INSTRUMENT FOR DETERMINING THE DIRECTION OF DIP IN CORES TAKEN IN INCLINED HOLES.*

By C. F. C. Moore, A.R.S.M., and N. F. Brown.

Summary.

The determination of the direction of dip as shown in a core with respect to north can be made with fair accuracy—in all but vertical wells—by correlating the core with the direction of deviation of the well, which in turn can easily be determined by the single-shot type of inclinometer.

A simple method of correlation is to obtain an acid-etch in a glass bottle attached to the core with its long axis parallel to the core-barrel; the low-point of the etch will then indicate the direction in which the well is deviating. An instrument to obtain such an etch is described.

The core is obtained with a conventional core-barrel, preferably of the non-rotating type, in the normal manner. At a pre-determined time coring is stopped, and the instrument, which is run inside the core-barrel, attaches itself to the top of the core. After a short interval the core is burnt-in, pulled, and carefully extracted from the core-barrel.

By means of suitable circular protractors, the dip in the core is correlated with the low-point of the acid etch, and hence with true north by correlation with the single-shot inclinometer reading.

Early in 1939 a test-well coring continuously on the gentle flank of a small, sharply folded asymmetrical anticline in Burma suddenly encountered steep dips. It was thought that these steep dips might possibly be associated with faulting, or that they might indicate that the well had gone over the crest and was drilling in the steep limb of the fold. If the latter explanation were correct, it was clear that it would be useless to carry the well deeper. It was therefore essential that the direction of dip should be determined with the minimum of delay.

Efforts to obtain a Schlumberger Electro-magnetic Dip Meter revealed that all the instruments in the East were fully occupied, and that an instrument would have to be obtained from France, a matter of at least six weeks. An even longer interval would elapse before the results from a Polar Orientation of a core, carried out in America, would be available. The instrument here described was therefore designed and, successfully run several times in this test well, gave reproducible results, and provided the necessary information as to the direction of dip.

General Principles.

The use of the single-shot type of inclinometer makes it possible to obtain an accurate directional survey of a well as the drilling proceeds. Providing that a well was not absolutely vertical, it appeared that all that was required to determine the direction of dip in a core was to correlate the core with the direction of deviation of the hole at that particular point. The direction of deviation being known from the single-shot

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inclinometer reading, it would then be possible to determine the direction of dip in the core.

A simple method of attaining this correlation would be by the attachment of an ordinary acid bottle to the core after it had been taken, but before it had been broken off from the parent strata. The low-point of an ordinary hydrofluoric-acid etch on the acid bottle would then indicate the direction of deviation of the hole, which in turn could be interpreted in terms of true north from the single-shot inclinometer reading.

It was necessary to design an instrument which could be run inside the core barrel and which would only attach itself to the top of the core after the core had been cut; and to arrange matters so that immediately after the instrument had attached itself to a core, a clear acid etch on the glass acid bottle would be quickly made, without greatly disturbing the normal safe coring procedure. The instrument would then have to maintain its relation to the core undisturbed by subsequently burning-in the core and pulling-out the core barrel.

METHOD OF RUNNING.

The core barrel used with this instrument is preferably of the non rotating type, and in practice the instrument (which is about 45 inches long overall and weighs about 70 lb.) is run inside the core barrel attached to the upper valve assembly in the manner shown in the accompanying figure. The core barrel is run in in the normal manner, and a suitable length of core taken, say 8–10 feet in a 20-foot core barrel. The instrument is provided with a time release, which can be set to trip after a suitable interval which will allow time for running in and cutting the core. A little before the predetermined time, coring is stopped with the bit on bottom, circulation being maintained. On the instrument being released it falls down the core barrel, and the sharp spike, which is set eccentrically on the bottom of the instrument, penetrates the top of the core and fixes the instrument in relation to the core. It is desirable to arrange matters, as far as possible, so that the top of the core is fairly soft, preferably shale.

Should the core be lost, the instrument is retained in the core barrel by the core catcher.

Immediately after the instrument is fixed to the top of the core, an acid-bottle reading is taken, an etch being made by hydrofluoric acid in a suitable size of glass acid bottle the relation of which with respect to the eccentrically mounted spike is known. In order to preserve the etch when made, water is later added to the acid in the glass bottle, and not only dilutes the acid, but also raises its level. The time required for the complete operation of taking the acid-bottle reading is about 2½ minutes.

The core is then burnt in in the usual way and the drill-pipe pulled. The core is very carefully extracted from the barrel (the upper end of which is kept slightly raised), in order not to disturb the relation between the instrument and the top of the core. It has been found useful to cut a line up the side of the core as it is extracted, in order that the entire length of core may be correlated with the instrument, in case the core breaks while being extracted, or it is subsequently found that there are no suitable indications of the dip in the upper part of the core near the instrument. After pulling the core, a single-shot inclinometer reading is taken to give the direction of deviation of that part of the hole from which core has been cut.

Using suitable circular protractors to fit round the core and the acid bottle, it is possible to correlate the direction of dip in the core with the orientation of the instrument, and so with the low-point of the etch of the contained acid bottle; thus the dip is correlated with the direction of deviation, which is known in relation to north from the inclinometer reading.

Determinations of the direction of dip are normally accurate to within plus or minus 10°, but the accuracy depends on the steepness of the dip as shown in the core and on the angle of deviation of the well. The greater both these factors, other things being equal, the greater the accuracy of the determination.

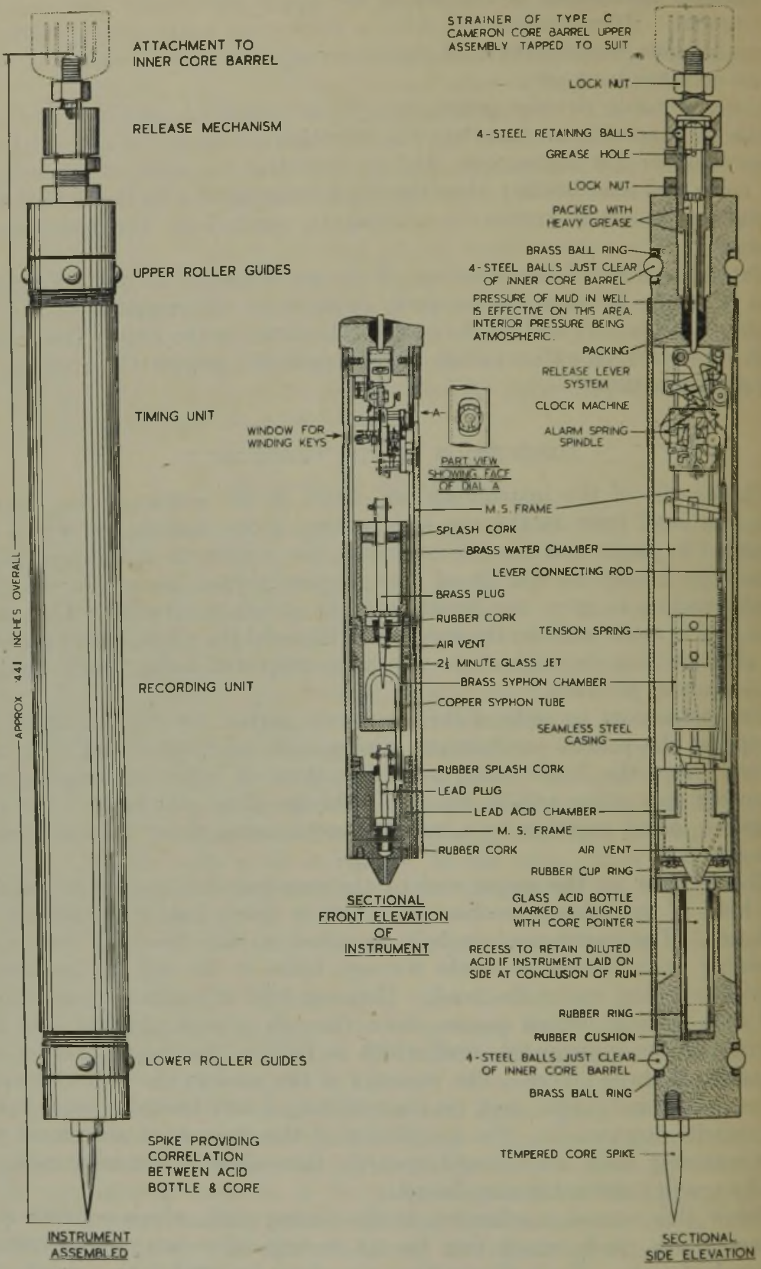
Description of the Instrument.

The details of the instrument are shown in the accompanying figures. The four steel balls at the top and bottom of the instrument, which are mounted in cages and are free to rotate, are a close fit in the core-barrel (which preferably should be of the one-piece type), to enable the acid-bottle reading to give the direction of deviation accurately. The outer steel case is made sufficiently strong to withstand the considerable pressure to which it may be subjected—say, in a deep well using heavy mud or drilling under pressure.

The instrument consists of three separate parts: the upper unit, which comprises the release mechanism, timing unit, and water and acid containers; and the lower unit, on the bottom of which is mounted the tempered core spike and in which is held the glass acid bottle; the two units are joined together by a seamless steel casing, taper threaded joints being used.

The strainer at the upper end of the core-barrel is tapped to receive the head of the release mechanism, which is firmly held in position by a lock-nut. The instrument is held attached to this head by four steel retaining balls, which protrude through holes in the top of the instrument into a ring cut in the head. They are held in position by the upper end of a spindle, which passes down through a packing-gland into the interior of the instrument, and which is held in the raised position by a system of three levers. The pressure of the mud in the well acts upon the area of this spindle, and, on the retaining levers being released, forces the spindle downwards. On completion of this downward movement the four retaining balls are released inwards, thus allowing the instrument to fall by gravity down the core-barrel.

Below this release mechanism is the timing unit, which consists of a robust alarm clock which can be set to trip after any predetermined interval of time. To facilitate this, the clock is fitted with a small dial (Dial A) in place of the usual dial on the clock-face by which the alarm clock is set. The clock rotates this dial (which is divided into 12 hours by quarters) one revolution in 12 hours, and the required time interval is



INSTRUMENT TO DETERMINE DIRECTION OF DIP IN CORES

Fig. 1.

set directly by rotating the small hand on the dial until it indicates the required interval.

On the clock alarm mechanism being tripped, the alarm-spring spindle rotates and winds up the flexible thin wire cable attached to it. This cable pulls down the first of a system of three levers. The first lever is normally kept in place by a light spiral spring. This first lever in turn releases the second lever, which is under tension from a fairly strong spiral spring anchored to the frame just above the lead acid chamber. This second lever in turn releases the third lever, which is of robust construction, and is designed to retain the spindle in the upper position against the well pressure and, on release, to utilise the well pressure acting on the spindle to operate the acid-bottle mechanism. In this way the effort of the clock is limited to the release of the first lever, a task easily within its capabilities.

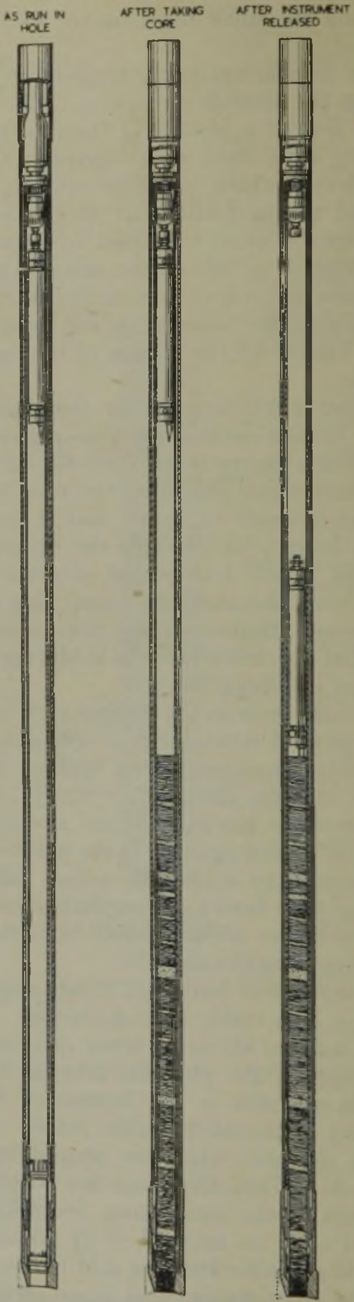
When the third lever is forced down by the spindle, a thin wire cable attached to its lower branch passes over a deep-grooved pulley and raises the connecting-rod which operates two levers, one of which raises the plug in the water chamber and the other the plug in the acid-chamber.

The water chamber is made of brass, and is mounted above a brass syphon chamber. A brass plug fits into the upper part of the hole cut through a rubber cork which is cemented into the bottom of the water chamber. A little above the cork the brass plug is fitted with a guide in the shape of a cross. Higher on the plug spindle, above the water level, a cork is mounted which is a loose fit in the upper end of the chamber and prevents the water splashing out.

In the lower end of the hole in the rubber cork is mounted a glass jet, the end of which is ground down until it will pass the required volume of water from the water chamber to the syphon chamber in exactly 2½ minutes. The brass syphon chamber is fitted with a copper syphon tube, which, after the water has reached the necessary level, syphons the water down through the special opening in the top of the lead-acid chamber. To ensure that the necessary syphoning action takes place even though some of the water may have been lost by splash or evaporation, the syphon tube is set to syphon before all the water from the upper chamber has passed down into the syphon chamber.

The acid chamber is made of lead, and is only required to hold sufficient acid to fill up about 1 inch inside the acid-bottle. The plug in this case is made of lead, and is fitted above its lower end with a guide in the form of a cross. The bottom of the plug fits into the hole in a rubber cork, which is cemented in position in the bottom of the chamber. At the upper end of the plug is mounted a thin rubber cork, which is a tight fit in the top of the chamber when the plug is in its lowered position, thus preventing splash. When the plugs are withdrawn from the water and the acid chambers at the same time, the acid flows down into the glass acid-bottle, and after an interval of 2½ minutes the water syphons down through the acid chamber into the acid bottle.

The strength of the hydrofluoric acid is so adjusted that it will make a good clear etch at the well temperature in 2½ minutes on the type of glass acid bottle to be used. On the conclusion of this period it is diluted with water.



METHOD OF RUNNING
INSTRUMENT IN CORE BARREL

Fig. 2.

Below the lead acid chamber is mounted a rubber cup-ring, which prevents the acid from running up and damaging the clock when the core-barrel is laid on its side at the conclusion of the run.

The tapered core-spike is set eccentrically on the bottom of the lower unit which carries the acid-bottle, and a line is scribed on the top of this unit indicating the direction of the spike from the centre. The acid-bottle, which is made of clear glass and is $1\frac{3}{32}$ inch O.D. and $6\frac{1}{4}$ inches long, sits on a rubber cushion, and is fitted with two rubber rings, which not only preserve the bottle from damage, but also ensure that it is concentric with the axis of the instrument. A vertical line is scribed on the acid bottle with a stellite pencil, and this line is made to coincide with the line showing the direction of the spike: thus providing the required correlation between the mark made by the spike on the top of the core and the direction of deviation shown by the acid-bottle.

A recess is cut in the lower unit of sufficient capacity to take the liquid contents to the acid-bottle when the instrument is laid on its side. As will be seen from the drawing, provision is made for equalizing the pressures within the various units of the instrument.

This instrument was designed for the Indo-Burma Petroleum Company, Ltd., to whom the authors tender their thanks for permission to publish this description.

A PRELIMINARY STUDY OF THE CHEMICAL CONSTITUTION OF KEROGEN.*

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.

Although the existence of rocks which yield oil on heat treatment has been known for several centuries, and although shale-oil industries have been in operation for more than a hundred years, even to-day very little is known of the organic matter or " kerogen " from which these oils are derived. The voluminous literature dealing with the oil-shales and shale-oils is concerned mainly with the economic and technical problems of obtaining and refining the crude oils; the chemistry of the shale-oils, particularly the lighter fractions, has been studied in some detail, but there has been little or no attempt at a fundamental attack on the chemical constitution of the parent kerogen. It should here be emphasized that the term " kerogen " does not imply any particular compound or group of compounds, but is merely a convenient name for the organic matter from which oil is obtained when rocks containing it are heated; hence the kerogens of different deposits may be chemically different, and may even vary in different parts of the same seam.[1]

The study of the chemistry of kerogen follows the same general lines as the study of coal, and involves two main series of operations—namely, (*a*) the determination of the chemical composition, and (*b*) investigation of the chemical constitution. With regard to the chemical analysis, whereas, with coals, determination of the chemical composition is straightforward, since the content of inorganic matter is generally low, in dealing with most kerogen rocks the (generally) high content of mineral matter introduces serious complications, and it has recently been shown by one of us (A. L. D.) [2] that unless the sample has been substantially completely de-ashed, the results obtained for the composition of kerogen are quite unreliable. Thus, many analyses of coals of all ranks are available from which it has been possible graphically to prove the continuity of composition of members of the peat-to-anthracite series, and to link the compositions of the less mature members of the series with those of modern plant materials, as has been done by O. C. Ralston,[3] G. Hickling,[4] and others. On account, however, of the difficulty of isolating the kerogens, the true compositions of only a few samples are known, and although these indicate that they do not form a section of the peat-to-anthracite series, by reason of their higher contents of hydrogen, it will be necessary to accumulate analytical data on several hundred samples before any conclusions can be reached with certainty as to the existence of similar " maturing curves " for kerogen rocks.

