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THE CLASSIFICATION OF OIL SHALES AND CANNEL COALS.*

By A. L. DOWN, Ph.D., A.R.C.S., D.I.C., and G. W. HIMUS, Ph.D., M.I.Chem.E., A.R.C.S.

SYNOPSIS

Attention is directed to the confusion that exists in the nomenclature and classification of naturally occurring oil-yielding materials. A system of nomenclature based on the principal plant and mineral constituents and a classification showing the inter-relationships and gradation of properties of these substances is put forward.

AT the Plenary Session of the Conference on Oil Shale and Cannel Coal, held at Glasgow in 1938, a resolution [1] was passed "That the Council of the Institute of Petroleum be invited to take steps to secure a standard nomenclature of the various oil-producing materials discussed or described in the various papers submitted to the Conference." The urgent need for such a standardized nomenclature, and also for a rational classification, is apparent from even a brief study of the literature. The object of the present paper is to suggest a rational system of nomenclature, coupled with a tentative classification which shall show the inter-relationships between the various classes of oil-yielding materials. While it is realized that the proposed classification is not final, in the opinion of the authors it is based on the most satisfactory data available, and may serve as a foundation on which further classifications can be developed as our knowledge of the chemistry of these materials increases.

Great confusion has arisen from two main causes—firstly, owing to the indiscriminate use of the terms "oil shale" and "cannel coal," and secondly, due to the great variety of names which have been applied by different investigators to one particular type of substance. Thus, different deposits containing large numbers of algæ † (*i.e.*, similar to that at Torbanehill, Scotland) have been variously referred to as "torbanite," "boghead coal," "algal coal," "albertite," "stellarite," "bathvillite," "bituminite," "kerosine shale," "brown cannel coal," "petroleum-oil-cannel-coal," "wollongite," etc., the last four being special names which have been applied at various times to the New South Wales "boghead" or "torbanite." Of these names, only "algal coal," which was suggested by Bertrand and Renault,[2] gives any indication as to the nature of the material. In any new system of nomenclature it is essential, first, to avoid names which have been widely misused hitherto, and secondly, to employ terms descriptive of the main constituents of the materials.

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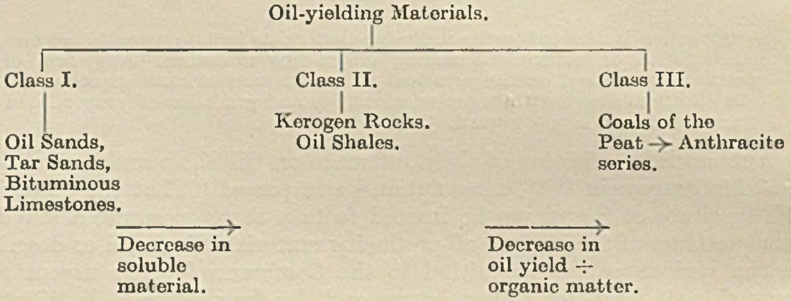
* Paper received 11th July, 1939.

† Although there has been much controversy as to the precise nature of the yellow bodies originally called "algæ" by Edgeworth David in 1889, the researches of K. B. Blackburn and B. N. Temperly [5] have, in the opinion of the authors, satisfactorily settled the question in favour of the algal theory.

Primary Classification.

Examination of the naturally-occurring materials from which oil can be obtained by heat treatment shows that they fall into three main classes : Class I, substances from which the greater part of the organic matter can be extracted by the normal solvents for petroleum; Class II, substances which yield 50 per cent. or more of their organic matter as an oil on heat treatment, but from which only a small proportion of the organic matter can be extracted by solvents; and Class III, material formed almost entirely from highly altered plant remains which yield only about 15 per cent. of the organic matter as oil.



These main groups are by no means sharply defined, and intermediate types are frequently met. Thus, R. H. McKee, working on a sample from Ione, California, obtained 10·98 per cent. extract with acetone and 10·16 per cent. extract with chloroform, both of which are equivalent to approximately 50 per cent. of the oil yield on distillation. The gap between Classes II and III is bridged by the variety of materials commonly referred to as cannel coals.

The scope of the present paper is confined to Classes II and III, the detailed work required for its extension to Class I not yet having been carried out.

Since the names " oil shale " and " cannel coal " have been frequently misused, and since the term " oil shale " is misleading, whilst " cannel " gives no indication of the nature of the material to which it is applied, it is advantageous to avoid using either. True oil shales contain no oil as such, the oil is only formed by the destructive distillation of the organic matter, to which Crum Brown applied the name " kerogen," or " oil-former," thus the materials in Class II may be given the general group-name " kerogen rocks." An important distinction between kerogen rocks and coals is the high proportion of mineral matter in the former. For the materials bridging the gap between Classes II and III (formerly known as " cannel coals ") the general name " kerogen coals " is suggested since the organic matter yields a relatively high proportion of oil and they are frequently associated with coals.

Whereas the banded constituents of bituminous coals may be sub-divided solely on a basis of the organic matter, the relatively small percentages of associated minerals being unimportant, in dealing with the kerogen rocks the chief mineral constituents must be taken into account. Only the general differences can be detected from the examination of hand specimens and, in the present state of our knowledge, the only satisfactory method of classification of kerogen rocks is one based on their principal organic constituents, as revealed by microscopic examination, and the nature of the associated mineral matter as determined by chemical analysis.

General Considerations on Kerogen Rocks and Kerogen Coals.

It is generally accepted that in the great range of organic deposits of sedimentary origin, the source-material was vegetable matter, and animal remains played little or no part. Strong support for this view is found in the work of H. R. J. Conacher,[4] who made comparative tests on (*inter alia*) normal Levenseat oil shale and on a sample from a band crowded with shells of lingula; he found that although the shells caused considerable increase in the percentage of ash, the yields of oil, when calculated on the dry, ash-free basis, were identical within the limits of experimental error. Moreover, there was no appreciable difference between the specific gravities and setting points of the oils from the normal shale and the lingula band.

The existence of such a great range of related materials can be attributed to two primary causes: (i) differences in the original plant materials, and (ii) differences in the conditions of deposition and the subsequent history of the deposits. The number of intermediate materials exhibiting a gradation of properties arises from the possibilities of mixtures of the source materials in various proportions and the limited number of proximate plant constituents. There is no evidence to suggest that there has been any essential alteration in the composition or constitution of these proximate plant constituents through the ages.

Kerogen Rocks.

The kerogen rocks are sedimentary deposits, containing organic matter, of which approximately 50 per cent. is yielded as an oil when the rock is heated to about 500° C.; they are very widely distributed, occur in continuous seams, covering considerable areas, and may differ widely in age. They are not usually intimately associated with coal seams. The kerogen content is very variable, and may range from 50 per cent. upwards to practically zero.

Examples of kerogen rocks of very different geological ages are: Esthonian (Lower and Middle Ordovician), Swedish (Silurian), American (Tertiary), Australian and Brazilian (Recent).

The great majority of kerogen rocks, when examined in thin sections under the microscope, show unresolvable masses of macerated plant debris containing a few spores and/or algæ. This organic matter can only be called "kerogen," hence the rocks may be logically designated "kerogen shales" or "kerogen limestones," according to the preponderating mineral constituent. Samples are found in which the organic matter consists in great measure of spores or algæ and where these recognizable constituents preponderate, it is suggested that the word "kerogen" should be replaced by the name of the recognizable constituent which predominates.

Typical photomicrographs of representative kerogen rocks are shown in Figs. 1 to 4.

KEROGEN COALS.

Kerogen coals are carbonaceous materials in which the organic matter is preponderant; they occur in lenticular patches, usually over a very limited area, and often associated with bituminous coals, with which they may form a compound seam, or into which they may grade either laterally or vertically. The majority of kerogen coals which have been described are of Carboniferous or Permo-Carboniferous age.

Under the microscope, thin sections show that the kerogen coals contain much macerated plant debris with considerable numbers of either algæ or spores, or both spores and algæ.

A number of these materials have been illustrated and described by W. J. Skilling.[6] Among these are the following: Lower Dysart, Fife, yielding 23·1 per cent. ash, is an algal coal; the Humph (16·2 per cent. ash) is a spore coal, while the 18-inch seam, New Cumnock, Ayrshire (16·2 per cent. ash), which contains both algæ and spores, is an intermediate type, or an algal-spore coal. Other examples of algal-spore coals are the Mercer, Pennsylvania, illustrated by R. Thiessen,[7] and the Kentucky, illustrated by E. C. Jeffrey.[8]

Deposits are known the organic constituents of which are similar to those of an algal coal, but which contain large proportions (50 per cent. or more) of mineral matter, predominantly clay, and owing to this high mineral content, these materials must be classified as algal shales, forming a link between the two main groups of kerogen rocks and kerogen coals. The Ermelo algal shale consists of masses of algæ embedded in a groundmass of unresolvable plant debris, as shown in the photomicrograph, Fig. 5. The proximate composition of this material shows it to contain kerogen and mineral matter in approximately equal proportions; the mineral matter consists of clay plus excess silica, with only 0·5 per cent. of carbonates. The Parrot Rough (Skilling, *loc. cit.*) is a similar material.

There is a related group in which the organic matter consists almost entirely of algæ, and in which the mineral matter may vary from as little as 5 per cent. to as much as 30 per cent. These materials are a special intermediate type between algal coals and algal shales, for which the only logical name is " algal rock," since algæ are the only important constituent. That so few algal rocks are known is due to the rarity of the occasions when the requisite enormous numbers of algæ, free from appreciable quantities of extraneous vegetable materials, became accumulated and preserved.

The spore coals grade insensibly into the durain of bituminous coals.

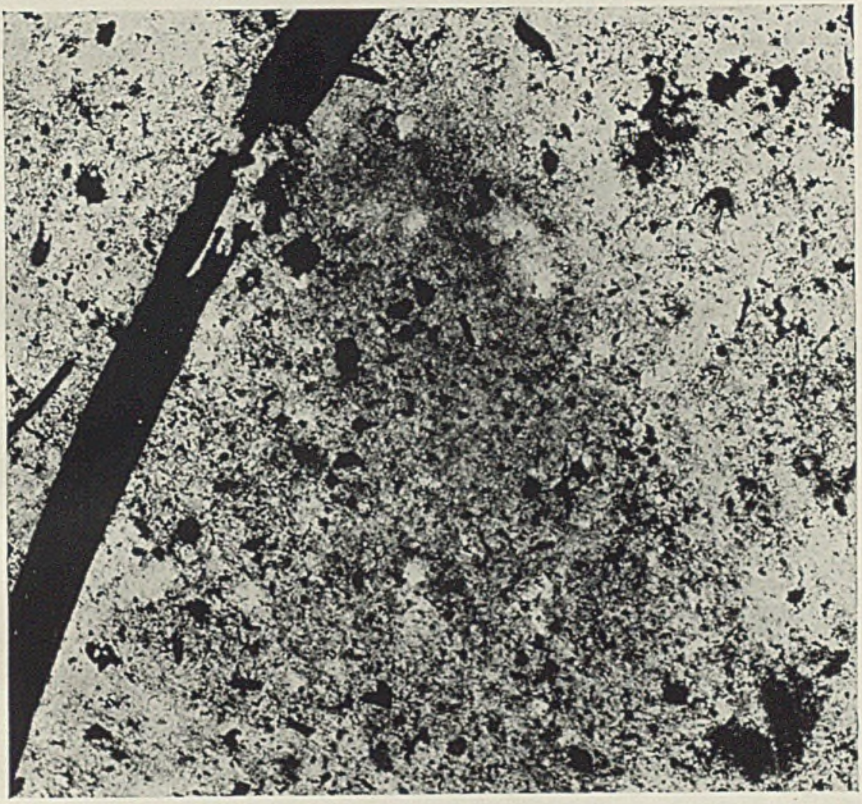
The foregoing conclusions as to the properties, differences, and interrelationships of these groups of materials have been set out in tabular form.

CONCLUSIONS.

1. Naturally occurring oil-yielding materials can be primarily divided according to the solubility of the organic constituents in the usual solvents for petroleum.

2. The insoluble materials can be divided into kerogen rocks, kerogen coals, and members of the peat-to-anthracite series.

3. The various groups can be sub-divided according to the chief plant



Horizontal.

Vertical.

Fig. 1.

KIMERIDGE KEROGEN SHALE, NORFOLK, SHOWING LAMINATED OR SHALEY STRUCTURE AND MACERATED PLANT DEBRIS. × 150.

[*To face p.* 332.

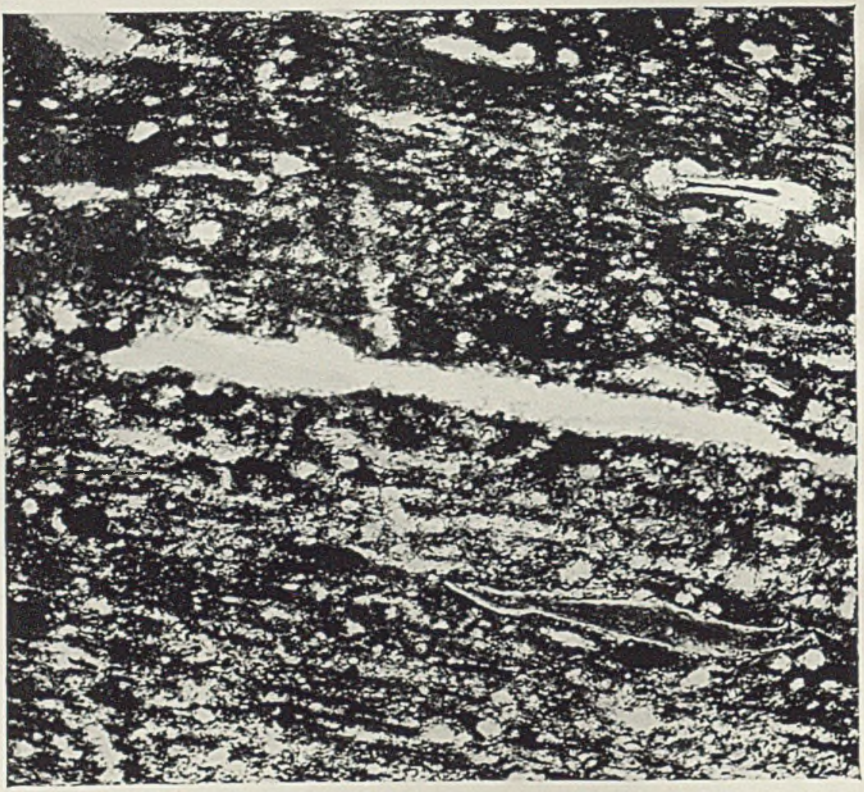
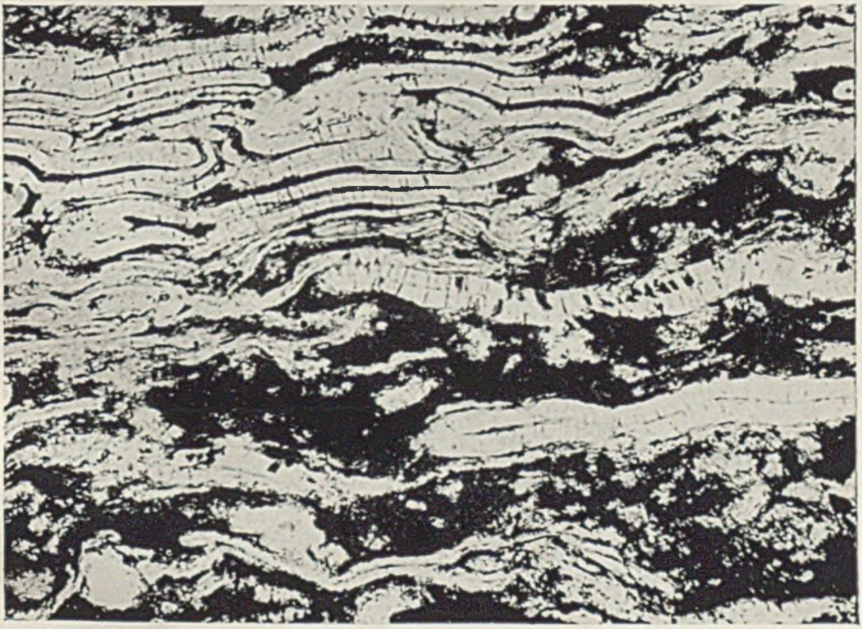


Fig. 2.

BROXBURN MAIN KEROGEN SHALE, SCOTLAND, SHOWING LAMINATED OR SHALEY STRUCTURE AND MACERATED PLANT DEBRIS. VERTICAL SECTION. × 150.

Horizontal.



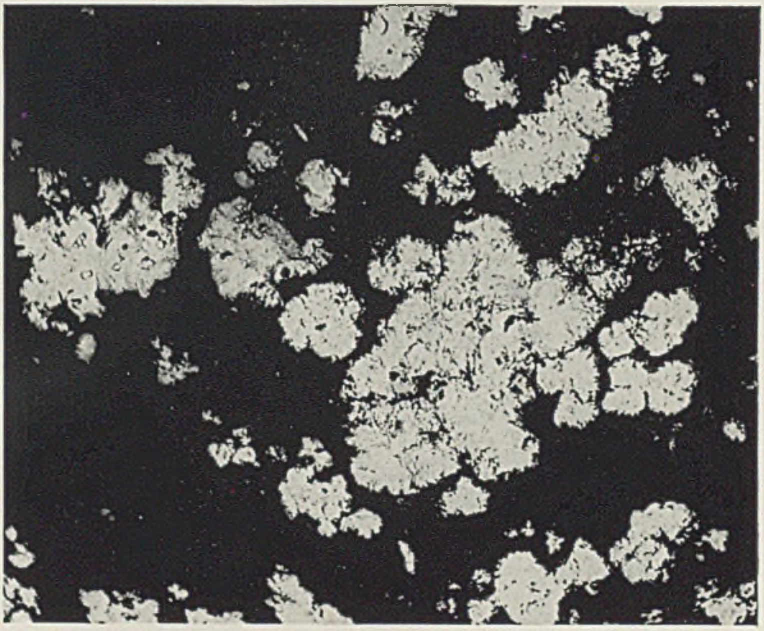
Vertical.

Fig. 3.

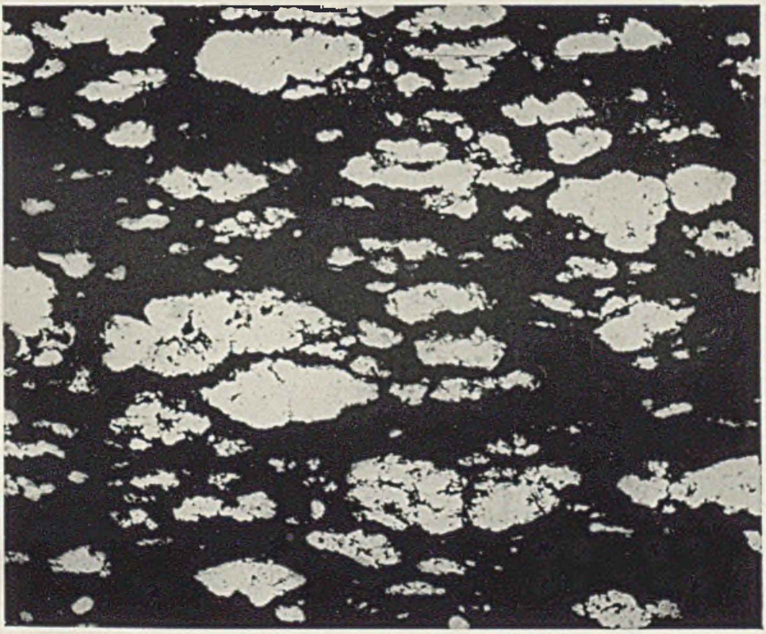
TASMANIAN SPORE SHALE SHOWING THE GREAT PREPONDERANCE OF CRUSHED SPORE CASES AND THE ABSENCE OF OTHER PLANT REMAINS. × 150.

FIG. 4.

ESTHONIAN ALGAL LIMESTONE, WITH GREAT ACCUMULATION OF ALGAL COLONIES TOGETHER WITH PIECES OF SHELLS. HORIZONTAL SECTION. × 150.



Horizontal.



Vertical.

Fig. 5.

ERMELO ALGAL SHALE, SOUTH AFRICA, SHOWING ALGAL COLONIES IN A DARK UNRESOLVED MATRIX. × 150.

constituents as seen in thin sections under the microscope, and the nature of the mineral matter, where important.

4. A rational nomenclature is based on the nature of the plant remains plus the nature of the mineral matter (where important), prefixed by an adjective explanatory of the locality from which the material was obtained.

Acknowledgments.

We desire to express our thanks to Professor A. C. G. Egerton, F.R.S., for his continued interest in the researches on oil-yielding materials, and to Dr. R. Crookall of the Geological Survey for the helpful suggestions he has made, also to Dr. J. M. Connor for his assistance in taking the photomicrographs.

Department of Chemical Technology,
Imperial College, S.W.7.
5th July, 1939.

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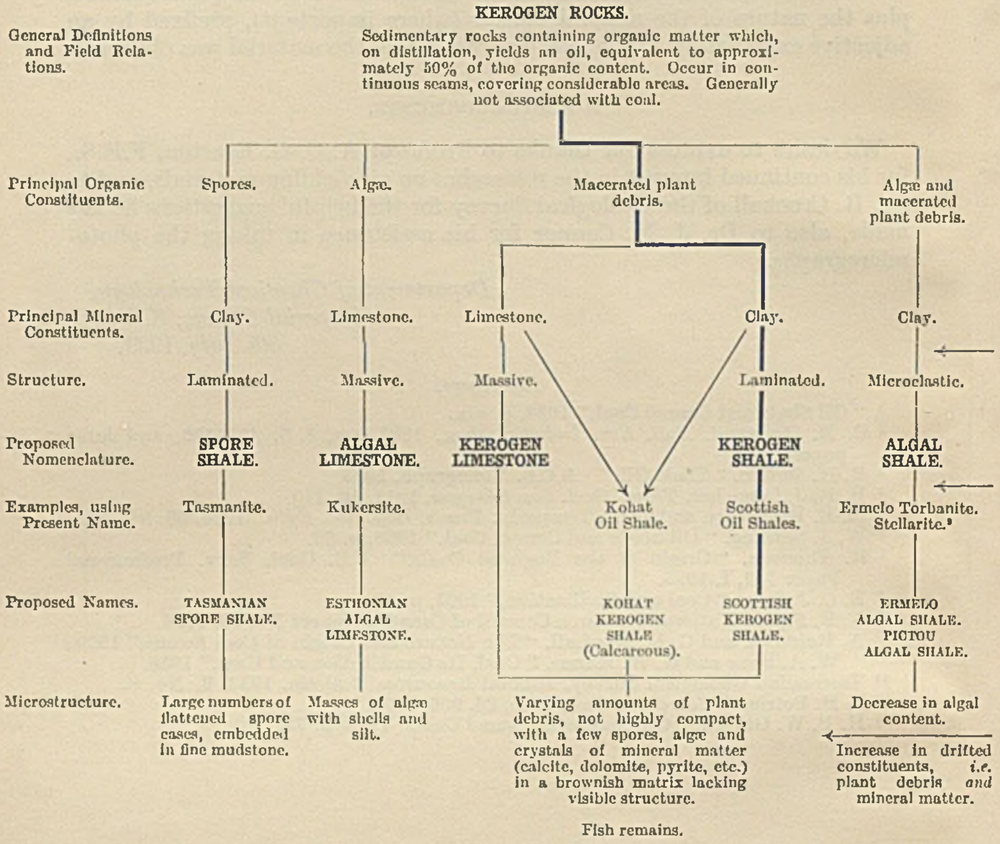
THE CLASSIFICATION OF KEROGEN

SHOWING THEIR INTER-RELATIONSHIPS AND



KEROGEN ROCKS.

General Definitions and Field Relations.	Sedimentary rocks containing organic matter which, on distillation, yields an oil, equivalent to approximately 50% of the organic content. Occur in continuous seams, covering considerable areas. Generally not associated with coal.					
Principal Organic Constituents.	Spores.	Algæ.	Macerated plant debris.			Algæ and macerated plant debris.
Principal Mineral Constituents.	Clay.	Limestone.	Limestone.		Clay.	Clay.
Structure.	Laminated.	Massive.	Massive.		Laminated.	Microclastic.
Proposed Nomenclature.	**SPORE SHALE.**	**ALGAL LIMESTONE.**	**KEROGEN LIMESTONE**		**KEROGEN SHALE.**	**ALGAL SHALE.**
Examples, using Present Name.	Tasmanite.	Kukersite.		Kohat Oil Shale.	Scottish Oil Shales.	Ermelo Torbanite. Stellarite.[9]
Proposed Names.	TASMANIAN SPORE SHALE.	ESTHONIAN ALGAL LIMESTONE.		KOHAT KEROGEN SHALE (Calcareous).	SCOTTISH KEROGEN SHALE.	ERMELO ALGAL SHALE. PICTOU ALGAL SHALE.
Microstructure.	Large numbers of flattened spore cases, embedded in fine mudstone.	Masses of algæ with shells and silt.	Varying amounts of plant debris, not highly compact, with a few spores, algæ and crystals of mineral matter (calcite, dolomite, pyrite, etc.) in a brownish matrix lacking visible structure. Fish remains.			Decrease in algal content. ← Increase in drifted constituents, *i.e.* plant debris *and* mineral matter.
Conditions of Deposition.	Organic matter mainly drifted.	Organic matter accumulated *in situ*.	Organic matter accumulated partly *in situ*, partly drifted.			Organic matter accumulated mainly *in situ*.

Proximate Composition.	*Tasmanian Spore Shale.*[11]	Esthonian Algal Limestone.	Kohat Kerogen Shale.	Broxburn Main Kerogen Shale.	Ermelo Algal Shale.
Kerogen	*26*	52	11·85	26·0	53·66
Clay	*27*	9·25	41·95	45·2	31·3
Excess Silica	*38*	5·75	8·0	8·4	11·3
$CaCO_3$	*Low*	26·95	20·3	2·1	0·5
$MgCO_3$	—	—	7·35	1·95	
$FeCO_3$	—	—	3·5	9·0	

	Ermelo Algal Shale.
Approximate ratio $\frac{\text{oil yield}}{\text{organic residue}}$.	0·6

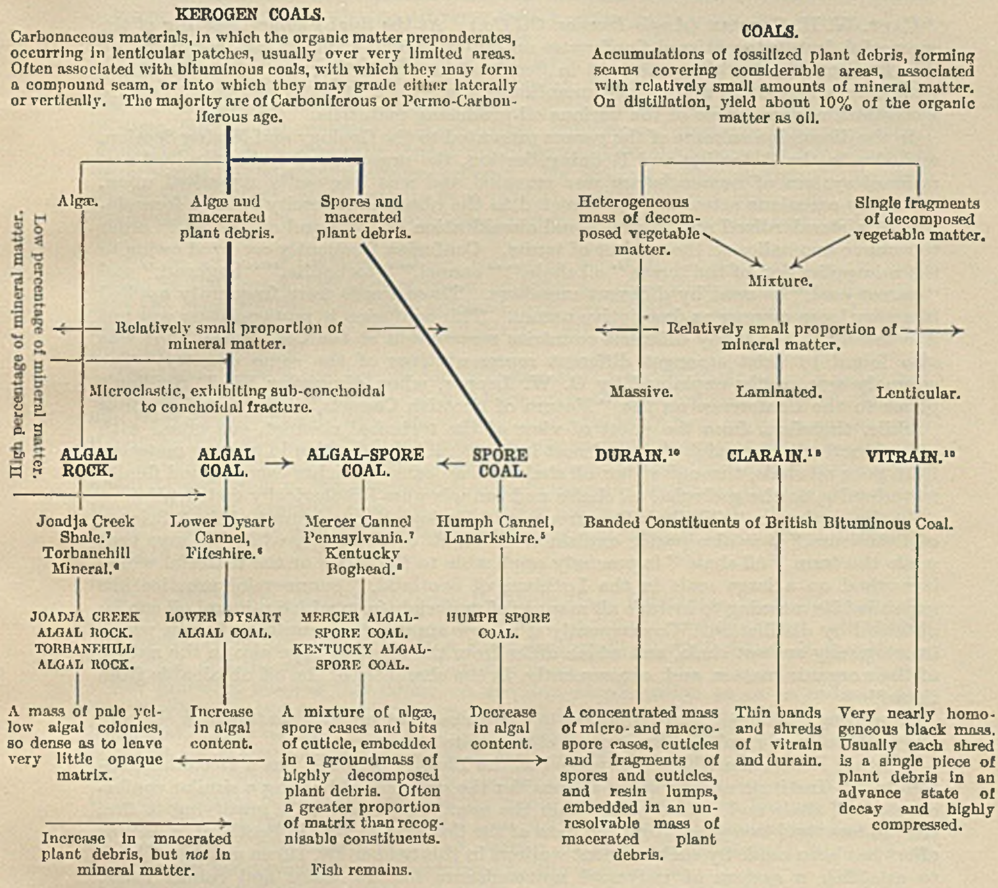
Oils obtained on carbonisation at 500° to 600° C., often contain paraffin wax (up to 10%), generally contain less than 10% of material soluble in aqueous caustic soda and have a calorific value of *over* 17,000 B.Th.U.'s per pound.

Note (1). Proximate compositions in italics are calculated from data given in references 11 and 12. The remainder from analyses by the authors.

Note (2). References 6 to 10 are to photomicrographs of the examples cited.

ROCKS AND KEROGEN COALS.

THEIR GRADATION INTO BITUMINOUS COALS.



KEROGEN COALS.

Carbonaceous materials, in which the organic matter preponderates, occurring in lenticular patches, usually over very limited areas. Often associated with bituminous coals, with which they may form a compound seam, or into which they may grade either laterally or vertically. The majority are of Carboniferous or Permo-Carboniferous age.

Algæ. — Algæ and macerated plant debris. — Spores and macerated plant debris.

High percentage of mineral matter. ← Low percentage of mineral matter.

Relatively small proportion of mineral matter.

Microclastic, exhibiting sub-conchoidal to conchoidal fracture.

ALGAL ROCK. — **ALGAL COAL.** → **ALGAL-SPORE COAL.** ← **SPORE COAL.**

Joadja Creek Shale.[7] Torbanehill Mineral.[4] — Lower Dysart Cannel, Fifeshire.[6] — Mercer Cannel Pennsylvania.[7] Kentucky Boghead.[8] — Humph Cannel, Lanarkshire.[5]

JOADJA CREEK ALGAL ROCK. TORBANEHILL ALGAL ROCK. — LOWER DYSART ALGAL COAL. — MERCER ALGAL-SPORE COAL. KENTUCKY ALGAL-SPORE COAL. — HUMPH SPORE COAL.

A mass of pale yellow algal colonies, so dense as to leave very little opaque matrix. — Increase in algal content. ← — A mixture of algæ, spore cases and bits of cuticle, embedded in a groundmass of highly decomposed plant debris. Often a greater proportion of matrix than recognisable constituents. → Decrease in algal content.

→ Increase in macerated plant debris, but *not* in mineral matter.

Fish remains.

COALS.

Accumulations of fossilized plant debris, forming seams covering considerable areas, associated with relatively small amounts of mineral matter. On distillation, yield about 10% of the organic matter as oil.

Heterogeneous mass of decomposed vegetable matter. → Mixture. ← Single fragments of decomposed vegetable matter.

Relatively small proportion of mineral matter.

Massive. — Laminated. — Lenticular.

DURAIN.[10] — **CLARAIN.**[10] — **VITRAIN.**[10]

Banded Constituents of British Bituminous Coal.

A concentrated mass of micro- and macro-spore cases, cuticles and fragments of spores and cuticles, and resin lumps, embedded in an unresolvable mass of macerated plant debris. — Thin bands and shreds of vitrain and durain. — Very nearly homogeneous black mass. Usually each shred is a single piece of plant debris in an advance state of decay and highly compressed.

Organic matter accumulated *in situ*.

Organic matter accumulated partly *in situ* and partly drifted. → Increase in proportion of drifted material.

Vegetable debris generally accumulated *in situ*. Sometimes drifted.

Joadja Creek Algal Rock.[12]
93
3·2
3·5
{ *Traces.* }

On account of the low proportion of mineral matter, a knowledge of its proximate composition is of little significance.

Joadja Creek Algal Rock.
10

Lower Dysart Algal Coal.
1·4

Humph Spore Coal.
0·6

The ratios for a number of British bituminous coals were all of the order of 0·2.

Torbanehill Algal Rock.
5·7

Oils obtained by carbonisation at 500° to 600° C. do not contain paraffin wax, generally contain upwards of 30% of material soluble in aqueous caustic soda and have calorific values of approximately 16,000 B.Th.U.'s per pound.

DISCUSSION.

Capt. W. H. Cadman (*Anglo-Iranian Oil Co.*): At the final Plenary Meeting of the successful first International Conference on Oil Shale and Cannel Coal, organized by this Institute, and which was held in Scotland in June 1938, one of the Sectional Resolutions submitted and carried unanimously called for steps to be taken to secure a standard nomenclature of the various oil-producing materials.

In the discussion on some of the papers presented to the Geology and Mining Section, and also to the Retorting and Refining Section, the urgent need for a standard and rational system of nomenclature was revealed and was frequently remarked upon. On many occasions attention was directed to the absolute necessity for the formulation of a standardized and international classification of coals and oil shales, in order to remove anomalies on the subject of terms. Confusion frequently occurred owing to the misapplication of the terms "oil shale," "cannel," "torbanite," "boghead," and "parrot coal," as used by different members. These words were frequently applied in a very loose manner as descriptive names. This confusion in nomenclature was not due merely to the many different countries represented at the Conference, as it was also found to exist amongst different representatives of the same country. The anomaly was partly explained by G. W. Lepper, when discussing W. J. Skilling's paper to the Conference on the "Nature of Scottish Cannels," in his remarks that "while, therefore, from the point of view of the technical chemist, concerned with oil production, there might be an almost imperceptible graduation in his raw material, from poor oil shale, through richer oil shale to lean cannels, richer cannels, and finally to torbanite, to the geologist, oil shales and cannels were lithologically distinct."

In the section on "Oil Shale Occurrence and Geology" in volume 4 of the "Science of Petroleum," it is also partly explained by H. R. J. Conacher, where he says that while the term "oil shale" is precisely applicable to the rocks or the material which is worked on a large scale in the Lothians of Scotland, "commercial practice has expanded its meaning to include all manner of materials from which mineral oil can be obtained by distillation. Consequently it is now applied to a number of cases which lithologically are not shale, and which differ from the Scottish type also in the nature of their organic matter, and, consequently, in the character of the oil obtainable from them."

According to Conacher, a reduction in the amount of mineral matter of a shale of the Lothian type results in its gradual change into a torbanite.

Another Resolution which was passed at the Plenary Meeting was a Recommendation to the Institute of Petroleum to consider the question of holding a similar conference on oil shale and cannel coal within the next ten years. It is gratifying to find that in less than two years from the date of the Conference held in Scotland, a serious effort has been made by such eminent workers in this field as Dr. Down and Dr. Himus to establish a system of universal nomenclature for oil shales and cannel coals. Whether their attempt will meet with universal approval or not remains to be seen.

The Institute of Petroleum in publishing this paper is making a step forward to the securing of a standard nomenclature. The authors have avoided, in their system of names, those which have been widely misused hitherto, and instead have employed terms which are descriptive of the main constituents of the materials.

Whilst many may agree with the authors that it would be advantageous to avoid using such names as "oil shale," "cannel coal," etc., the fact remains that these names have been in local and general use for so long that it is doubtful whether even prohibition by an Act of Parliament would prevent people from using them, including those who know that true oil shale contains no oil as such, but only produces oil when the organic matter it contains (kerogen) is subjected to destructive distillation by heat, and those who know that no "cannel coal" is to-day being used for the production of smoky luminous flames resembling the early "candles" when burning.

The authors boldly propose an entirely new nomenclature, to be based on the nature of the plant remains and on the nature of the mineral matter (where important), prefixed by an adjective explanatory of the locality from which the material was obtained. Thus Scottish oil shale becomes "Broxburn main kerogen shale Scotland," the Esthonian oil shale kukersite becomes "Esthonian algal limestone," South African Ermelo torbanite becomes "Ermelo algal shale," and so on.

It is difficult to see how the authors would discriminate between "Torbanehill mineral" (torbanite), "boghead cannel," and "parrot coal," in all of which the algal content is high. It will be remembered that the first two names became of historic interest on account of the controversy which arose concerning the nature of the materials in 1853 and which led to a lawsuit.

