1. The lubricant was supplied, under 22 psig pressure, to the test bearings from an external lube oil circulating pump through stainless steel piping. During operation, the lubricant was maintained under an inert helium atmosphere. Drawing D-2-02-054-2043 shows the flow diagram for the auxiliaries of the test rig. Two mechanical face seals, C-2-02-054-601 and C-2-03-054-602 are used in the test equipment to isolate the lubricant from the fuel cavity and from the atmosphere.

The Lubricant

Dowtherm "A" is the eutectic mixture of Diphenyl-Diphenyloxide (Fig. 2), consisting of 26.5% (by weight) Diphenyl and 73.5% (by weight) Diphenyloxide. This organic fluid was chosen as the lubricant because of its high radiation-resistance properties and because the products of decomposition from thermal breakdown remain soluble in solution*. Dowtherm "A" is not recommended for operation at temperatures in excess of 700°F where polymerization to higher molecular weight materials and high vapor pressures occurs. Table I and

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*The Dowtherm Handbook, Dow Chemical Company, Midland, Michigan, p 28.

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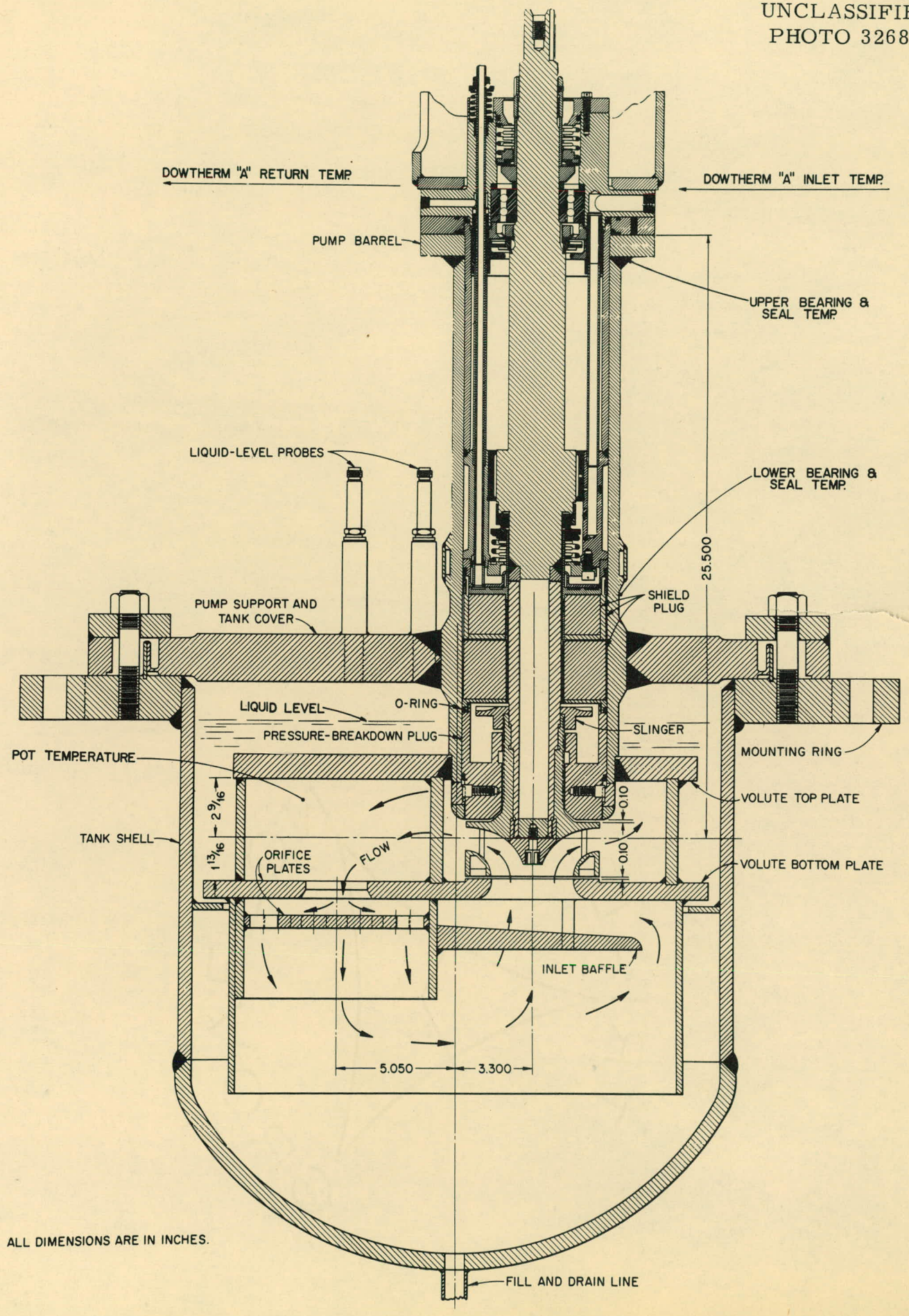

