THE ANALYSIS OF TRINIDAD CRUDE OILS.* II. THE PARAFFINIC OILS.

By F. MORTON † and A. R. RICHARDS. †

INTRODUCTION.

In a previous communication ¹ from these laboratories the analysis of a number of crude oils from the Forest Reserve Field was described. It was suggested that the crude oils of Trinidad consist essentially of two main types—namely, a paraffinic oil yielding, on distillation, a naphtha of the paraffin-aromatic type, and a naphthenic oil yielding a naphtha of mixed naphthenic type. Subsequent studies of the crude oils of the Forest Sands of the Bernstein Area² indicated that the intermediate character of the oils might be explained by the migration of the paraffinaromatic type oil into an area originally containing oils of the naphthenic type. In view of the fact that paraffinic type oils occur throughout the producing areas of Trinidad (*i.e.*, Guayaguayare, Morne Diablo, Forest Reserve, etc., etc.), it was desirable to examine these oils in order to ascertain whether or not a common history could be supported on chemical grounds.

The present communication deals with the analysis of fourteen individual crude oils drawn from four different areas. The examples given have been chosen from among several hundred as best illustrating the variations in crude-oil composition encountered within a single type oil. Freak oils, such as oils of unusual aromatic content, have been excluded, but examples of the "distillate oils" have been given to illustrate the fact that the composition of the naphtha from these oils is identical with that associated with the heavier oils in the same area.

The methods of analysis used throughout the survey have naturally been subject to modification from time to time. Originally crude oils were classified by reference to the physical constants of the fractions of a precisely fractionated naphtha plotted as the characteristic graph.¹ Where it was necessary to estimate the composition of a given fraction in terms of its constituent hydrocarbons, this was done by reference to fractions isolated in a more detailed study of bulk crude oils of Trinidad, the chemical composition of which had been established by combined physical and chemical methods. It was early realized that simple comparative data would be insufficient in view of the complicated nature of the geochemical problems involved, and that to extend the value of the survey beyond the needs of simple exploitation problems a detailed chemical analysis of the naphthas would be necessary. In order to maintain the continuity of the work, this was first attempted by extraction of the aromatic hydrocarbons from the individual fractions obtained by the precise fractionation of the naphtha after determination of the physical constants required to construct the characteristic graph. Determination of the physical constants after acid extraction enabled an approximate

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determination of the paraffin-naphthene ratio to be made, and from this the relative amounts of groups of hydrocarbons could be computed. It was realized that this procedure was open to serious objections. Firstly, the existence of constant-boiling mixtures in the original fractionation would preclude reliable comparison of the non-aromatic portion with published data, and secondly the use of sulphuric acid might lead to disproportionation and to destruction, or extraction, of non-aromatic material (more particularly hydrocarbons containing a tertiary carbon atom). A number of analyses proved that under carefully controlled conditions of extraction the results could be duplicated with ease. Further work has resulted in our discarding the characteristic graph in favour of a fractionation of the naphtha after removal of the aromatic hydrocarbons,³ thus enabling a more precise statement to be made concerning the chemical composition of the non-aromatic portion.

The analyses reported herein belong to the transition period, and are based on the early technique coupled with acid extraction of the individual naphtha fractions. Subsequent work has shown that the analyses given are sufficiently accurate to be used in geo-chemical studies, and the general findings have not been invalidated by later and more precise analysis.

METHODS OF ANALYSIS.

The methods of analysis employed throughout the present work are essentially those described in Part 1 of this series.¹ The Primary Distillation and Supplementary Analysis * remain substantially unaltered. In the naphtha characterization, however, the individual fractions are extracted with 98.5 per cent. sulphuric acid below 20° C. to constant aniline point and the physical constants of the fractions before and after extraction are recorded. As in previous work, the physical constants of the fractions prior to acid extraction have been used to construct characteristic graphs of the naphthas (Figs. 1–14) to which has been added the aniline point of the fractions after acid extraction. The physical constants of the aromatic-free fractions have been used to estimate the paraffinnaphthene ratio, and this ratio, together with physical properties, has been used in assessing the probable amounts of various hydrocarbon groups.

GENERAL RESULTS.

The analyses of fourteen crude oils are reported, five from Forest Reserve, four from Guayaguayare, three from Morne Diablo, and two from the Palo Seco field of Messrs. Siparia Trinidad Oilfields, Ltd. The routine analysis of these oils is given in Table I, together with the asphaltene content of the crude oils. The oils are arranged in order of ascending paraffinicity (see Table III), and not in any relation to their geological occurrence. It will be noted that the characteristics of the oils are similar, and that they exhibit the typical properties of paraffinic crude oils : *viz.*, high light fractions, low octane number, low crude oil gravity, low asphaltene content, low sulphur, etc. To these general similarities there are

^{*} In the supplementary analysis described in the J. Inst. Petrol., 1943, 29 (230), 59, a typographical error occurs. The factor for xylene given as $a = 0.39\Delta$ should read $a = 1.39\Delta$.

THE ANALYSIS OF TRINIDAD CRUDE OILS.





















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F1G. 9.



FIG. 10.





THE ANALYSIS OF TRINIDAD CRUDE OILS.



FIG. 13.



FIG. 14.

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Crude Evaluation Data.