The problem of the elucidation of the chemical constitution of kerogen may be attacked in three main ways: (*a*) by studying the mechanism and

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course of its thermal decomposition, with examination of the products, (*b*) investigation of the action of reagents, and (*c*) by studying the products of controlled oxidation.

The thermal decomposition of the organic matter is of outstanding importance, since the industrial application of the kerogen rocks depends on it. The actions whereby oil and gas are derived have been studied by a number of workers, usually under conditions which are less drastic than those employed in retorting. C. Engler[5] found that when a sample of New South Wales algal shale was heated for 5 hours to 400° C., the amount of material soluble in benzene increased from 1·4 to 55·2 per cent., which indicated that the initial stage in the decomposition was the formation of a soluble bitumen. R. H. McKee and E. E. Lyder[6] isolated an intermediate compound from Parachute Creek kerogen shale by vacuum distillation, and found it to be highly unsaturated, as shown by its almost complete solubility in concentrated sulphuric acid; the material was a solid or semi-solid bitumen which, on further heat treatment, broke down into an oil which was only about 50 per cent. unsaturated. From similar work, C. O. Blackburn[7] came to the conclusion "that the oil-forming constituents in Elko, Nevada, shale kerogen are products of polymerized montan wax, which upon thermal decomposition, de-polymerizes, and forms first, a primary product, montan wax." A. J. Carlson[8] examined the effect of heat treatment *in vacuo*, at 250°, 300°, and 350° C., on the solubility in carbon tetrachloride of the organic matter of three shales, derived respectively from Grand Valley (Colorado), Soldier Summit (Utah), and Montgomery County (Kentucky). The samples contained about 90 per cent. kerogen, the greater part of the mineral matter having been removed by treatment with acids. The gases evolved contained carbon dioxide, from which Carlson concluded, in view of the fact that the samples were heated in the absence of air and the low temperatures employed, that carboxyl groups were present in the kerogen. Work on samples from which varying amounts of mineral matter had been removed led to the conclusion that there was some chemical combination ("either adsorbed or true compound") between the organic and inorganic constituents. Recent work at the Imperial College[9] has shown that after removal of the mineral matter from a kerogen rock the solubility of the kerogen in acetone and chloroform may be materially increased, and examination of the absorption of shale-oil by clays has suggested that there is physical adsorption of part of the "soluble" material.

The study of the chemistry of kerogen would be simplified if all or a considerable part of the kerogen were soluble in organic solvents, but numerous investigations have shown that the insolubility of kerogen in organic solvents is a characteristic property which serves to distinguish true kerogen rocks from such materials as oil- or tar-sands, bituminous limestones, etc.

That certain kerogens, such as those in the shales of De Beque (Colorado) and Ione (California), are unsaturated is shown by their vigorous action with chlorine; R. H. McKee[10] found that absorption of chlorine caused a considerable increase in the solubility of the kerogen in alcohol.

Examination of the oils from different shales has proved that the kerogens were chemically very different. Whereas the Scottish shale-oils, and also those from Elko (Nevada), Capertree, and Newnes (New South Wales), contained considerable proportions of paraffin wax (about 12 per cent.), and generally resembled the paraffin-base crudes, oils from Swedish and Kentucky shales were asphaltic, paraffin wax being absent, while the oils from the shales of the Green River formation (Parachute Creek, Colorado, Soldier Summit, Utah, etc.) resembled mixed-base petroleums. The lighter fractions of certain shale-oils have been studied in some detail; Scottish [11] samples have been shown to consist almost entirely of paraffins, naphthenes, and olefines, and although aromatic hydrocarbons have been reported, the general opinion is that, if present at all, it is only in very small amounts. J. M. Petrie [12] found that the oil from the Joadja Creek algal coal (New South Wales) contained 9 per cent. of paraffin wax; the light fractions consisted of olefines and paraffins, the former preponderating. As the boiling point of the fractions increased, the percentage of olefines decreased, and none was detected in the fraction boiling above 280° C. The absence of aromatics in the oils does not imply that kerogen is entirely non-benzenoid in structure. Jones and Wheeler [13] and Pictet and Bouvier [14] have shown that the oils obtained by the distillation of bituminous coals *in vacuo* at 550° C. consist almost entirely of naphthenes and unsaturated hydrocarbons, notwithstanding the fact that on oxidation with alkaline permanganate, from 39 to 46 per cent. of the carbon of coal is converted into benzenoid acids. On the other hand, the presence of benzene, toluene, and *m*-xylene has been definitely established in Swedish shale-oils by Hellsing [15] and Holmberg.[16]

J. B. Robertson [17] oxidized samples of " oil shale, torbanite, cannel coal, peat, and lycopodium " with concentrated nitric acid. The products contained oxalic acid and other organic acids which gave empirical formulæ $C_{16}H_{22}NO_6$ and $C_{16}H_{24}NO_5$ when derived from Broxburn Main oil-shale and torbanite, respectively. He concluded that all the samples examined were of a similar nature, and arranged them in a series: lycopodium, torbanite, Broxburn oil-shale, peat, cannel coal, and bituminous coal, and suggested that each represented the end-point of decomposition of organic matter under a different set of conditions, thus directing attention to the profound importance of environmental influences in determining the final product obtained from a given raw material.

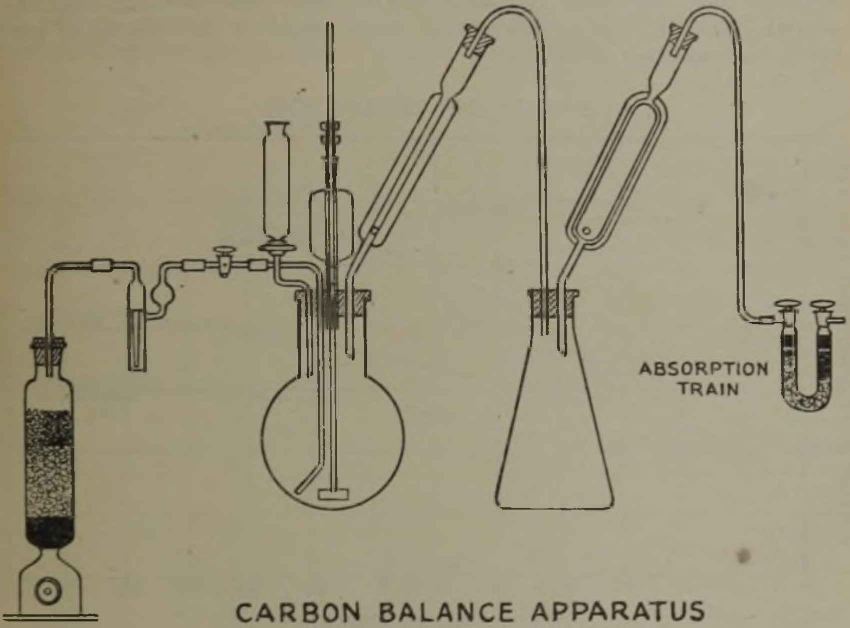
P. N. Kogerman [18] reported to the Glasgow Conference the results obtained by the mild oxidation of a rich sample of Estonian kukersite (algal limestone) with alkaline potassium permanganate at 30° C. About 8 per cent. of the kerogen was not converted into soluble products; the carbon balance was :—

Percentage of the carbon appearing in the products as :	
CO_2	35·6
Oxalic acid	43·8
Acetic and other fatty acids (mono- and di-basic)	21·6

One of the most important features of the results was the absence of any detectable benzenoid acids in the products, although benzenoid acids have invariably been important products of the oxidation of members of the peat-to-anthracite series.

THE PRESENT INVESTIGATION.

The most hopeful method for the preliminary study of the chemical constitution of kerogen was considered to be by controlled oxidation by alkaline potassium permanganate, and, with slight modification, the technique so successfully employed on coal by the late Professor W. A. Bone and his colleagues [19] was adopted. Oxidations may be carried out under "carbon-balance" or "bulk-oxidation" conditions, according as it is desired either to determine quantitatively the distribution of carbon among the various products of oxidation, or to prepare sufficiently large quantities of the soluble products for separation and identification.



CARBON BALANCE APPARATUS
FIG. 1.

Carbon-balance Oxidation.—The apparatus used is illustrated in Fig. 1. It consisted of a 2-litre bolt-head flask fitted with a motor-driven stirrer, tap-funnel, and condenser. From the condenser a tube led into a conical flask of some 750 ml. capacity, also fitted with a condenser, which was connected to an absorption train of calcium chloride and Sofnolite tubes. An amount of finely ground (100 mesh, I.M.M.) kerogen rock, equivalent to 1 gm. of carbon, was weighed into the flask and 100 ml. of 1·6 per cent. potassium hydroxide solution were added. The apparatus was swept out with air freed from carbon dioxide by being passed through a tower containing Sofnolite and a bubbler containing strong potash solution. Since, notwithstanding the alkalinity of the solution in the flask, a small quantity of carbon dioxide escaped during the oxidation, a weighed absorption train was attached to the second condenser, and a slow, continuous stream of CO_2-free air was passed through the system during the oxidation. The reaction flask was heated by being immersed in a bath of glycerine, maintained by means of a thermostat at 115° C., so that the alkaline solution boiled gently and the shale was kept in suspension by the joint actions of the stirrer and the boiling of the solution. When the solution started to boil, potassium permanganate was added as a 3 per cent. solution from the tap-funnel, the addition being made at a rate equal to that at which the permanganate was being reduced; from time to time a sample of the solution was drawn up into the tube, the solid matter was allowed to settle, and the colour was observed. If the sample of solution was colourless, further permanganate solution was run in. During the oxidation the original volume of the solution was periodically restored by draining the water from the jacket of the first condenser and distilling into the conical flask an amount of water equal to the volume of permanganate solution added.

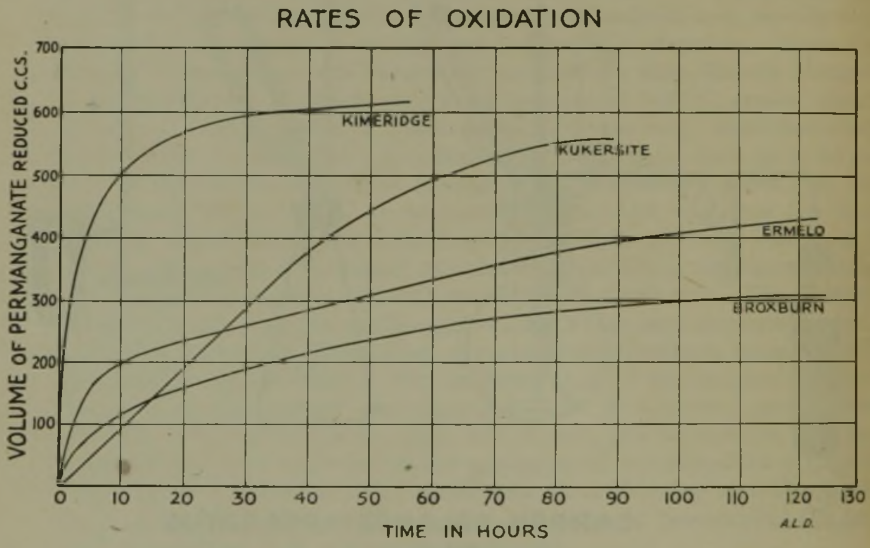


Fig. 2.

The rate of oxidation gradually decreased until it approximated to the rate of auto-decomposition of the permanganate (which had previously been determined under the conditions of the experiment); oxidation was then considered to be complete. Any carbon dioxide liberated during the reaction and remaining in the system was then swept into the absorption train, which was detached and weighed. The oxides of manganese and the residue from the shale were separated from the solution by sucking the latter off through a Jena-glass immersion filter, thoroughly washed with boiled-out distilled water, and the filtrate and washings were made up to 1 litre. The solids were then suspended in water, the oxides of manganese dissolved by means of sulphur dioxide, the residue was filtered off, washed, and dried, and the amount of unoxidised carbon determined by combustion.

The percentages of the original carbon oxidized to carbon dioxide, steam-volatile acids, oxalic acid, and non-volatile acids were estimated as follows. The carbon dioxide was determined by acidifying 100 ml. of the solution with dilute sulphuric acid and sweeping the CO_2 into a weighed absorption train; the resulting acid solution was steam-distilled to obtain the steam-volatile acids, which were titrated by standard alkali and calculated to acetic acid. Oxalic acid was estimated by precipitation as calcium oxalate and subsequent titration with $N/10$ potassium permanganate. The non-volatile acids were determined by neutralizing 100 ml. of solution, evaporating to dryness on a steam-bath, the carbon in the residue being determined by combustion. These acids were partly benzenoid and partly straight-chain.

The very marked differences in the behaviour of different kerogens to this method of oxidation was at once apparent from the variation in the rates at which the permanganate was reduced. Fig. 2 shows the volume–

TABLE I.

Analytical Data on the Samples Examined.

	Kimeridge Kerogen Shale.	Ermelo Algal Shale.	Estonian Algal Limestone.	Amherst Kerogen Shale.	Kohat Kerogen Shale.	Scottish Kerogen Shales.		
						Broxburn Main.	Middle Dunnet.	Pumpherston.
				Proximate Composition.				
Kerogen	59·25	53·65	52·0	53·05	11·85	26·0	16·25	18·2
Clay	16·6	31·3	9·25	24·55	41·95	43·6	45·8	45·5
Excess silica	12·35	11·3	5·75	12·65	8·0	10·7	20·7	19·75
Carbonates of calcium	1·35	0·5	26·95	0·1	20·3	1·9	6·8	4·9
„ magnesium			—		7·35	1·95		3·5
„ iron			—		3·3	9·7		1·9
Gypsum	3·5	0·1	0·5	0·9	0·45	0·3	0·1	Trace
Pyrite	1·9	0·95	2·0	0·9	—	1·3	0·5	2·0
Ferric oxide	2·35	—	—	2·6	—	—	6·05	2·2
Balance	2·7	2·2	—	3·55	6·8	—	3·8	2·2
				Composition of Kerogen.				
Carbon, %	68·98	79·75	77·3	77·46	72·58	80·41	78·63	80·02
Hydrogen, %	7·10	7·82	8·65	11·08	8·11	8·67	8·17	7·65
Nitrogen, %	1·38	1·56	0·2	1·24	1·34	2·32	2·65	2·30
Sulphur, %	8·83	1·22	1·45	0·80	0·81	0·10	1·23	0·61
Oxygen (diff.), %	13·71	9·65	12·4	9·42	17·16	8·58	9·32	9·42
Oil yield,* %	25·5	16·8	—	34·3	4·9	13·6	7·9	8·6
	From the richest of the four seams near Kimeridge, Upper Jurassic.	From a bore-hole core, Mooifontein No. 287. Supplied by Dr. P. E. Hall of the Fuel Research Institute, Pretoria. Permo-Carboniferous.	Weathered sample from an outcrop at Kohtla. Ordovician.	Collected by Dr. Colter from 1 mile due east of Forest Post 63, Htichera sheet, Amherst, Burma. Middle Tertiary.	Collected by Dr. Coulson from an outcrop near Kharak (Kark), N.W.F.P., India. Considered to be Lower Tertiary, probably Eocene.	Hopetown. Rich sample from Lodgment Dook, Eastside, Main Haulage Road. Seam 5 ft. 6 ins. thick, 504 ft. below surface.	Westwood Pit. South side of West Main Incline. Seam 9 ft. thick, 820 ft. below surface.	No. 3 Mine, Duddington. From Plain Shale Seam, No. 23 Level, No. 9 Dook. Seam 5 ft. 1 in. thick, 195 ft. below surface. Samples supplied by Scottish Oils, Ltd.

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* Gray–King Assay.

time curves for a number of samples. Broadly, it was found that the slower the initial rate of oxidation, the smaller was the percentage of carbon converted to soluble products.

The general analytical data for the eight samples of kerogen rocks which have been examined by the "carbon-balance" method of oxidation are given in Table I, and the results are shown in Tables II to IV.

