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Analyses of Alkylates and Hydrocodimers[1*]

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This paper presents the results of work by the American Petroleum Institute Research Project 6 on the analyses, with respect to individual hydrocarbon components, of 28 different alkylates and hydrocodimers. The samples reported include 15 sulfuric-acid alkylates (one C_3, six C_4, one C_4-C_5, four C_5, one hot-acid dimer, one hot-acid trimer, and one cold-acid trimer), five hydrofluoric-acid alkylates (one C_3, one C_3-C_4, one C_4, one C_4-C_5, and one C_5), and 8 hydrocodimers. The analyses were made utilizing analytical distillations performed at high efficiency with high reflux ratio, together with accurately measured values of boiling point (obtained during the distillation) and of refractive index of the fractions of distillate.

Also included in this report is a summary of the results of the subsequent spectrographic analyses, with respect to individual components, of one of the C_4 alkylates by six different laboratories, involving one Raman, one mass, and four infrared spectrometers.

I. Introduction

As part of its war research program, the American Petroleum Institute Research Project 6 at the National Bureau of Standards was called upon, by the Technical Advisory Committee of the Petroleum Industry War Council and the National Advisory Committee for Aeronautics, to determine the hydrocarbon components in a number of representative alkylates and hydrocodimers.[3]

This report presents the results of the analyses, with respect to individual hydrocarbon components, of 28 different alkylates and hydrocodimers, including samples of sulfuric-acid alkylates, hydrofluoric-acid alkylates, sulfuric-acid hydrocodimers, and phosphoric-acid hydrocodimers.

The correlation of the composition of these alkylates and hydrocodimers with the conditions of manufacture on the one hand, and with the properties of the product on the other, is made in another report by Gould and Field [1] [4]

II. Samples Analyzed

The 28 different alkylates and hydrocodimers for which analyses are given in this report are listed in table 1,[5] which gives the API Research Project 6 sample number, the name of the sample, the maker of the material, and the date on which the original report of analysis of the material was issued. Additional identification and properties of the samples, the character of the "feed" stocks, etc. are given in the paper by Gould and Field [1]. [5]

III. Procedure

The analyses were made by performing extended analytical distillations at high efficiency with high reflux ratio and utilizing accurately measured values of boiling points (to ±0.01 deg C), obtained

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[*] Presented at the annual meeting of the American Petroleum Institute, before the Division of Refining, at Chicago, Illinois, November 12, 1946.

[1] This investigation was performed at the National Bureau of Standards as part of the work of the American Petroleum Institute Research Project 6 on the Analysis, Purification, and Properties of Hydrocarbons.

[2] Research Associate on the American Petroleum Institute Research Project 6 at the National Bureau of Standards.

[3] In this report, the term "alkylate" is used, in conformity with industrial practice, to designate those mixtures of branched-chain paraffin hydrocarbons produced by the addition of olefins to paraffins. In particular, a propylene (or C_3) alkylate is one produced from materials that are largely propylene in the olefin stock and largely butanes in the paraffin stock; a butene (or C_4) alkylate is one produced from materials that are largely butenes in the olefin stock and butanes in the paraffin stock; a pentene (or C_5) alkylate is one produced from materials that are largely pentenes in the olefin stock and butanes in the paraffin stock; a dimer alkylate is one produced from materials that are largely octenes in the olefin stock and butanes in the paraffin stock; and a trimer alkylate is one produced from materials that are largely dodecenes in the olefin stock and butanes in the paraffin stock. Similarly, in conformity with industrial paractice, the term "hydrocodimer" is used to designate those mixtures of branched-chain paraffin hydrocarbons (largely octanes) produced by the hydrogenation of a "codimer" (largely octenes) that has been produced by the codimerization of butenes.

[4] Figures in brackets indicate the literature references at the end of this paper.

[5] The tables and figures are at the end of this paper.

during the distillations, and values of refractive index (to ±0.0001) obtained on the fractions of distillate after the distillation.

Complete details of the assembly, testing, and operation of the distilling columns used in this work are given in another report [2].

The procedure followed in the analyses of the alkylates and hydrocodimers reported here may be simply illustrated by following through one of the samples, as follows:

A volume of 5,500 ml of a C_4 Alkylate (H_2SO_4), sample 27, was placed in still 4 on April 3, 1944. The distillation was continued until May 18, 1944, approximately 1,100 hr, with distillate being removed at the rate of 4.7 ml/hr. At each hour during the distillation (which corresponds to each 4.7 ml of distillate), the temperature of the liquid-vapor equilibrium in the head of the column was recorded to the nearest 0.01 deg C, and the increment in the volume of distillate was measured. The distillation yielded 272 fractions of distillate, each about 19 ml in volume.

The refractive index, n_D, at 25° C, of each of the fractions of distillate was measured[6] to ±0.0001 with NBS Standard Sample of 2,2,4-trimethylpentane as a reference substance, on Valentine refractometers, Abbe type, graduated directly to 0.0001.

Plots of the boiling point, and of the refractive index of the fractions of distillate, as a function of the volume of distillate, were made on an expanded scale, with 1 mm on the horizontal scale equivalent to 5 ml in volume of the distillate, and with 1 mm on the vertical scale equivalent to 0.2 deg C in boiling point or to 0.0001 in refractive index. A reproduction of these plots for sample 27 is given in figure 19.

From its manner of preparation, the butene alkylate was known to be substantially all a mixture of paraffin hydrocarbons. The olefin content was checked by determining the bromine number, with pure, olefin-free "isooctane" as a reference.[7] The presence of possible small amounts of aromatic hydrocarbons, as well as olefin hydrocarbons, was checked by searching for abnormalities in the curve of refractive index versus volume, especially at or near the "break points". Where found in significant amount, allowance for the olefin or aromatic hydrocarbon was appropriately made in the reduction of the data from the curve of refractive index versus volume.

The next step in the reduction of the data was to determine the appropriate break points between adjoining horizontal or nearly horizontal parts of the curves of boiling point versus volume and refractive index versus volume. (For convenience, these parts of the distillation curve will be called "flats".)

The appropriate break point between two adjoining flats is that point at which the distillate has a composition that corresponds substantially to equal amounts of the material of the two flats. The break points can be determined easily in terms of equal volumes of material in the case of the curve of refractive index, and in terms of equimolal amounts in the case of the curve of boiling point. Actually, however, the difference between equal volumes and equimolal amounts is not significant in connection with the location of the break points in the present investigation.

In the simple case where each flat represents substantially one compound (as, for example, compound A in one flat and compound B in the succeeding flat), the appropriate break point in the curve of boiling point versus volume is at that volume where the distillate is, in mole fraction, 0.5 A and 0.5 B, which point is located as being at the temperature determined by the following relation:

$$0.5\, P_A + 0.5 P_B = P. \tag{1}$$

In eq 1, P_A and P_B represent the vapor pressures of pure A and pure B, respectively, at the sought-for temperature t_M, and P is the total pressure at which the distillation is performed. This ideal relation holds sufficiently well for the mixtures of branched-chain paraffin hydrocarbons encountered in this investigation. The sought-for temperature, t_M, will always be less than the average of t_A and t_B. The difference between t_M and the average of t_A and t_B becomes insignificant as t_B approaches t_A, and, when t_A and t_B differ only by a few degrees, the break point may be located midway in temperature between the two flats without significant error. The break point obtained for equimolal amounts is assumed to be the same as the break point for equal volumes, within the significance of the present data.

Whenever the material on either or both flats is

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[6] Edith M. Pauls, laboratory assistant on the API Research Project 6 performed most of these measurements.

[7] The bromine numbers were determined under the supervision of R. C. Hardy, of the Bureau's Section on Lubricants and Liquid Fuels.

composed of two or more components, the break point is located as outlined above, except that the temperatures on each of the two flats are taken as measured and considered to be the average for the components on the given flats, and further, the changes of the boiling point with pressure are taken as an average of those for the possible components.

Actually, while the location of the temperature of the break point becomes less certain, the greater the difference in temperature between the two flats, the uncertainty of the location of the break point in terms of volume of distillate is little affected because of the fact that, as the difference in the two temperatures increases, the break between the two flats becomes sharper and there is a much more rapid change of temperature with volume.

For the curve of refractive index versus volume, when two adjoining flats represent single components, *A* and *B*, respectively, the break point is located at that point at which, when a vertical line is erected, the area bounded by the vertical line, the refractive index curve to the left of the vertical line, and a horizontal extension (to the right) of the refractive index flat for compound *A*, is equal to the area bounded by the vertical line, the refractive index curve to the right of the vertical line, and a horizontal extension (to the left) of the refractive index flat for compound *B*. This procedure assumes the refractive indices to be additive with volume on mixing, which assumption will not introduce any significant error for the mixtures of paraffin hydrocarbons encountered in this investigation.

When one or both of the flats represent two or more components, the same procedure is followed, with the understanding that the refractive index flat represents the mean refractive index for the two or more components in each case.

If the data are exact and have been correctly reduced, the break points on the curve of boiling point versus volume will be located at the same volume as the break point on the curve of refractive index versus volume, within their respective limits of uncertainty. (In the present investigation, appropriate correction was made, as necessary, for the volume of liquid hold-up in the line between the thermometer and the receiver, in order to have the values of boiling point and refractive index apply exactly to the same part of the distillate.

The next step was to estimate the relative amounts of the individual components when two or three resolvable compounds occur in one flat. When there are only two possible components in one flat, the relative amounts of the two components can be calculated from the mean value of the boiling point on the flat and the known values of the boiling points of the two pure compounds (at the given pressure), according to relations

$$x_C + x_D = 1 \tag{2}$$

and

$$x_C P_C + x_D P_D = P_M, \tag{3}$$

where x_C and x_D are the mole fractions of the two components *C* and *D*, and P_C, P_D, and P_M are the vapor pressures, respectively, of pure *C*, pure *D*, and the mixture at the given temperature, *t*. An independent value for the relative amounts of the two components can likewise be calculated from the mean value of the refractive index on the flat and the known values of the refractive indices of the two pure compounds, according to eq 2 and the relation

$$x_C n_C + x_D n_D = n_M, \tag{4}$$

where n_C, n_D, and n_M are the refractive indices, respectively, of pure *C*, pure *D*, and the mixture. These two values of the relative amounts should be in accord within their respective limits of uncertainty.[8] However, when P_C is nearly equal to P_B, and n_C is nearly equal to n_D, the relative amounts of the two compounds cannot be determined from these properties.

When a given flat represents three components, *A*, *B*, and *C*, the relative amounts of the three components may be estimated from the following three simultaneous equations:

$$x_A + x_B + x_C = 1 \tag{5}$$

$$n_M = x_A n_A + x_B n_B + x_C n_C \tag{6}$$

$$P_M = x_A P_A + x_B P_B + x_C P_C. \tag{7}$$

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[8] The uncertainty in the value of the relative amounts of the two components in one flat determined from the curve of refractive index versus volume is given by the relation

$$\sigma x_C = [1/(n_D - n_C)]\,[x_C^2 \sigma^2 n_A + x_D^2\, \sigma^2 n_D + \sigma^2 n_M]^{1/2}.$$

In this equation, $n_D - n_C$ is the difference in the refractive indices of pure *C* and pure *D*, x_C is the mole fraction of the material which is component *C*, x_D (or $1 - x_C$) is the mole fraction of the material which is component *D*, and σn_C, σn_D, and σn_M are the uncertainties in the values of refractive indices of pure *C*, pure *D*, and the mixture, respectively.

The corresponding uncertainty for the case of the curve of boiling point versus volume is obtained by substituting vapor pressure or temperature for refractive index in the foregoing equation.

In these equations, x_A, x_B, and x_C are the fractions of A, B, and C, respectively; n_A, n_B, n_C, and n_M are the refractive indices of A, B, C, and the mixture, respectively; and P_A, P_B, P_C, and P_M are the vapor pressures of A, B, C, and the mixture, respectively, at the temperature on the flat. Whenever the value of a given property is nearly the same for two of the components, it will not be possible to determine the relative amounts of these two components, but only their sum, from the above relations.

When a given flat represents more than three components, it is not possible to calculate the amounts of the individual components without measuring an additional property which has sufficiently different values for the several components.

In the case of minor components appearing near the beginning or the end of one of the flats in the curve of boiling point versus volume, the amount of such components can be calculated from the curve of refractive index versus volume when these minor components differ sufficiently in refractive index from the main component of the given flat.

The values of refractive indices, and of boiling points at various pressures, for the pure paraffin hydrocarbons involved in this investigation were taken from the tables of the API Research Project 44 [3].

Following the above procedure, and referring to the curves of boiling point versus volume and refractive index versus volume in figure 19, the various components of the butene alkylate analyzed as sample 27 were determined as follows:

(1) From flats with one component: Material (largely *n*-butane) lower-boiling than isopentane; isopentane; *n*-pentane; 2,3-dimethylbutane; 2,2,4-trimethylpentane; 2,3,4-trimethylpentane; 2,2,5-trimethylhexane; 2,3,5-trimethylhexane.

(2) From flats with one major component, with one or more minor components at the beginning or end of the flat: 2-Methylpentane; 2,4-dimethylpentane; 2,3-dimethylpentane; 2,3,3-trimethylpentane.

(3) From flats with two major components, with one or two minor components at the beginning or end of the flat: 2,5-dimethylhexane plus 2,4-dimethylhexane.

(4) As minor components occurring at the beginning or end of a flat: 3-Methylpentane; 2,2-dimethylpentane; 2,2,3-trimethylbutane; 2-methylhexane; 3-methylhexane; 2,2-dimethylhexane; 2,2,3-trimethylpentane; 2,3-dimethylhexane; 3,4-dimethylhexane.

Table 2 summarizes the important details concerning the analytical distillation of each of the 28 samples.

IV. Analyses of 28 Alkylates and Hydrocodimers

Figures 1 to 28, inclusive, show graphically the results of the analytical distillations of the 28 samples listed in table 1. These illustrations show, as a function of the volume of distillate, and of the percentage by volume of distillate, the boiling point of the distillate and its refractive index. Table 2 gives some additional information concerning the analytical distillation of the 28 samples.

Tables 3 to 7 give the composition, with respect to individual components, of the material above pentanes, for each of the 28 samples, as follows: Table 3, two propylene alkylates and one mixed propylene-butene alkylate; table 4, seven butene alkylates; table 5, five pentene alkylates and two mixed butene-pentene alkylates; table 6, one "dimer" alkylate and two "trimer" alkylates; table 7, eight hydrocodimers.

The butene alkylate analyzed by the API Research Project 6 as sample 24 was also analyzed in part by several other laboratories. Table 8 gives a comparison of the analysis of this butene alkylate by the following laboratories: API Research Project 6, by the method described in this report; Standard Oil Co. (Indiana), by analytical distillation and physical properties of the distillate; Shell Oil Co., by analytical distillation and physical properties of distillate, plus infrared for 2,3,4-trimethylpentane and 2,3,3-trimethylpentane.

The values given in tables 9 to 13 have been calculated from the values given in tables 3 to 7. For the 20 alkylates and 8 hydrocodimers, table 9 gives the relative amounts of hexanes, heptanes, octanes, and nonanes, and higher paraffins. Tables 10, 11, 12, and 13 give, for the 28 samples, the relative amounts of some individual branched-chain hexanes, heptanes, octanes, and nonanes, respectively.

V. Results of Cooperative Spectrographic Analysis of an Alkylate

In order to obtain comparative data on the spectrographic analysis of a representative alkylate with the spectrometers then being brought into use by the laboratories of the petroleum industry, and also to see how such analyses might compare with analyses made by the method of extended analytical distillation (plus boiling point and refractive index) as described in this report, one of the alkylates analyzed in the present work was prepared for subsequent spectrographic analysis by several different laboratories.

The alkylate selected for this cooperative analysis was the butene alkylate analyzed as sample 27. The approximately 5 liters of distillate, collected as 272 fractions, was blended into 50 lots, as shown by the horizontal row of numbers near the middle of figure 19. From each of these 50 lots, 8 samples of 4 ml each were sealed in glass ampoules. The material remaining in each of the 50 lots was also sealed in glass ampoules for retaining. One set of 50 samples was sent to each of the laboratories for spectographic analysis. The laboratories participating in the cooperative spectographic analysis of sample 27, together with the methods used, and the date of reporting the analysis, are as follows: Standard Oil Development Co., Elizabeth, N. J.; with infrared spectrometer; analysis reported January 2, 1945. Atlantic Refining Co., Philadelphia, Pa.; with mass spectrometer; analysis reported June 22, 1945. Socony-Vacuum Laboratories, Paulesboro, N. J.; with infrared spectrometer; analysis reported July 25, 1945. Sun Oil Co., Norwood, Pa.; with Raman spectrometer; analysis reported October 8, 1945. Universal Oil Products Co., Riverside, Ill.; with infrared spectrometer; analysis reported April 24, 1946. Phillips Petroleum Co., Bartlesville, Okla.; with infrared spectrometer; analysis reported June 20, 1946.

The spectrographic analyses reported by the several cooperating laboratories are summarized in table 14. The results indicate good agreement not only among the laboratories using the same type of spectrometer (infrared), but also among those using different types of spectrometers (mass, Raman, infrared). Further, the results from the spectrographic analyses are in good accord with the analysis of sample 27 from the present work.

VI. Discussion

In connection with the analyses presented in this report, the following observations may be made:

In relative amount among the heptanes, octanes, and nonanes, the heptanes are largest in the propylene alkylates, the nonanes are largest in the pentene alkylates, and the octanes are largest in the butene alkylates and the dimer and trimer alkylates.

The various paraffin hydrocarbon isomers are produced in relative amounts that do not, in a broad sense, correspond to thermodynamic equilibrium, although in some cases, two or three isomers of not too dissimilar structure may be found in relative amounts corresponding approximately to thermodynamic equilibrium [4, 5]. This observation is apparent from the fact that the relative amounts of the individual dimethylhexanes and the individual trimethylpentanes can be appreciably altered by changes in the conditions of manufacture, as shown in the report by Gould and Field [1].

In the 15 alkylates having appreciable amounts of hexanes, the amount of 2,3-dimethylbutane was, on the average, 64 ±10 percent of the total hexanes.

In both the alkylates and hydrocodimers, the heptanes present in large relative amount are 2,4-dimethylpentane and 2,3-dimethylpentane, with 2,2-dimethylpentane, 2-methylhexane, and 3-methylhexane in small amount, and the other heptanes being substantially absent.

In the alkylates, the octanes present in large relative amount are 2,2,4-trimethylpentane, 2,3,4-trimethylpentane, and 2,3,3-trimethylpentane, with 2,5-dimethylhexane, 2,4-dimethylhexane, and 2,3-dimethylhexane in small amount and the other octanes being substantially absent.

In the hydrocodimers, excluding the hot-acid hydrocodimer, sample 35, the octane present in largest relative amount is 2,3,4-trimethylpentane, with 2,2,4-trimethylpentane, 2,2,3-trimethylpentane, and 2,3,3-trimethylpentane in smaller amount, 2,2-dimethylhexane, 2,5-dimethylhexane, 2,4-dimethylhexane, 2,3-dimethylhexane, and 3,4-dimethylhexane in still smaller amount, and the other octanes substantially absent.

In the 11 alkylates having appreciable amounts of nonanes, the relative amounts of the two trimethylhexanes present in large amount were substantially constant, being 82.9 ±1.5 for 2,2,5-trimethylhexane and 17.1 ±1.5 for 2,3,5-trimethylhexane.

The hydrocodimers, excluding the hot-acid hydrocodimer, sample 35, differ from the alkylates in usually having in relative amount, among the octanes, less 2,2,4-trimethylpentane, more 2,2-dimethylhexane, more 2,2,3-trimethylpentane, more 2,3,4-trimethylpentane, less 2,3,3-trimethylpentane, and more 3,4-dimethylhexane, and in relative amount among the heptanes, more 2,3-dimethylpentane and less 2,4-dimethylpentane.

The dimer and trimer alkylates, for the production of which [1] the olefin charging stocks were largely C_8 and C_{12} olefins, respectively, have compositions that are not greatly different from the regular butene alkylates.

Eight different highly branched paraffin hydrocarbons can be obtained, in a purity of about 90 mole percent or better, by efficient distillation (equivalent to 100 or more theoretical plates) of appropriate alkylates or hydrocodimers, as follows: 2,4-Dimethylpentane from C_3 alkylate; 2,3-dimethylpentane from C_3 alkylate; 2,2,4-trimethylpentane from C_4 alkylate; 2,2,3-trimethylpentane from hydrocodimer (hot-acid); 2,3,4-trimethylpentane from hydrocodimer (phosphoric acid); 2,3,3-trimethylpentane from C_4 alkylate; 2,2,5-trimethylhexane from C_5 alkylate; 2,3,5-trimethylhexane from C_5 alkylate.

Grateful acknowledgement is made to the Standard Oil Co. (Ind.), Shell Oil Co., Standard Oil Development Co., Atlantic Refining Co., Socony-Vacuum Laboratories, Sun Oil Co., Universal Oil Products Co., and the Phillips Petroleum Co. for permission to include in this report the results of analyses made by their respective laboratories, as indicated in sections IV and V of this report.

VII. References

[1] D. W. Gould and H. W. Field, Proc. Am. Petroleum Inst. **27** (III), (1946).

[2] C. B. Willingham and F. D. Rossini, J. Research NBS **37**, 15 (1946) RP1724.

[3] American Petroleum Institute Research Project 44 at the National Bureau of Standards. Tables 1a, 2a, 3a, 4a. Boiling point, *dt/dP*, refractive index, density, and freezing point.

[4] F. D. Rossini, E. J. Prosen, and K. S. Pitzer, J. Research NBS **27**, 529 (1941) RP1440.

[5] E. J. Prosen, K. S. Pitzer, and F. D. Rossini, J. Research NBS **34**, 255 (1945) RP1641.

TABLE 1.—*List of the 28 alkylates and hydrocodimers*

API Research Project 6 sample No.	Sample	Maker of the sample	Date of report of analysis
1	C_4 Alkylate (H_2SO_4)	Standard Oil Co. of New Jersey.	Oct. 31, 1942
2	do	Texas Co	Nov. 10, 1942
4	Hydrocodimer (solid phosphoric acid).	Standard Oil Co (Indiana).	Dec. 19, 1942
7	C_5 alkylate (H_2SO_4)	Standard Oil Co. of New Jersey.	May 22, 1943
9	C_4 Alkylate (H_2SO_4)	Atlantic Refining Co.	Nov. 30, 1943
10	do	do	Dec. 18, 1943
11	C_4-C_5 alkylate (H_2SO_4).	do	Dec. 11, 1943
12	C_5 alkylate (H_2SO_4)	do	Dec. 6, 1943
13	C_4 alkylate (HF)	Sinclair Refining Co.	Nov. 30, 1943
14	C_5 alkylate (HF)	do	Dec. 6, 1943
15	C_4-C_5 alkylate (HF)	do	Dec. 18, 1943
16	C_3-C_4 alkylate (HF)	do	Apr. 29, 1944
17	C_3 alkylate (HF)	do	Dec. 11, 1943
20	C_3 alkylate (H_2SO_4)	Shell Oil Co	Apr. 22, 1944
21	Trimer (hot acid) alkylate (H_2SO_4).	do	May 6, 1944
22	C_5 alkylate (H_2SO_4)	do	May 13, 1944
23	do	do	May 20, 1944
24	C_4 alkylate (H_2SO_4)	Standard Oil Co. of Ohio.	Nov. 30, 1943
27	do	Standard Oil Co. of New Jersey, Louisiana Division.	Oct. 15, 1944
33	Hydrocodimer (phosphoric acid).	Standard Oil Co. of New Jersey.	Oct. 31, 1944
34	Dimer (hot acid) alkylate (H_2SO_4).	Shell Oil Co	Oct. 15, 1944
35	Hydrocodimer (hot-acid).	do	Jan. 31, 1945
36	Hydrocodimer (Lawrenceville).	Texas Co	May 15, 1945
37	Hydrocodimer (Tulsa).	do	May 31, 1945
41	Hydrocodimer (Lima 6).	Standard Oil Co. of Ohio.	June 15, 1945
42	Hydrocodimer (Lima 7).	do	Sept. 15, 1945
43	Trimer (cold acid) alkylate (H_2SO_4).	Pure Oil Co	June 15, 1945
44	Hydrocodimer (HSO–1684).	Trimpell, Ltd	June 30, 1945

Table 2 — Information on the analytical distillation of 20 alkylates and 8 hydrocodimers.