Professor Hickling, who examined a very large number of cannels microscopically, found what he termed a typical cannel to consist of "very small shreds of vitrain-like material, in laminar structure, and to differ from durains by almost complete absence of algæ, but by the presence of spore exines, cuticles and resins in some quantity." From this, Dr. Mott concludes that it would appear that the source of oil from typical cannels may be the resinous matter present. Mr. Skilling points out that the material which Professor Hickling regards as a typical cannel will not burn with a smoky luminous flame, such as has always been regarded as a characteristic test for a cannel coal.

It is to be hoped that the authors will carry out more detailed work in the near future on the lines of the present paper, in order to bring other oil-yielding materials into the classification they have outlined, and particularly those of Class I, which includes the oil sand, tar sands, and bituminous limestones which have not been included in the paper.

They have done a real service by including at the end of their paper a tabulated classification of many kerogen rocks and kerogen coals, showing their inter-relationship and their gradations into bituminous coals. In this table they give the names commonly used at present, side by side with the new names now proposed for them in this system of nomenclature. As this classification gives, for the first time, a rational and scientific definition of the present names is there really any need to avoid the use of these old names, provided they are only used as defined by the authors of this valuable paper? Surely the proposed nomenclature should prevent misapplication of the old terms in future.

Mr. J. McConnell Sanders (*Asiatic Petroleum Co.*): Scientific classification has been defined [1] as "the formulation of a scheme of mutually exclusive and collectively exhaustive categories, based on the most important characteristics of the things concerned, and the actual relations between them."

For practical reasons this definition requires amplification so as to indicate the means whereby the important characteristics referred to may be ascertained and compared. This becomes of increasing importance when specific terms are employed in the classificatory nomenclature which are not self-explanatory.

Before commenting upon the very comprehensive system outlined by Down and Himus, it should be pointed out that the resolution passed by the Plenary Session of the Conference on Oil Shale and Cannel Coal in 1938 invited the Institute of Petroleum to consider the nomenclature of the various oil-producing materials discussed or described in the various papers submitted to the Conference.

With the exception of cannel, no varieties of coal entered into the deliberations of the Conference, hence the extension of the now proposed scheme so as to include the classification of coals of the peat–anthracite series is somewhat outside the scope of the original invitation.

Moreover, the classification of coals has already been the subject of consideration by other International Conferences, and according to Redmayne [2] the best of these classifications was that adopted by the International Geological Congress held at Toronto in 1913.

Under this scheme coals were divided into four main classes and three sub-classes, and it included not only cannel, but also lignite and brown coal. It is not proposed to discuss the merits or demerits of the Toronto scheme, the basis of classification being entirely different from that proposed by Down and Himus.

Nevertheless, the suggestion by the latter that the classification of oil-yielding materials should comprehend coals which under certain conditions may be said to also yield oils is entirely rational, and worthy of careful consideration.

As is well known, low-temperature coal tars, and especially vacuum tars, contain constituents which are identical with substances found in petroleum, and whereas a high-temperature tar is mainly aromatic in character, a low-temperature one is paraffinoid.

It is therefore necessary to closely define the conditions under which oil is produced by heat treatment if, as proposed by Down and Himus, their Class II (oil shales) are to be defined as "substances which yield 50 per cent. or more of their organic matter as *oil*," and are thus to be distinguished from Class III materials which yield only 15 per cent. as *oil*.

It is true that these definitions are taken in conjunction with the relative solubility of the organic matter in "normal solvents for petroleum," but the latter expression is somewhat ambiguous, both as regards the nature of permissible solvents and the conditions of extraction. As will be noted later, heat treatment of the material before application of a solvent might be considered a legitimate method of ascertaining the nature of the organic matter present.

There would appear, however, little difficulty in settling these details of practical procedure and adopting the primary classification into three main classes. As regards nomenclature, it is noted that it is proposed to abandon the names "oil shale" and "cannel coal," the first on the ground that it is misleading, and the second because it gives no indication of the nature of the material.

On the other hand, both these terms are very firmly established, and it would be difficult to replace them; neither should it be necessary if their misuse could be obviated by a more precise definition of their own meaning or that of the terms to which they are frequently misapplied.

Oil shale is perfectly well understood by technologists to mean "a shale capable of yielding oil" and it is no more misleading than such terms as "oil seed," "oil cake," and "oilstone," in which three distinct meanings are attached to the word "oil" and only one of the substances concerned is understood to contain oil as such.

Again, it might be contended that the term "cannel," if its derivation from "candle" is accepted, does in fact indicate the nature of the material, or at least one of its properties. Apart from this, cannel comes under Class C of the Toronto classification of coals, and thus earns the right to retain its place amongst technological terms.

Actually there is a vast number of accepted terms in technology which give no indication of the nature of the material to which they are applied, and yet are useful and convenient as type designations in a classificatory scheme.

It is suggested that the proposed alternative terms "kerogen rock" and "kerogen coal" should preferably be employed in the adjectival form, since kerogen is a substantive; and that the primary classification should be modified so as to adapt itself to the classification of sedimentary rocks suggested by H. B. Milner.[3]

Thus the latter's main group "B" (Rocks of organic origin) could have its fourth sub-division "B_4" (Carbonaceous rocks) changed as follows :—

B_4. Rocks yielding oil or tar by destructive distillation.

$B_4$1.		$B_4$2.		$B_4$3.	
Bituminous Rocks.		Kerogenous Rocks.		Carbonaceous Rocks.	
Character.	*Type.*	*Character.*	*Type.*	*Character.*	*Type.*
Arenaceous	Oil sands Tar sands	Calcareous	Kukersite	Anthracitic	Anthracite and semi-anthracite
Calcareous	Bituminous limestone	Argillaceous	Scottish oil shales Tasmanite	"Bituminous"	Bituminous coal
Argillaceous	Oil-bearing shales	Calcareo-argillaceous	Kohat oil shale	Kerogenous	Cannel coal
Asphaltic	Native asphalts Gilsonite	Sapropelic	Torbanites Bogheads	Lignitic	Lignite Brown coal
				Sub-lignitic	Peat

The practical application of this scheme as a preliminary sorting test does not require a very elaborate procedure. All the sedimentary rocks considered yield oil or tar by distillation; those in Group $B_4$1 are distinguished from those in the other two groups by the greater solubility of their organic matter as proposed by Down and Himus. Group $B_4$2 differs from $B_4$3 in that carbonization or "coalification" has advanced to a greater degree in the latter. Thus black cannel is considered as a kerogenous coal, whereas the lighter-coloured types of cannel which may contain a relatively larger proportion of preserved organic remains (kerogen) are considered as Sapropelic kerogenous rocks.

The secondary classification proposed by Down and Himus is based on the assumption that the organic remains, which constitute the kerogen in some of these oil- and tar-yielding minerals, can be readily and definitely identified as either algæ or spores.

It is true that the work of Blackburn and Temperley has shown most convincingly that the "yellow bodies" in a number of cannels and bogheads are the remains of an alga very similar to the living *Botryococcus Braunii*, but the position regarding the identification of other organic matter as spores is not so clear cut.

As pointed out by Stopes and Wheeler,[4] a group of crushed, semi-decayed, or bacteria-invaded spores may simulate other plant remains or algæ of various sorts. It is also possible, especially in the case of microspores, that thick-walled resting spores of algæ are alone preserved, or partly so, in which case the material containing them should rightly be designated as "algal."

There is a further objection to the use of the term "algal" when applied in connection with sedimentary rocks, in that it is liable to be confused with the same term as commonly employed to designate rocks, built up of or containing fossilized or mineralized algæ.

Thus Down and Himus use the term "algal limestone" to classify rocks of the Esthonian Kukersite type, but among petrographers the term is used to classify limestones which contain or are made up of the remains of such algæ as *Lithothamnion* or *Chara*.

Even the more general term "algal rock" might be criticized from this viewpoint, for, according to Solms-Laubach,[5] undoubted *Lithothamniæ* are abundant throughout the series of Tertiary deposits, and in some localities form almost the entire material of thick layers; they compose the granite-marble of the Nummulitic rocks.

The question arises whether it is necessary or desirable to attempt such a fine distinction between algæ and spores as being respectively indicative of distinct types of kerogen. The past history of investigations relating to the latter shows only too clearly that the practical identification of the "yellow bodies" has been a matter of such difficulty that even experienced observers have been content to adopt Crum Brown's indefinite term, or something equally noncommittal.

Sometimes bodies of spore-like appearance have been described as resins, the description being subsequently abandoned on the ground that they were insoluble in the usual resin-solvents. Although in some cases the actual organized remains have been identified as spores or algæ, it is worthy of note that resinous matter might well have been present, since several fossil resins are known to be insoluble until they have been heat-treated, and it is a well-known fact that the amount of organic matter removable by solvents from kerogenous material is increased by heat treatment.

Engler [6] states that certain insoluble "bitumens" become soluble after heating; Vignon [7] showed that the amount extracted from coal by treatment with pyridine, aniline, and quinoline increased in the same order as the increase in boiling point of the solvent, whilst McKee and Lyder [8] hold the view that the decomposition of kerogen by heat to form oil takes place in two stages, the insoluble kerogen being first converted into a soluble form which is unstable towards heat, this on further heating giving oil of the petroleum type of higher saturation and greater stability.

The present writer has found resin droplets, in the insoluble form, present in several varieties of crude petroleum, and often accompanied by spore cases, partly decomposed plant debris, and algal remains. Sometimes there have been found in the same crude oil fragments of woody tissue in which the cells lining schizogenous resin cavities were perfectly preserved, whilst resin was found dissolved in the oil.

Resinous matter in coals, cannels, and lignites has been the subject of extensive investigation, and it appears to be the consensus of opinion that resin, waxes, and higher fatty acids have exercised some kind of protective function in preserving the cuticles, spore cases, pollen exines, bark, and cork which are found in carbonaceous rocks.

These considerations seem to point the way to the conclusion that the real kerogen—the oil-former—does not entirely reside in the cuticular skeletons of algæ, the outer coatings of spores, or the relics of plant tissue, although these organic remains may contribute to the composition of the oil or tar produced by distillation.

In fact, as a basis for classification, it would appear that spores and algæ, or any other embalmed organic remains, are not mutually exclusive nor collectively exhaustive designations: they represent only the symptoms of the oil-yielding propensity in the materials concerned, not their primary cause.

In apparent opposition to this opinion, Blackburn and Temperley,[9] as a result of experiments on recent, dried coorongite, showed that whilst oily and waxy material could be extracted by solvents, the relatively insoluble residue could be presumed to be capable of yielding "paraffin products" by destructive distillation.

They also refer to the fact that cannels may or may not contain "yellow bodies," but when these do form a large proportion of the coal it becomes more valuable as a source of "paraffin" than of gas.

There appears to be an implied distinction between "paraffin" derived from cannel coal and "paraffin products" from recent coorongite, the latter presumably referring to any members of the paraffin series from methane upwards, the former to the wax which can be obtained by re-running the crude distillate and chilling the pressible "cut."

In either case these authors would seem to favour the hypothesis that oil is derived from the algal skeletons rather than from the matrix which surrounds them in the mineral. Whilst it is true, as shown by Legg and Wheeler,[10] that a modern cuticle (*Agave americana*) gave about 60 per cent. of vacuum tar containing hydrocarbons, and fossil cuticle from Russian paper coal gave about 20 per cent. less, the former was easily attacked by alkali, the latter only slightly, and thus, while accounting for the formation of hydrocarbons by the destructive distillation of cutin and accompanying fatty acids and waxes, the existence of sulphur and nitrogen compounds in the resulting oil is not explained.

If original cell contents are assumed to accompany the algal skeleton or spore coats in the kerogen, then not only sulphur and nitrogen, but perhaps the phosphorus which is found in the ash can be accounted for.

In this connection it is interesting to note the analysis of Balkash Sapropelite (presumably *Botryococcus*) given by Zelinsky.[11]

The latter states that 39 per cent. of the material is soluble in carbon tetrachloride, the extract containing free fatty acids and their esters. The organic matter is stated to have the following composition :—

	%
Carbon	73·76
Hydrogen	10·61
Sulphur	1·03
Nitrogen	0·56
Phosphorus	trace
Oxygen	13·74

In the case of Tasmanian oil shale, Kurth and Rogers [12] state that nearly, but not quite all the oil yield is produced from the amber-like bodies, which they suggest are not spore cases, but the spores themselves fossilized. They further state that the shale, freed from spore cases, produces some oil, but that the gas produced during distillation is free from hydrogen sulphide. The entire shale is shown to yield both ammonia and sulphur compounds.

In view, then, of the difficulty in establishing the identity of the "yellow bodies" in all cases, and because it is not yet established that kerogen is exclusively represented by algæ and/or spores, it is suggested that the latter terms are not entirely satisfactory for purposes of classification.

For practical purposes there is much to be said for a nomenclature which is self-suggestive of properties which are readily discernible or easily ascertainable. Many of the descriptive terms already commonly employed in the industry are of this nature. but confusion has arisen because materials having a single, or at best a few, physical properties in common have been designated by the same term.

Sometimes the misapplication has been in respect to the mineral component of the material, whilst in others it is the organic attribute which has been wrongly designated.

It was suggested by Macgregor [13] that the nomenclature should take into account such factors as appearance, structure, oil-yield, and ash content, whilst Roberts [14] affirms that if any attempt were made to simplify the nomenclature of cannels, attention should also be given to their coking propensities.

It may be suggested further that in gathering material for the purpose of classification more attention should be given to the possibilities of the minerals which accompany the kerogenous materials, and which may be recognized by petrographic methods or detected by chemical analysis.

Amongst the latter, certain elements, such as vanadium, nickel, and to some extent aluminium and magnesium, may have a special significance in relation to the organic constituents of the material.

For instance, Tasmanite contains as kerogen, bodies which are supposed to be the preserved spores of lycopodium. Since the *Lycopodineæ* are quite remarkable for their high aluminium content, and since the spores are large and easily separated from the mineral matrix, the estimation of aluminium in their ash would appear to have more value than the analysis of the bulk mineral.

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[12] Kurth, E. E., and Rogers, L. J., " Oil Shale and Cannel Coal," 1938, pp. 193–209.
[13] Macgregor, M., *ibid.*, pp. 8–17.
[14] Roberts, J., *ibid.*, p. 39.

DR. M. MACGREGOR (*Geological Survey*) : In a paper communicated to the Conference on Oil Shale and Cannel Coal held at Glasgow in 1938 I emphasized the desirability of securing, if possible, a standard nomenclature for the various oil-yielding materials included under the designations cannel, boghead, etc. I had in mind the difficulty experienced by the field worker in the lack of any standard series of categories to which to refer, and the fact that terms such as oil shale and cannel were used for materials differing widely in mode of occurrence, origin, and composition. Thus the term oil shale, long employed in Scotland in connection with the Lower Carboniferous shales of the Lothians, has been used to designate oil-yielding materials of many different kinds and ages. It has been used, for example, for the torbanites and cannels of New South Wales (Permo-Carboniferous); for the spore-rich " tasmanite " of the Mersey River Valley in Tasmania, regarded as a shallow-water marine sediment probably of Permo-Carboniferous age; for the Estonian " kukersite," a marine deposit of Ordovician age; for the " marahuito " of Bahia in Brazil, a somewhat variable material of algal origin, allied to torbanite (Cretaceous or Early Eocene); for the black carbonaceous shales of the Eastern United States (Devonian); and for other deposits of varying character in different countries. The term cannel, again, includes materials of different composition and widely different economic value. In putting forward my suggestion I envisaged the appointment of a small committee to examine and report upon the question, just as the British Association Committee on petrographic classification appointed in 1932 examined and reported on the nomenclature of igneous rocks. The authors of the paper now presented have boldly tackled the problem of both the nomenclature and the classification of the naturally occurring oil-yielding materials. Their nomenclature is based on the dominant plant and mineral constituents present and the classification is put forward merely as " a foundation on which further classifications can be developed as our knowledge of the chemistry of these materials increases." It is very doubtful, however, if the proposed nomenclature will be acceptable to those who have to deal with the raw materials in the field and laboratory. The introduction of such terms as " kerogen rocks " and " kerogen coals " appears superfluous. Nor does it seem in the least necessary to discontinue the use of such long-established names as oil-shale and cannel. It should be quite possible to retain these names for definite groups of oil-yielding materials, and to subdivide these further according to their essential macroscopic and microscopic characters. Cannels are micro-fragmental coals and form a graded series ranging from the richly algal brown and black bogheads, through algal-spore cannels with increasing proportions of decomposed plant debris forming a bright transparent groundmass, to canneloid shales containing a high proportion of inorganic matter. It should be quite possible to define the series brown boghead, black boghead, boghead-cannel, cannel, canneloid shale not only in terms of decreasing oil-yield, but also in terms of macroscopic and microscopic characters. The macroscopic characters used would include colour, lustre, fracture, streak, structure, etc. As regards the broad classification, the writer would prefer to see some such twofold grouping adopted as (1) Oil Shales; (2) Cannels (and Cannel-coals) excluding from present consideration bituminous coals which are looked upon as tar-providing rather than oil-bearing materials.

The problem is to find a simple and convenient classification based (*a*) on field observations and (*b*) on microscopic examination in the laboratory. The following might be tentatively suggested :—

Oil Shales	Calcareous	
	Argillaceous	Algal Spore-rich
Cannels	Canneloid shales—high content of inorganic matter	
	Cannel coals—plant debris and spores, with a varying amount of algal remains	
	Bogheads—largely algal	

Obviously this is only a skeleton classification, and in defining the different categories such criteria as mode of occurrence, nature of associated strata including position in the sedimentary cycle, should be taken into account, as well as the other characteristics already enumerated.

Dr. L. Slater (*Fuel Research Coal Survey Laboratory, Sheffield*) : We appreciate that the older term " cannel " has been used for a large variety of substances, both rich and poor in " oil-yielding " properties, and hence might with advantage be superseded by more precise terms such as those suggested. In using the new terms, however, it will have to be clearly borne in mind that the substances referred to form a continuous series, without sharp distinctions.

Most of the suggested terms have the merit of being self-explanatory, but " algal rock," although scientifically quite sound, is perhaps doomed to unsuccessful competition with the older and unscientific " boghead." " Algal rock " might be confused with " algal shale " unless structure was described each time the terms were used.

As the classification given in the paper is based on the three main groups " Kerogen rocks," " Kerogen coals," and " Coals," it seems very important that the meaning of the term " kerogen " should be made clear. On p. 331 the term is applied to " unresolvable masses of macerated plant debris containing a few spores and/or algæ." But if this is accepted as a definition, it follows from our experience that *all* coals contain very considerable amounts of kerogen. Would it not be better to exclude the unresolvable debris, and define kerogen as a collective term for spores and/or algæ only? This would make it roughly synonymous with the " Protabitumina " of the German petrologists, and also would be more in accord with the classification scheme given at the end of the paper.

We have encountered some samples of bright coals composed of fragments so finely divided that the usual banded appearance is practically absent. Such material is often considerably richer in volatile matter than the more normal material from the same seam, although microscopical work shows it to contain no algæ and no abnormal quantity of spores. Whether such material should be classified as a type of " kerogen coal " will thus depend entirely on a more precise definition of " kerogen."

Dr. R. A. Mott (*Department of Fuel Technology, University of Sheffield*) : The Classification proposed does not do full justice to special types of coals which are important for their oil-yielding capacity. It assumes that algæ and spores alone are the cause of the oil yields of cannel coals, and ignores the important part played by resins and resinous materials in this connection.

In the discussion on the paper by Mr. W. J. Skilling on " The Nature of Scottish Cannels " (*Oil Shale and Cannel Coal*, 1938, p. 40), I directed attention to the fact that Scottish cannels differed in composition from cannels examined by Professor Hickling and from those examined in other laboratories by Dr. W. A. Chao and by Dr. Holroyd. The *ordinary* cannel coal found associated with bituminous coal seams in England appears to conform to Hickling's description, and algæ are absent and spore exines, cuticles, and resins are present in some quantity. In the six cannels examined by Dr. Chao (a reprint of whose paper is enclosed) spores occurred only rarely, and the high oil-yielding properties were apparently due to a degraded resinous material.

Since fossil resin is found in lump form in many of the Japanese coals of Tertiary age (which have hydrogen content exceeding 6 per cent.) and in the Washington U.S.A. coals of the same age (which usually contains about 6 per cent. of hydrogen), and in young New Zealand coals this confirms the knowledge that the coniferous trees only developed in more recent geological periods. A place should be found for such coals in Table 7. I suggest that, under "Kerogen coals," p. 335, the title be altered to "spores, resins and macerated plant debris," and alongside the term "Spore Coal" be placed the term "Resinous Coals," examples of which are given above.

To these should be added cannel coals free from algæ and spores such as are described by Dr. Chao.

I suggest that it might also be proper to include the term "Cuticle Coal," an example of which is the *Papier Kohle* of Russia described by Legg and Wheeler in *J. chem. Soc.*, 1929, 2449.

Under the heading "Coals" below the statement "Vegetable debris generally accumulated *in situ* sometimes drifted" should be placed an arrow pointing to the Kerogen coals with the expression "Increase in proportion of drifted material." I suggest also that the term "organic residue" in the ratio of oil yield/organic residue requires definition. It appears to refer to an organic residue on heating to 500° C. Also the statement below this that "oils obtained by carbonization . . . generally contain upwards of 30 per cent. of material soluble . . ." should be altered to "up to 30 per cent."

Dr. H. B. Nisbet (*Heriot-Watt College, Edinburgh*): Dr. Down and Dr. Himus have done a great service in suggesting suitable generic terms to which can be referred substances commonly called oil shales and cannel coals. With regard more particularly to the latter group of substances and the closely related torbanitic shales, what is now required is a study of the various grades of material which will fall under the heads of kerogen coals and algal shales with the object of setting up standards for suitable sub-divisions. While such sub-divisions might be arrived at, as has been suggested by the authors, by microscopic examination, it is to be hoped that this will be correlated with fundamental chemical investigations. The kerogen coals or cannels (and algal shales) occur in a large variety of physical forms and are associated with widely differing amounts of mineral matter of varying composition. They possess occasionally fairly well-developed coking properties and at other times none at all, and they yield varying amounts of oils of differing characteristics on destructive distillation. It would be well, therefore, if a large number of deposits from various localities were fully investigated microscopically and chemically. Much information would doubtless also be obtained by suitable solvent extraction, and it would be of special interest to know if the constituents producing coking properties have any relation to the components causing this in ordinary coking coals as tracked down by Bone's benzene-pressure extraction method. A correlation of a large amount of data on such subjects would be extremely useful and would no doubt provide material on which a sub-classification could be built.

In 1924 Dr. E. F. Armstrong, in his Presidential Address to the Society of Chemical Industry, made the suggestion that the chemistry of fatty oils had not received the attention it deserved. During the intervening years we have seen great advances in our knowledge of this subject, largely due to the investigations of Prof. Hilditch and his school of research at Liverpool. It would appear that kerogen shales and coals offer a subject for fundamental research of a somewhat similar range, and it would be highly gratifying if the Glasgow Conference of 1938 and the paper now presented by Dr. Down and Dr. Himus provided the stimulus to start an investigation of this character.

Mr. W. J. Skilling (*Fuel Research Coal Survey Laboratory, Glasgow*): It is interesting to note that the authors are endeavouring to keep alive the resolution passed at the Conference on Oil Shale and Cannel Coal held in Glasgow in 1938.

The difficulty of arriving at a satisfactory grouping or system of nomenclature for such naturally occurring materials as oil shales, torbanites, and cannel coals is the merging of one into another. One may receive a number of hand specimens which to the eye of the field geologist are identical, but when examined in the laboratory by the chemist yield oils in varying quantity and of widely different chemical composition.

When the Boghead cannels or Torbanites are encountered, their identification presents little difficulty in the hand specimen. They invariably have a brownish shade of colour, are tough and difficult to break, and have a characteristic wooden sound when struck. The Lower Dysart Cannel of Fife possesses all the characteristics of a Torbanite—so much so that to apply the name "coal" to it is quite misleading.

The group of materials in which the hand specimens are almost indistinguishable but which in microsection show pronounced differences are the black, satin-surfaced cannel coals. These differences are also reflected in the varying oil yields obtained; thus the writer has observed that when algæ are easily identified in a specimen a high yield of oil has been found, but when they are difficult to detect in the finely macerated plant debris the yield approaches that of a bituminous coal and is more of a tarry than oily nature, having more oxygenated constituents and no indication of wax.

The authors have referred to the Humph Seam cannel as a spore coal and to the specimen from New Cunmock as an intermediate algal-spore coal. Based upon laboratory examination the writer would classify neither of these materials as spore coal, since spores form a very minute proportion of the plant debris. Typical spore coals are found forming bands in certain of the splint coal seams of Scotland and are described as durain. The spores are in such high concentration as to be visible without the use of a lens. Such coals have a matt or granular surface, as compared with the smooth, satiny surface of a cannel coal.

From experience in handling specimens, and from discussions with geologists and mining engineers, the writer is of the opinion that it would add to the existing confusion to introduce the terms "algal" and "kerogen" to the exclusion of the widely used "oil shale" and "cannel." Most of this confusion has been due to a tendency of some authors of papers on these materials to coin new words based upon the result of a laboratory examination of a limited number of specimens.

The whole problem of nomenclature centres round whether the geologist, the mining engineer, or the chemist should have the privilege of deciding upon the most appropriate name for these products of nature. It is for this reason that the writer would suggest the formation of a committee representing these professions and drawn from each of the coalfields of this country to discuss and decide upon a nomenclature for oil shales and cannel coal. Some representation of those foreign countries which produce and utilize these materials should be invited.

MR. R. J. FORBES (*N.V. de Bataafsche Petroleum Mij*): The authors are greatly to be commended for their effort to evolve, in spite of the comparatively unknown nature of the subject, a classification of these materials, and for their introduction of a series of names, which will undoubtedly facilitate discussion. The future development of a scientifically sound classification and nomenclature will be greatly assisted thereby.

As regards the last line of paragraph 1, page 330, it would perhaps be better to alter this to read "only about 15 per cent. of the organic matter as oil *on heating*."

In the table immediately below this paragraph I suggest that the words "bituminous rocks" be substituted for the list of oil-yielding materials given under Class I, since this list is, in any case, not complete. If it is desired to extend the list or to use it to supplement the table given as addendum to the paper, the authors would do well to consult the book by H. Abraham, "Asphalts and Allied Substances" (4th ed., New York, 1938, Chapter II), in which the classification of bituminous materials is dealt with in detail and from which a provisional system of classification and nomenclature could be derived.

I regret that I cannot entirely agree with the arrangement of the group "Coals" in the table appended to the paper.

The fact is that in the different kinds of coal durain, clairain, and citrain occur in variable quantities; these components of coal, thus, do not correspond with what is understood by Spore Shale, Algal Limestone, etc., in the same line of the same table. The question thus arises whether it is perhaps desirable that the classification should be extended, *e.g.*, according to the system of Jongmans, set out in detail in the book by D. J. W. Kreulen, "Grundzüge der Chemie und Systematik der Kohlen" (Amsterdam, 1936), which book further treats extensively of the materials in question. In this way the difference between cannel coals and Class II, Kerogen Rocks and Oil Shale, could also be more clearly brought out.

A brief indication of the methods by which solubility in various solvents, oil yield on heat treatment, etc., are determined would also be of interest, since the figures for the various materials given here are difficult to compare owing to differences in procedure.

I hope that the authors will regard these minor criticisms as a small contribution of building material towards the edifice of systematization of these materials which they are now, in so praiseworthy a manner, attempting to construct.

MR. JOHN ROBERTS (*Consulting Fuel Technologist*) : I should like to refer to page 332, para. 5 of the paper, where it is proposed to classify three types—namely, algal coals, algal shales, and algal rock. The difficulty here is that *all three* are algal rocks, and could be properly described as such. If " algal rock " contains organic matter which consists " almost entirely of algæ," perhaps the term *algite* would be suitable.

As the object of the Resolution was to standardize terminology, exception will be taken to the rather loose use of the term " mineral matter " in the paper. For example, " the mineral matter consists of clay. . . ." Clay is not a mineral, but a rock (page 332, para. 4).

PROFESSOR A. E. TRUEMAN (*The University, Glasgow*) : The authors are to be congratulated on their courage in tackling the difficult problem of the classification of oil shale and cannels. They have brought together a quantity of useful data which will be of great value in any discussion of the problems arising in the classification of these materials, although I am not convinced that the general scheme of their classification is likely to lead to any real clarification of the problems with which we are concerned. In the first place, if we divide the materials into two main groups corresponding to those which the authors have named the kerogen rocks and kerogen coals, I would suggest that " kerogenous rocks " and " kerogenous coals " would be more euphonious terms and more in keeping with the general character of petrographic nomenclature. The separation of these two groups, however, does little more than re-emphasize a distinction which has been fairly widely made, and discussion must be concerned mainly with the subdivisions which have been proposed.

I am bound to direct attention to the fact that the term " algal limestone " can scarcely be maintained as a type of kerogenous rock, since this name is customarily and widely used for a purely calcareous rock consisting mainly of the remains of calcareous algæ and having no relation to the materials considered here. I feel, also, that there is an objection to the use of the term " algal *rock* " as a type of kerogenous *coal*; it is surely inconsistent to use the word " rock " in the classification of this group, as it does not appear in the classification of the kerogenous rocks themselves.

The proposed names for individual rock types, such as Esthonian algal limestone in place of Kukersite and Tasmanian spore shale for Tasmanite, can scarcely be regarded as contributing to a classification, although for the present they may lead to more precision in the discussion of the materials. For the term " Kukersite " is available for any similar material, and its use for material from other localities than Esthonia would, if it is employed with a suitably restricted meaning, immediately convey the correct information about the deposit. But under the author's scheme the term " Kukersite " would disappear, and every individual locality would attach its name to the material under discussion.

These, however, are purely matters of terminology, and it appears to me that criticism of the authors' classification may go rather deeper than terminology. I wonder whether a satisfactory classification of such variable materials can be made on the basis of a more or less linear series. Since consideration must be given to variations in amount and character of organic material as well as to variations in amount and character of the inorganic materials, a more extended range of criteria is surely desirable. Moreover, it is necessary to have some indication of the range of compositions over which these terms can be applied; for example, while the proportion of kerogen in an oil shale may be over 50 per cent., there is presumably a continuous passage into shales with no kerogen. At what point in the series does a rock cease to be a kerogen shale ? Is it to be determined by the percentage of organic material present, or by the amount of oil yield ?

I am sorry to see the use of the term oil shale is not approved : whilst " oil shales contain no oil as such," however, it may also be noted that lead ore contains no lead " as such," but it is nevertheless lead ore, Dr. A. Wade (*Australia*): From a scientific and technical point of view I regard this paper as an excellent contribution on the question of classification. From a practical, working standpoint I am afraid that it will have little effect. Those who have to work mines in these materials and who have to deal with miners will go on using the old names to which they have long been accustomed, regardless of all that may be written on the subject. The Australian miner will still call the rock which is now being mined on a large scale in the Wolgan Valley—Oil Shale. So will the Tasmanian who mines Tasmanian Spore Shale.

This will not, I am sure, discourage the authors. Research students will welcome and use the classification. Possibly they may upset it in due course. They usually do.

Authors' Reply to the Discussion.

In 1936 a comprehensive research on the chemistry of oil shales and related materials was instituted at the Fuel Laboratories of the Imperial College. The investigation has for its primary object the elucidation of the chemical constitution of the organic matter in sedimentary rocks from which oil is obtainable by heat-treatment. A number of samples were obtained, covering wide geographical and geological ranges, all of which had two common properties: (*a*) that all gave a good yield of oil when retorted at 600° C. and (*b*) the yield obtained by Soxhlet extraction with organic solvents was low; in other respects, however, the samples were widely different. Initial search of the literature showed that the nomenclature of the various types of oil-yielding materials was in a state of confusion, and there was no systematic classification, so that samples could be readily identified, and hence correctly named. In view of the comprehensive nature of the researches envisaged correct nomenclature of the samples examined was particularly important.

It had been hoped that at the Oil Shale and Cannel Coal Conference in 1938 that the problems of the classification and nomenclature of these materials would be clarified. A number of authors directed attention to the urgent need of a standard nomenclature, but no constructive proposals were put forward until the Plenary Session when the resolution quoted at the beginning of this Paper was adopted.

Concurrently with the chemical investigations, the authors examined thin sections of the samples and collected all the available geological data. Whereas a chemical classification analogous to that adopted for coals could not be attempted owing to the lack of reliable data on the composition of the kerogen of a sufficient number of samples, it was found possible to suggest the petrological classification set out in this paper. Further, since the question of nomenclature had not been tackled, the system employed in the classification table was worked out and put forward with the object of stimulating interest and promoting the establishment of a satisfactory system. It was not anticipated that the suggestions would be allowed to pass without criticism, and it is gratifying to find that, even in the present circumstances, considerable interest has been aroused by the proposals.

Captain W. H. Cadman and Professor A. E. Trueman both directed attention to a difficulty which arises in any classification such as that described—namely, that it is quantitative, and not purely qualitative. The same argument applies to the classification of coals of the peat → anthracite series. It is quite easy to define an "algal rock," "algal coal," and "algal shale," but borderline samples are met with and their final allocation will depend to some extent on the opinion of the observer.

Dr. L. Slater points out that it is desirable that the term "kerogen" should be accurately defined; to this everyone will agree, but in the present state of our knowledge, any precise definition is practically impossible. Kerogen is a sedimentary material, formed (apparently) almost exclusively of the remains of plants and consisting of compounds of carbon, hydrogen, and oxygen, together with usually small percentages of nitrogen and sulphur. These compounds are of unknown, but certainly complex, constitution and high molecular weight. Kerogen is distinguished from the allied carbonaceous materials which form coal by yielding a greater proportion of oil when carbonized at 600° C., and so far as can be ascertained at present, it contains considerably more hydrogen (from 8 to 11 per cent. as compared with 5 to 6·5 per cent. for bituminous coals) for a given carbon content.

Both Dr. Slater and Mr. J. Roberts criticize the name "algal rock" for materials such as Torbanehill Mineral. The very small percentage of mineral matter in these samples did not warrant its inclusion in the name of the sub-group, and thus the only alternative was a term such as "algite" suggested by Mr. Roberts. The authors, however, wished to avoid coining any new words, the literature being already crowded with such terms, and thus adopted the sub-heading "algal rock."

Messrs. J. McConnell Sanders and R. J. Forbes question the inclusion of bituminous coals in the classification table. This was done because it seemed rational to indicate that there is gradation from the "kerogen coals" to bituminous coals. Further, the two classes are so intimately associated in nature that it was felt that this should be recognized in the table. No attempt of course has been made to include a classification of bituminous coals, since this has already been done by others.

Mr. McConnell Sanders points out that in the terms "oil seed," "oil cake," and "oil stone," the word "oil" has three different meanings. He could scarcely have furnished a better argument for our suggestion that the word "oil" should be absolved from having yet a *fourth* meaning in the term "oil shale."

The objection to the term "algal limestone" on the grounds that it is already used by geologists for calcareous rocks made up of the remains of algæ was not unforeseen. Such rocks are not, however, necessarily *kerogen rocks*, therefore the force of the objection can be done away with if this is made clear.

It is not suggested that kerogen consists exclusively of algæ and/or spores; on the contrary, many kerogen rocks show an almost entire absence of recognizable material, but on carbonization their oil yield is equivalent to more than 50 per cent. of the organic matter. The Kimeridge and Kohat kerogen shales, for example, are practically devoid of recognizable structures, microscopic examination reveals a few pieces of carbonized woody matter or plant remains in a structureless yellow matrix, but, nevertheless, they are true kerogen rocks. On the other hand, J. M. Petrie reported that in the case of the Joadja Creek algal rock, N.S.W., which gave an oil yield of 150 gal. per ton, gelatinous algæ constituted 90 per cent. of the organic matter.

While it is fully realized that the nature of the inorganic matter and its relation to the kerogen require more detailed study, until men and funds are available, the work must perforce be carried out on a more restricted scale than is desirable. Moreover it is important that the problems of classification and nomenclature be cleared up as early as possible in order to further the chemical researches, and to ensure that the nature of the samples investigated is universally understood.

The skeleton classification proposed by Dr. M. Megregor is very much on the same lines as that proposed by the authors, except that the terms "oil shale" and "cannel" are retained.

