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Chemistry - General

ARGONNE NATIONAL LABORATORY
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ENGINEERING PROPERTIES OF DIPHENYL

by

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REACTOR ENGINEERING DIVISION

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FOREWORD

The main body of the physical data on pure diphenyl is the property of the Monsanto Chemical Company and has been published by them in various technical reports and sales literature.

Data on vapor pressure, enthalpy and densities of liquid diphenyl and its saturated vapor were made available by members of the Monsanto Chemical Company research staff at Anniston, Alabama. This was also the source of information on the viscosity of diphenyl as a function of temperature, the Mollier diagram and the temperature entropy diagram.

The data on the thermal conductivity of Dowtherm A was furnished by the Dow Chemical Company.

The phase-rule diagrams for diphenyl and the diphenyl benzenes and for mixtures of diphenyl and its pyrolysis products along with viscosities of three mixtures were determined at Argonne.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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ABSTRACT

Data collected from the literature on the vapor pressure, enthalpy, liquid density, and vapor density of pure diphenyl are presented. A Mollier diagram, a temperature entropy diagram, and data on the viscosity of diphenyl as a function of temperature are also presented.

Data on the melting points of several binary systems containing diphenyl and for complex mixtures of diphenyl and its pyrolysis products are presented graphically. Graphs of viscosity versus composition at 130C for the systems are also presented.

I. PHYSICAL PROPERTIES OF DIPHENYL

These data were obtained by the research staff of the Monsanto Chemical Company and of the Dow Chemical Company. No discussion of the methods used in obtaining the data presented herewith will be given. Original sources can be consulted for the methods used in obtaining the data.

1. Miscellaneous Physical Data on Diphenyl

Table I consists of a collection of miscellaneous data on diphenyl. Part of these items were furnished by the Dow Chemical Company of Midland, Michigan, the remainder being taken from standard chemical handbooks.

2. Thermodynamic Properties of Diphenyl

The thermal properties of diphenyl are quoted in Table II from data compiled by the technical staff of the Monsanto Chemical Company.[1]

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[1] The following is quoted from the acknowledgement in the Monsanto Chemical Company's technical files at Anniston, Alabama.

"In collecting this data several different sources have been consulted, and we wish especially to acknowledge the work done by the following:

Professor J. M. Cork and Mr. D. A. Wilbur of the University of

Table I

MISCELLANEOUS PROPERTIES OF DIPHENYL

Molecular Weight, gms/gm mol	154.2
Melting point, °C	69.4
Specific gravity at 75.4°C, gms/cc	0.991
Lbs/gal at 75°C	8.27
Flash point (Cleveland Open Cup), °C	106
Fire Point (Cleveland Open Cup), °C	124
Specific heat at boiling point, Btu/(lb)(F)	0.60
Latent heat of vaporization at boiling point, Btu/lb	136.5
Heat of Fusion, Btu/lb	177.8
Solubility at 25°C, gms/100 gms solvent	
Acetone	95
Benzene	95
Carbon Tetrachloride	143
Ether	63
N-Leptane	19
Methanol	7
Water	0.1

Michigan for work done on vapor pressure, latent heat, and densities of both the vapor and liquid diphenyl.

Laboratory of Applied Chemistry, Massachusetts Institute of Technology, for work done on specific heat of the liquid which work was done by Messrs. L. W. Cummings, F. W. Stones, M. A. Volante, under the direction of Messrs. H. O. Forrest and Elmer W. Brugmann.

Mr. R. O. Fowler of the University of Michigan, for work on specific heat of the liquid at temperatures below the boiling point.

Messrs. John Chipman and S. R. Peltier, Georgia School of Technology, for their article appearing in Industrial and Engineering Chemistry, Volume 21, page 1106, (1929) relating to vapor pressures.

Dr. W. L. McCabe, University of Michigan, and associates for work done in collecting these data and preparing them for publication.

Professor W. L. Badger, Swenson Evaporator Company, for his cooperation in the preparation of these tables and for the timely and helpful suggestions which he has offered."

Table II

THERMAL PROPERTIES OF DIPHENYL

(Courtesy Monsanto Chemical Company)

Temperature		Pressure		Heat Content Btu/lb			Density lb/cu ft	
F	C	Hg Vac. In.	psi, abs.	Liquid	Latent	Total	Liquid	Vapor
156.6	69.2	29.9	0.015	0.0	190.9	190.9	-	-
160	71.1	29.9	0.017	1.4	189.0	190.4	-	-
165	73.9	29.9	0.020	3.4	187.5	190.9	-	-
170	76.7	29.9	0.024	5.4	185.5	190.9	-	-
175	79.4	29.9	0.028	7.4	183.5	190.9	-	-
180	82.2	29.9	0.033	9.5	182.0	191.5	61.36	0.00058
185	85.0	29.8	0.038	11.5	180.0	191.5	61.24	0.00067
190	87.8	29.8	0.044	13.6	178.5	192.1	61.11	0.00078
195	90.7	29.8	0.052	15.6	176.5	192.1	60.98	0.00092
200	93.3	29.8	0.060	17.7	175.0	192.7	60.85	0.00108
205	96.1	29.8	0.069	19.8	173.0	192.8	60.72	0.00127
210	98.9	29.8	0.080	21.9	171.5	193.4	60.59	0.00147
215	101.7	29.7	0.092	24.0	170.0	194.0	60.45	0.00169
220	104.4	29.7	0.105	26.1	168.5	194.6	60.31	0.00190
225	107.2	29.7	0.120	28.3	167.0	195.3	60.17	0.00214
230	110.0	29.6	0.137	30.4	166.0	196.4	60.03	0.00242
235	112.8	29.6	0.156	32.6	164.5	197.1	59.89	0.00273
240	115.6	29.6	0.177	34.8	163.5	198.3	59.75	0.00317
245	118.3	29.5	0.201	36.9	162.5	199.4	59.60	0.00359
250	121.1	29.5	0.227	39.1	161.5	200.6	59.46	0.0041
255	123.9	29.4	0.256	41.3	160.5	201.8	59.32	0.0047
260	126.7	29.3	0.289	43.6	159.5	203.1	59.18	0.0053
265	129.4	29.3	0.325	45.8	158.5	204.3	59.04	0.0059
270	132.2	29.2	0.365	48.1	157.5	205.6	58.90	0.0065
275	135.0	29.1	0.408	50.3	157.0	207.3	58.76	0.0071
280	137.8	29.0	0.457	52.6	156.5	209.1	58.62	0.0078
285	140.6	28.9	0.509	54.9	155.5	210.4	58.48	0.0086
290	143.3	28.8	0.568	57.2	155.0	212.2	58.35	0.0095
295	146.1	28.6	0.631	59.6	154.5	214.1	58.21	0.0105
300	148.7	28.5	0.701	61.9	154.0	215.9	58.08	0.0117
305	151.7	28.3	0.776	64.3	153.5	217.8	57.94	0.0129
310	154.4	28.2	0.860	66.6	153.0	219.6	57.80	0.0142
315	157.2	28.0	0.949	69.0	152.5	221.5	57.66	0.0156
320	160.0	27.8	1.050	71.4	152.0	223.4	57.52	0.0170
325	162.8	27.6	1.150	73.9	151.5	225.4	57.36	0.0187

Table II (Continued)