Sample No.	Material	Distillation								Analysis given in table
		Distilling column number[a]	Number of theoretical plates (approx.)[a]	Reflux ratio (approx.)	Rate of collection of distillate	Volume of charge	Volume of each fraction	Total time of distillation	Results plotted in figure	
					ml/hour	ml	ml	hours		
1	C_4 Alkylate (H_2SO_4)	H	110	120/1	5	2600	15	510	1	4
2	C_4 Alkylate (H_2SO_4)	H	110	120/1	5	2590	15	510	2	4
4	Hydrocodimer (solid phosphoric acid)	H	110	120/1	5	2600	15	575	3	7
7	C_5 Alkylate (H_2SO_4)	H	110	120/1	5	2600	15	530	4	5
9	C_4 Alkylate (H_2SO_4)	H	110	120/1	5	2600	15	600	5	4
10	C_4 Alkylate (H_2SO_4)	H	110	120/1	5	2600	15	550	6	4
11	C_4-C_5 Alkylate (H_2SO_4)	H	110	120/1	5	2600	15	600	7	5
12	C_5 Alkylate (H_2SO_4)	H	110	120/1	5	2595	15	575	8	5
13	C_4 Alkylate (HF)	H	110	120/1	5	2600	15	575	9	4
14	C_5 Alkylate (HF)	H	110	120/1	5	2565	15	530	10	5
15	C_4-C_5 Alkylate (HF)	Q	100	120/1	2.5	1600	7.5	695	11	5
16	C_3-C_4 Alkylate (HF)	2	100	120/1	2.5	1790	7.5	670	12	3
17	C_3 Alkylate (HF)	P	100	120/1	2.5	1625	7.5	620	13	3
20	C_3 Alkylate (H_2SO_4)	2	100	120/1	2.5	1800	7.5	670	14	3
21	Trimer (hot acid) Alkylate (H_2SO_4)	3	100	120/1	2.5	1760	7.5	740	15	6
22	C_5 Alkylate (H_2SO_4)	2	100	120/1	2.5	1790	7.5	740	16	5
23	C_5 Alkylate (H_2SO_4)	3	100	120/1	2.5	1790	7.5	790	17	5
24	C_4 Alkylate (H_2SO_4)	P	100	120/1	2.5	1600	7.5	620	18	4
27	C_4 Alkylate (H_2SO_4)	4	200	150/1	4.7	5500	19	1100	19	4
33	Hydrocodimer (phosphoric acid)	2	100	120/1	2.5	1800	7.5	740	20	7
34	Dimer (hot acid) Alkylate (H_2SO_4)	2	100	120/1	2.5	2000	7.5	770	21	6
35	Hydrocodimer (hot acid)	3	100	120/1	2.5	1800	7.5	700	22	7
36	Hydrocodimer (Lawrenceville)	3	100	120/1	2.5	2000	7.5	860	23	7
37	Hydrocodimer (Tulsa)	2	100	120/1	2.5	2000	7.5	990	24	7
41	Hydrocodimer (Lima 6)	2	100	120/1	2.5	2000	7.5	890	25	7
42	Hydrocodimer (Lima 7)	2	100	130/1	2.3	2000	9.2	910	26	7
43	Trimer (cold acid) Alkylate (H_2SO_4)	2	100	130/1	2.3	1970	9.2	890	27	6
44	Hydrocodimer (HSO-1684)	3	100	130/1	2.3	2370	9.2	1100	28	7

[a] See reference 2. Column H was the same as column 9 except that the length of the rectifying section was 2.71 meters (107 inches). Columns P and Q were similar to columns 2 and 3.

Table 3 – Analyses of two propylene alkylates and one mixed propylene-butene alkylate

Components	Boiling point at 1 atm.	C_3 Alkylate (H_2SO_4) Sample 20 (see figure 15)		C_3 Alkylate (HF) Sample 17 (see figure 14)		C_3-C_4 Alkylate (HF) Sample 16 (see figure 13)	
	°C	Percentage by volume (above pentanes)					
2,3-Dimethylbutane	58.0	3.5^{a} ± 1.0	5.3 ± 1.0	2.9^{a} ± 0.6	5.0 ± 0.5	1.4^{a} ± 0.7	2.3 ± 0.5
2-Methylpentane	60.3	1.7 ± 0.9		1.4 ± 0.5		0.9 ± 0.5	
3-Methylpentane	63.3	0.1 ± 0.1		0.7 ± 0.4			
2,2-Dimethylpentane	79.2	1.1 ± 1.1	27.3 ± 0.5	0.8 ± 0.8	19.0 ± 0.5	0.7 ± 0.7	4.9 ± 0.5
2,4-Dimethylpentane	80.5	26.2^{b} ± 1.5		18.2^{b} ± 0.8		4.2^{b} ± 1.0	
2,3-Dimethylpentane	89.8	36.1 ± 1.1	38.4 ± 0.5	21.1 ± 1.0	22.4 ± 0.5	4.5 ± 1.0	5.3 ± 0.8
2-Methylhexane	90.1	2.3 ± 1.1		1.3 ± 1.0		0.8 ± 0.5	
3-Methylhexane	92.0						
2,2,4-Trimethylpentane	99.2	7.8 ± 0.5		16.3 ± 0.5	16.5 ± 0.5	30.04 ± 1.0	
Olefins	99-109			0.2 ± 0.1			
Toluene	110.6					0.06 ± 0.02	
2,5-Dimethylhexane	109.1	2.5^{c} ± 0.8	3.3 ± 0.8	4.0^{c} ± 1.0	5.1 ± 1.0	9.1^{c} ± 2.0	11.4 ± 1.2
2,4-Dimethylhexane	109.4						
2,2,3-Trimethylpentane	109.8	0.8 ± 0.5		1.1 ± 0.6		2.3 ± 1.2	
2,3,4-Trimethylpentane	113.5	2.5 ± 1.0	6.9 ± 1.0	3.4 ± 1.5	8.2 ± 1.5	6.8 ± 2.0	17.5 ± 2.0
2,3,3-Trimethylpentane	114.8	3.2 ± 1.0		3.9 ± 1.5		6.7 ± 2.0	
2,3-Dimethylhexane	115.6	1.2^{d} ± 0.6		0.9^{d} ± 0.5		4.0^{d} ± 2.0	
Isoparaffins	115.6-124.1					1.3 ± 0.7	
2,2,5-Trimethylhexane	124.1	1.4 ± 0.7		4.5 ± 1.5		8.2 ± 1.5	
Isononanes	126-143	0.8 ± 0.5		2.4 ± 0.5			
2,3,5-Trimethylhexane	131.4					1.83 ± 1.0	1.9 ± 1.0
Aromatics	125-133					0.07 ± 0.04	
Isononanes	133-143					1.53 ± 0.9	1.6 ± 0.9
Aromatics	133-149					0.07 ± 0.04	
Isoparaffins	143-151	2.2 ± 1.0		3.3 ± 1.0			
Isoparaffins	>143					15.5 ± 0.9	
Isoparaffins	151-160	1.5 ± 0.7		2.2 ± 0.8			
Isoparaffins	>160	5.1 ± 0.8					
Isoparaffins	160-175			7.7 ± 1.5			
Isoparaffins	>175			3.7 ± 1.0			
Total		100.0		100.0		100.0	

[a] May include a small amount of 2,2-dimethylbutane.
[b] May include a small amount of 2,2,3-trimethylbutane.
[c] May include a small amount of 2,2-dimethylhexane.
[d] May include a small amount of 3,4-dimethylhexane.

Table 4 — Analyses of seven butene alkylates

Components	Boiling point at 1 atm.	C_4 Alkylate (H_2SO_4) Sample 1 (see figure 1)		C_4 Alkylate (H_2SO_4) Sample 2 (see figure 2)		C_4 Alkylate (H_2SO_4) Sample 9 (see figure 5)		C_4 Alkylate (H_2SO_4) Sample 10 (see figure 6)		C_4 Alkylate (H_2SO_4) Sample 24 (see figure 18)		C_4 Alkylate (H_2SO_4) Sample 27 (see figure 19)		C_4 Alkylate (HF) Sample 13 (see figure 9)	
	°C	Percentage by volume (above pentanes)													
2,2-Dimethylbutane	49.7	0.6 ± 0.4	8.8 ± 0.5	0.5_5 ± 0.03	12.5_5 ± 0.5		8.3 ± 0.5		9.4 ± 0.5	2.1^a ± 0.5			6.8 ± 0.5	2.1^a ± 0.5	
2,3-Dimethylbutane	58.0	5.5 ± 1.0		8.1 ± 0.6		6.5^a ± 0.5		7.0^a ± 0.9				5.2^a ± 0.9			
2-Methylpentane	60.3	1.8 ± 0.8		3.2 ± 0.6		1.8 ± 0.5		2.4 ± 0.9				1.2 ± 0.6			
3-Methylpentane	63.3	0.9 ± 0.6		0.7 ± 0.5								0.4 ± 0.2			
2,2-Dimethylpentane	79.2			0.7 ± 0.4	6.2 ± 0.5	0.5 ± 0.3	4.7 ± 1.0	0.8 ± 0.5	4.7 ± 1.0	1.1^c ± 0.5		0.2 ± 0.2	4.1 ± 0.5	2.6^c ± 0.5	
2,4-Dimethylpentane	80.5	$3.6^{b,c}$ ± 0.5		5.5^c ± 0.5		4.2^c ± 1.0		3.9^c ± 1.0				3.7 ± 1.0			
2,2,3-Trimethylbutane	80.9											0.2 ± 0.2			
2,3-Dimethylpentane	89.8	2.2 ± 1.1	3.1 ± 0.5	3.4 ± 0.8	5.1 ± 0.6	2.1 ± 0.5	2.8 ± 0.5	2.5 ± 0.5	3.0 ± 0.5	1.0 ± 0.5		2.6 ± 0.7	2.9 ± 0.5	1.9 ± 0.5	
2-Methylhexane	90.1	0.9 ± 0.5		1.7 ± 0.8		0.7 ± 0.4		0.5 ± 0.3				0.3 ± 0.2			
3-Methylhexane	92.0														
2,2,4-Trimethylpentane	99.2	30.1 ± 0.6		22.4 ± 0.6		25.9 ± 0.5		26.8 ± 0.5		35.5 ± 0.5		26.7 ± 1.0		41.7 ± 0.5	
"Unsaturated"	100-109			0.05 ± 0.03											
2,2-Dimethylhexane	106.8		9.9 ± 1.0		12.2 ± 1.0		9.6 ± 1.0		9.9 ± 1.0		5.4 ± 1.0	0.3 ± 0.2	8.8 ± 1.0		16.3 ± 1.1
2,5-Dimethylhexane	109.1	8.1^d ± 1.2		10.3^d ± 1.2		7.9^d ± 1.0		8.3^d ± 1.0		3.4^d ± 1.0		7.2 ± 1.5		13.4^d ± 1.2	
2,4-Dimethylhexane	109.4														
2,2,3-Trimethylpentane	109.8	1.8 ± 0.8		1.9 ± 0.8		1.7 ± 1.0		1.6 ± 0.8		2.0 ± 1.0		1.3 ± 0.7		2.9 ± 1.2	
2,3,4-Trimethylpentane	113.5	9.3 ± 1.2	27.5 ± 1.5	15.3 ± 2.0	29.1 ± 1.5	16.4 ± 2.0	32.7 ± 1.5	19.2 ± 2.0	36.4 ± 1.5	24.0 ± 2.0	51.6 ± 1.5	14.3 ± 2.0	31.5 ± 1.5	9.4 ± 2.0	25.6 ± 1.5
2,3,3-Trimethylpentane	114.8	14.5 ± 1.2		10.4 ± 2.0		12.1 ± 2.0		14.9 ± 2.0		25.2 ± 2.0		13.5 ± 2.0		10.0 ± 2.0	
2,3-Dimethylhexane	115.6	3.7^e ± 1.2		3.4^e ± 2.0		4.2^e ± 1.5		2.3^e ± 1.2		2.4^e ± 1.5		3.3 ± 1.5		6.2^e ± 2.0	
3,4-Dimethylhexane	117.7											0.4 ± 0.3			
Isoparaffins	>115.6									3.3 ± 0.5					
2,2,5-Trimethylhexane	124.1	12.7 ± 0.8		8.8 ± 0.8		4.9 ± 1.0		6.3 ± 1.5				4.9 ± 1.0		3.4 ± 1.0	
Isoparaffins	>124.1													6.4 ± 0.5	
2,3,5-Trimethylhexane	131.4	1.9 ± 0.6		1.9 ± 0.6								1.0 ± 0.5			
Higher boiling material	>131.4	2.4 ± 0.5		1.7 ± 0.5											
Isoparaffins	126-142					2.3 ± 0.5		2.0 ± 0.7							
Isononanes	132-143											0.5 ± 0.3			
Isoparaffins	142-160					2.9 ± 0.5						2.5 ± 1.0			
Isoparaffins	>143							1.5 ± 0.5							
Isoparaffins	160-180					3.8 ± 1.0						3.0 ± 1.5			
Isoparaffins	>180					2.1 ± 1.0						7.3 ± 1.5			
Total		100.0		100.0		100.0		100.0		100.0		100.0		100.0	

[a] May include a small amount of 2,2-dimethylbutane.

[b] May include a small amount of 2,2-dimethylpentane.

[c] May include a small amount of 2,2,3-trimethylbutane.

[d] May include a small amount of 2,2-dimethylhexane.

[e] May include a small amount of 3,4-dimethylhexane.

Table 5 — Analyses of five pentene alkylates and two mixed butene-pentene alkylates

Components	Boiling point at 1 atm	C_5 Alkylate (H_2SO_4) Sample 7 (see figure 4)		C_5 Alkylate (H_2SO_4) Sample 12 (see figure 8)		C_5 Alkylate (H_2SO_4) Sample 22 (see figure 16)		C_5 Alkylate (H_2SO_4) Sample 23 (see figure 17)		C_5 Alkylate (HF) Sample 14 (see figure 14)		C_4-C_5 Alkylate (HF) Sample 15 (see figure 11)		C_4-C_5 Alkylate (HF) Sample 11 (see figure 7)	
	°C	Percentage by volume (above pentanes)													
Cyclopentane	49.3			0.5 ± 0.3	0.7 ± 0.4			0.5 ± 0.2	0.6 ± 0.2					0.3 ± 0.1	0.6 ± 0.3
2,2-Dimethylbutane	49.7			0.2 ± 0.1				0.1 ± 0.1						0.3 ± 0.2	
2,3-Dimethylbutane	58.0	2.6^{a} ± 0.8	5.8 ± 0.5	2.7 ± 0.5	5.8 ± 0.5	3.2^{a} ± 1.0		2.1 ± 0.8	4.3 ± 0.9	1.6^{a} ± 0.5		1.5^{a} ± 0.5		2.8 ± 0.5	4.7 ± 0.5
2-Methylpentane	60.3	2.1 ± 0.8		2.0 ± 0.5				1.8 ± 0.9						1.4 ± 0.5	
3-Methylpentane	63.3	1.1 ± 0.5		1.1 ± 0.5				0.4 ± 0.3						0.5 ± 0.2	
Olefins	58–73	0.010 ± 0.005													
2,2-Dimethylpentane	79.2	1.8^{b} ± 0.8		2.1^{b} ± 0.5		1.5^{b} ± 0.8		1.7^{b} ± 0.5		1.4^{b} ± 0.5		1.8^{b} ± 0.5		2.3^{b} ± 0.5	
2,4-Dimethylpentane	80.5														
2,3-Dimethylpentane	89.8	1.7 ± 0.8		1.7 ± 0.5		0.9 ± 0.5		1.0 ± 0.5	1.5 ± 0.5	1.9 ± 0.5		1.7 ± 0.5		1.1 ± 0.5	1.9 ± 0.5
2-Methylhexane	90.1							0.5 ± 0.3						0.8 ± 0.4	
3-Methylhexane	92.0														
2,2,4-Trimethylpentane	99.2	13.1 ± 0.8	13.1 ± 0.8	12.4 ± 0.5		21.7 ± 1.0		17.2 ± 0.5		24.2 ± 0.5		33.3 ± 0.5		20.1 ± 0.5	
Olefins	73–100	0.010 ± 0.005													
2,5-Dimethylhexane	109.1	4.3^{c} ± 2.0	5.2 ± 2.0	4.1^{c} ± 1.0	4.8 ± 1.0	3.7^{c} ± 1.2	4.4 ± 1.0	3.9^{c} ± 1.0	4.7 ± 1.0	3.9^{c} ± 1.0	4.6 ± 1.0	10.1^{c} ± 1.0	12.2 ± 1.0	5.3^{c} ± 1.0	6.1 ± 1.0
2,4-Dimethylhexane	109.4														
2,2,3-Trimethylpentane	109.8	0.9 ± 0.5		0.7 ± 0.5		0.7 ± 0.4		0.8 ± 0.5		0.7 ± 0.4		2.1 ± 1.0		0.8 ± 0.5	
2,3,4-Trimethylpentane	113.5	6.6 ± 2.0	12.2 ± 2.5	4.2 ± 2.0	11.4 ± 1.5	9.4 ± 2.0	19.8 ± 1.0	6.4 ± 1.5	14.4 ± 1.5	5.4 ± 1.5	10.8 ± 1.5	7.1 ± 1.5	19.7 ± 1.5	11.6 ± 1.5	23.5 ± 1.5
2,3,3-Trimethylpentane	114.8	4.5 ± 2.0		7.0 ± 2.0		9.5 ± 2.0		7.1 ± 1.5		4.2 ± 1.5		8.1 ± 1.5		10.2 ± 1.5	
2,3-Dimethylhexane	115.6	1.1^{d} ± 0.5		0.2^{d} ± 0.2		0.9^{d} ± 0.5		0.9^{d} ± 0.4		1.2^{d} ± 0.6		4.5^{d} ± 2.0		1.7^{d} ± 0.8	
Olefins	112–125	0.04 + 0.02													
2,2,5-Trimethylhexane	124.1	34.2 ± 1.0		35.5 ± 2.0		29.5 ± 1.0		29.4 ± 1.5		29.3 ± 1.5		13.4 ± 1.5		24.0 ± 1.5	
2,3,5-Trimethylhexane	131.4	6.6 ± 1.0		8.8 ± 2.0		6.5 ± 1.3		5.6 ± 1.8		5.5 ± 1.5		2.7 ± 1.0		5.8 ± 1.5	
Isoparaffins	>131.4					12.5 ± 1.0									
Isononanes	132–144	4.4 ± 1.0		5.2 ± 1.0				5.2 ± 2.0		6.2 ± 1.0		4.7 ± 1.0		3.5 ± 0.8	
Isoparaffins	144–151			5.6 ± 1.0				3.8 ± 1.5		2.9 ± 1.0		1.5 ± 0.5		3.0 ± 0.8	
Isoparaffins	144–168	8.9 ± 1.0	9.0 ± 1.0												
Olefins		0.05 ± 0.03													
Isoparaffins	151–160			3.7 ± 0.5				2.2 ± 1.1		5.0 ± 1.0		1.2 ± 0.5		1.3 ± 0.5	
Isoparaffins	>160			2.3 ± 0.5				9.4 ± 1.5		6.6 ± 1.0		6.3 ± 0.5		3.2 ± 0.5	
Isoparaffins	168–189	3.1 ± 1.0	3.1 ± 1.0												
Olefins		0.04 ± 0.02													
Isoparaffins	>189	2.8 ± 0.5	2.9 ± 0.5												
Olefins		0.05 ± 0.03													
Total		100.0		100.0		100.0		100.0		100.0		100.0		100.0	

[a] May include small amount of 2,2-dimethylbutane.
[b] May include small amount of 2,2,3-trimethylbutane
[c] May include a small amount of 2,2-dimethylhexane.
[d] May include a small amount of 3,4-dimethylhexane.

Table 6-Analyses of three "dimer" and "trimer" alkylates

Components	Boiling point at 1 atm.	Dimer (hot acid) Alkylate (H_2SO_4) Sample 34 (see figure 21)		Trimer (hot acid) Alkylate (H_2SO_4) Sample 21 (see figure 15)		Trimer (cold acid) Alkylate (H_2SO_4) Sample 43 (see figure 27)	
	°C	Percentage by volume (above pentanes)					
2,3-Dimethylbutane	58.0	3.4[a] ± 0.9	4.9 ±0.5	4.2[a] ± 1.0	5.9 ±0.5	6.6[a] ± 0.8	8.4 ±0.6
2-Methylpentane	60.3	1.1 ± 0.5		1.7 ± 0.9		1.3 ± 0.7	
3-Methylpentane	63.3	0.4 ± 0.2				0.5 ± 0.3	
2,2-Dimethylpentane	79.2	0.3 ± 0.2	2.9 ±0.5	0.3 ± 0.3	4.9 ±0.5	0.5 ± 0.3	5.0 ±0.5
2,4-Dimethylpentane	80.5	2.6[b] ± 0.8		4.6[b] ± 0.8		4.5[b] ± 0.7	
2,3-Dimethylpentane	89.8	1.4 ± 0.5		2.6 ± 0.8	2.9 ±0.5	3.2 ± 0.8	3.6 ±0.5
2-Methylhexane	90.1			0.3 ± 0.1		0.4 ± 0.2	
3-Methylhexane	92.0						
2,2,4-Trimethylpentane	99.2	35.6 ± 1.0		30.5 ± 0.5		31.4 ± 0.7	
2,5-Dimethylhexane	109.1	7.2[c] ± 1.8	9.0 ± 1.5	8.4[c] ± 1.5	10.9 ± 1.0	8.3[c] ± 1.5	9.4 ± 1.0
2,4-Dimethylhexane	109.4						
2,2,3-Trimethylpentane	109.8	1.8 ± 1.2		2.5 ± 1.0		1.1 ± 0.6	
2,3,4-Trimethylpentane	113.5	15.7 ± 2.0	35.4 ±2.0	10.4 ± 2.0	24.6 ±2.0	14.9 ± 2.0	30.0 ± 1.5
2,3,3-Trimethylpentane	114.8	16.9 ± 2.0		11.9 ± 2.0		12.5 ± 2.0	
2,3-Dimethylhexane	115.6	2.8[d] ± 1.4		2.3[d] ± 1.1		1.9 ± 0.9	
3,4-Dimethylhexane	117.7					0.7 ± 0.4	
2,2,5-Trimethylhexane	124.1	2.4 ± 0.8		4.4 ± 1.5		3.4 ± 1.0	
Isononanes	127-143	0.6 ± 0.4		1.6 ± 0.8		1.1 ± 0.6	
Isoparaffins	143-151			0.6 ± 0.4			
Isoparaffins	143-160	1.1 ± 0.6					
Isoparaffins	147-152					2.3 ± 1.0	
Isoparaffins	151-160			0.4 ± 0.4			
Isoparaffins	>152					5.4 ± 0.5	
Isoparaffins	160-175	1.8 ± 0.8		1.5 ± 1.0			
Isoparaffins	>175	4.9 ± 0.8		11.8 ± 2.5			
Total		100.0		100.0		100.0	

[a] May include a small amount of 2,2-dimethylbutane.
[b] May include a small amount of 2,2,3-trimethylbutane.
[c] May include a small amount of 2,2-dimethylhexane.
[d] May include a small amount of 3,4-dimethylhexane.