Dr. R. A. Mott suggests that resinous and cuticle coals should be included under the section kerogen coals, such extra sub-headings can always be introduced where the facts, as ascertained by examination of the materials concerned, warrant their introduction.

Mr. W. J. Skilling points out that the questions under consideration cannot be answered by chemists alone; the authors are keenly aware that these individual problems and the whole general problem of kerogen rocks cannot be solved by attacking them from one angle only, the geologist, petrologist, palæobotanist, and chemist are all concerned.

Referring to Mr. J. Roberts' objection to the use of the term "mineral matter" in this paper, all rocks, including clays, are composed of minerals, which justifies calling the "matter other than organic" simply "mineral matter"; as an alternative the term "inorganic matter" could be used.

Professor A. E. Trueman appears to dislike the suggestion that "every individual locality" should attach its name to the material under discussion. The authors cannot agree; it is good petrological practice to state the locality from which a specimen is derived, since precision is thereby given. The name "granite" will probably conjure up as many visions as there are geologists who hear or read the name; each, in fact, will instinctively think of that variety of granite with which he is most familiar, it is the statement of locality which defines the particular variety of granite. Further, the geographical prefixes applied are chosen to represent the whole of a particular deposit, and not localities within the general area of the seam or seams.

Dr. H. B. Nisbet desires that microscopic examination shall be correlated with fundamental chemical investigations; this is precisely the view of the authors, and is at present being carried out at the Imperial College. Progress on the chemical side is necessarily slow, the determination of the percentage and composition of the kerogen cannot be made by direct analysis, but involves the rather lengthy de-ashing process described in an earlier paper.* The problem of chemical constitution has been attacked by controlled oxidation of the organic matter, with subsequent determination of the distribution of carbon and examination of the oxidation products, an investigation requiring several months. A number of samples have already been treated in this way, but a great many must be examined before any generalization will be permissible, and this will require a number of years to carry out. It was not considered advisable to present the results of chemical researches on a single sub-group of kerogen rocks in a paper dealing with the controversial questions of classification and nomenclature of the whole range of oil-yielding rocks.

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* *J. Inst. Pet.*, 1939, 25, 230–237. A similar method was adopted by J. W. Horner and W. W. Purdy, and a report prepared for the U.S. Bureau of Mines in 1925 but was not published until 1938, as Bulletin No. 415. At the time of publication of the paper on de-ashing the authors were unaware that this Bulletin had appeared.

ERRORS IN ACID-BOTTLE READINGS.*

By G. H. Scott, B.Sc., F.Inst.Pet.

Introduction.

A Teleclinometer survey was recently carried out at one of the wells of Apex (Trinidad) Oilfields, Ltd. The deviations recorded by this method were considerably greater than those obtained by the conventional acid bottle. Three wells had been surveyed prior to this, and had failed to show such marked discrepancies. In these three wells, however, the bit had followed a relatively more vertical course. It was therefore indicated that the divergence between the acid-bottle and Teleclinometer readings increased with the deviation, and the tests that were undertaken, and which are described herein, were carried out to check the correctitude of this supposition.

It was realized that the Teleclinometer readings of deviation might themselves be at fault and, in order to check these, a series of observations were obtained with a single-shot instrument.

The following table gives a comparison of the three sets of observations. Deviations are recorded in decimals of a degree in order to simplify calculations of average figures.

Depth, ft.	Teleclinometer deviation.	Single-shot.		Acid-bottle.		Acid-bottle difference to tele.	Acid-bottle difference to single shot.
		Depth, ft.	Deviation.	Depth, ft.	Deviation.		
720	4·34°	721	3·50°	721	2·71°	−1·63°	−0·79°
1200	4·67	1205	4·00	1200	2·50	−2·17	−1·50
1450	5·34	1446	4·50	1448	3·25	−2·09	−1·25
1680	5·45	1687	5·25	1685	4·00	−1·45	−1·25
2170	5·10	2169	4·00	2175	2·50	−2·60	−1·50
2410	4·31	2410	4·00	2395	2·50	−1·81	−1·50
2920	5·45	2919	5·25	—	—	—	—

The Teleclinometer deviations at these intermediate points were calculated on the assumption that the deviation between two known readings would be a gradational change. This assumption is considered fair in view of the fact that the drift was in a general eastward direction with no reversals. The single-shot and acid-bottle readings were taken at the actual depths given.

It will be noted firstly that there is much greater constancy in the difference between the acid-bottle and single-shot readings, and secondly that the Teleclinometer readings are constantly higher than the single-shot. A comparison of the two latter readings is given hereunder :—

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* Paper read to a Meeting of the Trinidad Branch held on 28th February, 1940.

Depths, ft.	Teleclinometer.	Single-shot.	Difference.
720– 721	4·34°	3·50°	0·84°
1200–1205	4·67	4·00	0·67
1450–1446	5·34	4·50	0·84
1680–1687	5·45	5·25	0·20
2170–2169	5·10	4·00	1·10
2410–2410	4·31	4·00	0·31
2920–2919	5·45	5·25	0·20

If all readings are taken into consideration and it is assumed that the deviation persists to half the distance between any two readings, average weighted deviations can be calculated. For this well they are as follows :—

Teleclinometer	4·85°
Single-Shot	4·36°
Acid-Bottle	2·50°.

It is therefore apparent that although there are some discrepancies between the Teleclinometer and single-shot readings, these are of a minor character in comparison with the very much lower readings obtained by the acid bottle.

TESTS.

In practice the acid bottle is lowered in a bill on a wire-line. In this case the readings were taken inside 2⅞-inch internal flush drill pipe, and the bills used were firstly one supplied by the manufacturers of the wire-line, using a large bottle, and secondly one of local manufacture using a small bottle.

Both bills were used in the tests, and, in order to guard against errors due to divergence of the axis of the bottle-holder from the axis of the bill, the bill was turned through varying amounts between each set of tests.

The true deviation was obtained by means of a plumb bob and an offset scale, and it is estimated that an accuracy of ±0·1° was obtained.

All acid-bottle readings were recorded by two observers with no preconceived idea of the actual readings, and in several of the tests the bottles were mixed and duplicate readings recorded.

Conditions in practice were followed as far as possible by varying the time of exposure to the acid and by using new and asphalt-filled bottles alternately.

In all, five series of tests were undertaken, and the results are shown in Table I. In recording acid-bottle deviations, " Face-Left " and " Face-Right " readings are taken on each bottle, and the mean recorded. It will be noted that in some cases there is some divergence between the readings recorded by the same observer and also by different observers. It must be admitted that the acid bottle is not a precision instrument, but in the majority of cases there is quite reasonable consonance between the various readings. Fig. 1 shows a small acid bottle drawn to scale, together with lines denoting horizontality and a deviation of 5°. This illustrates in a graphic manner the difficulties attendant on reading an acid bottle accurately to ¼°, and the fact that such close correlation was obtained in the readings shown on the table is quite noteworthy.

TABLE 1.

True Dev'n.	TEST 1.				TEST 2.					TEST 3.					
	Small bottle. Local bill.				Small bottle. Local bill (turned 30°).					Small bottle. Local bill (turned 90°).					
	Obs. 1.	Obs. 2.	Avge.	Diff.	Obs. 1a.	Obs. 1b.	Obs. 2.	Avge.	Diff.	Obs. 1a.	Obs. 1b.	Obs. 2a.	Obs. 2b.	Avge.	Diff.
°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
0·00	—	—	—	—	—	—	—	—	—	0·00	0·25	0·25	0·25	0·19	+0·19
0·75	0·50	0·00	0·25	−0·50	—	—	—	—	—	—	—	—	—	—	—
1·00	1·25	0·75	1·00	0·00	0·50	1·00	0·50	0·67	−0·33	1·50	1·00	0·75	0·75	1·00	0·00
2·00	1·75	1·75	1·75	−0·25	1·00	2·00	1·50	1·50	−0·50	2·25	2·00	1·50	1·75	1·875	−0·125
3·00	2·25	2·25	2·25	−0·75	2·75	2·75	2·25	2·58	−0·42	3·00	3·00	2·00	2·00	2·50	−0·50
4·00	2·75	2·75	2·75	−1·25	3·50	3·75	3·50	3·58	−0·42	4·00	3·75	3·25	3·00	3·50	−0·50
5·00	3·75	3·00	3·38	−1·52	3·50	3·75	3·50	3·58	−1·42	4·50	3·75	3·25	3·00	3·60	−1·40
6·00	—	—	—	—	—	—	—	—	—	4·00	5·00	4·50	4·50	4·50	−1·50
7·00	—	—	—	—	—	—	—	—	—	5·75	5·75	5·25	5·25	5·50	−1·50
7·50	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10·00	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

True Dev'n.	TEST 4.						TEST 5.		All-in avge.	Diff.
	Large bottle. Wire-line bill.						Avge.	Diff.		
	Obs. 1a.	Obs. 1b.	Obs. 2a.	Obs. 2b.	Avge.	Diff.				
°	°	°	°	°	°	°	°	°	°	°
0·00	0·50	0·50	0·50	0·50	0·50	+0·50	0·25	+0·25	0·31	+0·31
0·75	—	—	—	—	—	—	—	—	0·25	−0·50
1·00	0·75	0·75	1·00	1·00	0·875	−0·125	—	—	0·89	−0·11
2·00	2·50	2·50	1·75	2·25	2·25	+0·25	—	—	1·84	−0·16
3·00	3·00	2·025	2·25	2·25	2·53	−0·47	—	—	2·47	−0·53
4·00	2·75	2·75	1·75	2·25	2·375	−1·625	—	—	3·05	−0·95
5·00	3·50	3·75	3·50	3·50	3·56	−1·44	3·25	−1·75	3·47	−1·53
6·00	—	—	—	—	—	—	—	—	4·50	−1·50
7·00	—	—	—	—	—	—	—	—	5·50	−1·50
7·50	—	—	—	—	—	—	6·06	−1·44	6·06	−1·44
10·00	—	—	—	—	—	—	7·56	−2·44	7·56	−2·44

The all-in averages of acid-bottle readings were as follows :—

True deviation.	Acid-bottle deviation.	Difference.	Remarks.
0·00°	0·25°	+0·25°	
0·75	0·25	−0·50	
1·00	0·89	−0·11	
2·00	1·84	−0·16	
2·50	1·56	−0·94	Not recorded on Table I.
3·00	2·47	−0·53	
4·00	3·05	−0·95	
5·00	3·47	−1·53	
6·00	4·50	−1·50	
7·00	5·50	−1·50	
7·50	6·06	−1·44	
10·00	7·56	−2·44	

These points are shown in black in the chart (Fig. 2), and an average line has been drawn through them. The line of true deviation is shown as a dotted line.

This chart indicates a definite tendency to increased divergence between true and acid-bottle readings with increased deviation from the vertical. At low figures of deviation the acid-bottle reading is tolerably accurate, and it is for this reason that earlier Teleclinometer readings showed reasonable correlation with those of the acid bottle. It is interesting, however, to note that even this minor variation is very closely corrected by use of the chart, as is shown hereunder :—

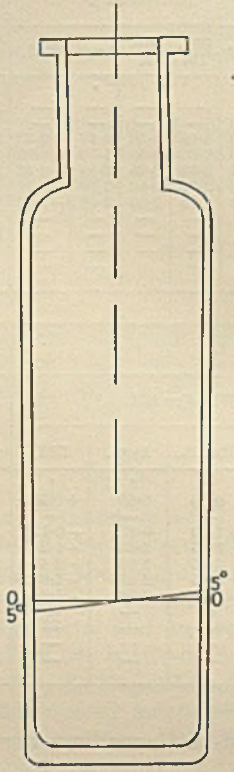

Fig. 1.

Well.	Weighted teleclinometer deviation.	Weighted acid-bottle deviation.	Corrected acid-bottle deviation.	Difference.
A	1·16°	0·88°	1·20°	+0·04°
B	1·12	0·80	1·05	−0·07

At the time these acid-bottle readings were taken it was the custom to drop the bill down the drill pipe, where it seated in a special sub. The bill was therefore accurately centred in the drill pipe. Now that a wire-line is used for lowering, no sub is provided. It is possible, if not probable, therefore, that the true deviation will tend to be minimized, owing to the tolerance between the bill and the internal cross-section of the drill pipe. In any case the corrected acid-bottle readings shown on page 349 are still somewhat on the low side in comparison with the readings obtained by the single shot. The single-shot readings have been selected as the instrument was a very close fit with its spring guides in 4½-inch casing.

Depths, ft.	Single-shot readings.	Acid-bottle readings.	Corrected acid-bottle readings.	Difference.
721	3·50°	2·71°	3·50°	−0·00°
1200–1205	4·00	2·50	3·25	−0·75
1446–1448	4·50	3·25	4·20	−0·30
1687–1685	5·25	4·00	5·15	−0·10
2169–2175	4·00	2·50	3·25	−0·75
2410–2395	4·00	2·50	3·25	−0·75
			Average :	−0·44

It is considered, however, that an average error of less than ½° is all that can be expected of the acid bottle.

It is probable that the discrepancy between true and acid-bottle readings of deviation is due to a combination of the following causes :—

(*a*) A tendency to read the etched line low for the higher deviations.
(*b*) Variation of the etched line from that of the original meniscus.
(*c*) Distortion of the meniscus at the liquid/glass contact at the higher angles of deviation.

In order to see if there was any possibility of observing these phenomena, a board was taken and a slot was cut in it to accommodate an acid bottle. This acid bottle was marked on the shoulders in such a way that it was oriented in exactly the same position for each observation. The board was held in retort stands and was tilted in one plane from horizontality through increments of 2½° to a figure of 10°. Water was first used in the bottle, and the position of the meniscus was marked on either side of the slot in the board. The water was then replaced by acid and the same procedure followed before etching had commenced. Between movements of the board a little more acid was added to ensure that the etched lines were not superimposed. The inclination was read in each case by a large protractor and parallel rule.

The following results were obtained for the deviation as recorded by the actual liquid-level line :—

True deviation.	Deviation of surface of liquid.	Average.	Difference.	Remarks.
0·00°	0·25°	—	+0·25°	Water.
0·00	0·25	0·25°	+0·25	Acid.
2·50	2·75	2·75	+0·25	Acid.
5·00	4·50	4·375	−0·50	Water.
5·00	4·25	—	−0·75	Acid.
7·50	7·25	7·25	−0·25	Acid.
10·00	8·75	8·875	−1·25	Water.
10·00	9·00	—	−1·00	Acid.

These results indicate that :—

1. There is no difference between water and acid if the actual fluid level is taken as the basis of measurement.

2. Some distortion of the meniscus must take place at the glass/liquid contact at the higher angles of deviation.

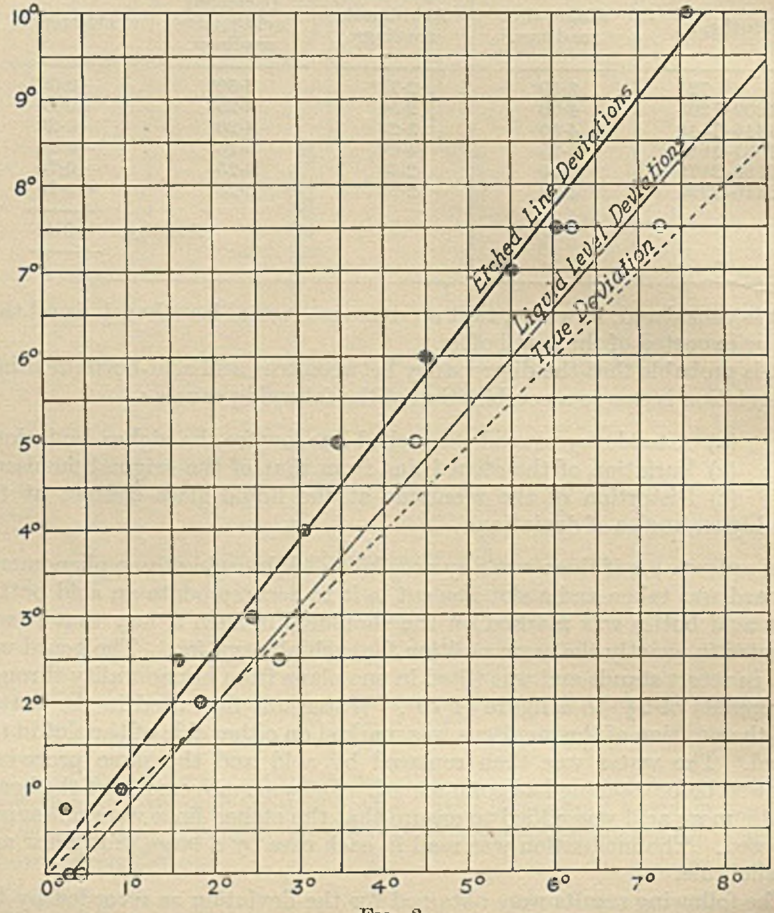

FIG. 2.

CHART SHOWING VARIATION BETWEEN OBSERVED AND TRUE DEVIATIONS. TO CORRECT ACID-BOTTLE READINGS, READ ON HORIZONTAL SCALE AND FOLLOW VERTICALLY TO THICK LINE. THEN OBTAIN TRUE READING ON VERTICAL SCALE.

E.g. Observed Deviation = 2·50°.
True Deviation = 3·25°.

The average of the above readings are plotted on Fig. 2 and the full black line is an average curve through them. It will be noted that whilst the deviation from the true inclination is quite appreciable in the higher ranges, it is of only minor importance in the range usually encountered in wells intended for verticality. Thus even at a true inclination of 5° the apparent deviation of the liquid level is 4·65°, which is quite sufficiently accurate.

In comparison with the above figures the etched-line readings were as follows :—

True deviation.	Etched-line deviation.	Error.
0·00°	0·375°	+0·375°
2·50	1·56	−0·94
5·00	3·25	−1·75
7·50	6·06	−1·44
10·00	7·56	−2·44

It is at once apparent that the deviation of etched-line readings from liquid-level readings and its much greater deviation from the true readings is a matter of considerable moment.

During the actual process of etching there was an apparent drop in the liquid level which did not appear to parallel the original liquid level. The fall in level is probably due to chemical interaction between the glass and the acid. The apparent non-parallelism of the earlier and later fluid levels may be due to variation of the contact angle between the glass and acid after the liquid and glass have undergone chemical change at the surface boundary.

CONCLUSIONS.

If deviations recorded by the acid bottle are merely used as indicators of relative verticality, it is considered that, if they are corrected by the use of the Chart (Fig. 2), they will be of sufficient accuracy for all practical purposes.

The desirability of carrying out oriented surveys in addition to the routine acid-bottle tests is governed by many factors, such as :—

(*a*) The average depth of the wells.
(*b*) The spacing interval.
(*c*) The extent of denudation of the producing formation.
(*d*) The extent of horizontal drift.
(*e*) The lengths to which an operator is prepared to go to ensure penetration of the producing formation at defined geographical points once the underground spacing pattern has been determined.
(*f*) The thickness and persistence of the oilsand bodies.
(*g*) The limits of accuracy in terms of relative verticality that can be obtained by conventional drilling at the average economic drilling speed.

This list could be expanded indefinitely, but the factors cited are sufficient in themselves to indicate the wide scope of the subject.

In the writer's opinion, if corrected acid-bottle deviations are used to calculate horizontal drift, assuming that such deviations are in one constant direction, and if such drift is less than 10 per cent. of the spacing interval, oriented surveys, although desirable, are not essential.

Any consideration of this subject leads inevitably to the conclusion that for all normal drilling operations a high standard of relative verticality should be the aim of all operators. Uncontrolled drilling may result in cheaper drilling costs at the expense of ultimate productivity. This is obviously uneconomical. As a measure of relative verticality the acid bottle is simple and trustworthy in the lower ranges of deviation. In the higher ranges recourse must be had to an oriented survey to determine the point of penetration into the producing zone.

In the three wells cited on page 349 the following horizontal drifts were recorded :—

Well.	Depth, ft.	Horizontal drift, ft.
A	3050	50·0
B	2300	41·5
C	4350	60·0

These wells were not specially selected because of their small deviation and are by no means abnormal.

The average well depth of the completions drilled by Apex (Trinidad) Oilfields, Ltd., in the past year, together with the average deviation and calculated horizontal drift were as follows :—

Average well depth, ft.	No. of readings.	Observed average deviation.	Corrected average deviation.	Average horizontal drift, ft.
4510	1 per 125·6 ft.	0·66°	0·85°	67·0

These figures might be further reduced by the use of longer drill-collar sections.

A short table is appended showing the horizontal drift of a 3000-feet well at various inclinations of the hole from the vertical.

Inclination of hole from vertical.	Horizontal drift, ft.	Vertical depth drilled, ft.
0·50°	26·1	3000
1·00	52·5	2999
2·00	104·7	2999
3·00	156·9	2996
4·00	207·4	2993
5·00	261·6	2989

The author wishes to express his thanks to Messrs. Apex (Trinidad) Oilfields, Ltd., for permission to read this paper.

THE USE OF BITUMEN EMULSION IN SOIL STABILIZATION.*

By A. E. Lawrence, B.Sc., A.I.C.

Introduction.

The subject of soil stabilization is one to which, until comparatively recent years, very little attention has been paid, either in the laboratory or in actual practice. This is even more so when the use of bitumen emulsion as a stabilizing agent is considered.

The development of soil stabilization has led to the establishing of many well-equipped soil-testing laboratories, and to many miles of constructional work being carried out, using the soil as a basis. This is due principally to the investigations of C. A. Hogentogler in America, and other notable soil scientists, such as Terzaghi and Atterburg. Their investigations, however, were not carried out from the point of view stabilization with bitumen emulsion or any other agent initially, but were rather concerned with the design of stable soil mixes by careful control of the grading, etc. This, in turn, led to the addition of various materials to the natural soil in order to improve the inherent stability. Among such materials may be mentioned calcium chloride, sodium chloride, tar, cement, bitumen, etc. The mode of action of these various materials is, however, entirely different. For example, the purpose of adding such chemicals as calcium chloride is to keep the moisture content of the soil at what is termed the " optimum moisture content "—that is, the moisture content at which it exhibits its maximum strength. The action of such binding agents as stable bitumen emulsion differs in that a waterproofing effect is imparted to the soil, and the soil must dry out as far as possible before the maximum resistance to water is attained.

The Use of Bitumen Emulsion in Soil Stabilization.

Definition.

For our purpose, it is convenient to divide soil stabilization into two categories :—

Soil stabilization without waterproofing.
Soil stabilization with waterproofing.

The first group may be defined as " the process of giving natural soils enough abrasive resistance and shear strength to accommodate traffic or loads under prevalent weather conditions without detrimental deformation."

This definition will also apply to the second group, with the proviso that the stabilization be achieved principally by the addition to the soil of a waterproofing agent such as bitumen emulsion.

In the first case stability is imparted to the soil simply by regrading; in the second case this stability is supplemented and made more effective by the addition of a waterproofing agent.

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* Paper read at a meeting of the Institute of Petroleum Asphaltic Bitumen Group on 16th January, 1940.

Composition of Soil.

In order to obtain a clear idea of what is meant by soil stabilization, it is necessary to consider the composition of soils in general, and the properties of each component part. Each soil may be considered to consist of four groups of materials :—

1. Mineral matter, including colloidal clay.
2. Organic matter.
3. Soil moisture.
4. Soil air.

Of these we are chiefly concerned with the mineral constituents and their relationships with water. It may be mentioned, however, that the presence of organic matter is, in general, detrimental to the stability of the soil.

The mineral matter is composed of particles differing widely in shape, size, and chemical composition, and having vastly different reactions to water. The first essential is to decide on the number of fractions to be distinguished and to define these fractions by particle size. Much confusion has hitherto existed on this point owing to the use of different scales in different countries. The International Society of Soil Science decided to use the following fractions :—

2—0·2 mm. Coarse sand.
0·2—0·02 mm. Fine sand.
0·02—0·002 mm. Silt.
Less than 0·002 mm. Clay.

This scale, however, while very convenient in that the successive particle size limits are at equal logarithmic intervals, is not sufficient for our purpose, and the following classification has therefore been accepted :—

Passing.	Retained.	
1″	. . . .	Large stone.
1″	¼″	Medium stone.
¼″	8 mesh (2 mm.)	Small stone.
8 mesh	36 „ (0·42 mm.)	Coarse sand.
36 „	300 „ (0·053 mm.)	Fine sand.
300 „	0·005 mm.	Silt.
0·005 mm.	0·001 mm.	Non-colloidal clay.
0·001 mm.	. . . .	Colloidal clay.
	(True colloid . . .	0·0001 mm.)

That portion of the soil passing the 8-mesh sieve is often called the soil mortar, although some workers prefer to reserve this term for that portion passing the 36-mesh sieve.

For general purposes it is customary to classify as clay any material which passes the 200-mesh sieve (0·076 mm.). It is the clay fraction which is the important part of the soil as far as soil stabilization is concerned, and it is worth while considering it in greater detail.

Clay consists of well-weathered materials, chiefly complex silicates, the most important constituent being aluminium silicate. The clay is pre-eminently the active portion of the soil, the coarser fractions being inert. The properties distinguishing clay from the remainder of the soil are :—

1. Retention of water by imbibition. Hence the presence of a considerable

proportion of clay in a soil confers a high water-holding capacity on the soil. This is important in connection with the drainage of a stabilized soil site.

2. Plasticity when mixed with certain proportions of water. No matter how much water is added to sand, a plastic mass is never obtained. When, however, a clay-bearing soil is mixed with a definite quantity of water, defined by the plastic limit, a plastic mass is obtained.

3. The clay fraction confers very marked cohesive properties on the soil. If sand, free from clay, be moistened with water, moulded, and allowed to dry, the sand crumbles with the slightest stress. In fact, the samples cannot be taken out of the moulding apparatus without breaking up completely. When, however, clay is admixed with the sand, a sample is obtained which may be removed from the mould with ease, and which will withstand considerable applied stresses, the force required to break the samples increasing with the increasing clay content. The following figures show the effect of increasing clay content (in this case taken to mean increasing 200-mesh content) as measured by a compression test :

Percentage of Clay.	Compression Test.
0	0 lb.
25	850 lb.
50	1,000 lb.
75	1,250 lb.
100	1,600 lb.

The clay used in these tests was a rather non-colloidal one, otherwise the figures would have been much higher.

THEORY OF SOIL STABILIZATION.

It is on this cohesive strength of clay that our conception of soil stabilization is based. A clay soil is extremely stable naturally when dry, but when it reaches a definite moisture content, it loses all its stability, and is easily deformed and displaced by a load. A wet clay soil may be considered to have its particles surrounded by two types of water—free and adsorbed. The free water has the ordinary freezing point, boiling point, etc., of ordinary water, and is easily removed by evaporation. The adsorbed water films, however, are held by molecular attraction to the clay particles and have higher boiling points, lower freezing points greater surface tension and are more viscous than free water. Moreover, they cannot be removed by evaporation, and according to Terzaghi, they become semi-solid substances at thicknesses < than 2 millionths of an inch. It is the strength of these thin films of moisture which gives stability to a clay-bearing soil when dry. When a wet clay soil dries, the free water evaporates, leaving the clay particles bound together by the strength of the thin films of water on their surface. This so-called " dry " clay may still contain 5 per cent. of water, which can only be removed by such a temperature as would cause chemical destruction of the clay itself. When, however, this clay is exposed to the action of water, it rapidly takes up water, due to the large number of capillary channels present, and the adsorbed films become thicker, and lose their strength, with the result that the soil mass falls to pieces. The essence of the above theory is due to Terzaghi, who has collected much experimental data in support of it. What happens when a stable bitumen emulsion is added to the soil is not clear, but the practical result remains that a clay-bearing soil that has been treated with a stable bitumen emulsion in the correct proportion is extremely resistant to capillary water. Sufficient bitumen is not added to waterproof the soil completely, as this would, in most cases, not be an economic proposition. The only case where this is done is in that of a very sandy soil, forming a bituminous sand carpet, which is rather different from soil stabilization proper. In general, enough bitumen is added to ensure that the water absorbed by the treated soil will never be sufficient to render the soil unstable and unable to carry a load.

CLASSIFICATION OF SOILS.

Before discussing the tests carried out on a soil to determine the amount of bitumen emulsion it is necessary to add, it will be advantageous to consider very briefly the groups into which soils have been classified for engineering purposes. Much of this work has been carried out in America, and was performed primarily to obtain definite figures for a soil which will carry a load under adverse moisture conditions. Such a soil has been termed an *A.1. Group* soil. For re-grading, this is the group that is aimed at. The size analysis of this group is :—

Not more than 50 per cent. to be retained on the 8-mesh sieve. The actual soil mortar to consist of (according to Hogentogler) :

Clay	5–10 per cent.
Silt	10–20 ,,
Fine sand . . .	20–50 ,,
Coarse sand . . .	35–50 ,,

This is stated to be "a well-graded material, highly stable under wheel loads, irrespective of moisture conditions."

There are seven other groups of soil, each of which has some characteristic which renders it unsuitable for bearing a load under moist conditions, unless treated in some way. It is usual to add either sand or gravel, or, in the case of a sand (Group III) clay, to bring the grading within the above limits, when the soil is presumably suitable for carrying a load in the presence of water.

Whilst it is quite true that a soil belonging to Group A.1. will carry a load in the presence of water better than one belonging to any other group, experiment has shown that the statement "irrespective of moisture conditions" needs modification. Samples were prepared of soils of various gradings (Group III omitted), dried, and subjected to a compression test. A curve was obtained which started at 500 lb. for the A.1. soil (with the lowest amount of clay) and rose to 2600 lb. for a soil containing the highest amount of clay (the soil actually belonged to Group VII). When these samples were subjected to a capillary water-absorption test, followed immediately by a compression test, the results were reversed, the A.1. soil taking a load of 20 lb., but the rest collapsed under their own weight.

Thus, although the A.1. soil withstood the action of water better than the remainder, the bearing capacity would not appear to be sufficient under *any* moisture conditions. In any case, the working limits are very restricted.

When, however, a well-graded soil is either completely or partly waterproofed with a stable bitumen emulsion, it is enabled to carry a load in the presence of water.

By complete waterproofing is meant imparting to the soil ability to resist complete immersion in water. This can only be achieved economically in a few cases.

By " partial waterproofing " is meant rendering the soil sufficiently resistant to *capillary* water absorption to enable it to carry a load under wet subsoil conditions. This may be economically achieved by the addition of bitumen emulsion to the soil.

Tests.

Turning now to the tests carried out on a soil which it is proposed to stabilize with bitumen emulsion, it is obvious that the most important is the *size analysis* test. For this purpose the soil is carefully sieved through the 1-inch, $\frac{1}{4}$-inch, 8-, 36-, and 200-mesh sieves. It is washed through the 200-mesh sieve until the issuing water is clean.

For determination of the percentage passing 0·005 mm. and 0·001 mm., a method dependent on the rate of settling of deflocculated soil is used.

It is advantageous to plot a grading graph, the percentages of each size being plotted on an arithmetic scale and the actual particle size on a logarithmic scale.

Having obtained the size analysis of the soil, it is usual to determine the liquid and plastic limit of the soil. The *liquid limit* may be defined as that percentage of water which it is necessary to add to oven-dried soil in order that the mixture may flow freely. It is determined by a standard method using a special grooving tool.

The importance of the liquid limit from the point of view of stabilization with bitumen emulsion lies in the fact that it is only when the soil is in this condition that it may be mixed evenly and easily with the emulsion to give a perfect dispersion of the latter throughout the soil mass. In applying this statement to practice, however, due consideration must be given to climate and other factors, such as drainage, appertaining to the area in question.

The *plastic limit* is defined as the lowest moisture content expressed as a percentage of the oven-dried soil at which the soil may be rolled into threads $\frac{1}{8}$-inch in diameter without the threads breaking into pieces. Here again it is very simply determined by a standard method.

It should be noted that both the liquid and plastic limit tests are carried out on that portion of the soil which passes the 36-mesh sieve.

The plastic limit of a soil represents that moisture content at which optimum consolidation will take place. Once the soil dries beyond the plastic limit, consolidation becomes more difficult, due to the tendency of the soil to crumble under the roller.

The difference between the liquid and plastic limits of the soil is known as the *plasticity index* of the soil. This index is a measure of the range over which the soil will remain plastic.

It is possible to calculate the plasticity index approximately from the liquid limit of the soil, if the type of soil is known. Generally speaking, the finer the state of subdivision of the soil, the higher is the plasticity index.

Having carried out a size analysis and determined the liquid and plastic limits of the soil, it may then be assigned to one of the eight groups. This then gives an excellent indication of the probable behaviour of the untreated soil under varying conditions. When, however, it is proposed to treat the soil with bitumen emulsion, these groups are relatively unimportant, as stabilization by this method permits of a much wider variation in the grading of the soil than any other method. It has, in fact, been stated by Hogentogler himself in a review of the study of Road Subsoils, reported in *Public Roads*, Vol. 19, No. 6, that "where only fine or poorly graded materials are available, asphaltic binders may be utilized to provide stable base courses to be covered with bituminous surfaces."

In practice, the limit for the quantity of fine material is set chiefly by economic considerations. Where too high a percentage of 200-mesh material is present, the quantity of emulsion involved makes the process too expensive. It appears from specifications issued by various American Highways Authorities, such as the Bureau of Public Roads, Texas State Highways, Ohio State Highways, etc., that it is not desirable for the percentage passing the 200-mesh sieve to be greatly in excess of 25. This has been precisely our experience both in the laboratory and in practice, that the best results are obtained, from both the technical and economic standpoints, when the 200-mesh content is between 20 and 30 per cent.

It is not claimed, however, that a satisfactory base cannot be obtained with low 200-mesh contents, but such cases cannot be termed true soil stabilization, which relies on the bonding action of the clay for its strength, as here the bitumen/clay ratio is such that the strength results from the bitumen itself. In order to determine whether satisfactory stabilization may be achieved with bitumen emulsion, cylinders are made and tested for capillary water absorption by standing them on a wet base for a definite time.

It may be wondered why the samples are not tested for water absorption simply by immersing them in a dish of water. The answer to this is twofold :—

In the first place, our conception of soil stabilizaton does not mean the complete waterproofing of the soil. What is inferred by soil stabilization with bitumen emulsion is rendering the soil sufficiently resistant to capillary water absorption to enable it to carry a load when laid on a wet foundation.

In the second place, total immersion would not represent the conditions obtaining in practice, where it would not be considered good engineering to have the subgrade of a road, parade ground, etc., continually under water. The top of a stabilized soil base is always sealed with a strongly water-resistant armour coat. Thus, the only source of water for the stabilized soil is from the subgrade, from which it will only take up water by capillarity.

These conditions have been reproduced as far as possible in the absorption chamber, the source of water being at the bottom only.

The second test carried out on these samples is the *compression test.* The samples immediately after removal from the water-absorption test are compressed and the maximum reading on the gauge before the sample cracks is noted. The test is carried out under standardized conditions, and pressure is applied at a uniform rate. It has been found that an untreated soil, when tested in the above manner, will not stand much more than 15 lb. per square inch, whereas the minimum pressure for a properly stabilized sample is in the region of 100 lb. per square inch. It is, in fact, not unusual to obtain a soil which, when properly stabilized, and after exposure to the water-absorption test, will withstand a pressure of 250 lb. per square inch.

The tests outlined above afford an excellent indication as to whether satisfactory stabilization has been achieved with bitumen emulsion. For confirmatory purposes, however, further detailed tests are carried out, which it is not possible to describe in a paper of this type.

The normal quantity of emulsion required is 6–10 per cent. of emulsion by weight of the soil fraction, exclusive of stone. This might appear to be rather a low percentage, but practical results have justified its use. If I may again be allowed to quote from the previously mentioned article by Hogentogler in *Public Roads*, he states :—

"In the case of bituminous treatments, there is apparently a rather flexible range of quantity of treating agents which may be used. As judged by their behaviour, mixtures near the upper limit of the range mentioned appear to be more critical than those near the lower limits, no radical failure being noticed in sections approaching excessive leanness, whereas an excess of bitumen has immediately produced plasticity and loss of stability."

PRACTICAL WORK.

The method adopted for the execution of soil stabilization in practice depends to a very large extent on the area in question. Where a relatively small area, such as a footpath or a small school-yard, is to be treated, it will probably be most convenient to mix the soil by hand or in a concrete mixer. For a larger area—say, over 5000 square yards—it is usually more convenient to carry out the work using earth-moving and mixing machines drawn by caterpillar tractors.