152.	23.7.42. 0.7853 48.7 29.0	60-1 60-1 55-1 18-0 56-6	39-9 0-8396 37-0 176-0 39-0	26.9.42. 0.06	
G. 153,	12,10,42, 64.5 27 0	83.2 0.7511 56.9 23.5 59.2	16-8 0.8324 38-5 162-0 35-0	12.10.42. 0.01	
G. 133B.	27.8.42, 0.7895 47.7 29.0	50.2 50.1 21.5 56.5	40.8 0.8406 36.5 180.0 38.0	26.9.42. 0-04	
F.R. 488B,	16.1.39. 0-8510 34-9 39-0	29-2 0-7607 54-5 19-0 58-7	$ \begin{array}{c} 70.8 \\ 0.8003 \\ 27.4 \\ 190.0 \\ 68.0 \\ \end{array} $	2.1.43. 0.09	
F.R. 651	31.8.42. 0-8075 26.2 76.0	0.01 1900 1981 1981 1981	(F.2) 76.7 0.9338 20.0 204.0 332.0	31,8,42, 1,25	
M.D. 11.	17.11.41. 0.8552 34.0 57.0	31.0 0.7581 55.1 235.0 60.3	69-0 0-9001 25-7 208-0 119-0	26.2,43.	
G. 151.	29,10,42, 0.8598 33-1 51.0	23.7 0.7549 56.0 22.5	76-3 0-8935 26-9 202-0 107-0	29.10.42. 0-84	olds, Ltd. holds, Ltd. nolds, Ltd. Palo Sec.
F.R. 637.	2,4,42, 0-8594 33.2 40-0	26.1 0.7592 54.9 21.5 61.8	74-9 0-8930 26-8 196-0 82-0	2,12,42,0.55	dd Leaseh dad Lease ad Leasel elds, Ltd.
M.D. 32.	22.3.42. 0.8736 30.5 68.0	25.3 0.7684 53.9 17.5	$\begin{array}{c} 74.7\\ 0.9100\\ 24.0\\ 170.0\\ 163.0\end{array}$	5,3,43, 0.28	o, Trinida rve, Trinid re, Trinid idad Oilfi
S.T.O.L. 35.	24.7.42. 0-8025 27.0 78-0	23-1 0-7544 56-1 22-0 59-2	76.9 0-9356 19-7 196-0 458-0	24.7.42 3.66	rne Diabl rest Rese ayaguaya aria Trin
F.R. 613	30.6.42. 0.8791 29.5 61.0	20.6 0.7571 55.4 21.5 60.5	$79.4 \\ 0.9109 \\ 23.8 \\ 198.0 \\ 163.0 \\ 163.0 \\ 163.0 \\ 103.0 \\ 103.0 \\ 103.0 \\ 103.0 \\ 103.0 \\ 100 \\$	30.6.42.	$D_{i} = M_{i}$ $G_{i} = G_{i}$ $G_{i} = G_{i}$
F.R. 651B.	23.9.42. 0-8973 26.2 80-0	1.00 0.7702 52.2 20.0 70.8	81.0 0.9256 20.9 190.0 244.0	1.4.43.	* M E S.T.C
8.T.O.L. 20.	31.7.42. 0.8612 32.8 43.0	21-7 0-7687 52.6 12-5 12-5	78-3 0-8875 27-9 208 0 70-0	1.8.42, 0.74	
M.D. 29B.	9.12.41. 0-9179 22-7 98-0	18-2 0-7660 53-1 25-0 71-0	81-8 0-9393 19-2 196-0 186-0	9.4.43. 2.92	
Field.* Well No.	Routine analysis. Dute sample drawn Urude oll : Sp. gr. at 60° F. (dry oll) Grav. dag. A.P.I. (dry oll) Grav. dag. A.P.I. (dry oll) Fisc. Say Univ. at 100° F.	Lotar suprut, a.w., Light reactions (F.B.P. 200° C.); "so of ende off" Spr. gr. at 60° F. "env. Mg. A.T. 100° C. Octane no. of light fractions (A S. T.M.)	% residue (L.B.P. 200° C.) Sp. gr. at 00° F. Grav. dug. A.P.I. Flash point (P.M.), "F Visc. Say. Univ. at 100° F.	Research analysis. Date sample drawn % Asphaltenes in orude, by wt.	

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G. 133B.	1-8 7-0 2-0	20.0	00000000000000000000000000000000000000	27.3	$ \begin{array}{c} 14 & 5 \\ 12 & 8 \\ 1 & 13 \end{array} $	8 975 01-91-91-999 0 08084460999	52.7
F.R. 651.	0.0 2.8 2.1	12.3	⊖∝∞∞,0,0,4,1,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0	33.2	15.6 17.6 0-89	90000000000000000000000000000000000000	54-5
F.R. 488B	0.7 4.6 1.3	14-3	0	31-3	14-05 17-25 0-82	60000000000000000000000000000000000000	54-3
M.D. 11.	2 3 0 9 2 3 0 9	14.5	048-09-0888-84 487-4968648-800	32.4	$16-9 \\ 15-5 \\ 1-09$	0 4 1 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5	53-0
G. 151.	2	17.3	01811510488181 884558948040898	30-0	15.35 14 65 1 05	©≈∞©≈≈≈≠≈≈≈≈≈ ∞∞≠∞∞∞∞≈≠≠∞∞∞≈≠	52.7
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M.D. 32.	0.7 4.6 1.1	13-9	-9760-90-1-999994-1 94600094-29004	37-9	20 5 17 4 1 18	0004000400040004 00004000040004	48-2
S.T.O.L. 35.	1-7 5-0 2-4	16.7	0000	37-2	$ \begin{array}{c} 17 & 7 \\ 19.5 \\ 0 & 92 \end{array} $	0.471004440401 0.4710044400401	46-1
F.R. 043.	1 7 4 9 2 2 4 2 2	16-2	10000000000000000000000000000000000000	42.8	$\begin{array}{c} 21.0\\ 21.8\\ 0.96\end{array}$	0.000004000000 0.0000040000000000000000	40-9
F.R. 651B.	2 2 5 5 0 2 2 5 5 0 2 5 2 5 0	11.9	8896	48-5	24-3 24-2 1-00	40,00000440000000	39-9
S.T.O.L. 20.	0-0-0-0-0-0-0-0-0-0-0-0-0-0-0-0-0-0-0-	19-5	000400400-0040000 0004000000-0000-	41.5	18-75 22-75 0 83	91440999990004099 96669999000009991	39-1
M.D. 29B.	1 5-7 2-9 2-9	20.3	014110100400000 401-40000400000	44-5	$\begin{array}{c} 22 & 35 \\ 22 & 15 \\ 1 & 01 \end{array}$	8 8 8 1 8 1 8 1 8 1 8 1 8 1 8 1 8 1 8 1	35.1
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TABLE II. Analysis of Secondary Distillates. Volume Per cent. Composition. THE ANALYSIS OF TRINIDAD CRUDE OILS.

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Comparison of Paraffinic Trinidad Naphthas.

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	Well No.		M.1 291	80. 8	T.O.L. 20.	F.R. 651B.	F R. 6.3	S.T.O.L. 35.	M.D. 32.	F.R. 637.	G. 151.	M.D. 11.	F.R. 651.	F.R. 488b.	G. 133B.	G. 153.	G. 152.
% on cruc Seconda Aromati Naphthe Paraffine	le : ry distillate ics		4 0129	19 19 28 28	17 99 3 49 7 46 7 04	10 86 1 28 5 27 4 31	20 38 3-30 8-74 8 34	$\begin{array}{c} 21 & 24 \\ 3 & 55 \\ 7 & 90 \\ 9 & 70 \end{array}$	17 56 2 44 6 66 8 46	17 01 2 65 6 39 8 97	17-21 2-98 5-16 9-07	23-03 3-36 7-46 12-21	16 08 1 98 5 35 8 75	31.66 4.61 9.91 17.14	41.65 8.33 11.37 21.95	71-21 12-39 18-87 40-46	50-36 9-72 12-04 28-60
% on seco Aromati Naphthe Paraffin	ndary distilla ics enes	te	20.444		19 4 41 5 39 1	11-8 48-5 39-7	16 2 42 9 40 0	16-7 37-2 46-1	13-9 37-9 48-2	16 6 31 7 52 7	17-2 30-1 52-7	14.6 32.4 53.0	12 3 33 3 54·4	14 3 31 4 54 3	20 0 27-3 52-7	17 4 25 8 56 8	19-3 23-0 56-8
Latio o6/o Latio pars	5 naphthenes Mins/naphthe	* nes	0.0	10	0 83 0 94	1.00 0.82	0-96 0-95	$\begin{array}{c} 0.92 \\ 1-24 \end{array}$	$\frac{1.18}{1.27}$	0-98 1-66	1.05 1.76	1.09 1.64	$\begin{array}{c} 0 & 89 \\ 1 & 63 \end{array}$	0.82 1-73	1.13 1.93	1 30 2 20	1.29 2.38

· See Table II.

exceptions. The octane numbers of light fractions of the oils from Wells 651, 651B, and M.D.29D are higher than are usual, whilst the asphaltene contents of the oils from Wells M.D.29B and S.T.O.L. 35 are high. Despite these exceptions the oils would be classified on the basis of the routine inspection data, as low-octane paraffinic crude oils.

