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PLAINTIFF'S EXHIBIT
UC-148

INVESTIGATION OF THE COWLES DISSOLVER FOR DISPERSION OF RESIN-GRADE ASBESTOS PRODUCTS IN EPOXY AND POLYESTER RESINS

SUMMARY

The Cowles Dissolver, which is comparable to mixing equipment used in the plastics industry, has been found effective for dispersing both R-G244 in polyesters and R-G144 in epoxies.

The intrinsic viscosity of the base resin and level of asbestos added are the principal factors determining the amount of energy and mixing time required for optimum dispersion. In the range of R-G244 additions normally recommended for thixotropic polyester resins, operating conditions approximating 3000 rpm (≈2400 FPM peripheral tip speed) for 10 to 20 minutes are adequate for proper dispersion with a Cowles Dissolver.

Good dispersion of R-G144 in epoxy systems requires approximately 3400 rpm (≈2700 FPM peripheral tip speed) for a period of 20-40 minutes with the Cowles Dissolver.

The operating conditions recommended above should apply for most resin-grade applications where viscosity of the thixotropic system is below 30,000 cps equivalent at 6 rpm Brookfield viscosity.

EXPERIMENTAL

A Cowles laboratory dissolver was used for this investigation employing a 3" impeller. The mixing speeds were at 2000 and 3400 rpm, respectively. These data were compared to a laboratory Homo-Mixer, 4 blades, 2" diameter at ≈5000 rpm. Mixing time was varied between 3 to 40 minutes.

Rohm-Haas Corporation Paraplex P-43 was used for the polyester resin and diluted with styrene to a base viscosity of 100 cps. The epoxy used was UCC ERL-2796 having a base viscosity of 150 cps.

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Viscosity measurements were obtained with a Brookfield viscometer at 25°C. All samples were hand stirred prior to measurement for viscosity.

DISCUSSION

1. Mixing Requirements for R-G244 in Polyester Applications

The mixing parameters required for optimum dispersion of R-G244 in polyester resin with a Cowles Dissolver are illustrated in Table I and Figures 1 and 2. Results show Cowles equipment to be effective for dispersing R-G244 in polyester resins. However, a minimum of 2000 rpm was required for 40 minutes to obtain an optimum viscosity at a loading of 0.5 phr R-G244. Approximately 10 minutes were adequate for R-G244 dispersion at 3400 rpm. It is apparent that the intrinsic viscosity of the base resin and level of asbestos added are the principal factors determining the amount of energy and mixing time required for optimum dispersion.

At the higher levels of R-G244, 1.0 to 2.0 phr, a minimum of 20 minutes mixing was required at a setting of 2000 rpm to disperse the R-G244. Samples prepared in less time contained visible lumps of asbestos. Additional mixing beyond 20 minutes decreased the viscosity, apparently due to degradation of the R-G244. Mixing 1.0-2.0 phr R-G244 at 3400 rpm was indicative of optimum viscosities between 5 to 10 minutes.

At the 0.5 phr level of R-G244 normally recommended for thixotropic polyester laminating resins, operating conditions approximating 3000 rpm (≈2400 FPM peripheral tip speed) for 10 to 20 minutes should be adequate for proper dispersion with a Cowles Dissolver.

2. Mixing Requirements for R-G144 in Epoxy Applications

The efficiency of the Cowles Dissolver for incorporating R-G144 in epoxy resins is shown in Table II and Figures 3 and 4.

Longer mixing time was required to disperse R-G144 in epoxy resin than was observed with R-G244 in the polyester system. A level of 2000 rpm on the Cowles Dissolver was not enough shear for adequate dispersion within the practical limits of mixing time. Based on these data, mixing conditions required for good dispersion of R-G144 (less than 2 phr) in epoxy resins should approximate 3400 rpm (≈2700 FPM peripheral tip speed) for 20-40 minutes with the Cowles Dissolver.

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Again it should be emphasized that optimum mixing conditions will vary depending upon the base viscosity of the resin system. The rate of energy input to the system is a direct function of viscosity. However, conditions recommended herein should apply for most Resin-Grade Asbestos applications where viscosity of the thixotropic system is below $\approx$30,000 cps at 6 rpm on a Brookfield viscometer.