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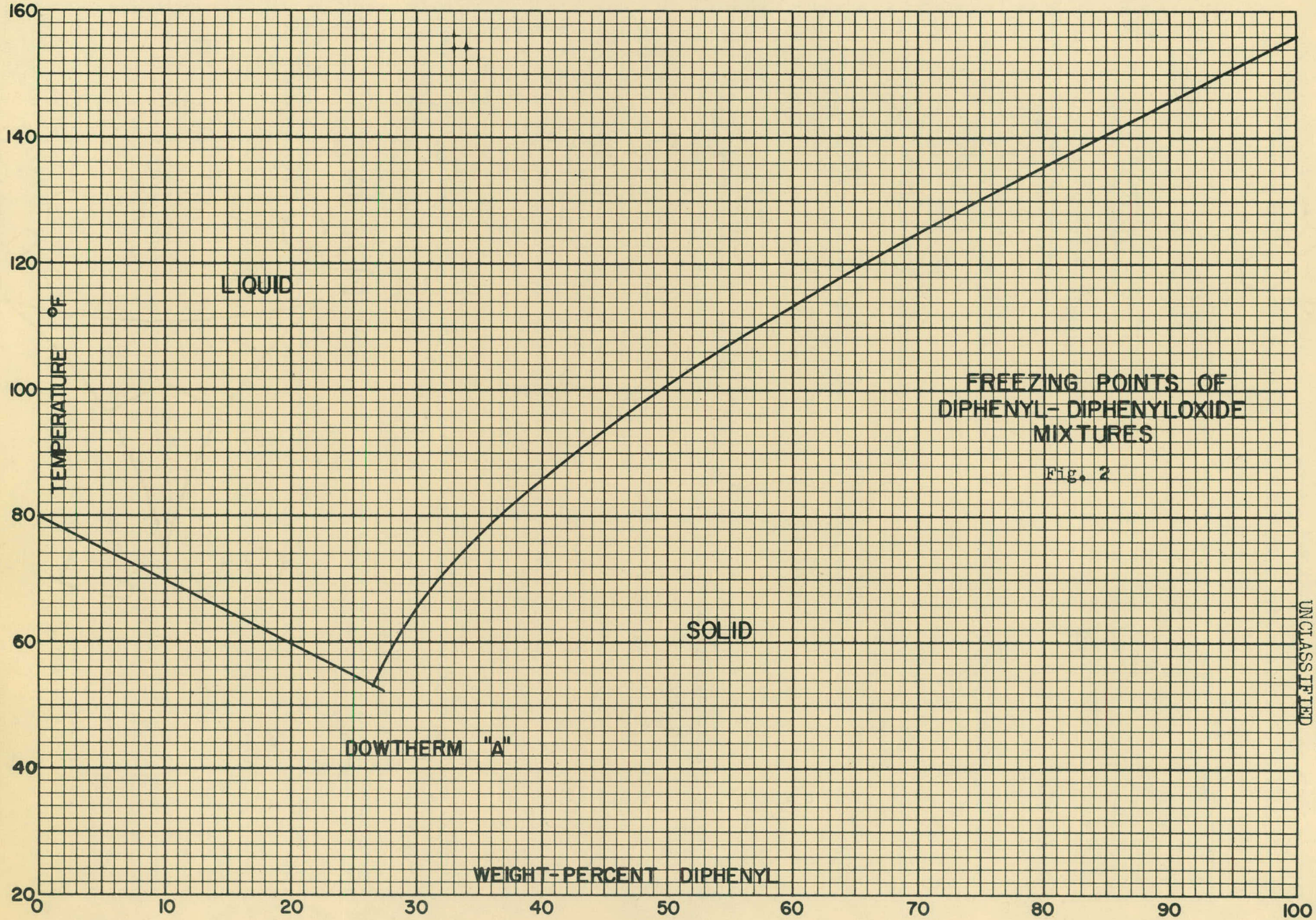

FREEZING POINTS OF DIPHENYL-DIPHENYLOXIDE MIXTURES

Fig. 2

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TABLE I

Properties of Dowtherm "A"

1. Surface tension at 25°C. . . . . 43 dynes/cm.
2. Flash point. . . . . 255°F.
3. Fire point . . . . . 275°F.
4. Auto ignition temperature. . . . . 1150°F.
5. Freezing point (liquid contracts on freezing). . . . . 53.2°F.
6. Boiling point (standard pressure). . . . . 495.8°F.
7. Stability - Decomposition rate of .3% for 100 hours at a temperature of 715°F and heat flux of 10,000 BTU an hour per square foot. No appreciable decomposition below 650°F.
8. Hue - Light staw-colored liquid.
9. Odor - Pungent.
10. Toxicity - No significant toxicity at vapor concentrations less than 7-10 ppm. Very slight irritation to skin from severe and repeated exposures.

Figs. 3, 4, 5, and 6 describe the pertinent physical properties of the fluid. The bearing tests were performed at about 180°F inlet lubricant temperature and 185°F return lubricant temperature. At these temperatures, Dowtherm "A" did not appear to corrode: a) mild steel, b) inconel, c) hardened steel, and d) stainless steel. Dark colored films, presumably oxides formed on brass and other copper alloys during these tests but discoloration of the bulk lubricant was not noticable to the unaided eye. Dowtherm "A" caused the Buna N rubber (Parker Compound 47041) elastomers to increase in both length and cross-section about 25% but this increase did not result in leakage during test operation. The organic liquid did not cause any detrimental effects upon the physical properties of the graphitar seal nose.

Test Results

The bearing tests were conducted under the following average operating conditions:

1. Shaft speed - 2600 rpm.
2. Salt #30 temperature - 1200°F.
3. Inlet lubricant temperature - 180°F.
4. Return lubricant temperature - 185°F.

Bearing and journal dimensions were taken after 194 hours, 1,194 hours, and 3,200 hours. These measurements showed evidence of an initial wear-in period during the first 1100 hours from a diametral clearance of 0.0034" to 0.0045", which thereafter remained constant until failure. The MRC #5309 double row ball bearing was given a visual inspection for evidence of wear and corrosion during each inspection period. At the end of the test no evidence of cracking, wear, or corrosion was observed. Seal nose wear was meansured for the last 2000 hours of test operation; and found to be .0016" for the upper seal and .0004" for the lower seal. Table 2 gives the numerical values of bearing and seal wear during the test period. Seal leak rates were less than some which have been observed with conventional lubricants (see Fig. 7). Six hours after start up in the beginning of the fourth test period (accumulated time 3,206 hours) a building power interruption caused the lube oil pump to stop. In less than 30 seconds after this outage, it was noted that the drive equipment was heavily overloaded and the test speed had reduced to zero. During disassembly it was noted that the three oil supply grooves in the bearing were uncovered by the journal for approximately one-quarter inch; thus a path existed during the entire test for direct escape of the pressure fed lubricant to the region external to the load carrying film of the bearing. It was further ascertained that a bearing of MF-3