Temperature		Pressure		Heat Content Btu/lb			Density lb/cu ft	
F	C	Hg Vac. In.	psi, abs.	Liquid	Latent	Total	Liquid	Vapor
330	165.6	27.3	1.27	76.3	151.5	227.8	57.22	0.0203
335	168.3	27.1	1.39	78.8	151.0	229.8	57.08	0.0219
340	171.1	26.8	1.53	81.3	151.0	232.3	56.93	0.0239
345	173.9	26.5	1.67	83.8	150.5	234.3	56.79	0.0260
350	176.7	26.2	1.83	86.3	150.0	236.3	56.65	0.0284
355	179.4	25.8	2.00	88.8	150.0	238.8	56.50	0.0311
360	182.2	25.5	2.18	91.4	149.5	240.9	56.36	0.0336
365	185.0	25.1	2.38	94.0	149.5	243.5	56.22	0.0366
370	187.8	24.7	2.59	96.5	149.0	245.5	56.08	0.0396
375	190.6	24.2	2.81	99.2	149.0	248.2	55.94	0.0427
380	193.3	23.7	3.06	101.8	149.0	250.8	55.80	0.0464
385	196.1	23.2	3.31	104.5	148.5	253.0	55.67	0.0497
390	198.9	22.6	3.59	107.1	148.5	255.6	55.53	0.0536
395	201.7	22.0	3.88	109.9	148.0	257.9	55.39	0.0575
400	204.4	21.4	4.20	112.6	148.0	260.6	55.24	0.0616
405	207.2	20.7	4.53	115.3	148.0	263.3	55.10	0.0659
410	210.0	20.0	4.89	118.1	147.5	265.6	54.96	0.0704
415	212.8	19.2	5.27	120.9	147.5	268.4	54.81	0.0753
420	215.6	18.4	5.67	123.7	147.0	270.7	54.67	0.0804
425	218.3	17.5	6.09	126.5	147.0	273.5	54.52	0.0859
430	221.1	16.6	6.55	129.3	146.0	275.3	54.37	0.0918
435	223.9	15.6	7.03	132.2	145.5	277.7	54.23	0.0982
440	226.7	14.6	7.54	135.1	145.0	280.1	54.09	0.1050
445	229.4	13.5	8.07	138.0	144.0	282.0	53.95	0.1120
450	232.2	12.3	8.64	140.9	143.5	284.4	53.81	0.1220
455	235.0	11.1	9.24	143.9	142.5	286.4	53.67	0.1310
460	237.8	9.8	9.87	146.8	142.0	288.8	53.53	0.1410
465	240.6	8.4	10.50	149.8	141.0	290.8	53.38	0.1510
470	243.3	7.0	11.30	152.8	140.5	293.3	53.24	0.1610
475	246.1	5.5	12.00	155.8	139.5	295.3	53.09	0.1700
480	248.9	4.0	12.80	158.8	138.5	297.3	52.93	0.1800
485	251.7	2.3	13.60	161.8	137.5	299.3	52.79	0.1920
490	254.4	0.5	14.40	164.9	136.5	301.4	52.64	0.2050
491.5	255.3	0.0	14.70	165.8	136.5	302.3	52.59	0.2100

Table II (Continued)

Temperature		Pressure psi		Heat Content Btu/lb			Density lb/cu ft	
F	C	Gage	Abs.	Liquid	Latent	Total	Liquid	Vapor
491.5	255.3	0.0	14.7	165.8	136.5	302.3	52.59	0.210
495	257.2	0.6	15.3	168.0	135.5	303.5	52.48	0.220
500	260.0	1.6	16.3	171.0	135.0	306.0	52.32	0.236
505	262.8	2.6	17.3	174.1	134.0	308.1	52.16	0.253
510	265.6	3.6	18.3	177.2	133.0	310.2	52.01	0.271
515	268.3	4.7	19.4	180.4	132.0	312.4	51.85	0.290
520	271.1	5.9	20.6	183.5	131.0	314.5	51.69	0.310
525	273.9	7.0	21.7	186.6	130.5	317.1	51.53	0.330
530	276.7	8.3	23.0	189.8	129.5	319.3	51.37	0.352
535	279.4	9.6	24.3	192.9	128.5	321.4	51.21	0.373
540	282.2	11.0	25.7	196.1	127.5	323.6	51.05	0.395
545	285.0	12.4	27.1	199.3	127.0	326.3	50.89	0.420
550	287.8	13.8	28.5	202.5	126.0	328.5	50.73	0.445
555	290.6	15.4	30.1	205.7	125.0	330.7	50.57	0.470
560	293.3	17.0	31.7	208.9	124.5	333.4	50.41	0.495
565	296.1	18.6	33.3	212.1	123.5	335.6	50.24	0.525
570	298.9	20.4	35.1	215.3	122.5	337.8	50.08	0.555
575	301.6	22.2	36.9	218.6	121.5	340.1	49.90	0.585
580	304.4	24.1	38.8	221.8	121.0	342.8	49.73	0.615
585	307.2	26.0	40.7	225.1	120.0	345.1	49.56	0.650
590	310.0	28.1	42.8	228.3	119.0	347.3	49.39	0.680
595	312.8	30.1	44.8	231.6	118.0	349.6	49.22	0.715
600	315.6	32.3	47.0	234.8	117.0	351.8	49.04	0.750
605	318.3	34.6	49.3	238.1	116.0	354.1	48.87	0.790
610	321.1	36.9	51.6	241.4	115.5	356.9	48.70	0.830
615	323.9	39.3	54.0	244.7	114.5	359.2	48.52	0.865
620	326.7	41.9	56.6	248.0	114.0	362.0	48.35	0.910
625	329.4	44.5	59.2	251.3	113.0	364.3	48.17	0.950
630	332.2	47.2	61.9	254.6	112.5	367.1	47.99	0.995
635	335.0	49.9	64.6	257.9	111.5	369.4	47.82	1.040

Table II (Continued)

Temperature		Pressure, psi		Heat Content Btu/lb			Density lb/cu ft	
F	C	Gage	Abs.	Liquid	Latent	Total	Liquid	Vapor
640	337.8	52.8	67.5	261.2	111.0	372.2	47.64	1.085
645	340.6	55.8	70.5	264.6	110.0	374.6	47.48	1.135
650	343.3	58.9	73.6	267.9	109.5	377.4	47.30	1.185
655	346.1	62.0	76.7	271.2	109.0	380.2	47.12	1.235
660	348.9	65.3	80.0	274.6	108.5	383.1	46.95	1.285
665	351.7	68.7	83.4	277.9	107.5	385.4	46.77	1.340
670	354.4	72.2	86.9	281.3	107.0	388.3	46.59	1.395
675	357.2	75.8	90.5	284.6	106.5	391.1	46.40	1.450
680	360.0	79.5	94.2	288.0	105.5	393.5	46.20	1.510
685	362.8	83.3	98.0	291.4	105.0	396.4	45.97	1.565
690	365.6	87.2	101.9	294.7	104.0	398.7	45.77	1.620
695	368.3	91.2	105.9	298.1	103.5	401.6	45.58	1.675
700	371.1	95.4	110.1	301.5	103.0	404.5	45.38	1.730
705	373.9	99.7	114.4	304.8	102.5	407.3	45.19	1.785
710	376.7	104.1	118.8	308.2	102.0	410.2	44.98	1.840
715	379.4	108.6	123.3	311.6	101.0	412.6	44.77	1.900
720	382.2	113.3	128.0	315.0	100.5	415.5	44.57	1.965
725	385.0	118.0	132.7	318.4	100.0	418.4	44.36	2.030
730	387.8	122.9	137.6	321.8	99.0	420.8	44.15	2.100
735	390.6	128.0	142.7	325.2	98.5	423.7	43.93	2.170
740	393.3	133.3	148.0	328.6	98.0	426.6	43.72	2.245
745	396.1	138.6	153.3	332.0	97.0	429.0	43.51	2.320
750	398.9	143.9	158.6	335.4	96.5	431.9	43.28	2.400
755	401.7	149.5	164.2	338.8	96.0	434.8	43.05	2.480
760	404.4	155.2	169.9	342.2	96.0	438.2	42.82	2.565
765	407.2	161.0	175.7	345.6	95.5	441.1	42.58	2.655
770	410.0	167.1	181.8	349.0	95.0	444.0	42.35	2.750
775	412.8	173.3	188.0	352.4	94.5	446.9	42.11	2.845
780	415.6	179.7	194.4	355.9	94.0	449.9	41.87	2.945
785	418.3	186.2	200.9	359.3	93.5	452.8	41.64	3.045
790	421.1	193.0	207.7	362.7	93.0	445.7	41.39	3.145
795	423.9	200.0	214.7	366.1	92.0	458.1	41.14	3.250
800	426.7	207.1	221.8	369.6	91.5	461.1	40.89	3.355
805	429.4	214.1	228.8	373.0	90.5	463.5	40.64	3.465
810	432.2	221.2	235.9	376.4	90.0	466.4	40.38	3.580