By comparison of the properties of the aromatic-free fractions with the physical constants of pure hydrocarbons and the synthetic mixtures, an attempt has been made to calculate the amounts of individual hydrocarbons or groups of hydrocarbons which constitute the paraffin or naphthene component of the various fractions. The results of these calculations are given in Table II, which lists for each crude oil the amounts of various hydrocarbons as a percentage of secondary distillate. The total paraffin-naphthene-aromatic content of the secondary distillate is given in Table III, both as the percentage in the secondary distillate and as a percentage of the parent crude oil. In Table III there is also recorded the ratio of *cyclo*hexane to *cyclo*pentane derivatives and the ratio of paraffins to naphthenes.

It is not claimed that the analysis given in Table II is anything more than an approximation based entirely on physical characteristics, and no proof is offered at the moment for the presence of any one of the individual hydrocarbons. The modified technique can, however, be carried out almost as quickly as the original and by its use it is possible to differentiate between oils which would otherwise be regarded as the same. A comparison of Figs, 1 and 10 with the data of Table III illustrates this point.

DISCUSSION OF RESULTS.

The Guayaguayare oils are the most paraffinic oils so far encountered. The wells 152, 153, and 133B are producing from the same horizon in the Goudron field, and although the naphthas are identical, the variations in light fraction content are somewhat surprising. Correlation in this area is difficult, and further investigations are being carried out. The absence of heavy ends and the low asphaltene content suggest that the oils have been subjected to some separation effect. Well 151 is situated in the Logeon spur, and the oil may be regarded as typical of the Guayaguayare area.⁴ It will be noted that the naphtha is very similar to the naphthas of the Goudron oils, and for this reason a similar source may be postulated. It is highly probable that the oils of Wells 152, 153, etc., have been formed from an oil of the 151 type.

The Forest Reserve oils are all from the Lower Cruse Horizon. Similar oils have been described previously, and the occurrence of naphthenic oils and oils of mixed character in the sands of the Lower Cruse series has been discussed.¹ The oils herein described are the most paraffinic so far encountered in this area, but the oils of Wells 651B and 643 show clearly the effect of mixing with a naphthenic type oil. The most paraffinic oils—those of Wells 488B and 651—are similar in character and contain less aromatic hydrocarbons than the Guayaguayare oils. Comparison of the oils of Well 151G. and 651F/R. indicates the lower aromatic content of the paraffinic oils of Forest Reserve.

Of the Morne Diablo oils, that of Well M.D.11 is from the Middle Cruse Horizon, whilst the oil of M.29B. is from the Upper Cruse. In this area a good deal of mixing has occurred, and the oil of M.D.29B is obviously a mixed oil. The paraffinic oil of M.D.11 is, however, typical of the Middle Cruse sands, and its similarity to the Forest Reserve oils of Wells 651 and 488B should be noted. Again, the oil is less aromatic than the comparable Guayaguayare oil.

Two oils from S.O.T.L. have been included for reference purposes. Both are from the Cruse series. Here, as at Morne Diablo, the occurrence of mixed oils is a feature of the area, and both oils show the admixture of a naphthenic oil. The high aromatic content is a characteristic feature of the oils from this area.

Reference to Table III shows that the increase in paraffinicity throughout the series is not accompanied by a general increase in aromatic content, and that although the naphthene content decreases with increasing paraffin content, this decrease is not uniform. If, however, the oils from similar areas are considered, it will be seen that the naphthene content decreases with increasing paraffin content, although the aromatic content does not show a uniform increase. It has been shown that aromatic hydrocarbons are normally associated with paraffin hydrocarbons in the naphtha of crude oils, and that in the predominantly naphthenic oils aromatic hydrocarbons are present in the naphtha in very small amounts.^{1, 5} It therefore follows that the crude oils under examination cannot be formed by the simple mixing of two parent crude oils, unless one of the oils has undergone considerable changes in aromatic content. Even within the limited area of the Lower Cruse sands of Forest Reserve, the variations in aromatic content are such as to preclude the formation of the oils by simple mixing of two oils unless it can be shown that the paraffin-aromatic component has undergone changes in aromatic content, as, for example, by adsorption during migration.

There is, however, insufficient evidence to support such a theory, and all that can be stated with certainty is that the paraffin-aromatic oils of Trinidad, although of the one type, exhibit fundamental differences throughout the producing areas examined.

ACKNOWLEDGMENT.

The authors wish to express their gratitude to Dr. C. J. May and Dr. H. G. Kugler of the Production and Geological Divisions for assistance in planning the survey; to Mr. A. E. Gerty of the Refinery Laboratory for data given in Table I, and to Mr. A. J. Ruthven-Murray and the Board of Messrs. Trinidad Leaseholds, Ltd., for permission to publish work carried out in the Company's Research Laboratories.

Thanks are also due to Messrs. Siparia Trinidad Oilfields, Ltd., for permission to publish the analysis of certain crude oils.

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DIAGNOSTIC CHARACTERISTICS OF CRUDE OIL: FLUORESCENCE ANALYSIS IN ULTRA-VIOLET LIGHT.*

By J. N. MUKHERJEE, C.B.E., D.Sc., F.N.I., † and M. K. INDRA, M.Sc. ‡

INTRODUCTION.

It has long been felt, especially by geologists, that a relatively simple method of distinguishing between oils of different origin would have important applications.

The more obvious of these applications are the detection of "salted" or faked oil seepages and the distinction between true oil-shows in the mud returns of an exploratory well and accidental contamination of the mud-fluid by lubricating oil from some part of the drilling rig. It is also necessary to have some means of detecting the presence of traces of crude oil in cores and in surface samples.

A larger sphere of inquiry is presented by the desirability of being able to distinguish between crude oils of different origins. The geologist, in his search for source-rocks, wishes to know whether the oil occurrences of a petroliferous region have the same origin or are derived from different sources. He may also wish to know whether oil occurrences of two neighbouring but possibly related regions have the same or different origins. This aspect of the subject has been summarized in a paper published posthumously from notes prepared by D. C. Barton.¹

It is well known that in one oilfield there may be a large range through which the physical properties of the oil vary. In the Badarpur oilfield in Assam the oil in two of the sands was much lighter in the southern part of the field than in the northern, the flash-point varying from below 80° F. to over 230° F. within three-quarters of a mile. Still more remarkable was the occurrence of a zone with light oil flashing at 70° F. sandwiched between two zones of heavy oil flashing at over 200° F. In the Digboi oilfield of Assam there are several types of oil showing a complex distribution depending partly on horizon and partly on geographical position. A still more striking example is provided by the oilfields of the Punjab. The oil recently found on the south side of the Soan syncline is a heavy asphaltic oil which contrasts sharply with the more normal crude of the Dhulian field on the north of the syncline, although both oils come from the same geological series and presumably from the same geological province.