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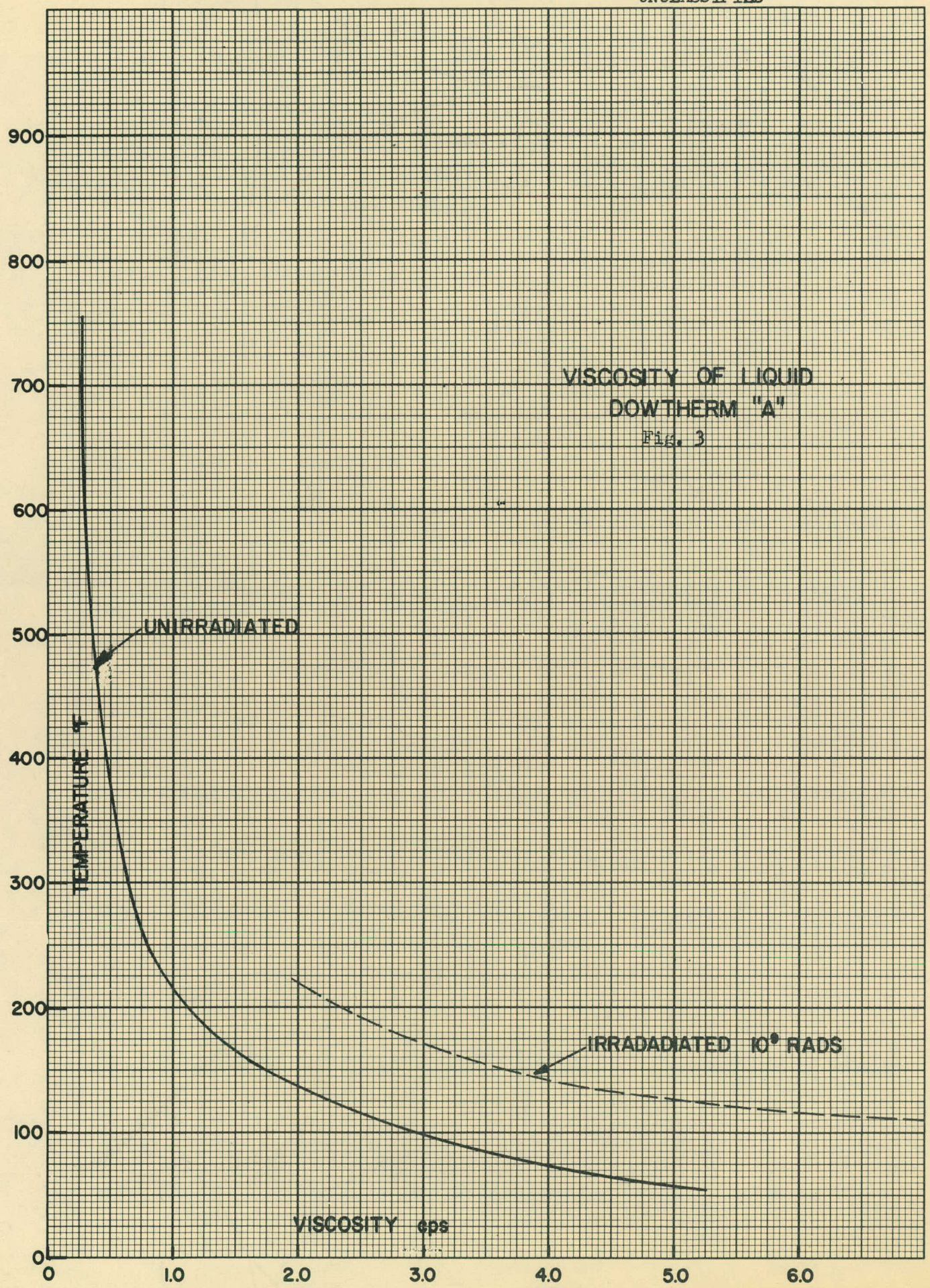

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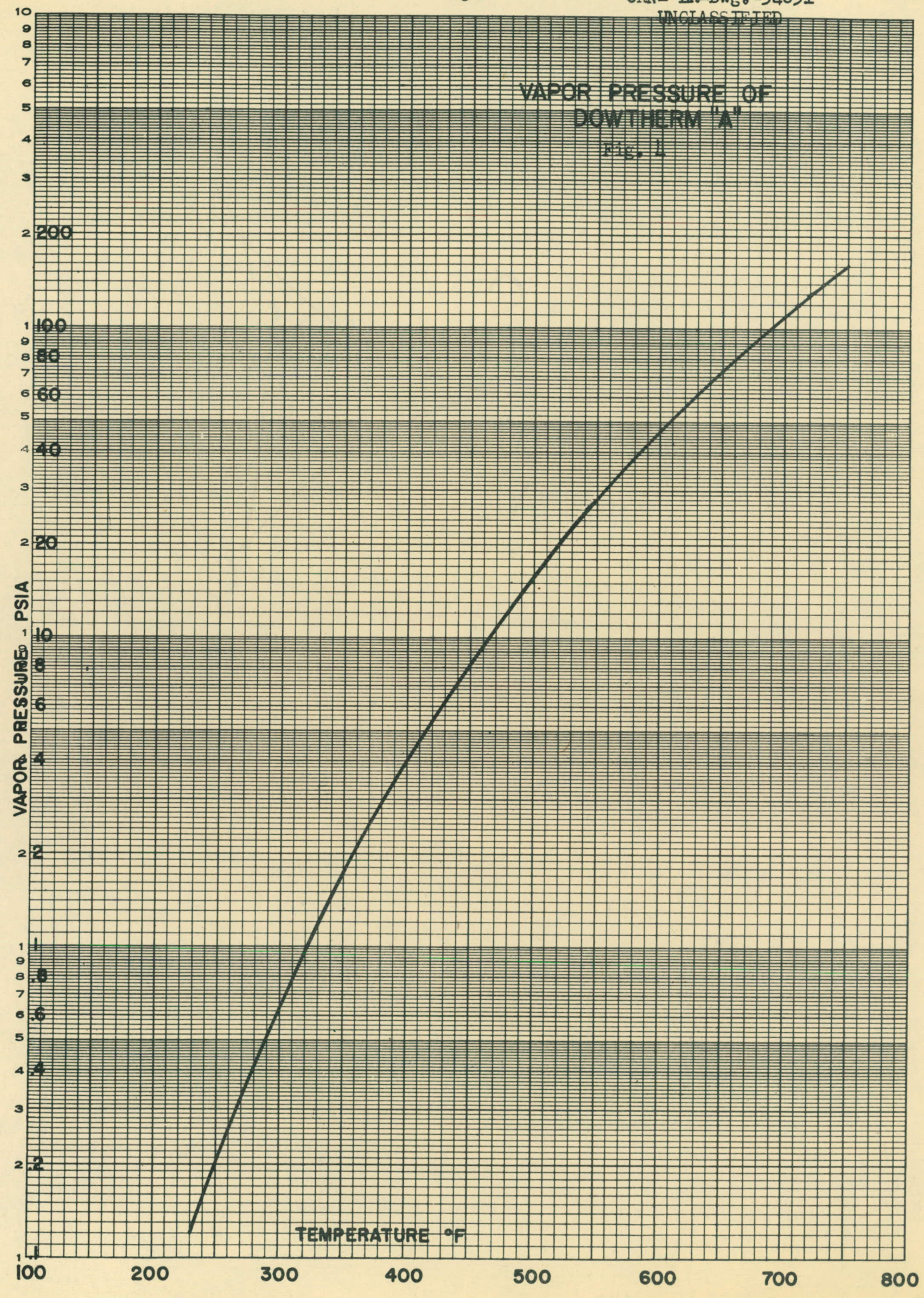