Table 7-Analyses of eight hydrocodimers

Components	Boiling point at 1 atm.	Hydrocodimer (hot acid) Sample 35 (see figure 22)		Hydrocodimer (solid phosphoric-acid) Sample 4 (see figure 3)		Hydrocodimer (phosphoric-acid) Sample 33 (see figure 20)		Hydrocodimer (Lawrenceville) Sample 36 (see figure 23)		Hydrocodimer (Tulsa) Sample 37 (see figure 24)		Hydrocodimer (Lima 6) Sample 41 (see figure 25)		Hydrocodimer (Lima 7) Sample 42 (see figure 26)		Hydrocodimer (HSO-1684) Sample 44 (see figure 28)	
	°C	Percentage by volume (above pentanes)															
Cyclopentane	49.3	0.2 ± 0.1	1.2 ± 0.5	0.7 ± 0.5		0.10 ± 0.05	1.6 ± 0.7	0.8 ± 0.4		0.2^a ± 0.1	3.0 ± 0.8	0.5 ± 0.3		0.5 ± 0.3		0.8 ± 0.3	
2,2-Dimethylbutane	49.7					0.10 ± 0.0_5				2.6 ± 0.8							
2,3-Dimethylbutane	58.0					1.4 ± 0.7											
2-Methylpentane	60.3																
3-Methylpentane	63.3																
n-Hexane	68.7																
Methylcyclopentane	71.8									0.2^a ± 0.1							
Benzene	80.1									0.03^a ± 0.01							
Heptanes	79-92	1.0 ± 0.5															
2,2-Dimethylpentane	79.2			1.2^b ± 0.5		0.9^b ± 0.5		1.0^b ± 0.6		3.6^b ± 0.8		0.6^b ± 0.3		0.7^b ± 0.4		2.4^b ± 0.5	
2,4-Dimethylpentane	80.5																
2,3-Dimethylpentane	89.8			1.1 ± 0.4	1.5 ± 0.5			1.7^c ± 0.8		15.0 ± 1.5	16.2 ± 0.8	1.4^c ± 0.7		1.3_5 ± 0.7	1.5 ± 0.7	7.4^c ± 0.6	
2-Methylhexane	90.1			0.4 ± 0.3						1.2 ± 0.8				0.1_5 ± 0.1			
3-Methylhexane	92.0																
Olefins	>90															0.1 ± 0.0_5	
Olefins	90-99															0.1 ± 0.0_5	
Olefins	36-99			0.2 ± 0.1													
2,2,4-Trimethylpentane	99.2	35.4 ± 1.0		9.9 ± 0.8		12.1 ± 1.0		6.6 ± 1.0		7.2 ± 1.5		11.2 ± 1.5		5.2 ± 1.0		27.4 ± 1.0	
Olefins	99-110	0.6 ± 0.3		1.5 ± 0.3												0.6 ± 0.3	
Toluene	110.6									0.05^a ± 0.03	12.8 ± 1.5						
2,2-Dimethylhexane	106.8	4.0 ± 1.5		1.2 ± 0.6	17.1 ± 2.0	2.7 ± 1.4	17.4 ± 1.5	2.3 ± 1.0		1.8 ± 1.0		2.1 ± 1.0	18.7 ± 1.5	1.8 ± 0.9	19.2 ± 1.5	0.9 ± 0.5	11.0 ± 1.5
2,5-Dimethylhexane	109.1	0.9 ± 0.7	26.9 ± 2.0	6.7 ± 2.0		2.9 ± 1.7		4.8 ± 2.0	15.4 ± 2.0	2.4 + 1.2		1.8 ± 1.2		7.4 ± 1.5		2.2 ± 1.1	
2,4-Dimethylhexane	109.4																
2,2,3-Trimethylpentane	109.8	26.0 ± 2.0		9.2 ± 3.0		11.8 ± 2.7		10.6 ± 2.5		8.5 ± 1.5		14.8 ± 2.0		10.0 ± 2.0		7.9 ± 1.5	
Olefins	>49									0.05 ± 0.03							
Olefins	49-110							0.1 ± 0.0_5				0.08 ± 0.04		0.2 ± 0.1			
Olefins	110-114	0.8 ± 0.4														0.2 ± 0.1	
Olefins	110-113.4			0.3 ± 0.1													
Olefins	113.4-114.7			0.4 ± 0.1													
Olefins	110-140							0.1 ± 0.0_5									
Olefins	>110											0.09 ± 0.05		0.2 ± 0.1			
2,3,4-Trimethylpentane	113.5	19.0 ± 2.0	27.4 ± 2.0	43.9 ± 2.0	58.1 ± 4.0	43.4 ± 4.3	62.7 ± 2.0	43.9 ± 2.0	56.5 ± 2.0	34.9 ± 2.5	44.9 ± 2.0	39.2 ± 3.0	50.7 ± 2.0	37.3 ± 2.5	49.3 ± 2.0	28.3 ± 2.0	33.3 ± 1.5
2,3,3-Trimethylpentane	114.8	7.0 ± 1.5		8.6 ± 2.0		15.0 ± 3.0		6.1 ± 2.0		5.2 ± 1.5		7.2 ± 2.0		4.6 ± 1.5		3.1 ± 1.0	
2,3-Dimethylhexane	115.6	1.4^d ± 0.7		5.6^d ± 3.0		4.3^d ± 2.1		6.5 ± 2.0		4.8 ± 1.5		4.3 ± 1.5		7.4 ± 2.0		1.9 ± 1.0	
Olefins	114-120															0.6 ± 0.3	
Olefins	114-115.6	0.6 ± 0.3															
Isoparaffins	>115.6	2.9 ± 0.8	3.1 ± 0.8			5.3 ± 1.0											
Olefins	>115.6	0.2 ± 0.1															
Olefins	114.7-115.5			0.4 ± 0.1													
Olefins	115.5-117			0.6 ± 0.2													
3,4-Dimethylhexane	117.7							2.9^e ± 0.9		5.3^e ± 1.5		4.6^e ± 1.5		3.9^e ± 1.5		1.1^e ± 0.6	
Isoparaffins	117-120			1.9 ± 1.0													
Olefins	117-120			0.4 ± 0.1													
Olefins	>120															0.9 ± 0.4	
Isononanes	120-132			2.0 ± 1.0													
Isononanes	122-127													1.7 ± 0.8			
Isononanes	127-135													2.6 ± 1.2			
Isononanes	122-135							2.9 ± 0.9		2.4 ± 1.2		2.4 ± 1.2					
Isononanes	122-144															2.6 ± 0.8	
Olefins	>132			0.2 ± 0.1													
Isoparaffins	>132			3.6 ± 0.6													
Isononanes	135-140							2.6 ± 0.8									
Aromatics	136-145									0.05^a ± 0.03	4.55 ± 0.8	0.07 ± 0.03	3.2 ± 1.0	0.08 ± 0.04	3.9 ± 1.2		
Isoparaffins	>135									4.5 ± 0.8		3.1_3 ± 1.0		3.8 ± 1.2			
Aromatics	>140													0.07 ± 0.04	11.1 ± 1.0		
Isoparaffins	>140							7.1 ± 0.8				6.5 ± 0.8		11.0 ± 1.0			
Isoparaffins	145-165															1.3 ± 0.6	
Isoparaffins	165-177.8															2.9 ± 0.9	
Isoparaffins	>177.8															7.3 ± 0.6	
Total		100.0		100.0		100.0		100.0		100.0		100.0		100.0		100.0	

[a] Hydrocodimer apparently contaminated, as with naphtha.

[b] May include a small amount of 2,2,3-trimethylbutane.

[c] May include a small amount of methylhexanes.

[d] May include a small amount of 3,4-dimethylhexane.

[e] May include some other octanes.

TABLE 8.—*Comparison of the analysis of the octanes in the butene alkylate, sample 24, by several laboratories*

[Values are percentage by volume (above pentanes)]

Components	API Research Project 6 (November 30, 1943)	Standard Oil Co. (Ind.) (July 29, 1943)	Shell Oil Co. (February 22, 1944)
2, 2, 4-Trimethylpentane	35. 5 ±0. 5	35. 8	35. 1
2, 5-Dimethylhexane 2, 4-Dimethylhexane 2, 2, 3-Trimethylpentane	5. 4 ±1. 0	6. 9	4. 8
2, 3, 4-Trimethylpentane	24. 0 ±2. 0	24. 1	25. 5
2, 3, 3-Trimethylpentane	25. 2 ±2. 0	25. 2	25. 5
2, 3-Dimethylhexane	2. 4 ±1. 5	1. 1	----

Table 9—Relative amounts of hexanes, heptanes, octanes, and nonanes and higher paraffins, in 20 alkylates and 8 hydrocodimers.

Sample No.	Material	Hexanes	Heptanes	Octanes	Nonanes plus Higher Paraffins	Total
		Relative amount by volume				
20	C_3 Alkylate (H_2SO_4)	5.3	65.7	18.0	11.0	100.0
17	C_3 Alkylate (HF)	5.0	41.5	29.7	23.8	100.0
16	C_3– C_4 Alkylate (HF)	2.3	10.2	60.3	27.2	100.0
1	C_4 Alkylate (H_2SO_4)	8.8	6.7	67.5	17.0	100.0
2	C_4 Alkylate (H_2SO_4)	12.6	1.3	63.7	12.4	100.0
9	C_4 Alkylate (H_2SO_4)	8.3	7.5	68.2	16.0	100.0
10	C_4 Alkylate (H_2SO_4)	9.4	7.7	73.1	9.8	100.0
24	C_4 Alkylate (H_2SO_4)	2.1	2.1	92.5	3.3	100.0
27	C_4 Alkylate (H_2SO_4)	6.8	7.0	67.0	19.2	100.0
13	C_4 Alkylate (HF)	2.1	4.5	83.6	9.8	100.0
15	C_4 –C_5 Alkylate (HF)	1.5	3.5	65.2	29.8	100.0
11	C_4 –C_5 Alkylate (H_2SO_4)	5.0	4.2	49.9	40.9	100.0
7	C_5 Alkylate (H_2SO_4)	5.8	3.5	30.6	60.1	100.0
12	C_5 Alkylate (H_2SO_4)	6.0	3.8	28.7	61.5	100.0
22	C_5 Alkylate (H_2SO_4)	3.2	2.4	45.9	48.5	100.0
23	C_5 Alkylate (H_2SO_4)	4.4	3.2	36.5	55.9	100.0
14	C_5 Alkylate (HF)	1.6	3.3	39.6	55.5	100.0
34	Dimer (hot acid) Alkylate (H_2SO_4)	4.9	4.3	80.0	10.8	100.0
21	Trimer (hot acid) Alkylate (H_2SO_4)	5.9	7.8	66.0	20.3	100.0
43	Trimer (cold acid) Alkylate (H_2SO_4)	8.4	8.6	70.8	12.2	100.0
35	Hydrocodimer (hot acid)	0.2	1.0	95.8	3.0	100.0
4	Hydrocodimer (solid phosphoric acid)	0.7	2.8	90.7	5.8	100.0
33	Hydrocodimer (phosphoric acid)	1.5	0.9	92.3	5.3	100.0
36	Hydrocodimer (Lawrenceville)	0.8	2.7	83.9	12.6	100.0
37	Hydrocodimer (Tulsa)	2.6	19.9	70.6	6.9	100.0
41	Hydrocodimer (Lima 6)	0.5	2.0	85.5	12.0	100.0
42	Hydrocodimer (Lima 7)	0.5	3.2	78.1	19.2	100.0
44	Hydrocodimer (HSO 1684)	0.8	10.1	74.6	14.5	100.0

Table 10 — Relative amount of 2,3-dimethylbutane in the hexane fraction of 15 alkylates.

Sample No.	Material	2,3-Dimethylbutane	2,2-Dimethylbutane plus 2-Methylpentane plus 3-Methylpentane	Total
		Relative amount by volume		
20	C_3 Alkylate (H_2SO_4)	66.0	34.0	100
17	C_3 Alkylate (HF)	58.0	42.0	100
16	C_3–C_4 Alkylate (HF)	60.9	39.1	100
1	C_4 Alkylate (H_2SO_4)	62.5	37.5	100
2	C_4 Alkylate (H_2SO_4)	64.5	35.5	100
9	C_4 Alkylate (H_2SO_4)	78.3	21.7	100
10	C_4 Alkylate (H_2SO_4)	74.5	25.5	100
27	C_4 Alkylate (H_2SO_4)	76.5	23.5	100
11	C_4 –C_5 Alkylate (H_2SO_4)	56.0	44.0	100
7	C_5 Alkylate (H_2SO_4)	44.8	55.2	100
12	C_5 Alkylate (H_2SO_4)	45.0	55.0	100
23	C_5 Alkylate (H_2SO_4)	47.7	52.3	100
34	Dimer (hot acid) Alkylate (H_2SO_4)	69.4	30.6	100
21	Trimer (hot acid) Alkylate (H_2SO_4)	71.2	28.8	100
43	Trimer (cold acid) Alkylate (H_2SO_4)	78.6	21.4	100
	Average	64± 10	36± 10	100

Table 11— Relative amounts of the heptanes in 20 alkylates and 7 hydrocodimers.

<table>
<tr><th rowspan="2">Sample No.</th><th rowspan="2">Material</th><th>2,2-Dimethyl-pentane</th><th>2,4-Dimethyl-pentane</th><th>2,3-Dimethyl-pentane</th><th>2-Methylhexane plus 3-Methylhexane</th><th>Total</th></tr>
<tr><th colspan="5">Relative amount by volume</th></tr>
<tr><td>20</td><td>C_3 Alkylate (H_2SO_4)</td><td>1.7</td><td>39.9</td><td>54.9</td><td>3.5</td><td>100.0</td></tr>
<tr><td>17</td><td>C_3 Alkylate (HF)</td><td>1.9</td><td>44.0</td><td>51.0</td><td>3.1</td><td>100.0</td></tr>
<tr><td>16</td><td>C_3–C_4 Alkylate (HF)</td><td>6.9</td><td>41.2</td><td>44.1</td><td>7.8</td><td>100.0</td></tr>
<tr><td>1</td><td>C_4 Alkylate (H_2SO_4)</td><td>—</td><td>53.7</td><td>32.9</td><td>13.4</td><td>100.0</td></tr>
<tr><td>2</td><td>C_4 Alkylate (H_2SO_4)</td><td>6.2</td><td>48.7</td><td>30.1</td><td>15.0</td><td>100.0</td></tr>
<tr><td>9</td><td>C_4 Alkylate (H_2SO_4)</td><td>6.7</td><td>56.0</td><td>28.0</td><td>9.3</td><td>100.0</td></tr>
<tr><td>10</td><td>C_4 Alkylate (H_2SO_4)</td><td>10.4</td><td>50.6</td><td>32.5</td><td>6.5</td><td>100.0</td></tr>
<tr><td>24</td><td>C_4 Alkylate (H_2SO_4)</td><td colspan="2">52.4</td><td colspan="2">47.6</td><td>100.0</td></tr>
<tr><td>27</td><td>C_4 Alkylate (H_2SO_4)</td><td>2.9</td><td>52.9</td><td>37.1</td><td>4.3</td><td>97.2[a]</td></tr>
<tr><td>13</td><td>C_4 Alkylate (HF)</td><td colspan="2">57.8</td><td colspan="2">42.2</td><td>100.0</td></tr>
<tr><td>15</td><td>C_4–C_5 Alkylate (HF)</td><td colspan="2">51.4</td><td colspan="2">48.6</td><td>100.0</td></tr>
<tr><td>11</td><td>C_4–C_5 (H_2SO_4)</td><td colspan="2">54.8</td><td>26.2</td><td>19.0</td><td>100.0</td></tr>
<tr><td>7</td><td>C_5 Alkylate (H_2SO_4)</td><td colspan="2">51.4</td><td colspan="2">48.6</td><td>100.0</td></tr>
<tr><td>12</td><td>C_5 Alkylate (H_2SO_4)</td><td colspan="2">55.3</td><td colspan="2">44.7</td><td>100.0</td></tr>
<tr><td>22</td><td>C_5 Alkylate (H_2SO_4)</td><td colspan="2">62.5</td><td colspan="2">37.5</td><td>100.0</td></tr>
<tr><td>23</td><td>C_5 Alkylate (H_2SO_4)</td><td colspan="2">53.1</td><td>31.3</td><td>15.6</td><td>100.0</td></tr>
<tr><td>14</td><td>C_5 Alkylate (HF)</td><td colspan="2">42.4</td><td colspan="2">57.6</td><td>100.0</td></tr>
<tr><td>34</td><td>Dimer (hot acid) Alkylate (H_2SO_4)</td><td>7.0</td><td>60.5</td><td colspan="2">32.5</td><td>100.0</td></tr>
<tr><td>21</td><td>Trimer (hot acid) Alkylate (H_2SO_4)</td><td>3.8</td><td>59.0</td><td>33.3</td><td>3.9</td><td>100.0</td></tr>
<tr><td>43</td><td>Trimer (cold acid) Alkylate (H_2SO_4)</td><td>5.8</td><td>52.3</td><td>37.2</td><td>4.7</td><td>100.0</td></tr>
<tr><td>4</td><td>Hydrocodimer (solid phosphoric acid)</td><td colspan="2">44.4</td><td>40.8</td><td>14.8</td><td>100.0</td></tr>
<tr><td>33</td><td>Hydrocodimer (phosphoric acid)</td><td colspan="2">6.7</td><td colspan="2">93.3</td><td>100.0</td></tr>
<tr><td>36</td><td>Hydrocodimer (Lawrenceville)</td><td colspan="2">37.0</td><td colspan="2">63.0</td><td>100.0</td></tr>
<tr><td>37</td><td>Hydrocodimer (Tusla)</td><td colspan="2">18.2</td><td>75.7</td><td>6.1</td><td>100.0</td></tr>
<tr><td>41</td><td>Hydrocodimer (Lima 6)</td><td colspan="2">30.0</td><td colspan="2">70.0</td><td>100.0</td></tr>
<tr><td>42</td><td>Hydrocodimer (Lima 7)</td><td colspan="2">31.8</td><td>61.4</td><td>6.8</td><td>100.0</td></tr>
<tr><td>44</td><td>Hydrocodimer (HSO 1684)</td><td colspan="2">24.5</td><td colspan="2">75.5</td><td>100.0</td></tr>
</table>

[a] Contained also some 2,2,3-trimethylbutane; relative amount 2.8.

Table 12 — Relative amounts of the octanes in 20 alkylates and 8 hydrocodimers.

Sample No.	Material	2,2,4-Trimethylpentane	2,2-Dimethylhexane	2,5-Dimethylhexane plus 2,4-Dimethylhexane	2,2,3-Trimethylpentane	2,3,4-Trimethylpentane	2,3,3-Trimethylpentane	2,3-Dimethylhexane	3,4-Dimethylhexane	Total
		Relative amount by volume								
20	C_3 Alkylate (H_2SO_4)	43.3		13.9	4.4	13.9	17.8	6.7		100.0
17	C_3 Alkylate (HF)	55.1		13.5	3.7	11.5	13.2	3.0		100.0
16	C_3-C_4 Alkylate (HF)	49.9		15.1	3.8	11.3	11.1	6.6	2.2[a]	100.0
1	C_4 Alkylate (H_2SO_4)	44.5		12.0	2.7	13.8	21.5	5.5		100.0
2	C_4 Alkylate (H_2SO_4)	35.2		16.2	3.0	24.0	16.3	5.3		100.0
9	C_4 Alkylate (H_2SO_4)	38.0		11.6	2.5	24.0	17.7	6.2		100.0
10	C_4 Alkylate (H_2SO_4)	36.7		11.3	2.2	26.3	20.4	3.1		100.0
24	C_4 Alkylate (H_2SO_4)	38.4		3.7	2.2	25.9	27.2	2.6		100.0
27	C_4 Alkylate (H_2SO_4)	39.9	0.4	10.8	1.9	21.3	20.2	4.9	0.6	100.0
13	C_4 Alkylate (HF)	49.9		16.0	3.5	11.2	12.0	7.4		100.0
15	C_4-C_5 Alkylate (HF)	51.1		15.5	3.2	10.9	12.4	6.9		100.0
11	C_4-C_5 Alkylate (H_2SO_4)	40.5		10.7	1.6	23.3	20.5	3.4		100.0
7	C_5 Alkylate (H_2SO_4)	43.0		14.1	2.9	21.6	14.8	3.6		100.0
12	C_5 Alkylate (H_2SO_4)	43.4		14.3	2.4	14.7	24.5	0.7		100.0
22	C_5 Alkylate (H_2SO_4)	47.3		8.1	1.5	20.5	20.7	1.9		100.0
23	C_5 Alkylate (H_2SO_4)	47.4		10.7	2.2	17.6	19.6	2.5		100.0
14	C_5 Alkylate (HF)	61.1		9.9	1.8	13.6	10.6	3.0		100.0
34	Dimer (hot acid) Alkylate (H_2SO_4)	44.5		9.0	2.3	19.6	21.1	3.5		100.0
21	Trimer (hot acid) Alkylate (H_2SO_4)	46.2		12.7	3.8	15.8	18.0	3.5		100.0
43	Trimer (cold acid) Alkylate (H_2SO_4)	44.4		11.7	1.5	21.0	17.7	2.7	1.0[a]	100.0
35	Hydrocodimer (hot acid)	37.7	4.3	1.0	27.7	20.3	7.5	1.5	[b]	100.0
4	Hydrocodimer (solid phosphoric acid)	11.4	1.4	7.7	10.6	50.4	9.9	6.4	2.2[a]	100.0
33	Hydrocodimer (phosphoric acid)	13.1	2.9	3.1	12.8	47.1	16.3	4.7	[b]	100.0
36	Hydrocodimer (Lawrenceville)	7.9	2.8	5.7	12.7	52.4	7.3	7.7	3.5[a]	100.0
37	Hydrocodimer (Tulsa)	10.3	2.6	3.5	12.1	49.7	7.4	6.8	7.6[a]	100.0
41	Hydrocodimer (Lima 6)	13.1	2.5	2.1	17.4	46.0	8.5	5.0	5.4[a]	100.0
42	Hydrocodimer (Lima 7)	6.7	2.3	9.6	12.9	48.1	5.9	9.5	5.0[a]	100.0
44	Hydrocodimer (HSO 1684)	37.6	1.2	3.0	10.9	38.9	4.3	2.6	1.5[a]	100.0

[a] May include some other octanes.