Kimeridge Kerogen Shale, Dorset (Table II).—This was the first shale to be examined; four carbon balances were obtained, the first before the modification of the apparatus for maintaining the concentration of the solution constant was introduced. The spent permanganate solution therefore diluted the liquor, resulting in less drastic conditions than obtained in subsequent experiments; this was equivalent to a shorter time of oxidation. Two balances were carried out under the standard conditions, and the results serve to show the reproducibility of the results. Practically complete oxidation was secured, but in achieving this a portion of the higher acids formed in the earlier stages of the oxidation were further oxidized to carbon dioxide and oxalic acid. In researches on the permanganate oxidation of coals,[19] it has been shown that with the occasional exception of small quantities of succinic acid, the non-volatile acids were entirely benzene–carboxylic acids, and that the percentage of these acids and the other oxidation products steadily increased as the carbon was progressively attacked. Further, work on the permanganate oxidation of chemically pure acids [20] has shown that whereas benzene–carboxylic acids were not attacked, straight-chain acids were oxidized

TABLE II.

Carbon Balances on Kimeridge Kerogen Shale.

	1.	2.	3.	4.
		"Standard" conditions.		Kerogen at 3·3% mineral matter.
Percentage carbon as:				
Carbonic anhydride	47·97	49·76	47·78	51·20
Acetic acid	3·10	8·32	9·57	8·52
Oxalic acid	24·24	30·95	30·58	24·88
Non-volatile, non-oxalic acids	19·73	10·53	9·37	13·62
Total C in products	95·04	99·56	97·38	98·22
Unoxidized	4·45	0·64	1·45	0·84
Total	99·49	100·20	98·83	99·06
Distribution of Oxidized Carbon.				
Carbonic anhydride	50·5	50·0	49·0	52·1
Acetic acid	3·2	8·4	10·0	8·7
Oxalic acid	25·5	31·1	31·4	25·3
Non-volatile, non-oxalic acids	20·8	10·5	9·6	13·9
Total	100·0	100·0	100·0	100·0
Oxidation time, hrs.	54	57	58	30
Ratio $KMnO_4/C$	17·1	18·4	19·0	19·0

fairly readily to carbon dioxide and oxalic acid. It must therefore be concluded that a considerable proportion of the non-volatile, non-oxalic acids formed in the initial oxidation of the Kimeridge kerogen shale are of a type not produced from coals, and the percentage of carbon oxidized to benzenoid acids cannot exceed 10.

A sample of Kimeridge kerogen (the mineral content of which had been reduced to 3·32 per cent.) was oxidized, and the rate of reaction was found to be nearly double that of the untreated samples. In 30 hours over 99 per cent. of the carbon was converted into soluble products; the solution was found to contain an appreciably higher percentage of non-volatile, non-oxalic acids. This presumably is explicable by the shorter time of oxidation having been insufficient for the further oxidation of all the straight-chain acids which were first formed.

Since the percentage of sulphur in Kimeridge kerogen is very high (8·83), the solution from the carbon balance oxidation was examined for sulphur compounds, and it was found that the whole of the organic sulphur had been oxidized to SO_3.

Ermelo Algal Shale, South Africa (Table III).—This material is entirely different, both in general appearance and microscopic structure, from the Kimeridge kerogen shale. Unlike the Kimeridge, the rate of oxidation was very slow, and although at the end of 32 hours the rate of reduction of permanganate was about equal to its rate of auto-decomposition, analyses showed that not more than 50 per cent. of the carbon had been

TABLE III.

Carbon Balances on Ermelo Algal Shale.

	1.	2.	3.		Total.
			i.	ii.	
			Stage oxidation.		
Percentage carbon as :					
Carbonic anhydride . . .	19·48	30·68	25·72	11·36	37·08
Acetic acid	6·12	5·12	3·57	3·18	6·75
Oxalic acid	0·77	13·24	9·19	2·97	12·16
Non-volatile, non-oxalic acids .	28·81	17·19	21·38	2·15	23·55
Total C in products . . .	55·18	66·23	59·86	19·66	79·52
Unoxidized carbon . . .	44·82*	34·19	40·14*	20·77	20·77
Total	100·00	100·42	—	—	100·29
Distribution of Oxidized Carbon.					
Carbonic anhydride . . .	35·2	46·3	43·0	57·8	46·6
Acetic acid	11·1	7·7	6·0	16·2	8·5
Oxalic acid	1·4	20·0	15·3	15·1	15·3
Non-volatile, non-oxalic acids .	52·2	26·0	37·7	10·9	29·9
Total	100·0	100·0	100·0	100·0	100·0
Oxidation time, hrs. . . .	32	145	50	75	125
Ratio $KMnO_4/C$ . . .	7·1	13·2	—	—	12·1

* Unoxidized carbon obtained by difference.

converted into soluble products. The most interesting feature of this balance is the very small percentage of carbon appearing as oxalic acid, whilst at the same time the total amount of non-volatile acids was very high, over 50 per cent. of the oxidized carbon being thus accounted for. In the second oxidation the run was continued until the amount of permanganate reduced was equal to that required for complete oxidation, as calculated from the first experiment; the total time was 145 hours. Examination of the resulting solution, however, showed that the percentage of carbon converted into soluble products had risen from 55 to only 66. The additional permanganate had therefore been largely employed in the further oxidation of non-volatile, non-oxalic acids formed in the earlier stages of the reaction to carbon dioxide and oxalic acid. The proportion of acids thus attacked is readily seen from the distribution of carbon in the oxidation products; the distribution of oxidized carbon is very similar to that obtained from the oxidation of immature coals such as brown coals and lignites. The percentage of carbon as non-volatile, non-oxalic acids—namely, 17, or 26 per cent. of the oxidized carbon—is much higher than that obtained from the Kimeridge shale. In view of the very long time of oxidation, and the very slow rate of reduction of permanganate during the final 20 hours, it may be concluded that these acids were benzenoid, since the aliphatic acids oxidize fairly rapidly.

In an attempt to obtain more complete oxidation, a sample of the algal shale was oxidized in two stages; after 50 hours the solution was sucked off via a Jena-glass immersion filter, a fresh volume of potassium hydroxide solution was added, and the oxidation was continued for a further 75 hours. The two solutions were worked up separately, with the results shown in columns 3 (i) and 3 (ii) of Table III; the former may be considered as an ordinary carbon balance intermediate between Nos. 1 and 2. This stage-oxidation was successful in reducing the amount of carbon in the residue to 20 per cent., the reduction of permanganate by preferential attack of the primary oxidation products having been prevented. Oxidation in the second stage proceeded very slowly, the kerogen residue being more resistant to attack than bituminous coals or anthracites; examination of the distribution of the 20 per cent. carbon oxidized in the second stage indicates that only a small part of the structure could be benzenoid.

Table IV summarizes the results of carbon balance oxidations of three widely differing types of kerogen rocks; each was much more resistant to oxidation than Kimeridge kerogen shale, and in no case was oxidation complete. A striking feature of the carbon balance on the Amherst shale is that, apart from carbon dioxide, only 7 per cent. of the carbon was oxidized to acids other than oxalic. The Amherst kerogen is distinguished by containing a higher percentage of hydrogen than any other kerogen examined, and is therefore more highly saturated. Similarly, nearly all the oxidized carbon of the Estonian algal limestone (kukersite) appeared either as carbon dioxide or as oxalic acid, only 4 per cent. being converted into non-volatile acids other than oxalic. The carbon balance on the Kohat kerogen shale resembles those on Kimeridge shale; although the rate of oxidation was much less and 7 per cent. of the carbon remained unoxidized, the general distribution of carbon in the products was very similar.

TABLE IV.

Carbon Balances on Amherst and Kohat Kerogen Shales and Estonian Algal Limestone.

	Amherst.	Kohat.	Estonian.
Percentage carbon as :			
Carbonic anhydride	40·88	42·72	50·64
Acetic acid	2·92	3·98	8·05
Oxalic acid	27·24	31·48	28·55
Non-volatile, non-oxalic acids . .	3·99	14·60	3·82
Total C in products	75·03	92·78	91·06
Unoxidized carbon	25·08	7·07	8·69
Total	100·11	99·85	99·75
Distribution of Carbon in the Oxidation Products.			
Carbonic anhydride	54·5	46·1	55·6
Acetic acid	3·8	4·3	8·8
Oxalic acid	36·3	33·9	31·4
Non-volatile, non-oxalic acids . .	5·4	16·4	4·2
Total	100·0	100·0	100·0
Oxidation time, hrs. . . .	132	125	115
Ratio $KMnO_4/C$	22·1	17·4	19·3

Scottish Kerogen Shales (Table V).—Three samples were examined, and also a sample of substantially ash-free (mineral matter 1·12 per cent.)

TABLE V.

Carbon Balances on Scottish Kerogen Shales.

	Broxburn Main.	Middle Dunnet.	Pumpherston.	
			Shale.	Kerogen.
Percentage carbon as :				
Carbonic anhydride . .	30·41	28·14	21·03	21·34
Acetic acid . . .	3·57	5·09	4·46	3·81
Oxalic acid . . .	11·67	14·92	10·68	9·64
Benzenoid acids . . .	10·78	13·72	13·08	13·95
Total C in products . .	56·43	61·87	49·25	48·74
Unoxidized carbon . .	43·38	38·92	51·35	51·26 *
Total . . .	99·81	100·79	100·60	100·00
Distribution of Carbon in Oxidation Products.				
Carbonic anhydride . .	53·9	45·5	42·7	43·8
Acetic acid . . .	6·3	8·2	9·1	7·8
Oxalic acid . . .	20·7	24·1	21·7	19·8
Benzenoid acids . . .	19·1	22·2	26·5	28·6
Total . . .	100·0	100·0	100·0	100·0
Time of oxidation, hrs. .	190	120	125	75
Ratio $KMnO_4/C$ . . .	10·0	12·7	9·3	7·7

* Unoxidized carbon obtained by difference.

kerogen. The rates of oxidation were very low, and not more than 50–60 per cent. of the carbon was converted into soluble products. Considered together, the four carbon balances closely resemble one another, the most marked difference being the greater percentage of carbon dioxide from the Broxburn Main, which may be correlated with the much longer reaction time. Although the Pumpherston kerogen was attacked considerably more rapidly than the untreated shale, the two carbon balances show close agreement, indicating that the de-ashing process had little or no chemical effect on the kerogen. In view of the very long periods of oxidation and the almost negligible rate of reduction of permanganate in the later stages, it is probable that the non-volatile acids, other than oxalic, were almost entirely benzenoid, resembling those from bituminous coals. The percentage distribution of oxidized carbon in the Scottish shales is very similar to that obtained from a number of Irish peats as reported by W. A. Bone and others,[21] although with the peats the rate of oxidation was faster and complete oxidation was obtained.

Permanganate Bulk-Oxidations.—While the carbon-balance method of oxidation gives valuable information as to the quantitative distribution of the oxidized carbon between carbon dioxide, steam-volatile, oxalic, and non-volatile, non-oxalic acids, only very general conclusions as to the nature of the acids can be reached, and it is therefore necessary to carry out bulk oxidations to prepare the non-volatile and volatile acids in sufficiently large quantities to enable them to be separated and identified.

The quantity of material taken for a bulk oxidation depended on the percentage of kerogen in the sample and the yields of the acids to be obtained; this information was derived from the results of the carbon balance. The quantity required was generally from 500 to 1000 gms. The finely divided rock was suspended in about 10 litres of water, containing sufficient potassium hydroxide to give a ratio of alkali/kerogen of about 1·6; the liquid was gently boiled, and successive small quantities of solid permanganate were added to the solution, which was well stirred, the volume being maintained by the addition of boiling distilled water from time to time. When the rate of reduction of permanganate had fallen to about 1 gm. per hour, boiling was discontinued, the solution was filtered off, and the large quantities of oxides of manganese and residue from the shale were washed by boiling with distilled water. The combined filtrate and washings were evaporated to a known volume, usually 4 litres, and the distribution of carbon in the oxidized products was determined on a small fraction.

The bulk of the solution was acidified by the addition of the requisite quantity of concentrated hydrochloric acid, and the carbon dioxide was expelled by boiling under a reflux condenser. The acid liquor was next steam-distilled to separate the volatile acids, between 3 and 5 litres of distillate being collected; the acids were neutralized with sodium hydroxide and recovered as sodium salts by evaporating the solution to dryness. The oxalic acid was separated from the liquor in the distillation flask by precipitating it as calcium oxalate, thus giving a filtrate containing only non-volatile, non-oxalic acids and potassium chloride, from which the acids were obtained by evaporating to dryness and extracting successively with ether and acetone in a Soxhlet apparatus. By this means two mixtures of crude acids were obtained, the compositions and equivalents of which could be determined.

The mixtures of crude acids were converted into their methyl esters by one or other of two methods. The ether-soluble acids were redissolved in ether and treated with diazomethane, formed *in situ* by the action of sodium hydroxide on nitrosomethyl urea, and after washing with sodium carbonate solution and distilled water the ether was distilled off, leaving a mixture of methyl esters. The acids which had been extracted with acetone were treated with ammonia of s.g. 0·88, maintained at 0° C., whereby benzene hexacarboxylic acid was separated as insoluble ammonium mellitate. The ammoniacal solution of the salts of the lower acids was boiled until neutral, and the acids were precipitated as their silver salts by adding a boiling solution of silver nitrate. The silver salts were filtered off immediately, washed, dried, and converted into the methyl esters by boiling under reflux with methyl iodide in dry ether. The insoluble ammonium mellitate was dissolved in water (above 0° C.), methylated in the same way, and the ester was recrystallized from absolute alcohol. Subsequent treatment of the methyl esters varied with each oxidation according to their quantity and character.

Four samples of kerogen rocks, Kimeridge, Broxburn Main, Ermelo, and Estonian, were investigated by bulk oxidation. Brief details are given below and the results are summarized in Table VI.

TABLE VI.

Acids Obtained by the Alkaline Permanganate Oxidation of Kimeridge, Estonian, Broxburn, and Ermelo Kerogen Rocks.

Kimeridge Kerogen Shale.	Estonian Algal Limestone.	Broxburn Main Kerogen Shale.	Ermelo Algal Shale.
CO_2.	CO_2.	CO_2.	CO_2.
Acetic acid.	Acetic acid.	Acetic acid.	Acetic acid.
Oxalic acid.	Oxalic acid.	Oxalic acid.	Oxalic acid.
Succinic acid.	—	—	—
Benzoic acid.	—	Benzoic acid.	—
o-Phthalic acid.	—	—	—
p-Phthalic acid.	—	—	—
—	—	Benzene pentacarboxylic acid.	Benzene pentacarboxylic acid.
Mellitic acid.	—	Mellitic acid.	Mellitic acid.

Kimeridge Kerogen Shale, Dorset.—1000 gms. of sample were oxidized in two equal portions, 3500 gms. permanganate being added to each over a period of 25 hours. The action was very vigorous, and got out of hand in the early stages unless external heating was discontinued. Altogether 50 gms. of crude non-volatile, non-oxalic acids were obtained, approximately half of which were soluble in ether, the remainder in acetone. Their composition was C = 40·2; H = 5·3; O = 54·5 per cent., which corresponds closely with that of succinic acid—namely, C = 40·67, H = 5·08, O = 54·25 per cent. The mixture of esters was a colourless, mobile liquid; on standing, no crystals separated, so the esters were fractionally distilled under a pressure of 1–4 mm. of mercury, six fractions boiling between 35° and 140° C. being collected. The higher fractions were pale yellow, viscous liquids from which some methyl esters crystallized, whilst the lower fractions were colourless mobile liquids which could not be induced to crystallize. These fractions were hydrolyzed by boiling under reflux with 10 per cent. baryta, the solution was evaporated to dryness, the residue was acidified, and the acids were extracted with dry ether. Succinic acid preponderated in the lower fractions, and *o*-phthalic acid was also identified, whilst the methyl esters of *o*- and *p*-phthalic acids were identified in the higher fractions. From the acids extracted with acetone, the neutral methyl ester of benzene hexa-carboxylic acid (mellitic acid) was isolated.

A small quantity of white crystalline solid separated from the steam-distillate, the crystals being small plates, melting at 118° C. The only sparingly soluble acid which is volatile in steam is benzoic; the identity of the acid was confirmed by preparing the *p*-bromophenacyl ester, which melted at 119° C., thus proving benzoic acid. This observation acquires additional interest, since while the other acids recorded have been obtained from the oxidation of coal, *benzoic acid has never been found among the products.* After evaporating the neutralized steam distillate to dryness, the presence of acetic acid was confirmed by the formation of its *p*-toluidide (m.pt. 145° C.).

Estonian Algal Limestone.—300 gms. of a partly de-ashed sample were oxidized during 62 hours, 3455 gms. of potassium permanganate being reduced. Only acetic acid was identified in the steam-volatile acids, and no solid material separated from the distillate. The methyl esters of the non-volatile, non-oxalic acids were obtained as a pale yellow liquid; the quantity was too small for convenient fractionation, and since no crystalline material separated, the esters were hydrolyzed with baryta. Succinic acid was apparently present, but was not definitely identified, and no indications of other acids were obtained. Thus with the Estonian algal limestone the only oxidation products proved were carbon dioxide, acetic acid, and oxalic acid. No evidence of the presence of benzenoid acids was obtained.