If in any one of such instances the physically different oils have indeed a common origin we should expect to find some characteristic common to the oils but differentiating them from others which had another origin.

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Again, the oil from seepages is, naturally, often somewhat different from the oil still within the oilsands of the same oilfield, and the usual physical tests may show little or no connection between the two, but as the origin is the same, we should expect to have some distinctive characters present in each.

Many investigations have been made into this problem. One method of approach has been described by Barton. He separated each sample into fractions boiling within successive ranges of 25° C. and determined the specific gravities. The graph connecting specific gravity and boiling-point was termed the gravity-interval pattern, and Barton's figures suggest that weathering had little effect on the pattern, which seemed to be much the same for oils believed to be of the same origin, but differed with oils of different origin. It is doubtful whether enough work has been done to demonstrate the reliability of methods of this type.

Among other possibilities of finding a diagnostic characteristic are the detection of some elements present in very small quantities and the recognition of unusual compounds; the use of infra-red rays is also proving to be a promising line of research. In each case it is only by prolonged investigation that we can hope to distinguish characters which depend on what may be termed accidental variations attributable to the later stages in the history of the crude from the fundamental differences diagnostic of the origin of the crude.

In a search for suitable methods, particularly ones which are rapid in application and capable of employment with small quantities of material, we have begun in Calcutta a number of experiments with ultra-violet fluorescence and chromatography. These have yielded interesting and promising results in the differentiation of true oil-shows from spurious ones (whether accidental or faked), although it has not yet been possible to apply the methods to oils from different geological provinces. The object of this paper is to describe the methods used and give examples of the results obtained, in the hope that criticisms and suggestions will be forthcoming.

There appear to be few published papers bearing on the differentiation of crudes by fluorescence analysis, and these were not available in Calcutta until our investigations had made considerable progress. Our provisional programme included a study of the effects of solvents, concentration, light filters, and fluorescence quenchers on the fluorescence of various oils. We soon found that direct visual observation was insufficiently sensitive, and accordingly developed a technique based on chromatography and capillary analysis.

PREVIOUS WORK.

A. Bentz and R. Strobel ² examined the fluorescence of a drop of oil placed on filter paper beneath a quartz mercury lamp. They noticed that refined oils gave a blue fluorescence, whilst the crudes examined gave yellows and browns. Melhase ³ applied fluorescence analysis to many Californian crudes and noticed that oils from different sands show some difference in their fluorescence. Since our present work was completed we have found that R. Grader ⁴ has described the use of chromatography for separating fractions of crude oil.

METHODS USED.

Fluorescence Quenchers. K. Trautzl⁵ showed that aromatic nitrocompounds remove the fluorescence of mineral oils, and we have used nitrobenzene as a quencher to estimate the strength of the fluorescence. The samples of oil were added to chloroform to give 0.1 per cent solutions, and nitrobenzene diluted ten times with chloroform was added drop by drop until fluorescence was quenched. The number of drops needed was taken as a measure of the strength of the fluorescence.

Spot Test. In this simple test a drop of the oil was allowed to spread on a piece of non-fluorescent filter paper and examined in ultra-violet light.

Fluorescence in Solvents. Another simple test is the examination of the fluorescence given by the oil when in dilute solution.

Capillary Analysis. A strip of non-fluorescent filter paper (20 cm. by 2 cm.) is hung with 5 cm. of its lower end immersed in the solution to be examined. The liquid rises by capillary action until equilibrium is attained in a few hours, the height to which the liquid rises depending on its interfacial tensions, density, etc., and on the nature of the paper. If several substances are present in the solution, the individual solutes tend to separate at different heights, and thus form zones in which they are concentrated. This method, which has been used under the name of capillary analysis, was first developed by Goppelsroeder.⁶ Danckwortt and Pfau ⁷ used this method in conjunction with fluorescence for the examination of solutions containing a mixture of fluorescent substances. It has the advantage of fixing the separated components, and the strips can be used later for comparison, reference, etc.

Chromatography. The use of adsorbents for decolorizing oil dates back to very early days in the refining of petroleum products. Animal charcoal was used at first, followed by clays about 1893, and for many years bauxite has been used in the Burma refineries. The selective adsorption of hydrocarbons and coloured components used in chromatography is thus based on much earlier work in the petroleum industry. This method of separating constituents of complex organic substances was discussed in some detail by Tswett.⁸ The oil to be examined is dissolved in a suitable solvent (for which we used petroleum ether), and the solution run slowly through a column packed with the adsorbent (Brockmann alumina or activated bentonite); the dissolved oil is adsorbed on the surface of the alumina or bentonite in a series of bands which constitute the chromatogram. With oil there is a deep brown zone at the top of the column. below this a yellow region, and the rest of the column is colourless. In ultra-violet light the top region appeared very deep brown, the middle one creamy-yellow, and the rest blue. The different regions of the chromatogram were separated, and chloroform extracts made. These were examined in ultra-violet light to see what fluorescence they had, and then subjected to capillary analysis. To obtain more detailed data we are investigating the results of washing down the chromatogram with successive solvents of gradually increasing polarity. The chromatogram is flushed with petroleum ether until the washing liquid is colourless. The column is then sucked dry and the process repeated with benzol, and

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again with chloroform. The extracts obtained in this way using these three solvents in turn are examined for fluorescence.

The theory of chromatographic and capillary analysis has not yet been fully worked out, but such factors as interfacial tensions, contact angles, polar character of different parts of the molecules of the adsorbent, solvent, and solutes which affect wetting of a surface and the spreading of liquids are considered to be operative in determining the suitability of different solvents and adsorbents for the separation of the constituents of a mixture.

RESULTS.

Samples Used. A number of samples were of crude oil from the Digboi oilfield, Assam, others were refined oils from the same source, two were artificial "crudes," and one was a chloroform extract of a resin. The Hanovia Universal Fluorescence lamp was used as a source of ultra-violet light.

Fluorescence Quenchers. Using the amount of nitrobenzene needed to remove the fluorescence as a measure of the intensity of the fluorescence, we found that one crude gave a value of 55 (on an arbitrary scale) and seven others between 25 and 35, whereas the resin extract gave only 15 and the artificial "crudes" only 8 and 10.

Spot Test. The tests of kerosine, three spindle oils, turbine oil, and crank-chamber oil all gave a blue fluorescence when a spot was placed on filter paper. A cylinder oil differed, having a greenish-blue outer ring with a yellowish-green central part. The crudes varied, one yielding only a deep yellow colour and the other a blue outer ring with yellow inside this and a grey centre. The artificial "crudes" had no yellow rings and gave black centres.