[b] Some 3,4-dimethylhexane not included.

Table 13 — Relative amounts of two nonanes (trimethylhexanes) in 11 alkylates

Sample No.	Material	2,2,5-Trimethylhexane	2,3,5-Trimethylhexane	Total
		Relative amount by volume		
16	C_3-C_4 Alkylate (HF)	81.8	18.2	100
1	C_4 Alkylate (H_2SO_4)	87.0	13.0	100
2	C_4 Alkylate (H_2SO_4)	82.2	17.8	100
27	C_4 Alkylate (H_2SO_4)	83.0	17.0	100
15	C_4-C_5 Alkylate (HF)	83.2	16.8	100
11	C_4-C_5 Alkylate (H_2SO_4)	80.5	19.5	100
7	C_5 Alkylate (H_2SO_4)	83.8	16.2	100
12	C_5 Alkylate (H_2SO_4)	80.1	19.9	100
22	C_5 Alkylate (H_2SO_4)	81.9	18.1	100
23	C_5 Alkylate (H_2SO_4)	84.0	16.0	100
14	C_5 Alkylate (HF)	84.2	15.8	100
	Average	82.9 ± 1.5	17.1 ± 1.5	100

Table 14–Summary of the results of the cooperative analyses of the butene alkylate, Sample 27.

Components	Boiling Point at 1 atm.	APIRP6 (Oct. 15, 1944)		Std. Oil Dev. (Jan. 2, 1945) (Infrared)	Atlantic (June 22, 1945) (Mass)	Soc. – Vac. (July 25, 1945) (Infrared)	Sun Oil (Oct. 8, 1945) (Raman)	U.O.P. (April 24, 1946) (Infrared)	Phillips (June 20, 1946) (Infrared)
	°C	Percentage by volume of the total alkylate							
Isobutane	−11.7	8.3 ± 0.5		8.2		0.03			
n–Butane	−0.5				0.34	0.31		0.25	0.37
Neopentane	9.5				0.06	0.07			0.09
Isopentane	27.9				8.02 [a]	8.00 [b]		8.20 [c]	8.00 [d]
n–Pentane	36.1	0.6 ± 0.3		0.4	0.35	0.40		0.43	0.46
2,2–Dimethylbutane	49.7	0.0	6.2 ± 0.5	0.0	0.0	0.00		0.02	0.0
2,3–Dimethylbutane	58.0	4.7 ± 0.8		4.4	4.84	4.82		4.72	4.76
2–Methylpentane	60.3	1.1 ± 0.5		1.2	1.02	1.00		0.98	1.00
3–Methylpentane	63.3	0.4 ± 0.2		1.1	0.42	0.43		0.46	0.45
2,2–Dimethylpentane	79.2	0.2 ± 0.2	3.8 ± 0.5	0.0	[e]	0.00		0.00	0.02
2,4–Dimethylpentane	80.5	3.4 ± 0.9		3.4	3.55	3.49	3.4[f]	3.56	3.50
2,2,3–Trimethylbutane	80.9	0.2 ± 0.2		0.2	[e]	0.20	0.27	0.28	0.25
2,3–Dimethylpentane	89.8	2.3 ± 0.6	2.6 ± 0.5	2.4	2.32	2.71	2.6	2.44	2.25
2–Methylhexane	90.1	0.3 ± 0.2		0.1	0.18	0.07	0.2	0.10	0.16
3–Methylhexane	92.0			0.2	0.15	0.04		0.06	0.13
2,2,4–Trimethylpentane	99.2	24.3 ± 0.9		24.6	24.4	24.28	24.1	24.40	24.41
2,2–Dimethylhexane	106.8	0.2 ± 0.2	8.0 ± 0.9	0.0		0.05	7.6	0.10	0.08
2,5–Dimethylhexane	109.1	6.6 ± 1.4		4.3	4.48	4.37		4.46	4.43
2,4–Dimethylhexane	109.4			3.0	2.70	2.70		2.76	2.83
2,2,3–Trimethylpentane	109.8	1.2 ± 0.6		1.3	1.21	1.02	1.1	1.34	1.21
2,3,4–Trimethylpentane	113.5	13.0 ± 1.8	28.7 ± 1.4	12.0	12.4	12.73	12.5	12.38	12.62
2,3,3–Trimethylpentane	114.8	12.3 ± 1.8		12.7	12.3[f]	12.64	12.7	12.49	12.25
2,3–Dimethylhexane	115.6	3.0 ± 1.4		3.1	3.0[f]	2.49	3.3	2.56	2.84
3,4–Dimethylhexane	117.7	0.4 ± 0.3		0.2		0.63		0.73	0.52
2,2,5–Trimethylhexane	124.1	4.5 ± 0.9				4.56	4.0[f]	4.25	4.28
2,3,5–Trimethylhexane	131.4	0.9 ± 0.5							
Higher–boiling Isoparaffins	>131.4	12.1 ± 0.5							
Total		100.0							

[a] 0.09 percent of pentenes also found.
[b] 0.08 percent of pentenes also found.
[c] 0.03 percent of olefins also found.
[d] Trace of 2–methyl–1–butene.
[e] The sum of 2,2–dimethylpentane and 2,2,3–trimethylbutane reported to be 0.25 percent.
[f] Corrected for a small amount of this component occurring in adjacent lots not analyzed by this laboratory.

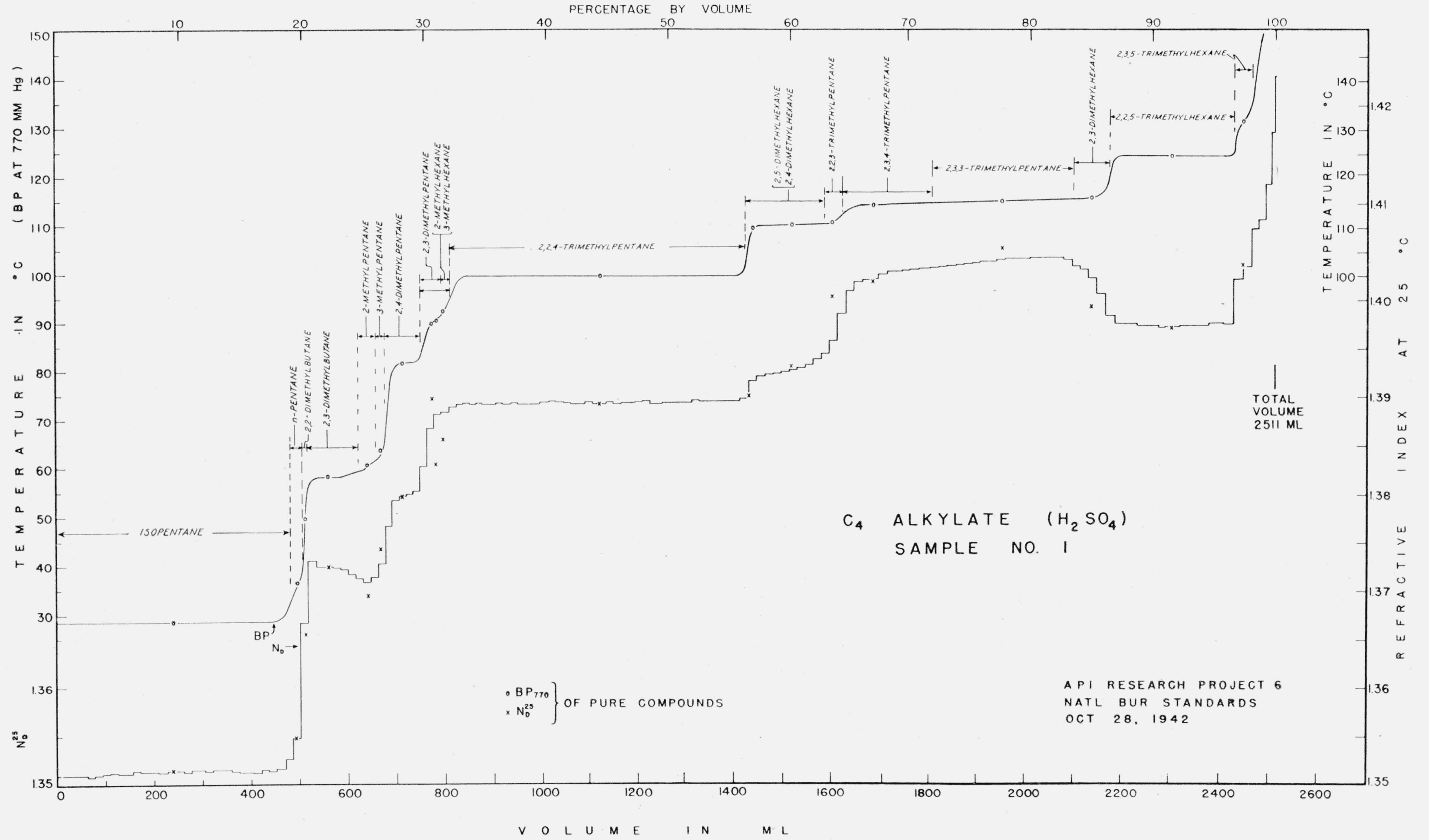

FIGURE 1.—*Results of the analytical distillation of C_4 alkylate (H_2SO_4), sample 1.*

Details are given in table 4.

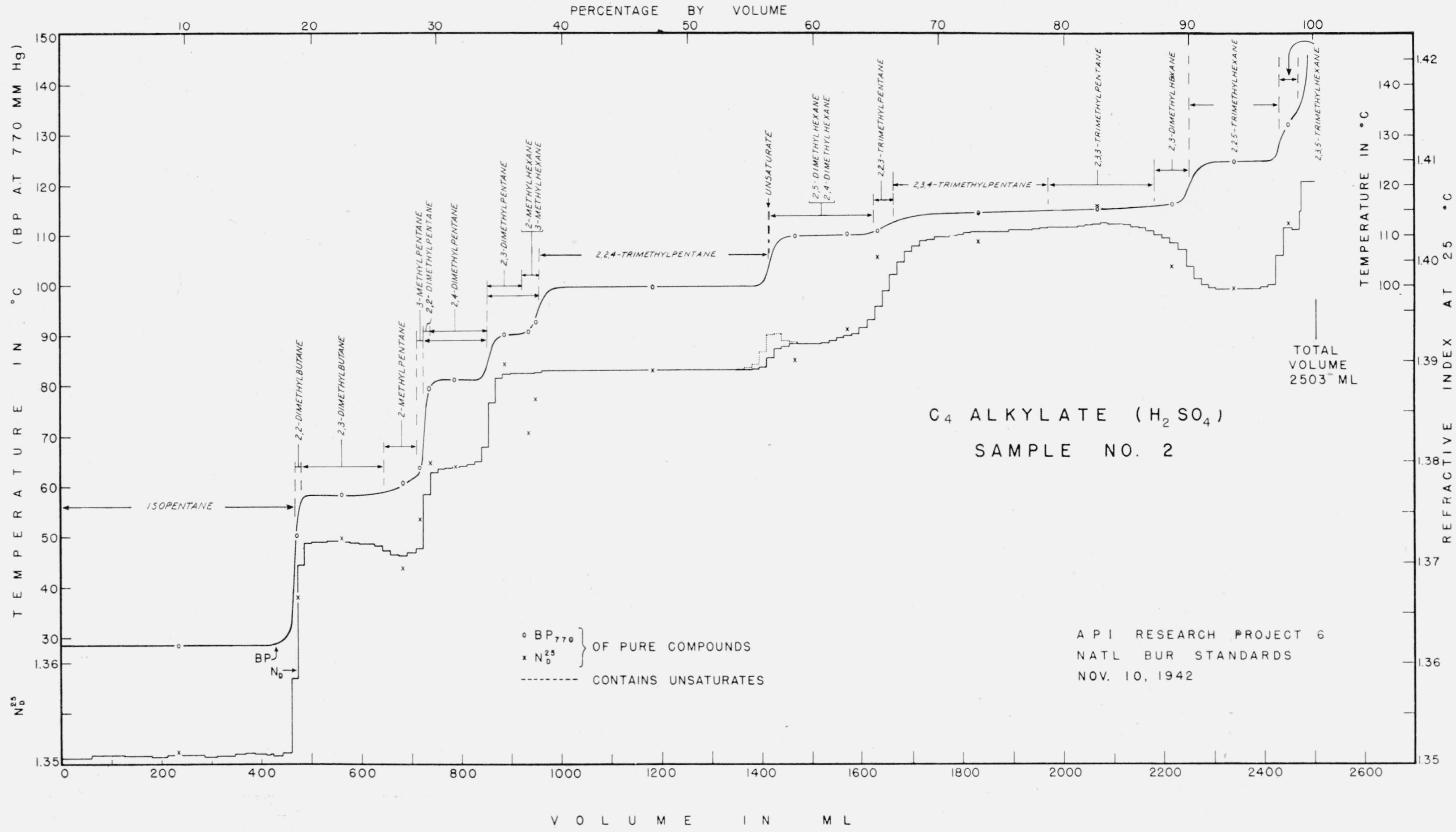

FIGURE 2.—*Results of the analytical distillation of C_4 alkylate (H_2SO_4), sample 2.*

Details are given in table 4.

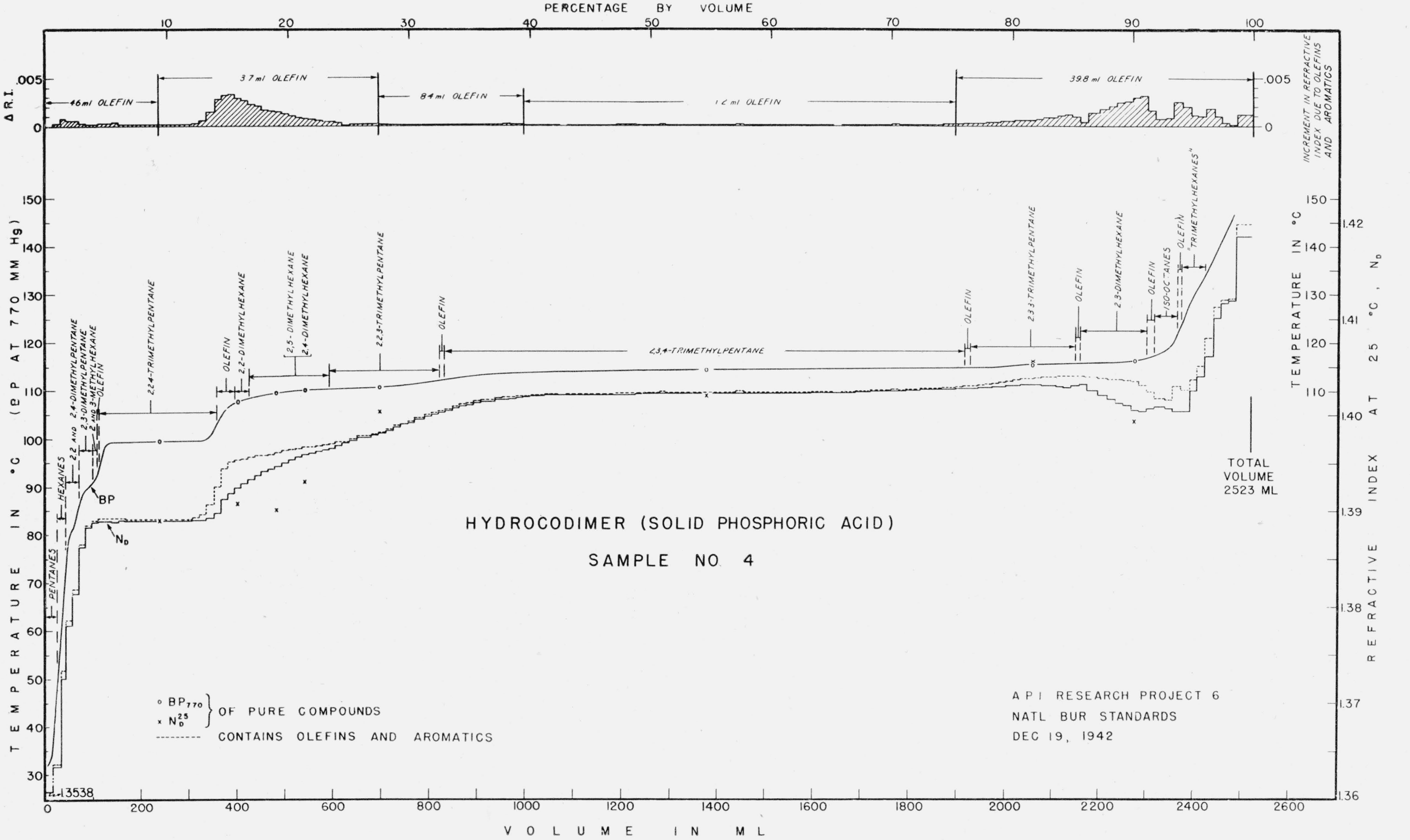

Figure 3.—*Results of the analytical distillation of hydrocodimer (solid phosphoric-acid), sample 4.*

The upper part of the figure gives the amounts of olefins from determinations of bromine numbers, and the shaded area gives the increment in refractive index caused by the presence of small amounts of olefins and smaller amounts of aromatics in this material. Details are given in table 7.

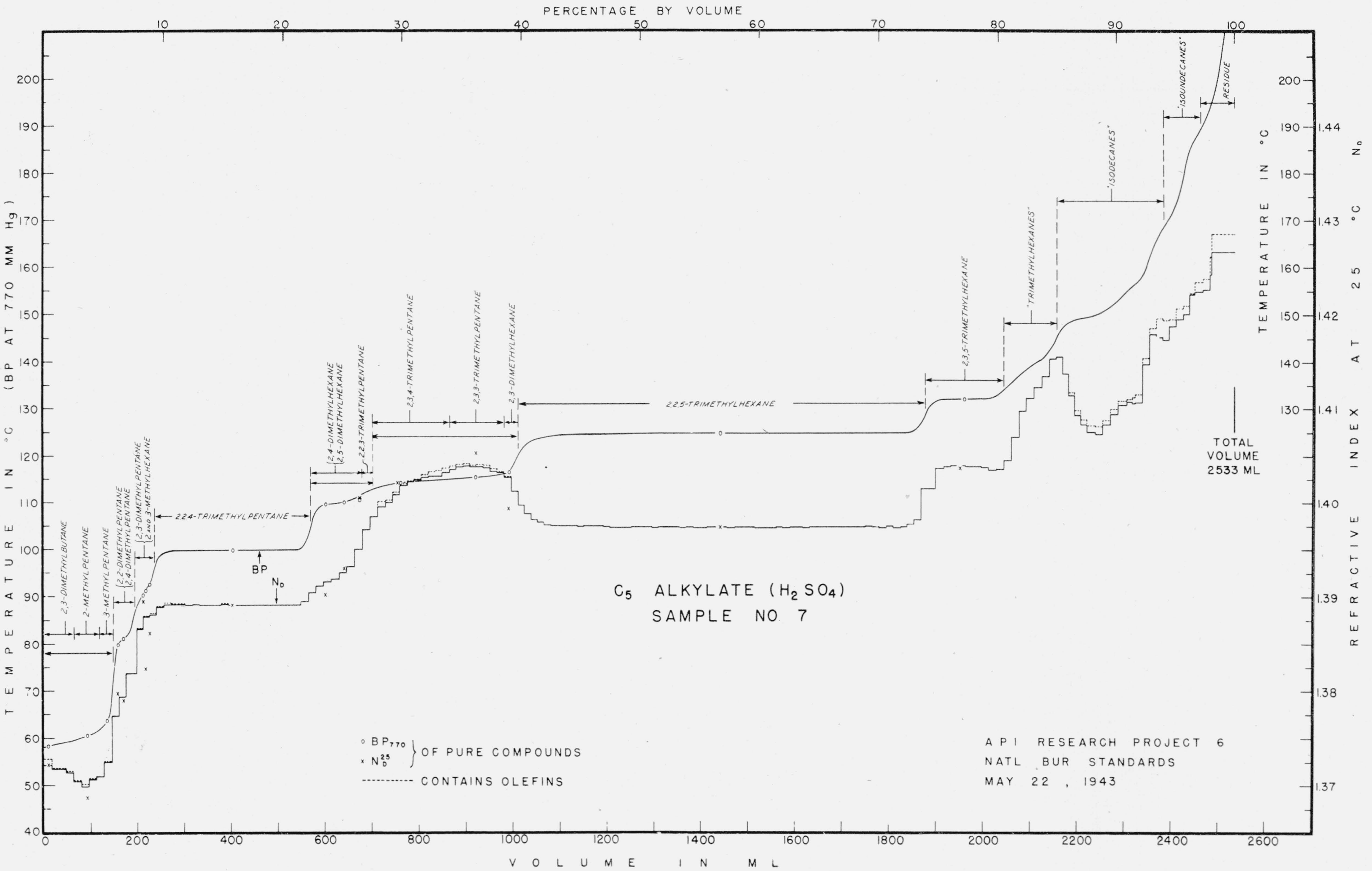

FIGURE 4.—*Results of the analytical distillation of* C_5 *alkylate* (H_2SO_4), *sample 7.*

Details are given in table 5.