Broxburn Main Kerogen Shale.—This was taken as being representative of the Scottish kerogen shales; 1000 gms. of the dry shale were oxidized with 2500 gms. of permanganate over a period of 70 hours. The carbon balance oxidations of these shales showed that a large proportion of the carbon remained unoxidized; determinations of the carbon remaining in the residue from the bulk oxidation showed that only 35 per cent. of the carbon had been converted into soluble products. The organic residue was investigated further by taking a representative sample, dissolving the oxides of manganese by means of sulphur dioxide, partly removing the mineral matter by acid de-ashing; the residue was then analysed. The composition found was $C = 77{\cdot}15$, $H = 9{\cdot}20$, $O = 13{\cdot}65$, which showed that the residue was an intermediate product formed by the oxidation of the original kerogen, but which was still insoluble in aqueous alkali, and therefore not acidic. The low ratio of carbon to hydrogen (8·4) suggests a non-benzenoid character.

During the steam-distillation for removal of volatile acids a small quantity of benzoic acid, in the form of white crystalline plates melting at 120° C., separated from the distillate, but the acidity of the distillate was due mainly to acetic acid.

The residual solution contained 54 gms. of oxalic acid, which was precipitated with the equivalent quantity of calcium acetate. By treating the acids with ammonia of s.g. 0·88 at 0° C., about 10 gms. of ammonium mellitate were obtained, part of which was converted into the neutral methyl ester (m.pt. 185° C.) via the silver salt. The remainder of the acids was taken up with ether and methylated, using diazomethane; on distilling off the solvent, a considerable portion of the esters crystallized at once. These crystalline esters were found to be largely the ester of benzene pentacarboxylic acid, forming small, pale yellow needles melting at 145° C., and a small amount of the ester of benzene hexacarboxylic acid. The quantity of liquid esters remaining was small, hence esters with low boiling points, such as methyl succinate and methyl phthalate, could have been present only in small quantities. Both the benzene pentacarboxylic and the benzene hexacarboxylic acid were present in considerable quantity, the former apparently preponderating, equivalent to about 5–10 per cent. of the kerogen.

Ermelo Algal Shale.—Study of the carbon balance oxidations of this shale showed that during the early stages of the reaction considerable proportions of non-volatile, non-oxalic acids were formed, which were subsequently further oxidized to carbon dioxide and oxalic acid. Hence, with a view to obtaining as high a percentage of these acids as possible, the bulk oxidation was carried out for only 15 hours; 500 gms. of dry shale were used, and the total quantity of permanganate reduced amounted to 2000 gms.

During the steam-distillation for separation of volatile acids, no benzoic acid crystallized, and only acetic acid could be detected in the distillate.

Analysis of a sample of the solution showed that 45 per cent. of the carbon had been oxidized to non-volatile acids, 10 per cent. being oxalic acid; this was removed as calcium oxalate and the remaining acids as ether- and acetone-extracts. The ether-soluble acids, approximately 40 gms., were redissolved and methylated with diazomethane. On removal of the ether, the esters deposited crystals, the mother-liquor was decanted off, the crystals were recrystallized from alcohol and the neutral esters of benzene pentacarboxylic acids identified. A considerable proportion of the esters remained as a colourless liquid, but no lower acids could be identified.

General Discussion and Conclusions.

Sedimentary deposits containing organic matter capable of yielding oil on distillation are widely distributed over the earth's surface, and are found in all geological formations, with the possible exception of the Pre-Cambrian. The majority were laid down in fresh or brackish water, although some occur in marine horizons. Microscopic examination shows that vegetable matter contributed largely as the source material of kerogen, some of the deposits (so far as the organic constituents are concerned) being made up almost exclusively of one particular plant material (such as algæ in the famous Torbanehill deposit, or spores in the Tasmanian spore-shale); the majority, on the other hand, exhibit an almost irresolvable mass of macerated plant debris with but few spores and algæ.

Although the presence of numerous animal remains in some kerogen shales, such as the Kimeridge shale, has led several observers to postulate an animal origin for the organic matter, such evidence as is available is in favour of the view that, as in the coals, vegetable remains formed practically exclusively the parent material of the organic matter, and animal remains played little or no part. Thus, the kerogen shales of the Scottish Lothians, which occur in the Lower Carboniferous, were derived from plants similar to those which gave rise to the great bituminous coalfields of Britain. Further, there is no reason to suppose that the proximate plant constituents of previous eras—namely, the cellulose, lignins, proteins, fats, waxes, and essential oils—differed in chemical constitution from those which form modern plants, although considerable variation in the relative proportions of those constituents may, doubtless, have occurred. There was therefore, as far as is known, little difference in the chemical characteristics of the parent materials of the members of the peat-to-anthracite series and of the kerogen rocks of different ages; their well-marked differences must have been in large measure due to the history of the deposits during and after their formation.

Excluding a few isolated and comparatively small deposits, such as those of Torbanehill and Joadja Creek, one very marked difference between kerogen rocks and coals is the much higher percentage of inorganic matter in the former. On removal of the organic matter by incineration, the mineral residue from coals falls to a fine powder, whereas that from the kerogen shales retains its original shape and size. The structural strength of the coals is therefore due to the highly compressed state of the organic material, whereas in the kerogen rocks the large content of inorganic matter provides the structural strength, and it may well be that the effect of pressure on the organic matter, in so far as this has contributed to the maturing of coals, may have been modified in the kerogen rocks.

The plant remains from which coals were formed was frequently accumulated *in situ*; kerogen rocks, on the other hand, are usually of drift origin, the vegetable debris being water-borne and deposited in shallow lakes and estuaries. During transportation, classification of the vegetable matter would take place, and, concomitantly, much of the less resistant constituents would probably be destroyed, leaving the more resistant materials to form the source material of the kerogen. On the other hand, in the formation of coals all the proximate constituents of the plants would be present.

As already pointed out, the determination of the empirical composition of kerogens presents certain difficulties, and only a limited number of results are available. Such data as there are indicate that kerogens have a higher content of hydrogen than members of the peat-to-anthracite series; the hydrogen in kerogen usually ranges from 8 to 12 per cent. as compared with from 2·5 to 7 per cent. in anthracite and peat, respectively. Some coals have abnormally high hydrogen, which, however, is still lower than the hydrogen in kerogen, and microscopic examination shows that these coals contain unusually large numbers of spores. Although spore cases have been detected in many kerogen rocks, their numbers are usually small; they are certainly not present to any appreciable extent in Ermelo algal shale, Torbanehill, or Newnes algal rocks, the higher hydrogen contents of which may be due to the presence of algæ which are not found in bituminous coals. According to M. D. Zalessky,[22] the organic matter of the Balkash sapropelite (presumably botyrococcus) contains C = 73·76, H = 10·61, and O = 13·74. Further, Petrie [12] has reported that in a sample of Newnes algal shale from Joadja Creek, yielding only 6·55 per cent. of ash, the kerogen of which was estimated to consist of 90 per cent. of algæ, contained C = 79·75, H = 12·76, O = 5·81 per cent. These, however, are only isolated examples; in the majority of samples, including the Scottish, Kimeridge, Nevada, Kohat, Amherst, and St. Hilaire kerogen shales, very few algæ can be detected, the greater part of the organic matter being made up of tiny, partly carbonized fragments of plant remains and macerated vegetable debris. Furthermore, so typical an algal material as the Ermelo algal shale, the kerogen of which probably consists of some 50 per cent. of algæ, is decidedly low in hydrogen, the kerogen containing only 7·85 per cent. It seems therefore that either the algal material in this shale is associated with much debris which is low in hydrogen, or, alternatively, that the environmental conditions during and subsequent to deposition have resulted in a greater loss of hydrogen (probably as methane and/or water) than has occurred in shales such as that of Newnes. In this connection it may be mentioned that David White [23] suggested in 1925 that there were three separate "maturing" lines, one each for the humic coals, the cannels, and the alga bogheads, which merged into a common line in the semi-bituminous stage. In view of the paucity of evidence as to the true compositions of a sufficient number of kerogens, it would be premature to accept this suggestion; the available evidence appears to be adverse. What data there are suggest that, as in the peat-to-coal series, it is environment rather than original material which decides the characteristics of the final product.

In addition to carbon, hydrogen, and oxygen, nitrogen and sulphur are found in all kerogens, but how these elements are combined is at present unknown. There is also strong presumptive evidence that in some samples a small percentage of iron is combined in the organic matter.

Constitution.—A summary of the results of the alkaline permanganate oxidation of a number of kerogen rocks, together with data obtained from the oxidation of lignin and members of the peat-to-anthracite series (for comparison), is given in Table VII. It can be seen that, except for the Kimeridge shale, the kerogens were more resistant to oxidation than any of the coals other than the macroscopic constituent fusain. Practically complete oxidation (98–99 per cent.) of the coals was achieved in 50 hours, and even with anthracite, the most resistant type, 92 per cent. of the carbon had been converted into soluble products after 60 hours. In contrast to this, 43 per cent. of the carbon in Broxburn Main kerogen shale remained unoxidized after 190 hours. This failure to obtain anything like complete oxidation is partly due to the protective effect of the large proportion of mineral matter in most kerogen rocks, since carbon-balance oxidation on de-ashed samples showed that the rate of oxidation was nearly twice as fast. It should be noted that fusain showed great

TABLE VII.

Carbon-balance Oxidations.
Lignin, Peat-to-Anthracite Series [19] *and Fusain.*[24]

	Lignin.	Peats.	Brown Coals and Lignites.	Bituminous Coals.	Anthracite.	Fusain.
Percentage carbon as :						
Carbon dioxide	57–60	49–61	45–57	36–42	40	22
Oxalic acid	12–21	15–28	9–23	13–14	6	4·5
Acetic acid	2·5–6	2–5·5	3–7·5	1·5–4·5	2	0·5
Benzenoid acids	12–16	10–25	22–34	39–46	46	21
Unoxidized	—	—	—	—	8	52
Time required for oxidation, hrs.	Up to 50 or 60.					190

Kerogen Rocks.

	Kimeridge.	Kohat.	Estonian.	Amherst.	Ermelo.	Scottish.
Carbon dioxide	49	43	50	41	31	25
Oxalic acid	31	31	29	27	13	12
Acetic acid	8	4	8	3	5	4
Non-volatile, non-oxalic acids	11	15	4	4	17	3
Unoxidized	1	7	9	25	34	46
Time of oxidation, hrs.	56	125	115	132	145	125

resistance to oxidation, only about 50 per cent. of the carbon being attacked in 190 hours. There are, however, no other similarities between fusain and the kerogens; the distribution of carbon in the oxidation products is quite different, half the oxidized carbon from fusain appearing as benzenoid acids. Moreover, fusains are characterized by exceptionally low hydrogen contents as compared with the other macroscopic constituents of coals.

Considering the oxidations in detail, the Kimeridge kerogen was readily and completely oxidized; this ease of oxidation may perhaps be due to the high percentage of organic sulphur in the molecules. In the initial stages of the reaction some straight-chain acids are formed (succinic acid was isolated) which are subsequently further oxidized. Not more than 10 per cent. of the carbon is present as aromatic nuclei, the oxidation products including benzoic, *o*-phthalic, *p*-phthalic, and benzene hexacarboxylic acids, only the last being present in any quantity. The distribution of the carbon of the Kimeridge kerogen is similar to that of a number of Turraun peats examined at the Imperial College. There are, however, two important differences : (*a*) that a small quantity of benzoic acid was obtained from the kerogen, indicating the presence of simple aromatic nuclei, probably attached to side-chains, and (*b*) the greater part of the benzenoid acids consisted of benzene hexacarboxylic (mellitic) acid, whereas in the oxidation products from peat, benzene pentacarboxylic acid preponderated over mellitic acid.

Carbon-balance oxidations of Ermelo shale indicated that, although a considerable proportion of straight-chain acids was formed by the initial oxidation, these acids were subsequently decomposed, but there still remained some 17 per cent. of the carbon as non-volatile, non-oxalic acids. In view of the time of reaction and the comparative readiness with which the aliphatic acids are oxidized to carbon dioxide and oxalic acid, it is probable that the remaining acids were almost entirely benzenoid. From the bulk-oxidation, considerable amounts of benzene penta- and hexacarboxylic acids were isolated, and there was evidence of the presence of smaller quantities of less fully carboxylated benzenoid acids, although none were isolated. No benzoic acid was detected in the products of oxidation.

Whereas with the Kimeridge and Ermelo samples prolonged oxidation resulted in a decrease in the quantity of non-volatile acids other than oxalic, with Broxburn Main kerogen shale the reverse was observed. After an oxidation lasting 130 hours, 41 per cent. of the carbon was converted into soluble products, but only 0·5 per cent. was present as non-volatile, non-oxalic acids. On oxidizing a second sample for 190 hours, the percentage of these acids increased to 10·7 and the total carbon oxidized to 56·4 per cent. The carbon balances of the three Scottish samples show marked similarities; the distribution of the oxidized carbon among the products resembles that for brown coals and lignites, but large proportions of the Scottish kerogens remained unoxidized. Since it was possible to obtain almost complete oxidation of coals, it is suggested that certain kerogens contain one or more resistant constituents which are absent, or nearly so, from coals; microscopic examination suggests that the algæ may be the missing constituent, and subsequent experience on the oxidation of Newnes algal shale tends to confirm this suspicion. The oxidation products from Broxburn Main kerogen shale contained a considerable quantity of benzene hexacarboxylic acid, some pentacarboxylic acid and a trace of benzoic acid.

The oxidation of Estonian algal limestone was remarkable for the very small percentage of carbon oxidized to non-volatile acids other than oxalic; the identity of these acids could not be established; certainly, no ammonium mellitate could be separated by treating the crude acids with ammonia. Carbon balances indicated that a considerable quantity of non-volatile acids were formed in the earlier stages, but since these were further oxidized, they must have been succinic and other straight-chain acids. Only acetic acid was found in the steam distillate. These results are in agreement with the work published by P. N. Kogerman (*loc. cit.*), but the presence of mono- and di-basic fatty acids has not been confirmed.

No higher fatty acids than acetic were detected by Randall, Benger, and Groocock[20] in their examination of the oxidation products of more than fifty substances of known constitution, including hydrocarbons, aromatic hydrocarbons, aromatic substances containing a carbonyl group, aromatic carboxylic acids, heterocyclic compounds, ethers, and aldehydes. It should be noted that Kogerman's alkaline permanganate oxidation was carried out at 30° C., whereas in the authors' experiments the solution was boiled.

While no detailed conclusions can yet be reached as to the chemical constitution of kerogen, the following inferences may legitimately be made :—

(i) The constitutions of some kerogens resemble, broadly, the constitution of coal in that there is definite evidence of a benzenoid structure, which is, however, less pronounced than that in coal. This may arise from a similarity in the original materials from which the kerogens were formed.

(ii) Other kerogens (notably that of the Estonian algal limestone) differ in constitution from coal, in that there is no evidence of benzenoid structure. This may be correlated with a difference in the original debris from which the kerogen was formed, or from different environmental conditions during and subsequent to deposition. In the inorganic matter of the Estonian material, calcium carbonate preponderates over clayey matter, which may have profoundly influenced that course of bacterial attack in the early stages of formation of kerogen; the effect of this limestone environment may also have modified the course of the changes which took place after the blanketing of the original deposit beneath subsequently-formed strata.

(iii) There is evidence that certain kerogens contain two types of compound, one comparatively easily oxidizable by alkaline potassium permanganate, the other highly resistant to attack. It is evident that in dealing with these kerogens, which include those of the Scottish, Ermelo, and Amherst kerogen rocks, stage oxidation will be necessary; preliminary oxidation with alkaline permanganate must be followed by more vigorous attack with a view to converting the "refractory" carbon into soluble products.

Finally, the authors desire to express their thanks to Professor A. C. G. Egerton, F.R.S., for helpful criticism and his continued interest in the work, also the Department of Scientific and Industrial Research for a grant to one of us (A. L. D.) which enabled the work to be carried out.

Imperial College,
18*th July,* 1940.

References.

[1] McKee, R. H., and Goodwin, R. T., *Colorado School of Mines Quarterly*, 1923.
[2] Down, A. L., *J. Inst. Petrol.*, 1939, **25**, 230–237.
[3] Ralston, O. C., *U.S. Bureau of Mines, Tech. Pap.* 93, 1915.
[4] Hickling, G., *J. Inst. Fuel*, 1932, **5**, 326.
[5] Engler, C., *Die Chemie und Physik, des Erdöls*, 1913, **1**.
[6] McKee, R. H., and Lyder, E. E., *J. Ind. Eng. Chem.*, 1921, **13**, 613–618.
[7] Blackburn, C. O., *Colorado School of Mines Quarterly*, 1922, **17**, (4).
[8] Carlson, A. J., *Univ. of California Publications in Engineering*, 1937, **3**, 295–342.
[9] *J. Inst. Petrol.*, 1939, **25**, 817.
[10] McKee, R. H., "Oil Shales," Amer. Chem. Soc. Monograph, 1925.
[11] Smith, G. H., and Peutherer, W. B., "Proc. Conf. on Oil Shale and Cannel Coal," 1939, p. 315.
[12] Petrie, J. M., *J. Soc. chem. Ind.*, 1905, **24**, 996–1002.
[13] Jones, D. T., and Wheeler, R. V., *J. chem. Soc.*, 1914, **105**, 141, 2562; 1915, **107**, 1318; 1916, **109**, 708.