Table II (Continued)

Temperature		Pressure, psi		Heat Content Btu/lb			Density lb/cu ft	
F	C	Gage	Abs.	Liquid	Latent	Total	Liquid	Vapor
815	435.0	228.6	243.3	379.9	89.0	468.9	40.12	3.700
820	437.8	236.3	251.0	383.3	88.5	471.8	39.84	3.825
825	440.8	244.2	258.9	386.7	87.5	474.2	39.56	3.955
830	443.3	252.2	266.9	390.1	86.5	476.6	39.28	4.090
835	446.1	260.3	275.0	393.6	86.0	479.6	38.99	4.230
840	448.9	268.6	283.3	397.0	85.0	482.0	38.69	4.375
845	451.7	277.3	292.0	400.5	84.0	484.5	38.40	4.530
850	454.4	286.2	300.9	403.9	82.5	486.4	38.10	4.690
855	457.2	295.1	309.8	407.4	81.5	488.9	37.79	4.860
860	460.0	304.2	318.9	410.8	80.0	490.8	37.48	5.040
865	462.8	313.5	328.2	414.2	78.5	492.7	37.17	5.225
870	465.6	323.1	337.8	417.7	77.0	494.7	36.84	5.420
875	468.3	332.9	347.6	421.1	75.5	496.6	36.49	5.625
880	471.1	342.9	357.6	424.6	74.0	498.6	36.14	5.845
885	473.9	353.1	367.8	428.0	72.5	500.5	35.79	6.070
890	476.7	363.5	378.2	431.5	71.0	502.5	35.41	6.320
895	479.4	374.1	388.8	435.0	69.5	504.5	35.01	6.570
900	482.2	385.0	399.7	438.4	67.5	505.9	34.58	6.850
905	485.0	396.1	410.8	441.9	66.0	507.9	34.14	7.140
910	487.8	407.5	422.2	445.3	64.0	509.3	33.68	7.455
915	490.6	419.0	433.7	448.8	62.0	510.8	33.16	7.790
920	493.3	430.9	445.6	452.2	59.5	511.7	32.61	8.145
925	496.1	442.9	457.6	455.7	56.5	512.2	32.02	8.520
930	498.9	455.2	469.9	459.1	53.5	513.6	31.40	8.930
935	501.7	467.7	482.4	462.6	50.5	513.1	30.70	9.440
940	504.4	480.6	495.3	466.0	47.0	513.0	29.93	10.070
945	507.2	493.6	508.3	469.5	43.0	512.5	29.07	10.800
950	510.0	506.9	521.6	473.0	39.0	512.0	28.14	11.700
955	512.8	520.4	535.1	476.4	34.5	510.9	27.10	12.700
960	515.6	534.3	549.0	479.9	29.5	509.4	26.00	13.850
965	518.3	548.4	563.1	483.3	24.5	507.8	24.90	15.150
970	521.1	562.7	577.4	486.8	19.0	505.8	23.60	16.550
975	523.9	577.3	592.0	490.2	12.5	502.7	22.20	18.050
980	526.7	592.3	607.0	493.7	0.0	493.7	19.60	19.600

3. Mollier Diagram

The Mollier Diagram of the diphenyl system is shown in Figure 1.

4. Temperature-Entropy Diagram for Diphenyl

The temperature-entropy diagram is shown in Figure 2. A temperature-entropy diagram for water is also included for comparison.

5. Viscosity Data

The viscosity of diphenyl as a function of temperature is shown in Table III. Data were obtained using Ostwald type viscometers by standard techniques.

Table III

VISCOSITY OF DIPHENYL AT VARIOUS TEMPERATURES
(Determined by Eugene C. Bingham, Monsanto Chemical Company)

Temp, F.	Viscosity, Centipoises	Temp, F.	Viscosity, Centipoises
160	1.439	330	0.501
170	1.309	340	0.480
180	1.208	350	0.459
190	1.114	360	0.440
200	1.034	370	0.422
210	0.961	380	0.405
220	0.901	390	0.388
230	0.848	400	0.374
240	0.797	410	0.360
250	0.752	420	0.347
260	0.711	430	0.335
270	0.673	440	0.324
280	0.636	450	0.313
290	0.605	460	0.303
300	0.574	470	0.293
310	0.549	480	0.284
320	0.524	482	0.283

6. Thermal Conductivity

Data on the thermal conductivity of diphenyl are not available. It is felt, however, that due to the high diphenyl content and basic similarity of Dowtherm A to diphenyl, data for the thermal conductivity of Dowtherm A would lead to no serious errors. Figure 3 shows a plot of these data as well as data for Dowtherm E as a function of temperature.[2]

7. Coefficients of Heat Transfer

Data are lacking on this property. Figure 4 graphically presents the liquid film coefficient for Dowtherm A inside pipes. In this figure G' = mass velocity in $lb/(sec)(ft^2)$, h = film coefficient of heat transfer in $Btu/(hr)(ft^2)(F)$, and D' = inside diameter of pipe in in.[2]

II. DATA ON MIXTURES OF DIPHENYL WITH OTHER MATERIAL

Since chemical reactions of diphenyl occur under conditions which would be encountered in heat transfer systems, it is of interest to consider the results of mixing some of the more common reaction products of diphenyl with the pure material. In general, the more probable compounds would be the isomeric terphenyls and tetraphenyls, and several alkyl benzenes.

The most significant physical properties of such systems might be their melting points, vapor pressures, and viscosities. Thermal properties are also important, but these would probably not differ greatly from the same properties for diphenyl if variation in composition of the system is restricted to those ranges where melting points and viscosities are not too greatly changed.

No data are available on the physical properties of mixtures of diphenyl with the various pure alkyl benzenes which might be formed by ring scission in the diphenyl molecule. Neither are data available on the properties of the binary systems consisting of diphenyl and the isomeric tetraphenyls. Preliminary work at Argonne has yielded the data presented below on binary systems of diphenyl and the three isomeric terphenyls and on mixtures of diphenyl with still bottoms from the diphenyl purification stills at the Anniston, Alabama, plant of the Monsanto Chemical Company. The latter tar-like material is considered to be probably quite representative of the complex systems which might result from the pyrolysis or radiolysis of diphenyl.

Melting points of all of these mixtures were determined by conventional methods, mostly by observation of cooling curves run on large samples of originally molten material. Viscosities were determined at 130°C using Ostwald pipettes.

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[2] "Dowtherm for Accurate High Temperature, Low Pressure Heat," The Dow Chemical Company, Midland, Michigan

1. Mixtures of Diphenyl with o-Diphenylbenzene

Figure 5 shows data on the melting points of the system diphenyl-o-diphenylbenzene. Viscosities for the same system determined at 130 C are plotted as functions of composition in Figure 6.

2. Mixtures of Diphenyl with m-Diphenylbenzene

Data on melting points for this system are plotted in Figure 7, while the kinematic viscosities at 130 C are plotted against composition in Figure 8.

3. Mixtures of Diphenyl with p-Diphenylbenzene

Data on melting points for this system are shown in Figure 9. Figure 10 gives data on kinematic viscosities for these mixtures only up to a composition of 20 per cent p-diphenylbenzene. The melting points for compositions much above this temperature were too high to be liquid at 130 C, and since this was a practical limit for both the equipment used and for some of the other systems studied it was concluded that comparable data for all systems would be preferable. These data indicate that systems containing p-diphenylbenzene might be expected to give deposits of solid material first when operated at lower temperatures.

Plotted on the graph of Figure 9 are several points taken from data published in the literature.[3] These were added in order to give a comparison with the Argonne data.

4. Mixtures of Diphenyl with its Pyrolysis Products

The pyrolytic still bottoms mentioned above have the analysis shown in Table IV.

Figure 11 shows melting points for this system, and Figure 12 gives the kinematic viscosity in centistokes for the system as a function of composition at 130C.