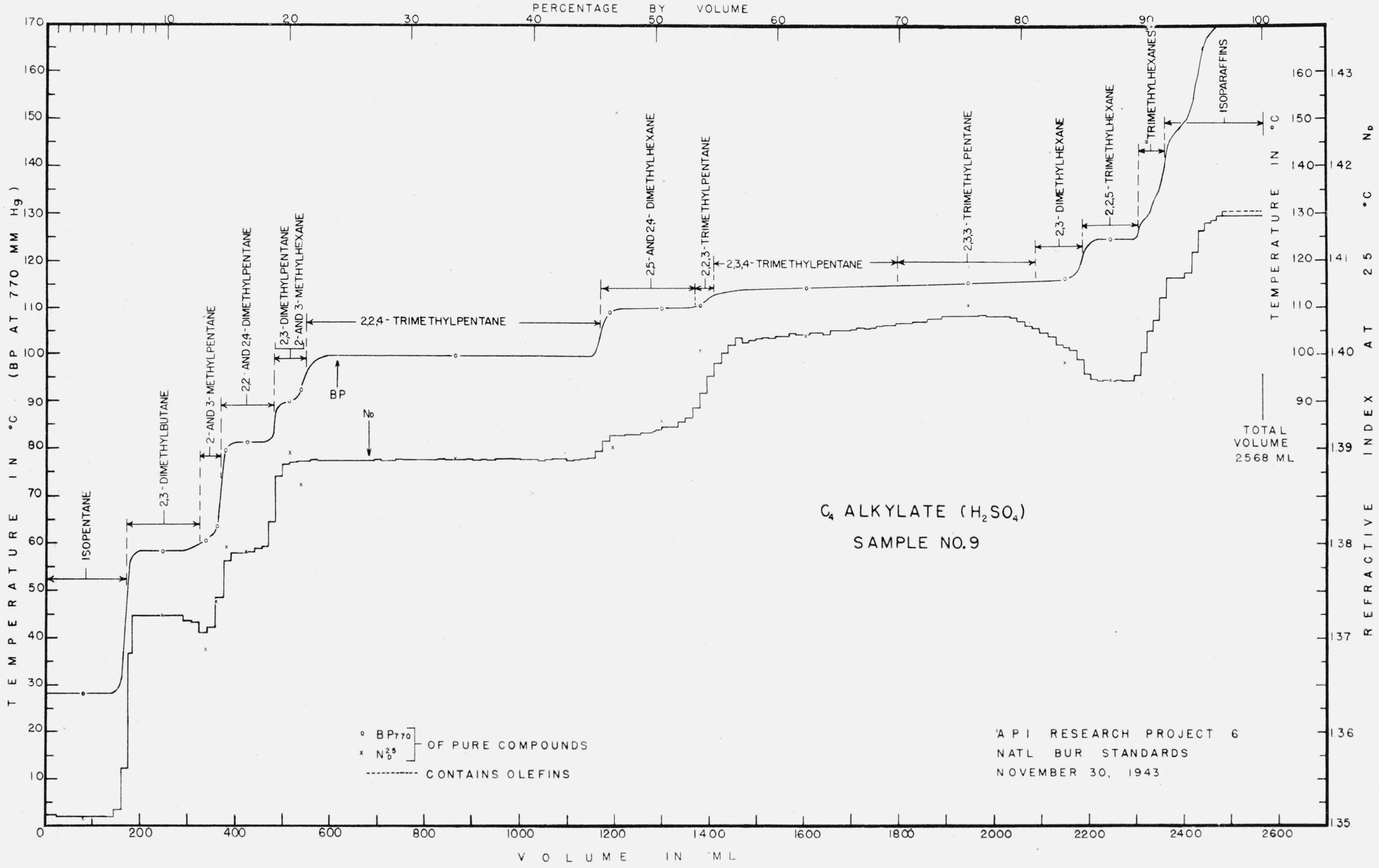

FIGURE 5.—*Results of the analytical distillation of* C_4 *alkylate* (H_2SO_4), *sample 9.*

Details are given in table 4.

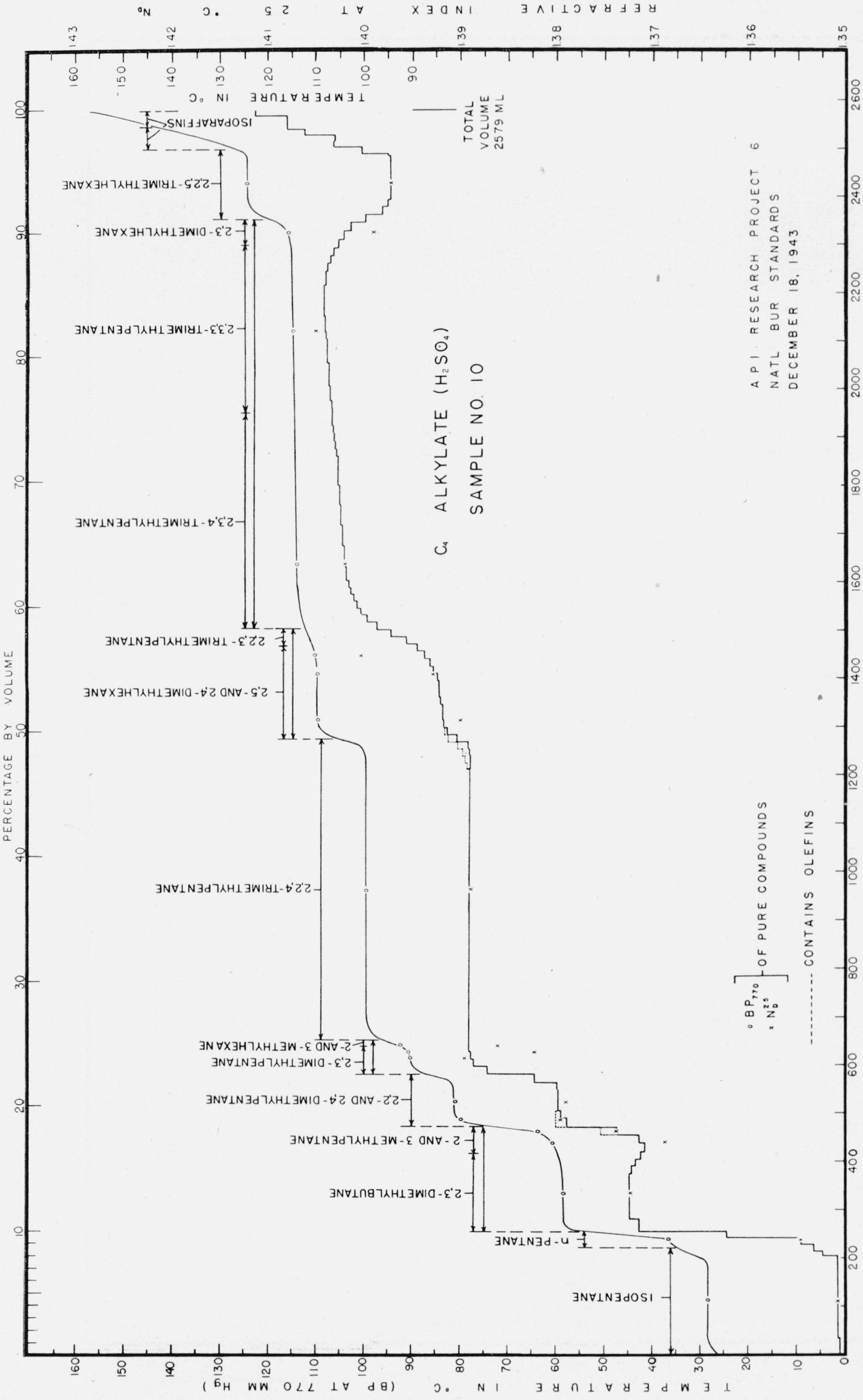

FIGURE 6.—*Results of the analytical distillation of* C_4 *alkylate* (H_2SO_4), *sample 10.*

Details are given in table 4.

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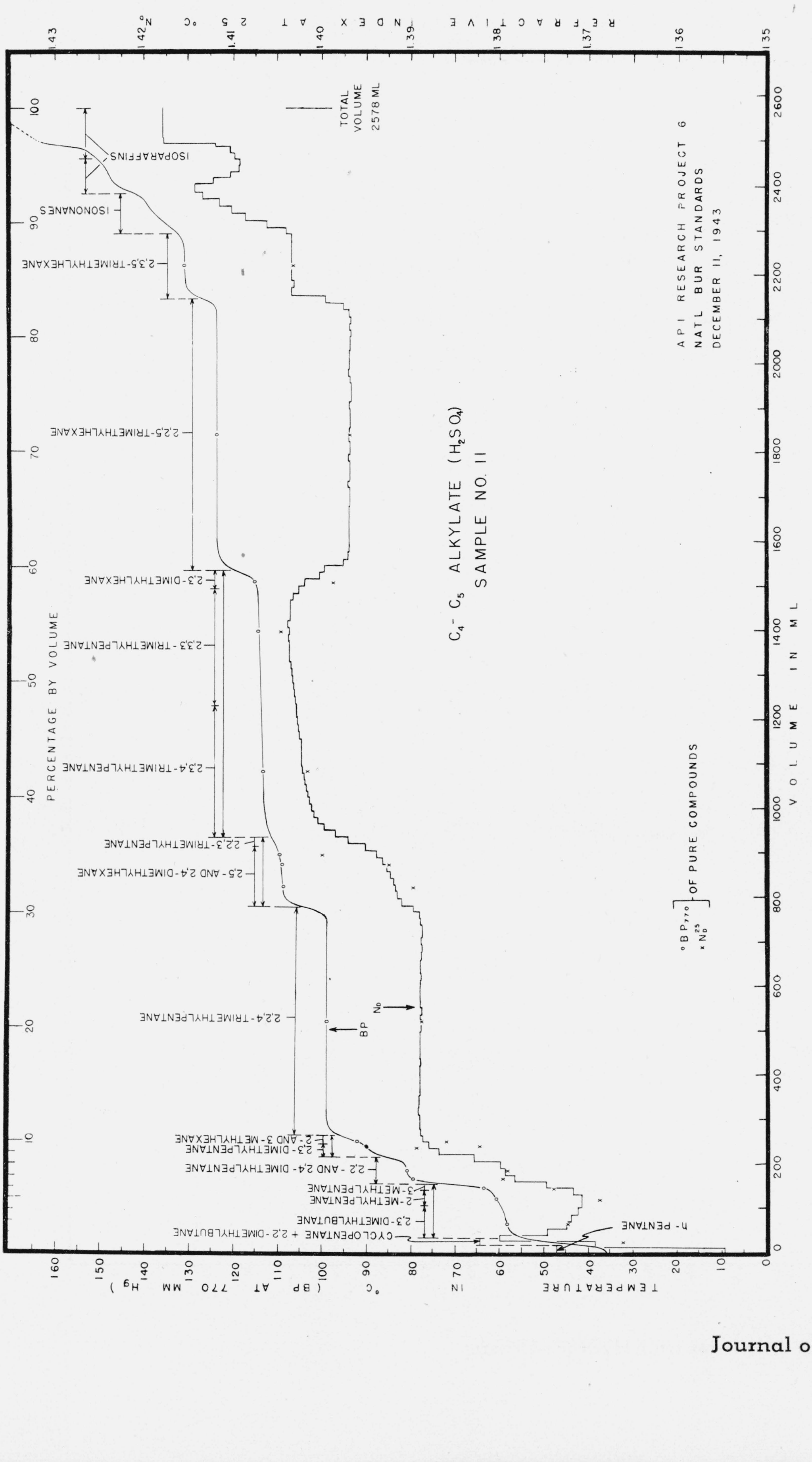

FIGURE 7.—*Results of the analytical distillation of* C_4-C_5 *alkylate* (H_2SO_4), *sample 11.*

Details are given in table 5.

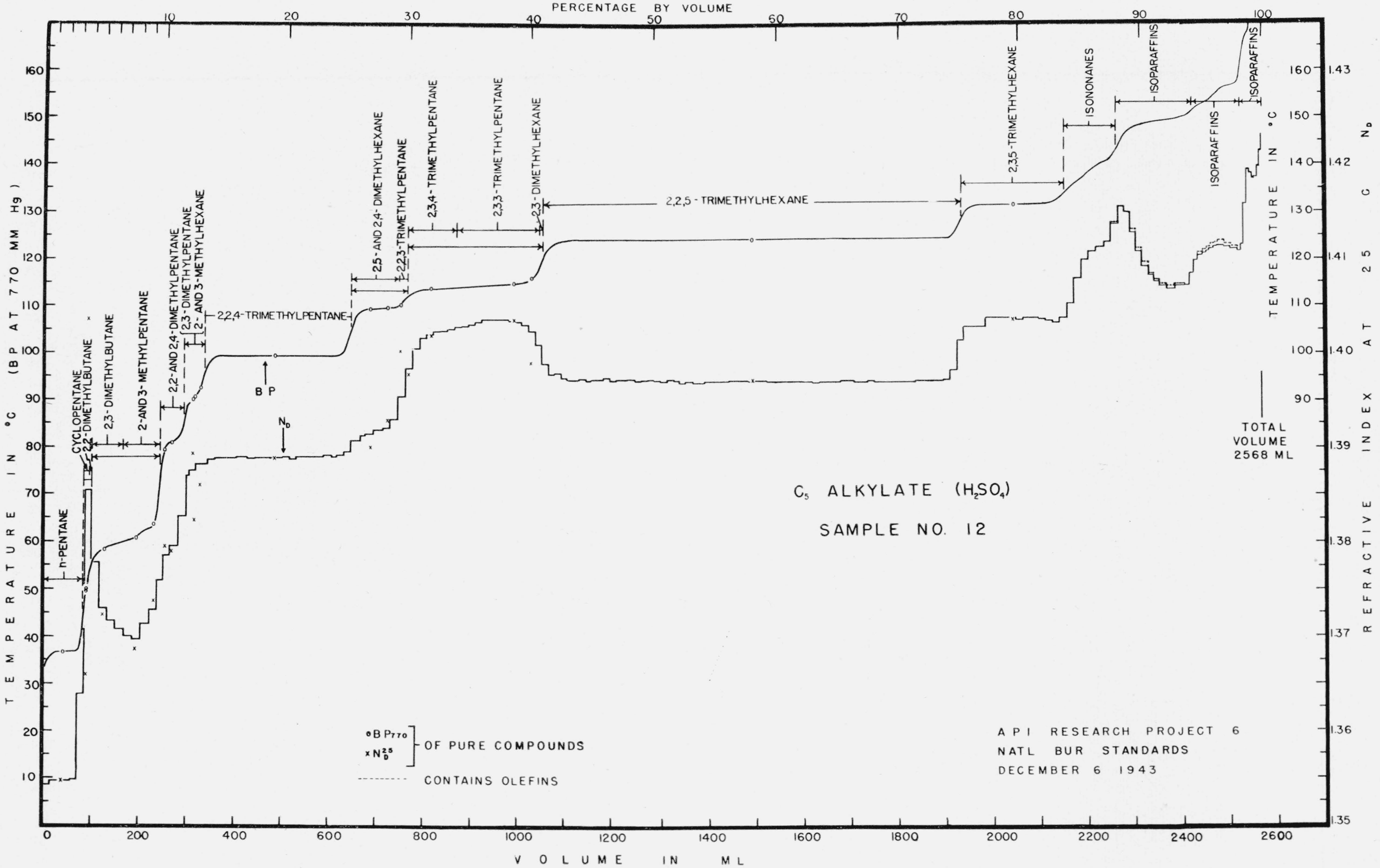

FIGURE 8.—*Results of the analytical distillation of C_5 alkylate (H_2SO_4), sample 12.*

Details are given in table 5.

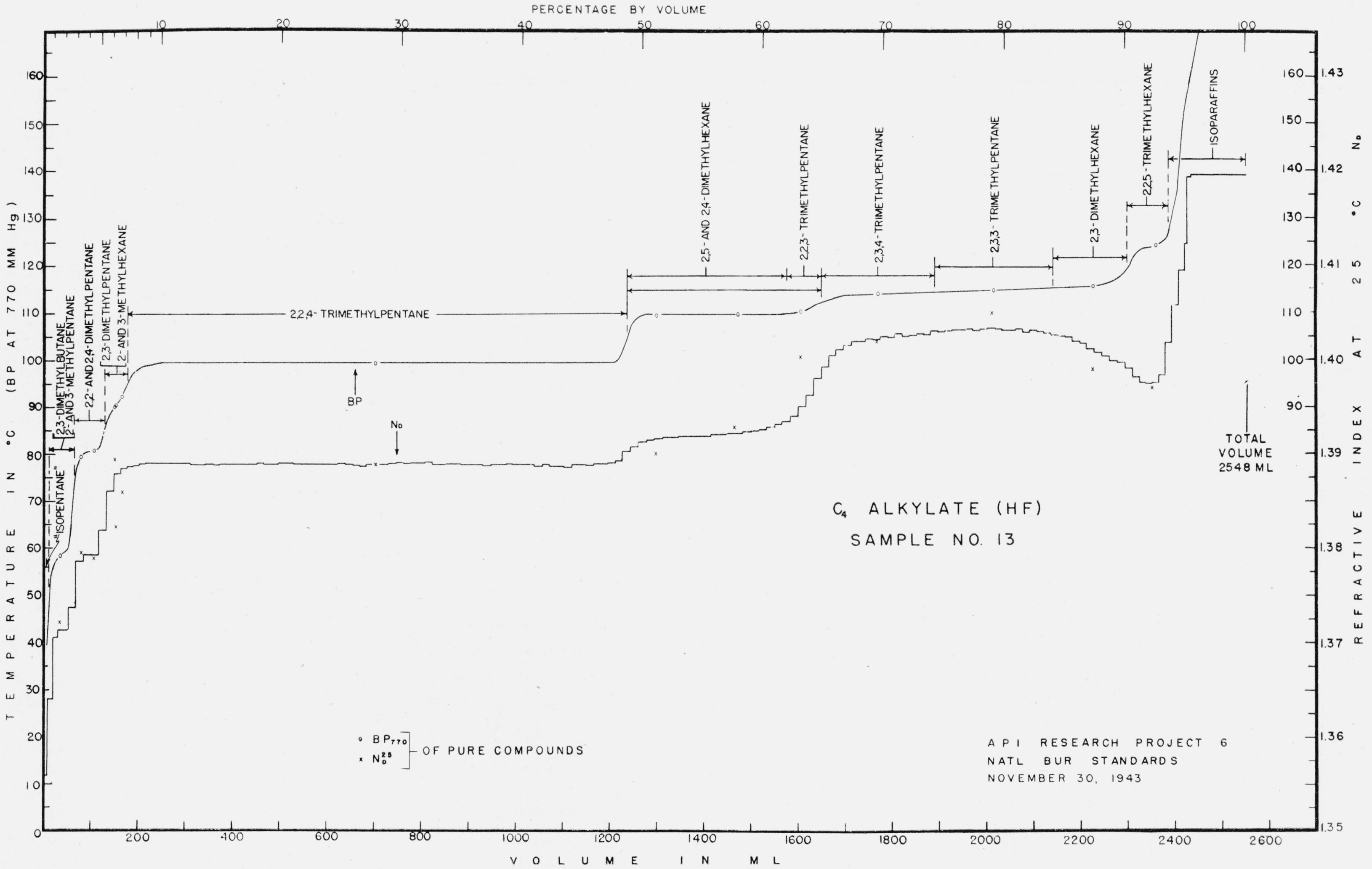

FIGURE 9.—*Results of the analytical distillation of C_4 alkylate (HF), sample 13.*

Details are given in table 4.

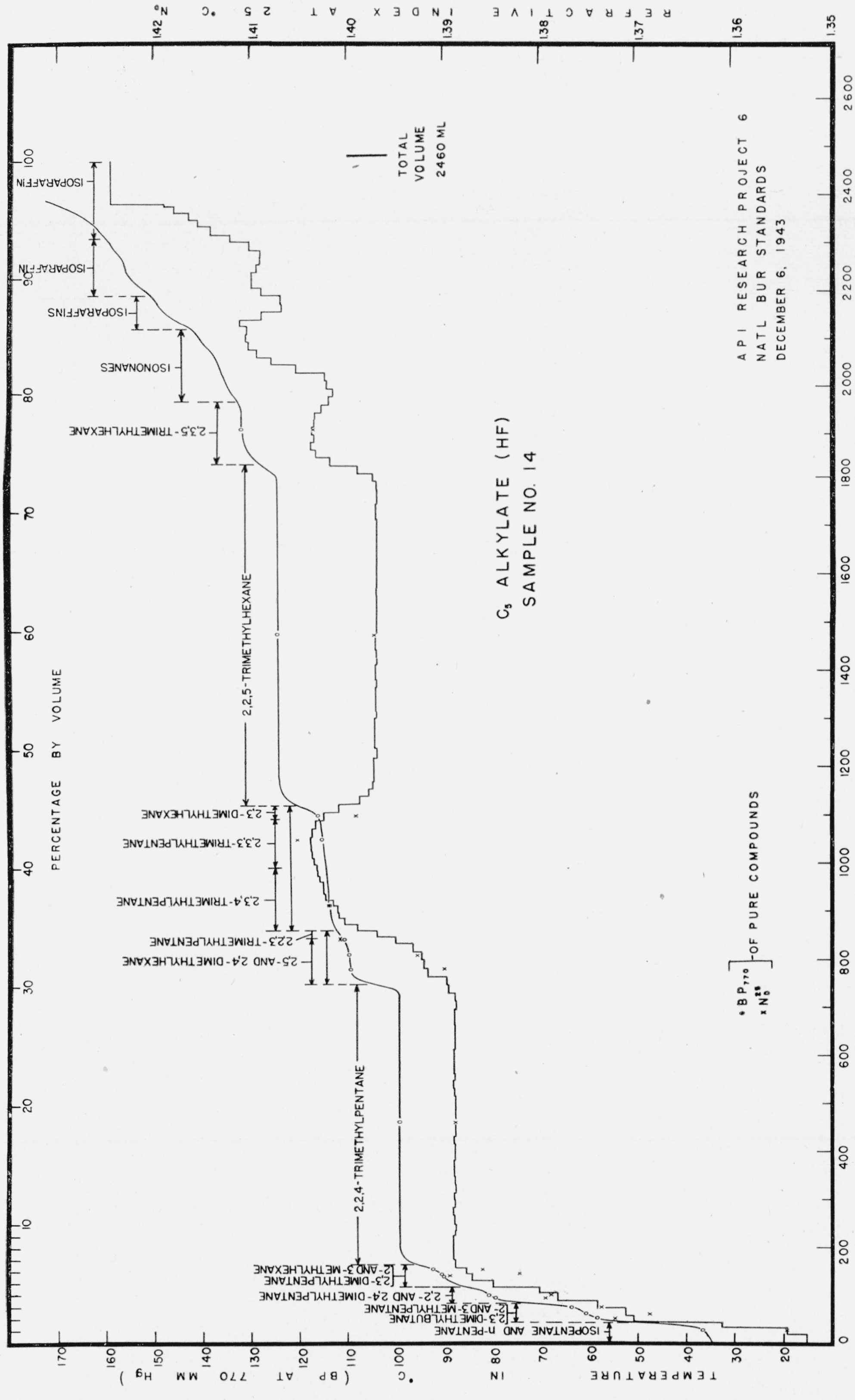

FIGURE 10.—*Results of the analytical distillation of* C_5 *alkylate* (HF), *sample 14.*

Details are given in table 5.