Fluorescence in Solvents. Examination of the fluorescence of different oils in solution in chloroform, benzol, acetone, and carbon tetrachloride has shown that the heavier refined oils give fluorescence with much smaller concentrations than either the lighter refined oils or the crudes. In chloroform, benzol, and acetone blues are dominant, and there is not much contrast between the oils of different origin. In carbon tetrachloride, however, the refined oils tend to be blue and the crudes yellow, but there are several exceptions. In general, fluorescence tests using solvents are less helpful than the spot test, but by the use of a series of solvents it is possible to distinguish between different samples.

Capillary Analysis. Chloroform was found to be the most suitable solvent, and 1 per cent solutions of the oils were used. The simpler refined products gave blue zones extending throughout the area in which the filter paper had absorbed the solution, but the eylinder oil and a benzene solution of bitumen gave non-homogeneous fluorescence. The crude oils give blue and yellow, or blue, yellow, and brown. The artificial crudes included a grey tinge, and resin extract a bluish-green.

Whilst the fluorescence observed in the solution of an oil in a test-tube is the resultant of the fluorescences shown by the different groups of compounds in the oil, capillary analysis provides an easy method of effecting a partial separation of crude oil into constituents showing different fluorescence on filter paper. The crudes examined showed yellow fluorescence both in the spot test and (especially) in the capillary analysis, and it seems probable that by carrying out the tests under standard conditions it would be possible to distinguish not merely between crude oil and refined products, but even between fairly closely related crudes.

Chromatography with Alumina. Three samples of crude were examined and two samples of artificial "crude," all being added as a dilute solution in petroleum ether. The top, middle, and bottom of the chromatogram were separately extracted with chloroform and the fluorescence examined. In each case the extract from the top was creamy-yellow and that from the bottom blue, there being some difference in depth of colour; the extract from the middle portion gave results which were slightly different, the crudes giving light yellow changing to blue or brown on dilution, and the artificial "crudes" light blue. These results did not appear to be sufficiently striking to be by themselves of great diagnostic importance, but better evidence was obtained by capillary analysis of the three extracts, the crude oils giving almost similar fluorescence differing appreciably from the artificial "crudes." The true crudes showed yellows and browns for the extracts from the top and middle parts of the columns, and greenishblue and yellow for the extracts from the bottom bands. The artificial "crudes" were much more blue in the extracts from the middle and bottom bands.

A variant of this method of combining chromatography with capillary analysis was tried, consisting of fractional washing with solvents of increasing polarity. Petroleum ether containing 1 per cent of the oil was slowly passed through the alumina which had been previously wetted by the solvent. The chromatogram was washed successively with petroleum ether, benzol, and chloroform until the liquid coming through was colourless. The extracts so obtained were evaporated and the residue dissolved in chloroform to enable the fluorescence to be studied both directly and by capillary analysis. Three natural crudes and an artificial "crude" were examined, and the best differentiation was found in the capillary analysis of the extract in petroleum ether. The artificial "crude" gave the blue colour characteristic of refined oil, whilst the true crudes gave either yellow or blue and yellow zones. There was close resemblance between two of the crudes, but the third is clearly of somewhat different character. Differences in the extracts in benzol and chloroform were not so distinctive.

Chromatography with Bentonite. Three samples of crude and one of artificial "crude" were examined. About 40 grams of bentonite from Kashmir, activated by boiling with dilute sulphuric acid, washing, drying, powdering, heating to 400° C., and cooling in a desiccator, were packed in a glass tube of 1.5 cm. diameter. The column was moistened with benzine ($60-80^{\circ}$ C.), and 1 c.c. of oil in 100 c.c. of the benzine was allowed to pass slowly down the column. The liquid passing through was collected in two batches, the first one being colourless and the second portion of light greenish-yellow colour. The column was then washed with pure solvent. The development of the chromatogram was continued till the filtrate again appeared colourless. In ordinary light the chromatogram was deep brown at the top, then pink, and the remainder grey. The brown and pink regions were separated and the grey region arbitrarily

divided; each portion was extracted with chloroform and the solutions examined in ultra-violet light and by capillary analysis. The extracts from the chromatograms of the four samples showed very little differences, but the filtrate that passed through the bentonite showed interesting differences. The coloured filtrates from the three true crudes showed greenish-yellow fluorescence in the capillary analysis, but the artificial " crude " had a blue fluorescence. A further experiment was made with the bentonite filtrates from each of the three crudes : the residual oil from the filtrates was obtained by distilling off the benzine, and this was dissolved in chloroform to give equal concentrations. It was found that the oils obtained from the colourless filtrates gave blue fluorescence, samples A and C being a much deeper blue than B. With the oils obtained from the coloured filtrates, A and C were again alike, but in this case they gave a lighter blue than B. The close resemblance of A and C, and their slight difference from B, are in line with the results of the extracts from the chromatogram formed on alumina.

GENERAL CONCLUSION.

By the combination of spot tests and capillary analysis with filter paper it was possible to distinguish with ease and comparative rapidity between the refined oil samples, the crude samples, the artificial "crudes," and an extract of resin. One of the samples of crude oil was found to be distinctly different from the others. The intensity of fluorescence, as determined by the amount of nitrobenzene needed to quench fluorescence, is different for different oils, and there seems to be a difference between the true crudes and the artificial ones. These results suggest a simple means of testing whether supposed oil seepages or oil-shows in the mud returns of an exploratory well are genuine. The method also suggests ways of making a reliable test of samples collected during geological mapping or obtained by coring, when it is desired to know if traces of oil are present.

The chromatographic separation of the oils into different fractions and subsequent capillary analysis of those fractions is a longer process, but the work done in Calcutta suggests that it may be possible to develop the method for the diagnosis of different types of crude oil.

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SOME CHINESE CLAYS AS ADSORBING AGENTS.*

T. J. SUEN † and F. H. YAO.†

In a previous paper ⁷ it was reported that "white clays" produced in Szechuan could be used to reduce the gum content of gasoline obtained by cracking of vegetable oils. As a continuation of that work some more clays produced in Nanchuan and Tsunyi have also been tried. They seem to be more suitable than the white clays previously studied, and while further work is still being carried on, this paper reports some of the results so far obtained.

DESCRIPTION OF THE CLAYS.

The geology of Nanchuan clays has been only very briefly studied.⁴ It is known, however, that there occur different varieties of different chemical compositions, with the silica content varying from less than 20 per cent. to more than 60 per cent. Two samples obtained there were studied. The first was of low silica content, of which the following properties were observed. It was white-coloured, with a slightly greasy feel, and adheres to the tongue. It disintegrated in water. When methylene-blue solution was treated with the powdered material, the former was decolorized. It did not turn blue-litmus red, but bleached it, neither did it show any distinctive base-exchange capacity when treated with sodium chloride solution. Its chemical composition is shown in Table I. As a mineral species it should be classified as collyrite.²

The other clay sample from Nanchuan was of high silica content, yellowish-grey in colour, and slightly adhering to the tongue. It was not dense, and readily disintegrated on squeezing. Its reactions towards water, methylene-blue, litmus, and sodium chloride solutions were the same as those of the previous sample. It belongs to the species cimolite (Table I).