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[3] R. J. Hood, E. E. Hardy, A. M. Ellenburg, and H. B. Richards. "The Solubility of p-Terphenyl in o- and m-Terphenyls and in Diphenyl," J. Am. Chem. Soc., 75, 436, (1953)

Table IV

APPROXIMATE ANALYSIS OF PYROLYTIC MATERIALS

Component	Per cent
Diphenyl	0.8
o-terphenyl	9.9
m-terphenyl	44.7
p-terphenyl	20.4
triorthophenylene	2.0
tetraphenyls and higher	22.6

16

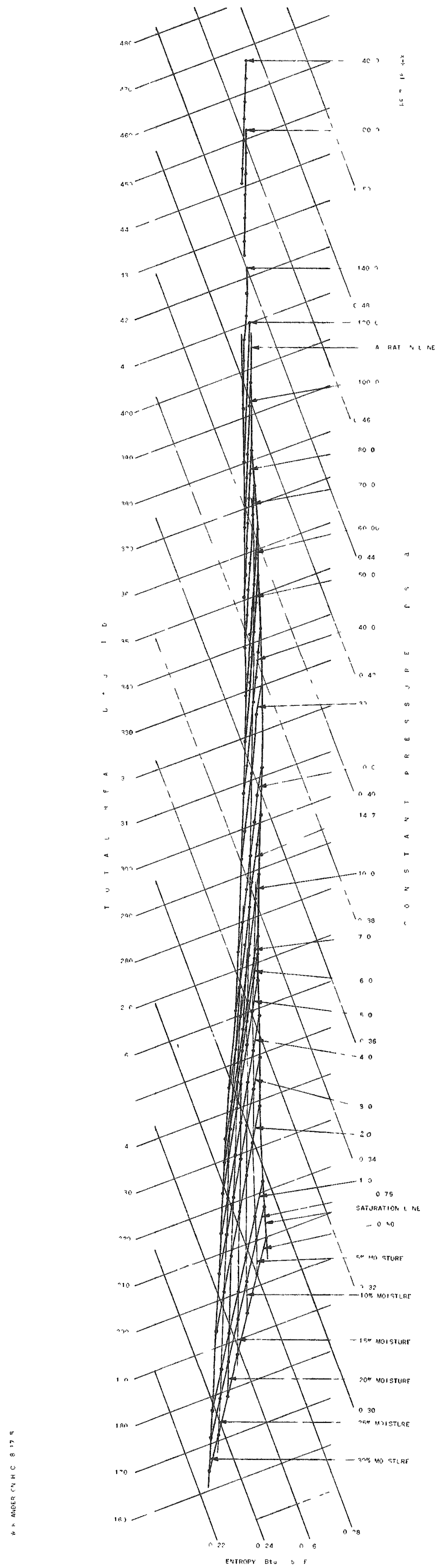


FIG 1
M LLIER DIAGRAM FOR E PHENYL

17

) RTESY M N ANTO CHEM A
(ORW 9(9091)