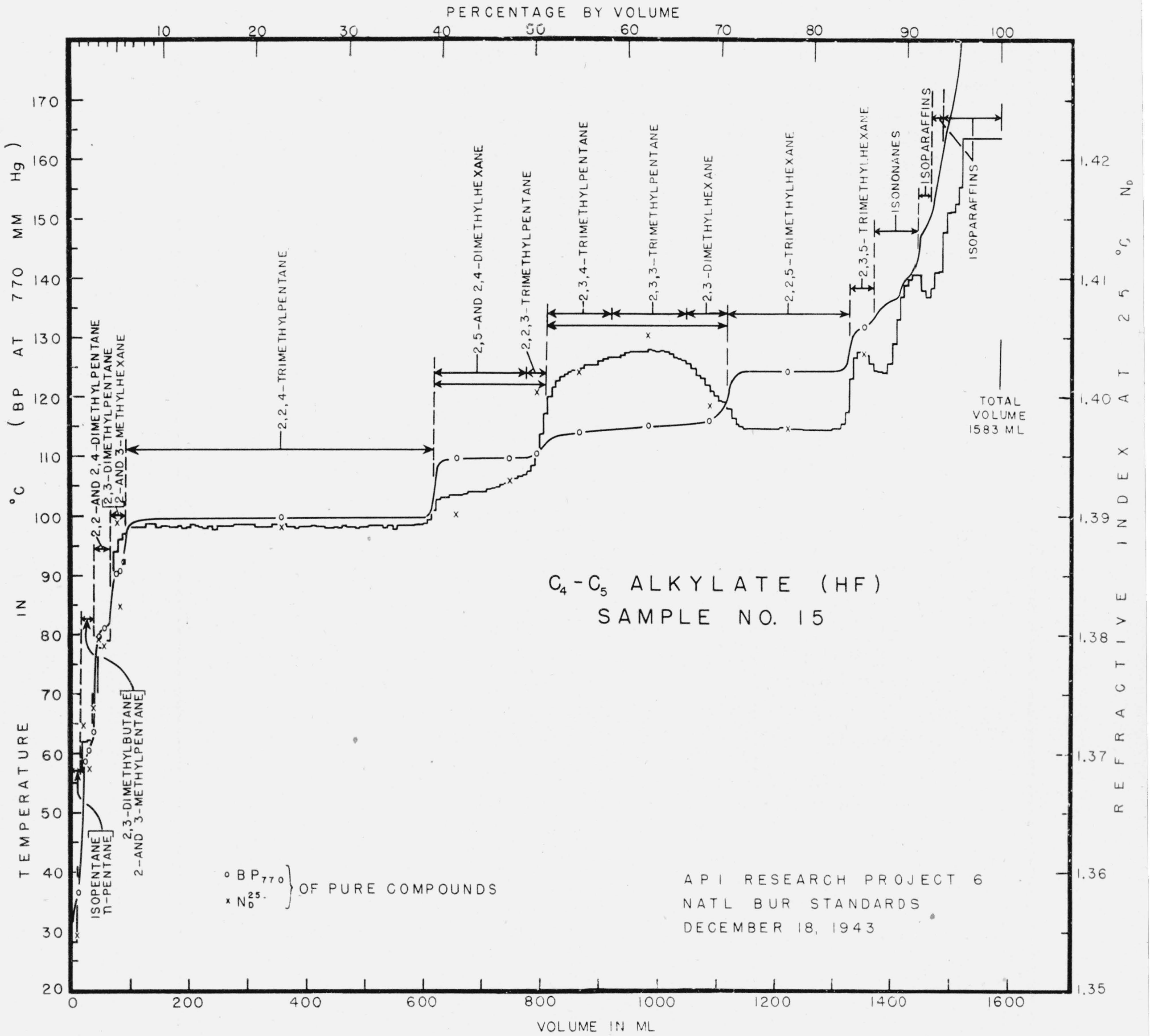

FIGURE 11.—*Results of the analytical distillation of* C_4-C_5 *alkylate* (HF), *sample 15.*

Details are given in table 5.

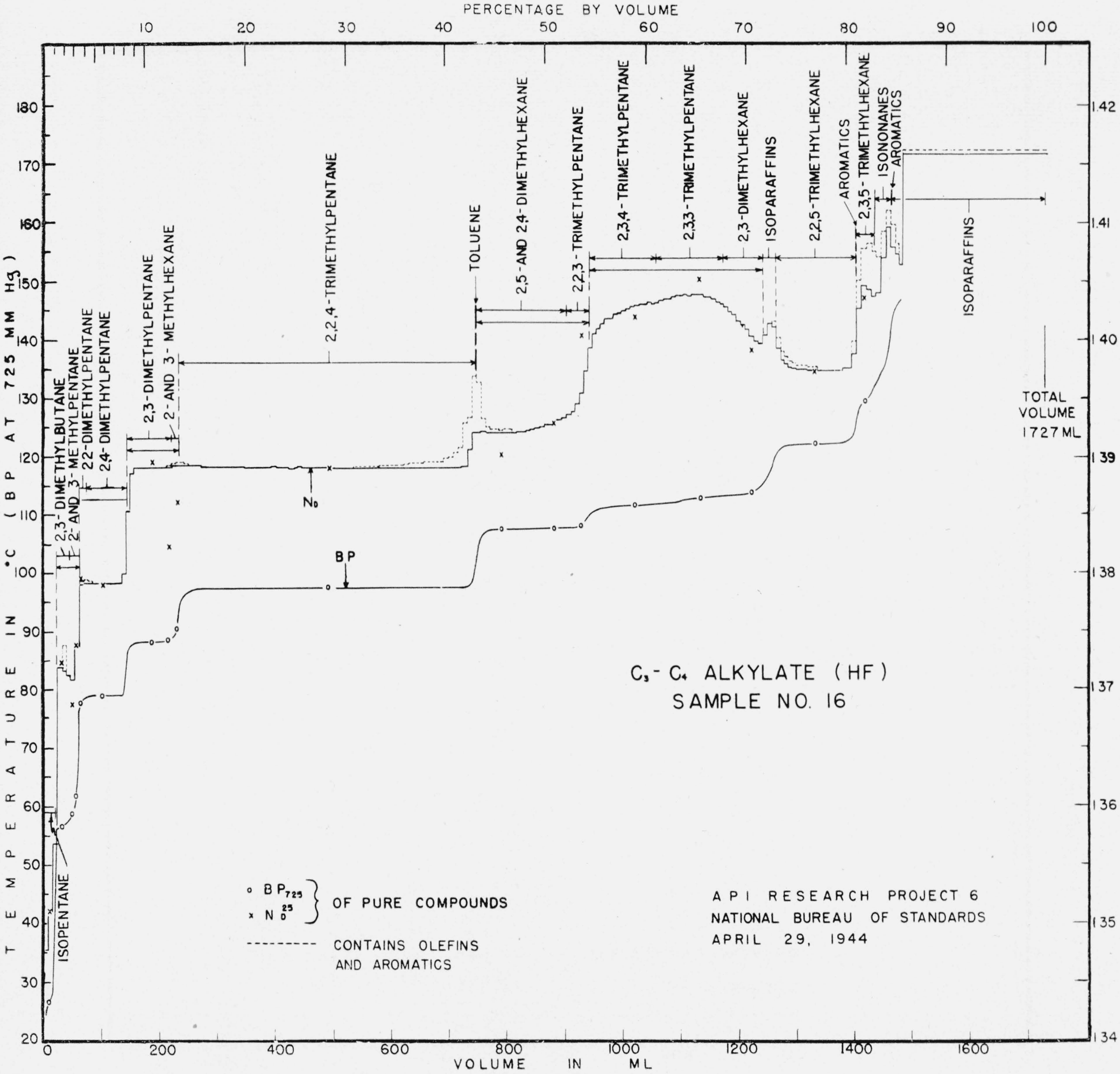

FIGURE 12.—*Results of the analytical distillation of* C_3-C_4 *alkylate* (HF), *sample 16.*

Details are given in table 3.

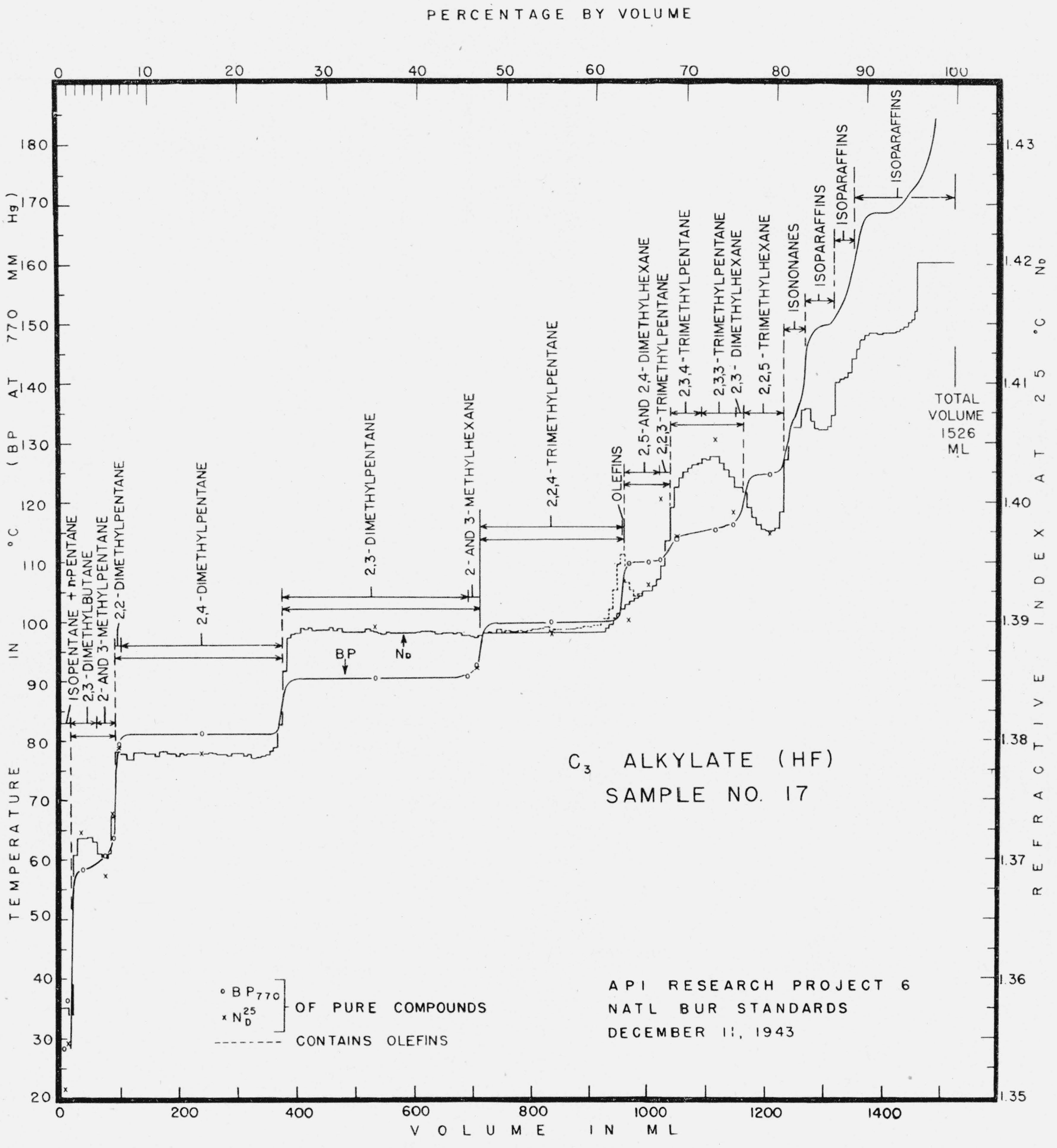

FIGURE 13.—*Results of the analytical distillation of* C_3 *alkylate* (HF), *sample 17.*

Details are given in table 3.

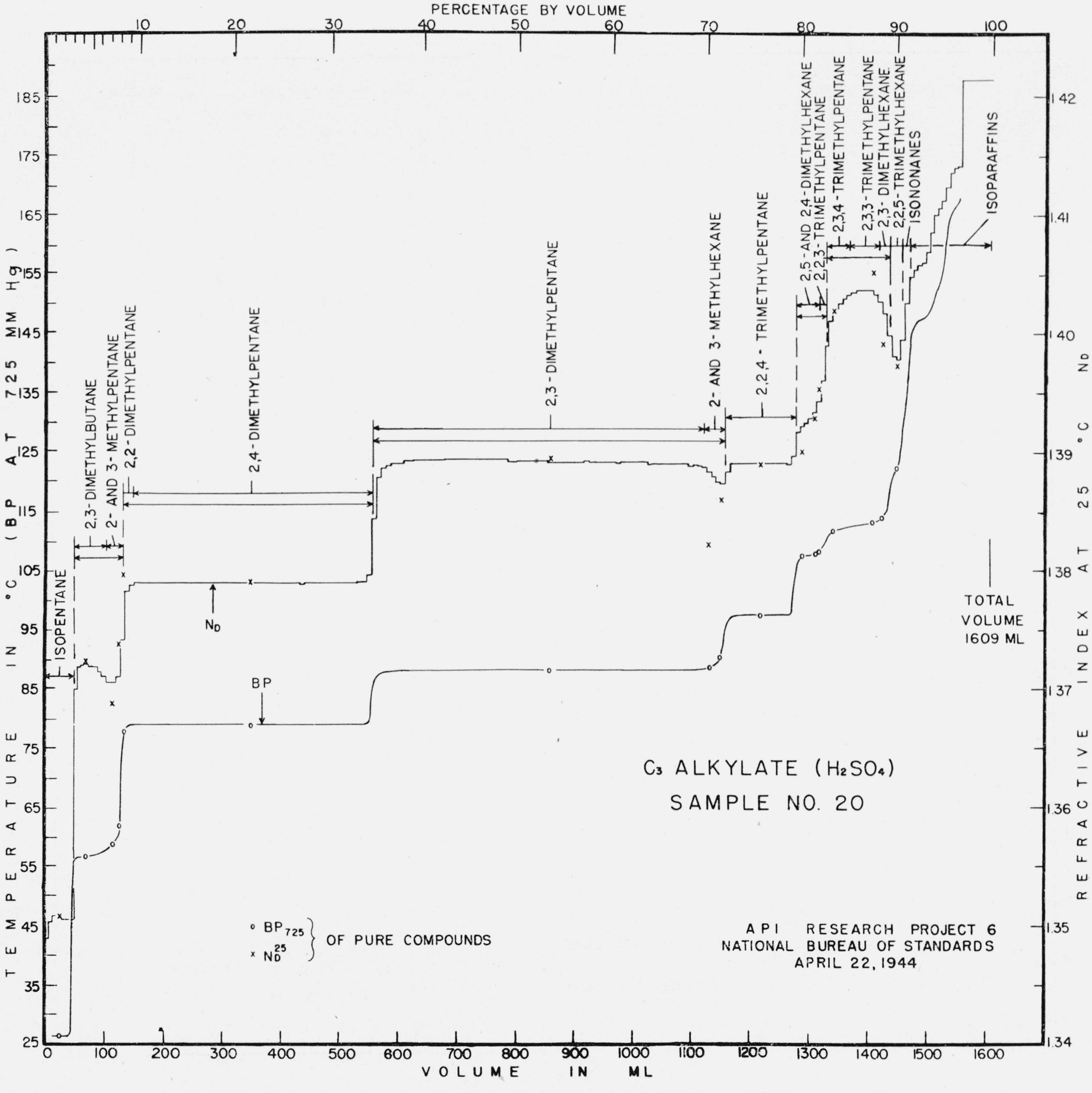

FIGURE 14.—*Results of the analytical distillation of* C_3 *alkylate* (H_2SO_4), *sample 20.*

Details are given in table 3.

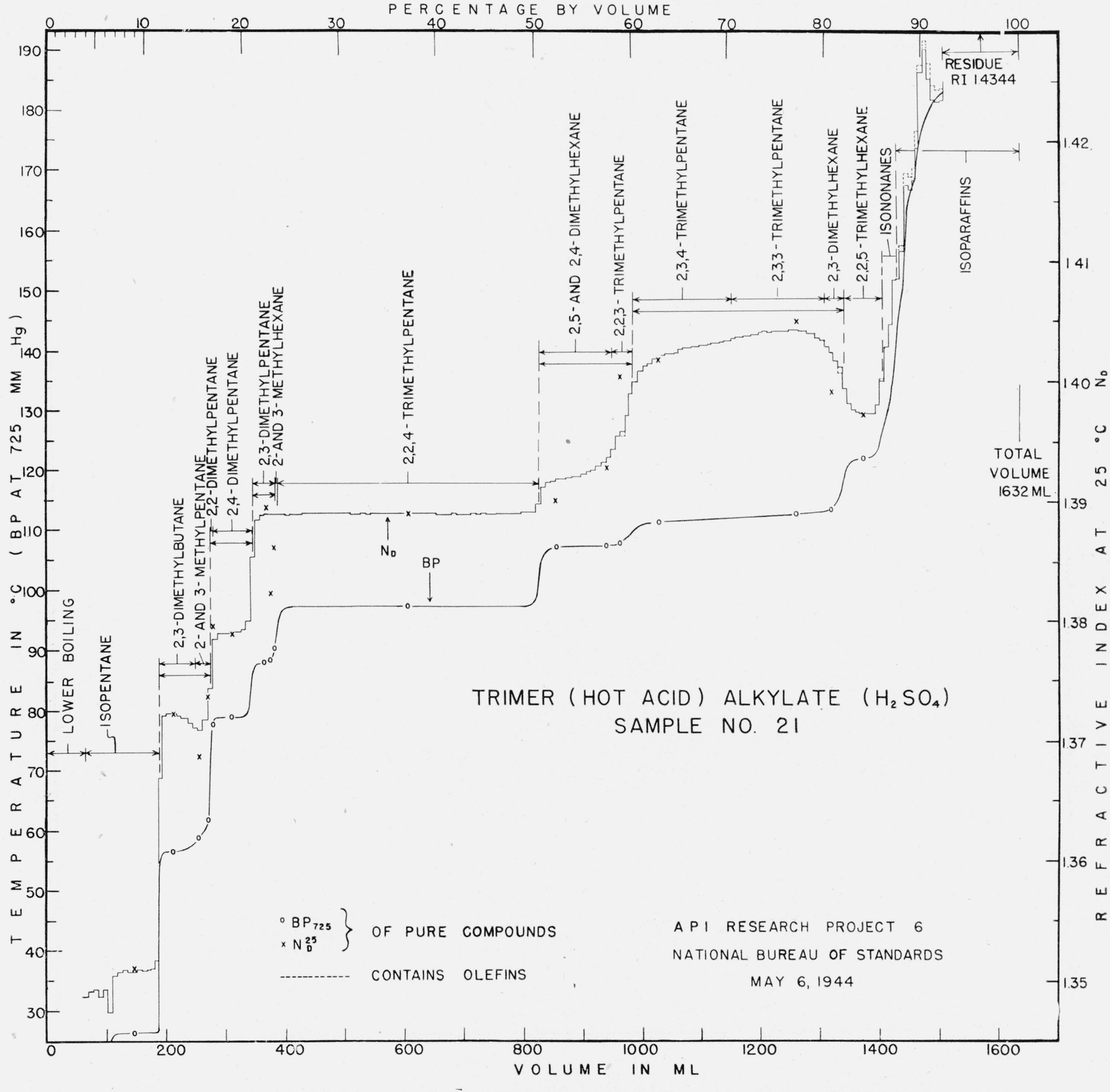

FIGURE 15.—*Results of the analytical distillation of trimer (hot-acid) alkylate* (H_2SO_4), *sample 21.* Details are given in table 6.

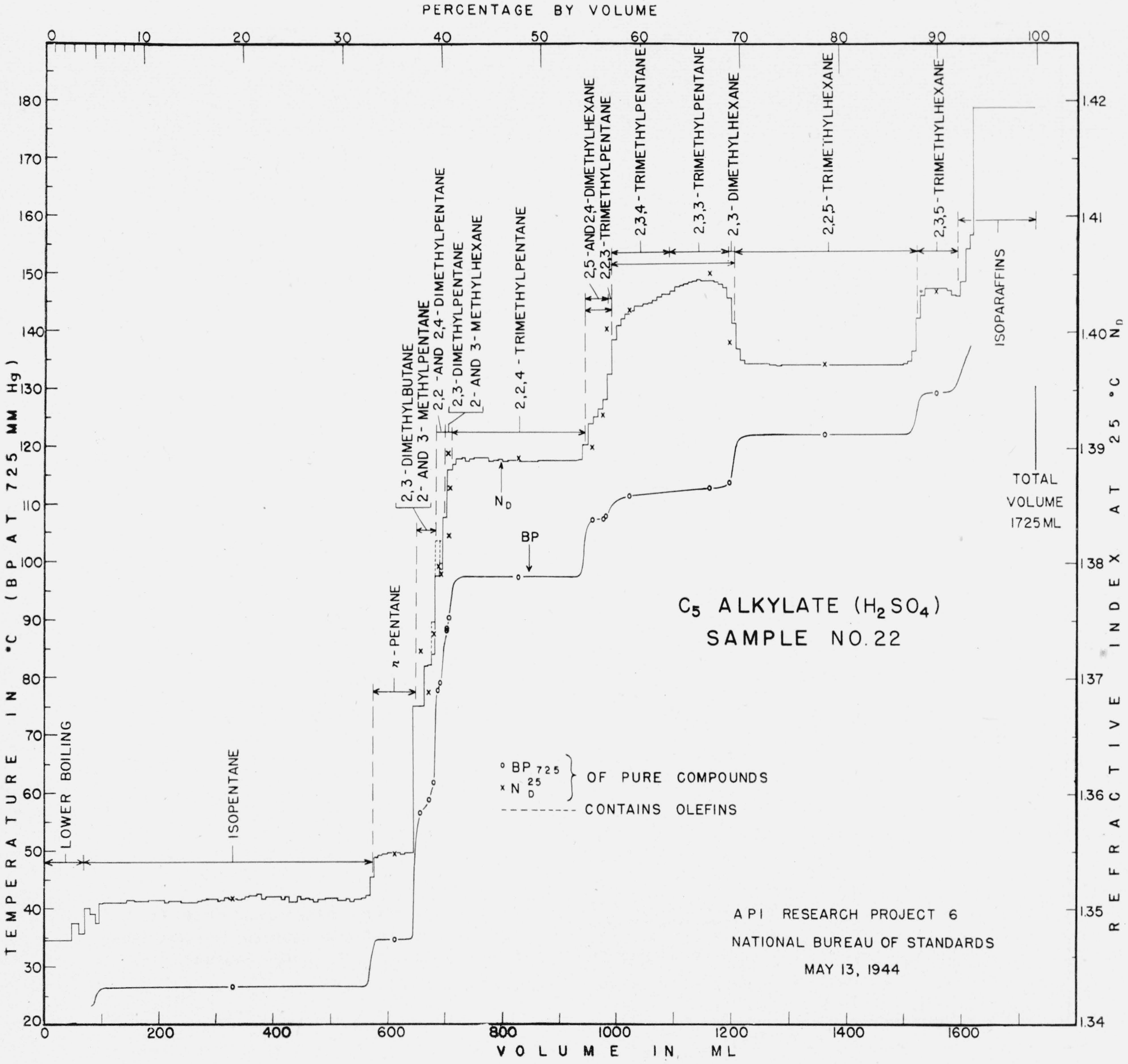

FIGURE 16.—*Results of the analytical distillation of* C_5 *alkylate* (H_2SO_4), *sample 22.*

Details are given in table 5.