[14] A. Pictet and M. Bouvier, *Compt. rend.*, 1913, **157**, 1436; 1915, **160**, 629.

[15] Hellsing, G., and Troedssen, J. S. W., *Ark. Kem. Min. Geol.*, 1925, **9**, [22], 1-12; *Chem. Zentr.*, 1926, I, 2064.

[16] Holmberg, B., *Iva*, 1930, pp. 26–34.

[17] Robertson, J. B., *Proc. Roy. Soc. Edin.*, 1914, **34**.

[18] Kogerman, P. N., "Proc. Conf. on Oil Shale and Cannel Coal," 1939, pp. 115–123.

[19] Bone, W. A., and Himus, G. W., "Coal: Its Constitution and Uses," 1936, pp. 181–193.

[20] Randall, R. B., Benger, M. B., and Groocock, C. M., *Proc. Roy. Soc.*, (**A**), 1938, **165**, 432–452.

[21] Bone, W. A., Parsons, L. G. B., Sapiro, R. H., and Groocock, C. M., *ibid.*, 1935, **148**, 492–522.

[22] Zalessky, M. D., *Brennst. Chemie*, 1925, **6**, 365–369; 1926, **7**, 35–37.

[23] White, David, *Trans. Amer. Inst. Min. and Met. Eng.*, 1925.

[24] Bone, W. A., and Bard, B. J. A., *Proc. Roy. Soc.*, (**A**), 1937, **162**, 495–501.

THE COMPOSITION OF THE ASH OF TASMANIAN SPORE SHALE.

By G. W. HIMUS and S. RUDRAKANCHANA.

IN the course of the discussion on the paper by Down and Himus on the "Classification of Oil Shales and Cannel Coals" (*J. Inst. Petrol.*, 1940, **26**, 340), Mr. J. McConnell Saunders wrote, ". . . 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 material."

In their reply (p. 347) the authors agreed that ". . . it is fully realized that the nature of the inorganic matter and its relation to the kerogen require more detailed study . . .", and, in fact, this study is being carried on in a small way at the present time, and the suggestion of Mr. McConnell Saunders has been followed up with a view to ascertaining whether evidence of the lycopodian origin of the spores in Tasmanite could be substantiated by an examination of their ash.

To this end, a sample of Tasmanite was divided into fractions of different specific gravity by means of mixtures of bromoform, carbon tetrachloride, and benzene, with a view to concentrating the mineral matter in the sinks and the organic matter in the floats. By suitable treatment on these lines, concentrates yielding as little as 4·65 per cent and as much as 90·4 per cent of ash were obtained, together with a number of intermediate fractions, and the ashes left on incineration of several of these products were analysed. The results are tabulated below.

COMPOSITIONS OF THE ASHES FROM FRACTIONS OF TASMANIAN SPORE SHALE.

Ash, %.	4·65	83·36	88·30	90·4
	%	%	%	%
SiO_2 . . .	71·05	75·35	74·75	74·9
TiO_2. . . .	0·85	0·85	0·9	0·8
Fe_2O_3 and MnO .	6·45	5·4	5·8	5·95
Al_2O_3 . . .	11·7	12·1	12·05	11·85
CaO . . .	1·5	1·25	1·5	1·0
MgO . . .	2·55	1·75	1·8	1·65
SO_3	0·85	0·7	0·75	0·7

The results of the analysis of the ash from the de-ashed Tasmanite are probably somewhat (though not seriously) less accurate than the others, since the quantity of ash available was very small.

The table shows that the compositions of the ashes are surprisingly similar: whether the original material consisted largely of spores of nearly pure mineral matter made very little difference to the composition of the ash. It is quite evident that there was no tendency to concentrate one element of the inorganic matter at the expense of any of the others during the process of de-ashing. The simple method suggested by McConnell Saunders of using the content of alumina as a criterion of the lycopodian nature of the spores in Tasmanite is therefore unsatisfactory. At the same time, it should be pointed out that the evidence provided by an examination of the products of the nitration of the spores (E. E. Kurth and L. J. Rogers. "Oil Shale and Cannel Coal," 1938, p. 201) that the spores may be derived from lycopods, is not called into question.

An interesting point which arose in the preparation of low-ash Tasmanite is referred to here because it may explain a difficulty which may be met with in de-ashing similar materials. It was found that better separation could be effected and a better yield of concentrated spores giving a lower ash could be obtained if the fine-grinding of the material were carried out by hand than if mechanical grinding were employed. When the sample was ground to *minus* 90-mesh (I.M.M.) in a steel end-runner mill, the yield of floats was lower and the ash on the floats at a given specific gravity was greater than if reduction had been carried out by hand. The explanation seems to be that sufficient heat was produced in mechanical grinding to cause incipient softening of the organic matter, which, coupled with the greater pressure in the end-runner mill, caused the finely-divided fragments of the spores to adhere to the fine particles of mineral matter, forming tiny compound particles which were sufficiently small to pass a 90-mesh screen. With the lower rate of grinding and the lower pressure obtaining when hand-grinding was practised, no such softening with consequent sticking together of organic and inorganic matter took place.

Imperial College.
12*th October,* 1941.

OBITUARY.

WILLIAM REGINALD ORMANDY.

W. R. Ormandy was a Founder Member of the Institute of Petroleum, and served on the Council from 1919 to 1929. He was elected a Vice-President in 1926.

To those who had the honour of personal friendship the loss of Ormandy leaves a gap impossible to fill and a loss that is irreplaceable, for he was not only a man of science with many facets of interest, but also a very human and kindly personality. He was born in 1870, educated at Wigan Grammar School, and Owen's College, Manchester, where he graduated, becoming Bishop Berkeley Fellow in 1890. He took his Doctorate in 1894 after three years' work at Tubingen. For four years he taught at the Crewkerne Grammar School and at the Technical School, St. Helens. These five years probably helped to formalize Ormandy's mind—he always remained a teacher—informative in matter and impressive in diction, with a wide range of reading and knowledge and no little share of wisdom.

He had an astonishingly wide range of professional interests. He was research chemist to Messrs. Pilkington, Ltd., to the St. Helens Cable & Rubber Works, to Joseph Crosfield's of Warrington, and eventually head of a well-known firm of Consultants in Manchester and London.

Being a man who believed his fellow-creatures to be as interesting as chemical entities he rapidly found scope for his abundant energy in a multiplicity of societies. He served on the Council of the Institute of Petroleum for many years, on the Council of the Institution of Chemical Engineers, of the Institute of Metals and of the Ceramic Society. He was a Past-President of the Institute of Automobile Engineers, and Chairman of the Chemical Engineering Group of the Society of Chemical Industry.

He was specially interested in liquid and gaseous fuels, and perhaps it is not generally known that he was intimately concerned with the earliest work on hydrogenation of coal and oil carried out by Bergius. In point of fact he pioneered the development of this subject in Great Britain.

In no less degree was he active in insisting on the value of alcohol as a component of motor spirit, and in fact was Consultant to the Distiller's Company for many years.

One of his outstanding researches was concerned with the action of olefines on sulphuric acid. In this work he showed that a saturated hydrocarbon was produced. This statement brought about a storm of controversy, but subsequent investigation showed that Ormandy was right. Is it too much to say that here he was the lineal ancestor of modern processes of hydro-polymerization ?

But reverting to Ormandy the man, those who knew him best carry pleasant memories of an outstanding personality, a controversialist brilliant in speech and repartee, kindly and tolerant in his dealings with his associates, a man of great knowledge but not deficient in understanding.

Ormandy was a particularly live and active member of our Institute until his health began to fail. He was a regular attendant at meetings and conferences, a ready speaker, and an excellent debater. He adorned every subject which he touched.

A. E. Dunstan.

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.

M M

Geology and Development.

1207.* Philippine Drilling to Continue with Heavy Rotary. T. P. Sanders. *Oil Gas J.*, 24.7.41, **40** (11), 18.—Geologically the Philippines are comparable in many respects to the Dutch East Indies. The stratigraphy is highly complicated by a great number of unconformities, and steep dips are common. Oil seeps occur on the Bondoc Peninsula. Here drilling difficulties have been severe. Eighteen years ago wells were drilled on the island of Luzon, but they are not believed to have been well located or sufficiently deep.

The Daanbantayan Peninsula of Cebu Island is a domal or anticlinal structure with 900 ft. closure and dips of about 16°. No oil-seeps occur in this area, but a tar-sand is found 25 ml. to the east on the island of Leyte, and on the west coast of Cebu, near Toledo, an oil-sand outcrops. At Daanbantayan a hole has reached 6010 ft., and is shut in awaiting heavier equipment. A well is being drilled at Bariti, 80 ml. to the south. G. D. H.

1208.* Several New Discoveries Boost Jackson County, Texas, Activity. F. L. Singleton. *Oil Gas J.*, 4.9.41, **40** (17), 22.—A semi-wildcat in the Texana gas-distillate field shows promise of opening the first crude production on that structure. The well is at 5780 ft., and has been cemented to test the Marginula at 5102 ft. It gave pipe-line oil in a brief drill-stem test. Texana was discovered by torsion-balance work, and in 1939 gas distillate was found at 5705 ft.

Jackson County has eleven oil- and gas-fields, eight of them discovered in the last two and half years. Although Miocene production was found in the Cordele field, the main objective is the Marginula-Frio, which is productive in nine of the fields. The producing depth is mainly 4700–6300 ft., but the basal Frio gives oil in one field at 7300–8600 ft. All the fields appear to be domal, with two or more producing sands.

West Ranch is the biggest field. Lolita is second and has three sands in the Frio. Francitas largely yields gas distillate from three sands at 7300–8600 ft. Ganado and West Ganado appeared small at first, but improved their status.

A map shows the location of the Jackson County fields, and a table gives the discovery date, formation, producing depth, number of wells, and daily average and cumulative production. G. D. H.

1209.* Well Logs and Field Data of Active Areas—West Central Oklahoma. Anon. *Oil Gas J.*, 4.9.41, **40** (17), 50.—The dominant features of this area, known as the Anadarko basin, are the Arbuckle–Wichita system of echelon anticlines in the south, and the Nemaha ridge on the east. All the important development between these old mountain systems has been along the edges, except for a few tests in the heart of the area and a small oil-well on the Binger dome in Central Caddo County. Even where there has been development, as at Cement and Chickasha, correlation has been very difficult because of complicated structural and stratigraphical conditions.

The first production on the north slope of the Arbuckle–Wichita system was at Cement twenty-five years ago, and that field has been developed sporadically. Twenty different formations are productive down to 6500 ft., and the production is 7500 brl. of oil/day, and 532,500,000 cu. ft. of gas/month. Chickasha, a related structure to the south-east, has been an important gas-producing area for many years. Many years ago shallow production was opened at Gotebo, and in 1939 the Hobart pool was discovered. Sayre gives shallow production. To the south-east, on a series of sharp folds south of the Arbuckle–Wichita mountains, are the important shallow fields, Graham, Fox, Walters, Robberson, Velma, Knox, Tussy, Tatums, and Sholem Alechem, discovered between 1917 and 1921. In 1937 deep production was found at Milroy, in 1935 at Fox, and in 1941 at Velma.

Prospecting will probably be for the Hunton and Simpson on the trend north-west from Cement.

Correlation of the Pennsylvanian with that of East Oklahoma or North Texas is very difficult. G. D. H.

1210.* Geological and Geophysical Profiles through the Eola Field, Louisiana. W. P. Jenny. *Oil Gas J.*, 11.9.41, **40** (18), 42.—It is known that large unconformities may occur between the Wilcox and Cockfield on structures along the Sparta–Wilcox trend of Texas and Louisiana, and therefore it is unwise to appraise deeper structural possibilities from a few scattered normal or almost normal Cockfield wells.

A north–south section through the Eola field shows an almost continuous regional dip of 120 ft./ml. in the Cockfield, in spite of its overlying a faulted Wilcox structure with an uplift of 300 ft. There is only a slight suggestion of the Wilcox structure reflected in the Cockfield.

In the east–west profiles, the micromagnetic profile agrees well with the Wilcox structure, and the reflection profile gives a fair impression of the Wilcox structure, but indicates a closure of only 100 ft. The intricate fault pattern and possible lateral change in over-all velocities may explain the imperfect agreement. The Cockfield profile is a good indication of the Wilcox structure in spite of the unconformity.

Similar unconformities between the Wilcox and Cockfield are reported on other structures, and in addition to the local structural unconformities, there are probably large unconformities on regional structures in this belt. The large positive and negative regional magnetic trends observed in this belt may indicate anticlinal and synclinal regional trends in the Wilcox below a normal Cockfield. Such regional structures may in turn affect the seismic velocities and so influence the seismic interpretation. G. D. H.

1211.* Well Logs and Field Data of Active Oil Areas—North-eastern Texas and North-western Louisiana. Anon. *Oil Gas J.*, 25.9.41, **40** (20), 56B.—Within the area dealt with lies the East Texas Embayment, with a series of faults on the north and west, and the broad, flat Sabine uplift of North-west Louisiana on the east. At present the Eocene production is not high and the Upper Cretaceous is not of great importance. Woodbine production is limited to the East Texas Embayment. The first Woodbine pools were on the faulted western side of the East Texas Embayment, and the East Texas field occurs where the Woodbine is truncated against the Sabine uplift. Production has been found on a few structures recognized as deeply buried salt domes.

Early prospecting in the Lower Cretaceous was on the higher parts of the Sabine uplift, and Rodessa in 1935 demonstrated the value of the Lower Cretaceous.

Near Lisbon distillate production has been found in the Smackover lime below 10,000 ft. This test ended in Jurassic salt at 11,834 ft.

A map, set of well logs and a generalized stratigraphical column are included.

G. D. H.

1212.* Ellenburger Structure Large in West Wichita County, Texas. R. M. Sanford. *Oil Gas J.*, 25.9.41, **40** (20), 70.—The K.M.A. deep field and the Electra deep field form one of the largest productive Ellenburger lime structures yet discovered. Most of the K.M.A. deep development has consisted of deepening old wells, and the same is true of Electra, where the old holes only require to be deepened by 900 ft. The area has three productive spots. K.M.A. produces from the Ellenburger at 4350–4400 ft., the deep production being in the south-western part of the old field. Sixty deep wells have proved 5000 acres.

In the Electra area two additional Ellenburger lime-producing spots have been found.

Only the K.M.A. Ellenburger high has been amply tested and found productive. The Ellenburger high just west of K.M.A., with 200 ft. of closure, has only one deep well, and that failed to make commercial production. Just north of Electra is a high with 150–175 ft. of closure, and this is at the top of the structure. It appears likely that there may be continuous deep production from K.M.A. to Electra. All the areas of closure are along the Electra Arch.

The Ellenburger lime is more prolific than the regular K.M.A. wells in that part of the field, and many wells here have initial potentials of over 1000 brl./day.

A stratum contour map of the Ellenburger is included. G. D. H.

1213.* Peak Drilling Activity Forces Illinois Production Upwards. H. F. Simons. *Oil Gas J.*, 9.10.41, **40** (22), 12.—September's oil output was the highest in Illinois since August 1940, when the Centralia and Salem Devonian development ended. The current production is more than 430,000 brl./day. During the first seven months of 1941 the steady production averaged 339,000 brl./day. In September 380 tests were completed, forty-six being wildcats and thirteen of these discovered new fields or extended old ones.

Seventy-one new fields or extensions have been discovered this year, and those made between 1st July and 22nd September are tabulated with the pertinent data. The most important fields are Johnsonville and Woodlawn. The Hoodville–Dale–Rural Hill area seems likely to be one of small pools.

The coal domes in the southern part of the State may become important features. Tests on the tops of these were poor, but good production has been found around the edges and along the sides of the domes. The Dale–Hoodville area is near such a dome, and the Rural Hill field may be similarly situated. G. D. H.

1214.* Well Logs and Field Data of Active Oil Areas—South-west Texas. Anon. *Oil Gas J.*, 9.10.41, **40** (22), 52B.—The roughly triangular area bounded by the Rio Grande and the Gulf of Mexico on the west and east, and extending as far north as Corpus Christi, contains 200 oil- and gas-fields. The early search was for salt domes, of which two were found with only a small production. During the 1920's a number of shallow fields were found along the Mirando sand trend which yields oil mainly from the Jackson and in places from the Frio, Catahoula and Yegua. Typical of the better fields along this trend is the Government Wells–Loma Novia group, in which production is obtained from a number of eastward-dipping sands. Deeper drilling along this trend is establishing lower pays as possible sources, down to and including the Cook Mountain.