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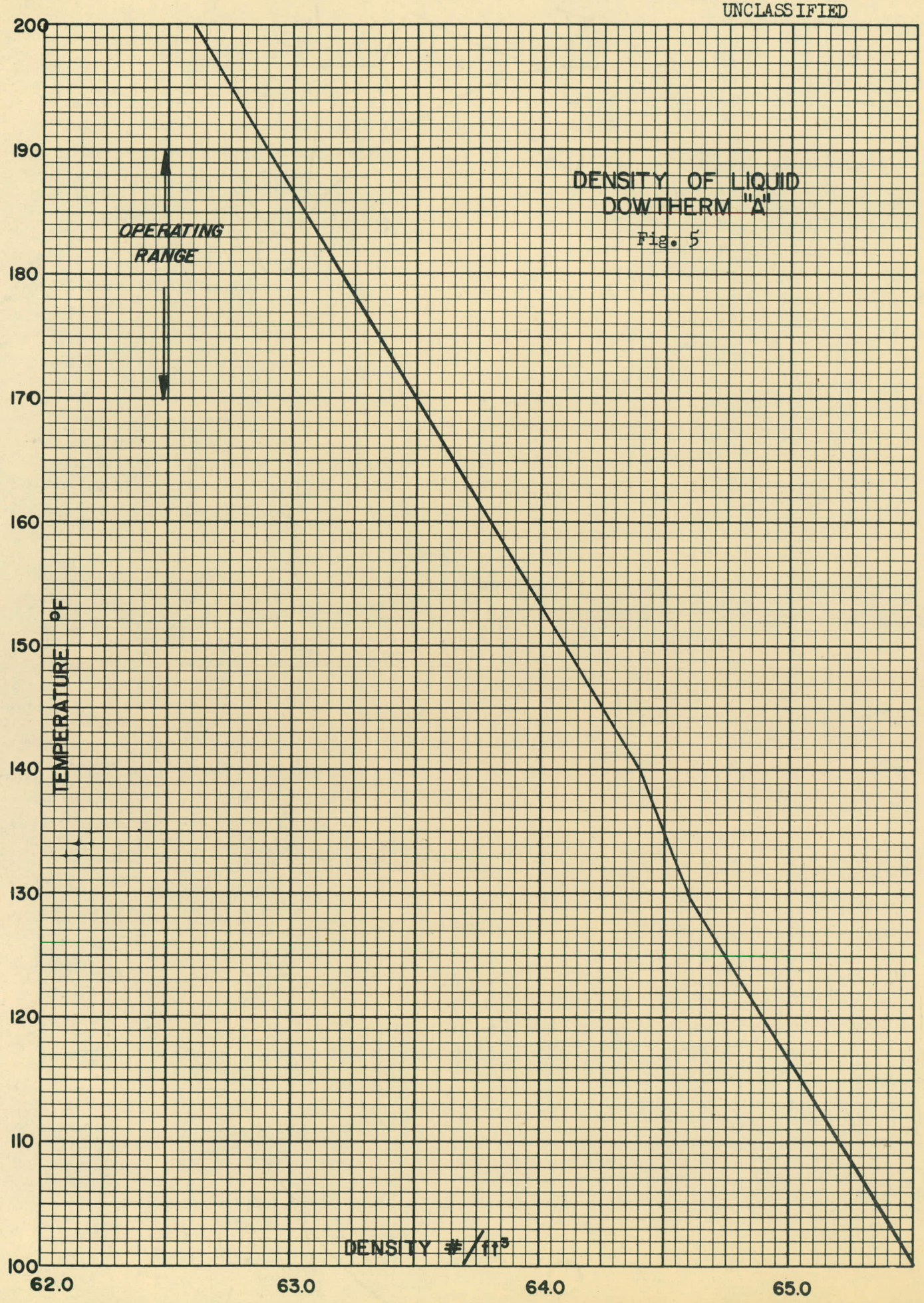