When the rapid treatment of a large area is required, a special mixing machine is used.

It is not proposed to describe these methods in detail, as they are best observed from the films.

CONCLUSION.

Whilst it has not been possible in the time available to deal with the soil stabilization in all its aspects, or to elaborate on such questions as laboratory technique and control methods, it is hoped that sufficient has been said to indicate what are believed to be the underlying principles. Much interest has been shown in the subject in the last few years, and this interest shows no signs of waning. It is in America, however, that the greater part of the work has been carried out. In that country official tests have been carried out using different materials for the treatment of soils—*e.g.*, bitumen emulsion, tar, cement, etc.—and I cannot do better than conclude by quoting some of the conclusions that have been reached by the American Bureau of Public Roads as reported in various issues of their journal, *Public Roads*.

1. " It is indicated that all the methods employed may be successful, but the relative economy of the various methods depends on local conditions associated with the project. Mechanical stabilization assumes the availability of an ample aggregate supply. Economy limits cement stabilization to soil types requiring a relatively small amount of cement. In other cases, bituminous treatments will generally prove more economical and adaptable."

2. " In bituminous stabilization three methods of treatment—machine mixing, sub-oiling, and road mixing—have all been successfully employed. The sections of road-mixed material are of too recent date to be fairly compared with the other sections, but the results obtained so far give no indications of inferiority."

3. " Under the conditions used, and based on the length of service thus far observed, no appreciable difference has been noted in the stability produced, or the durability obtained with the various bituminous agents used."

SOIL MECHANICS IN FOUNDATION ENGINEERING.*

By R. L. James, B.Sc., A.M.Inst.C.E., A.M.I.Struct.E.

For many years engineers and chemists have studied the properties of building materials such as steel, concrete, and timber, until to-day it is possible to design huge chords of a Sydney Harbour Bridge in high-tensile steel alloys and to compute the effects on it of the primary stresses of loading, impact, and wind, and the secondary stresses imposed by temperature and joint deformation. Our knowledge of concrete water cement ratios, grading, and workability also permits the safe design of a boulder dam, or a fifteen-storey reinforced-concrete building subjected to earthquake stresses.

It is only during comparatively recent years, however, that soil has received much attention as an engineering material. This despite the fact that soil problems are important in earth-fill dams, stopbanks, retaining walls, building and bridge foundations, irrigation and drainage schemes, tunnel linings, railway cuttings and embankments, harbour reclamation, landing-fields and road subgrades.

Agricultural soil physicists such as Atterberg, Oden, Robinson, and Russell were among the first to establish definite soil tests as a means to describing soils of which there was some practical field experience. Two English engineers, Crosthwaite and Bell, published papers on the lateral pressure of soils on retaining walls, in the *Proceedings of the Institution of Civil Engineers.*

Then came Dr. Terzaghi, who has exerted a very considerable influence over the subject from an engineering point of view. As lecturer in the American Roberts College in Constantinople, as Professor of Soil Mechanics at Massachusetts Institute of Technology, and as Professor of Civil Engineering at the Hoch Schule, Vienna, he has concentrated on showing what movements of water will occur in the soil under given forces of load or water pressure, and what settlements or slips may result. Dr. Casagrande of Harvard University has elaborated on the calculations of Boussinesq in order to predict the stresses imposed at different points of a soil mass under large area foundations of different shapes. The Americans Gilboy, Bouyoucos, Krynine, Hogentogler, and Proctor have devised or modified tests as an aid to describing the soils encountered. Men at the Rothamsted Agricultural Experimental Station, such as Russell, Coutts, Keene, and Rachowski, have thoroughly explored several other tests, particularly those dealing with water absorption and swelling. Dr. Hanna and Dr. Tschebotareef have done valuable work in Cairo comparing laboratory predictions of settlement with levels taken periodically on actual buildings. The American Bureau of Roads has divided soils into eight classes for highway work, and this classification has been copied with

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* Paper read at a meeting of the Institute of Petroleum Asphaltic Bitumen Group on 16th January, 1940.

little change by the Main Roads Board of Victoria, Australia. Soil laboratories have been organized more recently in England in collaboration with the work of the Building Research Station and the Road Research Station.

Soil work was commenced in New Zealand at Canterbury College in 1930. About the first four years were devoted to a study of the tests, and the remainder of the time to building up tables of soil information, tracing relationships between the various physical properties, and advising on actual practical problems of construction and design. As a result we have now been able to select a few tests on which the greatest number of physical properties of engineering importance depend. We use these tests to compare new soils with those of which we have definite constructional experience.

There is an increasing flood of literature on soil mechanics these days in the technical press—some printed in German, others in Dutch, Swedish, Russian, and in Calculus. Articles on soil mechanics by mathematicians with no engineering experience and by engineers with shaky laboratory technique must often be read with a certain amount of discrimination.

Soil Behaviour.

Soils consist of sand, silt, clay, and humus or organic matter. The sand may be silica, and the clay hydrated aluminium silicate, but the names do not depend on chemical composition. Clays owe their behaviour chiefly to the fact that the grains are very small and platy rather than spheroidal. The humus is important chiefly because of its effect on the water-holding capacity of the soil. The fine particles of clay will remain suspended for a long time in water—that is to say, they are colloidal. They have a surface area large compared with their weight, and hence the electrical charges on their surfaces are much more important than the forces of gravity. Small particles of clay may be introduced into a drop of water on the slide of a high-powered microscope, and it will be seen that many of the particles or specks are constantly in motion, darting this way and that—in Brownian movement—due to bumps by molecules of water always in vibration.

It is considered that each colloidal speck is surrounded by a film of liquid which helps to cushion the blow when two particles collide. This film may be charged negatively or positively, and if the charges are altered by adding an electrolyte or by passing a current through the column, the protecting film leaves the particle. On collision they stick together (or "flocculate"), their weight becomes more important than their surface charges, and they sink. This flocculation—or gathering together in flocks—is well known, whence the use of lime to improve the tilth of the soil in agriculture.

Influence of Grain Shape.

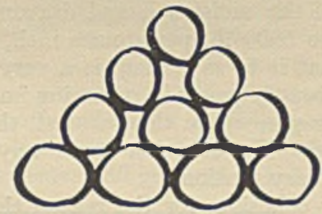
There is the famous Reynold's bag experiment. A rubber bag was filled with sand and the stopper opening sealed; the shape of the bag could be easily altered. The voids were then filled with water and the top was sealed. The bag became as solid as a rock. When clay was tried the bag could be deformed due to the sliding of some particles over others. This occurred because the clay grains were platy. This platyness makes the determination of the settling rate of clay particles in suspension rather an arbitrary measurement for the grains with the same horizontal diameter fall at the same rate—like tin plates in a dividing competition. We pretend that we are measuring the diameters of spheres.

A very fine or colloidal powder or quartz has no plasticity because the grains are not platy.

Influence of Grain Size.

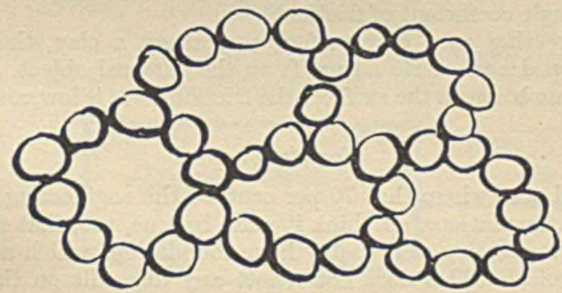
Why does a clay soil hold a lot of water? Much more than sand.

In a suspension column sand grains, under the influence of their weight, roll until they come to depressions and build up a cannon ball structure.



With this formation equal spheres would have a maximum volume of voids of 47·6 per cent.

But if the falling particles are very small, the initial friction will check their rolling tendency so that they stick and build up a fairly spongy structure. If colloidal particles are gathered in flocks by means of an electrolyte, the clay forming may have an open texture with 94 per cent. voids.



More water can therefore be retained.

Capillary Forces.

Surface tension at the top of a fine capillary tube will lift water up a considerable height. This tension force or negative hydrostatic pressure has its maximum amount just under the surface of the column. It can be understood that this effect becomes a big factor when there are thousands of these capillaries to a square inch of clay. Of course in a soil the voids do not form straight tubes. The voids are very small too, so that the ordinary laws of capillarity and viscosity may not perhaps apply rigorously.

In some experiments it was found that for clay with a compressive strength of 740 lb. per square inch, the maximum capillary force = 2440 lb. per square inch; clay with a compressive strength of 1220 lb. per square inch, the maximum capillary force = 4840 lb. per square inch. In loading tests there is a difference between the downward vertical load applied and the upward capillary force. The unbalanced pressure forces the water out of the test specimen. Since that volume of water has gone, the particles can move together. In other words, settlement occurs. Since it takes time for the water to go out, settlement may occur slowly.

Shrinkage.

The shrinkage on drying is stated to be caused by the surface tension existing in the voids of the moist soil and drawing the particles closer. The force may be up to 5000 lb. per square inch, and acts towards the centre of the clay. That is to say, there is a very considerable suction; whence the use of clay beauty-packs in removing impurities from the skin. Since the clay has more pore space than a sand, there is more shrinkage in a clay than in a sand. The cohesion across any section of a clay soil is due to this same capillary tension.

Dried soils still show cohesion, for the reason that they contain some water which cannot be evaporated.

Swelling.

If the soil be covered with water, the surface-tension forces vanish and the specimen swells.

Friction.

There are several different types of slips possible in sand, and there is no definite single coefficient of friction.

A weight resting on a clay surface compresses a clay, the outflowing liquid is trapped and exerts an uplift on the external object. With such a small pressure between the surfaces the friction force is low, and the object slips.

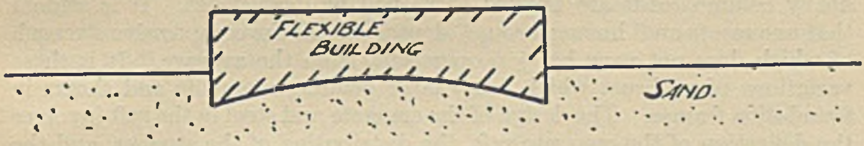
Foundations.

I have read somewhere that 70 per cent. of the engineering failures are due to faulty foundations. I think it must be true, too, that many buildings which are standing well to-day have foundations which are over-safe and uneconomical. This does not reflect any discredit on the engineers who have pinned their faith to a 12-inch block of hardwood loading test, or who have relied on the driving of test-piles. It is just that the whole matter is very complex, and as time goes on we are learning a little more about the many factors involved. It is not yet possible to give a completely connected story or to lay down hard-and-fast rules for the guidance of all engineers, but it is possible to get a little closer than before—perhaps the factor of safety can be decreased from say $2\frac{1}{2}$ to $1\frac{3}{4}$ in a great many cases.

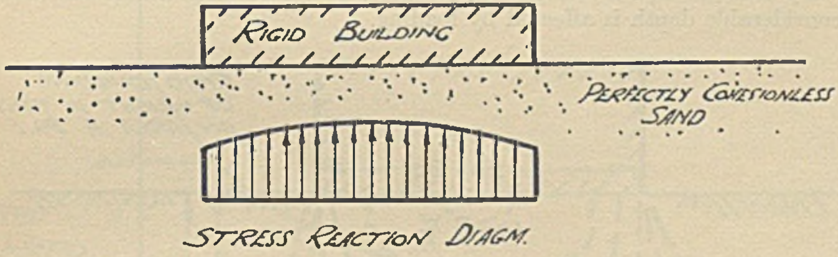
It is not correct to imagine that because 2 tons can be carried on 1 square foot, it is only necessary to make a rigid footing slab 100 square feet in area to carry 200 tons. There are too many other factors for us to do that any longer.

1. *The Distribution of Stresses below a Foundation.*

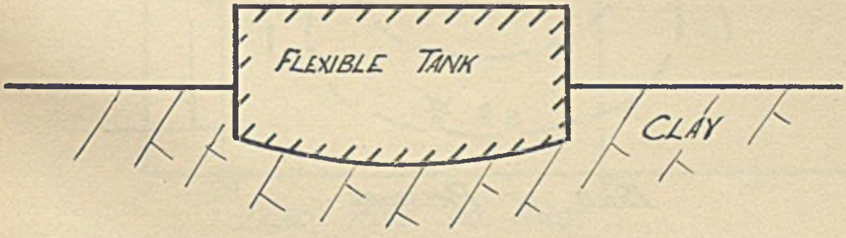
Dr. Terzaghi, of Vienna, assisted by the American Foundation Committee of the American Society of Civil Engineers, has organized a survey of the settlement of a large number of European buildings and structures. In each building he has fixed about twenty brass tubes, into which reference-plugs screw, and these are observed at intervals with a water-level fitted with a special micrometer. A great deal of interesting information has been collected in this way, and in particular he has found that a building on shallow foundations sinks around the edges.

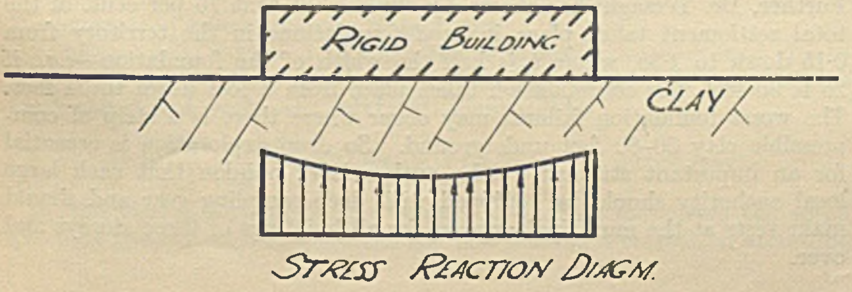


This was particularly noticeable with flexible tanks. If the building is quite rigid, and cannot sink more at one place than another, then the soil reactions are least at the sides and greatest in the centre.



(I should mention in passing that clays are the opposite—*e.g.*, flexible tank behaves as shown in the diagram below.)



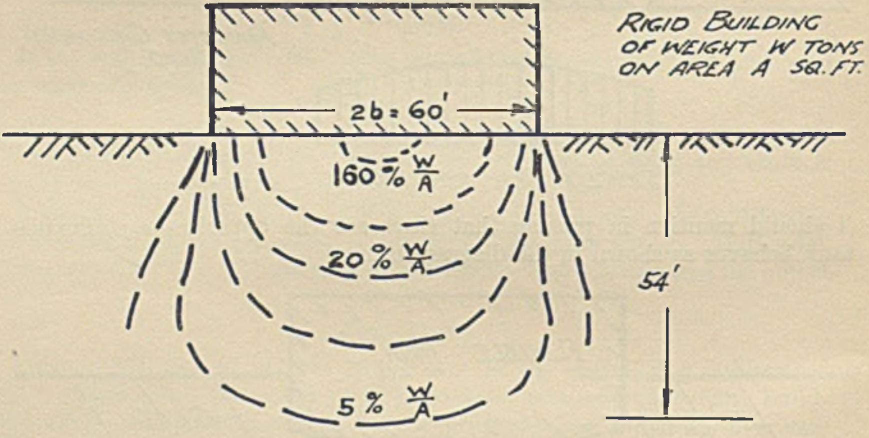


If foundations are placed deeply in sand, they tend to behave as clays in this matter of pressure distribution, but there is some doubt on this point. It will be found easy to remember that for a flexible structure

"*S*urface *s*ands *s*ettle at the *s*ides."

The curved surface that would be produced if the superimposed structure were perfectly flexible and the soil were perfectly uniform is called "the basic form of the settlement trough." Of course this is seldom completely realized in practice. Where hard spots of soil occur there will be local "pimples" on the "basic trough." Where there are soft spots or where heavy column loads are applied there will be depressions. It is seldom that one meets an "homogeneous" deposit of soil the compressive strength of which does not vary by ± 50 per cent. from the average. It is these variations of upthrust which cause large bending moments and shears in foundation frames. The design of the concrete and steel in the raft involves the deflection of the concrete raft, the distribution of the stresses, and the variability of the soil settlement. Articles on the design of rafts in this way appear in *Concrete and Constructional Engineering*, 1936 (giving a very heavy design) and in the *Structural Engineer*, March 1935.

By Boussinesq's mathematical studies it has been shown that soil at a considerable depth is affected by loading.



BULB OF PRESSURE.

Further, Dr. Terzaghi has shown by experiment that 75 per cent. of the total settlement takes place in *sand* foundations in the territory from 0·1*b* down to 1·8*b*, where *b* is half the width of the foundation—*e.g.*, if 2*b* is 60 feet, the consolidation takes place from 3 feet down to 54 feet. The worst foundation failures may occur where there is a strip of compressible clay 50–80 feet underground. So deep exploration is essential for an important structure. The author is of opinion that each large local authority should be equipped with deep sampling gear and should make tests at the municipal expense for all buildings of three storeys and over.

2. *Ratio of Stress to Settlement.*

The majority of soil engineers use a method adopted by Dr. Terzaghi.

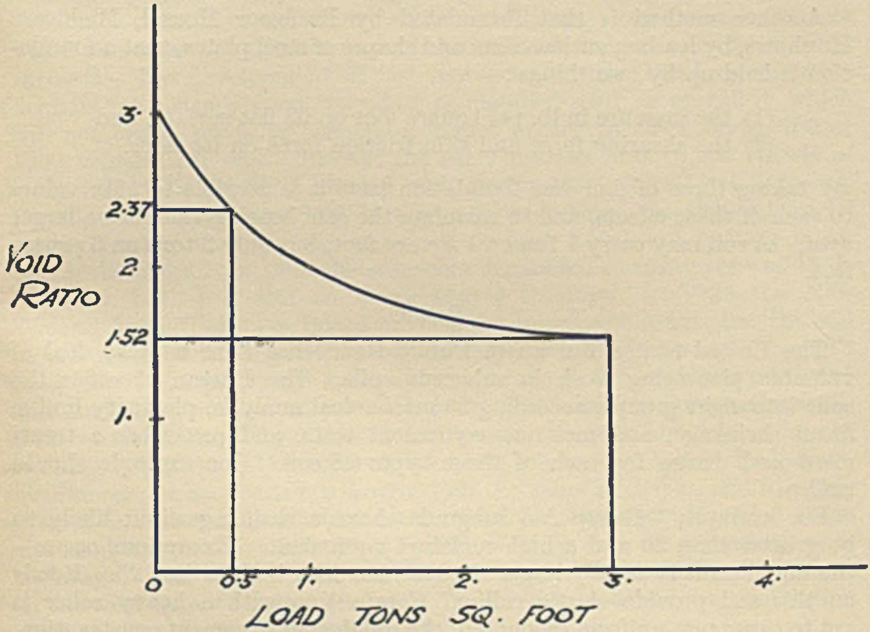
A soil pat (undisturbed), obtained with a special sampling device, rests between two porous stones and is compressed by a piston fitted with accurate dials to record the amount of movement. There must be a free outlet for water squeezed out of the pore spaces.

Moisture content, compression settlement, and voids ratio are all closely connected, and one of these is plotted against the pressure in tons per square foot or kgm./cm.^{2} The voids ratio $= \frac{\text{vol. of voids in soil}}{\text{vol. of solids in soil}}$. This is given the value e_1 when the pressure is p_1, or e_2 when the pressure is p_2.

Then total settlement under foundation

$$Q = D_1 \times \frac{e_1 - e_2}{1 + e_1}$$

Where D_1 = thickness of soil layer under pressure p_1.



For example in a case given by Hogentogler.

e changes from 2·37 to 1·52 when the total load changes from ½ ton to 3 tons per square foot. So that if 3 tons per square foot rests on this muck soil (5 feet thick), the total settlement will be

$$Q = \frac{2{\cdot}37 - 1{\cdot}52}{1 + 2{\cdot}37} \times 5 \text{ feet} = 1{\cdot}26 \text{ feet} = 15 \text{ inches (say).}$$

3. The rate of settlement can be calculated from measuring the speed at which water passes through the soil and making a correction according

to the ratio of thickness of soil layer in the field to thickness of soil sample in the laboratory.

Professor Buisman finds that when compression settlements are plotted against the logarithm of the time in minutes, a straight line is obtained. He then very bravely predicts how much a building will settle in ten centuries.

A variation of the general method of calculation is used by the Foundation Soils Research Laboratory in Cairo.

They find Young's Modulus for the soil by loading it in an oedometer. Then the actual Young's modulus in the field is taken to be from 1¼ to 4 times this, according to the class of soil. Then for a given stress the strain can be calculated. The stress is the weight of the building per square foot of foundation at a given depth, and the strain is the settlement divided by the thickness of the oil stratum.

Fourteen buildings are under observation for settlement in Cairo—this in spite of some reluctance by engineers, architects, and builders, who maintained that their buildings were so well designed and constructed as to be free from the least settlement.

Another method is that formulated by Professor Housel, Michigan. He shows, by loading various sizes and shapes of steel plates, that a foundation is held up by two things :—

(1) the pressure in lb. per square foot on its flat surface, and
(2) the shearing force and skin friction force on its sides.

By taking three of four size foundation tests it is possible to affix values to each of these effects, and so calculate the safe bearing value for a larger area. A soil may carry 1 ton on 1 square foot, but only 3 tons on 6 square feet.

Roads.

The United States Bureau of Public Roads has done a great deal of valuable pioneering work in subgrade soils. The Bureau classifies the soils into eight groups, according to mechanical analysis, plasticity limits, lineal shrinkage, and moisture equivalent tests, and prescribes a treatment and design for each of those types of soil. One example should suffice.

For example, " Group A-5 subgrades have a shrinkage limit likely to be greater than 30 and a high moisture equivalent. Exceptions occur—the liquid limit is usually larger than 35, but may be less than 25. Roads on this soil provide elastic riding. Compaction with a heavy roller is apt to cause non-uniform rebound of the soil during pavement construction. Drainage must be provided to intercept seepage and reduce the adverse effects of frost heave. In the treatment a bituminous application should be followed by a cushion and a porous base course. Clay may be added with good results. Macadam should not be used until the subgrade has been stabilized by both treatment and drainage."

There is still a certain vagueness in the classification. It is full of such terms as "may be," "usually," "likely to be," and in practice it will be found that the test values for a soil "usually" permit it being placed in two or even three groups out of the eight. The author feels that this is because several of the tests chosen measure properties only rather indirectly connected with road construction practice. You can take just that portion of the soil which passes the 40-mesh sieve and find what moisture content it will have when you can roll it in a thread the size of a match—that is, find the lower plastic limit. Or you can find how many times you must knock a dish in a certain way to make a crack in the soil heal up along 1 mm. of height—that is, find the Lower Liquid Limit. You are measuring something about a portion only of the soil under forces and conditions with no proved theoretical or practical relationship to ordinary road engineering. The other two tests employed—centrifuge moisture equivalent and shrinkage limit—although presenting some laboratory difficulties, have a more definite connection with practice, but the Bureau classification tests make no attempt at finding the properties most important to the road engineer—the strength of the soil in tension, compression, or shear. The author does not suggest that the Atterberg plasticity tests be discarded, only that they should be supplemented for classification purposes.

Road subgrade design has been important in New Zealand, because thousands of miles of the county roads and highways run through districts which cannot as yet afford to provide bituminous, tar, or concrete wearing-surfaces. The development of fast motor traffic has therefore created a demand for a strong stone macadam or metalled road, as we call it, which will not crush, ravel, or corrugate, in wet or dry weather, under 100 or 1000 vehicles per day. Briefly, the early practice was to use spawls of stone from 3 to 6 inches, blinded with quarry stone from 1½ to ½ inches. By about 1915 all stone had to pass a 2½-inch ring. In 1920 advanced county engineers were ordering 2-inch to dust metal and putting in an 8-inch thickness. In 1928 the engineers demanded so many tons of 1½–¾, so many ¾–½, ½–¼, and so many tons ¼ to dust. In 1936 the New Zealand Main Highways Board advised for important roads that the soil mortar material passing shall we say 10 mesh, must have a tensile strength of at least 15 lb. per square inch, a lineal shrinkage of less than 5 per cent., and must have at least 25 per cent. passing 200 mesh. Corrugations will form wherever the subgrade is low in tensile strength, and frost heave or swelling will occur if the lineal shrinkage is too great. Bases of concrete, bituminous, or tar roads are designed on the same principle, and in many cases it is considered sufficient to use a 4-inch thickness of graded stone and sand-clay in order to carry a 1½-inch wearing coat for secondary main highways. The stone, sand, and clay are watered and thoroughly mixed on the road by auto patrol graders. Traffic may be used for consolidation when the clay content is sufficiently high.

A further development of road subgrade design is the use of bituminously stabilized soil in this country, where the high compressive strength of a dried sand clay is maintained by bituminous emulsion waterproofing. Since the natural materials are used in situ there is little cost for excavation and little cost in the haulage of materials to the site. Speed of construction is of the order of an acre and a half per day. There are a large number of practical points to be watched in the design and construction of stabilized soil roads, car parks, and aerodromes, points such as the choice of aggregates, design and control of mixes, surveying, drainage, choice of plant, organization of labour, and the variation of the process under changing weather conditions. It is not possible to include these in the short space of this paper.

In general, progress in soil mechanics can be achieved only by a close co-ordination of accurate laboratory work and vigorous civil engineering work in the field. In addition, there must always be intermediate tests—large-scale laboratory specimens and small field experiments to make a continuous connection between the laboratory and the job. Only in this way can we hope to avoid the errors which lie in wait for a pure theorist or a science despising foreman.

The author has attempted only a very general and rather elementary outline of the present position in regard to soil mechanics, and hopes it will be agreed that there is some interest and importance in even a very commonplace material.

DISCUSSION.

MR. A. H. D. MARKWICK (*Road Research Laboratory*) said: Mr. James has criticized the "simplified" tests for soils on the ground that they do not measure any true physical property of the soil which has a direct practical application. They cannot, of course, give any direct measure of the mechanical properties of the soil, for these depend on the original granular structure, which is destroyed in making the tests. The tests are therefore identification tests, and the test values obtained have been shown to be closely related to the mechanical analysis of the soil. In spite of the obvious grounds for criticism, the tests have been widely accepted. They were adopted as "Tentative Standards" by the A.S.T.M. in 1935, and I understand that last year they were accepted as "Standards."

The effective stabilization of soil depends on the control of the moisture content. Providing the moisture content is kept below certain limits depending on the type of soil, the soil will remain hard indefinitely. The soil must not, however, dry out too much, or the surface will disintegrate under traffic. Stabilization with bitumen emulsion is only one of many methods which have been tried in recent years, and the voluminous literature on the subject recorded, for example, in "Road Abstracts" affords abundant evidence of the efforts made abroad in recent years to develop this type of secondary road construction. So far as this country is concerned those methods of stabilized soil construction which rely on the drying out of the mixed material are restricted to the spring and summer months, and I think it is important if soil stabilization in this country is to develop along sound lines that such limitations should be carefully borne in mind. One speaker has referred to the importance of sealing the surface of soil roads, and I should like to support him on this point. In fact I was told last year that it had been possible in the Baltic countries to construct aerodromes by merely applying surface dressings using bitumen emulsion. This was applied in the summer. I have not, however, heard how far this type of construction was really durable and to what extent it is resistant to the severe frost action experienced there every year. I should like in conclusion to congratulate both the authors on the lucid presentation of their papers.

OBITUARY.

DR. CHARLES K. FRANCIS.

Dr. Charles K. Francis died at his home in Tulsa, Okla., on 25th March, 1940. He was well known as the technical editor of the *Oil and Gas Journal* from 1926 until the time of his death.

Dr. Francis was born in Chester, Pa., on 17th June, 1875, and graduated from Brown University, Providence, R.I., in 1899. He then served as an instructor at Brown, and was later a member of the faculty of the Georgia School of Technology. In 1904 he obtained his master's degree at Brown, after which he taught chemistry in Converse College, South Carolina, the University of Illinois, and the University of Missouri. In the last-named institution he received the degree of Doctor of Philosophy in 1910, moving then to Stillwater, Okla., where he was Professor of Petroleum Technology in Oklahoma A. & M. College, and also chemist at the Agricultural Experiment Station. He remained in Stillwater until 1917, when he moved to Tulsa to enter the practical work of the oil refinery.

Dr. Francis served successively as chief chemist for Cosden & Co. (now Mid-Continent Petroleum Corp.), manager of refineries, and chemical director for Transcontinental Oil Co., chief chemist and technical superintendent for Cosden & Co., vice-president in charge of manufacturing for Producers & Refiners Corp., and chief technologist for Skelly Oil Co.

From 1920 to 1924 he was a member of the advisory committee of the Federal Specifications Board. In 1925 he served as President of the Oklahoma section of the American Chemical Society, as a councillor in 1926, and was for three years state chairman of essay contests in the organization.

Dr. Francis was elected a Member of the Institute of Petroleum in 1927, and was a delegate to the World Petroleum Congress in Paris in 1937, serving as Honorary Chairman in the section of physics, chemistry, and refining.

GEORGE WILLIAM EDWARD GIBSON.

George William Edward Gibson died in September 1939, at the age of 62. He was born in Rotterdam, and at the age of 16 entered the Rotterdam house of Messrs. Tangye of Birmingham. In 1905 he took over the representation of Messrs. Hayward–Tyler & Co., Ltd., in North-western Europe, residing at The Hague. During the war of 1914–1918 Mr. Gibson worked on the military and naval intelligence staff of the British Government in Holland. In 1919 he was transferred to the London office of Messrs. Hayward–Tyler & Co., Ltd., with whom he was associated until his death.

He was a Member of the Royal Institution of Engineers of the Netherlands, and was elected a Member of the Institute of Petroleum in 1920. Mr. Gibson enjoyed the friendship of many engineers both in this country and on the Continent, and was an expert in the problems of pumping petroleum and its products.

ROBERT JOSEPH STRINGER.

Robert Joseph Stringer, A.M.I.Mech.E., who died on 25th January, 1940, was connected with the oil industry for over thirty years. He was born in 1881, and was educated at Halifax. He was apprenticed with Messrs. Cole, Marchent, and Morley, Ltd., of Bradford, from 1896 to 1901, and at the same time he attended evening classes under Professor Charnock at the Municipal Technical College. On completing his training he joined the staff of Messrs. Edward Ripley & Son, Ltd., of Bradford, as a draughtsman, and after leaving the company in 1903 he held similar positions with a number of firms, including Messrs. Dick, Kerr and Co., Ltd., of Preston and Messrs. Davey, Paxman and Co., Ltd., of Colchester.

He became technical and consultant engineer to the Vacuum Oil Co., Ltd., in 1906, and during the next twelve years he travelled to Australia, New Zealand, and New York in the firm's interests. From 1918 to 1920 he practised as a consulting oil engineer in America and Europe. He was then appointed managing director and lubricating oil expert of the Record Oil and Grease Co., Ltd., a position which he held until his death.

Mr. Stringer was elected a Member of the Institute in 1921.

FRANK BENJAMIN LEA.

Frank Benjamin Lea died on the 21st April, 1940, at his home in South Australia. He was eighty years old. Mr. Lea was born in Leicestershire and educated at Owens College, Manchester, and London University, where he graduated in 1882. For over twenty-five years he was engaged in electrical and mechanical engineering work in England. In 1910 he went out to Rumania as Joint Manager of the Rumanian Oilfields, Ltd., at Ploesti. He returned in 1914 to the London offices of the Anglo-Mexican Petroleum Co. For twelve years he was in charge of their foreign business in crude oil and fuel oil. In 1926, at the age of sixty-seven, he went out to Australia to become Secretary and Manager of a company marketing asphalt products in South Australia—Messrs. Asphalt Cold Mix (Aust.) Pty., Ltd., Melbourne. He continued his association with this company until the time of his death.

Mr. Lea was elected an Associate Member of the Institute of Petroleum in 1919. He was transferred to Member in 1927, and to Fellow in 1938.

Although he was nearly eighty years old at the time of his election to Fellowship, Mr. Lea had written to the Council expressing his appreciation of this honour, and relating how he valued his monthly journals.

ABSTRACTS.

AUTHOR INDEX.

The numbers refer to the Abstract Number.

The original papers referred to in the abstracts marked with an asterisk may be borrowed by Members from the Institute Library.

The assistance of the Director of Fuel Research of the Department of Scientific and Industrial Research is acknowledged in the preparation of those abstracts appearing above the initials D. F. R.

Geology.

949.* Subsurface Geology of Chester Series in Illinois. L. E. Workman. *Bull. Amer. Ass. Petrol. Geol.*, 1940, **24**, 209–224.—Occupying most of the southern half of Illinois, all the formations of the standard Chester series can be identified in the area.

A geological map and two cross-sections are furnished, showing the stratigraphic relations of the formations. These are mainly conformable and similarly so with the underlying formations of the Iowa series of the Mississippian. Warping, uplift, and peneplanation prior to the deposition of the Pennsylvanian have resulted in truncation of the beds throughout the basin.

Production has come mainly from the lower part of the Chester series below the top of the Cypress sandstone, and also from the upper part of the underlying St. Genevieve formation. The maximum thickness of the Chester series (shown on an isopach map) is 1450 ft. Two important pre-Pennsylvanian anticlines are indicated. In these are located the major number and features of the Illinois oilfields : one, the La Salle anticline, and the other, the uplift which extends south-east from the Sorento region.
G. S. S.

950.* Subsurface Geology of Iowa (Lower Mississippian) Series in Illinois. J. N. Payne. *Bull. Amer. Ass. Petrol. Geol.*, 1940, **24**, 225–236.—The Iowa series lie below the Chester group, and their definite separation depends on insoluble residues ; but their distinctive lithologies can be used for correlating. The Meramec, Osage, and Kinderhook groups are defined.

The Meramec consists of the St. Genevieve, St. Louis, and Salem formations, which include cherty and oolitic limestones and dolomites. Oil production is from all three formations, and especially from the Fredonia member of the St. Genevieve, which readily lends itself to separation by means of insoluble residues. The Osage shales and cherty limestones are doubtful oil producers, whilst the Kinderhook group is mainly structureless shales.

The thickness of the Iowa series has been determined by isopachs (a map of which accompanies the paper) and a maximum of 2000 ft. has been obtained in Gallatin Co. The La Salle and Carlinville–Centralia anticlines, folded in pre-Chester times, have been revealed by thinning of the series. G. S. S.

951.* The Type Permian ; its Classification and Correlation. C. O. Dunbar. *Bull. Amer. Ass. Petrol. Geol.*, 1940, **24**, 237–281.—The major part of this paper describes the Permian Basin west of the Urals, and is accompanied by maps and sections to illustrate the location and stratigraphy.

The region is divisible into two dominant structural elements—the Russian Platform and the Uralian Geosyncline. The pioneer work of Murchison in defining the Permian System is discussed and an analysis of the stratigraphy of the Permian Basin, as known at present, is given. In addition, the Middle and Upper Carboniferous beds of the basin are described ; these include the zone of *Triticites*, which thins rapidly westward from the geosyncline, and is represented in the Moscow Basin by the well-known Gshelian.

The writer stresses the ambiguity of the term " Uralian," which was given to a series of limestones at the base of the Permian and at the top of the Carboniferous. This term was used by De Lapparent and Tschernyschew to denote a time-phase, but is here considered to represent only a facies. Tschernyschew's work in correlating limestones in the Timan and Ufa plateaux is shown to be partly erroneous, as the Ufa plateau section continues much higher stratigraphically than that of the Timan. It is suggested that "Uralian" be abandoned or given a more precise definition.

The Permian is divided into five series: the Sakmarian, Artinskian, Kungurian, Kazanian, and Tartarian. The Sakmarian is the *Pseudoschwagerina* zone, and its reef structures (the Shikhans) are described. The Artinskian shales, sandstones, and conglomerates are considered to be the equivalent of part of the Ufa plateau limestones (Uralian), whilst the salt-bearing series (Kungurian) vary greatly in lithology and thickness. The Tartarian are continental deposits of redbed facies and occupy the central part of the basin; they are not of great thickness, the upper part being included in the Triassic.

The Russian section is correlated with the areas of marine Permian in the south-west United States and in South China; the Permian fusuline zones are useful in such correlation.

Deposition continued in the Russian basin from Middle Carboniferous into Upper Permian with only minor interruptions. The greatest physical change came at the beginning of the Sakmarian, when the Uralian geosyncline began to deepen rapidly and when also a marked faunal change took place with the sudden appearance of the genera *Schwagerina*, *Pseudoschwagerina*, and *Paraschwagerina*. In America and in South China there is a similar widespread break below the same faunal zone—a correlation which suggests that the base of the *Pseudoschwagerina* marks the beginning of Permian times. G. S. S.