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TABLE I

EFFECT OF SHEAR FORCES ON THE RHEOLOGICAL PROPERTIES OF R-G244 ASBESTOS IN POLYESTER RESIN*

R-G244 (phr)	Mixing Time (Min.)	Brookfield Viscosity (cps) at 25°C and 6 rp		
		Cowles 2000 rpm	Cowles 3400 rpm	Homo-Mixer ≈5000 rpm
0.5	3	-	-	850
0.5	5	675	725	-
0.5	20	775	725	-
0.5	40	850	700	-
1.0	5	-	5000	-
1.0	20	-	4600	-
1.0	40	-	4400	-
2.0	3	-	-	19,500
2.0	5	25,500	25,500	-
2.0	20	24,000	22,000	-
2.0	40	20,000	13,500	-

*Polyester Resin - Rohm & Haas Corp. Paraplex P-43 polyester (base viscosity adjusted to 100 cps with styrene)

Mixing Parameters:

Cowles Dissolver - 3" diameter impeller
Homo-Mixer - 4 blades 2" diameter

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TABLE II

EFFECT OF SHEAR FORCES ON THE RHEOLOGICAL PROPERTIES OF R-G144 ASBESTOS IN EPOXY RESIN*

R-G144 (phr)	Mixing Time (Min.)	Brookfield Viscosity (cps) at 25°C and 6 rp		
		2000 rpm	3400 rpm	≈5000 rpm
1.0	3	-	-	2900
1.0	5	625	1800	-
1.0	20	1100	2700	-
1.0	40	1450	2800	-
2.0	3	-	-	13,000
2.0	5	3400	10,500	-
2.0	20	6500	10,000	-
2.0	40	8600	10,000	-

*Epoxy Resin - Union Carbide Corp. ERL 2796 epoxy (base viscosity 150 cps)

Mixing Parameters

Cowles Dissolver - 3" diameter impeller
Homo-Mixer - 4 blades 2" diameter

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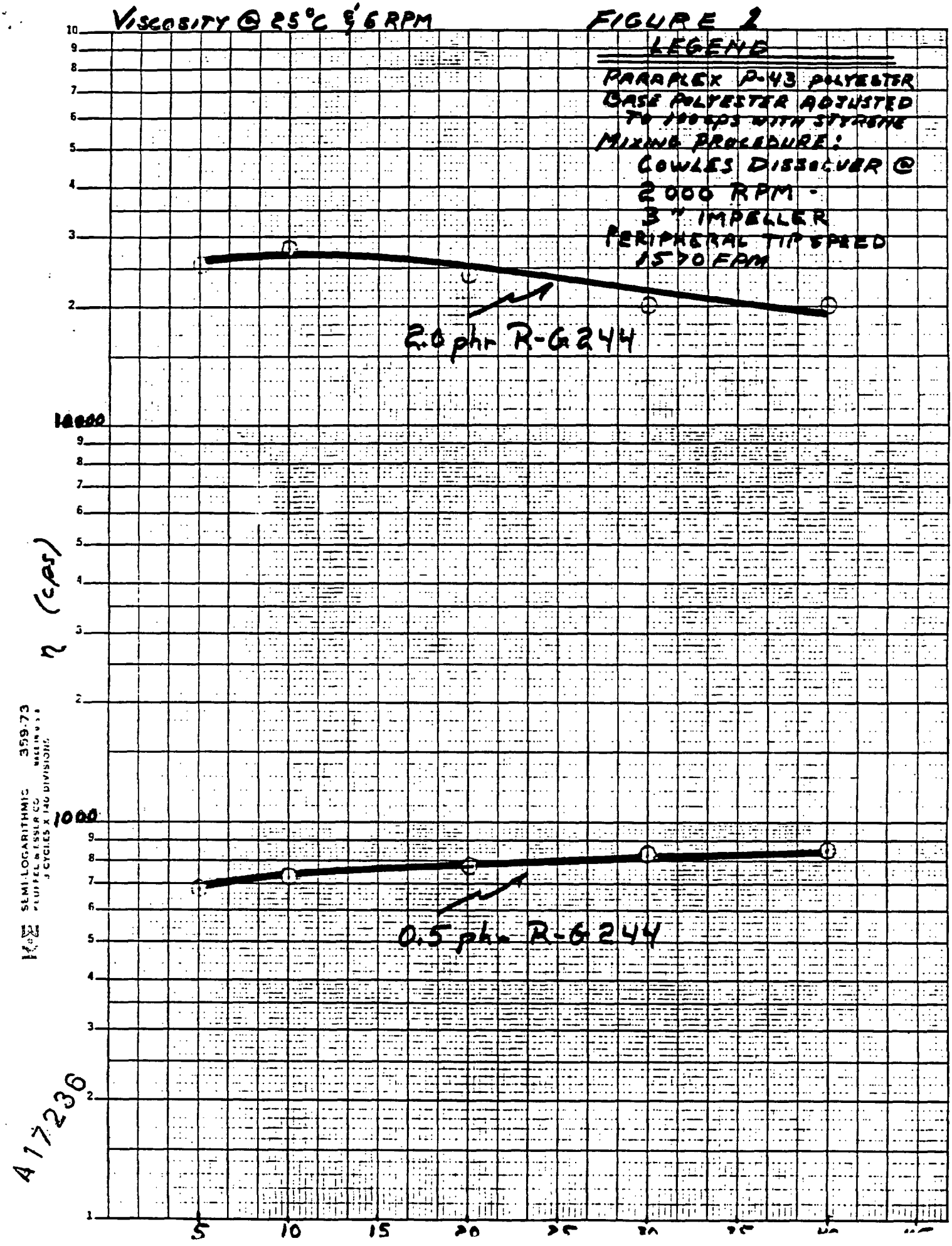
VISCOSITY @ 25°C & 6 RPM
FIGURE 2
LEGEND
PARAPLEX P-43 POLYESTER
BASE POLYESTER ADJUSTED
TO 100 CPS WITH STYRENE
MIXING PROCEDURE:
COWLES DISSOLVER @
2000 RPM -
3" IMPELLER
PERIPHERAL TIP SPEED
1570 FPM
2.0 phr R-G244
0.5 phr R-G244
η (cps)
10000
1000
5
10
15
20
25
30
35
40
SEMI-LOGARITHMIC 359-73
KEUFFEL & ESSER CO.
3 CYCLES X 140 DIVISIONS