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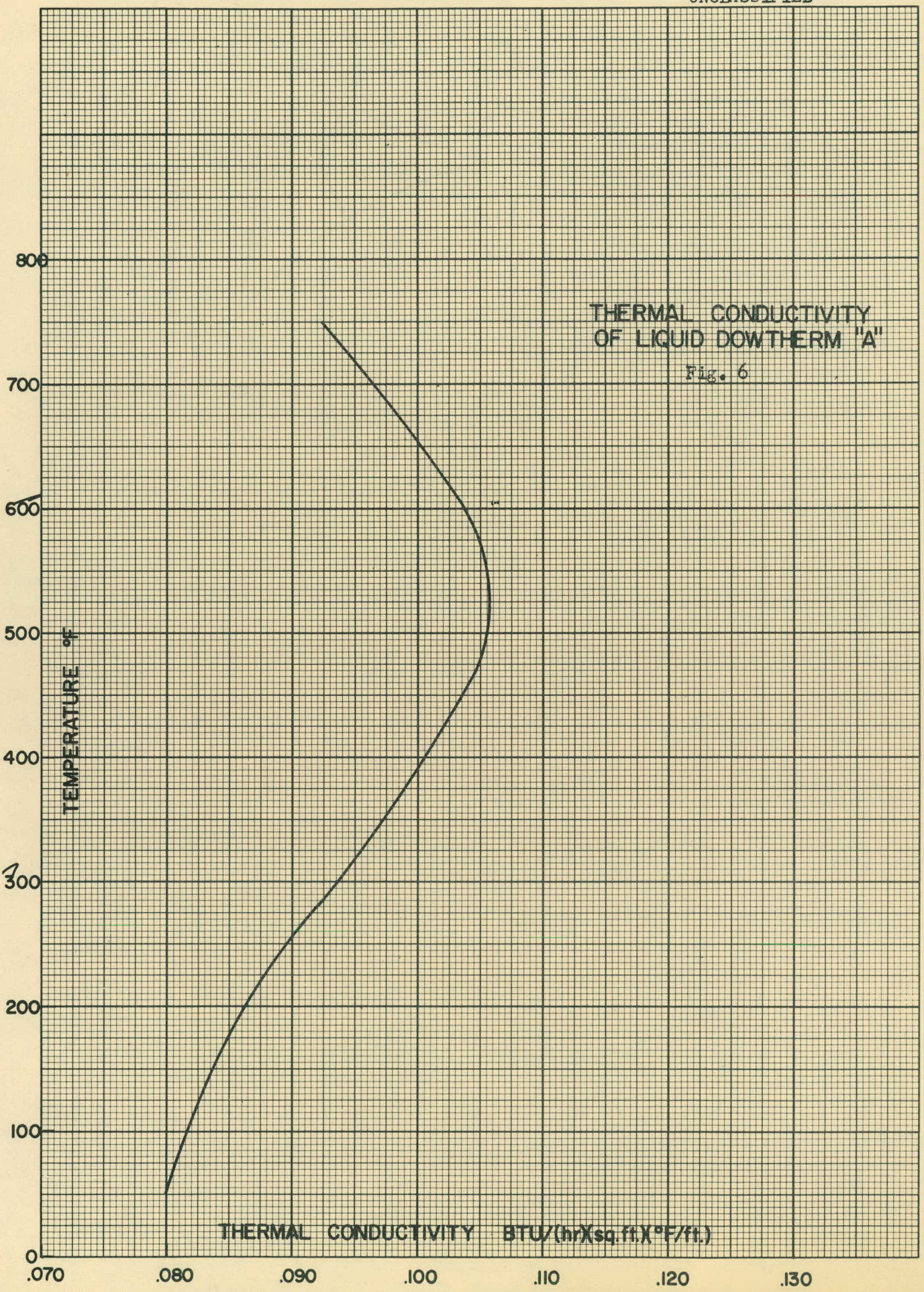
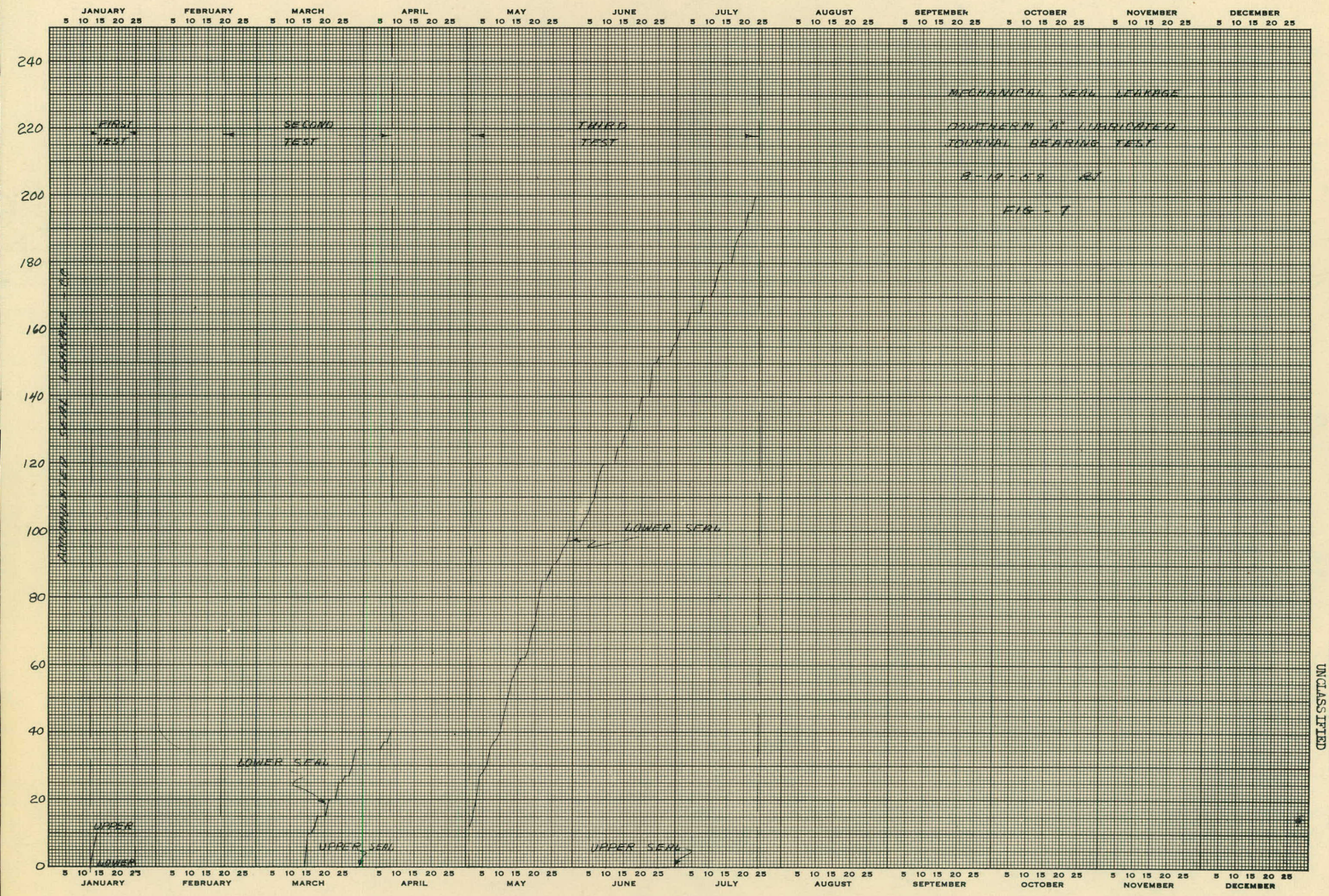


TABLE 2

Operation Time - Hrs.	Bearing ID (inches)	Journal OD (inches)	Bearing Journal Clearance	Upper Seal Nose Height (inches)	Lower Seal Nose Height (inches)	MRC #5309 Double Row Ball Bearing
0	3.4036	3.4002	0.0034	Not obtained	Not obtained	New
194	3.4033	3.3995	0.0038	Seal changed Measurement not obtained	Seal changed Measurement not obtained	No visible change No corrosion
1,194	3.40425	3.39975	0.0045	Seal changed Measurement .13165	Seal changed Measurement .1415	No visible change No corrosion
3,200	3.4041	3.39971	0.0044	Same seal as above .1300 wear = 0.0016	Same seal as above .1411 wear = 0.0004	No visible change No corrosion
3,206	Seizure net change at failure = + .0005	Seizure net change at failure = - .00049		Same seal as above measurement not obtained	Same seal as above measurement not obtained	No evidence of immediate failure. No visible corrosion