16

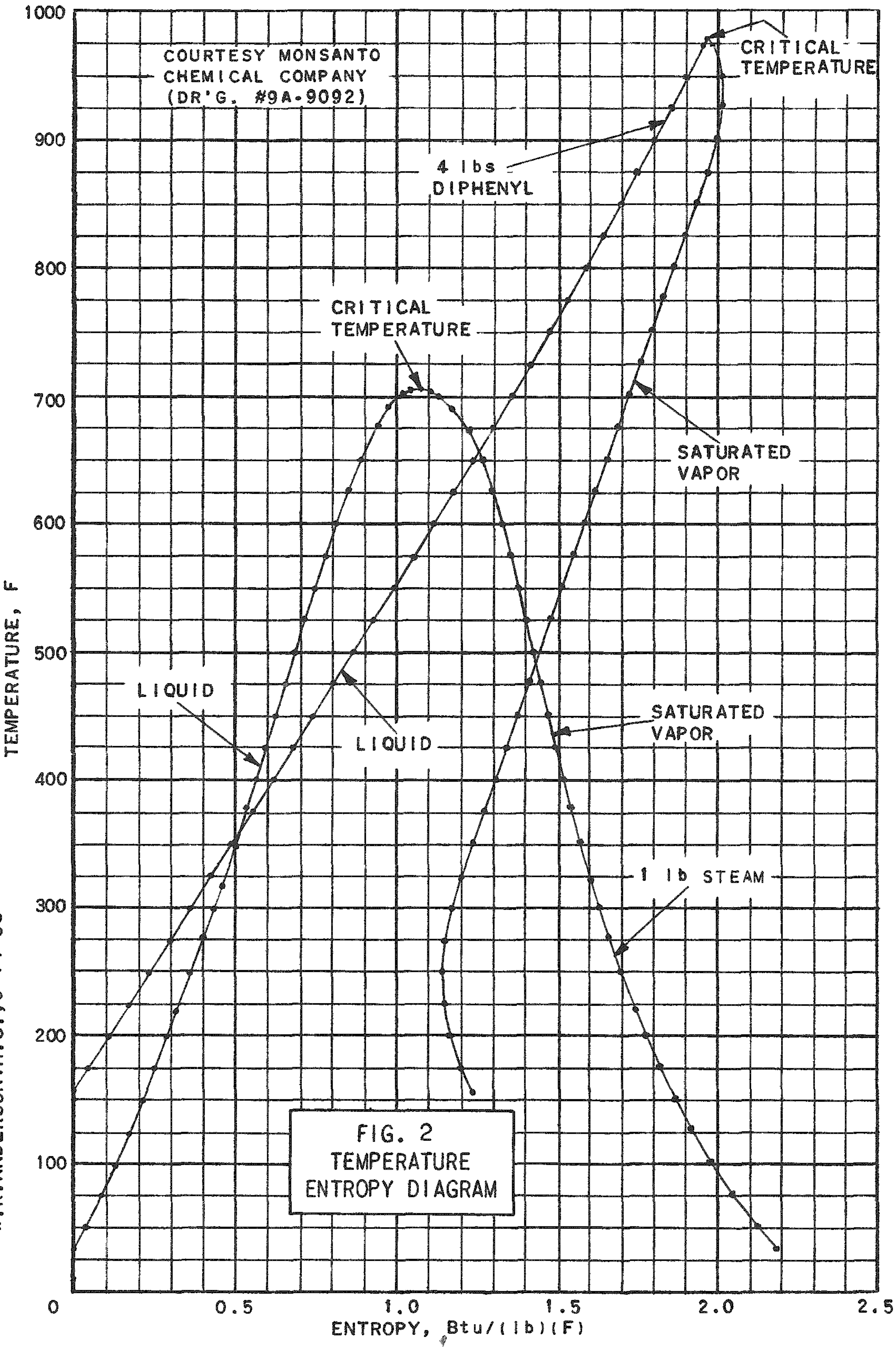


FIG. 2
TEMPERATURE
ENTROPY DIAGRAM

W.K.ANDERSON:H.C.,8-14-53

RE-7-11506-A

19

W.K. ANDERSON: F.S. 8-17-53

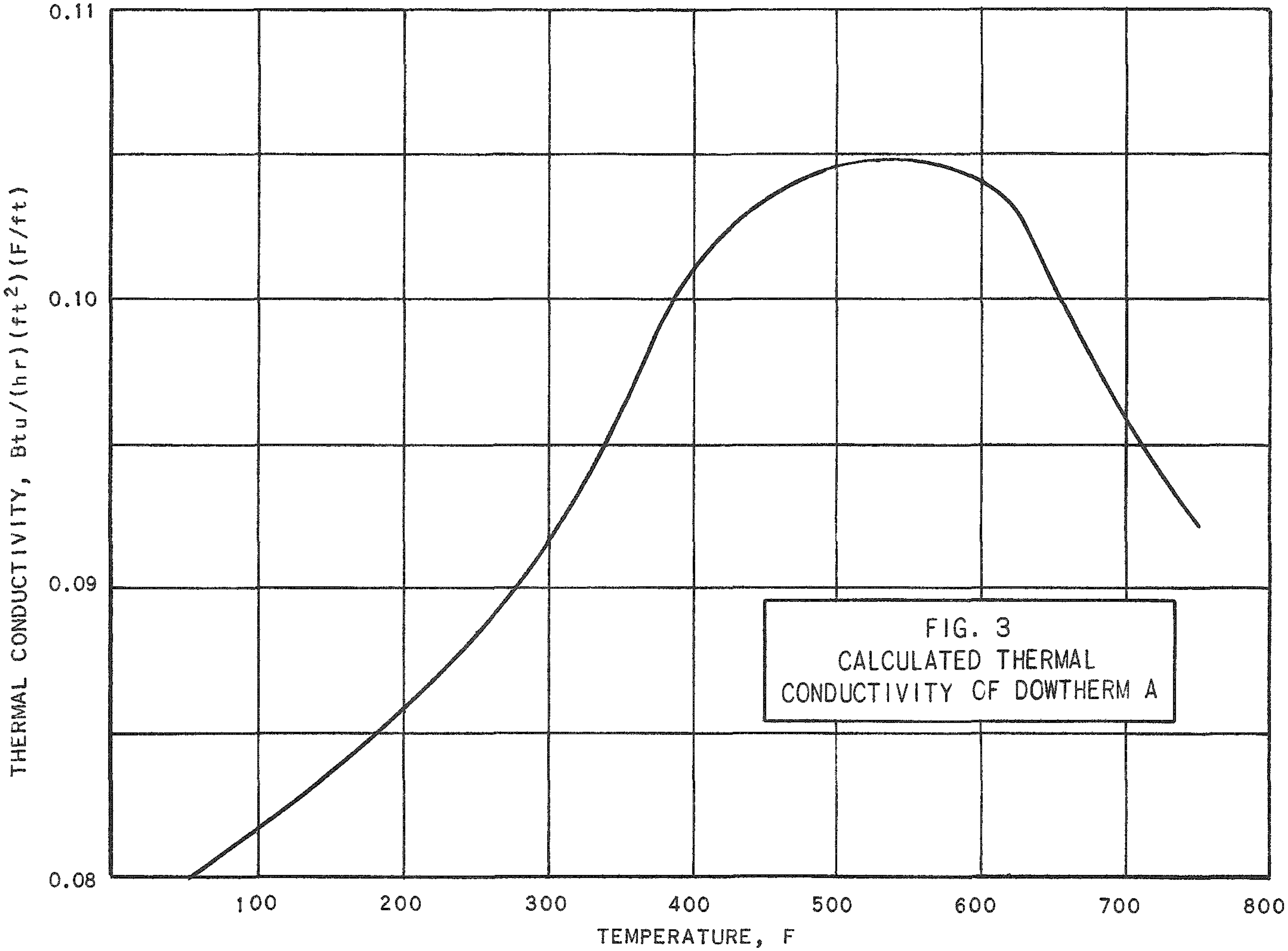
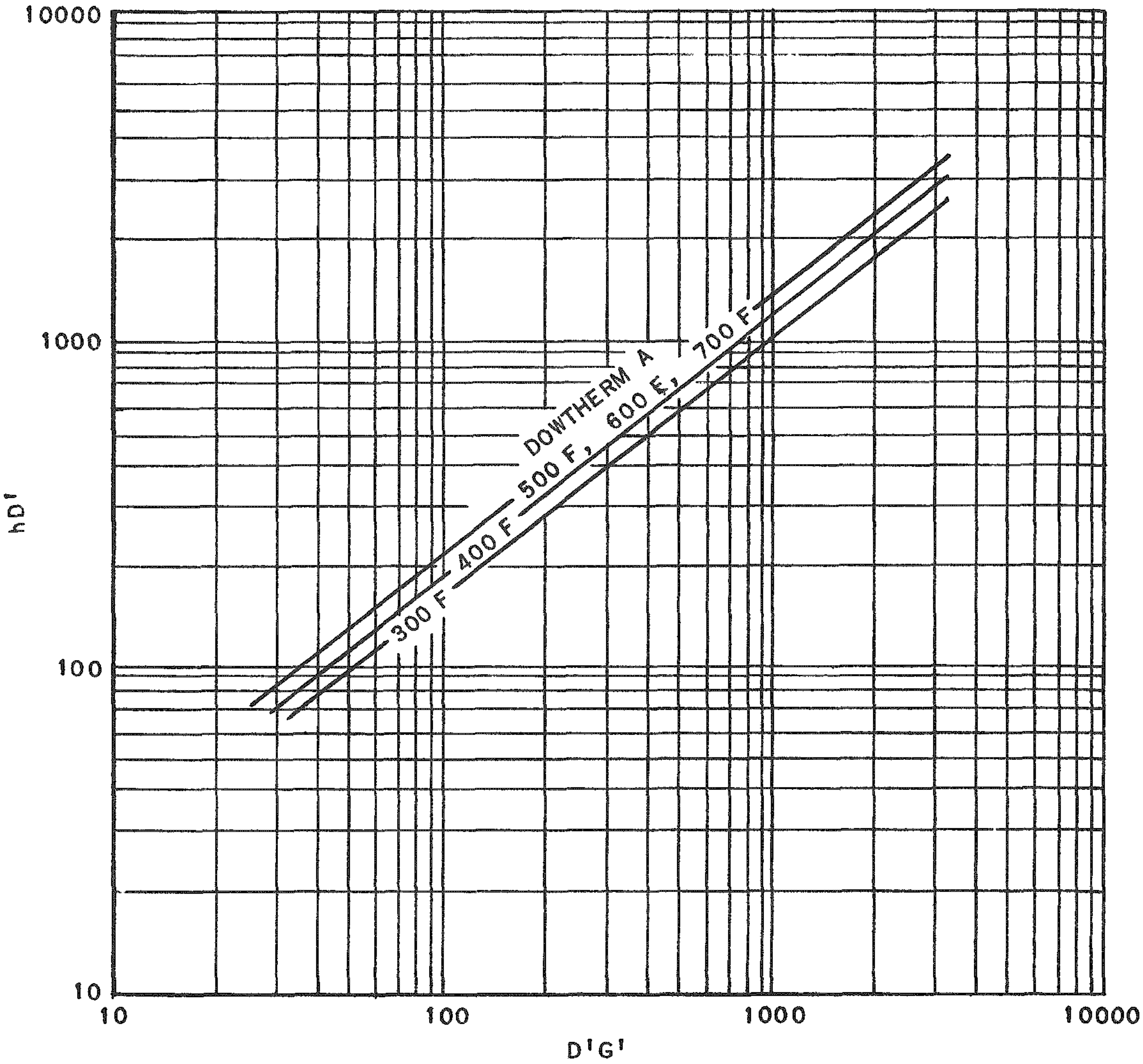


FIG. 3
CALCULATED THERMAL
CONDUCTIVITY OF DOWTHERM A

RE-7-11505-A

COURTESY DOW CHEMICAL CO

RE-7-11507-A



D' = DIAMETER - in.
G' = MASS VELOCITY - lb/(sec)(ft^2)
h = FILM COEFFICIENT - Btu/(hr)(ft^2)(F)

W.K. ANDERSON:H.C.,8-18-53

FIG. 4
LIQUID FILM COEFFICIENT
FOR DOWTHERM INSIDE PIPES

COURTESY DOW CHEMICAL CO.