The third sample was obtained from Tsunyi. The geological information concerning this clay is also very meagre.⁶ It was reddish-white in colour, waxy, adhering to the tongue. When placed in water it became translucent, with an increase of one-fifth in weight. Its powder was able to bleach methylene-blue solution and turn blue-litmus red, and showed distinctive base-exchange capacity—*i.e.*, sodium chloride solution when treated with it became acidic to litmus. It belongs to the species halloysite (Table I).

In order to increase the adsorbing power of the clay, the collyrite was acid-treated in various ways. One portion of it was treated by a method similar to Salmi's.⁵ One kilogram of the clay was boiled with 2000 ml. of sulphuric acid solution of 15 per cent. strength for 3 hours. The mixture was settled, decanted, and washed with distilled water until no acid could be detected in the washings. It was then filtered, dried at 100° C., and

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ground to pass a 100-mesh screen. The acid-treating leached out about 35 per cent. of the original material.

Another portion of the collyrite was treated similarly by dilute hydrochloric acid. The concentration of the acid used was 11 per cent. and the weight leached out was 32 per cent. of the clay.

According to Nutting,^{3, 5} for certain types of clay the addition of certain salts, such as iron, aluminium, and magnesium salts, to the treating acid would impart a higher activity to the clay than would be caused by treating with acid alone. With this point in view, a further portion of the collyrite was treated with a 15 per cent. sulphuric acid solution containing 1 per cent. each of ferrous sulphate, aluminium sulphate, and magnesium sulphate. The method of treating was the same as above. The weight of material leached out amounted to 25 per cent.

The chemical compositions of all the samples, treated and untreated, and their designations are given in Table I.

TABLE I.

Analyses of Clay Samples.

Designation :	I.	II.	III.	IV.	V.	VI.
Species :	Colly- rite.	I, treated with H_2SO_4 .	I, treated with HCl.	I, treated with H ₂ SO ₄ - sulphates.	Cimo- lite.	Halloy- site.
Moisture, % Loss on ignition, % SiO ₂ , % Al ₂ O ₃ , % F σ_2O_3 , % CaO, % MgO, % Na ₂ O, et al., %	$\begin{array}{r} 4 \cdot 08 \\ 34 \cdot 23 \\ 12 \cdot 82 \\ 42 \cdot 94 \\ 0 \cdot 40 \\ 2 \cdot 04 \\ 1 \cdot 94 \\ 1 \cdot 55 \end{array}$	$ \begin{array}{r} 1 \cdot 92 \\ 38 \cdot 24 \\ 18 \cdot 50 \\ 33 \cdot 08 \\ 0 \cdot 62 \\ 0 \cdot 52 \\ 0 \cdot 71 \\ 6 \cdot 41 \\ \hline 100 \cdot 00 \\ \end{array} $	$ \begin{array}{r} 1 \cdot 58 \\ 39 \cdot 04 \\ 18 \cdot 20 \\ 32 \cdot 20 \\ 1 \cdot 00 \\ 0 \cdot 44 \\ 0 \cdot 14 \\ 7 \cdot 40 \\ \hline 100 \cdot 00 \end{array} $	3.76 39.60 20.84 30.20 1.00 0.30 0.35 3.95 100.00	$ \begin{array}{r} 1 \cdot 14 \\ 4 \cdot 57 \\ 62 \cdot 80 \\ 23 \cdot 50 \\ 2 \cdot 11 \\ 1 \cdot 01 \\ 1 \cdot 05 \\ 3 \cdot 82 \\ 100 \cdot 00 \\ \end{array} $	$ \begin{array}{c} 11.02\\ 12.89\\ 35.40\\ 33.39\\ 2.73\\ 1.17\\ 0.13\\ 3.27\\ \hline 100.00\\ \end{array} $

DECOLORIZATION OF OILS.

The decolorization power of the clays was tested with three different kinds of oils—*i.e.*, vegetable gasoline, rape-seed oil, and light lubricating oil. The gasoline samples, produced by cracking of tung oil, were obtained in this plant. They were unrefined and untreated and reddish-coloured. The rape-seed-oil samples were bought from the local market. The lubricating-oil samples consisted of medium cuts from Yümen crude oil, fractionated under vacuum. The distillates were stored in glass bottles without any treatment for several months. Before testing with clays they were partly dewaxed by chilling and filtration.

In making the decolorization tests, 20-ml. oil samples were mixed respectively with 0.1 g., 0.2 g., 0.5 g., 1.0 g., 2.0 g., 3.0 g., etc., of clay powders in test-tubes. They were heated with shaking and stirring at the desired temperature in an oil-bath for a definite length of time. For gasoline samples the duration of heating was 5 minutes, while for the other two kinds of oils it was 10 minutes. They were then filtered, cooled, and their colour intensities compared in a Klatt colorimeter. A blank was always included.

It should be mentioned that different-coloured components in the oils were not uniformly removed by the clays. For instance, a reddish-coloured oil after clay treatment became more or less greenish in appearance.



FIG. 1.

That is, the clay was more effective in removing the colour in the red region than that in the green region. For ease of comparison, an oil sample was always compared with one treated with the nearest amount of clay—e.g., rape-seed-oil sample treated with 0.2 g. of clay was compared with the blank, and that treated with 0.5 g. of clay compared with that treated with 0.2 g. of clay, etc. The results were calculated in terms of per cent. of original colour in the blank unremoved, assuming that the colour intensity is inversely proportional to the depth of liquid column under examination in the colorimeter.

The experimental results are given in Tables II to IV. Some of them are plotted in Figs. 1 to 3.



FIG. 2.

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Decolorization of Gasoline.

Clay.	Oil.*	Temp., °C.	%	Colour	Unrem	oved at 20 m	ter Tre I. Oil.	ating, g	g. Clay j	per
			0.1.	0.2.	0.3.	0 ∙5.	0.7.	1-0.	$2 \cdot 0.$	3 0.
I	G-1	90				59		44	33	
II	G-1	30	39	30	_	18	17		_	
II	G-1	90	52		29	22	17		11	8
III	G-1	30	42		27	21	17	16	_	—
III	G-1	90	66		26	24				
III	G-2	30	80		70	63		56	47	43
III	G-2	90	82		62	56		51	45	44
IV	G-1	30	45		32	28		23		
IV	G-1	90	50		25	25				
v	G-1	30		71		52		35	_	18
V	G-1	90		71		47	·	41	28	27
VI	G-2	30	77		67	60		53	44	42
VI	G-2	90	73		56	46	-	38	35	34

* Colour of original gasolines in A.S.T.M. colour number : G-1, 2 minus; G-2, 14.



TABLE III.

Decolorization of Rape-seed Oils.