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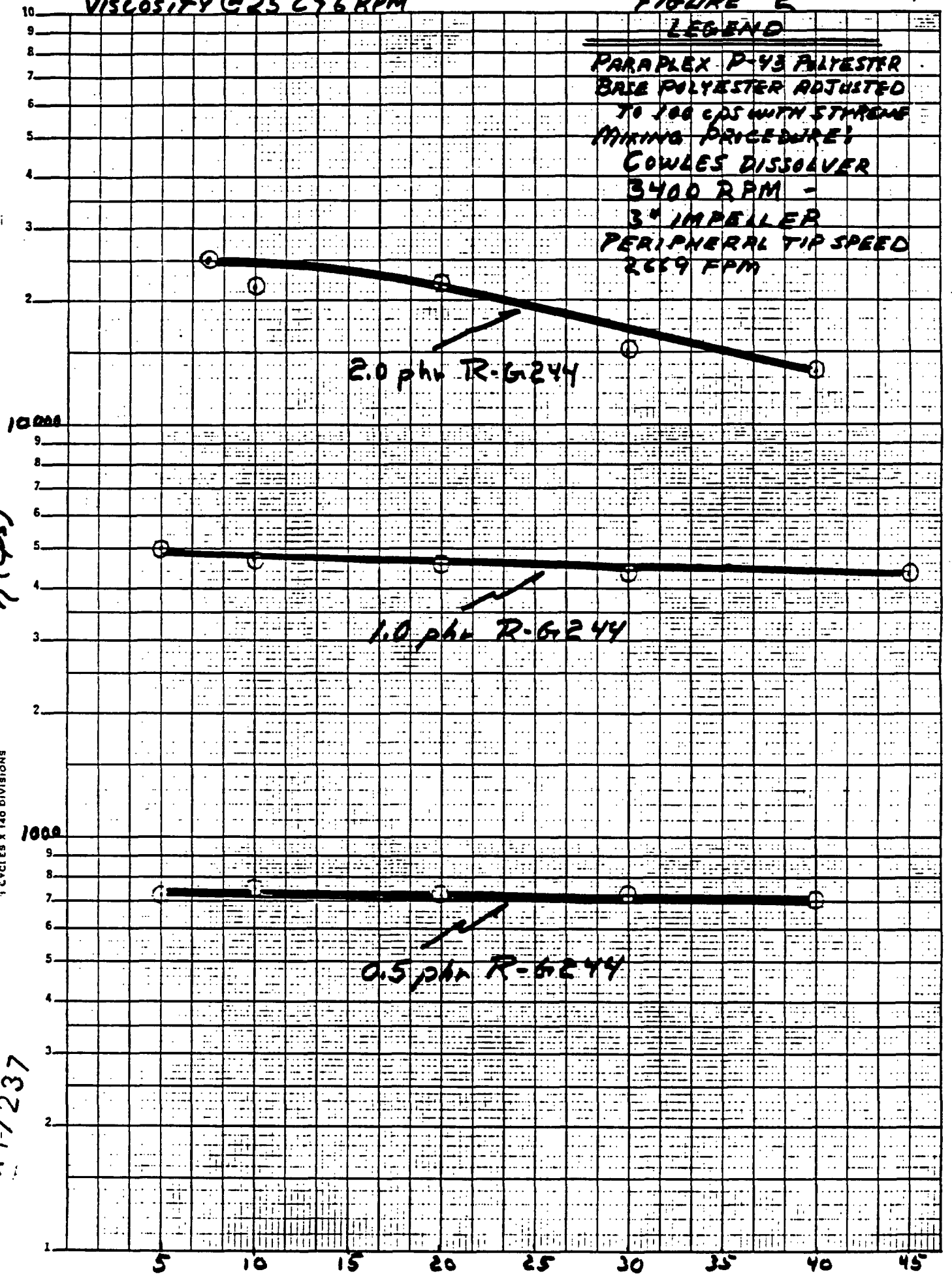
VISCOSITY @ 25°C & 6 RPM