Below the Mirando pay a relatively thick series is locally productive, and has good possibilities. The Wilcox is believed to be more favourable than the Mount Selman.

The Benavides–Pettus trend includes a number of fields in which sands in the same general series as the Mirando sands produce down-dip where they form wedge edges. These sands are generally of Jackson and Cockfield age, producing at 4000–5000 ft. South of Duval County on this trend the overlying Frio and Vicksburg yield oil. The next trend lies in the Frio sands, which are a down-dip phase of the outcropping Catahoula. This series has provided the most prolific producing areas of South Texas. In the past year crude has been found down-dip from gas-distillate structures.

Along the coast is the most easterly producing trend, the Marginula.

A map, generalized stratigraphical column, and a series of well logs are included. G. D. H.

1215.* Dakota Lease Play Continues with Little Drilling. Anon. *Oil Gas J.*, 9.10.41, **40** (22), 89.—Although hundreds of thousands of acres have been leased in North and South Dakota, only one major drilling operation has been undertaken in this general area, and that lies in Montana, just over the North Dakota line. The well found oil-shows at 6700 and 8360 ft., and is expected to go to 10,000 ft. In western South Dakota there are likely drilling sites.

On the Two Top structure a well was abandoned at 1100 ft. after reporting gas, and a second well was junked. Two wells in the Black Hills of western South Dakota are reported to be shut down.

8,000,000 acres have been leased in North and South Dakota. G. D. H.

1216.* Wilcox Trend Play Maintains Mississippi Exploration. R. M. Sanford. *Oil Gas J.*, 16.10.41, **40** (23), 76.—The newest Wilcox discovery at Larto Lake, Louisiana, is only 40 ml. north-west of the centre of Wilkinson County, South-west Mississippi, an area where there has been much leasing recently. Some Mississippi wells have penetrated the upper few hundred feet of Wilcox, but most Mississippi wells stopped short of the Wilcox zone, which will be several thousand feet deeper than in the productive fields of the neighbouring part of Louisiana. North and east from Wilkinson County the Wilcox rises to depths comparable to those of the Louisiana area.

Several tests drilled on the Wilcox trend in South-west Mississippi have found favourable shows and outlined local structures. In Central Wilkinson County a well encountered promising shows in the lower Miocene at 4472–4479 and 4573–4579 ft. In the north-central part of the same county a well found shows in the Cockfield at 3905–3910 ft. Moody's Branch marl gave gas in the south-western part of Wilkinson County.

Apart from the south-western part, most of southern Mississippi is considered to contain a large subsurface salt basin. This embraces many interior domes and local structures. On the southern rim of the salt basin is the Wiggins ridge, on which wells have found shows of oil.

Mississippi's latest prospective oil discovery, the Cary field, is on the Sharkey platform, a structure consisting of Upper Cretaceous beds laid unconformably on uplifted and eroded Lower Cretaceous beds. The only well is giving 46 brl. of oil/day with 419 brl. of salt water from 3285 ft.

Mississippi's oil fields are Tinsley (61,777 brl./day), Pickens (357 brl./day) and the Cary well. G. D. H.

1217.* Johnsonville Pool Nears Limits after Rapid Development. H. E. David. *Oil Gas J.*, 16.10.41, **40** (23), 83.—The new Johnsonville pool of Central Wayne County has been largely responsible for the impressive rise in Illinois production during the past few months. Its daily average is 60,000 brl. from the McClosky. Since 15th July, nearly 100 wells have been completed with average initial productions of almost 2000 brl./day. The largest well gave 9300 brl./day. The depth of the McClosky is about 3040 ft. and the average pay thickness 18 ft. Some wells find four pay-breaks. The flowing life of the wells is short and the initial decline rapid.

Production covers nearly 4000 acres, with the north, north-west and south-east limits partly defined.

The Aux Vases sand has been proved capable of production in this field, several wells having reported saturation capable of giving 1000 brl. wells. No well has explored deeper horizons at Johnsonville. Shallow Benoist production seems possible.
G. D. H.

1218.* Completions above 100 Daily First Time since 1937. Anon. *Oil Wkly*, 8.9.41, **103** (1), 49.—For the first eight months of this year completions were 1·8% below those for the corresponding period of last year. During August 2822 wells were completed.

A table gives the numbers of rigs in operation on 1st August and 1st September, 1941, and on 1st September, 1940, by States, with the state of activity on 1st September, 1941. A second table lists by States the total wells drilled during the first eight months of 1941 and their status, and also the wells drilled during August 1941.
G. D. H.

1219.* Drilling Activity near High Established in 1937. Anon. *Oil Wkly*, 13.10.41. **103** (6), 34.—During September the number of completions per day was the highest so far this year, and averaged 102·6 wells per day, as compared with 82·8 per day for September last year, and 99 per day during July and August 1941. During the first nine months of 1941 the average weekly completions were 3·8% more numerous than for the same period of 1940.

Tables give by States and districts the total rigs in operation on 1st October, 1940, 1st September, 1941, and on 1st October, 1940; the details of the field activity on 1st October, 1941; the monthly completions for September 1940, August 1941, September 1941, and their initial oil production; the cumulative completions for the first nine months of 1940 and 1941; details of the completions in the first nine months of 1941 and the initial outputs of the wells. G. D. H.

1220.* Current Exploration and Leasing Activity in the Dakotas. Anon. *Petrol. Engr*, July 1941, **12** (11), 58.—Oil exploration in North and South Dakota is spreading after being confined mainly to the central sections of the States. Recently interest has been shown in Perkins, Brule, Charles Mix, Codington, Spink and Beadle Counties, and the Black Hills in South Dakota, and in Adams County, North Dakota. Leases are said to cover 7,500,000 acres. A well on the Cedar Creek anticline, Montana, near the Dakota boundary, has reached 6000 ft. The Minnelusa is to be tested near Rapid City, and this area is only a few miles east of the Osage field, Wyoming.

The most active leasing is in the central part of the Dakotas. G. D. H.

1221.* Shallow Wilcox Accelerates North Louisiana Development. M. M. Kornfeld. *Oil Wkly,* 15.9.41, **103** (2), 16.—The Olla field of La Salle Parish, Louisiana, discovered in 1940, was the first large producer of oil from sands below the top of the Eocene Wilcox group. Urania, 4 ml. to the west, has given 23,000,000 brl. of oil from the Cana River–Wilcox contact between 1925 and 1940. Late in 1940 the Nebo field opened up a second deeper Wilcox zone at 3350–3697 ft., 1300 ft. below the top of the Wilcox. Six oil- and three gas-fields have now been found in North Central Louisiana, at 2250–5124 ft. This up-dip Wilcox development is in an area previously condemned by dry holes in the Cockfield–Sparta–Upper Wilcox.

The Olla trend is a tongue-shaped " high " centred in La Salle Parish. It runs over 100 ml. slightly west of north. The feature is shown by magnetic maps and by the isopachyte maps of the Cockfield and the Wilcox. Along the crest are the Urania–Tullos–Georgetown (Upper Wilcox), White Sulphur Springs (Cockfield), Olla (Middle Wilcox), Zenora, Little Creek, Trout Creek, Nebo, Hemphill, Walters, and Lake Larto (all in Middle Wilcox) oil-fields. The gas areas are Big West-Lowe, Trout Creek, and Summerville (all Middle Wilcox). Production ranges 600–1635 ft. below the top of the Wilcox.

In this area there are three major sand zones below the top of the up-dip Wilcox, and each is divided. Individual sand correlation from field to field is not attempted because of the irregular nature of deposition and distribution.

The discovery well data are tabulated, and a map and series of electrical logs and a mud analysis log are appended. G. D. H.

Geophysics and Geochemistry.

1222.* Core Drill and Seismograph Greater Discovery Factors in Kansas Oil Development. J. A. Kornfeld. *Oil Wkly,* 28.7.41, **102** (8), 32.—An increasing proportion of oil discoveries in western Kansas are attributable to the core-drill and reflection seismograph, whilst there has been a decrease in the effectiveness of subsurface methods.

Exploratory work in western Kansas is complicated by the low relief of the buried erosional features on the Central Kansas uplift, the effects of post-Ordovician and post-Mississippian erosion, the blanketing by the Pennsylvanian, the numerous unconformities, overlaps, and stratigraphic variations.

The core-drill was most effective in 1935, surface methods were most prolific in 1936, and the reflection seismograph, alone or in conjunction with other methods, gave the best results in 1937. It is too early to assess the value of geochemical methods in this region.

Early in July a major producing area was discovered 15 ml. north-west of Lakin, the structure having been outlined by the reflection seismograph and core-drill. The core-drill holes are taken to 1500–2000 ft., and are electrically logged and used for geophone tests for detecting and analysing abnormal structural and stratigraphical conditions. Core-drilling permits the determination of the attitude of the Permian beneath the Cretaceous, and the form of the Fort Riley limestone is a clue to structural conditions beneath the pre-Pennsylvanian unconformity.

The Cimarron anhydrite has proved a satisfactory reflecting horizon in some seismic work, but deeper horizons are required. In continuous profiling the divergence of the reflection intervals may be an indication of stratigraphic traps or pinch-outs on the flanks of the Central Kansas uplift.

Tables show the percentages of discoveries attributable to the various methods in 1939 and 1940, and the numbers of discoveries by core-drilling, the seismograph, and surface geology each year since 1920. The use of the core-drill and reflection seismograph in this area is discussed in some detail. G. D. H.

1223.* Geological Interpretation of Regional Magnetic Anomalies in Central and Southern United States. W. P. Jenny. *Oil Wkly,* 22.9.41, **103** (3), 17.—During recent years it has been shown that the majority of magnetic anomalies in areas of thick sedimentation are due to the magnetic content of certain sedimentary horizons. Certain anomalies are due to thickening of relatively shallow magnetic horizons. The anomalies may be due to the sediments, to the basement, or to both. Thinning of magnetic sediments over an anticline may cause the magnetic highs to be in the synclines.

In the Amarillo–Wichita–Arbuckle mountain systems, the magnetic picture corresponds closely with the topography of the basement igneous rocks. The magnetic vectors in the Appalachian area are generally lined up in a north-westerly direction, and are largely negative. West of the Appalachians is a series of positive anomalies pointing to an uplift of the basement along the western boundary of the mountains.

In the Gulf Coast area the basement is very deep, and the main magnetic anomalies are due to the sediments. Many of the magnetic highs are due to the thickening of magnetic beds in basins, but farther inland deep-seated anticlinal axes may be connected with magnetic highs.

The magnetic maximum in the centre of the Illinois basin is probably due to thickening of the Pennsylvanian and Mississippian beds.

The occurrence of thick, non-magnetic Ordovician limestones is probably the cause of the negative anomalies in the central area of the Ozarks and the Cincinnati dome. The northern end of the La Salle anticline is marked by a positive anomaly due to approach of the basement to the surface, and the southern end shows a negative anomaly due to thinning of magnetic shales on the anticlinal axis. Uplifts of the basement in Michigan give positive anomalies.

Basement trends, as revealed by magnetic anomalies, may be a key to the location of stratigraphic traps.

A map shows the regional magnetic anomalies in sixteen States of Central and Southern U.S.A. G. D. H.

Drilling.

1224.* Vermiculite Finding Increasing Application in Oil Industry. T. P. Sanders. *Oil Gas J.*, 31.7.41, 40 (12), 155.—Vermiculite is a member of the mica family which contains water of crystallization, together with free water held as microscopic inclusions within the laminated structure. On sudden heating the water is changed to steam, causing each particle to puff up almost instantaneously to about fifteen times its original size.

Since the expanded mineral will resist temperatures up to 2450° F. without fusing and because of its myriads of tiny dead air cells, it is an ideal insulator against heat loss. Its use on engine mufflers and on engine-room walls as a sound-absorbing material is well established, and exhaustive tests have now shown it to be of great value as a drilling mud.

It is mined near Libby, Mont., and is expanded by dropping through a special furnace at 2000° F. This product can then be used in a granular form as an insulator, or cast into bricks or other forms using a small amount of binder. In any form it is fireproof, rotproof, and entirely unreactive. An entire refinery in California has been insulated with vermiculite, and its use in brick form is being developed for the inside of cracking units. Oil tankers liable to bombing attacks use a covering of this mineral for decks and fire walls. As a drilling mud it is supposed to have ideal qualities for sealing off porous formations and is capable of remaining indefinitely suspended in water. C. L. G.

1225.* Use of Acid-Soluble Cement in Cementing Oil and Gas Wells. R. L. Tracey. *Oil Gas J.*, 25.9.41, 40 (20), 56.—In connection with the use of acid-soluble cement the acid jet-gun is described. If a removable squeeze tool is used, tools are not required for drilling out the cement left in the casing. The acid jet-gun, with jets directed at a slight angle downward, will remove the cement quite rapidly. This gun can be run on a measuring line (a safe procedure when inhibitors are used in the acid) to a position in a seating nipple at the bottom of the tubing. When a desired vertical distance has been drilled, the gun is quickly pulled out of the hole and the downward-directed jets are replaced by horizontally directed jets. The treatment then proceeds as in the case described above, after the cement has been drilled out with tools to a suitable level.

After discussing the various uses to which acid-soluble cement can be put, it is concluded that : (i) Acid-soluble cements, as shown by both laboratory and field data, possess the desirable properties of oil-well cements ; in addition, they are more durable in brines and more easily removed from wells by acidizing, thus making possible improved cement practices. (2) When acid-soluble cement is used, the cement can be acid-treated and removed much more completely than when regular cement is used. (3) Acid-soluble cement has extra setting abilities in oil zones and when intimately mixed with oil or salt water. (4) The length of time which the acid-soluble cement has been in a well apparently has no detrimental effect on the ease with which the cement can be removed with acid. (5) Treated bentonitic material in quantities up to 3% can be used with the acid-soluble cement without apparent effect on its ability to be removed by acid. (6) Acid-soluble cement can be squeezed against adjoining oil, water, and gas formations indiscriminately. Later it can be removed selectively from behind perforations in casing or liner, or from below the casing seat by jetting in an horizontal plane with the acid jet-gun. (7) The results of several acid-soluble cement squeeze jobs are tabulated.

In removing the cement, volumes of acid varying from 500 to 5000 gal. were used, by both the jet-gun and tubing methods. A comparison of the production figures before the squeeze job and after acidizing shows that in every case the water production was greatly decreased, and that the oil was substantially increased in three of the wells. A. H. N.

1226.* Applying Formation Logging Through Mud Analysis. H. F. Simons. *Oil Gas J.*, 2.10.41, **40** (21), 33.—The instruments used consist of a gas detector, a salt-water detector, an ultra-violet light for detecting oil, a rate-of-penetration indicator, and instrumental means for determining the amount of fluid moving in and out of the hole. The depth, rate of penetration, gas, and fluid lag are self-recording. This latter instrument enables fluid coming out of the hole to be correlated with the depth at which it emerged from the bit and picked up part of the fluids in the formation being drilled. Using the data obtained from these instruments it is possible to tell the interface between two formations, the content of the formations, the oil-gas interface, and often the relative porosity and permeability in a producing formation.

The mud-logging procedure has two major applications : the location of possible pay zones with the determination of their economic importance as encountered, and the obtaining of information which will aid the operator in selecting the proper completion procedure. Where several oil- or gas-bearing horizons are encountered, the best zone can be selected.

The information obtained is logged in a manner similar to other methods of identifying formations, and the results can be compared directly with them, although the data are obtained in an entirely different manner.

A typical log is given, and the significance of various points of importance is explained.

Mud logging has been widely used in practically every area in which the rotary method is practicable, including East, West, and North Central Texas, the Gulf Coast of Louisiana and Texas, Northern Louisiana, Mississippi, New Mexico, Oklahoma, California, and Kansas. Its principal use in Proven fields has been the location of upper oil- or gas-bearing strata and the obtaining of information necessary to a proper completion. This means that only certain sections of the hole are logged. Such a record shows proper perforation points, gas–oil ratio to be expected, and best place to set a packer, shoot, etc. Unnecessary coring of possible producing horizons is also eliminated. It also gives a permanent record on which to base remedial work.

On wildcats it provides a safe means of eliminating unnecessary cores, which are costly and in some cases hazardous. In one case a well was drilled to 10,000 ft. with only five cores being taken in three different horizons, but the drilling operation was stopped about fifty times to determine whether to core a sand or not. Previously the operator would have ordered the taking of many of these cores to make sure he did not pass up an oil sand.

In areas where hard formations are encountered the procedure is to drill 3 or 4 ft. into a zone after a definite break has been noted on the rate of penetration recorder. Circulation is continued until the mud which was around the bit has been brought to the surface and analysed. From the intensity of the showings of oil or gas a decision can be reached whether to core or to drill ahead.