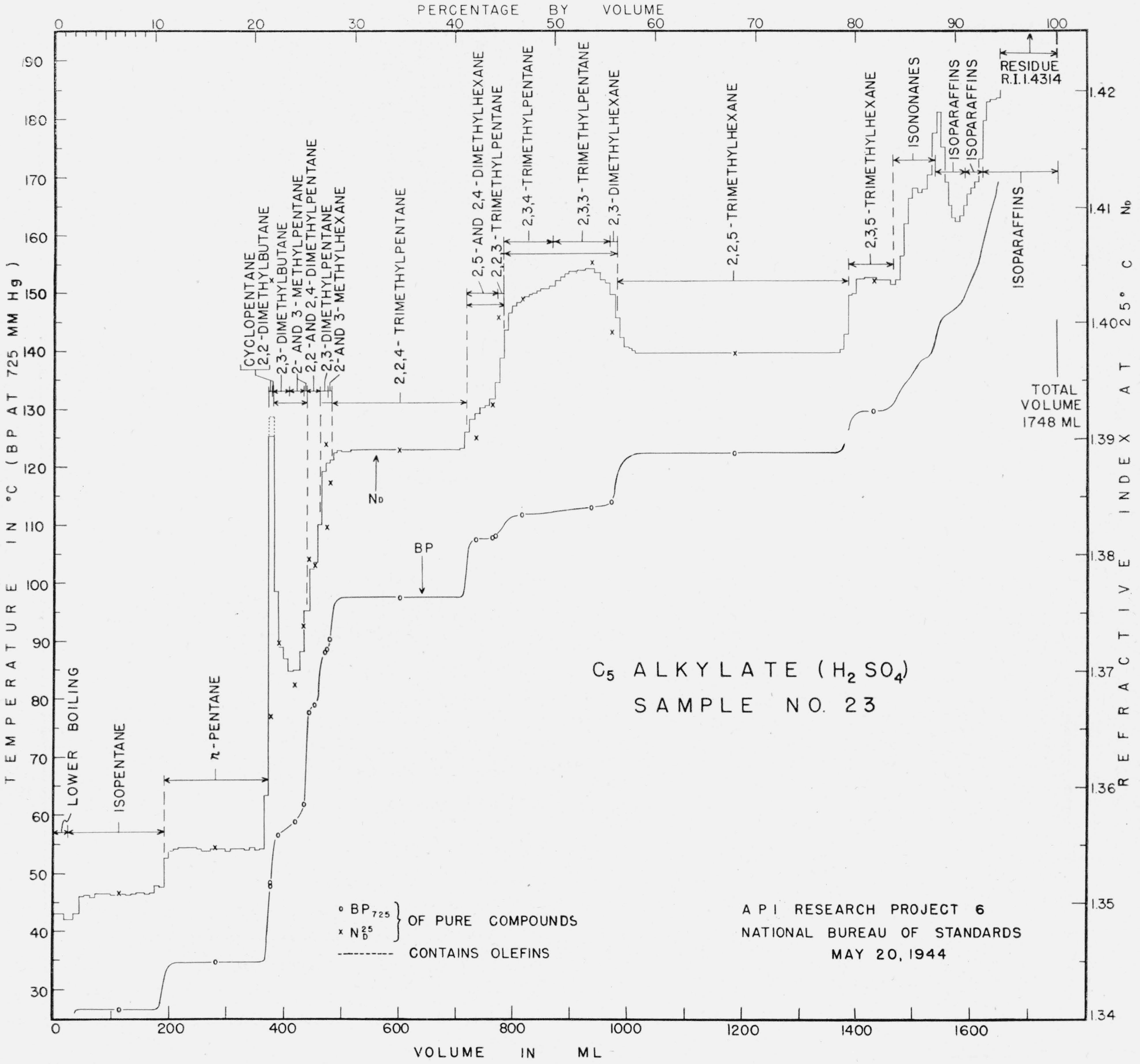

FIGURE 17.—*Results of the analytical distillation of* C_5 *alkylate* (H_2SO_4), *sample 23.*

Details are given in table 5.

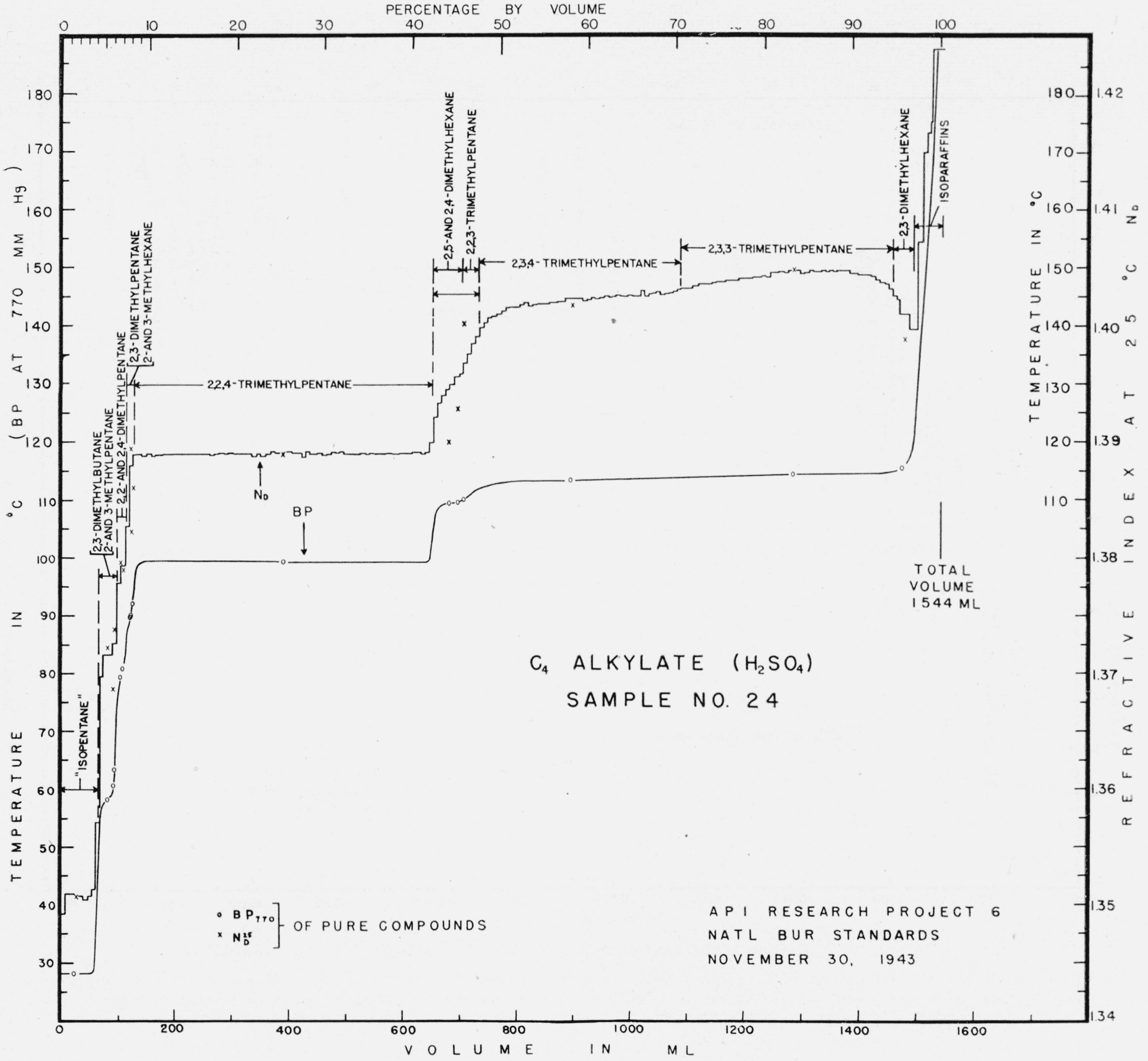

FIGURE 18.—*Results of the analytical distillation of* C_4 *alkylate* (H_2SO_4), *sample 24.*

Details are given in table 4.

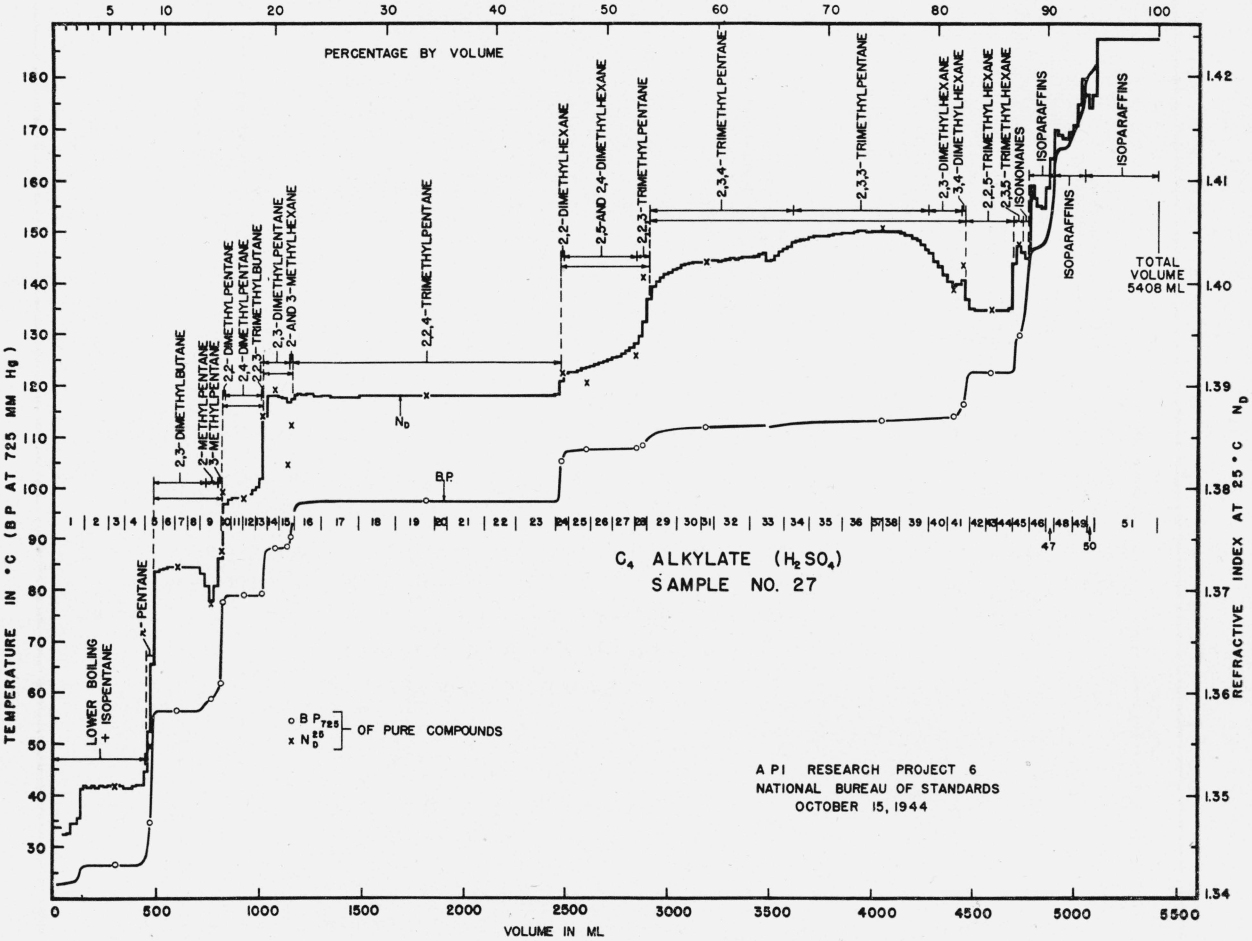

FIGURE 19.—*Results of the analytical distillation of* C_4 *alkylate* (H_2SO_4), *sample 27.*

Details are given in table 4. Near 3,500 ml, the lapse in the boiling-point curve was caused by a brief halting of the distillation, with the still being placed on total reflux before resumption of withdrawal of distillate. The dip in the refractive-index curve at this point reflects the effect of the additional reflux.

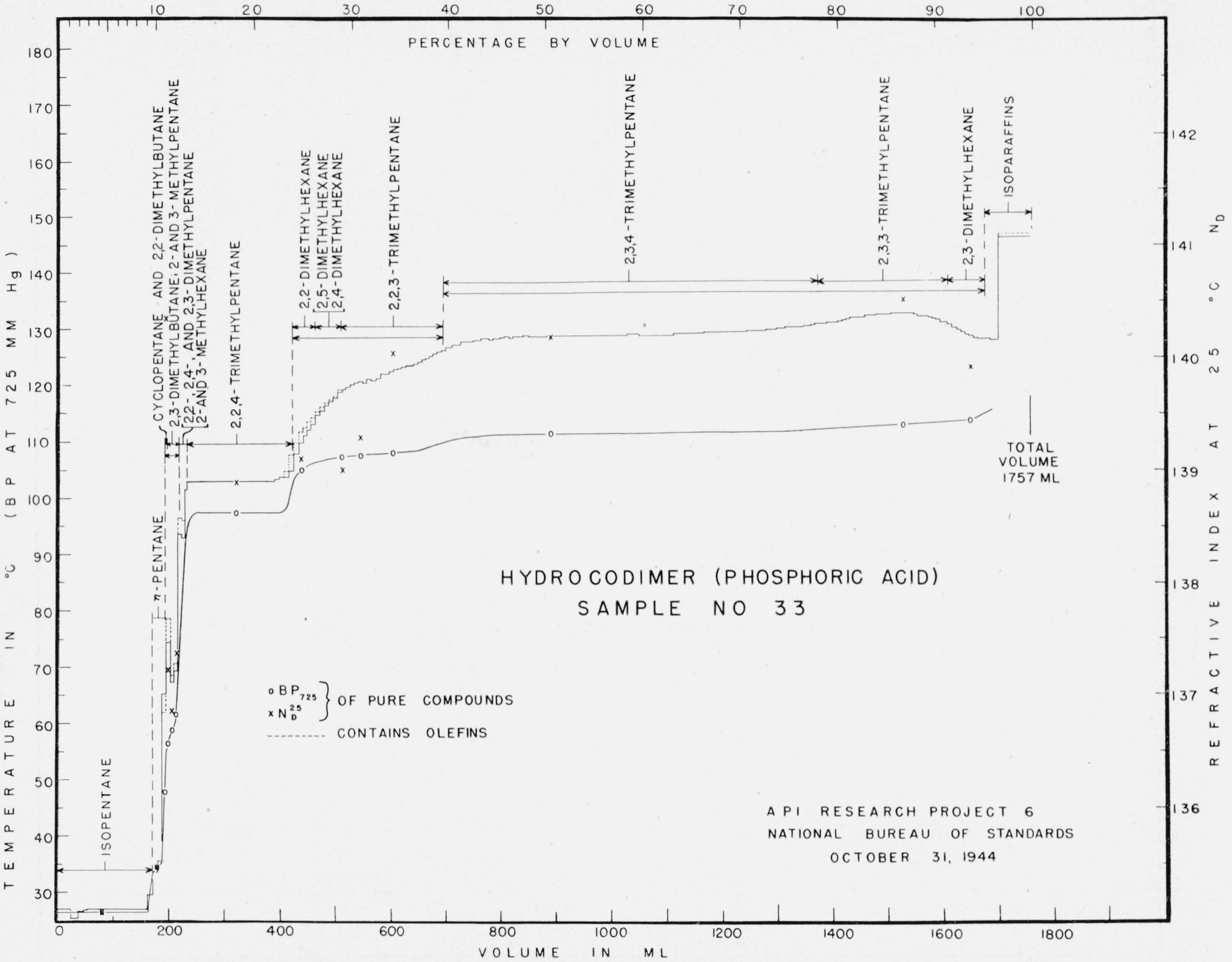

FIGURE 20.—*Results of the analytical distillation of hydrocodimer (phosphoric acid), sample 33.*

Details are given in table 7.

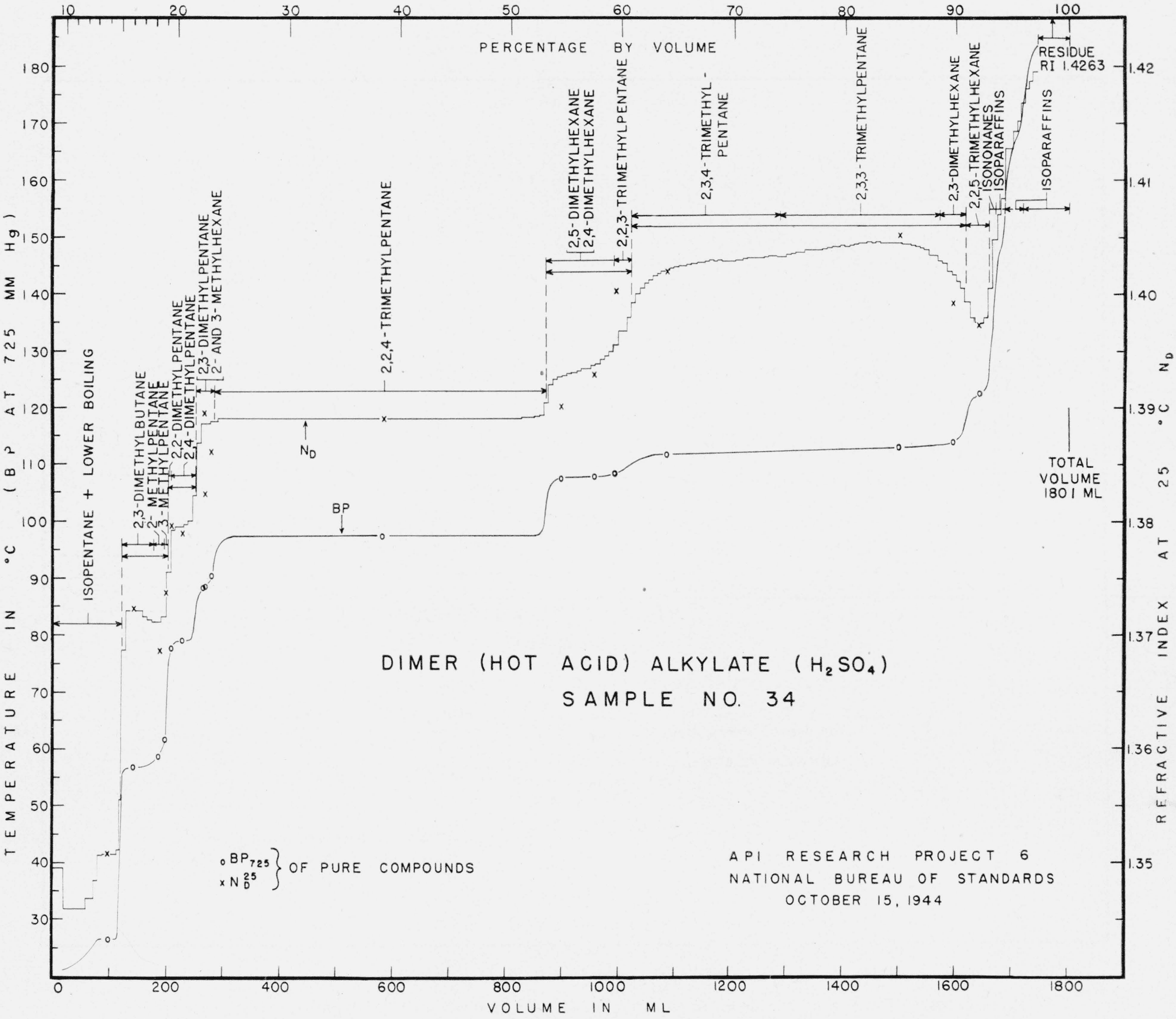

FIGURE 21.—*Results of the analytical distillation of dimer (hot-acid) alkylate* (H_2SO_4), *sample 34.* Details are given in table 6.

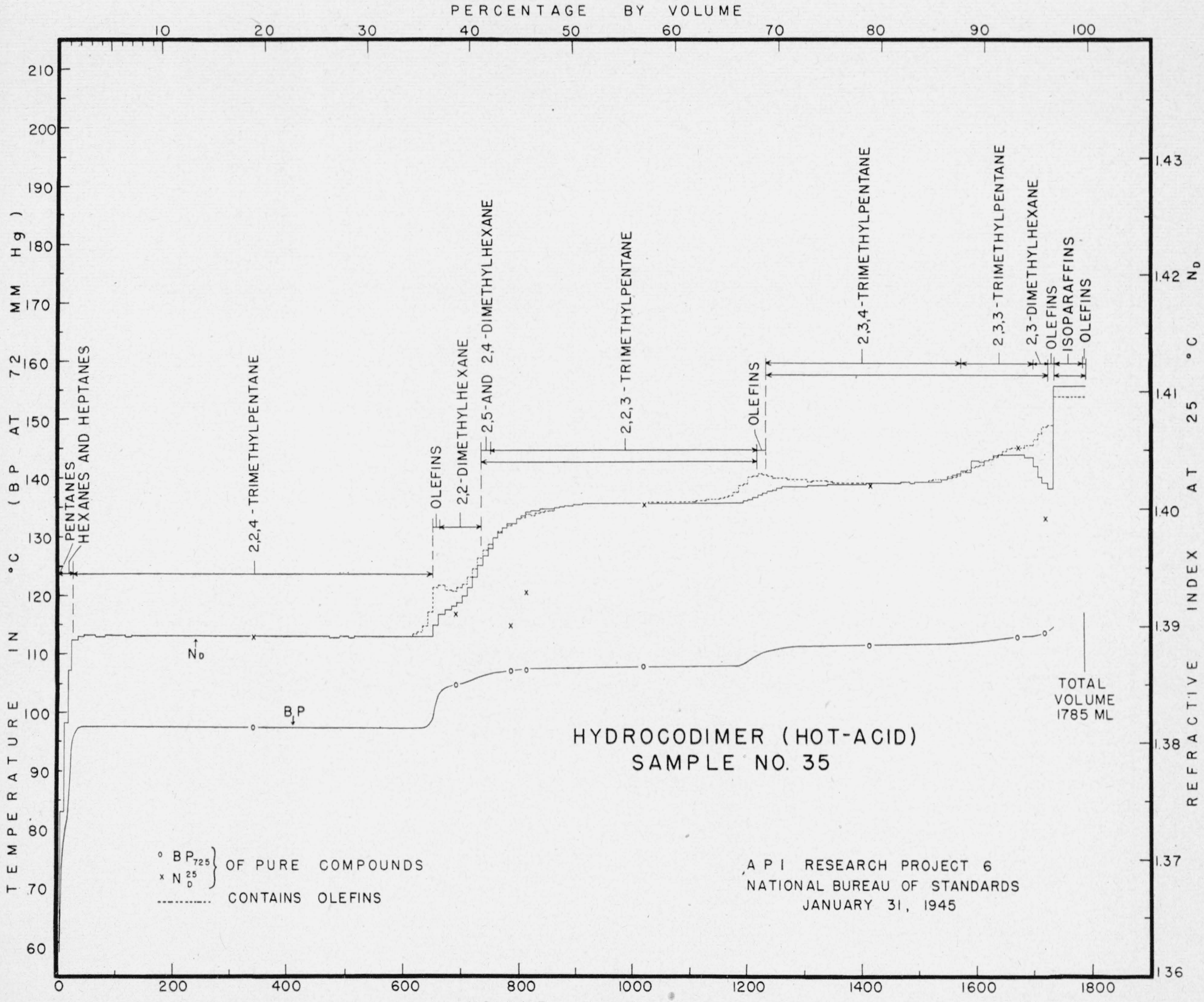

FIGURE 22.—*Results of the analytical distillation of hydrocodimer (hot-acid), sample 35.*

Details are given in table 7.