FIGURE 2



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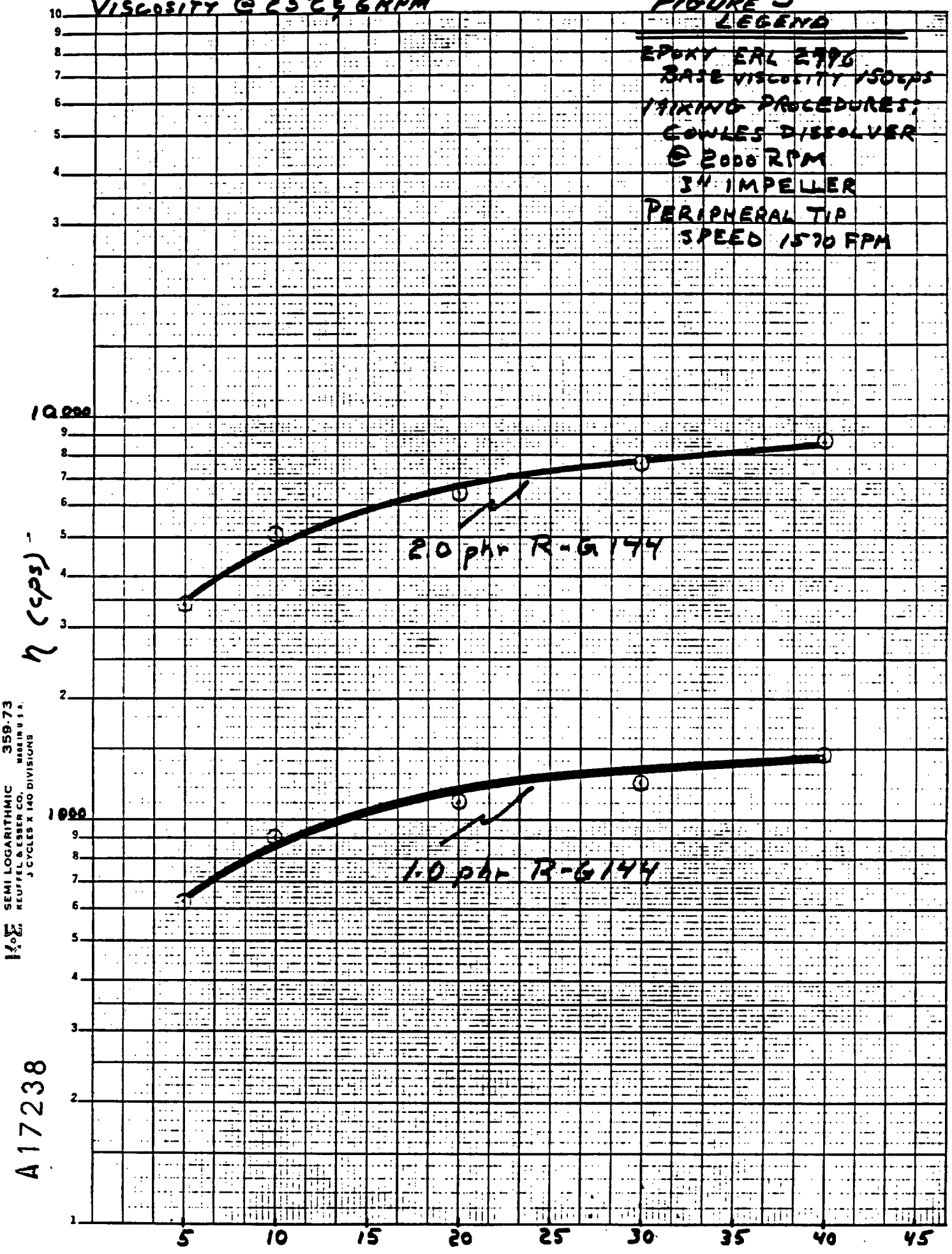
VISCOSITY @ 25°C & 6RPM
FIGURE 3
LEGEND
EPOXY EAL 2796
BASE VISCOSITY 150cps
MIXING PROCEDURES:
COWLES DISSOLVER
@ 2000 RPM
3" IMPELLER
PERIPHERAL TIP
SPEED 1570 FPM
2.0 phr R-G 174
1.0 phr R-G 144