Clay.	Oil.*	Temp.,	% Co	lour Unre	emoved af 20 m	fter Treat l. Oil.	ing, g. Cla	y per
			0.2.	0.5.	1 .0.	1.5.	2.0.	3.0.
I	R-1	110		75	65		55	
I	R-1	200			77		68	62
II	R-1	110	75	61	44		25	10
II	R-1	180		74	56	_	33	19
III	R-1	30	84		60	_	45	39
III	R-1	110	_	69	46		26	14
III	R-1	180	85	67	51	_	35	25
III	R-2	110		60	48	33	28	16
III	R-2	180		62	44	35	26	16
IV	R-1	110	80	67	49		30	13
IV	R-1	180	_	67	48		25	15
V	R-1	180	_	84	72	_	57	46
VI	R-2	110		63	42	31	25	15
VI	R-2	180		55	35	22	18	11
							1	

* Colour of both the original oils in A.S.T.M. colour numbers is 31 minus.

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Clay.	Oil.*	Temp., ° C	% Colou	ir Unremov	ved after Tr 20 ml. Oil.	reating, g.	Clay per
			0.5.	1.0.	1.5.	2 ·0.	3.0.
II III III III III V VI VI	L-1 L-1 L-1 L-2 L-2 L-2 L-1 L-2 L-2	200 110 180 200 110 180 180 110 180	59 75 77 64 68 67 70 65 58	49 67 64 53 60 53 60 51 40		39 60 50 43 43 38 53 35 22	35 59 46 41 30 27 52 26 16

TABLE IV. Decolorization of Lubricating Oils.

* Colour of the original oils in A.S.T.M. colour number: L-1, 8 minus; L-2, $4\frac{1}{2}$ minus.

DEGUMMING OF GASOLINE.

The procedure for degumming tests was a modification of the vapourphase treatment method previously described.⁷ A 500-ml. round-bottom flask was fitted with a Pyrex-glass column of 35 mm. inside diameter and about 30 cm. high, which in turn was fitted with a thermometer and connected to a condenser. The outside of the column was wound with one or two layers of asbestos twine to prevent excessive heat loss. One hundred grams of the clay under investigation were packed in the column, covering a depth of about 14 cm.

The clay packings in the column were in the form of either tablets or granules. As the acid-treated collyrite disintegrated completely to a fine powder, it was pressed into tablets about 12 mm. diameter and 4-5 mm. depth. The untreated clays were simply broken into granules and screened. The 3-4-mesh size was used for packing. The halloysite granules firmly retained their form, without any disintegration after long use. The collyrite and cimolite granules, however, were not very strong. They formed an appreciable amount of small particles during the time of use, and might cause some trouble by clogging up the column. This fact may be of considerable importance from the engineering point of view.

The gasoline samples employed were very low-grade products obtained in the plant by cracking of tung oil. They contained considerably more higher-boiling fractions than are commonly included in gasolines. A 200-ml. portion was used in each distillation over the clay. Only the fractions boiling up to 200° C. were collected. The residue, in average amounting to about 20 per cent. of the charge, was discarded before the next 200-ml. gasoline sample was distilled. Each distillation took about 20-30 minutes. The clay-treated distillate was washed with alkali and water and its gum content determined by the copper-dish method.⁹ Blank tests with the column packed with the same volume of broken porcelain were also carried out. During the treatment the clays gradually blackened, indicating that chemical reactions were taking place.

The stability of the clay-treated gasolines was also tested. Composite

samples were stored in glass bottles and placed in the dark. The colour intensity, acid number, and gum content of these samples were determined from time to time.

The experimental results are given in Tables V and VI.

TABLE V.

Gum Cont	lents of	Clay-treate	d Gasolines	(mg.	per	100 ml.	.).
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No	o. of	Cut.		Clay I.	Clay II.	Clay V.	Clay VI.
Gasoline	э.			G-3	G.3	G.3	G-4
Blank				285	285	285	189
lst			-	277	35	53	
2nd				257	54		1
3rd		•	•	282	63	45	_
4th		•		222	00	10	13
5th		•	•	239	27	56	10
6th		•	•		65		22
7th	•	•			52	66	
8th		•	•		134(2)	00	36
9th	•	•	•		59	67	
loth		•	•		126	59	30
llth	•	•	•		00		00
12th		•	•		139	45	26
13th	•	•	•		200	45	20
14th	•	•	•		200		20
15th	•	•	•			40	02
l6th	•	•	•				31
17th	•	•	•			63	01
18th	•	•	•			00	91
loth	•	•	•			191	41
20th		*	•			100	
20011 22nd	•	•				100	12
24th	•	•	•				16
26th		•					15
20011 98th	•	•					10
20th	*	•					29 96
JUUI	•	•	•			_	50

TABLE VI.

S	ta	bil	ity	of	Clay	<i>i-trea</i>	ted (Fasol	ines.
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Time After Treating.			Gasoline	e G-3 Trea Clay V.	ted with	Gasoline G-4 Treated with Clay VI.		
			Colour.*	Acid No.	Gum.†	Colour.*	Acid No.	Gum.†
Fresh . 1 week 2 weeks 1 month $1\frac{1}{2}$ months 3 months 7 months	• • • •	•	2·5 3·3 4·2 	 0.40 0.26	64 30 60 	0·2 0·3 0·3 0·4 0·5 0·7 —	0·24 0·14 0·19 0·35 0·30	36 31 29 -36 16 49

* Colour intensity is that equivalent to % $K_2Cr_2O_7$ solution $\times 10^3$. † Gum content in mg. per 100 c.c., determined by copper-dish method.

DISCUSSION.

The various clay samples showed different degrees of effectiveness in the individual treatments. In general, the Tsunyi halloysite stands out as the most active among all the clay samples studied. Its gum-reducing capacity is particularly impressive. As shown in Table V, after thirty distillations it was still useful. The experiments were discontinued only because the gasoline sample in use was exhausted. The cimolite is effective as a gum-reducing agent, but its decolorizing power is poor. The untreated collyrite is hardly useful, and becomes active only by acid treatment. The different processes of treating the collyrite bring about very slight variations in the decolorizing power. The choice of sulphuric acid or hydrochloric acid is therefore inconsequential, and the addition of salts shows no beneficial effect.

The acid treatment of clay is a tedious process. In the present circumstances it is not advisable to carry it out on a large scale. For this reason no attempt was made to acid-treat the cimolite and halloysite.

Among the oil samples investigated, the resistance to bleaching varies with the individual oil samples, as shown in Tables II to IV. The effect of temperature during the decolorization is quite noticeable, the optimum temperature of treatment being different in different cases. For the gasolines, moderate temperatures seem to be suitable. For the rape-seed oils, 110° C. gives better results in most cases. For the lubricating oils, temperatures of 180–200° C. appear to be more advantageous than lower temperatures.

It is sometimes considered that a clay with a higher ratio of silica to alumina has a greater adsorbing power.⁵ This does not agree with the data obtained here. The halloysite has a much lower ratio of silica to alumina than the cimolite, but shows a far greater activity.