952.* Carboniferous–Permian Boundary. R. C. Moore. *Bull. Amer. Ass. Petrol. Geol.*, 1940, **24**, 282–336.—The problem of the definition of the boundary between the Carboniferous and Permian is here reviewed in the light of the requisites and purposes of a systematic classification. The geological system, as a major stratigraphical unit, was first conceived by English geologists, and in the definition of boundaries of the various recognized systems the following criteria have been used: (1) unconformities, (2) palæontological breaks, (3) marked changes in lithologies. Substantial agreement in usage is more important as a factor in definition of boundaries than priority of definition. It is preferable to have a standard classification that is understood by all, and geological practice demands that definition of the boundaries of the Carboniferous and Permian systems in Europe and North America should be in agreement.

The Carboniferous–Permian boundary in England, Russia, and North America is discussed critically. In England, except possibly in Warwickshire, the hiatus in the position of the boundary is very considerable. Russian geologists have placed the beds of the *Pseudoschwagerina* zone in the Upper Carboniferous and the Artinskian strata, immediately above, in the Permian. This has been contested by C. O. Dunbar, who states that the boundary between the *Pseudoschwagerina* zone and the Artinskian was not a time boundary, but between two facies. Recent Russian work also advocates the placing of the boundary at the base of the *Pseudoschwagerina* zone (Sakmarian).

Investigation of the Carboniferous and Permian strata of North America indicates that the majority opinion has favoured, since the earliest work, the placing of the boundary at the base of *Pseudoschwagerina* zone—that is, at the base of the Wolfcamp series in Texas and the Big Blue series in Northern Mid-Continent. Early determination was based primarily on palæontological evidence, but recent work has shown the existence of a large physical break at the base of the Wolfcamp deposits.

The Sakmarian of Russia now placed in the Carboniferous is regarded as the equivalent of the Lower Permian Wolfcamp. In Europe also the line at the base of the Rotliegende (Autunian), lowermost Permian, is not as high as the top of the *Pseudoschwagerina* zone. Although some Russian geologists regard the boundary as the base of the zone of *Pseudoschwagerina*, opinion is very divided. Evidence from North America, West Europe, and many other parts of the world makes revision of the boundary in Russia to include correlative beds in the Permian extremely desirable. The conclusion reached and suggestion given in the paper is that the revision of the lower Permian boundary in the type area would accord best with palæontological and stratigraphical relationships in different parts of the world.

A bibliography of nearly 250 entries is given. G. S. S.

953.* Classification of Permian Rocks. C. A. Tomlinson and Others. *Bull. Amer. Ass. Petrol. Geol.*, 1940, **24**, 337–358.—This is a report of the Association's Sub-committee appointed " to prepare a digest and recommendations for the classification and nomenclature of Permian rocks of the United States."

Among the various recommendations made are : (1) that the Permian rocks of the world should be recognized as an independent geological system ; (2) that a standard reference section for America is desirable, and therefore the Permian of the Delaware Basin in West Texas and in South-East New Mexico should be utilized as such a standard ; (3) that the zone *Pseudoschwagerina* and *Properrinites* be recognized as comprising the lowest part of the Permian System ; (4) that the disconformity which nearly everywhere separates the Permian in North America from the Triassic be recognized as the upper boundary of the system ; (5) that the Permian of North America be divided into the following series : Wolfcamp, Leonard, Guadalupe, and Ochoa.

In addition, the problems of defining geological systems, together with their relation to stratigraphical principles, are reviewed. G. S. S.

954.* South–North Cross-Section from Pecos County through Ector County, Texas, to Roosevelt County, New Mexico. W. C. Fritz and J. FitzGerald, Jr. *Bull. Amer. Ass. Petrol. Geol.*, 1940, **24**, 15–28.—In the preparation of this section—drawn from south to north along the eastern side of the Central Basin platform—thirty-eight sample logs are used.

Pre-Cambrian and *Cambrian.*—Although there is little evidence of these systems in Crane County, both are thought to be present. Other formations which are shown in the section are :—

Ordovician is represented by the Ellenburger dolomite and the overlying Simpson formation. The former appears on the section in the southern portion in Pecos and Crane Counties, and represents the Lower Ordovician and possibly the Upper Cambrian. The Simpson is very similar lithologically to that usually described in Oklahoma.

The *Silurian–Devonian* systems are represented by a limestone tentatively called Fusselman, which appears only in Crane County.

The *Permian* occupies a larger interval than the total of all other ages on the section. Approximately 6480 ft. of deposits are recorded from one well, the base of the system not being reached. The system is divided into seven parts, which, in ascending order, are : Abo, Yeso, San Andres, Whitehorse, Upper Castile, Rustler, and post-Rustler.

The San Andres group extends the full length of the section, ranging in thickness from 1300 to 1700 ft. In the southern part a crystalline dolomite predominates, which grades northward into an evaporite sequence—the upper part mainly salt and anhydrite, the lower retaining some of the characteristic crystalline dolomite. Most of the oil produced in Ector and in five other counties in Texas, as well as from the Hobbs, Vacuum, and Lovington pools in Lea County, New Mexico, is from sediments of San Andres age.

The Whitehorse group unconformably overlies the San Andres and has a thickness varying from 1300 to 1650 ft. In the West Texas–New Mexico Permian Basin the Whitehorse is divided into five formations. Most of the oil produced from the Central Basin platform comes from sediments of the Whitehorse sea.

The section passes through most of the Upper Castile Basin and shows its northern limit. The Upper Castile formation itself is mainly salt, and unconformably overlies the Whitehorse. No economic production of oil or gas is known from deposits of Upper Castile age, although non-inflammable gas has been obtained from the Cowden anhydrite member over structurally high areas in Central Gaines County, Texas.

G. S. S.

955.* South–North Cross-section from Pecos County through Winkler County, Texas, to Roosevelt County, New Mexico. E. H. Woods. *Bull. Amer. Ass. Petrol. Geol.*, 1940, **24**, 29–36.—This section extends 260 miles northward along the western side of the Central Basin platform ; thirty sample logs are used.

Pre-Cambrian and Ordovician sediments are found in the south in Pecos County. The Permian is the only other Palæozoic formation that occurs, the lowest beds of which (the Yeso) are found in both the north and south. Above the Yeso is the Glorieta, the basal sandstone of the San Andres series ; these are brown dolomites grading north into interbedded anhydrite, salt, and dolomite. The Whitehorse group overlies the San Andres. The Grayburg, the lowest member of the Whitehorse, occurs in four wells, and the Yates Sand, an upper bed, is very widespread. All oil and gas production north of Pecos County is from Whitehorse dolomite and sands below the top of the Yates.

The Upper Castile salt and anhydrite are best developed in the centre of the section, whilst the Rustler which overlies them unconformably consists of porous dolomite and salt. The post-Rustler consists mainly of red shales and sands, and includes the Dewey Lake series. Above come the Triassic Tecovas beds. Post-Cretaceous silt and caliche rest on the Triassic and Permian.

These data illustrate the south-westerly retreat of the Permian sea and the corresponding southward shift of the conditions of salinity. G. S. S.

956.* Geologic Section from Fisher County through Andrews County, Texas, to Eddy County, New Mexico. R. I. Dickey. *Bull. Amer. Ass. Petrol. Geol.*, 1940, **24**, 37–51.—This section correlates outcrops on the east and west sides of the Permian Basin, especially those of the Whitehorse group; forty-two logs were used.

Sediments range from Upper Cambrian to Quaternary, but detailed discussion is limited to the Upper Permian, into which nearly all the wells of the Western Texas basin are drilled. On the eastern side Pennsylvanian occurs, the division between it and the Permian being taken at the appearance of the fusulinid *Schwagerina.*

The Lower Permian Clear Fork group consists in the east of shale and evaporites, but grades west to dolomite. A subsequent elevation occurred, and much clastic material is present in the overlying San Andres beds, which are the so-called "Blaine of Texas."

The Whitehorse consists of five formations—the Grayburg, Queen, Seven Rivers, Yates, and Tansill—which can be recognized by their contrasting lithology. The lowest beds, of great economic importance, are here named Grayburg; they are traceable from west to east across the basin, and unconformably overlie the San Andres. The Yates sand varies greatly in thickness, but is widespread in occurrence, and hence is used as a marker in mapping the sub-surface structure.

Overlying unconformable Upper Castile salt is thickest in the Midland Basin, whilst above it is the Rustler, representing the last marine invasion. The top is an erosion surface on which the Dewey Lake sands were deposited. Triassic and post-Triassic beds in part overlie the Dewey series. G. S. S.

957.* Stratigraphy, Eastern Midland Basin, Texas. L. R. Page and J. E. Adams. *Bull. Amer. Ass. Petrol. Geol.*, 1940, **24**, 52–64.—The Midland Basin is one of the three major structural features of the South Permian Basin, and has a regional westerly dip on its eastern side.

Thick series of red sandstones, clays, salt, and silts, nearly all of Permian age, have been recognized by surface and sub-surface methods. These formations were laid down in a restricted sea which retreated southward in Permian times; gradations from nearshore clastics to gypsum and to marine limestones and dolomites are also recognized; the upper beds belong only to the onshore and intermediate zones. The Dewey Lake, which is described, is at the top of the Permian, and represents the final retreat of the sea and the filling of the basin with red sands.

The basal Clear Fork group consists largely of reddish shale with seams of white gypsum, with dolomite predominating in the west. The San Andres group above in the east is made up mainly of clastics, whilst traced westwards they are replaced by dolomite. An angular unconformity separates the San Andres from the Whitehorse group, an outcrop characterized by fine-grained red sandstone with frosted quartz grains in all but the lowest formation. The Upper Permian group, separated from the Whitehorse by a time break, is a thick series of saline deposits. The Upper Castile Salt is the main salt series of the Southern Basin, and is succeeded conformably by the uppermost Permian Sands of the Dewey Lake formation.

The Dickum group, of Triassic age, is composed of red terrestrial deposits, and include the Tecovas silt and the upper Santa Rosa and Chinle formations.

Cretaceous beds, where present, consist of a basement sand probably of Paluxy age, and rest unconformably on the Permian and Triassic. G. S. S.

958.* Structural Development, Yates Area, Texas. P. B. King. *Bull. Amer. Ass. Petrol. Geol.*, 1940, **24**, 134–142.—The surface dome, near Iraan in eastern Pecos

County, forms a well-marked closed structure in the Permian Basin. This paper, accompanied by sections, gives a comprehensive account of its structural development, together with a brief stratigraphical summary.

The structural development of the Yates area was initiated in beds older than any so far penetrated in the dome, which was overlain by the Whitehorse and Castile Salt formations.

The early Cretaceous period saw great solution and slumping of these salt deposits, and produced a solution syncline over the crest of the Yates dome which became filled with a plug of non-marine clastics. Slight warping in late Tertiary or Pleistocene times again exposed the salt to solution, and slumping of the unsupported sediments around the plug developed the ring syncline responsible for the present surface. This Cretaceous structure overlying arched Permian limestone was therefore developed by salt solution rather than by folding, a solution which occurred in two stages.

G. S. S.

959.* Palæozoic Stratigraphy of Franklin Mountains, West Texas. L. A. Nelson. *Bull. Amer. Ass. Petrol. Geol.*, 1940, **24**, 157–172.—The area described in this paper lies within 104° 30′ and 109° W. longitude and 31° and 34° N. latitude, and includes the cities of El Paso and Silver City. Lying within West Texas and South New Mexico, it offers a Palæozoic section from the Pre-Cambrian to the Permian. The mountain ranges have mainly a parallel north to south trend, and enclose basins of unconsolidated deposits characteristic of the Basin-and-Range structural type. The Franklin Mountains rise abruptly on their eastern side from the level of the bolson.

Palæozoic rocks approximate to 8000 ft. in thickness; each formation is described with accompanying stratigraphical diagrams to show the succession and location.

Pre-Cambrian is everywhere the basal formation except in the Hueco Mountains. In the Franklin Mountains a newly-named granite, the Red Bluff, forms part of this base. The oldest known Palæozoic formation is the Bliss Sandstone, here assigned to the Upper Cambrian; absent in the Oscura Mountains in the north, this deposit appears in the south and rapidly thickens. The Ordovician is represented by the El Paso Limestone (1000 ft.) and the Montoya Limestone. The massive dolomitic limestone of the Middle Silurian, the Fusselman Limestone, occurs in the Franklin Mountains, whilst the Middle and Upper Devonian are found in the western part.

Pennsylvanian, here known as the Magdalena formation, is described in detail. Consisting of 1600 ft. of thinly bedded dark grey limestone, it has been divided into three zones: the Bishop's Cap, Berino, and the La Tuna. The characteristic lithology and fauna of these zones are given.

The Permian, in the Franklin Mountains, is represented by the Hueco sediments (650 ft.). They are fine-grained light-coloured limestones, and are separated from the Magdalena by alluvial deposits. This formation is overlain in most of the area by the Comanche. G. S. S.

960.* Correlation of Pennsylvanian Rocks of New Mexico. C. E. Needham. *Bull. Amer. Ass. Petrol. Geol.*, 1940, **24**, 173–179.—The Pennsylvanian rocks of New Mexico, which consist of 1500–1800 ft. of sediments, are known as the Magdalena Formation. They are divided into two lithological types, a lower (600–700 ft.) of sandstones, shales, and thin limestones, and an upper (800–1000 ft.) mainly of limestone with interbedded sandstones and shales.

These sediments are probably of marine origin, and in correlation with other regions chief reliance is placed on their fossil content. Of the large fauna preserved, those of the brachiopods and fusulinids have been used as a basis for regional correlation.

The lowest Pennsylvanian in New Mexico, up to 700 ft., lies below the *Wedekindllina* and *Fusulina* zone, and belongs to that of the *Fusulinella.* It is probably correlative with the Lower Cherokee and Lower Atoka. Above this, the *Wedekindllina* and *Fusilina* occur, and the series can be correlated with the Upper Cherokee and Upper Atoka. These equivalents of the Des Moines beds are recognized in New Mexico, where they attain a maximum thickness of 1000 ft.

Beds of Kansas City and Lansing age in the Missouri series are characterized in New Mexico by the occurrence of *Triticites nebraskensis*, *Neospirifer latus* and *Echinoconchus semipunctatus.* *Triticites* and various brachiopods in the beds above belong to the Lower and Middle Virgil and Lower Cisco age.

The highest Pennsylvanian beds contain *Triticites ventricosus*, and are considered to be Lower Wabaunsee in age. They are well developed in the Sacramento Mountains; elsewhere they are thinner due to the Pennsylvanian–Permian unconformity, a break which is known to be of small magnitude. G. S. S.

961.* Upper Palæozoic Section of Chinati Mountains, Presidio County, Texas. J. W. Skinner. *Bull. Amer. Ass. Petrol. Geol.*, 1940, **24**, 180–188.—Upper Palæozoic sediments outcrop in four large areas along the periphery of the Chinati uplift. J. A. Udden, in 1904, gave the name Chinati series to these sediments of the Shafter area; he recognized three formational divisions: the Cieneguita (1000 ft.), the Alta (3500 ft.), and the Cibolo (1400 ft.). He concluded that the Cieneguita and Alta were of Pennsylvanian age, and that the Cibolo might be Permian. Later writers assigned the entire Chinati series to the Permian.

This paper deals with areas visited to the north-west and west of Shafter. From both lithological and faunal characteristics the Chinati Mountain Palæozoic sections appear to consist of a sequence of Pennsylvanian beds and a nearly complete Glass Mountain Permian section. Udden's conclusions were therefore nearly correct, later confusion having arisen owing to lithological resemblances in the Chinati and Pennsylvanian formations. G. S. S.

962.* Morrow Group of Adair County, Oklahoma. C. A. Moore. *Bull. Amer. Ass. Petrol. Geol.*, 1940, **24**, 409–434.—This paper is the result of field work and laboratory studies on the rocks of the Morrow group which lie at the base of the Pennsylvanian system. The beds immediately above and below the Morrow are also described.

The Pitkin formation (Chester group), which forms the top of the Mississippian, underlies the Morrow disconformably. It is a limestone, but argillaceous and granular lithologies are also recognized.

In all sections the basal formation of the Morrow (the Hale) rests on eroded Pitkin limestone, and generally there is a phosphatic conglomeratic bed at its base. The Hale is variable lithologically, and it is difficult to interpret the relationships of adjacent sections. It is mainly calcareous sandstone, and is distinguished from the overlying Brentwood limestone by its insoluble residues. The Hale–Brentwood contact is poorly exposed, and is represented by a change in lithological character and residues.

The Bloyd formation, above the Hale, consists of two limestone members, the Brentwood and Kessler, which are separated by dark carbonaceous shale. The Brentwood contains thin shale bands, and in parts of the area cannot be separated from the overlying shale. The Kessler is cut out by the pre-Atoka erosion in the western half of the county. It is distinguished from the Brentwood by its higher percentage of insoluble residue.

There is a disconformable contact between the Bloyd and the Atoka sandstone and shale; this is the lowest formation of the Des Moines group, and nearly everywhere the contact is masked. Numerous sections and photographs accompany the paper. G. S. S.

963.* Subsurface Miocene of Southern Louisiana. A. C. Elisor. *Bull. Amer. Ass. Petrol. Geol.*, 1940, **24**, 435–475.—These Miocene sediments lie in an area south of a line drawn from the southern part of Beauregard Parish to the southern part of St. Tammany Parish. The western boundary is formed by the Sabine River, and the eastern limit by the Mississippi River.

A variation in depositional conditions is shown by the sediments, and a transition occurs from a brackish-water facies in the west to a marine facies in the east. The two provinces are roughly divided by the Atchafalaya River.

In the eastern province, the following four zones (in descending order) are recognized: the *Rangia microjohnsoni* zone, the *Uvigerina lirettensis*, the *Operculinoides*, and the *Planulina harangensis* zone; the position of the last zone is in doubt.

The western province has the *Rangia microjohnsoni* and the *Potamides matsoni* zones. It also includes a series of undifferentiated sands and shales which contain a brackish-water fauna and are probably the equivalent of part of the *Uvigerina lirettensis* and *Operculinoides* zones.

All these palæontological zones are described; they range in thickness from 500 to 600 ft. in the case of the *Potamides*, to more than 2590 ft. in that of the *Uvigerina* zone. The *Planulina harangensis* occurs below the *Uvigerina lirettensis* zone; no well has yet penetrated beyond it, and the correct correlation is unknown. It is considered by some palæontologists to be Oligocene in age because certain of its species occur in this formation.

Eight strike sections are also described in detail and are shown graphically. In addition, a locality map is furnished, together with six full-size plates illustrating the fossils described. G. S. S.

964.* Permian in Parts of Rocky Mountain and Colorado Plateau Regions. A. A. Baker and J. S. Williams. *Bull. Amer. Ass. Petrol. Geol.*, 1940, **24**, 617–635.—Recent work in the South Wasatch Mountains in North-Central Utah has revealed the presence of a thick sequence of Permian rocks that may become a standard section of the Western United States. Cross-sections and a composite correlation diagram of the whole area accompany the paper.

In the Colorado plateau the Permian is characterized by shifting conditions of deposition and an intermingling of sediments derived from different sources. Except for the Rico formation and the top Kaibab limestone, all the beds are of continental facies. In the Mineral Mountains, Utah, similar stratigraphical relationships are seen; the Kaibab limestone thins eastward and is underlain by a quartzite, probably of Permian age.

The Triassic Woodside Shale overlies the Permian in the southern Wasatch Mountains, where the upper part consists of the Park City formation. The latter is mainly limestone, but its middle shale member contains the Phosphoria fauna. At its type locality the lower part of the Park City formation has long been considered to be Pennsylvanian in age, but the writers suggest that this may need correction, as Lower Park City beds have yielded Permian fossils. Below the Park City in the southern Wasatch are the Diamond Creek Sandstone and the Kirkman Limestone, both tentatively assigned to the Permian; beds somewhat below the top of the Oquirrh formation, which lies under the Kirkman, may form the Pennsylvanian Permian boundary.

In North Utah and South Idaho, the Upper Park City is equivalent to the Rex chert member of the Phosphoria formation; both are overlain by red Triassic shale. The type locality of the Phosphoria occurs at Phosphoria Gulch, Idaho, where it forms 900 ft. of chert and phosphatic shale.

There is a general eastward change in the Permian rocks which is characteristic of the whole area. Fossiliferous marine beds occur in the west, and grade eastward to sparsely or non-fossiliferous red mudstones, grits, and conglomerates.

G. S. S.

965.* Possibilities of Heavy-Mineral Correlation of Some Permian Sedimentary Rocks, New South Wales. D. Carroll. *Bull. Amer. Ass. Petrol. Geol.*, 1940, **24**, 636–648.—This paper gives the results of a mineralogical examination of six core samples from Permian sediments at Kulnura, N.S.W. It was carried out with a view to fixing the position of a particular bed of grit or fine conglomerate, 30 ft. in thickness.

The heavy minerals obtained were divided into two groups, detrital and authigenic; these are described, and the percentage composition of the residues indicated showed that there were well-marked mineralogical variations. The average type of mineral percentages obtained were, however, not satisfactory as a basis for comparison and contrast, since so few specimens were used and because of the great distance of the bore-site from outcropping Permian beds. Similar heavy minerals to those obtained occur also in other Permian and Triassic rocks of the Hunter River district, indicating continuous sedimentation over a wide area. Although it is considered unwise to draw conclusions from so few specimens, evidence seems to show that Kulnura grit is part of the upper marine series (Upper Permian), probably the Muree stage.

The need for examining a large number of specimens of all sediments and an investigation of local variations is stressed by the writer as an essential to correlation problems of this nature. G. S. S.

966.* Petrology of Whittier Conglomerates, Southern California. G. J. Bellemin. *Bull. Amer. Ass. Petrol. Geol.*, 1940, **24**, 649–671.—The Whittier conglomerates are a series of Pliocene and Miocene conglomerate lenses which occur in the north-west part of the Puente Hills.

The chief rocks making up the conglomerates are: granite (21 per cent.), biotite gneiss (16 per cent.), and smaller amounts of pegmatites, aplites, and dacite. The granite is termed the "Conglomerate Granite," and has myrmekitic intergrowths of quartz and felspar. The gneiss varies in texture from lenticular to banded types, with quartz, orthoclase, and biotite as its principal minerals. The conglomerate rock-assemblage is typically felsic; plagioclase is not common, and hornblende is very rare.

Possible source areas for the conglomerate are considered to be from the north or east. The eastern area, especially the Perris Block, consists largely of igneous rocks rich in plagioclase, abundant hornblende, and biotite. Metamorphic rocks also occur, though they are not so common, quartz–orthoclase–biotite gneiss being relatively rare. The northern area, the San Gabriel Mountains, consists almost entirely of igneous and metamorphic rocks, the former including granites, quartz monzonites, and diorites. The "Conglomerate Granite" is identical with granite from the Mount Waterman region in the San Gabriel Mountains.

From the rock correlations, a general similarity to the San Gabriel Mountains and a dissimilarity to the Perris Block region, it would seem that strong evidence points to the fact that the San Gabriel Mountains are an important, and possibly the principal, source of the Whittier conglomerates. Thus, also, it is likely that there existed during late Miocene and early Pliocene times a mountain mass of approximately the same composition and at about the same place as the present San Gabriel Mountains.

G. S. S.

967.* Deposition of Lissie and Beaumont Formations of Gulf Coast of Texas. R. J. Metcalf. *Bull. Amer. Ass. Petrol. Geol.*, 1940, **24**, 693–700.—The Lissie and Beaumont formations are an integral part of a single cycle of sedimentation which began with the rejuvenation of coastal plain streams and the deposition of the coarse poorly-sorted Lissie material. Later, finer sediments formed the Beaumont clays and sands.

The Lissie and Beaumont beds are a comparatively thin group, and represent only a very short time interval. The former were laid down on a peneplained surface, and are characterized by gravel, sand, and ferruginous nodules. There was a later period of entrenchment of the major streams, and material from the interior was deposited nearer the coast. The change from Lissie deposition to Beaumont was merely one to finer sediments brought down by the major streams which built up their channels and produced distributaries under a flood-plain environment. A later phase of the Beaumont was produced by gentle subsidence in the coastal area when the rivers built deltas and cut channels across the plain.

The physical evidence left by this sequence of events shows a lack of stability of deposition and the process of re-working the material many times. The study of these conditions may help to give a better understanding of the mode of formation of earlier land deposits in the Gulf Coast area. G. S. S.

968.* Sparta-Wilcox Trend, Texas and Louisiana. J. D. Todd and F. C. Roper. *Bull. Amer. Ass. Petrol. Geol.*, 1940, **24**, 701–715.—The Sparta and Wilcox are Lower Eocene sediments which have come into recent and increasing importance as oil reservoirs. They form a series of sands and shales between − 5000 ft. and − 10,000 ft. contours; at the latter level shale appears and marks the lower productive limit.

Earlier discoveries of oil in these formations led to poor results, but recent statistics show that wells carried to the Sparta and Wilcox have proved productive. Two fields especially are noted: Joe's Lake, Texas, producing from the Wilcox, and Ville Platte, Louisiana, from the Sparta. Both appear to be large, flat structures. A new discovery has occurred at Eola, Louisiana, where the reflection seismograph indicates that it has a similar structure. Core analyses and average porosities of the sands bored are given.

There has been a slow development in these fields, due to the fact that sub-surface structure does not always conform to that at the surface, and that little oil exists above the 5000 ft. level. It is now also realized that many of the flatter traps are preferable because they cover more area and suffer less from faulting. The real effective exploitation of the trend is therefore just beginning, and it appears likely that the ultimate producing area will rival that in the coastal region.

The paper is illustrated by diagrams, electrical logs, and photomicrographs.
G. S. S.

969.* Results of Recent Field Studies in Osage, Washington, and Nowata Counties, Oklahoma. M. C. Oakes. *Bull. Amer. Ass. Petrol. Geol.*, 1940, **24**, 716–730.—Rocks of Pennsylvanian age belonging to the Missouri sub-series occur in the area, and a sufficient number of Kansas units are present in northern Oklahoma to enable definite correlation to be made.

The Missouri is separated from the underlying Des Moines by an unconformity, and is probably similarly overlain by the Virgil. The Missouri has been divided into two groups : Skiatook and Ochelata. The Seminole formation is at the base of the former, while Checkerboard beds, here raised to formation rank, which lie above, consist of alternating limestone and calcareous shale. Erosion probably preceded the deposition of the overlying Coffeyville beds, and the Hogshooter, which succeeds them, can be correlated with the Winterset limestone of Dennis formation in Kansas. The name Hogshooter, in Oklahoma, is preferred to Dennis because of its older usage. Above is the Nellie Bly formation of shales and brown sandstones, and the Dewey limestone, at the top of the Skiatook, is the equivalent of the Drum limestone of Kansas.

The lowest formation of the Ochelata is the Chanute, often resting unconformably on Skiatook beds. The overlying Iola varies in thickness, being greatest to the south and west, and above them lies the Wann formation, a new name given to about 100 ft. of shale. It is succeeded by the Torpedo sandstone and shale, which is unconformably overlain in the north and south by the Birch Creek limestone. The latter is identical with the Panther Creek limestone, and may be equivalent to the Little Kaw limestone of Kansas. Above it lie the Okesa sandstone and shale. The highest beds of the area, the Cheshewalla sandstone, occurring in the north-west, may be above the unconformity which marks the top of the Missouri. G. S. S.

970.* Completions in 1939 Normal. J. McIntyre. *Oil Gas J.*, 25.1.40, **38** (37), 76–77.—In 1939 27,053 wells were completed in U.S.A., 18,453 of which were classified as oil wells and 2031 as gas wells ; 6355 were dry holes. No great fields were discovered, but a large number of new fields were found, and much new production was added by discoveries of pay sands in already known fields.

The well data are summarized for 1938 and 1939 by States, and the main features of the developments in the various areas are noted. G. D. H.

971.* Domestic Crude Production in 1939 1,255,783,534 brl. J. McIntyre. *Oil Gas J.*, 25.1.40, **38** (37), 78–79.—The 1939 oil production of the U.S.A. exceeded that of 1938 by 54,900,135 brl. The production of each State and of the major oil fields are tabulated for the years 1930–1939, inclusive. G. D. H.

972.* Gulf Coast Drilling Increases, but Fewer Discoveries in 1939. N. Williams. *Oil Gas J.*, 25.1.40, **38** (37), 88.—During 1939 thirteen new fields were opened in Louisiana and twelve in Texas, whilst new sands were found and important extensions made in many proven fields. Probably the most outstanding development was the extension of the Tertiary Wilcox play into coastal Louisiana by the discovery of the Eola field. Exploration round the flanks of known salt domes has added several million barrels of new reserves. The other important developments are noted, and the daily average and monthly production are tabulated for the fields. The wells drilled in 1939, the results, and the new discoveries are listed. G. D. H.

973.* Mississippi and Arkansas Find New Sources of Oil Production. G. Weber. *Oil Gas J.*, 25.1.40, **38** (37), 97.—Mississippi's first oilfield was brought in in 1939. In Arkansas two Smackover lime fields were discovered (Big Creek and Dorcheat). There was mild development at Lewisville and the high-pressure gas-condensate fields in North Louisiana were further developed.

The daily and monthly average productions are given for the fields of Arkansas, North Louisiana, East Texas border, and Mississippi, and the results of drilling in 1939 are summarized. G. D. H.

974.* Cement, St. Louis and Creek County Pools Set Oklahoma Pace. D. Dalrymple. *Oil Gas J.*, 25.1.40, **38** (37), 104.—Almost without exception wildcatting results in Oklahoma in 1939 were disappointing, but there was a revival of operations in several old producing areas. The main developments are noted. The outstanding wildcat opened the Hobart pool at 1049–1055 ft. in the Viola. Hunton lime production has been found in the old Milroy field, and Viola production at Chism.

The daily average and monthly productions of the various Oklahoma fields are given, and the discoveries are listed. G. D. H.

975.* Despite Proration Canada Established Another High. V. Lauriston. *Oil Gas J.*, 25.1.40, **38** (37), 122.—The Canadian output in 1939 was 7,743,313 brl., against 6,946,479 brl. in 1938. Of the four productive regions, New Brunswick alone showed a decline. The volumes of gas marketed increased in all areas. In Alberta, Turner Valley showed an increased oil production in spite of proration, but the small outlying pools declined in output, although some production was obtained from new wells in the Del Bonita area, at Steveville, and at Lloydminster. A new gas-field was opened at Malahide, Ontario. G. D. H.

976.* Many New Pools Found in Kansas; Proven Areas Extended. D. Dalrymple. *Oil Gas J.*, 25.1.40, **38** (37), 126.—Field activity in Kansas was at its lowest since 1935, but there was an improvement late in 1939. Wildcatters opened some forty new oil-pools and several gas-pools, and extended many old areas. There were extensions at Silica, Trapp, Bemis, South Burnett, Bloomer, Wherry, Genesco, and Chase. Late in the year oil was found near Falls City, South-East Nebraska, in the Forest City basin. The Kansas oil and gas discoveries of 1939 are listed, together with the number of wells, producing formation, depth, and initial production. A summary is given of the wells and wildcats, and the daily average and monthly productions are tabulated for the various fields. G. D. H.

977.* Production Outside the U.S. Establishes a New Record. H. S. Norman. *Oil Gas J.*, 25.1.40, **38** (37), 81.—In 1939 the extra-U.S.A. oil production of 814,028,960 brl. was 4% higher than in 1938. Venezuela had a 9·5% rise, which is not a true measure of its possibilities. Russia's increase was 2%. New production records were established in Trinidad, Colombia, and Argentina. The outputs of Mexico and Rumania fell. Saudi Arabia has risen to importance as an oil-producer, and the Ras Gharib field has boosted Egypt's output. G. D. H.

978.* New Mexico Led Development in Rocky Mountain District. T. R. Ingram. *Oil Gas J.*, 25.1.40, **38** (37), 148.—During 1939 seven new producing areas were opened in New Mexico. Loco Hills is outstanding, and gives oil from a Permian sand at 2874 ft. The new discoveries of New Mexico are listed, together with the depths and producing formations.

Activity in Colorado was sub-normal. Deepening a Fort Collins well revealed oil saturation in the Dakota and commercial production was obtained. One gas-find was made in Wyoming in addition to the discovery of deeper pays and the extension of old fields. The gas was found at Horne Valley. A small oil discovery was made in the Madison in Montana, west of Pondera, and extensions were opened in some fields.

The wells drilled in these States in 1939 are listed, and the daily average and monthly productions of the various fields are tabulated. G. D. H.

979.* Twenty-seven Pools Discovered, Four Extended in Illinois. Anon. *Oil Gas J.*, 25.1.40, **38** (37), 157.—The most outstanding feature of 1939 was the rise in output of the Salem field. Six pay horizons were found in East Illinois, and Cypress production was obtained in the central-basin fields. Devonian production was proved at Salem, Sandoval, Sorento, Bartelso, and Centralia. In the south-eastern part of the State the discovery of oil in Gallatin County extended the productive limits of the Illinois basin considerably. Data about the discovery wells of the new field extensions are given, together with the daily average and monthly productions of all the fields and a summary of the wells completed in 1939. G. D. H.

980.* Nebraska Discovery is Feature of Forest City Play. D. Dalrymple. *Oil Gas J.*, 25.1.40, **38** (37), 160.—Nebraska's first oil-pool came in in 1939, yielding oil from the Hunton lime in the hitherto unproductive Forest City basin. This basin has been tested in Missouri, Iowa, Kansas, and Nebraska. Showings of oil were found in some of the Missouri wells. Oil and gas were found in the Gardner district of Johnson County, Kansas, in the Squirrel and Bartlesville sands. The results of drilling in Missouri and Nebraska are tabulated. G. D. H.

981.* California adds Four Oil-Fields in 1939; Extensions of Pools. L. P. Stockman. *Oil Gas J.*, 25.1.40, **38** (37), 163–166.—New fields were opened at North-East Coalinga (Fresno County), and Arvin, Paloma, and Strand (Kern County). Arvin gives oil from a fault-trap in the Lower Pliocene. At North-East Coalinga oil is obtained from the Eocene on a broad south-east-plunging nose. The Strand oil is from the Upper Miocene. Seismic work showed a structure at Paloma, and oil was found at a depth of 10,178 ft.

A number of old fields were extended or had deeper producing horizons penetrated. Tables give the daily average and monthly productions of all the fields, and the results of the wells drilled during 1939.

A new method of curtailment was introduced in 1939. G. D. H.

982.* Thirty-five New Oil- and Gas-Fields Opened in South-West Texas. F. L. Singleton. *Oil Gas J.*, 25.1.40, **38** (37), 168.—In addition to new fields there were many important extensions and new sand discoveries in 1939. Probably the outstanding development was the extension of the Frio-Vicksburg play through Jim Wells, Brooks, Hidalgo, and Starr Counties, and the expansion of the Tertiary Wilcox trend play from the Upper Gulf Coast district through the Pettus trend as far south as Webb County. Twenty-four new oil- and gas-pools were found in the Corpus Christi district. In Victoria County there were shallow Catahoula discoveries (Cologne and Victoria). The Rincon field, a former distillate-producer, gave oil.

The results of wells drilled in 1939 are summarized, and tables give the daily average and monthly productions for all the fields. G. D. H.

983.* North and Central Texas Areas had One of Busiest Years. D. H. Stormont. *Oil Gas J.*, 25.1.40, **38** (37), 174.—In 1939 thirty-one new fields were found, in addition to new oil horizons in old fields. Two Ordovician fields were discovered in Cooke County, and two Strawn fields. Strawn, Granite Wash, and Bend lime production was obtained in new discoveries in Montague County. Pools were opened in the Bend and Strawn series of Stephens County. There was much wildcat activity on the Palo Pinto lime trend extending across Jones County and north-west Shackleford County.

The discoveries are tabulated, together with the depths, production, and oil-bearing formations, and the daily average and monthly outputs of all the fields are tabulated.
G. D. H.

984.* East Texas Wildcatting in 1939 had no Important Results. R. M. Sanford. *Oil Gas J.*, 25.1.40, **38** (37), 182.—Three new pools were opened in Woodbine sand areas (Henderson, Leon, and Navarro Counties); a shallow Strawn pool in Denton County and a Glen Rose distillate pool in Limestone County. A deep lower Marine Trinity wildcat campaign spread over most of the area. The discoveries are listed, together with depths, outputs, and oil horizons.