η (cps)
10,000
1000
5
10
15
20
25
30
35
40
45
SEMI LOGARITHMIC 359-73
KEUFFEL & ESSER CO. MADE IN U.S.A.
3 CYCLES X 140 DIVISIONS
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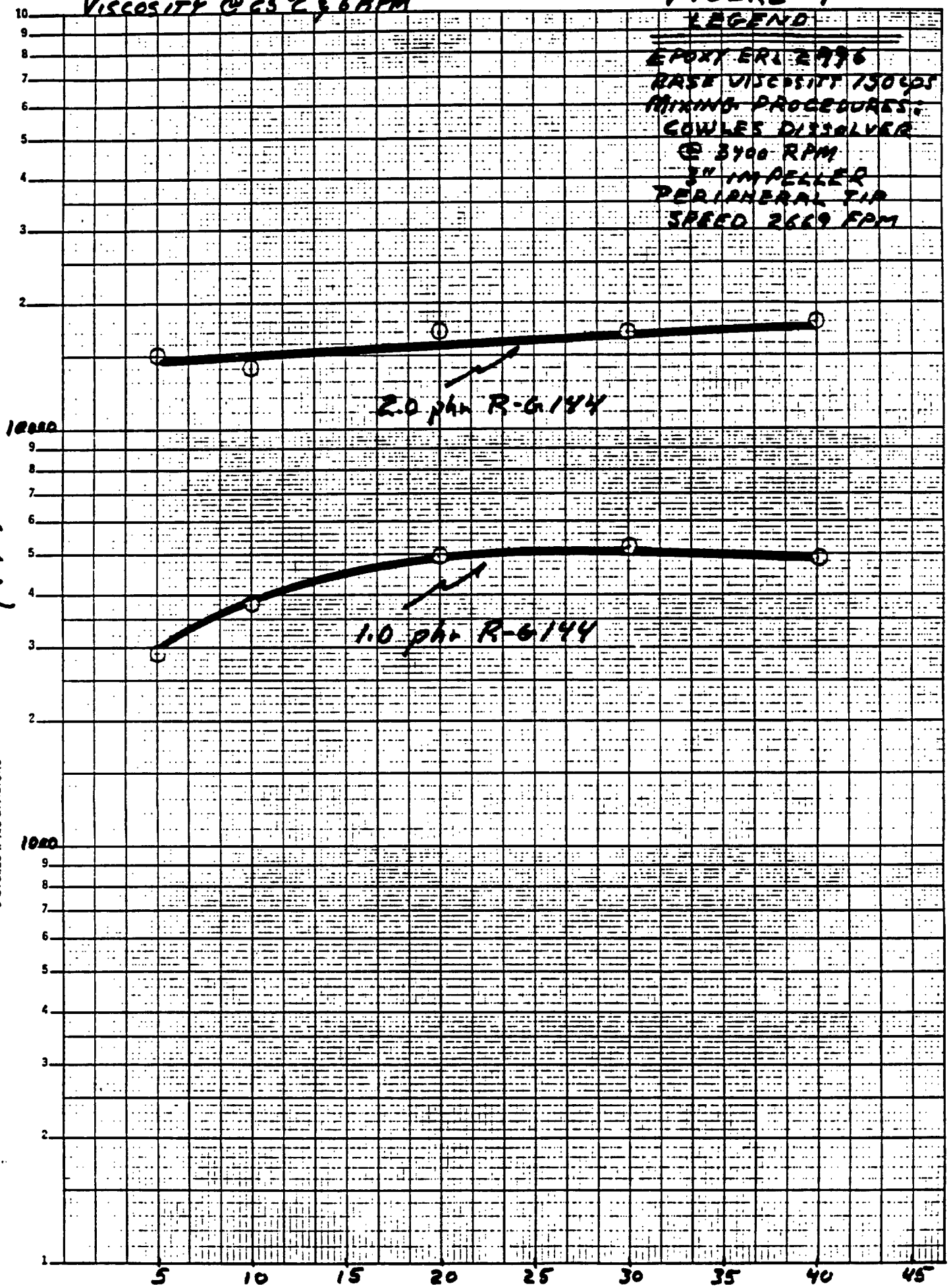
FIGURE 4



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