The accuracy of the various instruments used is discussed. A. H. N.

1227.* Triplex Steam Pumps Gaining Favour on California Rigs. T. P. Sanders. *Oil Gas J.*, 2.10.41, **40** (21), 50–51.—Characteristics of the new triplex pumps have been thoroughly established, but are new in rotary drilling, and their use on deep tests in two different fields will furnish additional data for evaluating this departure from the long-established duplex design. Two considerations were primarily responsible for the triplex mud pump. One was the possibility of making a pump which by itself would have sufficient capacity for deep drilling, thereby rendering it unnecessary to compound two pumps. The other consideration was the realization that the overlapping of strokes would greatly reduce pounding and would produce a more constant pressure on the discharge manifold.

An entirely new design for the steam-valve mechanism made it possible to operate on a much shorter cushion in the steam cylinders, thereby reducing the necessary cylinder length and also the steam requirement. The triplex is an 18 × 7 × 20-in. pump, but its overall length is less than that of regular pumps having a 20-in. stroke. Overall length including skids is 12 ft. 7 in.; width is 7 ft. 11 in., and its height, including the air chamber, is 8 ft. 9 in. Its weight is 31,500 lb. It can be moved on the highways without dismantling and without a special permit.

A new feature is seen in the construction of the mud end of the pump. Each cylinder is a separate steel casting, and they are all interchangeable. A serious accident might call for a new cylinder casting but not for an entire new mud-end. The cast steel manifolds, together with the three cylinder castings, make five separate castings in the mud end.

Installation of the liners is unique. A large-diameter set-screw extending through the centre of the cylinder head is used to tighten the liner in the cylinder casting without removing the head. Within the cylinder is the line-spacer, which has an external rim for centring the liner. The spacer-ring butts against the end of the liner, and is held in place by means of the large setscrew previously mentioned. Friction is reduced by means of a roller thrust-bearing, so that when the adjusting screw is turned down, the operator can easily tell when there is a metal-to-metal contact at both ends of the liner. This arrangement not only makes it possible to ascertain that the liner is tight at all times, but also makes for convenience in removing and exchanging liners. A packing-ring prevents leakage around the adjusting screws.

A. H. N.

1228.* Slim-Hole Drilling Develops Changes in Technique. H. F. Simons. *Oil Gas J.*, 23.10.41, **40** (24), 32.—Comparing slim-hole operations with big-hole drilling is difficult because of the large number of factors which must be evaluated. As the slim-hole rigs being discussed are company operated, they have a definite schedule laid out, and a rig never has to wait on a location, but moves directly to it as soon as the pay-string of pipe is set. This is in contrast to the contract rig, which is generally torn down and temporarily racked while waiting for a location. The divergence in the operation does not end there, but extends to the overhead and investment charges, which are substantially higher for the contractor. A general comparison of the operating end can be and has been made by many of the companies, and shows that when competently operated the slim-hole rigs have no disadvantage while drilling and have a definite advantage in moving, operating, labour, bit, and casing costs.

Two of the rigs used in the East Cromwell field are equipped with 84-ft. derricks and two with 58-ft. derricks. The latter can be raised in 5 min. after the unit has arrived at the location, and the blocks remain strung while moving. It takes approximately 1 hr. to bolt the top half of the 84-ft. derrick to the bottom portion, which is attached to the raising mechanism and which remains on the truck, and then raise the derrick. The blocks have to be strung each time. The taller derricks more than justify the additional rigging-up time as at 3500 ft. it takes only 2½ hr. to make a trip, whilst on the shorter masts trips require 3½ hr. As it requires from twelve to fifteen bits to make the hole, the operating time on each well is reduced by 7–10 hr. by using the taller derricks. Later model rigs of the same type can carry the 84-ft. derricks in the field and require only a few minutes longer to raise than the single masts.

Details are given of the engines, lines, mud system, drilling, and fishing operations used. Drill-stem tests are frequently resorted to and are carried out as easily and with as much certainty as on the larger holes. The coring programme varies with the locality, but cores are frequently taken on the slim-hole rigs and over a period of time the recovery has averaged about 80%. Electric logging is used extensively to determine the pay horizons in the small holes, and the operation is conducted without difficulty. The use of mud analysis as a means of logging in wildcats and in lime country produces a more immediate reading, as the smaller holes ensure quicker return of the drilling fluid.

In short, slim-hole drilling presents some changes in operation, many advantages, and practically no disadvantages. A. H. N.

1229.* Shell Using Steam-Operated Pipe-Tongs at California Rig. T. P. Sanders. *Oil Gas J.*, 23.10.41, **40** (24), 48.—The drilling power-tong is an adaptation from the previously designed pneumatic McFadyen geared tubing tong. The chief reason for its development was to avoid the accident hazard presented by the spinning line and cathead. Secondary reasons were reductions of round-trip time and uniform make-up for all joints of the drill-string.

Unlike the pneumatic tubing tong, the steam drill-string tong is only used while the pipe is being run into the hole, as the pipe is unscrewed by spinning out with the rotary table when coming out of the hole. It now appears improbable that a portable power tong will even be suitable for breaking down drill-pipe because of the high torque required for breakout.

In the power tong the self-engaging jaws are mounted within a large circular main gear, which has an open throat to permit insertion over the pipe. This main gear is operated by two drive-gears so placed that one will always be engaged while the other is opposite the throat or cutaway portion of the main gear. The two drive-gears are operated by a fourth gear, and this in turn is connected to the crankshaft of a four-cylinder radial engine of a type commonly used in mines to drive small pumps.

Built for compressed air, high-pressure gas, or any other expansive medium, the tong engine is operated by steam at the Shell rig. A regulator on the supply line reduced the steam pressure to a constant 120 lb. The tong is counterbalanced in the derrick like regular tongs, and a wire " backup " line is used to keep it stationary while it is applying torque. A. H. N.

1230.* Portable Drilling Unit Used as Moving Tool. Anon. *Oil Wkly*, 13.10.41. **103** (6), 36.—A light-weight, truck-mounted portable drilling and well-servicing unit has been pressed into moving service by a California operator. With the telescoping derrick extended the mast serves as a long boom, and with it compressed it affords straight lift with high capacity. When not required for servicing the unit is not allowed to stand idle, but assists in moving large, 8000-ft. drilling rigs with 122-ft. derrick mounted on skids and substructure. A. H. N.

1231.* Mud Analysis as a Basis for Well Logging. H. L. Flood. *Petrol. Engr*, September 1941, **12** (13), 21–26.—A well is assumed to be drilled with a 10-in. bit at a depth of 5000 ft. at a rate of 10 ft./hr., and 800 brl. of mud is circulated/hr. The volume of the material cut, pulverized, and removed from the hole would be 9425 cu. in., the equivalent of 41 gal., or nearly 1 brl./hr., representing 1 part in 800 or 0·125% of the fluid circulated. If the porosity of the formation is, say, 30%, and the pores are filled with fluid, approximately one-third of a barrel/hr. of formation fluid will be added to the circulated fluid—a ratio of approximately 1 part in 2400.

If the pore space were filled with gas at a pressure of, say, 200 atmospheres (3000 lb./sq. in.), gas from the cuttings would enter the mud at the rate of 330 cu. ft./hr.

These figures give one an idea of the volume of formation fluids (oil, gas, and water) that are in the mud-returns. Instruments used in mud-logging are sensitive enough to detect even minute quantities of oil or gas; gas volumes as small as 1 cu. in./hr. can be detected in the drilling mud. It is important to note that the weight of the mud column prevents the inflow of fluids from the wall of the hole, hence formation fluid (oil, gas, or water) returns is that from the drill cuttings only.

In addition to detecting the presence of oil or gas, it is obviously important to determine accurately the depth at which the indications of oil and gas are observed. This is done by adjusting for the " lag," or the time required for the fluid to reach the surface.

Thus, the mud-logging equipment employed consists of: (1) equipment for the detection and measurement of oil and gas (and also salt water) in the mud returns, and (2) equipment for correlating the showings of oil and gas with the depths.

The equipment housed in a trailer in one particular form of apparatus, and which is used for logging mud is described, together with the procedure involved in the various measurements. Typical logs obtained in West Texas are included.

An interesting part of the apparatus is the depth-meter. This meter registers on two counters, showing depth of the hole and the distance bit is off bottom, respectively. The latter counter registers only when a trip is made or the bit is raised off bottom while circulating. This instrument is entirely automatic in operation. It has two selsyn motors, one of which is actuated by the movement of the travelling block in the rig. Movement of this motor energizes a companion motor behind the instrument panel. Downward movement of the bit increases the reading of the depth-meter. When the movement of the bit is upward the depth-meter remains stationary and the counter showing the distance off bottom begins operating.

Although the primary purpose of the depth-meter is to apprise the logging operator of drilling progress, it serves as a check against the driller's tally of depth. It also shows the rate of penetration by recording in ft./hr. the time required to drill the formations. A. H. N.

1232.* Mathematical Analysis of Whipstock Setting. A. W. McCray. *Petrol. Engr*, September 1941, **12** (13), 63.—The correct solution of a directional or objective drilling problem, from an engineering viewpoint, must be based on these principles: (1) The well must reach the desired objective; (2) for economical drilling, the least possible number of whipstock settings must be used; (3) furthermore, the amount of curvature in the well bore must be kept at a minimum in order to obtain maximum economy and ease of operation of the well during production. The last two principles go hand in hand; with any given whipstock angle, satisfying the conditions of one satisfies the conditions of the other.

Most wells are drilled to reach a definite point, whether it be under the derrick floor or a point having several hundred feet horizontal displacement from the top of the hole. In the problem considered here, a well has been drilled part way down and a survey of the hole has been made. Information is then available giving the location of the bottom of the hole drilled (or some take-off point above bottom may be selected) and the horizontal direction and inclination from the vertical at that point will also be given by the survey. Knowing this, and the position of the objective point, the problem consists of calculating the required whipstock settings.

After setting down the principles of solid geometry on which the solution of the problems of whipstock setting are based, 3 figures are given. A vector solution is shown in Fig. 1 that gives the theoretically correct direction in which to point a whipstock in order most economically to reach a definite objective point. This solution should be repeated for each setting in order automatically to correct for deviations from the ideal deflection that will occur in actual practice. Fig. 2 is an alignment chart that can be used to give the direction a new section of hole should assume, and Fig. 3 is an alignment chart giving the fractional length of a section of drilled hole that will appear on a horizontal map. The two alignment charts can be used for plotting possible future courses of the hole. In this manner an economic study can be made showing the best point to take-off from the original course of a well in order to reach some new objective. A. H. N.

1233.* Electric Power Used to Drill World's Second Deepest Well. C. F. Forsberg and W. A. Sawdon. *Petrol. Engr*, September 1941, **12** (13), 117.—Although drilled with equipment not designed for drilling to the depths penetrated, Honolulu Oil Corporation experienced little trouble in reaching 14,622 ft. in a well recently drilled with electric power at Buena Vista Hills near Taft, California. This well, designated as 25-P, is the deepest electrically-drilled well in the world, and came within 382 ft. of reaching the record of the only other well that is deeper. No particular depth was contemplated when the well was begun on 1st June, 1940, as the objective was a thorough test of the oil and gas possibilities of the structure.

The rig was installed in a 136-ft. derrick, and 1⅛-in. wire line was used for the deeper hoisting. The draw-works was driven by two 8-pole, 440-volt, 125-h.p. variable-speed motors direct-connected through flexible couplings to a twin motor reduction gear. The motors and reduction gear were mounted on one base as a unit, and powered the draw-works through a chain drive from the reduction gear. The motors were operated with oil-immersed magnetic controls through a small master switch so arranged that the two motors always operated on similar points of resistance, and thus divided the load equally. Either one or both motors could be used for hoisting. This provided for uninterrupted operation in case trouble developed with one motor or its control, as a single motor run at lower rates of speed could usually be employed for hoisting. This feature was used to advantage several times during the drilling of the well.

The controls for the draw-works motors were installed, in a portable house and permanently wired together. This equipment can be moved from one location to another after the drilling of a well is completed ; when wiring a rig it necessitates only the running of the cables from the motors to the terminals at the portable control house and then making connections. This reduces wiring to a minimum and saves considerable time when rigging-up.

The drilling operations and mud control are described. It now appears that, with equipment of proper size, electrical power can be used to drill deep wells such as this with economy, with minimum trouble from the power end, and with results as satisfactory as can be obtained with any other form of power.

The operation of the two mud-pumps was reasonably satisfactory, but better performance could be obtained with modern control that permits stalling of the motors over an appreciable period. Better operation in paralleling the pumps would also have been possible with the new types of control now available.

Modern deep-hole drilling demands speed, and in order to meet this requirement it would seem that a 300-h.p. motor on the rotary machine and two 300-h.p. motors on the draw-works, with all necessary apparatus to go with them, would be desirable. Large mud-pumps driven by motors of proper size would also be required, and would eliminate the overloads that were necessary to drill this well. Features of the electric motor that must always be kept in mind are the high pull-out torque usually built into the motor and the capability of the motor to stand excessive overload for a time. These features are naturally dependent on the design, but the usual type of variable-speed motor selected for this work has a pull-out torque of approximately 400%, which means that it can do a very considerable job in an emergency. A. H. N.

1234.* Water Used to Drill-in Lime Wells in West Texas–New Mexico Area. H. L. Flood. *Petrol. Engr*, September 1941, **12** (13), 138.—One town-site well recently drilled was completed in 15 days, including the time required for setting casing. Although the well itself is relatively unimportant, being only a routine operation, the equipment used in its drilling is one of the newest rigs in use in the area and is an example of the lightweight, streamlined assemblies now gaining in popularity for drilling to 5000-ft. depths.

After 175 ft. of 9⅜-in. casing had been set and cemented, the well was drilled to a depth of 4201 ft., using fifteen 8¾-in. rock bits. The 5½-in. oil string was set at a depth of 4128 ft. and cemented with 518 sacks of cement. Approximately 11 lb. mud was used during the drilling. Weight of 8 to 10 points is usually carried on the bit by drillers in this area.

While waiting for the oil string cement to set, the drill pipe was laid down and preparations made for drilling-in the well using tubing as drill-pipe. Clear water was circulated while the well was drilled-in. Every effort is exercised in completing wells in the Permian limestone sections to avoid plugging the formation with mud or any material that might reduce the flowing capacity of the well. Clear water, having less weight than mud, will impose less pressure against the formation.

A 4¾-in. rock bit and a 2-ft. drill collar sub were used on the tubing drill string and a 3-in. kelly was used to rotate the pipe while drilling-in. Approximately 3 points of weight were carried on the tubing.

The rig used is described.

1235.* Control of Filtration Characteristics of Salt-water Muds. G. R. Gray, J. L. Foster, and T. S. Chapman. *Petrol. Tech.*, September 1941, A.I.M.M.E. Tech. Pub. No. 1351, 1–9.—When strata containing soluble salts are encountered in the course of drilling, the salts are incorporated in the mud, flocculating the clay solids and increasing tremendously the water loss by filtration. Laboratory examination was made of the effects on filtration characteristics and viscosity of salt-water muds of the addition of natural gums (tragacanth, karaya, ghatti), seaweed (Irish moss), or gelatinized starch. In each case the volume of filtrate in 30 min. decreased as the amount of gum, starch, or seaweed was increased (1% of gum, starch, or seaweed gave a very small amount of filtrate in all cases). Except for ghatti gum and starch, the viscosity increased continuously with the amount of gum, etc.

Field tests were made with gums and gelatinized starch, and in addition to filtration being reduced, there was other evidence of improvement in wall-building properties in the freedom from stuck drill-pipe and ease of running casing to bottom in holes drilled with treated muds.

The average cost of muds for fifty wells drilled with starch-treated muds was slightly less than for seventeen wells drilled with untreated muds. G. D. H.

1236.* Comparison of Marsh-funnel and Stormer Viscosities of Drilling Muds. J. E. Owen. *Petrol. Tech.*, September 1941, A.I.M.M.E. Tech. Pub. No. 1373, 1–9.—The Marsh funnel and Stormer viscometers were calibrated by means of a series of liquids in which the density was 7·1, 9·3, and 11·0 lb./gal., and the viscosities 2·5–55 centipoises. It was found that the higher the density the greater the weight needed to give a certain rate of rotation of the Stormer viscometer. Nineteen of the drilling muds were adjusted to a Marsh-funnel efflux time of approximately 40 sec., and divided into three groups according to the density, whilst seven were adjusted to an efflux time of about 32 sec. All the muds were thoroughly stirred for 15 min. before testing. A linear relationship was found to hold between the logarithms of the Stormer cylinder test speed and the resulting apparent viscosity. In the case of the muds adjusted to a Marsh efflux time of 40 sec., the various curves in each of the three density groups intersected at about the same point, and the viscosity corresponding to this point was approximately that of the muds as determined by the Marsh-funnel calibration. The inference is that Marsh-funnel viscosities and Stormer values would be about equal at cylinder speeds of 1000–1200 r.p.m. Thus it is concluded that Marsh-funnel viscosity measurements are expressible in absolute units that may be correlated with Stormer viscosity measurements, provided the latter are made at 1000–1200 r.p.m. or extrapolation is made to these speeds, since it is difficult to make measurements at such high speeds.