The East Texas field is now on the decline, and plugging of depleted wells far exceeds new completions. The results of drilling in East Texas in 1939 are summarized, and the daily average and monthly productions of the fields are given. G. D. H.

985.* Michigan Crude Production Rose to an All-Time High in 1939. O. C. Pressprich. *Oil Gas J.*, 25.1.40, **38** (37), 184.—In 1939 the Michigan production was 23,566,406 brl. 20,338,000 brl. of reserves were discovered. Nine fields were found and seven were extended. The outstanding strike was the Walker–Wyoming–Tallmadge area, which gives oil from the Traverse lime. There were revivals at Salem and New Salem, with continued success in the Traverse. Some seismic work was started late in the year.

The new discoveries, depths, productions, etc., are listed, and tables give summaries of the completions and daily average and monthly productions for all the fields.
G. D. H.

986.* New Pools and Deep Pays in West Texas; Quiet in Panhandle. D. H. Stormont. *Oil Gas J.*, 25.1.40, **38** (37), 191.—Nine new producing areas resulted from wildcatting in 1939. At Cedar Creek production is in the San Andres (Perm.) lime. The Apco pool in the Ellenburger lime covers 2500 acres. In Ector County a new and deeper lime-pay was found in the Lower Permian. The Yates is productive at Fromme. Great activity led to the uniting of the Wasson and Bennett fields. There were no discoveries in the Panhandle.

A table shows the discoveries, their productions, depths, etc., and the results of drilling are summarized. The daily average and monthly productions of the fields are tabulated. G. D. H.

987.* Eastern and Western Kentucky, Indiana, Ohio, and Eastern Fields. Anon. *Oil Gas J.*, 25.1.40, **38** (37), 196.—Tables summarize the results of drilling during 1939 in Eastern and Western Kentucky, Central and South-Eastern Ohio, the Lima field, Indiana, and the Eastern fields (Pennsylvania, etc.). G. D. H.

988. Illinois Discoveries not Equalling Drop. H. F. Simons. *Oil Gas J.*, 23.5.40, **39** (2), 31.—The results of recent drilling in Illinois are not sufficient to offset the decline in output from the Devonian lime of the Salem pool. In the renewed efforts this year there have been fourteen discoveries, including extensions and new pay horizons. Nearly all are in the south-east of the State.

The most important pool found is Irons, in White County. The oil is at a depth of about 2500 ft. in the Hardingsburg sand of the Chester series. The reserves are estimated to be 1,000,000 brl.

The Albion pool, of Edwards County, gives McClosky and Waltersburg production, and the Bridgeport sand is reported to be oil-saturated. McClosky production has been found in Jasper County and Cypress production in Hamilton County.
G. D. H.

989.* U.S.S.R.; Russian Oil Survey. J. Wegrin. *World Petrol.*, April 1939, **10** (4), 62; May 1939, **10** (5), 61; June 1939, **10** (6), 119; July 1939, **10** (7), 52; Aug. 1939, **10** (8), 62; Sept. 1939, **10** (9), 54.—The Caucasian oilfields give 91% of the entire Russian output, 75% being from Baku, 10% from Grozny, and 6% from Maikop. Ishimbayevo gives 3%. The aggregate refining capacity is 1,157,000 brl./day, with 89% of it in the Caucasian area. The home consumption is about 23,850,000 tons/annum.

The fields of the Baku region are listed. They obtain oil from Tertiary beds which consist of clays and sandstones with important æolian sands. There are many oil seeps and evidences of petroleum such as mud volcanoes. Many of the fields have 18–20 producing sands, which are often lenticular.

Of the 7500–8000 wells, 1200–1500 are shut down for one reason or another. About 67% of them are under mechanical operation, whilst only 400 flow. Outputs range from 2 to 80 tons/day. The upper sands are now exhausted, and wells are now being taken to 8000–10,000 ft., with the average depth 2500–3500 ft. Well spacing is 1–4 hectares. Electricity is widely used for drilling. Two 600-ml. pipe-lines run from Baku to Batum.

There are about 200 petroliferous regions in Circasia, of which Grozny is the oldest and most important. The original prolific but short-lived wells were opened in 1893 on an anticline. In 1913 the new Grozny fields came into operation, and extended to Vosnessenski. The Grozny fields are in Tertiary beds, which consist of shales, sandy clays, limestones, and dolomites. There are several petroliferous horizons, and there are productive anticlines at Alkhazovo, Eldarovo, Molgabek, Adjurt, and Vosnessenski.

North of the Caucasus there is commercial oil in sands of the Mediterranean and Maikop beds. The Lower Maikop beds are oil-bearing at Maikop, whilst in Daghestan, at Benoi, Berekei, and Kosh Mensil, they yield gas. Gorski Mountain and Molgabek are complicated structures the development of which is retarded by their isolation.

Up to 1937, 80,000,000 tons of oil had been recovered from the Grozny group of fields, 95% being from Old and New Grozny. The crude is paraffin-base with the present wells 5000–6000 ft. deep. 23% of the wells flow, and they drain 1–4 hectares each. A 372-ml. pipe-line runs through Maikop to Tuapas.

There was primitive production at Maikop in 1821, but modern development dates from 1907. The Maikop beds are productive, and oil has also been found in the Mesozoic. Kutaiski is a monocline dipping at 30°, and other favourable areas are under study.

The Georgian fields south of the Caucasus give about 335,000 tons of oil/year. Naftalan and Pirsagat are the most important zones. North of the Caucasus, in Daghestan, are a number of small fields of which the structures are complex. High hopes are held of this district, which lies on the Caspian coast. The Kuban–Black Sea area, which gives about 20,000 tons of oil/year, is being tested.

The Emba area is said to have large oil reserves and 1200 salt domes. The oil is believed to be in Jurassic beds. The wells are deeper than is general in the other Soviet fields. Oil reserves are estimated to be far in excess of 40,000,000 tons.

The main development of the Ural–Volga region dates from about 1929. Most of the oil found is in the Carboniferous, but some is in the Permian. The area is considered to have good prospects, and pipe-lines are to be built with connections to the industrial centres of Siberia. New refineries are to be constructed.

A little oil has been produced in the Ukraine. G. D. H.

990.* Preliminary Report on the Application of the Mass Spectrometer to Problems in the Petroleum Industry. H. Hoover and H. Washburn. *Petrol. Tech.* (*A.I.M.M.E,*), May 1940, Tech. Pub. No. 1205, 1–7.—Work has shown that it is possible to run a qualitative and quantitative analysis of an unknown mixture of hydrocarbon gases with an accuracy better than ± 5% of each of the various constituents. The method is relatively rapid.

The form and use of the mass spectrometer are briefly described. The instrument is highly sensitive, and a sample of gas as small as a tenth of a cubic millimetre at N.T.P. can be used. Distinction between methane or ethylene and ethane is very easy, even though the former two are 20,000 times as abundant as the latter, and hydrocarbons can be determined in the presence of other gases.

Differences in cracking patterns permit the detection of isomers.

Interesting observations have been made on the distribution and quantities of various hydrocarbons in soil samples, cores, and drilling mud samples. A routine technique has been developed for qualitative and quantitative determinations of the paraffin series, including methane, ethane, propane, butane, pentane, and still heavier members, together with some of their isomers.

The instrument is not portable, but may possibly be suitable for some of the problems in refinery practice. G. D. H.

991.* Deep Venezuelan Producer Larger than First Indicated. Anon. *Oil Wkly*, 13.5.40, **97** (10), 15–18.—El Roblo No. 2 has been thoroughly tested in the intervals 9349–9520 ft. The former gave oil at the rate of 1113 brl./day on a $\frac{5}{16}$-in. choke, and the latter 1816 brl./day on a $\frac{1}{2}$-in. choke. An earlier test in the 9620–9647-ft. interval gave oil at the rate of 189 brl./day. This well is about 6 ml. from the Mene Grande pipe-line. Locations have been selected for El Roble No. 3 and El Roble No. 4.

The El Roble structure is large and gives oil from Oligo–Miocene beds. It is a few miles from the San Joaquin field. G. D. H.

Drilling.

992.* Electrical Equipment on Rotary Drilling Rigs. G. R. Prout. *Petrol. Engr*, May 1940, **11** (8), 33.—This long paper discusses two arrangements of equipment which provide easy means of obtaining the advantage of being able to utilize full available engine horse-power under all drilling conditions. In one of these schemes two engines are used, each driving a large and a small generator specially designed for oilfield work. The method of connecting up under various conditions, the characteristics and controls of the generators and motors, the degree of flexibility, and various advantages obtainable are detailed. Advantages are summarized as: (1) Complete manœuverability and flexibility of rig operation are provided under all conditions of drilling or emergency operations. (2) The drilling load is automatically divided between the two or more engines. (3) The maximum output of engines is limited automatically to a safe value by generator design. (4) The power is smoothly and gradually applied to the load, and high torque at very low speeds is afforded, with consequential avoidance of shock loads. (5) The maximum output of both engines can be fully, easily, and safely used for hoisting service. (6) High empty-hook speed is automatically provided. (7) The mud pump motor will slow down and stall in case of excessive pump pressures due to plugged bit or pipe, probably saving both power and fluid ends of the pump. (8) Pump speed can easily be controlled over a wide range. (9) The engines operate at constant speed regardless of speed-torque requirements of the load. (10) Engine speed can be reduced when drilling conditions do not require full power output of the engines at full speed, and still provide all the rig manœuverability and flexibility of control provided at full speed. (11) Low fuel consumption. (12) Electric energy available for lighting and auxiliary services from exciters, eliminating necessity of running small separate engine-generator for this purpose. (13) Closed cooling-water system can be used with very little make-up water required. (14) Engines and generators can conveniently be situated at any place round the rig.

The more important advantages are illustrated in the case of recovering a stuck pipe by pulling at maximum allowable line load, rotating at creeping speed, and circulating mud simultaneously. The second deepest hole in the world was drilled to a depth of 14,582 ft., using diesel full-electric rig. Details of this rig are included.

Rigs using diesel electric systems but driving the pumps mechanically from the engine are similarly studied. A. H. N.

993.* New Magnetic Method for Orienting Deflecting Tools. Anon. *Petrol. Engr*, May 1940, **11** (8), 48.—The orientation is accomplished by the use of a non-magnetic sub containing two small magnets and provisions for seating a directional magnetic single-shot instrument. Cross-sectional sketch and details are given. A. H. N.

994.* Deepening and Completing a Well in the Lisbon Field, Louisiana, Pt. 4. P. D. Torrey and F. H. Miller. *Petrol. Engr*, May 1940, **11** (8), 103.—The fourth part of this exhaustive paper follows similar lines to the previous three, in that it details, with extensive data, every step undertaken in deepening a certain well. Sizes, weights, loads, and other characteristics of equipment and operations are given.

This part continues the discussion on drilling, mud control, weight on bit, depth measurements, coring, and fishing jobs, and gives suggestions for the prevention of the last operations.

A summary of the drilling procedure is given in order to bring into prominence various important points and suggestions resulting from these studies, in the hope of reducing drilling time on future similar jobs.

This part concludes with completion and sand-testing procedures. Further parts will be published later. A. H. N.

995.* Drilling and Completion Practices Involving Use of Light-Weight Alloy Metal. R. C. Graham. *Petrol. Engr*, May 1940, **11** (8), 121.—The uses of drillable light-weight alloys in multiple-zone production, and in special cases of shooting just below the casing, are detailed and illustrated by sketches and tables. Care is exercised in lowering the pipe in the hole, although it is generally handled as an ordinary pipe, because alloy casing cannot withstand the same vertical column load as steel. It is ideally suited for removal either by the use of a piloted-type five-bladed drag bit or a conventional wall-scraper. Rotary table speeds ranging from 50 to 125 r.p.m., and a bit weight of 2000 lb., have proved most satisfactory, the average rate of removal being 5 ft./hr. This rate of removal has been influenced by cement behind the removable section. Mud screens or some other adequate method must be used for removing the cuttings from the mud.

Reviewing the progress made during the last year by operators in the Illinois Basin in the use of drillable metal, it is observed that twin well drilling for multiple sands has been greatly reduced, with resultant larger profits to the operator owing to a reduction in his investment costs. It has permitted the adequate testing of doubtful formations that were cased-off in testing lower sands. A method of reducing high gas–oil ratios has been made possible by the insertion and supervised removal of drillable metal in casing strings, and, finally, better bottom-hole cement plugs for water shut-offs are more easily obtained. A. H. N.

996.* Latest Developments in Oilfield Equipment Displayed at Petroleum Exposition. Anon. *World Petrol.*, May 1940, **11** (5), 42–87.—This long treatise gives diagrams, photographs, characteristics, and detailed descriptions of oilfield equipment exhibited at Tulsa, Texas. The apparatus described are extremely varied, and range from derricks and drilling equipment to production engineering necessities and accessories. A. H. N.

997.* Effect of Formation Permeability on Plastering Behaviour of Mud. H. T. Byck. *Oil Wkly*, 3.6.40, **97** (13), 19–20; cf. also *Oil Gas J.*, 30.5.40, **39** (3), 50–51. *Paper presented before American Petroleum Institute.* It has frequently been stated that the loss of liquid from drilling mud increases with increased permeability of the formation penetrated. Several recent papers which present a theoretical analysis of the filtration of muds point out that this factor should have little or no influence on the mud plastering. The present paper presents extensive experimental data to check this important point.

The results from experiments with representative muds without chemical or other treatment are found to indicate the same water loss and mud-sheath thickness on cores of widely different permeabilities.

Such results cast grave doubt on the ability to force either cement slurries or whole mud into homogenous formations; and it appears necessary to conclude that the appearance of mud or cement in wells adjacent to the one under consideration can take place only through crevices, channels, fractures, caverns, or similarly large pores.

A. H. N.

998.* Drilling Curve Climbs Sharply to Highest Point Since 1920 Peak. L. J. Logan. *Oil Wkly*, 13.5.40, **97** (10), 12–14. Tables and a graph illustrate the statement of the title. A. H. N.

999.* Some of the World's most Difficult Operating Problems. R. W. Harrison and W. F. Knode. *Oil Wkly*, 20.5.40, **97** (9), 48–54. Operations in Turner Valley have presented great difficulties both in drilling and producing operations. The characteristics of this field in Canada are outlined.

An average well costs approximately $160,000 to turn into the tank, mainly due to hard drilling. The time required from spudding to the cementing of the oil string at an average depth of 8000 ft., is from 4 to 5 months, with an additional 2 or 3 weeks to drill the lime section and complete the well. The drilling equipment is described, and the size and characteristics of components are given.

Completion work is similarly described, together with various methods of acidizing and cleaning the wells.

Paraffin accumulation in tubing is a serious problem, requiring constant attention. The greatest difficulty is experienced during the period of low allowables. One effective means of combating this nuisance is to blow the well down through wide-open connections for about an hour, at weekly intervals. Details are given. A. H. N.

1000.* Welding Surface Casing at Oklahoma City. Anon. *Oil Gas J.*, 2.5.40, **38** (51), 37. Substantial savings in the cost of wells at Oklahoma City are being effected by the use of light-weight welded pipe for surface casing. The procedure of setting such casing strings is given. In all cases the strings have had float shoes of the slip type which are welded on to the string. A. H. N.

1001.* Tool-Joint-Wear Data kept on Simplified Records. H. F. Simons. *Oil Gas J.*, 2.5.40, **38** (51), 39.—Practices with regard to tool-joint maintenance and replacements in drilling Illinois wells are given. Average life of drill-pipe in this basin is from 50,000 to 60,000 ft., the tool-joints requiring replacements at least once and sometimes twice during this lifetime. Additional footage may be gained on the last set by having a ring of hard-surfacing material applied on the drill-pipe at the tool-joint shoulder. This treatment cannot be used with new pipes, as replacements of joints would then be very difficult.

A detailed record is kept of the wear of the tool-joints, and an example of such a record is reproduced. The illustration is studied in detail to explain the usefulness of the data recorded. A. H. N.

1002.* Devonian Drilling. H. F. Simons. *Oil Gas J.*, 9.5.40, **38** (52), 74.—Great difficulties are being encountered in drilling for Devonian production in the Illinois basin. The major problem appears to be the prevention of loss of mud into the formation and the sticking of the drill-pipe while coming out of the hole. In the best areas from 5 to 6 tons of aquagel are required for the mud, whilst the worst areas for loss of circulation require from 10 to 12 tons. In addition, considerable quantities of fibred material are used to plug up the pores in the formation, so that a sheath is formed. Details of a method of controlling the mud are given.

Loss of cement in setting casing is a similar problem. Various methods of eliminating this trouble in cementing operations are described. In one method the porous formation is cemented before running-in the casing, using a retainer just above the sand. Another method is to use a multiple-stage cementing tool and a casing shoe. A variation of this is to squeeze the cement through the ports of the cementing tool and use two retainers to localize the cement to the formation by placing them below and above the tool. Details of pressures encountered are given.

Another method is to run the casing in the ordinary manner and cement round the bottom with approximately 300 sacks. After allowing time for the cement to take its initial set, a second batch is forced into the hole behind the pipe through the braden head, the cement being forced downwards to displace the fluid into the formation.

This method is also applied with a variation by other operators. A. H. N.

1003.* Technical Aspects of Carter Pressure Core Barrel. P. Reed. *Oil Gas J.*, 16.5.40, **39** (1), 114.—The significance of data obtainable from using a Carter pressure-core barrel is discussed in detail. The more general applications of pressure cores and pressure-core data are : (1) A more certain determination of reservoir content than is furnished by the conventional non-pressure-type core barrel. (2) Locations of gas caps and determination of content. (3) Studies of oil, gas, and water gradients through a producing zone. (4) Studies in well spacing. (5) Studies of oil remaining in place in depleted fields by drilling and coring intermediate wells. (6) Studies of various methods and rates of production by working on cores while they are under pressure. (7) Studies of contamination of cores. Various other uses are discussed, including the possibility of coring unconsolidated sands.

A new core barrel has recently been completed very similar in design to the original experimental one, except that it is now possible to cut a core 2⅜ in. in diameter instead of the original 1⅝ in. The length of the core is 8 ft. 6 in. A description and detailed sections and photographs reveal the mechanism employed.

Since drilling fluid has a tendency to precede the drill into formations, special attention has been paid to the prevention of contamination. This meant increasing the size of the core and a study of mud control and treatment. Such studies resulted in designing a high-pressure wall-building tester for muds ; the apparatus is described. High-pressure differentials and temperatures are employed to approximate bottom-hole conditions. The rate of water loss is measured at constant pressure differential and temperatures. A. H. N.

1004.* Operating Economics in Lake Centralia–Salem Field, Illinois. T. P. Sanders. *Oil Gas J.*, 23.5.40, **39** (2), 50.—Because of highly competitive drilling in this field, technical advancements in production engineering are mainly ignored. Steps towards economy are, however, constantly being taken.

It has been found that for the U.S.A. as a whole 75% of the total sum expended on the average well throughout its life is spent before any oil is produced. This suggests that development work represents the most advantageous field for economy.

Furthermore, operators found it possible to reduce their development costs for shallow wells from $10,000 to $8,000/well. This fact, however, did not mean a saving of only 20%. The average expected recovery/well was $18,000—*i.e.*, 80% profit on money originally invested. With the new economical development this figure rose to 125%, due to the fact that a million dollars could be spread over a greater number of wells than was possible previously, thus bringing in a 45% greater profit.

The paper details the various steps taken to effect economy in development. Drilling masts were substituted for derricks for wells down to 3400 ft. Loss of circulation was a difficult problem, and methods of solving it were evolved. Use of cement in one of many methods specially evolved for the field is overcoming this difficulty. Use of fibrous materials with the cement, multiple-stage cementing with or without packers to localize the cement into the porous formation, cementing through the braden head, and variants of these methods are used.

Economies in pumping and other production operations are practised by the use of the correct equipment. A. H. N.

1005.* Difficult Completion Job. J. P. O'Donnell. *Oil Gas J.*, 23.5.40, **39** (2), 68.—The successful completion of a wildcat well which blew open for three weeks before it was brought under control is described. While blowing wild, the well had a flow measured at more than 50 million cu. ft./day. Several factors contributed to make the job of bringing the well under control one of unusual difficulty. Casing had not been run before the well drilled itself in, and highly porous formations, as well as deep-shale gas pockets, carried off mud and cement when attempts were made to kill the well. Either a break in the water string or channelling around the shoe permitted mud and cement to escape also through shallow water sands.

Details of three unsuccessful, and a fourth successful attempt to kill the well are given. Aquagel, fire clay, and Fibrotex were used. Mud and cement were pumped in by two separate units. A. H. N.

1006. Patents on Drilling. W. Schwemlein. U.S.P. 2,198,744, 30.4.40. Appl. 24.10.36. Pitman connection.

F. E. Patton. U.S.P. 2,198,836, 30.4.40. Appl. 6.11.37. Surveying instrument for testing the straightness of a vertical member such as a drill-pipe before it enters the hole.

R. L. Waxler. U.S.P. 2,198,849, 30.4.40. Appl. 9.6.38. Drill bit.

H. S. Pierce. U.S.P. 2,199,292, 30.4.40. Appl. 17.11.38. Heavy duty drive chain.

J. F. White. U.S.P. 2,199,298, 30.4.40. Appl. 17.11.38. Fishing tool.

L. F. Athy and H. R. Prescott. U.S.P. 2,199,367, 30.4.40. Appl. 10.8.38. Method of logging bore-holes electrically.

C. M. Anderson. U.S.P. 2,199,582, 7.5.40. Appl. 28.3.38. Reverse clutch and gearing unit.

A. C. Catland. U.S.P. 2,199,692, 7.5.40. Appl. 11.8.37. Demountable blade bit.

A. C. Catland. U.S.P. 2,199,693, 7.5.40. Appl. 18.11.38. Well reamer.

G. R. Huff. U.S.P. 2,199,725, 7.5.40. Appl. 16.3.39. Self-lubricating stuffing-box for oil wells.

F. G. Beckman. U.S.P. 2,199,733, 7.5.40. Appl. 11.5.38. Combination rotary table and pack-off head.

F. G. Beckman. U.S.P. 2,199,734, 7.5.40. Appl. 11.5.38. Portable rotary table.

F. G. Beckman. U.S.P. 2,199,735, 7.5.40. Appl. 29.12.38. Packing gland.

W. V. Bowles. U.S.P. 2,199,738, 7.5.40. Appl. 7.4.39. Tool joint for drill stem.

M. E. Bolles. U.S.P. 2,199,873, 7.5.40. Appl. 3.10.38. Oil well rig on wheels.

E. C. Hamm. U.S.P. 2,199,969, 7.5.40. Appl. 6.3.39. Straight pull tool jar.

D. U. Shaffer, F. D. Hobbs, and E. C. Hamm. U.S.P. 2,199,972, 7.5.40. Appl. 27.5.38. Circumorbital cutting tool.

J. W. McNeil. U.S.P. 2,200,093, 7.5.40. Appl. 18.10.38. Pipe wrench.

T. A. Taylor and C. F. McComas. U.S.P. 2,200,210, 7.5.40. Appl. 28.9.38. Safety device for rotary drilling rigs.

J. W. MacClatchie. U.S.P. 2,200,337, 14.5.40. Appl. 18.12.37. Drill bit.

C. C. Winslow. U.S.P. 2,200,482, 14.5.40. Appl. 13.8.38. Rock bit.

R. L. Kerr. U.S.P. 2,200,505, 14.5.40. Appl. 30.8.38. Locating device for use in bore-holes.

J. B. Newsom. U.S.P. 2,200,516, 14.5.40. Appl. 27.7.37. Drill hole sheave carrier.

M. Schlumberger. U.S.P. 2,200,683, 14.5.40. Appl. 24.1.36. Core taking device.

F. A. Bent, A. G. Loomis, and H. C. Lawton. U.S.P. 2,200,710, 14.5.40. Appl. 19.2.38. Method of sealing water-bearing formations by introducing into formation a water soluble salt of hydrofluosilicic acid and reacting it with an alkali salt to produce a precipitate.

J. E. Hall. U.S.P. 2,200,716, 14.5.40. Appl. 27.6.38. Casing protector applicator tool.

C. L. Henry. U.S.P. 2,200,775, 14.5.40. Appl. 15.8.38. Derrick.

H. T. Ringrose. U.S.P. 2,201,055, 14.5.40. Appl. 27.7.37. Apparatus for indicating the presence of inflammable vapours or gases electrically.

I. C. Bell. U.S.P. 2,201,219, 21.5.40. Appl. 16.10.37. Drill bit.

W. D. Owsley and R. L. Shook. U.S.P. 2,201,299, 21.5.40. Appl. 21.3.38. Multiple stage cementing.

J. F. Shaw. U.S.P. 2,201,379, 21.5.40. Appl. 2.6.39. Drill bit of roller type with side cutters.

C. J. Gallagher. U.S.P. 2,201,434, 21.5.40. Appl. 10.2.40. Fishing tool.

J. A. Zublin. U.S.P. 2,201,569, 21.5.40. Appl. 21.2.38. Compact roller drilling bit.

J. A. Zublin. U.S.P. 2,201,570, 21.5.40. Appl. 3.1.39. Rotary earth boring bit.

T. S. Park. U.S.P. 2,201,673, 21.5.40. Appl. 6.11.37. Rotary drilling machine.

C. A. Doud. U.S.P. 2,201,813, 21.5.40. Appl. 12.2.38. Device for laying pipe at an oil rigging.

D. E. McKee. U.S.P. 2,201,909, 21.5.40. Appl. 19.5.36. Bore-hole inclination transmitter comprising a pendulum and a number of eccentrically spaced contact rings to transmit an impulse when the pendulum contacts any one of them.

A. L. Straub. U.S.P. 2,202,173, 28.5.40. Appl. 29.6.39. Well cementing device.

F. N. Osmun. U.S.P. 2,202,260 and 2,202,261, 28.5.40. Appl. 28.8.39 and 23.8.37 respectively. Safety joint adapted for use in a string of pipe in a well.

C. J. Esseling. U.S.P. 2,202,446, 28.5.40. Appl. 7.11.39. Pipe grip for rotary tables.

G. J. Nash. U.S.P. 2,202,461, 28.5.40. Appl. 1.11.37. Detachable float plug for casings.

C. J. Haynes. U.S.P. 2,202,656, 28.5.40. Appl. 15.7.38. Well-logging electrode.

J. T. Ellis. U.S.P. 2,202,985 and 2,202,986, 4.6.40. Appl. 22.5.39 and 24.7.39 respectively. Pipe cutters.

G. P. Ellis and J. T. Ellis. U.S.P. 2,203,011, 4.6.40. Appl. 8.4.37. Pipe-cutter.

H. E. Grau and R. K. Hertel. U.S.P. 2,203,139, 4.6.40. Appl. 3.12.38. Drilling-hook having a universal joint so that hook can tilt relative to stem.

M. Hokanson. U.S.P. 2,203,216, 4.6.40. Appl. 18.1.39. Drill bit. A. H. N.

Production.

1007.* Portable Laboratories for Core Analysis. D. H. Stormont. *Oil Gas J.*, 2.5.40, **38** (51), 49–50.—Immediate analysis of cores eliminates the time lost in the transportation of such cores and yields more accurate results. A description is given of laboratories on trucks which are completely equipped to analyse cores immediately on removal from the barrel for permeability and porosity values, for fluid index, and for per cent. residual-oil saturation, as well as such items as gas–oil and oil–water contact and gravity of oil.

The procedure followed is detailed. One sample/ft. is usually sufficient, but where sands are extremely variable two samples/ft. are tested. The results of the analysis are available approximately 3 hr. after the core is pulled, which is usually sufficiently rapid to keep up with coring operations.

A typical analysis chart is studied to illustrate the use of the methods. A. H. N.

1008.* Metals in Production. W. L. Nelson. *Oil Gas J.*, 2.5.40, **38** (51), 52.—This is the fourth of a series of articles on the metallic materials that have been recommended by equipment and metal manufacturers for use in producing equipment. A table gives recommended percentage composition, in terms of carbon, manganese, nickel, molybdenum, and " others," the physical properties in terms of yield point, endurance limit in air and in H_2S, and Brinell hardness, as well as notes on heat treatment for metals used in rods and couplings. In all twenty-six metals are thus described.

" Endurance limit " is defined as the maximum load in lb./sq. in. which the material can sustain during a limitless number of load applications or reversals of stress. A table shows a range from 30,000 to 59,000 lb./sq. in. for endurance limit in air, with a corresponding range of 11,000–22,000 in H_2S ; the lowest limit in air is, however, not necessarily low in H_2S and *vice versa*. A. H. N.

1009.* Recycling Becomes Important Phase of Oil Operations. E. Kaye. *Oil Gas J.*, 9.5.40, **38** (52), 34.—The quantity of liquid recovered in a recycling plant for producing from distillate fields is very small. Thus, the gas is brought to the surface and run through the plant with a minimum of pressure drop, and the effect of retrograde condensation is achieved as a plant function and is avoided in the reservoir.

At least five variations of extraction methods are in use, each varying from the other by the extent of cooling and circulation of the materials subjected to retrograde condensation.

A great deal remains to be learnt about the behaviour of the dry gas returned to the reservoir after separation of the distillate. Theoretical calculations and certain data show that a well pattern for input and output wells can be designed for a field so that substantially all the wet gas is recoverable.

There is practically unanimous agreement that in the development of a gas-distillate field, unit operation is fundamental. A. H. N.

1010.* Correct Well Completion and Design of Gathering Systems Important in Recycling. G. Weber. *Oil Gas J.*, 9.5.40, **38** (52), 66.—The gathering system in a recycling plant in East Texas is described. The well connections, type of equipment used, as well as well condition and completion methods, are detailed. Gravel packing is adopted in order to assure large capacity in both producing and injection wells. The paper is made complete by a map showing the plan of the field system and tables giving characteristics for well-head pressures and temperatures. A. H. N.

1011.* Surface-Controlled Intermitter Utilizes Static Fluid Column. D. H. Stormont. *Oil Gas J.*, 9.5.40, **38** (52), 88–89.—The paper describes a new type of intermitter which is entirely mechanically controlled from the surface with relatively simple controlling equipment. It is different from any other intermitter hitherto in use, in that it makes use of a static-fluid column established from the flow device to the top of the hole. This fluid column acts as a medium of control between the two points. It transmits a force applied at the surface to the bottom of the hole, where it moves a piston, which in turn directly closes the gas-valve on the intermitter. When the pressure is released from the dead-fluid column, the piston moves upward, opening the valve to allow gas to inject into the chamber. As the flow intervals and periods of gas injection are regulated by the controls placed on the surface connections of the wells, they will operate regardless of the conditions set up in the well itself. Lifting is accomplished with low gas–oil ratios and high efficiencies.

The apparatus and method of operation are detailed. A. H. N.

1012.* Novel Clean-Out Machine on a Large Lease. D. H. Stormont. *Oil Gas J.*, 9.5.40, **38** (52), 92.—To service and clean out about 300 wells of 4200-ft. producing depth each, and located on a 22,000-acre lease, a shop-welded pipe trailer was found most effective. A 50-ft. mast was welded in a conventional manner, but was hinged at the bottom of each leg so that it folded back on the trailer when in transport or could be raised to the vertical position when on the location. Supports welded on top of the trailer allowed the mast to rest snugly on the trailer and obviated shifting. The whole assembly is hauled by a six-wheel truck on the bed of which a 75-h.p. gasoline engine and draw-works were installed. A. H. N.

1013.* Water-Flood Proves Successful in Miami County, Kansas. D. Dalrymple. *Oil Gas J.*, 16.5.40, **39** (1), 104–105.—A review of repressuring by air and by water-flooding operations is given. Results appear successful. A. H. N.

1014.* Stabilization through Proper Well Spacing. D. R. Knowlton. *Oil Gas J.*, 6.6.40, **39** (4), 16.—The ultimate problem of the oil-production business is to make income exceed cost. The principal costs are three: leasehold, development, and operating. The income is from sales, the sufficiency of which depends on quantity and price. The producers have but a scant control on price. The quantity of current sales is controlled (in U.S.A.) by regulatory proration in some States, and by purchaser or pipe-line proration in others. The quantity of ultimate sales is limited to the quantity of recoverable oil in the reservoir. Hope for stabilization therefore lies in reducing costs. In these there is but slight control over leasehold costs.

The reduction of developing and operating costs offers the best possibilities for improving the producers' businesses. There is one simple principle and two simple means for effecting such improvements.

The principle is to develop reserves with less capital expenditure than is necessary at present. The means are to use wide well spacing and unit operations of pools.

This principle and the two means for reducing costs are discussed after the analysis, and their application is illustrated by studying cases in Magnolia and Texas. In particular the short-sightedness in not adopting unit controls is condemned.

A current example of the results possible under unitization is found in Oklahoma, where a pool is developed under unit production by four operators. This control made it possible to develop the reservoir efficiently and to take advantage of a pronounced and efficient water drive. The sands have zones of varying permeability, and for efficient development, it was decided to reduce the rate of withdrawal and pressure maintenance was instituted. Over 4½ million brl. of crude have been produced in the last 2 years, with a bottom-hole pressure drop of only 4 lb. The lifting cost has been only 3·1 cents/brl. A. H. N.

1015.* Co-Operative Repressuring Plan Yielding Returns in Louisiana. G. Weber. *Oil Gas J.*, 6.6.40, **39** (4), 38.—The history of the field discussed is one of boom production and decline at a rapid rate. Several factors contributed to the reversals. Close drilling, on a 20-acre spacing pattern over much of the field, was not justified on the basis of reserves, and was found unnecessary for drainage. This was rectified later, and operators reverted to 40-acre spacing for later drilling development. Pipe-line proration and reductions in crude prices contributed further to the field's decline in importance, and reservoir pressure dropped rapidly in the absence of an effective water drive. Details are given.

A co-operative repressuring plan is now yielding returns to operators who adopted it recently. The system is described and illustrated in some detail. Initial investment, following completion of the well, has been nominal, and operating costs are low, contributing to success of the co-operative conservation project. Reversal of the production decline of many months has resulted. A. H. N.

1016.* Retrograde Condensation and Distillate Wells. F. W. Laverty. *Oil Wkly*, 6.5.40, **97** (9), 13–18.—Up to the critical temperature, compressing hydrocarbon gases at constant temperature results in increased condensation into the liquid phase. Above it the opposite occurs—*i.e.*, retrograde condensation where the liquid phase diminishes with increase in pressure at constant temperature. Retrograde condensation occurs only when a mixture of gases is compressed. The greater the difference in critical temperatures of the components of the mixture, the greater the range in which retrograde phenomena will occur.

Graphs are reproduced to show the relative amounts of fluid in the reservoir at various temperatures and pressures, assuming a case of a reservoir with a mixture of light hydrocarbons. The liquid phase increases with increase in pressure up to 1000 lb./sq. in., the retrograde point, after which it diminishes to zero at 2500 lb./sq. in. and 60° F. The retrograde point is practically the same for various curves of constant temperature, but the higher the temperature the lower is the pressure at which the liquid vanishes.

The principles of retrograde phenomena are applied to production practices in the so-called distillate wells, where the crude is maintained in the vapour state, by maintaining the pressure at the appropriate value for the particular crude, and thus greatly decreasing irrecoverable crude which would condense and wet the sand grains.

The first matter to be settled when the distillate field is drilled in is to determine the quantity of distillate that can be produced, the fluid ratio, the optimum working pressures, and the pressure to which it will be necessary to recompress the gases to return the residue gas to the formation. Typical cases are studied to illustrate the procedure. A. H. N.

1017.* Injection Method for Salt-Water Disposal. Part 2. B. Mills. *Oil Wkly*, 6.5.40, **973** (9), 19–26; cf. Abstract No. 914 for **Part 1.**—The first instalment of this article discussed conditions generally conducive to salt-water injection, and specifically outlined the nature of disposal efforts in the East Texas field. Descriptions of disposal plants and wells operated by Tide Water Oil Co. and Magnolia Petroleum Co. were also included. The second instalment describes several additional plants operating successfully in East Texas.

In each case a flow-sheet diagram is given, supplemented by photographs of various components of the plant. A. H. N.

1018.* Portable Meter Units Aid in Special Well Gauging. Anon. *Oil Wkly*, 6.5.40, **97** (9), 27.—Two principal factors are involved in taking the potential of a well: (1) the actual recording of the reservoir pressure in lb./sq. in. for each given rate of production; and (2) the accurate gauging of the fluid as it comes from the well.

The paper describes a gauging unit mounted on automobile chassis for portability, designed to solve the second problem without undue congestion at the wells to be tested. A. H. N.