21

RE-7-11521-A

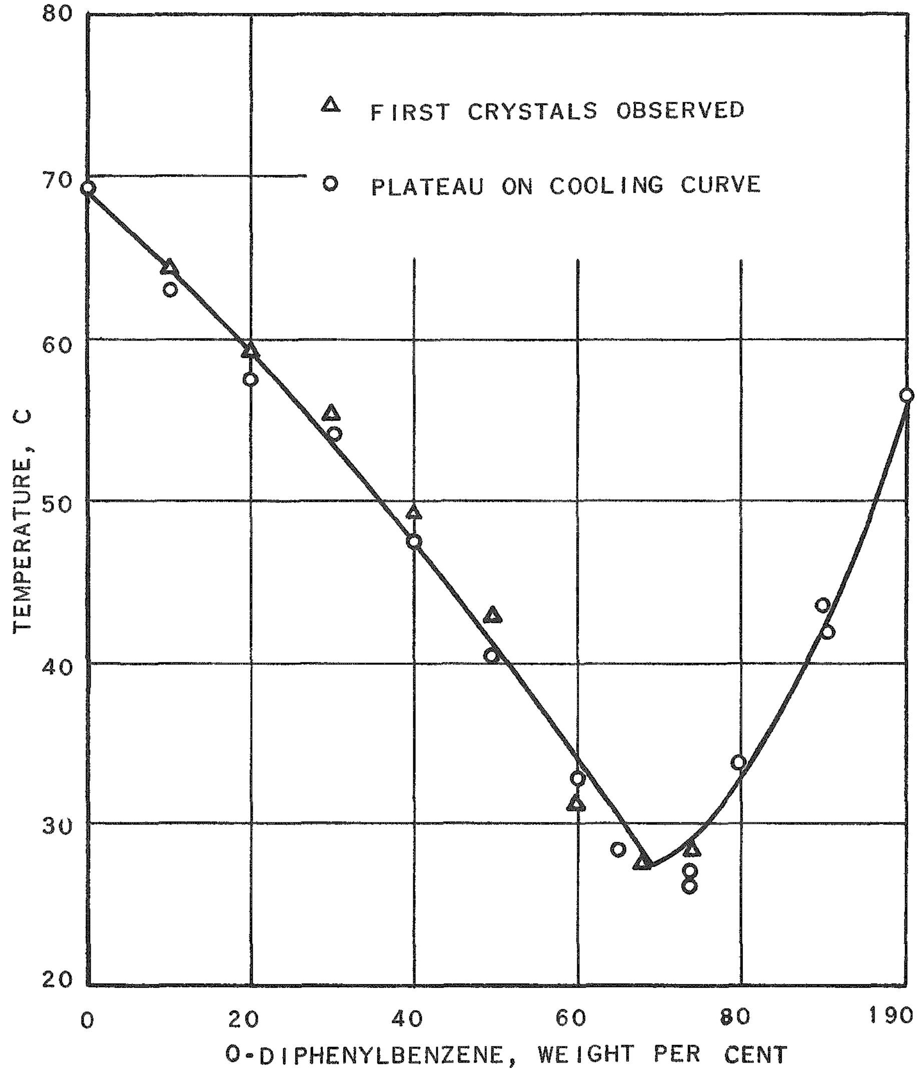


FIG. 5
MELTING POINTS
FOR THE SYSTEM
DIPHENYL --- O-DIPHENYLBENZENE

W.K. ANDERSON: F.S.,8-19-53

801 021

W.K.ANDERSON:F.S.,8-25-53

22

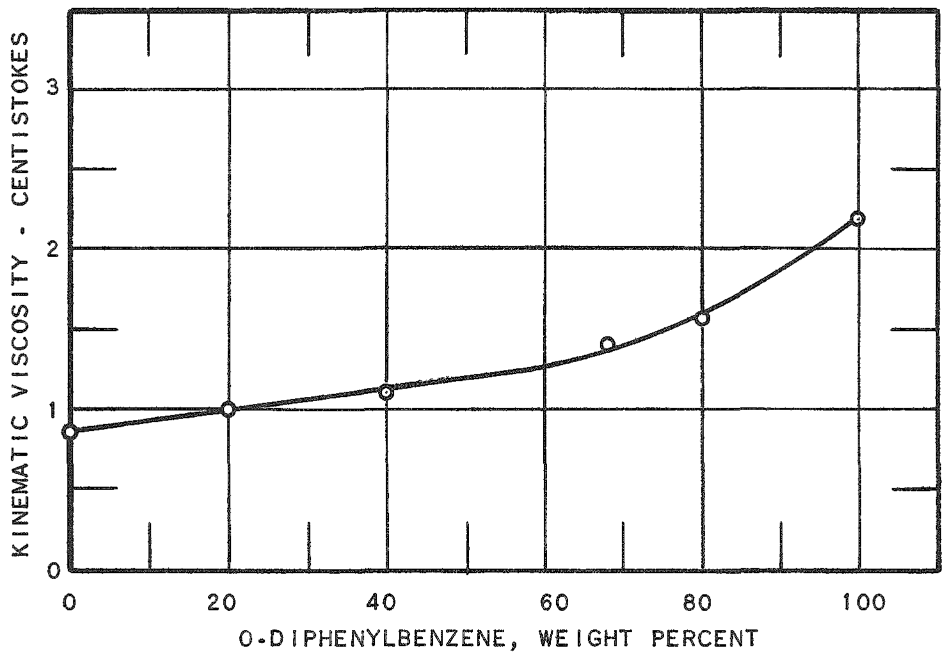
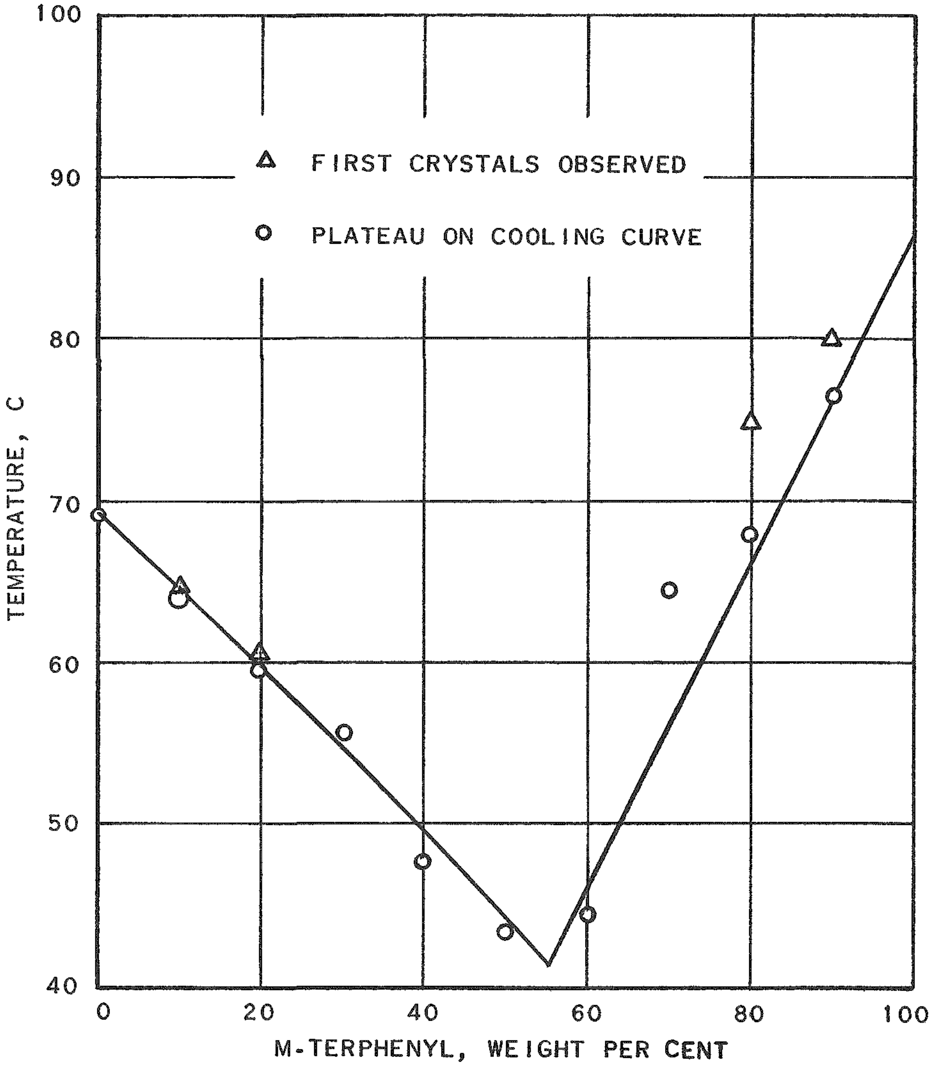