As a gum-reducing agent the halloysite may be advantageously applied industrially. With the data given in Table V, a simple calculation shows that 1 ton of clay will yield at least 12,000 gallons of gasoline with a copper-dish gum content below 30 mg. per 100 ml., stable at least for a few months, which is quite permissible for ordinary uses. At the prevailing prices of the items involved, the cost of clay treatment of the gasoline is estimated to be only a fraction of 1 per cent. of the total cost. Moreover, according to the experience of the Universal Oil Products Company of Chicago, when converting the yield of gasoline per unit quantity of clay from the laboratory-test data to plant scale a factor of at least 10 should be multiplied.⁸ If this is also true in the present case, the cost of treating with clay could be further reduced.

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SECOND LIST OF DEFINITIONS.*

BY STANDARDIZATION SUB-COMMITTEE NO. 11-NOMENCLATURE.

THE first list of definitions prepared by the Standardization Sub-Committee No. 11 was published in the September 1944 issue of the *Journal*. The present list extends the number of terms defined, and it is hoped from time to time to publish further lists dealing with other phases of petroleum nomenclature.

The definitions and descriptions of terms used in the petroleum industry which appear in this list represent the usual meanings ascribed to such terms inside the industry. It should be appreciated that the Institute of Petroleum does not consider itself, as a body, responsible for any legal interpretation which might be placed upon these definitions.

The membership of Sub-Committee No. 11 is as follows :--

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- Aromatics. A group of hydrocarbons, of which benzene is the parent. They are called "aromatics" because many of their derivatives have sweet or aromatic odours. These hydrocarbons are of relatively high specific gravity and possess good solvent properties. Certain aromatics have valuable anti-knock characteristics. Typical aromatics are : benzene, toluene, xylene.
- Asphalt. Natural or mechanical mixtures in which bitumen is associated with inert mineral matter. The term is normally qualified by indication of type or origin—e.g., lake asphalt, natural asphalt, etc. In the United States this term is generally used to describe the material known in the United Kingdom as Asphaltic Bitumen or Bitumen (q.v.)Asphaltic Bitumen or Bitumen. Black to dark brown solid or semi-solid cementitious material, which consists essentially of hydrocarbons or hydrocarbon derivatives, and which gradually liquefies when heated. These materials are usually obtained as residues from the distillation of petroleum. See also Blown Bitumen.

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- Asphaltic Cement. Asphalt or bitumen, or blends of these with one another or with flux oils, such that the product is a binder having cementing qualities suitable for the manufacture of asphalt pavements, mastics, etc.
- Aviation Gasoline. Specially blended grades of gasoline suitable for use in aircraft engines. These fuels have high anti-knock ratings, high stability, a high overall volatility, and low freezing points.
- Benzene. A pure aromatic hydrocarbon (q.v.) of characteristic odour occurring in significant proportions in certain Far Eastern crude oils, but usually obtained from by-products of the carbonization of coal.
- Benzine. An out-of-date term for gasoline.
- Benzole. A mixture, predominantly composed of aromatic hydrocarbons obtained as a by-product of the carbonization of coal, either from coal gas by absorption or from coal tar by distillation. This mixture, after washing and rectification to concentrate the benzene and eliminate undesirable constituents to any desired extent, is classified in Great Britain according to purity as "Motor Benzole," "Industrial Benzole," "90's Benzole," "Pure Benzole," and "Pure Benzole for Nitration." Recognized specifications for these British grades are issued by the National Benzole Association.
- Black Oils. A general term applied to the heavier and darker coloured petroleum products such as heavy diesel fuel, fuel oil and some cylinder stocks (q.v.).
- Bloom. The bloom of an oil is its colour by reflected light when this differs from its colour by transmitted light. Many petroleum oils which appear red or yellow by transmitted light exhibit a blue or green bloom.
- Blown Bitumen. A semi-solid or solid product obtained primarily by the action of air upon hot bitumen, with a resultant increase in the melting point.
- Bright Stock. A lubricating oil of high viscosity prepared from a cylinder stock by further refining—e.g., solvent extraction dewaxing, acid treatment, and/or earth treatment.
- Bunker Oils. Any fuel oil or diesel fuel taken into the bunkers of ships.
- Bunker Fuel. See Bunker Oil.
- Cracking. A process whereby the relative proportions of products obtainable from an oil may be altered by bringing about changes in the chemical structure of the constituent hydrocarbons. These changes characteristically involve increasing the yield of lighter and lower-boiling material at the expense of the heavier and less volatile. A primary purpose of the cracking process is the production of gasoline from heavier distillates.

In some processes, the essence of cracking operations is the subjection of the raw material to high temperature for a limited time; such an operation is known as "thermal cracking" as distinct from "catalytic cracking," a development in which the essential feature is that the operation is carried out in the presence of a substance—*i.e.*, the catalyst—which promotes the cracking of the oil.

Cutback. Bitumen which has been rendered liquid by the addition of a suitable diluent such as white spirit, kerosine, or creosote.

Cylinder Stock. Dark-coloured residual lubricating oil of high viscosity used as the basis of steam cylinder oil.

- Ethyl Fluid. The proprietary name for a brand of anti-knock compound containing tetraethyl lead (q.v.) as the active constituent.
- Extreme-Pressure Lubricant. A term which is applied to a lubricating oil or grease which contains a substance or substances specifically introduced to increase film strength—*i.e.*, to increase the ability of an oil or grease to maintain the surfaces of highly loaded gears in a satisfactory condition.
- Flux Oil. An oil of low volatility suitable for blending with bitumen or with asphalt, to yield a product of softer consistency or greater fluidity. Selected residual fuel oils may be used for this purpose.
- Gear Oil. An oil suitable for the lubrication of gears. Gear oils vary in characteristics according to their specific application.
- Hypoid Lubricants. Types of extreme-pressure lubricants (q.v.) used for the lubrication of hypoid gears.
- Lake Asphalt. Natural asphaltic material occurring in surface deposits in natural depressions of the earth's crust.
- Natural Asphalt. Mixtures occurring in nature in which bitumen is associated with inert mineral matter.
- Mastics. Bituminous preparations of various viscosities employed in many branches of building work—e.g., as an adhesive and waterproofing agent when bedding wood-block flooring on concrete, etc.
- Octane Number. The octane number of a gasoline is a measure of its antiknock value. The higher the octane number, the higher the antiknock quality of the gasoline.

This quality is determined in a standard engine by matching for detonation the gasoline under test against a mixture of *iso*-octane and normal heptane, both pure hydrocarbons, the percentage by volume of *iso*-octane in that mixture being noted as the octane number.

- Road Oil. An oil intended for cold application to road surfaces for binding and water-proofing purposes. Petroleum residues and light cutbacks are among the products used as road oils.
- Tetraethyl Lead. A volatile lead compound which, when added in small proportions to gasoline, increases the octane number (q.v.). For this purpose, tetraethyl lead is used in the form of ethyl fluid.