1019.* Paint Coatings Reduce Air Deterioration of Casing. F. R. Cozzens. *Oil Wkly*, 6.5.40, **97** (9), 36.—Air-pressuring wells eventually results in rapid deterioration of casing, tubing, and other underground equipments, due to oxidation, particularly in localities where salt water is prevalent. To reduce the rate of deterioration, paints and pipe insulators have been used, the treatments having to be resistant to acids, alkalis, salt, sulphur, iron, and to resultant oxides.

A treatment of outstanding merit under practical field tests consists of using two paints, a combination of asphalt and aluminum. The method is described.
A. H. N.

1020.* Modification of California Proration Formula Proposed. Anon. *Oil Wkly*, 6.5.40, **97** (9), 41.—A detailed and illustrated discussion is made of the failure of the present proration formula in certain instances, and a new one is outlined. The modified formula has three component parts. The first is a gradual reduction in the minimum allotment. The second is reduction in the remaining allotment resulting from a change of power factor. The third part contemplates continued reduction of the top allotment, which, however, because of the contributions of the preceding two steps, will not be as drastic as the top allotment cuts which have been made since June 1939. A. H. N.

1021.* Injection Method for Salt-Water Disposal. Part 3. B. Mills. *Oil Wkly*, 13.5.40. **97** (10), 19–27.—This paper concludes the symposium on the procedure and methods employed by East Texas injection systems for salt-water disposal. Again flow-sheets, photographs, and a detailed description are given for each plant discussed.

In conclusion it is stated that experience in the East Texas field indicates that salt-water disposal wells may be a suitable method in several localities. However, proper conditions must be in existence for the procedure to have possibilities of success. A. H. N.

1022.* Review of the Principles of Oil Reservoir Performance. T. V. Moor. *Oil Wkly*, 3.6.40, **97** (13), 15–18. *Paper presented before American Petroleum Institute.*—A summary of the conclusions obtained is as follows : Production of oil is accomplished by displacement of oil from the pores of the sand either with gas or with water. In both cases some oil is left in the sand, because sands which contain only a small amount of oil do not readily transmit oil through their pores. Less oil is left in a sand from which oil has been displaced by water drive than would be left by a gas drive. In water-drive fields it is important that production be sufficiently slow to permit the water to flood the fine as well as the coarse sands. Gas caps should not be permitted to decrease in size due to production at excessive gas–oil ratios. Wells are important mechanical units, and must be completed properly and kept in good repair. A number of strategically located wells is necessary to provide for adequate control of the displacement of oil by water or gas, but otherwise the number of wells drilled is of minor importance.

When multiple zones of oil-bearing sand are present, the displacement of oil can be carried out most efficiently by producing one zone at a time.

The gas and water must be conserved ; and, unless the reservoir contains an ample supply of these fluids to provide for the displacements of all recoverable oil, it may be advisable to return at least a portion of the gas or water produced to the reservoir. Production operations should be carried out in such a manner as to keep recoverable oil concentrated in as small a part of the sand as possible. A. H. N.

1023.* Prevention and Removal of Paraffin Accumulation. W. Y. Brown. *Oil Wkly*, 3.6.40, **97** (13), 22. *Paper presented before American Petroleum Institute.*—This study is founded on the opinions and facts furnished by individuals and companies in reply to a questionnaire recently circulated to producers throughout the industry under the sponsorship of the American Petroleum Institute. Thus the paper discusses means and methods now popularly employed in the oil-producing areas of the U.S.A. for both preventing and removing paraffin accumulation, with particular reference to new and improved techniques which have appeared during the past decade.

The problem is considered only from the producer's standpoint, which includes both prevention and removal of waxy deposits laid down by most crude oils in their movement from an underground reservoir to lease storage tanks.

The paper is a long one and treats the causes for wax deposition as a foundation study for its prevention and removal. The questionnaire survey shows that methods now being used by operators to remove paraffin deposits in the old fields include batch treatment of hot water, steam, gasoline heat generators ; and commercial solvents or softeners. A. H. N.

1024.* Balancing Unequal Central Power Loads. Anon. *Oil Wkly*, 20.5.40, **97** (11), 45–47.—In general, the switch from flowing to pumping wells does not occur all over a lease simultaneously, but is a gradual transition, beginning with the locations nearest the source of water drive or towards the edge of the field where the sand thins out. Under such conditions it is necessary to balance the central power with " dummies." These counterbalances are tied in to the power as a well would be, with the load of lifting the counterbalance weight spaced to offset the return stroke of the rods in an oppositely situated well.

The methods of calculating and installing counterbalance weights are briefly described. Illustrations show typical installations. A. H. N.

1025.* Compressed-Air Repressures Sand, Cleans Wells, etc. Anon. *Oil Wkly*, 27.5.40, **97** (12), 14–18.—Compressed air used for formation repressuring has been adapted to perform a variety of other duties in a field in Oklahoma, including cleaning out of pumping wells, operation of central pumping powers, lifting and handling of engine jacket, interstage and high-pressure cooling water, etc. Some of the procedures are innovations of interest.

Special fittings and procedures are adopted so that now, after many attempts, a dirty well can be cleaned efficiently and with little power expense. A detailed description of the equipment and procedure is included.

An interesting item is the use of the compressed air in the compressor lubricating system. As an air control float falls below a predetermined height, it sets in operation the air-lifting mechanism, which brings oil from a well to a separator, from which air-free oil flows by gravity to a second tank. Safety devices are described. A. H. N.

1026.* Estimating Recoverable Oil of Curtailed Wells. W. W. Cutler, Jr., and H. R. Johnson. *Oil Wkly*, 27.5.40, **97** (12), 19.—Since almost all oil wells in the U.S.A. have been produced under curtailment, the usual method of plotting production decline curves from records of unrestricted production during equal intervals of time and of estimating future production by extending these curves has become impossible in the majority of cases. Various methods utilizing data obtained under curtailed conditions, such as the volumetric method and methods using bottom-hole pressures for estimating recoverable oil, are reviewed.

A solution for the problem is, however, offered, which takes the form of plotting curves for curtailed and uncurtailed conditions. An explanation of the method is given. It is believed that this construction of production decline curves from production records of curtailed wells is theoretically sound. However, its results will depend entirely on the reliability of the potential recorded. The older the field, the more reliable should be the recorded potentials.

Family curves for groups of wells may be made from the production decline curves of curtailed wells in the same manner as from curves of uncurtailed wells.

The authors are of opinion that for fields where accurate production and potential test records are available, this method will furnish reliable estimates of recoverable reserves of oil. A. H. N.

1027.* "Killing" Wild Gas Well. K. C. Sclater. *Petrol. Engr*, May 1940, **11** (8), 23–24.—After a gas well was completed it blew out at the surface some distance from the well. A small crater formed about 150 yards away, and the gas then blew out in a water well which had been drilled to supply water for the boilers. Attempts to kill the well, first with mud and then with cement, proved entirely unsuccessful, and the cement appeared at the crater.

The use of a spring packer was equally a failure. It seemed certain, however, that if the tubing was packed off the casing near the surface, killing the well would be facilitated. A chain packer was designed and used successfully in conjunction with golf balls.

The packer consisted of a number of chains suspended from a collar welded to the outside of the tubing. The lower ends of the chain were welded to another collar, which floated freely on the tubing, but which was temporarily fixed thereto by small cross-wires. Just below the chain packer was a special coupling with a sidewall opening and a deflector for the sealing material pumped down the tubing.

The chain packer was lowered 20 ft., the cross-wires were cut, and golf balls were pumped down, using a lubricator at the head of the well, fifteen at a time. The arrangement formed an effective seal, after which the well was killed using water, then mud, and finally cement. A. H. N.

1028.* Removal of Drilling Mud from Formation by Use of Acid. S. C. Morian. *Petrol. Engr*, May 1940, **11** (8), 117.—Research and development work have been in progress in an effort to design a method to remove the mud sheath from sand formations. Such materials as commercial hydrochloric acid, various mud thinners and conditioners, mechanical washers, as well as acid-soluble mud have been used. Of these only acid-soluble mud proved practical on any large scale.

Since not all operators use this type of mud, attempts were made to devise a solvent for ordinary muds. Conclusions regarding the formula, volume, and technique of application of the mud acid to be used are outlined. It is compared with hydrochloric acid and found superior in various respects.

The most satisfactory results have been obtained when using 1000 gal. of acid for each 10 or 15 ft. of exposed pay section. Half of the total volume may be mud acid and the balance composed of a wash solution.

The basic technique followed in new wells is outlined. This consists of washing with and then injecting the mud acid into the pay, followed by swabbing to bring in the well. A. H. N.

1029. Screening Effects of Gravel on Unconsolidated Sands. B. Gumpertz. *Petrol. Tech.* (*A.I.M.M.E.*), May 1940, Tech. Pub. No. 1195, 1–8.—Apparatus is described in which the screening effects of gravel on unconsolidated sands can be examined. This consisted of a gently tapering column of sand with a gravel section at the outlet end. Oil was driven through the sand and gravel at different rates by gas under pressure, and the rate of oil and sand efflux was determined at intervals. The sand distribution within the gravel was also determined.

It was found that the largest grains of a gravel to be used for screening unconsolidated sand over the entire range of flow velocities should bear a diameter ratio of 11 to the sand at the 10 percentile analysis. For velocities below $1{\cdot}0 \times 10^{-3}$ ft./sec. at the well surface this ratio can be increased to 16. The minimum width of the walls of a gravel pack, to give good screening action, seems to be that just sufficient to start bridging action. This width may be that of several grains of the gravel. In a gravel pack there is no relation between flow velocity and gravel-sand size ratio and the distribution of sand in the pack. Some sand was found to migrate the length of the pack in all cases. G. D. H.

1030. Factors Influencing Permeability Measurements. A. J. Carlson and M. C. Eastman. *Petrol. Tech.* (*A.I.M.M.E.*), May 1940, Tech. Pub. No. 1196, 1–6.—An air permeameter suitable for permeability measurements on core samples is described. It was found that the method of cutting the sample had no significant effect on the permeability value, and the condition of the exposed surfaces did not seem very important. Sealing-wax mounting gave more consistent results than the use of a rubber stopper, probably due to air by-passing between the sample and stopper in the latter case in some core-holders. Turbulent flow is probably responsible for some discrepancies in permeability measurements, but for the cores tested it would appear that turbulence could be avoided by keeping the rate of flow below 1 ml./sec./sq. cm., measured at the mean pressure in the sample. G. D. H.

1031.* Modified Formula before Producers. Anon. *Petrol. World*, May 1940, 37 (5), 136.—A new method of allocating production to individual wells is proposed. If the revised method is accepted it will give greater weight to the potential factor and less to the depth factor than has been practised hitherto.

The plan, as presented, has three parts :—

(1) A gradual reduction in the minimum depth allotment.

(2) A reduction in the remaining allotment by changes in the power factor.

(3) Continuation of the reductions in top allotment, but on a less severe basis than has been the case in the past. A. H. N.

1032. Patents on Production. E. V. Watts. U.S.P. 2,198,957, 30.4.40. Appl. 3.9.37. Cellular sucker-rod string consisting of individually sealed hollow sections joined end to end, the ratio of external diameter to wall thickness of each section decreasing with depth.

G. J. Barrett and S. Robichaux. U.S.P. 2,199,020, 30.4.40. Appl. 17.5.38. Cutting tool for cutting pipe inside a well.

L. S. Smith. U.S.P. 2,199,085, 30.4.40. Appl. 5.4.39. Oil-well shut-off.

G. A. Humason and W. J. Clay. U.S.P. 2,199,225, 30.4.40. Appl. 17.9.37. Pressure sampling device.

J. M. Hait. U.S.P. 2,199,490, 7.5.40. Appl. 18.4.38. Submersible pump.

C. Howard. U.S.P. 2,200,172, 7.5.40. Appl. 10.6.37. Tubing cutter.

K. Calvert. U.S.P. 2,200,487, 14.5.40. Appl. 2.11.38. Bullet-type casing perforator.

J. H. McCabe. U.S.P. 2,200,030, 14.5.40. Appl. 12.12.38. Pressure-tank gauge and sampling device.

F. A. Thaheld. U.S.P. 2,200,758, 14.5.40. Appl. 25.1.36. Rod guide for pumping wells.

F. H. Eckert. U.S.P. 2,200,790, 14.5.40. Appl. 16.6.38. Pump jack.

R. A. Wilson and R. A. Smith. U.S.P. 2,200,943, 14.5.40. Appl. 24.11.36. Well-pumping device.

E. Kerman. U.S.P. 2,201,096, 14.5.40. Appl. 5.7.38. Method of locating and repairing suction strainer damages in wells.

H. M. Greene. U.S.P. 2,201,209, 21.5.40. Appl. 4.3.39. Method and means for perforating well casings by attaching a charge to the casing itself.

E. P. Halliburton. U.S.P. 2,201,311, 21.5.40. Appl. 24.12.36. Apparatus for indicating the position of devices in pipes by causing a vibration to ensue on its passing a joint in the pipe. The vibrations are recorded at the surface.

K. Ford. U.S.P. 2,201,433, 21.5.40. Appl. 16.1.39. Liner hanger.

S. A. Mullins. U.S.P. 2,201,447, 21.5.40. Appl. 27.5.38. Fluid taking tool for oil wells or the like.

B. E. Parrish. U.S.P. 2,201,451, 21.5.40. Appl. 27.2.37. Well swab.

W. K. Thomas. U.S.P. 2,202,034, 28.5.40. Appl. 1.6.37. Well heater.

H. F. Cypher. U.S.P. 2,202,192, 28.5.40. Appl. 24.7.39. Casing-head structure comprising a tube to be inserted in casing with a tight seal between it and the casing, the tube having a valve under control.

W. S. Sease. U.S.P. 2,202,404, 28.5.40. Appl. 25.5.38. Apparatus for determining horizon productivity of wells having a velocity-responsive element which electrically translates rate of flow in well into signals at surface.

E. Topanelian. U.S.P. 2,202,439, 28.5.40. Appl. 9.8.38. Pumping apparatus with surface-operated deep well motor.

J. D. Nixon. U.S.P. 2,202,462, 28.5.40. Appl. 7.11.38. Means for intermittently controlling the flow of fluids.

J. C. Myer. U.S.P. 2,202,504, 28.5.40. Appl. 26.4.39. Device for controlling the transmission of power to pumps in a centralized pumping system.

M. F. Aloi. U.S.P. 2,202,887, 4.6.40. Appl. 26.6.39. Well-casing perforator using explosives and projectiles.

F. E. Steele. U.S.P. 2,202,970, 4.6.40. Appl. 14.3.38. Oil-well pump.

F. C. Kniss. U.S.P. 2,203,265, 4.6.40. Appl. 22.5.37. Perforating gun for oil wells.

E. B. Hall and A. L. Armentrout. U.S.P. 2,203,595, 4.6.40. Appl. 21.4.36. Device for use in wells, being a formation tester. A. H. N.

Cracking.

1033. Patent on Cracking. M. Pier. U.S.P. 2,203,470, 4.6.40. Appl. 21.7.37. Process for cracking hydrocarbon mixtures boiling above 250° C., which are substantially free from asphalts, sulphur, and nitrogen compounds, and which result from the reduction of carbon monoxide. The hydrocarbon mixture is preheated with a refining agent having an acid reaction and then subjected to cracking. H. B. M.

Hydrogenation.

1034. Patents on Hydrogenation. J. Blumenfeld. E.P. 520,201, 17.4.40. Appl. 14.10.38. Catalytic hydrogenation of ketones and aldehydes carried out in a substantially anhydrous medium in the presence of an alcoholate which is soluble in the substance to be hydrogenated, *e.g.*, *iso*propylate.

H. E. Potts. E.P. 521,391, 21.5.40. Appl. 18.10.38. Process for the destructive hydrogenation of liquid distillable carbonaceous materials containing solid matter in dispersion with hydrogen or gases containing free hydrogen under high pressures and at a high temperature. A tube preheater is used which is provided with return bends which have internal parts in the form of a scoop, constructed of, or coated with a corrosion-resistant material having a Brinell hardness of more than 400.

H. B. Kipper. U.S.P. 2,199,633, 7.5.40. Appl. 1.7.38. Process for chlorination and dehydrogenation of petroleum hydrocarbons to produce unsaturated chlorinated hydrocarbons. The hydrocarbons are treated simultaneously with chlorine and nitric acid at temperatures below 150° C. H. B. M.

Polymerization.

1035.* Thermal Reforming Plus Polymerization Pulls Octane Ratings Upward. R. P. Maso and N. C. Turner. *Nat. Petrol. News*, 3.4.40, **32** (14), R. 113–R. 114.—The disadvantage of the high gas loss attendant on thermal reforming is minimized by combining the process with polymerization. In a particular instance given the yield of reformed product of 70 octane number was 80%. This yield may be increased by 5% by polymerization without alteration of the octane number. Alternatively, by working to a constant yield, a gain of 2·5 in the octane number may be obtained. H. G.

1036. Polymerization of Ethylene by Alkyl Radicals. J. C. Jungers and L. M. Yedandapalli. *Trans. Faraday Soc.*, 1940. **36**, 483–493.—The polymerization of ethylene by alkyl radicals has been examined. The yield for any one radical increases with increasing ethylene pressure, decreasing (alkyl) iodide pressure, and light intensity. For the radicals taken together it decreases down the series methyl, ethyl, *n*-, and *iso*-propyl. The polymer is formed by bimolecular additions of ethylene molecules to radicals. The differences in the photodecomposition rates of the alkyl iodides and their polymerization yield differences are explained in terms of steric factor. The structural differences between *n*- and *iso*-propyl iodides are clearly revealed both in their photodecomposition rates and polymerization yields. Two mechanisms account for the disappearance of radicals in this polymerization—*i.e.*, saturation through capture of a hydrogen atom and bimolecular recombination of radicals. D. F. R.

1037. Patents on Polymerization. E.I. Du Pont de Nemours. E.P. 520,255, 18.4.40. Appl. 17.10.38. Separation of volatile constituents from a liquid composition containing heat-polymerizable unsaturated organic compound by bringing an inert gas into contact with the liquid composition and entraining the volatile constituents with the gas.

Standard Oil Development Corp. E.P. 521,023, 9.5.40. Appl. 10.11.38. Process for the production of polymers of halogenated *iso*-olefins. A halogenated *iso*-olefin is treated in the liquid state with a non-volatile mineral acid of between 50% and 100% strength at a temperature between 40° and 100° C. Thereafter the polymers so formed are separated from the reaction mixture.

F. T. Hamblin. E.P. 521,489, 23.5.40. Appl. 19.8.38. Preparation of a polymerizable composition comprising methyl methacrylate in admixture with a polymerization inhibitor, which in the presence of methyl methacrylate at 100° C. or above is volatile, in such proportion that it has substantially inhibitory properties at temperatures up to 40° C., but has substantially no inhibitory properties at temperatures of 100° C. or above.

J. A. Franceway. U.S.P. 2,201,767, 21.5.40. Appl. 2.7.36. Production of polymers of high molecular weight and soluble in lubricating oils by subjecting substantially saturated oxygen-containing material to a high tension electric discharge for a period sufficient to effect substantial polymerization. H. B. M.

Refining and Refinery Plant.

1038.* Refineries Operating in United States, Canada, and Mexico. Anon. *Oil Gas J.*, 28.3.40, **38** (46), 157.—A list is given of the refineries in the United States, Canada, and Mexico, with details of personnel, crude oil capacity, cracking capacity, type of refinery, and type of cracking plant. C. L. G.

1039.* 100 Refineries Now Converting Mercaptans with Copper Salts. M. G. Van Voorhis. *Nat. Petrol. News*, 17.4.40, **32** (16), R. 122–R. 129.—Two copper-sweetening processes are in use—viz., the dry or solid process, and the liquid process. In the former the gasoline to be treated is passed through a bed of Fuller's earth impregnated with cuprous chloride. In order to provide for the continuous regeneration of the reagent, filtered air, in amount dependent on the mercaptan content, is dissolved in the gasoline by bubbling air through the charge in a small mixing chamber. Small, controlled amounts of water are also incorporated by admitting steam at intervals. In the liquid process gasoline is agitated with 40% volume of a solution containing 14% wt. $CuSO_4,5H_2O$ and 13% wt. NaCl. Agitation is accomplished in a centrifugal pump constructed from corrosion-resistant metal, and settling takes place in a glass-lined tank. Regeneration of the reagent is carried out by aeration in a wooden tank. Residual copper salts in the treated gasoline, if present, are removed by washing with alkaline sodium sulphide. H. G.

1040.* Caustic Wash takes most of the Load Off Doctor Sweetening Process. Anon. *Nat. Petrol. News*, 3.4.40, **32** (14), R. 115–R. 116.—In the example given, gasoline is treated with 20% volume of 10% NaOH solution in a two-stage continuous wash system installed before the conventional "doctor" sweetening process. By this means 60–65% of the mercaptans are removed. The resulting product is claimed to possess a higher susceptibility to tetraethyl lead, representing a saving of 0·10–0·15 c.c. per gallon. H. G.

1041.* Preventing Condenser Scale. F. J. Mathews. *Petrol. Times*, 23.3.40, **43** (1106), 264–265.—Sodium metaphosphate added to condenser feed-water has the effect of increasing the temperature and/or concentration at which calcium carbonate is precipitated. Examples are given in which the addition of the reagent in amount equivalent to 2 p.p.m. has postponed descaling indefinitely. Dosage depends on local conditions and whether the feed system is open or closed. In closed systems periodic replenishment is necessary owing to the slow conversion of the metaphosphate into the orthophosphate. H. G.

1042. Patents on Refining and Refinery Products. J. Bibby and Sons. E.P. 520,233, 18.4.40, Appl. 11.10.38. Process for the removal of impurities from oil or other liquid by the addition of a solid absorbent and subsequent removal of suspended matter by a process of electrostatic precipitation.

S. F. Warren. E.P. 521,417, 21.5.40. Appl. 18.11.38. Improvements relating to solvent-extraction processes. A number of solvents are used having different boiling points, and are brought into heat-exchange in such a way that the vapours of each solvent of a higher boiling point give up their latent heat of condensation wholly or partly to the solution in the solvent with the next boiling point. The lower-boiling point liquid is thus caused to evaporate without any more energy being used than is necessary to evaporate the solvent with the highest boiling point.

C. M. Loane and B. H. Shoemaker. U.S.P. 2,199,108, 30.4.40. Appl. 13.12.37. Preparation of a petroleum product of the class of oils and waxes highly resistant to oxidation containing a technical white oil obtained from a high-sulphur crude oil, in small but sufficient quantities to render the petroleum product resistant to oxidation.

B. Clayton. U.S.P. 2,199,401, 30.4.40. Appl. 1.8.39. Refining animal and vegetable oils containing free fatty acids and colouring matter. An alkaline refining agent is mixed with the oils at a temperature sufficiently high to prevent the formation of a stable emulsion. H. B. M.

E. R. P. E. Retaillau. U.S.P. 2,200,703, 14.5.40. Appl. 18.5.38. Refining of hydrocarbon oils by the injection into heated hydrocarbon vapours of an aqueous solution having a concentration of 0·2–20% of a reagent consisting of sulphuric acid. 0·02–1 lb. of reagent is used per barrel of oil.

E. R. P. E. Retaillau. U.S.P. 2,200,704, 14.5.40. Appl. 18.5.38. Refining of hydrocarbon oils by the injection into heated hydrocarbon vapours of an amount of a dilute reagent solution having a concentration of 0·5–20% in a solvent which is chemically inert and which consists predominantly of organic sulphonic acid. 0·05–1 lb. of reagent is used per barrel of oil.

H. J. Willmann. U.S.P. 2,203,373, 4.6.40. Appl. 24.12.38. Method of deodorizing non-drying animal and vegetable oils, fats and waxes by subjecting them to the action of X-rays.

Fire Prevention.

1043.* Causes, Prevention, and Control of Fires on Light Liquid Hydrocarbons. H. A. Heiss. *Oil Gas J.*, 28.3.40, **38** (46), 135.—The recent increase in the recovery of light petroleum fractions for use in, *e.g.*, polymerization and alkylation processes has led to the paying of greater attention to the fire hazards involved in the storage and handling of such products. A major oil company has developed a programme of study in the reduction of these hazards by the education of employees on the fundamental properties of light petroleum products and the nature of their fire hazards, and by experiments on methods of extinguishing and improvements to equipment to eliminate fire hazards.

A discussion of this programme is presented, demonstrations used in the lectures being described. The second part deals with the types of fires possible, their probable location, and the most effective means of extinguishing. Fires are possible in process equipment lines and pumps or storage tanks, the last-named being the most likely. Experiments were carried out in a 3 ft. diam. 7 ft. high tank, containing absorption naphthas, and using as extinguishers fire foam, carbon dioxide, and steam. It was found that open tank fires of absorption naphthas of vapour pressure higher than 35–40 lb. could only be extinguished with fire foam with difficulty, and required more than the rate of 0·1 cu. ft. per sq. ft. per minute, which was found effective for naphthas of lower vapour pressure. Steam alone was not found effective even for stocks of 30·4 lb. vapour pressure, while carbon dioxide alone was effective on stocks of 43·8 lb. vapour pressure, but required excessively large quantities. Vent fires could not effectively be extinguished with fire foam or CO_2, while the application of CO_2 over a layer of foam was effective, but required impracticably large quantities of CO_2. The application of steam (or possibly CO_2) to the base of the flame appears to be the most satisfactory method. Water in the form of fog directed in a horizontal direction across the opening of the vents from a point 3–6 ft. upwind from the flame was also successful. It is recommended that a non-explosive atmosphere should be maintained in the vapour space of the tank to eliminate the risk of roof removal by explosion, and prevent open tank fires. Pressure relief equipment, grounding the tanks as protection against lightning, and location in an isolated area would also minimize the possibility of rupture from causes other than internal pressure. C. L. G.

Chemistry and Physics.

1044. Hydrogen Fluoride as a Condensing Agent. X. Rearrangements. J. H. Simons, S. Archer, and D. I. Randall. *J. Amer. chem. Soc.*, 1940, **62**, 485–486.—The authors report exchange reactions in which hydrogen fluoride was used as the catalyst instead of other more commonly used agents. These rearrangements were *tert.*-butylbenzene with phenol at 0° C. to give benzene and *tert.*-butylphenol, the latter in 10% yields ; benzophenone oxime to benzanilide in the Beckmann rearrangement (72% yield); phenyl acetate to *p*-hydroxyacetophenone in poor yields at 100° C. (Fries rearrangement); *p*-cresylbenzenesulphonate to 2-hydroxy-4-methyldiphenyl sulphone in yields of 10%—this also at 100° C. R. D. S.

1045. New Route to 9-Alkyl- and 9-Aryl-anthracenes. C. K. Bradsher. *J. Amer. chem. Soc.*, 1940, **62**, 486–488.—This consists of cyclization of *o*-benzyl phenyl ketones by refluxing in a mixture of hydrobromic and acetic acids, a reaction seemingly characteristic of the β-(β-styryl) vinyl alcohol structure. R. D. S.

1046. Dehydration of Some Tertiary Alcohols Containing the *cyclo*Hexane Ring. W. A. Mosher. *J. Amer. chem. Soc.*, 1940, **62**, 552–554.—1-Methyl*cyclo*hexanol, 1-ethyl*cyclo*hexanol, 1-*iso*propyl*cyclo*hexonal, and dimethyl*cyclo*hexylcarbinol were prepared and dehydrated with iodine and the resulting olefins ozonized. From the analysis of the products of ozonolysis the ratios of the isomers in the dehydration products were determined. Dehydration will apparently take place in such a manner that the double bond occurs principally in the ring when this is possible—that is to say, the hydrogen atoms attached to the ring are less firmly bound than those of a more aliphatic nature. A proton is lost more readily from the *cyclo*hexane ring than from a methyl, ethyl, or *iso*propyl group. R. D. S.

1047. Synthesis of 6-Hydroxy-3 : 4-Benzpyrene and 8-*iso*Propyl-1 : 2-Benzanthracene from 9 : 10-Dihydrophenanthrene. L. F. Fieser and W. S. Johnson. *J. Amer. chem. Soc.*, 1940, **62**, 575–577.—6-Hydroxy-3 : 4-benzpyrene was formed by cyclization of 4-chryseneacetic acid which was prepared by the Reformatsky conversion, followed by dehydrogenation, of 4-keto-1 : 2 : 3 : 4-tetrahydrochrysene; the preparation of this latter from 9 : 10-dihydrophenanthrene has already been described. The synthesis of 8-propyl-1 : 2-benzanthracene involved dehydrogenation of a hydrocarbon mixture prepared from 8-keto-3 : 4 : 5 : 6 : 7 : 8-hexahydro-1 : 2 benzanthracene, another compound obtained from 9 : 10-dihydrophenanthrene. R. D. S.

Motor Fuels.

1048.* Autoxidation and Gum-Forming Tendencies of Certain Hydrocarbons. B. Berger and R. W. Bost. *Oil Gas J.*, 28.3.40, **38** (46), 81.—The mechanism of gum formation in gasoline is being studied by examining the relationship between the structure of pure hydrocarbons and their tendency to form oxygenated derivatives and gums. Eight pure hydrocarbons have been selected, four of the unsaturated cyclic series—viz., pinene, limonene, *cyclo*hexene and tetralin; three of the unsaturated acyclic series, viz., diallyl, 2-methyl-butene 2, and di*iso*butylene, and finally *iso*-octane; 24 samples of each were placed in ampoules containing 20 c.c. of the hydrocarbons, and, in addition, (*a*) 0·2 gm. benzoyl peroxide, (*b*) 0·2 c.c. butyraldehyde, and (*c*) 0·2 c.c. acetic acid. These, together with blanks, were exposed on the roof of a building for 3 months, samples being examined every fortnight for peroxide, acid, and gum content.

The pure hydrocarbons showed the greatest tendency to form peroxides, the acids (formed from the addition of benzoyl peroxide, butyraldehyde, and acetic acid) tending to favour the decomposition of peroxides in the sunlight. Peroxide formation is also restricted by the available oxygen being used in the oxidation of, *e.g.*, butyraldehyde. Pinene and limonene showed two peaks in the peroxide–time diagrams, indicating the formation of two types of peroxide, whilst *cyclo*hexene, being simpler in structure, showed only one peak. No free aldehydes were found as a result of autoxidation, suggesting their immediate oxidation to acids. The pure hydrocarbons showed little tendency to acid formation, but the addition of benzoyl peroxide to the unsaturated hydrocarbons led to the formation of benzoic acid. Low acidity was found in the case of the hydrocarbons (except 2-methyl-butene 2), to which butyraldehyde was added. Acid removal is attributed to (1) decomposition in the sunlight, under the influence of peroxides, (2) addition to the double bonds of unsaturated hydrocarbons, and (3) combination with hydroxyl groups formed in the experiments. The hydrocarbons can be placed in the following order of gum formation: limonene, tretalin, pinene, diallyl, *cyclo*hexene, di*iso*butylene, 2-methylbutene 2, and *iso*-octane.

Most of the hydrocarbons reached a maximum gum formation after 4 weeks, the gum content falling on further exposure, possibly owing to its destruction by sunlight. Benzoyl peroxide increased gum formation in every case, with the exception of tetralin, available oxygen being apparently utilized in acid formation in this case. Butyraldehyde and acetic acid affected the quantity of gum formed, depending on the structure, reducing gum in the case of pinene, but increasing it in the case of diallyl. An investigation of the gums obtained by evaporating a solution in acetone and drying in air for a long time indicated that the gums formed from cyclic hydrocarbons contained two oxygen atoms per hydrocarbon unit, there being at least three units in a gum. Further work on the structure of the gums is in hand. C. L. G.

1049. Patents on Motor Fuels. A. L. Mond. E.P. 520,115, 15.4.40. Appl. 27.10.38. Process for the catalytic conversion of unsaturated hydrocarbon material, and particularly for the saturation of mono-olefinic hydrocarbons boiling within the range of gasoline, *e.g.*, octenes.

Texaco Development Corporation. E.P. 520,159, 16.4.40. Appl. 13.10.38. Treatment or production of gasoline hydrocarbons by adjusting the ratio of *iso*paraffins to olefins in a hydrocarbon of gasoline boiling range or below to at least 1 : 1 without the addition of extraneous hydrocarbons. Thereafter the mixture is subjected to the action of an alkylation catalyst and the *iso*paraffins thus alkylated with the olefins.

Les Usines de Melle. E.P. 520,257, 18.4.40. Appl. 28.10.38. Preparation of a hydrocarbon anti-knocking fuel for spark ignition engines by mixing with a hydrocarbon fuel at least 10% by volume of an aliphatic organic ester.

Standard Oil Development Corporation. E.P. 520,229, 18.4.40. Appl. 13.9.38. Production of gasoline by cracking higher-boiling hydrocarbon oil in the presence of a solid adsorptive catalyst.

Standard Oil Development Corporation. E.P. 520,564, 26.4.40. Appl. 1.12.38. Improved motor fuel composed of *iso*pentane, *iso*propyl ether, and a branched-chain saturated paraffin containing at least 8 carbon atoms in the molecule.

W. E. Lyons and W. S. Guthmann. U.S.P. 2,197,477, 16.4.40. Appl. 6.12.37. Inhibition of gum formation in a liquid hydrocarbon of the gasoline type is achieved by incorporating with the liquid hydrocarbon a small proportion of a β-diketone. The amount added is sufficient to inhibit gum formation, but insufficient materially to lower the spontaneous ignition temperature of the hydrocarbon.

M. A. Dietrich. U.S.P. 2,197,851, 23.4.40. Appl. 12.8.38. Preparation of a motor fuel consisting substantially of hydrocarbons, but having incorporated therein a small proportion of an *N*-substituted organic sulphonamide which has a boiling point of at least 300° C., a melting point below 75° C., and a high solvent power for kawri gum.

T. W. Bartram. U.S.P. 2,199,021, 30.4.40. Appl. 12.2.36. Preparation of a mineral-oil composition containing a mineral oil hydrocarbon of the type tending to form gum during storage and a small amount of a reaction product, formed by condensing substantially two molecular proportions of an aromatic compound, having a hydroxyl radical substituted on the nucleus thereof, with substantially one molecular proportion of a ketone.

P. Subkow. U.S.P. 2,201,306, 21.5.40. Appl. 12.8.35. Production of cracked and polymer gasoline by the admixture of a normally liquid hydrocarbon fraction with an alkyl halide and heating the mixture to a cracking temperature. Thereafter the mixture is commingled with a normally gaseous hydrocarbon, passed into a reaction chamber, and submitted to polymerization.

F. R. Bean. U.S.P. 2,201,553, 21.5.40. Appl. 3.4.37. Prevention of deterioration of motor fuel by the incorporation of *N*-furfurylaminophenol.

J. T. Crook. U.S.P. 2,201,965, 21.5.40. Appl. 20.12.37. Conversion of liquid hydrocarbon fuel into gaseous fuel by passing the former without admixture of air through a catalyst chamber in contact with nickel ammonium sulphate. H. B. M.

Gas, Diesel and Fuel Oils.

1050. Patent on Gas, Diesel, and Fuel Oil. Standard Oil Development Corporation. E.P. 520,568, 26.4.40. Appl. 1.4.39. Fuel for compression-ignition engines of the diesel type composed of a hydrocarbon fuel and a small amount of an organic compound, containing an oxy-nitrogen sulphur group, attached to the carbon. The ignition properties of the fuel are thereby improved. H. B. M.

Lubricants and Lubrication.

1051.* 200 Lubricant Additive Patents Issued in 1938–1939. M. G. Van Voorhis. *Nat. Petrol. News*, 6.3.40, 32 (10), R. 67.—A survey of the patent literature relating to additives to lubricating oil is presented. The reagents mentioned fall into five classes, of which extreme pressure agents represent the biggest. The other classes relate to stability at high temperature and oxidation resistance, the lowering of pour points, improvement of viscosity index, and the inhibition of bearing corrosion. H. G.

1052.* Soap-Thickened Chassis Lubricant is First Additive Application. Anon. *Nat. Petrol. News*, 20.3.40, 32 (12) R. 88–R. 89.—The article is primarily a description of a recently developed additive for lubricating oil. The dope is claimed to be a highly complex organic base with a wide range of properties. Added in small quantity to automobile engine oil it is claimed to lower pour point, increase viscosity index, and to control acidity, sludge, and lacquer formation. It is further stated that by an alteration of the chemical characteristics of the dope its properties as an additive may be altered selectively. For instance, its relative effect on pour point and viscosity index may be altered independently, and independently of its reaction towards other undesirable features in the treated oil. H. G.