FIG. 6
KINEMATIC VISCOSITY OF MIXTURES OF
DIPHENYL WITH O-DIPHENYLBENZENE AT 130C

RE-7-11555;A

23

RE-7-11520-A



W.K.ANDERSON: F.J.S,-8-19-53

FIG. 7
MELTING POINTS
FOR THE SYSTEM
DIPHENYL —— M-DIPHENYLBENZENE

891 023

W.K.ANDERSON:F.S., 8-25-53

34

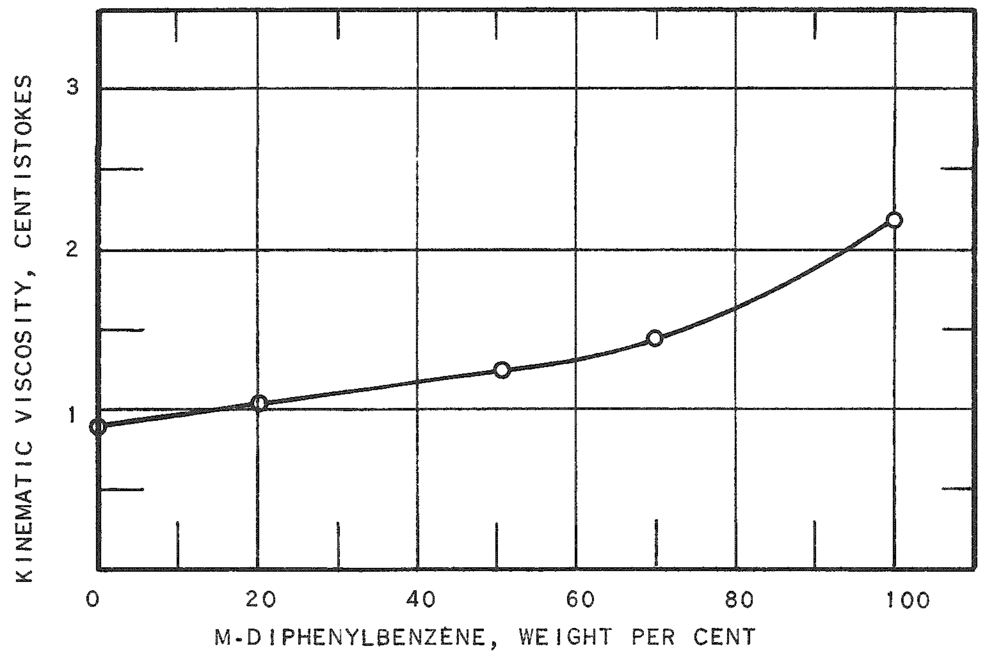
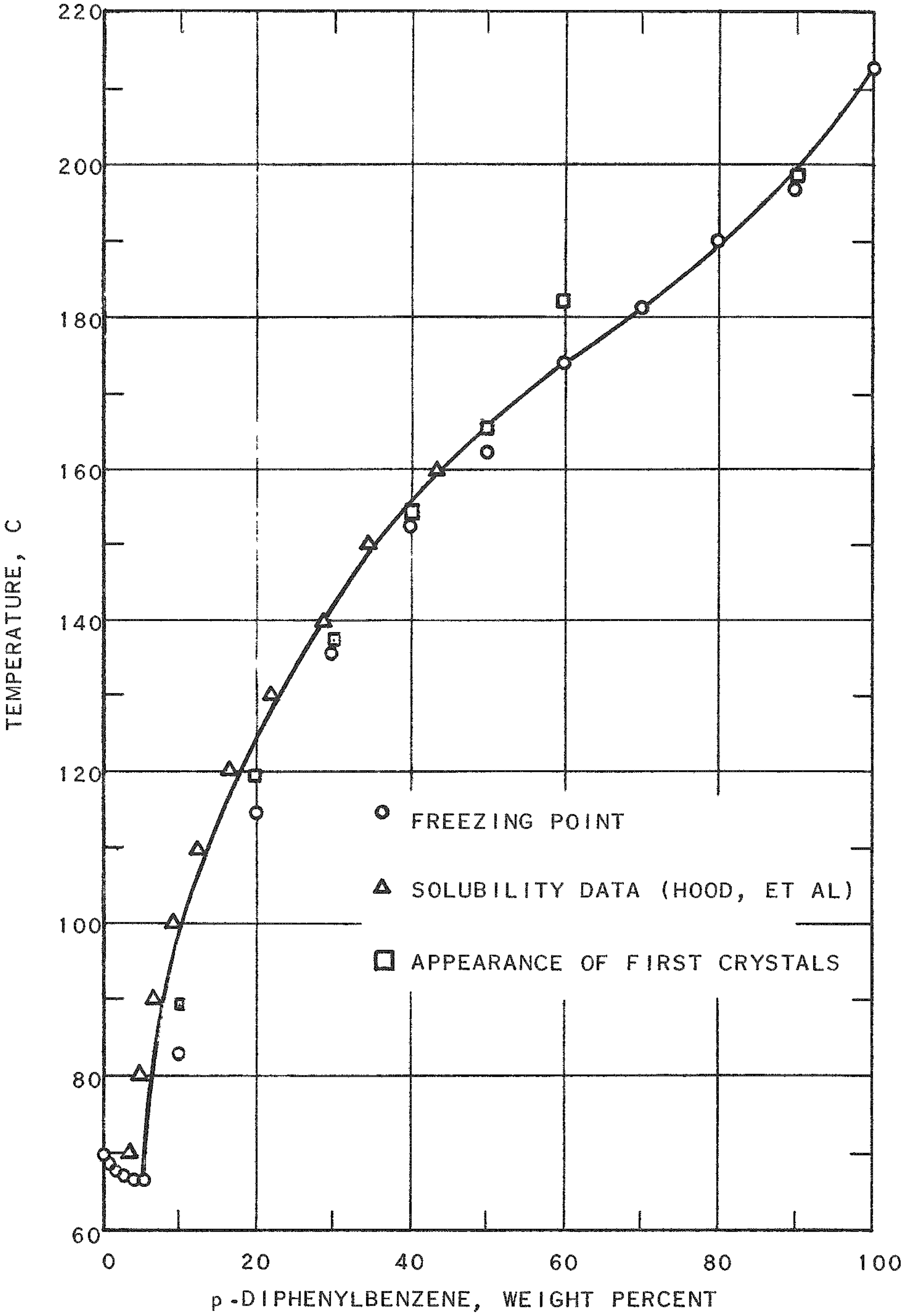