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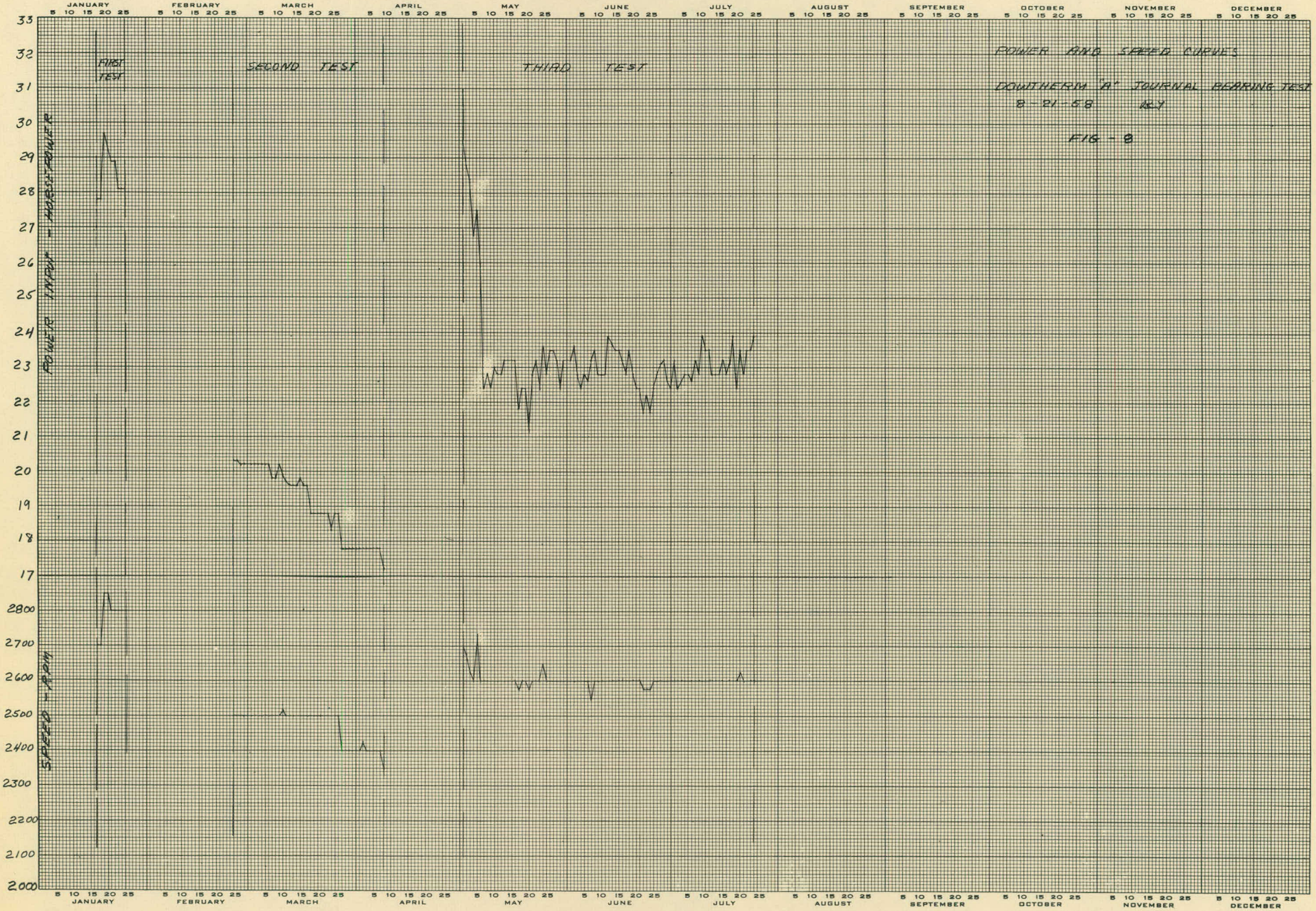
design had in error been assembled to a proper MF-2 journal. However, it is believed that this bearing would have continued to operate for a longer period of time had the lube oil pump remained in operation. Figs. 8, 9, and 10 show the daily averages of pump power, speed and important temperatures. Figs. 11 and 12 are photographs of the bearing and journal after seizure occurred.

Conclusions

Dowtherm "A" can be used successfully as a lubricant for extended operation with antifriction and pressure fed hydrodynamic bearings under conditions similar to these tests. It can also be isolated satisfactorily using mechanical rotary face type seals. Its use with the materials of the test rig was satisfactory and no changes in appearance or physical properties were observed except with the Buna N elastomers and copper alloys.