1053. Patents on Lubricants and Lubrication. J. I. Wasson. U.S.P. 2,196,374, 9.4.40. Appl. 9.2.38. Improved method of dewaxing a mineral oil by mixing with it a polyester of a hydroxy fatty acid secured by auto-condensation of a high-molecular-weight mono-hydroxy fatty acid, chilling the oil, and separating the precipitated wax.

T. S. Hodgins. U.S.P. 2,196,796, 9.4.40. Appl. 17.7.39. The drying properties of oils containing naturally occurring anti-oxidants are improved by removing the anti-oxidants by treating at substantially room temperature with nitric acid. The p_H value of the materials being treated is kept only slightly acid by confining the quantity of nitric acid used to 0·025–0·50% by weight of the oil being treated. The operation is continued just until the refractive index begins to increase.

E. W. Fuller. U.S.P. 2,196,963, 9.4.40. Appl. 1.2.39. A minor proportion of a thio-aldehyde is admixed with a mineral-oil fraction in sufficient amount to inhibit the deleterious effects of oxidation on the oil.

D. R. Merrill. U.S.P. 2,197,153, 16.4.40. Appl. 23.2.37. Preparation of a normally fluid mineral oil lubricant comprising an oil-soluble organic base soap of an unsaturated fatty acid of at least ten carbon atoms condensed with an aryl compound.

W. A. Lutz. U.S.P. 2,197,433, 16.4.40. Appl. 3.2.39. Preparation of a stable oxygen-resistant, non-bleeding lubricating grease having a low absorbability in rubber by mixing 15–20% calcium stearate with 85–75% of a paraffinic petroleum oil of viscosity exceeding 500 Saybolt at 100° F. The oil must be substantially free of poly-naphthenic constituents.

A. W. Ralston and E. J. Hoffmann. U.S.P. 2,197,712, 16.4.40. Appl. 14.10.38. Preparation of a mineral-oil composition containing as a pour-point depressor, an acylated indene, the acyl group having at least twelve carbon atoms.

M. Pier and F. Christmann. U.S.P. 2,197,769, 23.4.40. Appl. 2.12.37. Preparation of a lubricant containing a mineral lubricating oil and a condensation product of paraffin wax, having a molecular weight above 350. The product has a viscosity of at least 3° (Engler) at 99° C., is soluble in hydrocarbon lubricating oils, and is effective in depressing the pour point of waxy lubricating oils. It is obtained by subjecting the wax to the action of a silent electric discharge in order to increase its viscosity.

D. E. Badertscher, H. G. Berger, and F. M. Seger. U.S.P. 2,197,781, 23.4.40. Appl. 3.12.37. Preparation of an extreme pressure lubricant by admixing with a hydrocarbon lubricating oil a small proportion of the product obtained by the reaction of perchloromethylmercaptan with an unsaturated organic material.

O. M. Reiff and E. W. Johnson. U.S.P. 2,197,836, 23.4.40. Appl. 8.10.38. Mineral-oil composition comprising a viscous mineral-oil fraction and sufficient of an oil-miscible metal salt of a keto acid to inhibit oxidation of the oil.

S. Musher. U.S.P. 2,198,210, 23.4.40. Appl. 3.1.39. An oil normally subject to oxidative deterioration selected from the group consisting of the hydrocarbon oils, glyceride oils, and essential oils can be effectively stabilized against deterioration. A stabilizing agent is used, consisting of a small proportion of sugar selected from the group consisting of crude cane and crude beet sugar.

O. M. Reiff, F. P. Otto, and J. J. Giammaria. U.S.P. 2,198,275, 23.4.40. Appl. 18.10.39. An improved mineral-oil composition is obtained by admixing with a viscous mineral-oil fraction a small proportion of a metal salt of an alkyl-substituted aromatic-aliphatic carboxylic acid in which the alkyl substituent is attached to the aromatic nucleus and is derived from an aliphatic hydrocarbon having at least 20 carbon atoms.

G. A. Hope. U.S.P. 2,198,307, 23.4.40. Appl. 30.11.37. Preparation of a lubricating composition comprising a hydrocarbon lubricant oil and in admixture therewith a small amount of a salt of a polyvalent metal.

A. Pollak and R. Hastings. U.S.P. 2,198,562, 23.4.40. Appl. 27.4.39. Manufacture of sulphurized cutting oils by heating tall oil with agitation with up to 30% by weight of sulphur in the temperature range 300–400° F. The solution of the sulphur is controlled to give a minimum of sludging by terminating the heating within 2–4 hr.

F. X. Govers. U.S.P. 2,198,575, 23.4.40. Appl. 27.2.36. Manufacture of high viscosity index lubricating oil having a low pour test from wax-bearing mineral oil.

P. J. Wiezevich, J. C. Zimmer, and A. J. Morway. U.S.P. 2,198,851, 30.4.40. Appl. 6.11.36. Preparation of an improved normally liquid lubricating oil consisting of a mineral oil, an aluminium soap, and a small percentage of a high-boiling ester selected from the class consisting of esters of polyhydroxyl alcohols with monobasic acids.

R. Rosen. U.S.P. 2,199,187, 30.4.40. Appl. 24.7.38. Composition of matter comprising a waxy mineral lubricating oil and a small amount of an ester formed from a long-chain aliphatic alcohol and a cyclic carboxylic acid. H. B. M.

C. C. Towne. U.S.P. 2,199,352, 30.4.40. Appl. 23.3.38. Improved lubricating oil is prepared by depolymerizing a dispersion of rubber in an aromatic solvent with a depolymerizing agent. The depolymerized rubber is reacted in the presence of one of a group of compounds, consisting of halides and halogen acids of tin, to produce a resinous polymer, which is thereafter precipitated and separated, and finally dissolved in a minor proportion in a petroleum lubricating oil.

V. B. Bray. U.S.P. 2,200,534, 14.5.40. Appl. 19.4.38. Preparation of a low-pour-point lubricating oil composed of a lubricating oil having a relatively higher pour point blended with a small quantity of a pour point reducing agent extracted from a cracked pitch by the use of a higher-boiling hydrocarbon-oil fraction.

E. Bösing. U.S.P. 2,201,120, 14.5.40. Appl. 17.8.38. Process for producing lubricating oil of high quality from a wax-free hydrocarbon mixture containing same, together with low-quality oil constituents.

D. E. Badertscher, H. G. Berger, and F. M. Seger. U.S.P. 2,202,641, 28.5.40. Appl. 23.11.37. Production of an extreme-pressure lubricant consisting of a hydrocarbon oil and a minor proportion of the oil-miscible product obtained by the reaction of a halogenated aliphatic hydrocarbon and an alkali thiocyanate in such proportions that the product contains both sulphur and chlorine.

O. L. Brandes. U.S.P. 2,202,826, 4.6.40. Appl. 17.1.38. Preparation of a lubricating composition for use in internal-combustion engines, etc., comprising a major amount of a mineral lubricating oil and not more than 2% by weight of nickel naphthenate and an alkylated monohydric phenol.

T. J. Brown. U.S.P. 2,203,044, 4.6.40. Appl. 11.1.39. Manufacture of a lubricant comprising a mineral lubricating oil and 2–10% of *para*-cymene to lower the pour point of the oil.

K. P. Powers. U.S.P. 2,203,102, 4.6.40. Appl. 18.1.38. Manufacture of a lubricant comprising a petroleum lubricating oil, 0·05–0·1% stearic acid and 0·05–0·5% by weight of a mild extreme pressure agent selected from the class consisting of esters and thioesters of phosphorus acids.

T. G. Roehner, E. S. Carmichael. U.S.P. 2,203,507, 4.6.40. Appl. 11.12.37. Manufacture of a lubricant containing more than 50% of a heavy mineral-oil fraction, about 20% of palm oil, and about 20% of substantially non-corrosive sulphur-containing extreme-pressure lubricant bases.

Standard Oil Development Corporation. E.P. 520,792, 3.5.40. Appl. 1.11.38. Method for renewing the oxidation and decomposition resisting properties of lubricating oil during use. Successive portions of the oil are circulated through a bed of an oxidation and decomposition resisting substance which has a low solubility in oil.

I. M. Colbeth. E.P. 520,970, 8.5.40. Appl. 5.11.38. Production of a lubricant consisting of a major proportion of a mineral oil and a minor proportion of an ester of a non-drying long-chain aliphatic acid obtained from a natural oil and having at least eleven carbon atoms and a short-chain primary saturated aliphatic alcohol having not more than two hydroxyl groups. The composition is substantially free from fatty oils and also from emulsifying agents.

Socony-Vacuum Oil Company. E.P. 521,203, 15.5.40. Appl. 10.11.38. Production of a lubricating composition having incorporated a major proportion of a lubricating oil and a minor proportion of the phosphorus-amine reaction product obtained from phosphorus trichloride and an amine having at least one hydrogen atom attached directly to the nitrogen atom of the amine. H. B. M.

Asphalt and Bitumen.

1054. Patents on Asphalt and Bitumen. R. Lichtenstern. E.P. 520,525, 26.4.40. Appl. 26.5.38. Improvement of tars or asphalts by treating with metal chlorides. A basic mass is prepared by subjecting any desired bituminous material with the action of heat to the action of a concentrated solution of a metal chloride, and heating a bituminous material of the same or a different kind after incorporating with it a small quantity of the basic mass.

A. H. Batchelder. U.S.P. 2,200,484, 14.5.40. Appl. 5.4.38. Preparation of an asphaltic composition by separating asphalt into an oil fraction and an asphaltene fraction by the use of a selective solvent. Thereafter a substantially undissolved, non-colloidal dispersion of the substantially oil-free asphaltenes is formed. This has a lower viscosity than the original asphalt.

R. E. Burk and C. H. Whitacre. U.S.P. 2,200,914, 14.5.40. Appl. 14.7.38. Manufacture of asphalt by air-blowing a residuum and introducing a small amount of chlorine while heating.

E. C. Daigle. U.S.P. 2,203,081, 4.6.40. Appl. 2.7.38. Production of a blended asphaltic product by oxidizing a straight-run residuum of a highly naphthenic nature to approximately the desired penetration for the final product. Thereafter a small amount of a straight residuum of a more asphaltic nature is blended with the oxidized asphalt. Oxidation is continued until the final blended asphalt is produced possessing the desired properties. H. B. M.

Special Products.

1055.* Contribution to the Manufacture of Metallurgical Coke from Petroleum Coke. H. Hendler. *Monit. Pétr. roum.*, 1940, **41**, 445–446.—The author outlines the possibilities of utilizing, in Rumania, coke from cracking processes as a metallurgical coke. T. C. G. T.

1056. Patents on Special Products. R. Robinson and A. Lowe. E.P. 519,894, 9.4.40. Appl. 6.10.38. Manufacture of *B*-(4-hydroxy-3-methoxyphenyl)-*iso*propylamine and its salts by condensing an aralkyl ether, preferably the benzyl ether, of 4-hydroxy-3-methoxybenzaldehyde with an α-halogenopropionic ester.

Röhm and Haas A.-G. E.P. 520,164, 16.4.40. Appl. 13.10.38. Manufacture of esters of unsaturated polymerizable acids by the reaction of esters derived from these acids and from alcohols of relatively lower molecular weight with alcohols of relatively higher molecular weight, or phenols. The lower alcohols are set free and the esters of the higher alcohols formed are removed from the reaction zone during the reaction.

I.G. Farbenindustrie A.-G. E.P. 520,198, 17.4.40. Appl. 14.10.37. Extraction of phenols from aqueous solutions by bringing the solution into intimate contact with liquid esters of carboxylic acids, the boiling point of which is sufficiently below that of the phenols to allow separation of the esters by distillation.

G. T. Morgan and L. P. Walls. E.P. 520,273, 18.4.40. Appl. 7.10.38. Preparation of nitro-derivatives of phenanthridine by cyclizing an acylated nitro-*o*-xenylamine or a substitution product thereof having a free orthoposition by means of a 5-valent phosphorus compound.

Chemical Works (Sandoz). E.P. 520,396, 23.4.40. Appl. 21.10.37. Manufacture of new condensation products by the treatment with aldehydes of alkylureas of pyridinium compounds.

Gutehoffnungshutte Oberhausen A.-G. E.P. 520,480, 25.4.40. Appl. 11.10.38. Partial oxidation of gaseous or vaporous hydrocarbons in the presence of small quantities of nitrogen oxides and solid catalysts in the form of oxides which are difficult to reduce, *e.g.* oxides of silicon, zinc, magnesium, titanium, cerium, alone or in mutual admixture. The initial mixtures are passed through a number of uniformly heated tubes or ducts containing, or made of, the catalysts.

H. Frisch. E.P. 520,620, 29.4.40. Appl. 14.11.38. Production of styrene from commercial xylene by chlorinating the xylene, separating the chlorinated constituents and treating them to recover the styrene.

N. V. Orgachemia. E.P. 520,707, 1.5.40. Appl. 28.10.38. Process for the preparation of di-(*p*-aminobenzene-sulphonyl)-*p*′-aminobenzenesulphonamide and its acyl derivatives.

J. G. Fife. E.P. 521,068, 10.5.40. Appl. 17.11.38. Production of mono-alkylol ketones by reacting di-alkylol ketones with ketones, if desired in the presence of condensing agents, *e.g.*, substances showing an alkaline reaction.

Phillips Petroleum Company. E.P. 521,092, 10.5.40. Appl. 9.8.38. Process for the separation of a mixture of paraffinic and olefinic hydrocarbons having four or five carbon atoms in the molecule, into a paraffinic fraction and an olefinic fraction.

H. Dreyfus. E.P. 521,202, 15.5.40. Appl. 10.11.38. Manufacture of fatty acids from their salts by bringing carbon dioxide into contact with a solution of the salt in concentrated aqueous ethyl alcohol maintained at a temperature above 70° C.

Standard Oil Development Corporation. E.P. 521,296, 17.5.40. Appl. 12.11.38. Construction of an insulated electrical conductor, comprising as an insulating medium a low-pour-point synthetic oil consisting of reaction products having a molecular weight above about 300 and obtained by further polymerization of lower polymers containing 8–20 carbon atoms of normally gaseous *iso*-olefines.

United States Rubber Products, Inc. E.P. 521,576, 24.5.40. Appl. 8.12.38. Manufacture of aliphatic ketone-diarylamine anti-oxidants by reacting diarylamine in liquid form with an aliphatic ketone introduced in vapour form by pressure into the liquid diarylamine at a temperature between 100 and 200° C.

C. M. Alexander. U.S.P. 2,200,463, 14.5.40. Appl. 14.1.31. Production of lower-boiling hydrocarbons from higher-boiling hydrocarbons by subjecting vapours from the latter and steam to elevated temperature and pressure in the presence of potassium carbonate and condensing the vapours.

B. T. Thurman. U.S.P. 2,201,061, 14.5.40. Appl. 8.6.38. Stabilization of glyceride oil products prepared from oils having fatty acid radicals containing more than two double bonds by the addition of a vegetable phosphatidic material.

A. P. Anderson. U.S.P. 2,201,466, 21.5.40. Appl. 21.1.38. Preparation of natural petroleum plastic, translucent in thin layers, substantially free from asphaltenes, substantially solid at atmospheric temperature, completely soluble in 860 A.P.I. naphtha, and more than 75% insoluble in an equal volume of acetone at 77° F. The product has a lower temperature susceptibility than that of asphaltic resins.

V. Ipatieff and R. E. Schaad. U.S.P. 2,202,104, 28.5.40. Appl. 18.4.36. Production of di*iso*butene from a normally gaseous mixture consisting essentially of four carbon atom hydrocarbons and containing *iso*butene and normal butenes. The mixture is subjected in vapour phase at a temperature of about 210° F. and under a pressure of 100 lb./sq. in. to the action of a siliceous catalyst containing approximately 30% phosphoric acid in order selectively to polymerize the *iso*butene.

J. C. Morell. U.S.P. 2,202,115, 28.5.40. Appl. 30.12.37. Production of octanes by the subjection of butanes at a temperature of −50 to 20° C. to treatment with butenes in the presence of hydrochloric acid and zinc.

E. C. K. Montclair and A. T. Fiore. U.S.P. 2,202,387, 28.5.40. Appl. 26.3.38. Preparation of an insecticide containing a mineral oil distillate, a poly-alkyl phenol, and a third substance selected from the group consisting of rotenone, oleoresins containing rotenone, etc. H. B. M.

Detonation and Engines.

1057.* Fuel Injection Gives Safety Fuel Performance Equal to Gasoline. M. G. Van Voorhis. *Nat. Petrol. News*, 3.4.40, **32** (14), R. 106–R. 108.—The results obtained on the Wright 1820 G (single-cylinder) engine with aviation safety fuel with a flash-point as high as 134° F. are stated to be encouraging. Fuels are available which show a power output and minimum specific fuel consumption equal to that of *iso*-octane. Determinations of power output, mean effective pressures, and fuel consumption carried out on five safety fuels indicated that an increase in the distillation range has only a negligible effect on performance until the distillation range exceeds 350–500° F. Better performance was obtained when using a multi-orifice injection nozzle as compared with single-jet nozzles. The apparent disadvantages of heavy fuels as compared with gasoline are starting difficulties, extreme crankcase dilution, troubles due to low cylinder temperatures as would prevail in an idling engine during a long glide. At present an engine must be started on gasoline or propane. H. G.

1058.* Distillate Fuels for Tractors Holds Own with Gasoline. Anon. *Nat. Petrol. News*, 3.4.40, **32** (14), R. 110–R. 112.—Tests on 338 tractors over a period of 20 years by the University of Nebraska Tractor Testing Laboratory indicate that there is no tendency to use any particular fuel. On the basis of horse-power-hours per gallon distillate fuels compare favourably with gasoline. Since 1920 the average fuel consumption of tractor engines has fallen by 33%. H. G.

BOOK REVIEW.

A New Dictionary of Chemistry. Edited by Stephen Miall, LL.D. Pp. 575. Longmans, Green & Co. 1940. Price 42*s*.

This very admirable volume can be heartily recommended not only to chemists, but also, as the Editor points out, to " doctors, druggists, physiologists, chemical manufacturers, works managers, chemical engineers, patent agents, lawyers, journalists and many others." And this is no idle saying.

In the very limited space of 575 pages the contributors have packed an astonishing wealth of material, accurate and concise. A really comprehensive selection of typical examples of the numerous groups of organic substance has been successfully achieved, and a careful examination has shown that considerable judgment must have been exercised to ensure that a well-balanced choice has been effected.

The elements and their more important compounds are reviewed from a variety of aspects, crystal structures are demonstrated by X-ray analysis, representative mineral species are discussed, compounds of pharmacological importance are described, attention is given to the phenomenon of chemical change. Catalysis, thermodynamics, surface chemistry, and physics are not ignored. In point of fact the dictionary is not only filled with useful matter, but it is eminently readable as well. The appendix giving the physical constants of 1800 organic compounds is a welcome addition to the dictionary.

Special reference should be made to the biographical entries relating to chemists past and present who have made some contributions of importance to their science. This must be the first occasion on which a " Chemical Who's Who " has been published, and a delicate task it must have been. But it adds something of human interest to the dictionary when H. E. Armstrong is found reposing between Argon and Arnica, or Caro cheek by jowl with Carnallite and Carotene. Perhaps one day the Editor will extend and amplify his biographies and make them up into a separate volume.

Only one complaint. Your reviewer has failed to find a disquisition on Entropy. He must confess that for many years this illusive quantity has eluded him—he did hope against hope that a definition even in the Miallian sense would be forthcoming.

It is unnecessary to say that the book is handsomely printed, bound and produced—and it is confidently predicted that it will find a place in every laboratory and in the libraries of the eminent men referred to in the first sentence.

A. E. D.

BOOKS RECEIVED.

New Zealand Official Yearbook, 1940. 9¼ × 6″, 1041 pp. End map. Pubd. Census and Statistics Division N.Z. Government. 7*s*. 6*d*.

This 48th issue of the statistical Abstract for New Zealand follows the same lines as its immediate predecessor. The statistics relate to 1938.

Under " Petroleum " it is stated that the total production of crude for the year was 116,585 gallons from three wells at New Plymouth. Following the passing of the Petroleum Act, 1937, considerable interest has been displayed by some of the major oil organizations. Fifty-nine prospecting licences have been granted over 10,514 square miles throughout the country.

The consumption of petrol during 1938 is returned as 96,896,000 gal. The total duty on motor spirit is now 1*s*. 2*d*. The proceeds from 6*d*. per gallon of this tax are earmarked for road purposes, and the balance is levied for general revenue purposes.

Imports of motor spirit, valued at £1,891,339 in 1938, mainly come from Dutch East Indies and U.S.A.

B.S.S. No. 894—1940. The Determination of the Flow and Drop Points of Fats and Allied Substances. Pp. 11. British Standards Institution, 28 Victoria Street, S.W.1. Price 2*s*.

The apparatus employed for the determination of the flow and drop points of fats and allied substances is of the Ubbelohde type. It is more closely specified than the existing I.P. standard (Method L.G. 11) chiefly as regards the dimensions of the glass cup. In the B.S. Specification the internal diameter of the cup is specified as well as the outside diameter. A further difference between the two kinds of apparatus is to be found in the length of the thermometer bulb, which has been increased in the B.S. Specification.

B.S. Glossary of Highway Engineering Terms. Pp. 77. April, 1940. British Standards Institution, 28 Victoria Street, S.W.1. Price 5*s*.

The History of Alberta Oil. By F. K. Beach and J. L. Irwin. Pp. 62, plus map. Issued by the Department of Lands and Mines. Published by the Publicity and Travel Bureau, Edmonton, Alberta.

This pamphlet gives a general review of the history and development of the oil industry in Alberta. It is concluded that for the successful maintenance and advancement of Alberta's oil industry certain factors are necessary. One is the continued conservation of the oil and gas resources of the province by means of orderly development, and another is the maintenance of a price structure that will be adequate to assure continued production of oil. Alberta produced a record year in 1939 with her total oil production of 7,594,411 brl.

International Union of Chemistry, 28 rue St. Dominique, Paris.

1. **International Table of Atomic Weights, 1940** (10th Report of Committee on Atomic Weights).
2. **International Table of Stable Isotopes, 1940** (5th Report of Committee on Atoms).
3. **Rules for the Nomenclature of Inorganic Compounds.**

The text of the first two Reports is in English, French and German; the text of the third Report is in English.

The Committee on Atomic Weights (Chairman: Prof. G. P. Baxter, Harvard) records work carried out during 1938–39, and tabulates internationally recognized atomic weights and atomic numbers of 86 elements.

The Committee on Stable Isotopes (Chairman: Dr. F. W. Aston, Cambridge) records the Atomic Numbers (Z), the Mass Numbers (A) and Relative Abundances of the stable isotopes of 83 elements. One small discrepancy was noted. The table of Atomic Weights employs the symbol " Cb " and the table of Stable Isotopes the symbol " Nb " for the element columbium (niobium).

The third Report (" Nomenclature of inorganic compounds ") is " an attempt to produce a uniform, rational nomenclature, especially for scientific purposes." Some of the recommendations will doubtless arouse controversy (*e.g.*, the substitution of " halogenides " for " halides," and the discouragement of the suffixes " -ous " and " -ic " as valency indications). The impression obtained is that it is fortunate that the symbolic notation of chemistry is independent of language or personal predilection.

INSTITUTE NOTES.

July, 1940.

TELEGRAPHIC ADDRESS.

Telegrams and cables for the Institute should be addressed: "Instpetech Birmingham."

CANDIDATES FOR ADMISSION.

The following have applied for admission to the Institute or transfer to another grade of membership, and in accordance with the By-laws the proposals will not be considered until the lapse of at least one month subsequent to the issue of this *Journal*, during which any Fellow, Member, or Associate Member may communicate by letter to the Secretary, for the confidential information of the Council, any particulars he may possess respecting the qualifications or suitability of any candidate.

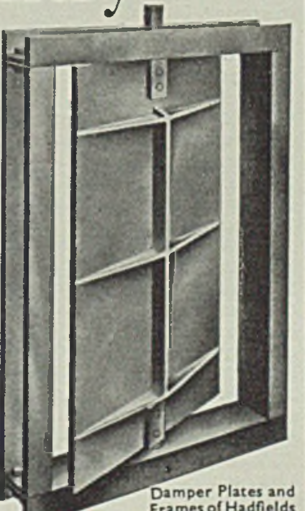
The object of this information is to assist the Council in grading candidates according to the class of membership.

The names of the candidate's proposer and seconder are given in parentheses.

Kuhn, Wayne Edward, Ph.D., Chemical Engineer. (*The Texas Company*) 135 East 42nd Street, New York. (*K. G. Mackenzie ; L. de Florez.*)

Mills, Leonard, Chemist, 55, County Road, Ormskirk, Lancs. (*Vigzol Oil Refining Co., Ltd.*) (*P. Bilton ; S. Elliman.*)

Moon, Alec, Engineer, c/o Messrs. Shell-Mex & B.P., Ltd., Shell-Mex House, London, W.C.2. (*R. G. Strickland ; H. E. Priston.*)



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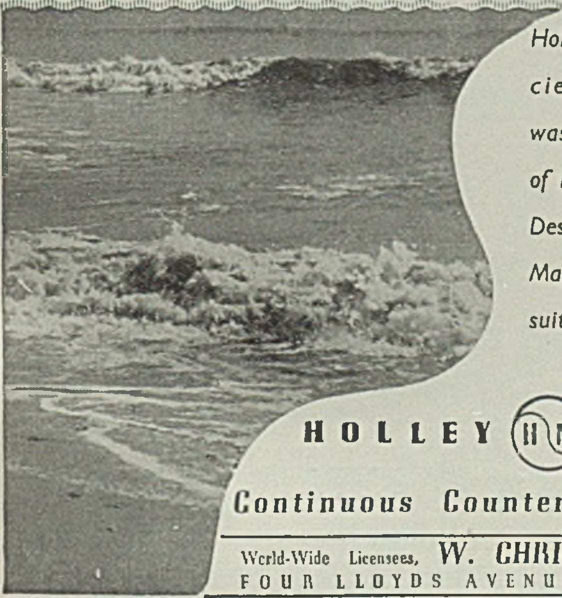

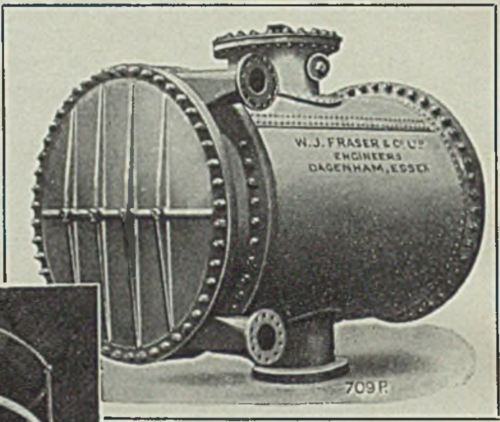
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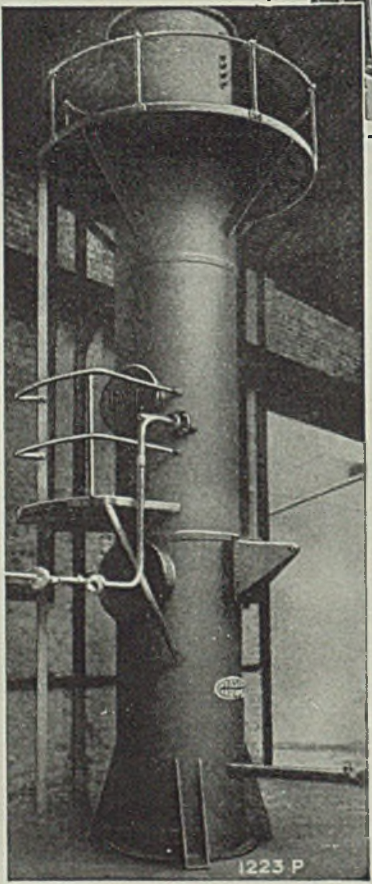
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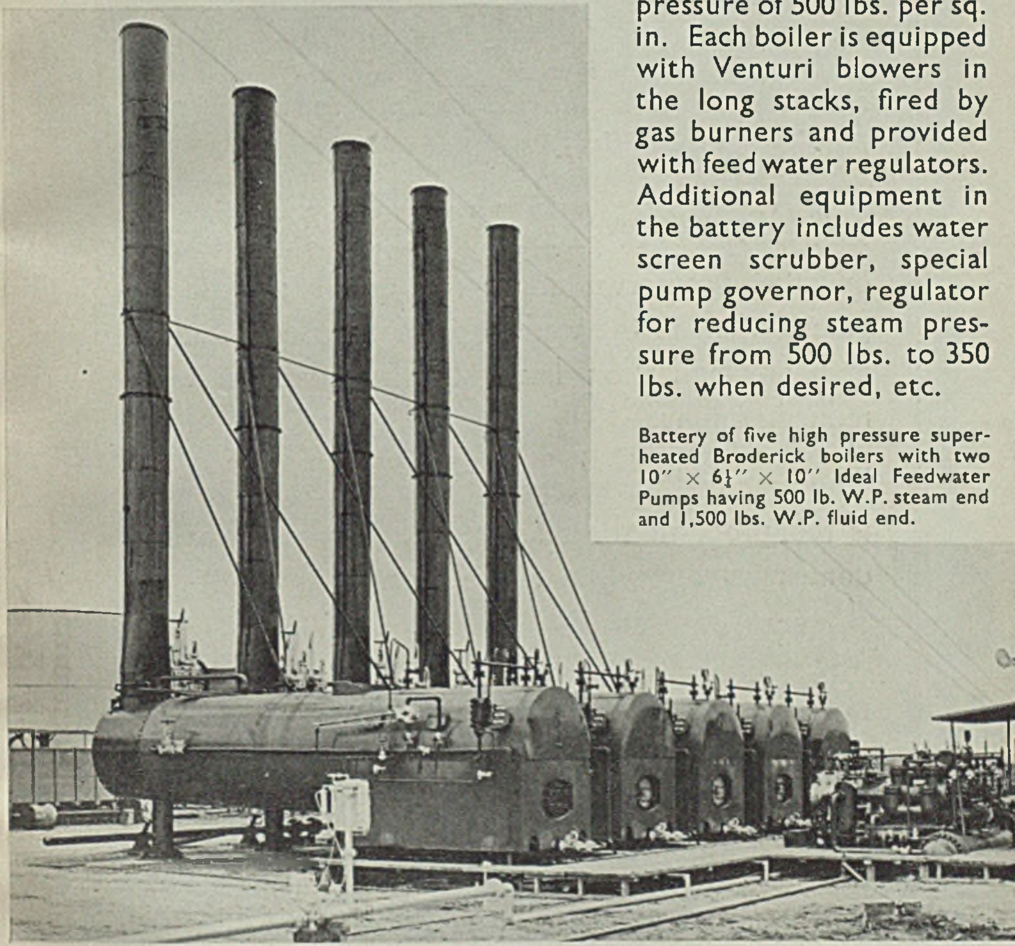

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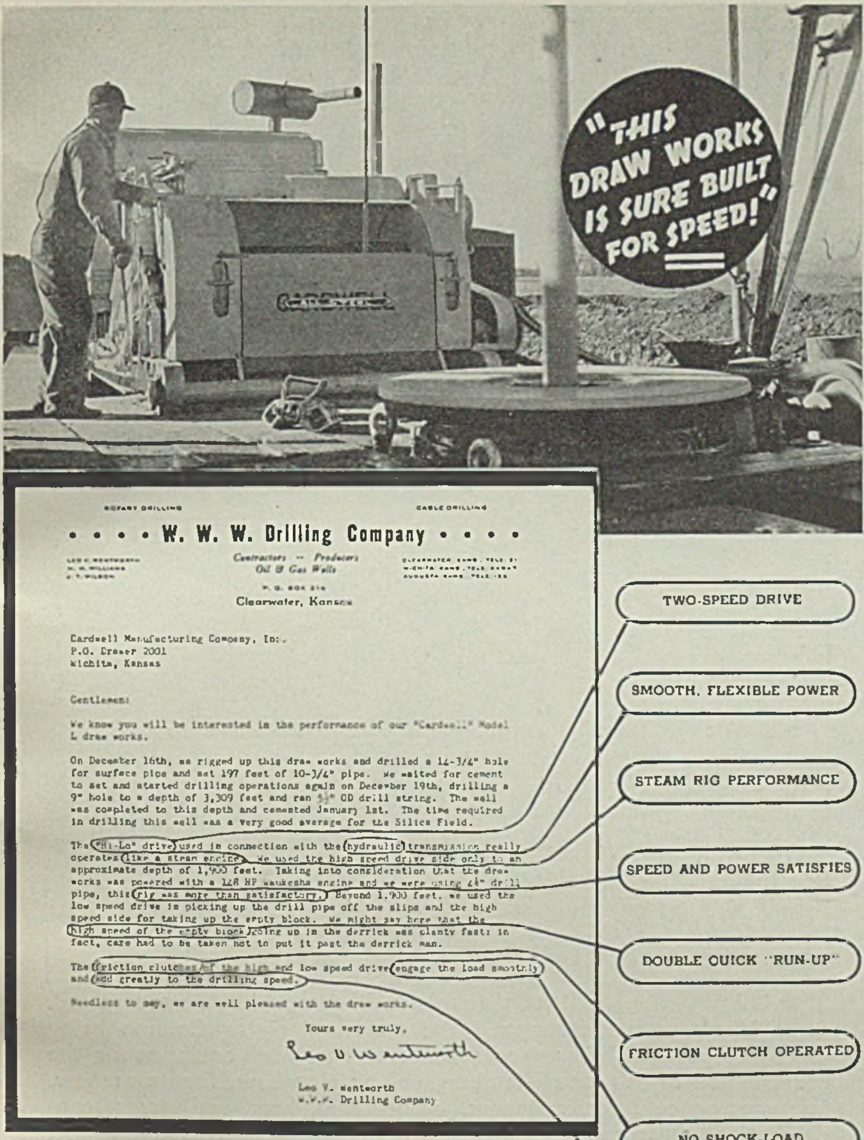

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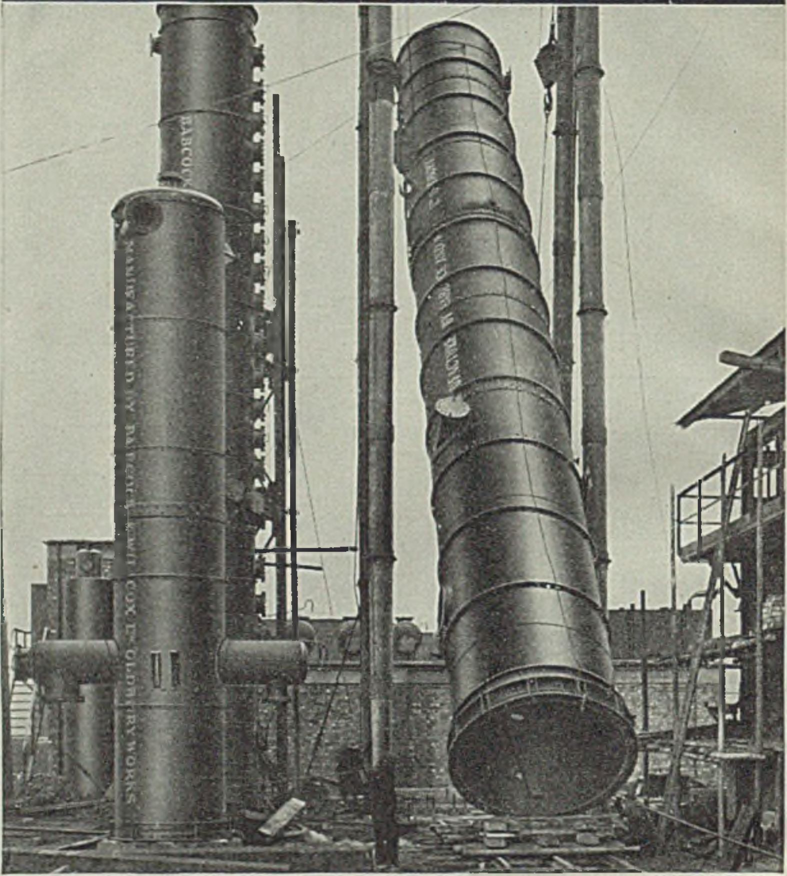
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