FIG. 8
KINEMATIC VISCOSITY OF
MIXTURES OF DIPHENYL WITH
M-DIPHENYLBENZENE AT 130 C

RE-7-11554-A

25



RE-7-11522-A

W.K.ANDERSON:F.S.,8-20-53

FIG. 9
MELTING POINTS FOR THE SYSTEM
DIPHENYL --- p-DIPHENYLBENZENE

W.K.ANDERSON:F.S,8-25-53

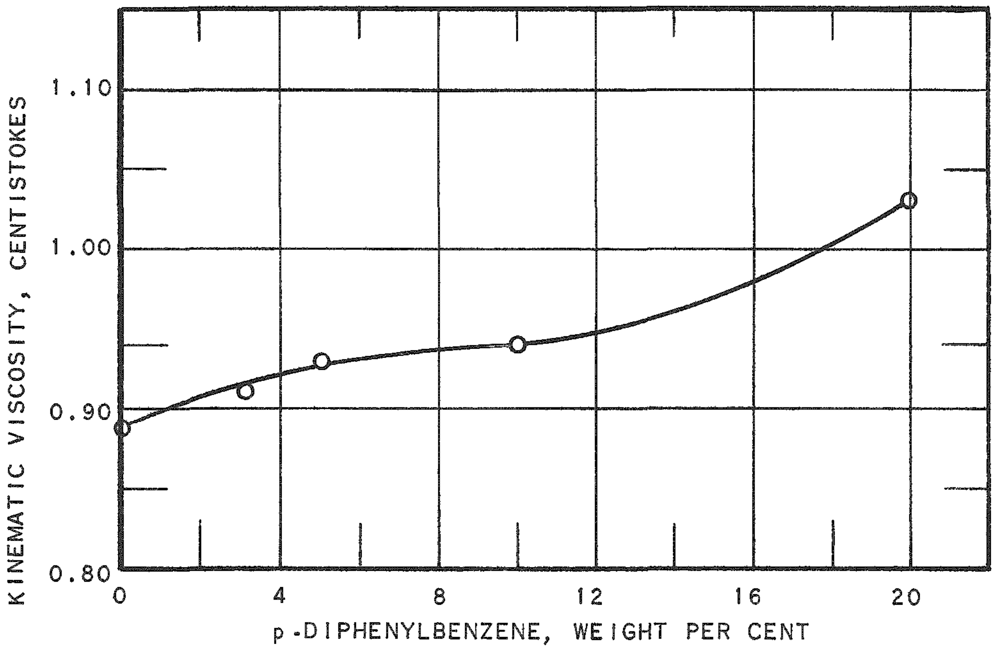


FIG. 10
KINEMATIC VISCOSITY OF MIXTURES
OF DIPHENYL WITH p-DIPHENYLBENZENE AT 130 C

RE-7-11556-A

W.K.ANDERSON:G.A.K,7/27/53

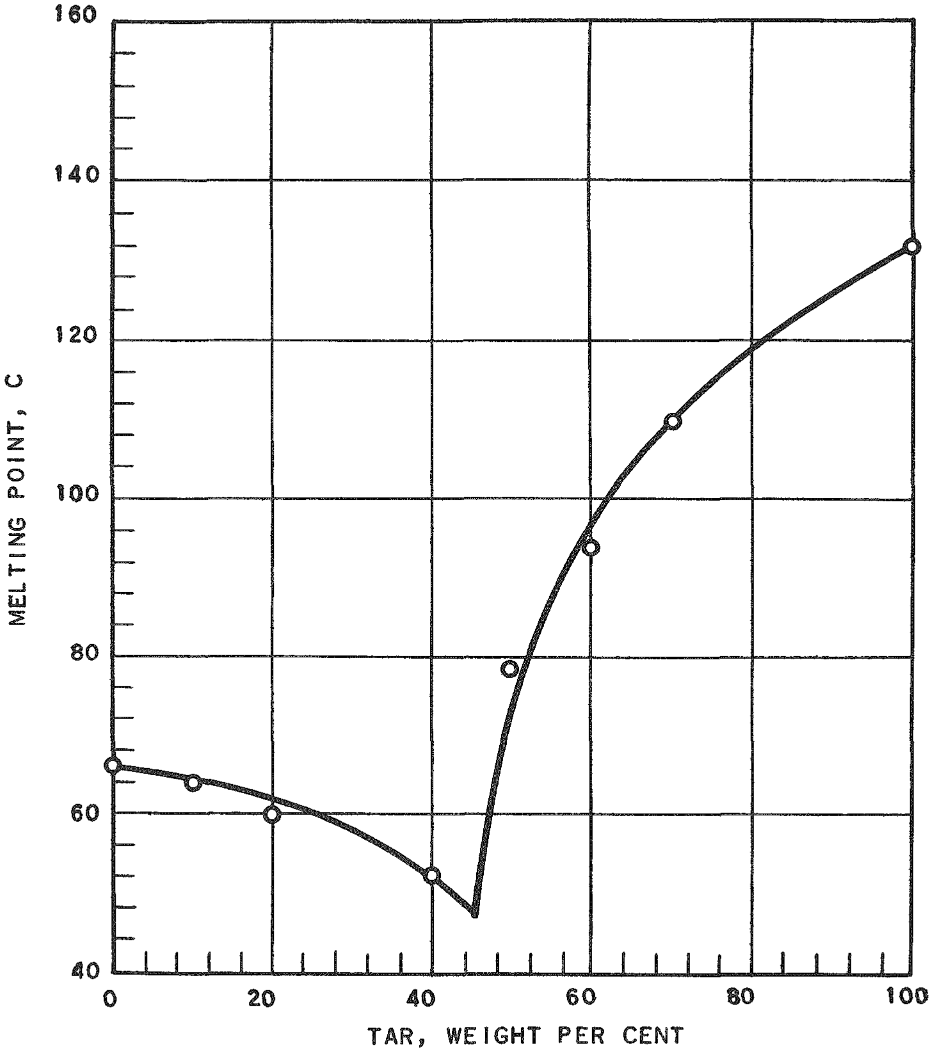


FIG. 11
MELTING POINTS FOR THE SYSTEM DIPHENYL-TAR

RE-7-11387-A

W.K.ANDERSON:G.A.K,7/27/53

28

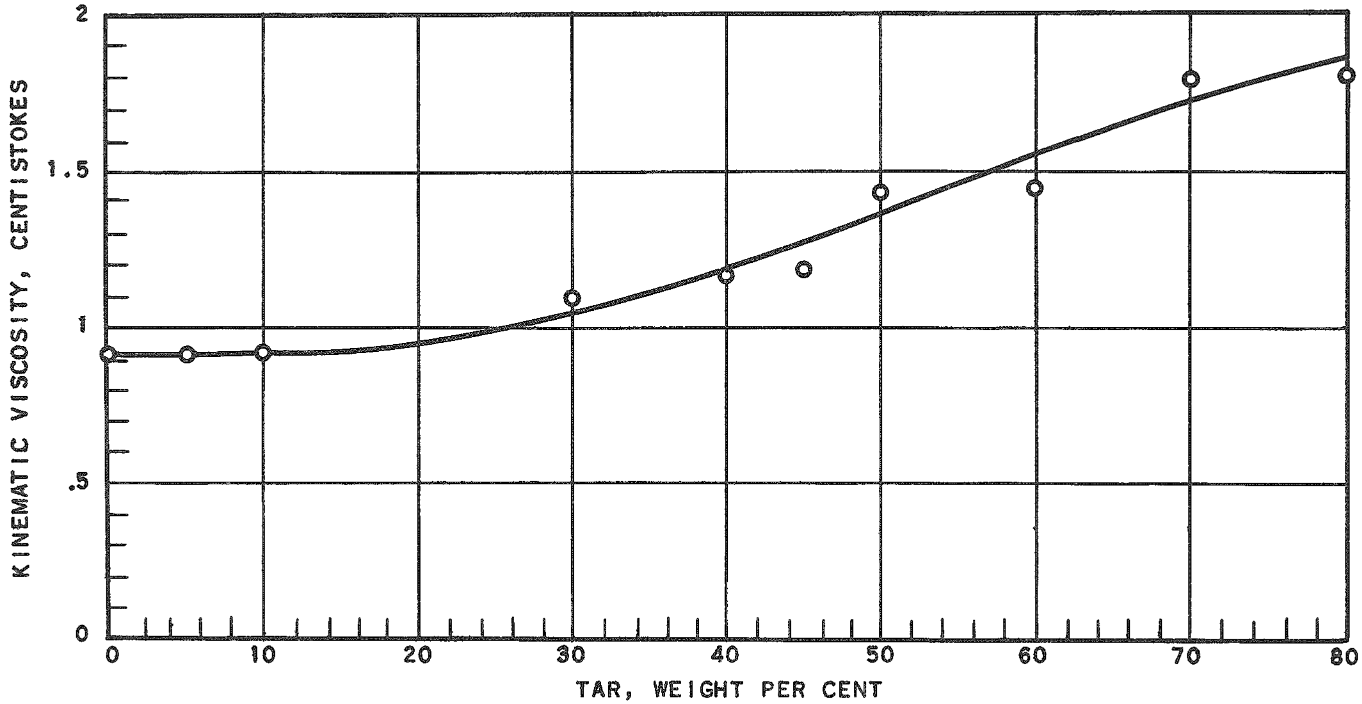


FIG. 12

KINEMATIC VISCOSITY OF MIXTURES OF DIPHENYL WITH PYROLYTIC TARS AT 130 C

631 029

RE-7-11383-A