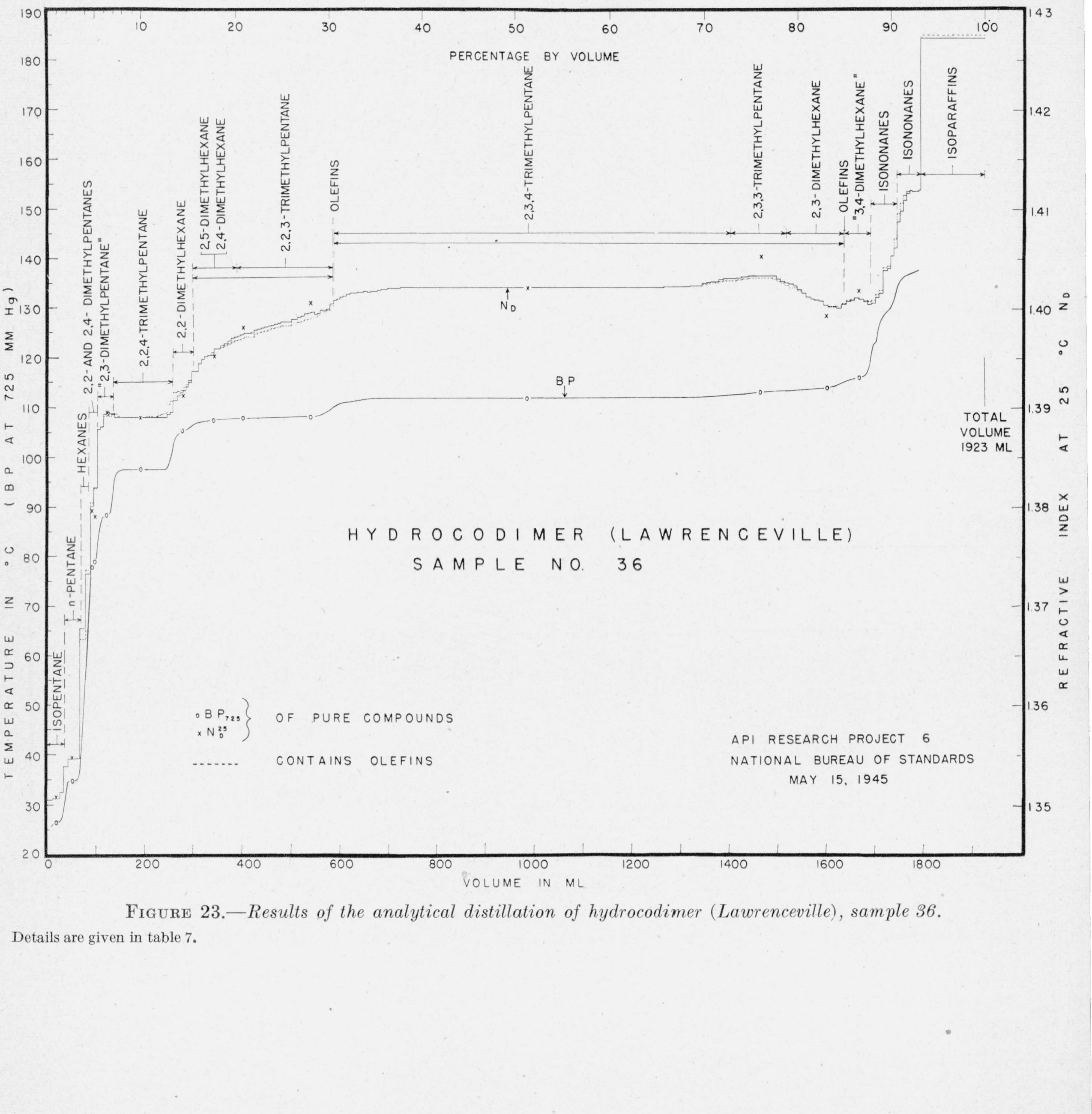

FIGURE 23.—*Results of the analytical distillation of hydrocodimer (Lawrenceville), sample 36.*

Details are given in table 7.

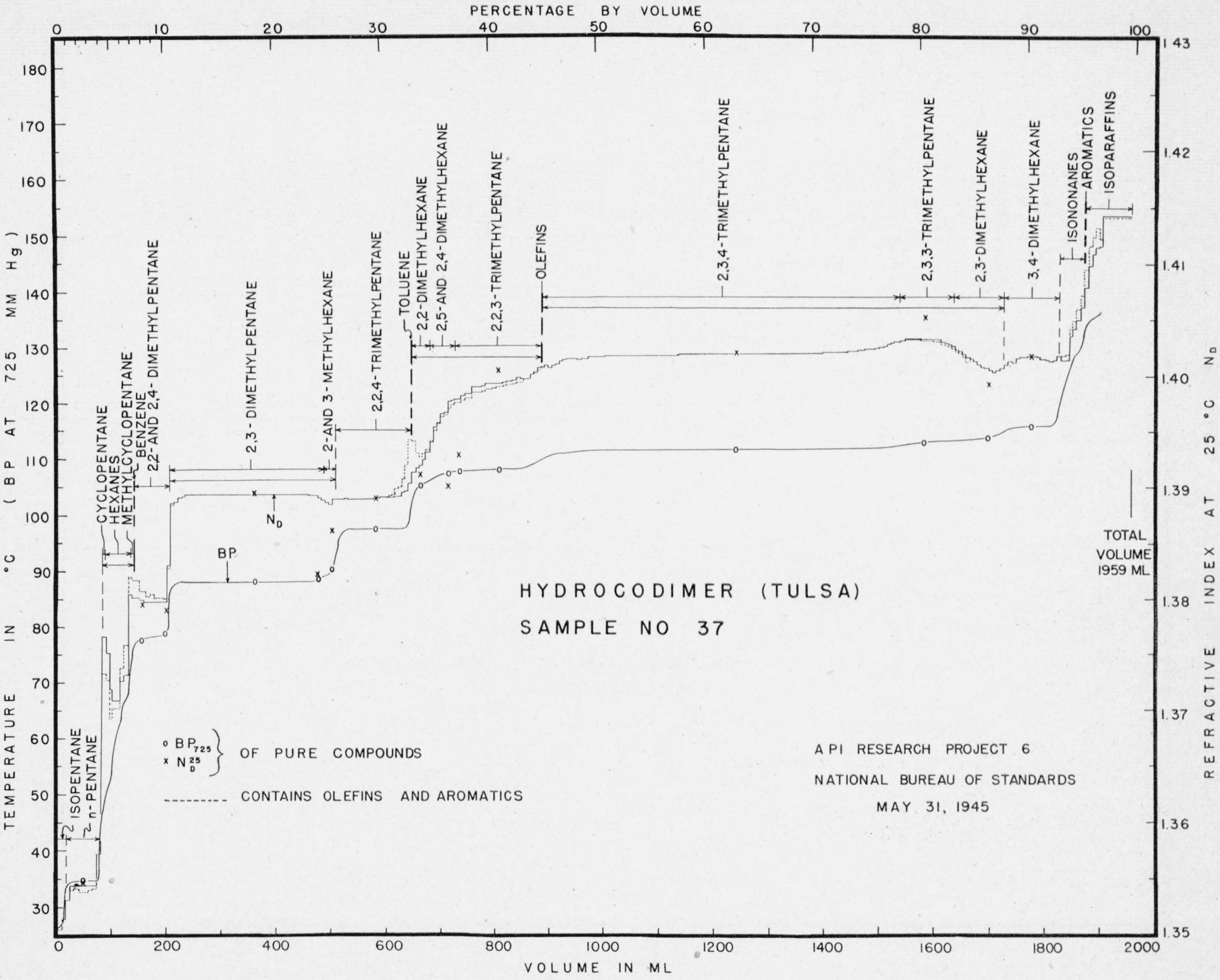

FIGURE 24.—*Results of the analytical distillation of hydrocodimer (Tulsa), sample 37.*

Details are given in table 7.

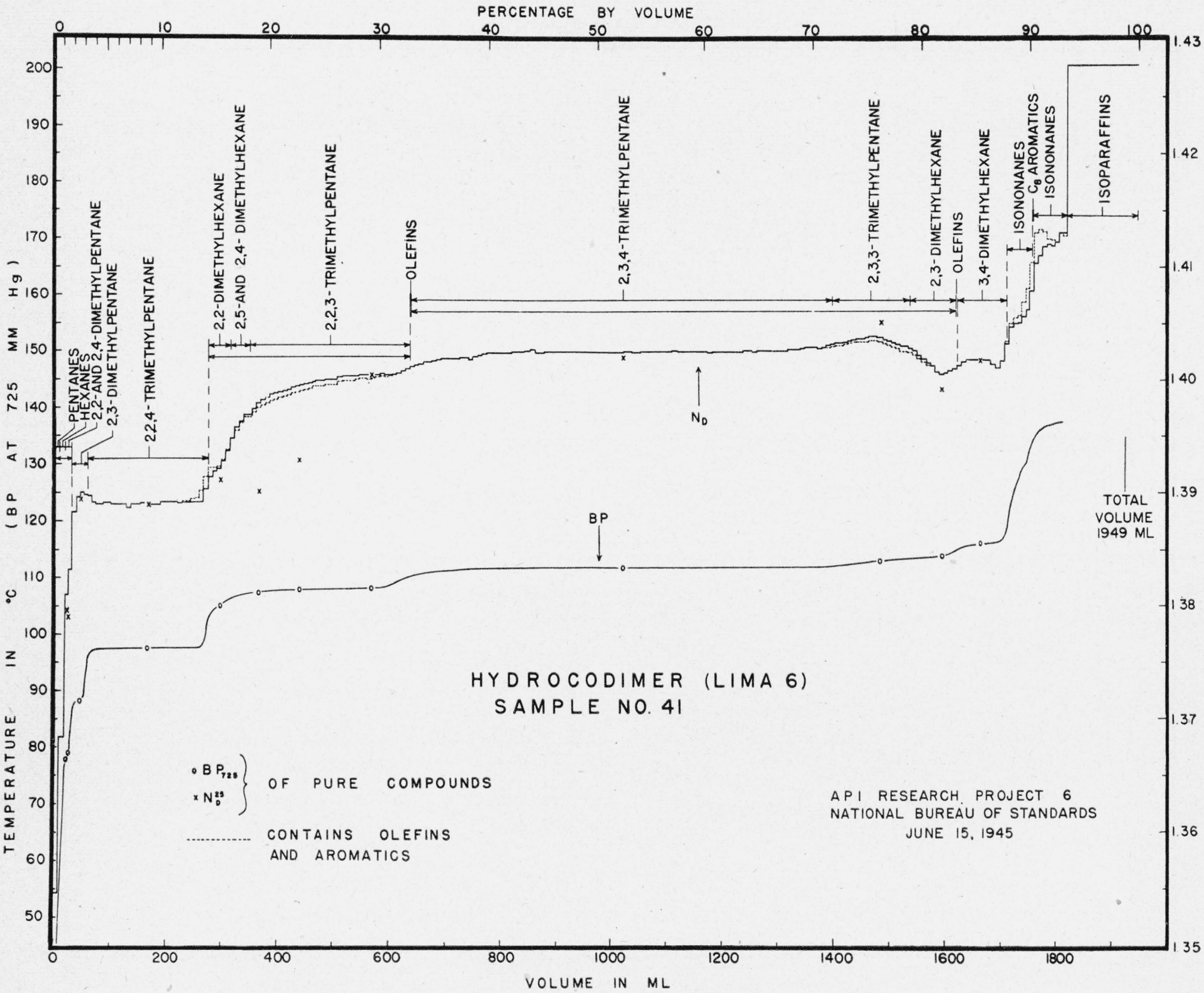

FIGURE 25.—*Results of the analytical distillation of hydrocodimer (Lima 6), sample 41.*

Details are given in table 7.

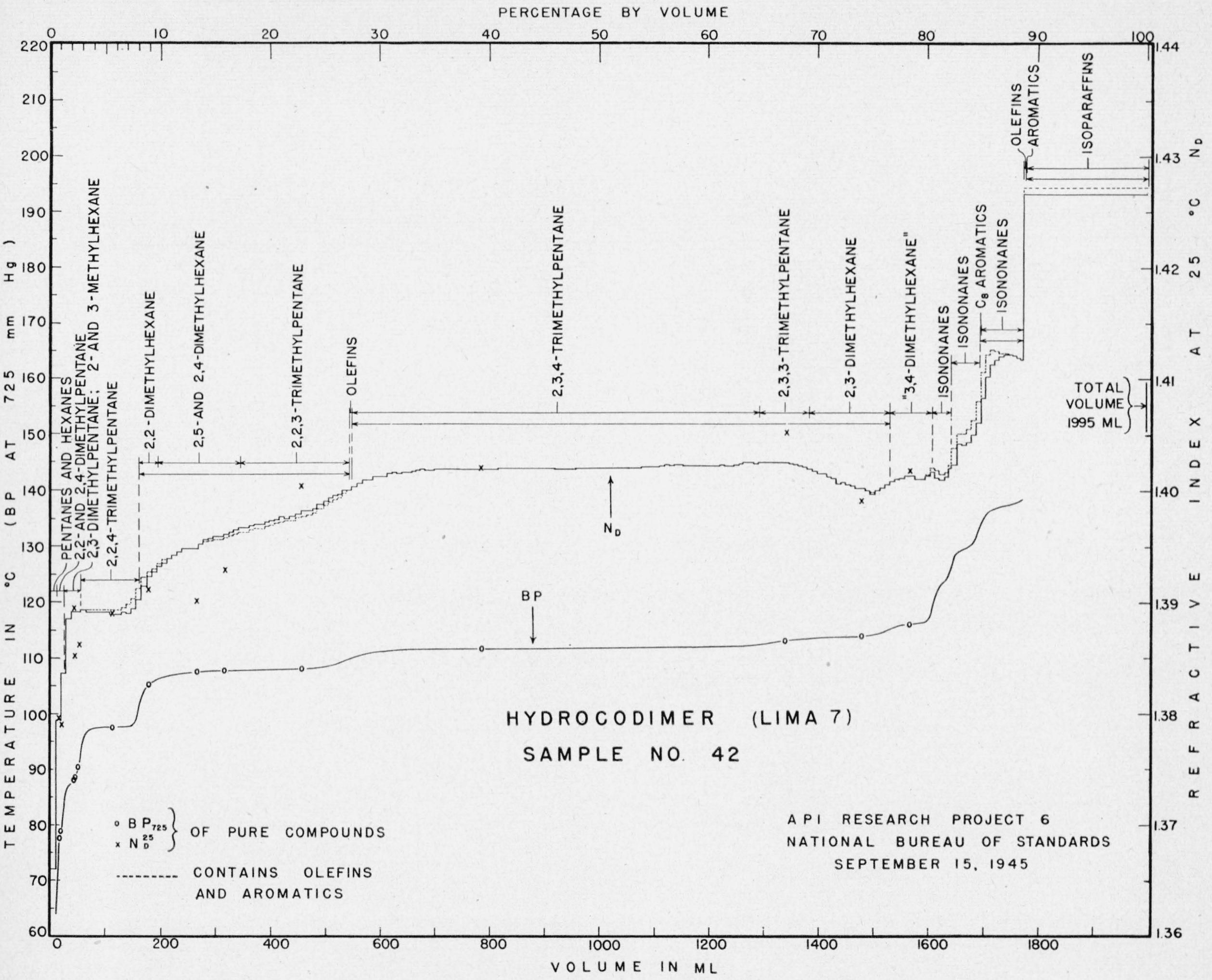

FIGURE 26.—*Results of the analytical distillation of hydrocodimer (Lima 7), sample 42.*

Details are given in table 7.

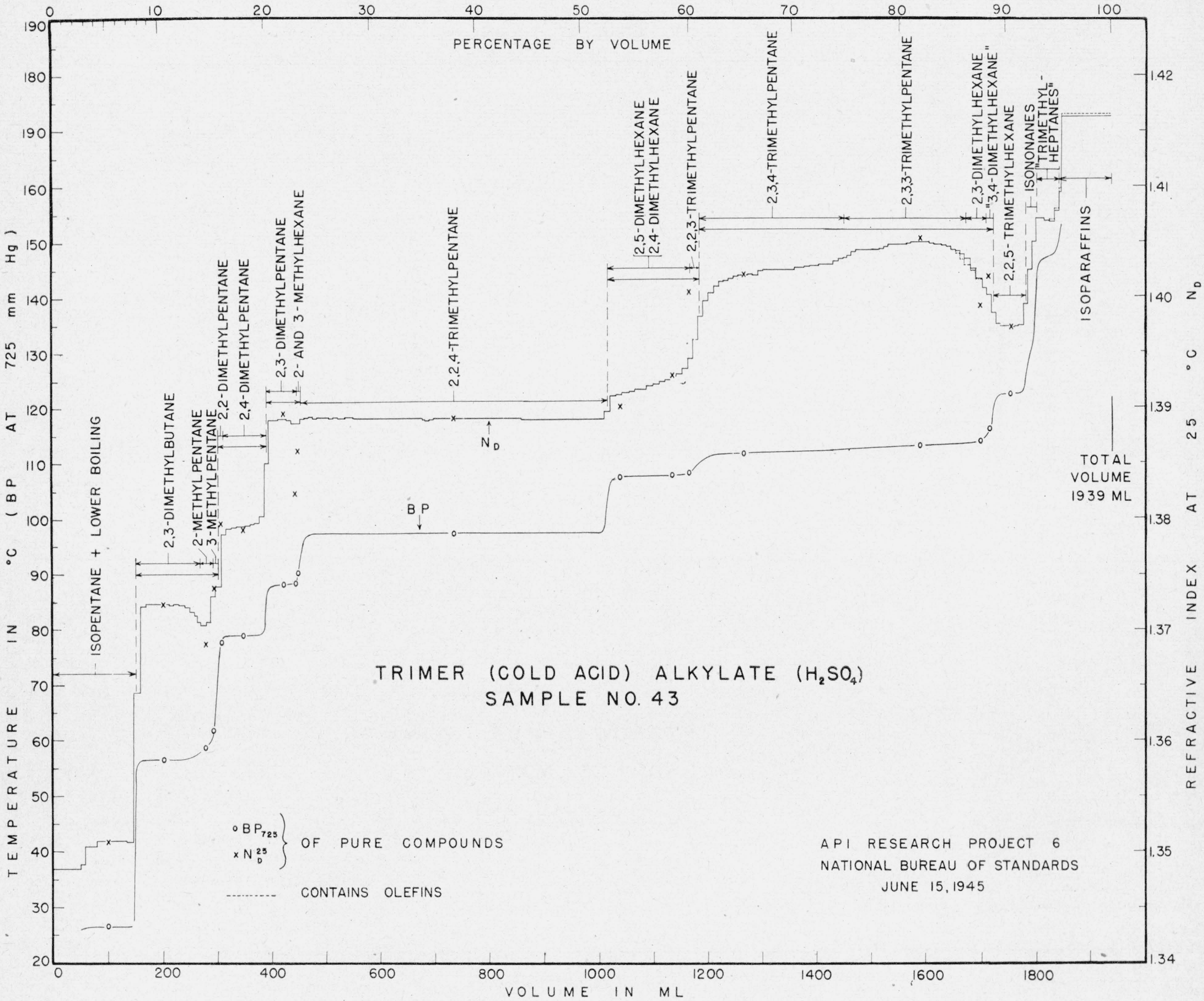

FIGURE 27.—*Results of the analytical distillation of trimer (cold-acid) alkylate* (H_2SO_4), *sample 43.*

Details are given in table 6.

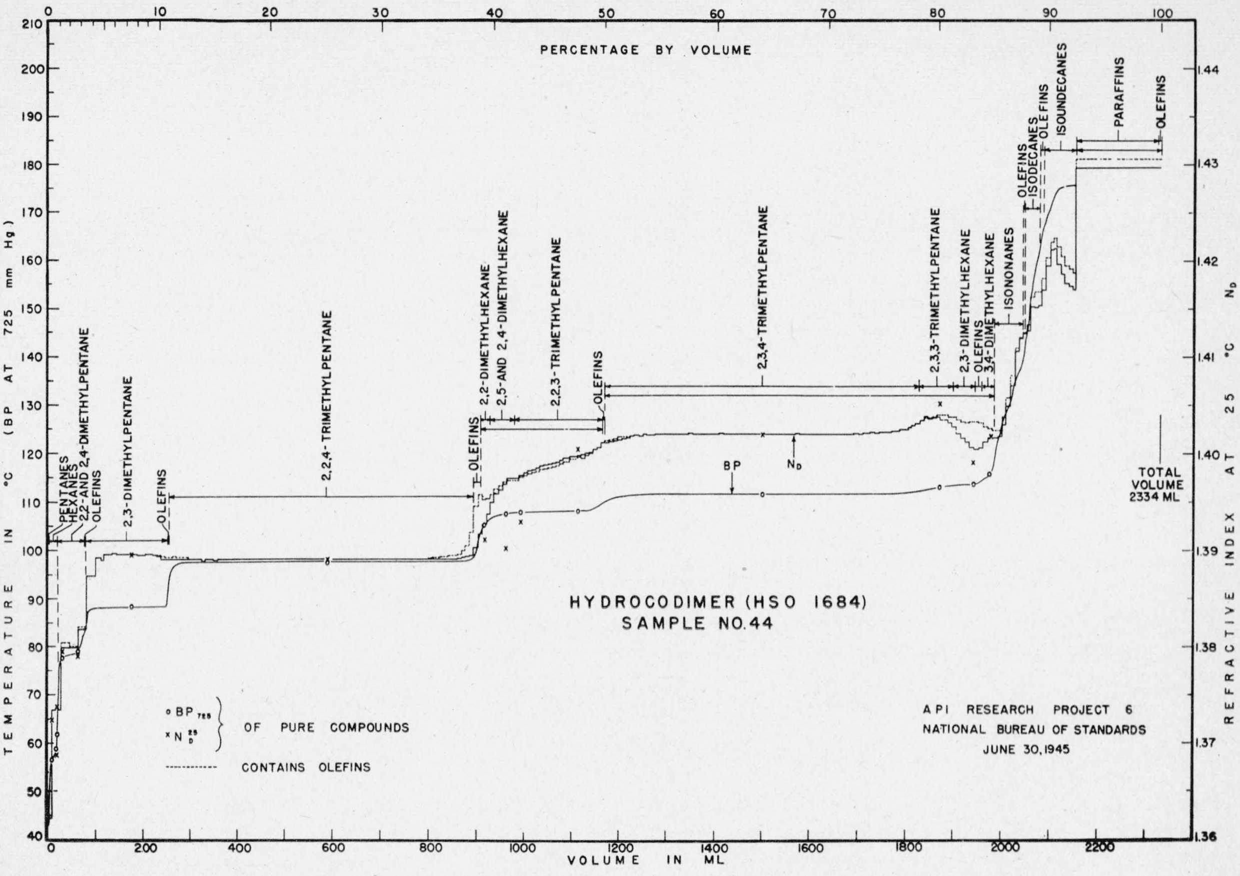

FIGURE 28.—*Results of the analytical distillation of hydrocodimer* (HSO–1684), *sample 44.*

Details are given in table 7.

WASHINGTON, September 16, 1946.