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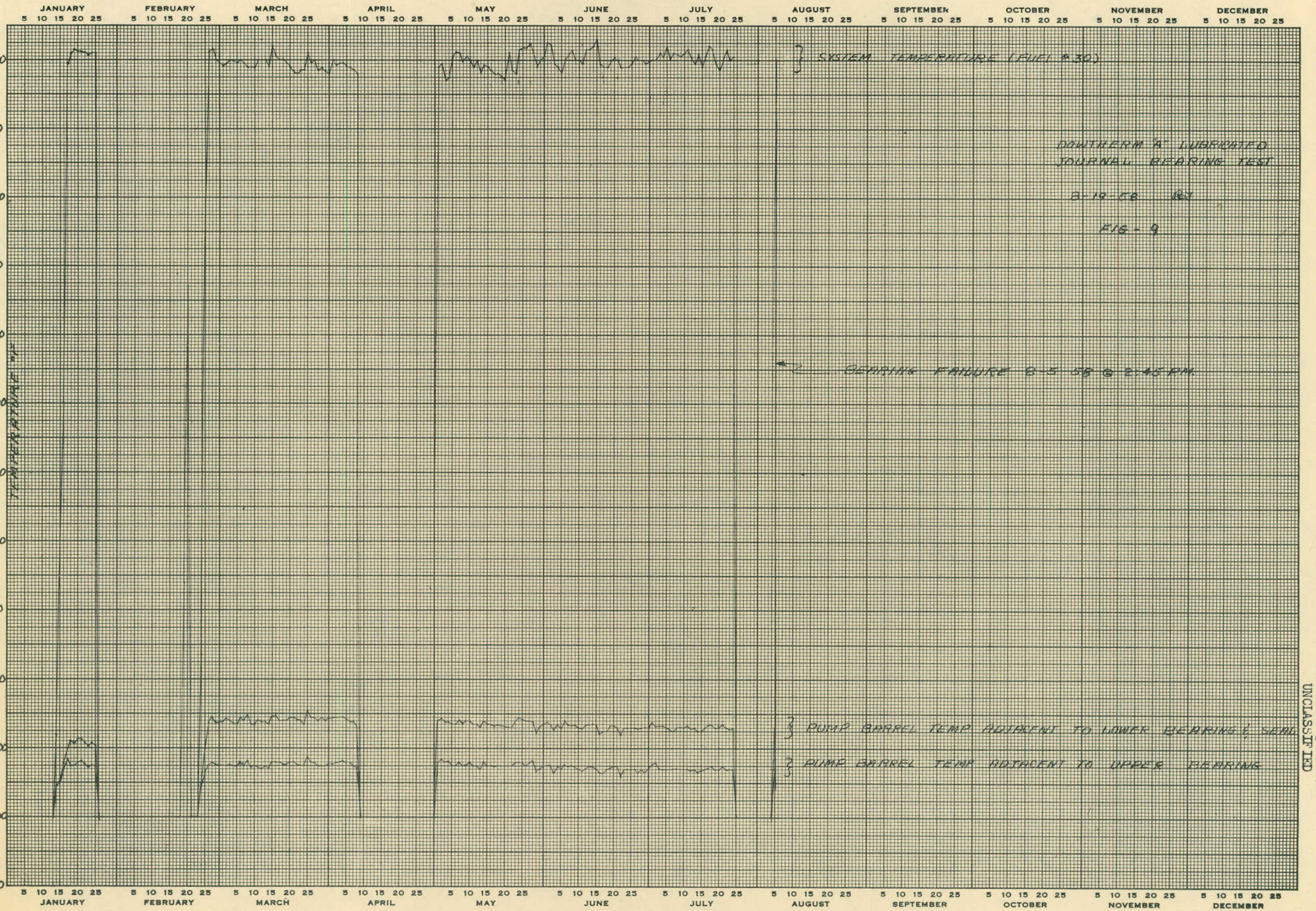

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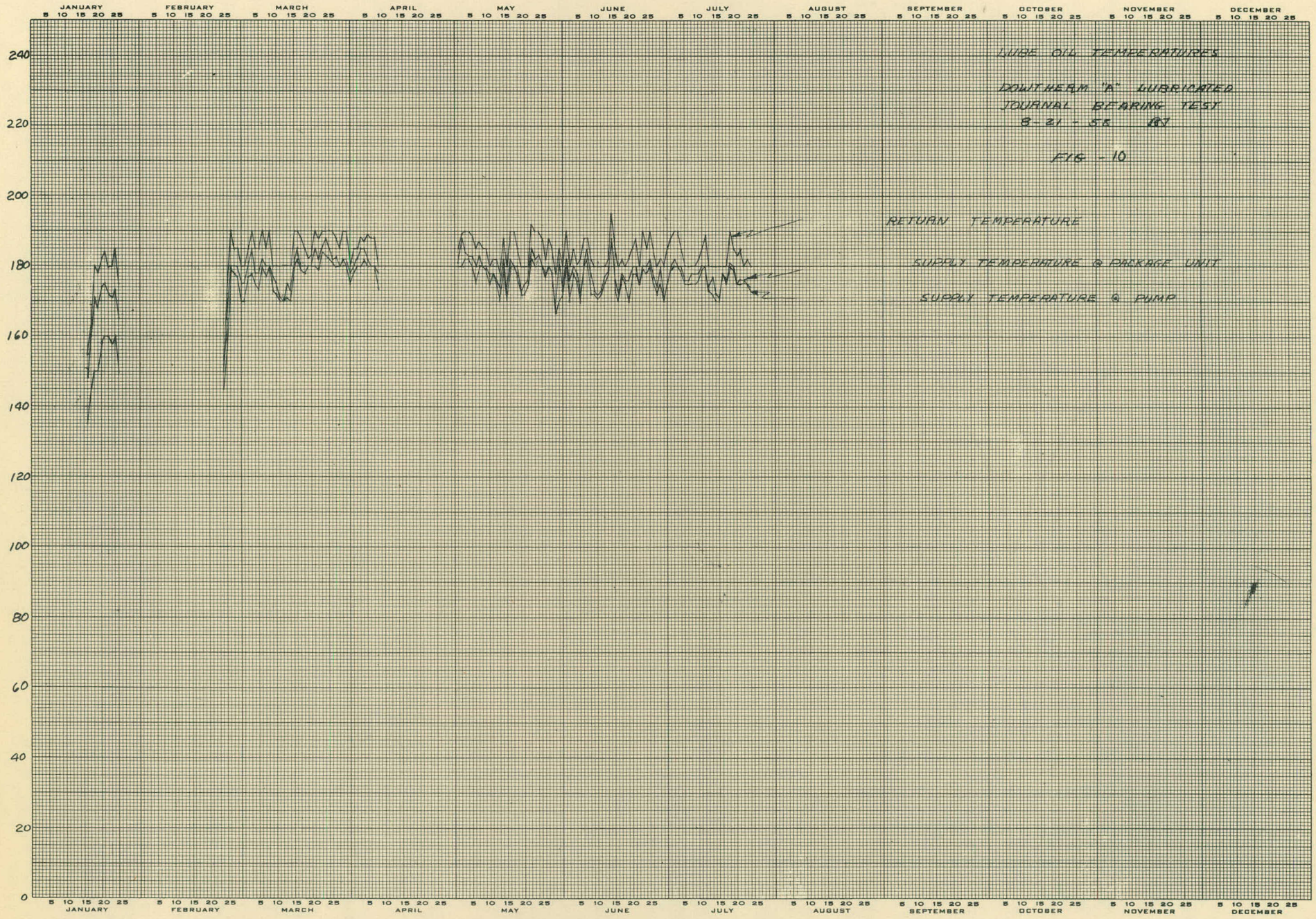

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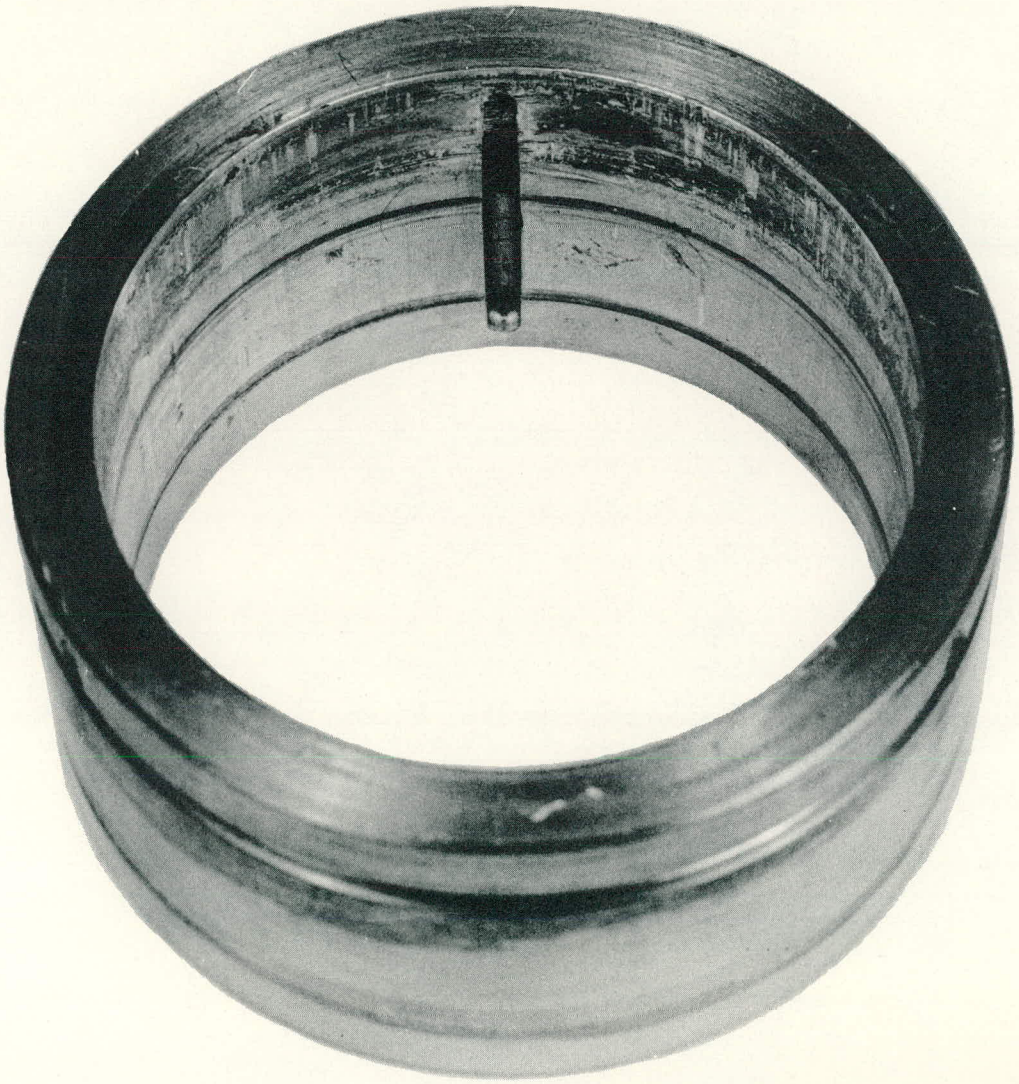

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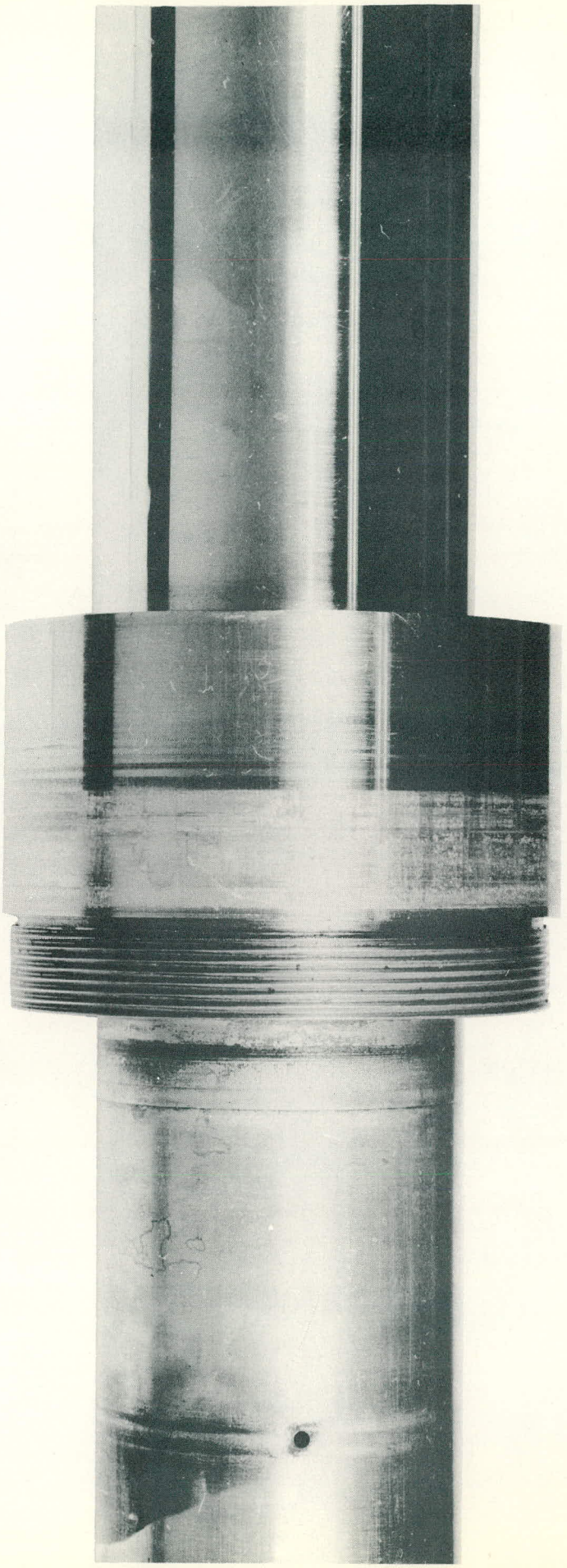

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