The slope of the log-viscosity–log-r.p.m. curves is seemingly a measure of the initial shear strength of the mud. G. D. H.

1237. Patents on Drilling. D. Scaramucci. U.S.P. 2,253,536, 26.8.41. Appl. 29.6.39. Apparatus for cementing wells fitted with a measuring line and weights.

D. Scaramucci. U.S.P. 2,253,537, 26.8.41. Appl. 29.6.39. Apparatus for cementing wells with a measuring line using a pair of electrical conductors.

F. L. Darling. U.S.P. 2,253,691, 26.8.41. Appl. 6.11.39. Hose clamp.

H. W. Schuetz. U.S.P. 2,253,729, 26.8.41. Appl. 31.10.40. Thread protector for pipes.

L. B. Smith. U.S.P. 2,253,735, 26.8.41. Appl. 6.3.39. Method of making drill-jars for oil-wells.

R. B. Gaunt. U.S.P. 2,253,776, 26.8.41. Appl. 7.11.38. Deep-well apparatus comprising packing elements.

A. R. Maier and J. M. Shimer. U.S.P. 2,254,183, 26.8.41. Appl. 12.9.40. Table-seal for well-drilling rotaries.

D. Scaramucci. U.S.P. 2,254,246, 2.9.41. Appl. 18.8.39. Apparatus for cementing wells with two cementing plugs.

R. Brinneman. U.S.P. 2,254,563, 2.9.41. Appl. 27.4.39. Brake apparatus for oil-well pulling equipment. A. H. N.

Production.

1238.* Gas-gathering and Discharge Systems—Louden Pool Repressuring Project. J. R. Randolph. *Oil Gas J.*, 25.9.41, **40** (20), 46. *Paper Presented before American Petroleum Institute.*—Originally designed on the basis of engineering and geological estimates of future gas potentials and pool extent, the gathering system is now being further extended to serve a total of 173 leases from which some 19,000,000 cu. ft. of gas is produced daily. Seventy-one miles of welded pipe-line ranging in size from 2 in. to 16 in. are required to carry this gas from lease-tank batteries to the two compression plants, which are capable of a daily throughput of 17,000,000 cu. ft. Casing-head gas content ranges from 4 gal./1000 cu. ft. in richer areas to 0·6 gal./1000 cu. ft. in gas-cap regions, with the average falling at about 2·14 gal./1000 cu. ft.

Gas and oil from producing wells flow through a common flow-line into the lease separator or tank battery. Each separator is maintained under pressure by two regulators, one on the gathering system line and one on the vent-line. The latter regulator is set to open at a slightly higher pressure than the former, in order that separator gas will escape at the vent only when the flow is so great that the gathering line cannot handle the total volume. A second regulator is placed immediately down-stream from the pressure-actuated lease regulator. These vacuum-operated regulators, set only on leases which produce excessively dry gas, are adjusted to open when the gathering-line vacuum exceeds 5 in. of mercury. In this way the field gas of lowest gasoline content is vented until the supply to the plants falls and causes a vacuum on the lines, at which time the various vacuum-actuated regulators open and admit the lower gasoline content gas into the lines to maintain the supply to the plants.

When wells are tested for oil potential, or when no separator is needed at the battery, oil and gas flow is routed directly into the tank battery. Tank thief-hatches hold 8 oz. pressure on the welded steel tanks, causing gas to leave through the 3-in. overhead vent-line. Escape of this gas at the vent-line riser is prevented by a stack-valve set to open at a pressure slightly lower than that held by the tank hatches. A regulator on this line is set to open at approximately 10 oz. pressure to admit gas from the tank battery into the gathering lines. The orifice meter measures all gas entering the system from the lease.

Details of the system are given and illustrated. A. H. N.

1239.* Completion Methods Employed in Wabash Valley Area. F. C. Ploeger and J. R. Vaughan. *Oil Gas J.*, 25.9.41, **40** (20), 52. *Paper Presented before American Petroleum Institute.*—In drilling wells in this area it is not unusual to encounter as many as five possible producing horizons, consisting of McClosky lime, Aux Vases, Benoist, Cypress, and Tar Springs. When this condition is encountered, attempts have been made to produce two or more of these formations in the same oil-string. This has been done by the use of removable casing of several kinds, the most common being an aluminium alloy. This can be removed by a wall-scraping tool or by shooting. A magnesium-alloy pipe has also been used to place opposite an upper producing horizon which can be removed by a wall-scraper, by shooting, or by the use of acid. Because of the inability to obtain aluminium pipe, a low-carbon light-steel casing has been substituted. This has been effectively removed by wall scraping.

Aluminium alloy has been given preference due to its resistance to corrosion and because the properties of this pipe more nearly approach the requirements of the operator, relative to the selection of steel casing. It was found that aluminium alloy pipe is not affected by corrosion by chemical action and can be left intact in the oil-string until such time as it is desired to remove it.

The low mechanical properties of alloy and the low-carbon casing necessitate much care in handling and running. To obviate any possibility of damaging the joints in making up the threads, chain-tongs are used, being placed at least 12 in. from the end. Power-tongs should never be used.

In many cases it was not possible to secure drillable pipe, so regular steel casing was set through the upper pays. In doing this, the couplings were placed above and below the pay-zone, which would eliminate ripping or shooting a coupling when opening. The method of reaming has proved very successful. A regular blade will cut out the alloy pipe, whilst a tool-steel blade is required to cut out the low-carbon pipe. The latter has been replaced by a regular blade having a tool-steel insert capable of cutting 60 ft. The low-carbon pipe will ream out at a rate of from 4 to 5 ft./hr., which is slightly faster than the rate of removing alloy casing. Other methods are also described.

Where the operator desires to produce two or more pays simultaneously in the same string, several methods have been practised in opening the upper zones. A great number of wells have been completed by first shooting the lower horizon with nitroglycerine and, after testing same, gun-perforating the upper sands. As a general rule the increase in production after opening the upper pays was negligible; it often rose at the time of shooting, but rapidly declined to normal. Such results may be credited to the low permeability of the sand. The use of the gun perforator has been very effective in one area when opening the Waltersburg sand. One well typical of the area was swabbing 141 brl./day from a lower pay, and after shooting with nine ⅝-in. bullets/ft. in the Waltersburg sand it swabbed 216 brl./day.

Methods of completion as practised in this area at present lead to the conclusion that: (1) 7-in. casing for the oil-string is preferred because of the possibility of deeper production and the need for heavy shooting; (2) producing one zone at a time and beginning from lowest producing level would be the most economical were such a plan accepted by all operators in any area, upper pays to be produced at a latter date by plug-back jobs. A. H. N.

1240.* Pressure-maintenance Project Conserves Reservoir Energy. N. Williams. *Oil Gas J.*, 2.10.41, **40** (21), 30–31.—In the reservoir under discussion, located in South-west Texas, approximately 2,500,000 cu. ft. of gas has been returned to the producing horizon. In addition to the conservation of this gas, bottom-hole pressure of the sand has been stabilized, insuring prolonged flowing life for the producing wells and greater ultimate recoveries than could otherwise be expected. Nearly 1,000,000 brl. of oil has been withdrawn from the reservoir since pressure maintenance was started.

Involved in the project is the upper first Government Wells sand, the field's principal producing horizon, which, in its oil phase, lies at a depth around 3400 ft. This sand has a comparatively large, pronounced gas-cap, and, by the return of all produced gas to this horizon, it is hoped to preserve the pressure as nearly as possible to its original value. First bottom-hole pressure readings were made in 1937, at which time, with development of the sand in its early stages, the pressure was approximately 1300 lb. Before the pressure-maintenance operations were started in March 1940 the reservoir pressure had declined to about 1200 lb., but since then it has been held practically constant.

The structure is indicated to be a domal-shaped anticline with sands overlying and extending down the sides in more or less symmetrical contours. The oil-productive area of the upper first Government wells sand is circling the structure in a comparatively narrow strip, about three to four 700-ft. locations wide, roughly skirting the outer productive limits of the shallower sands.

Sand thickness averages 50 ft. Gas-oil contact has been found to be at a subsea depth of 2744 ft., with the water level at a subsea depth of approximately 2800 ft., leaving an oil column of approximately 56 ft. Through preservation of the gas-cap and controlled withdrawals it is hoped to maintain a uniform rise in the water-level to obtain the most effective utilization of the water-head in efficient recovery of the oil. Surface elevation of the field ranges from 550 to 600 ft.

To date forty-seven oil-wells have been completed in the upper first Government Wells sand. One rig is being kept running in a steady systematic development programme. There are fifteen producing wells in the various other sands. At present only the upper first Government Wells sand is being developed, most of the shallower wells having been drilled prior to the opening of this sand. So far the development has extended only around the south half of the structure. The spacing programme, based on locations 707 ft. apart at 1000 ft. intervals diagonally, allows an average well density of one well to 11·4 acres.

The plant used is described. A. H. N.

1241.* East Texas Salt-water Injection Plants Vary Widely in Design. D. H. Stormont. *Oil Gas J.*, 9.10.41, **40** (22), 34–35.—Injection of salt water to sands below the oil-pay in the East Texas field has passed the 60,000-brl. daily mark. Furthermore, new plants under construction are expected to raise the daily total to more than 80,000 brl. by the end of this year. The plants used for treating this large volume of water prior to its injection vary widely in design and capacity. Practically all, though, are based on the same fundamental principles of thorough aeration and adequate settling time followed by filtration.

In bringing formation waters to the surface their equilibrium is disturbed by the change in temperature and pressure, contact with foreign materials, and exposure to air. In East Texas the principal task is to cause the iron in the water to change from the ferrous state into ferric compounds, so that it drops out as an insoluble precipitate and can be removed by decantation and filtration ; also to permit any dissolved gases to escape. By allowing adequate aeration followed by sufficient settling time, most operators have been achieving the desired results with relatively simple equipment.

Aeration is accomplished in a variety of methods, some of which are : flow through stepped-flume sections, over corrugated concrete slabs, forced-draught aerating towers, flow over baffles or from troughs, and by use of settling tanks having large surface exposure.

Most of the systems require pressure on the injection wells only when " breaking down " the formation of the starting of operations. After the injection begins taking water in sufficient volume, the hydrostatic head is sufficient to force the water into the porous sections of the injection horizons. The static fluid level in most wells is around 1000 ft. Building up of back pressures is combated by back-washing or flushing and swabbing the wells to remove bacterial or other deposits from the face of the sand.

Several of the input wells have been drilled primarily as injection wells, but most of them are former oil producers that have been drilled several hundred feet deeper. The wells are drilled to levels below shale-breaks in the lower Woodbine sand, generally at least 100 ft. below the oil–water contact. Most of them are placed near the west edge of the field, but some drilled as injection wells are outside the field's limits.

A. H. N.

1242.* Automatic Production Dispenser Cleans and Meters Oil. T. P. Sanders. *Oil Gas J.*, 9.10.41, **40** (22), 36.—The device described is for removing automatically water and sand and gas from a well's production and then pumping and metering the clean oil. The original installation was so successful that additional wells were soon equipped. As a large-scale undertaking it became very desirable to reduce the per-well investment. First move in this direction was the substitution of 60-brl. scrubbers for the 200-brl. vessels, and next was the adoption of meters having an hourly capacity of 80 brl. as a substitute for the 260 brl./hr. meter of the first installation.

The final improvement took place when an ingenious method was devised for making one meter serve a number of wells. This reduced the number of meters required to a fraction of what would otherwise have been required.

There are now twelve multiple-well hook-ups, each of which uses a single meter for gauging individually the production from four or more wells. The usual scrubbing and metering hook-up is centrally located among four producing wells, which may be either flowing or pumping. Each well produces into its own 60-brl. scrubber. When the level of the clean oil in scrubber No. 1 reaches a selected point, a fleat makes contact to close an electric circuit. Simultaneously three things happen : a relay switch breaks contact on each of the float-switch circuits of the other scrubbers, thereby making it impossible for any of the other tanks to discharge fluid through the meter before the flow from scrubber No. 1 has been completed ; a magnetic valve situated on the oil line between scrubber No. 1 and the meter is opened ; in the meter head, a solenoid actuates a lever which shifts gears to engage the registering dial for scrubber No. 1 to the meter shaft.

Opening of the magnetic valve makes a contact to close another circuit which starts the motor of the pump. Oil from scrubber No. 1 is then delivered into the gathering system, its volume being recorded by the individual registering dial, until a selected level is reached where the float-switch will operate to close the magnetic valve, disengage the gears of the registering mechanism, and shut down the pump. If, in the meantime, one of the other separators has filled up past the level at which it is regulated to discharge, its electric circuit controls the same processes. A. H. N.

1243.* Gas-lift Used for Efficiently Producing Small Lease. N. Williams. *Oil Gas J.*, 9.10.41, **40** (22), 44.—The paper deals with a particular field where deep sands producing under very low heads and which are troubled with a lot of water are worked. Four wells are used. Requirements of these wells total a little over 650,000 cu. ft. of gas daily, with the plant handling in the neighbourhood of 20,000,000 cu. ft. monthly. Requirements for the individual wells range from 135,000 cu. ft. to about 150,000 cu. ft. daily, the amount varying according to individual conditions and the volume of fluid to be lifted. The volume usually figures out on a basis of about 1800 cu. ft. of gas/brl. of fluid lifted.

Gas from the supply well is delivered to the suction of the compressor at a pressure of 275–290 lb., and is discharged to the well input system at a pressure of 575 lb. Pressures required for operation of the lifts vary according to wells. One well is operating at pressures as low as 350 lb., whilst another takes as much as 500 lb. Operating pressures run from 420–450 lb.

In the wells is a specially adapted bottom-hole gas-actuated pump-type lifting valve designed and made by the operators. It is set and operates in such a way that no outside pressure that might retard the entry of the fluid into the bottom of the hole is ever applied to the producing sand.

The gas-actuated lifting valve is set in the hole with only the length of the fluid-accumulating chamber on the bottom. This chamber, extending through the sand section opposite casing perforations, is a section of pipe-bull plugged on bottom, but equipped with back-pressure valve-operated ports for the entry of fluid. The length of the chamber is governed to accommodate only the volume of fluid to be unloaded at a time, which in these instances is about a barrel. To lift more fluid at a time would require the injection of a greater volume of gas, thereby increasing costs. When the chamber is full the injected gas operates valves to unload the fluid, and shuts off when the chamber is emptied.

A packer seals off the annular space between the casing and the flow-string.

A. H. N.

1244.* Volume-control Repressuring Successful on Small Lease. H. E. David. *Oil Gas J.*, 16.10.41, **40** (23), 46.—The particular lease in question has recovered approximately 20,000 brl. oil/acre to date and daily production has been increased by almost 600% since the start of the repressuring programme. The pool, in the past, has produced approximately 220,000,000 brl. of oil from approximately 16,000 acres, and the possibility of recovering a similar quantity in the future is an important factor in Oklahoma's potential reserves.

The project on the Sinclair Prairie Kiefer lease has also revealed important operating data on gas repressuring. It has demonstrated the feasibility of small-scale operations and the results to be obtained from close control of the pressures in a particular area.

One of the principal problems in repressuring a small area in a large reservoir is the prevention of migration of the oil towards the offset properties. The Glenn Pool repressuring project has been very successful in building up the pressure in the sand and increasing recovery of oil on the property under secondary development without causing movement of oil across the lease to the offset properties.

This has been accomplished by repressuring only the centre portion of the 160-acre lease, and by close control of the volumes of gas injected into the pressure wells and frequent checking of the pressures and volumes on all the producing oil-wells. This method allows the engineers to determine when oil and gas in the sand are approaching the boundary lines. Reduction of the pressures and volumes injected will check this migration.

The plan originally called for the injection of a definite volume of 25,000 cu. ft. of air daily into each input well. As the project was expanded, however, this volume was gradually increased until tests of the line-wells on the lease indicated that the air and oil would soon begin migrating off the lease. The volume was then decreased, and at present slightly more than 25,000 cu. ft. of air and gas is being injected.

A. H. N.

1245.* Filtration Formation Cementing of Low Gas–oil Ratio Wells. J. I. Laudermilk. *Oil Gas J.*, 23.10.41, **40** (24), 56.—The processes involved in filtration formation cementing are similar to the functional performance of the old-type charcoal-sand-and-gravel filter used in the purification of water, although naturally in reverse operation. The cement should be injected into the well as an extremely thin slurry, thus permitting it to filter through the more permeable regions of the producing formation and gradually to be strained out or deposited along the paths of the flow-channels, thereby reducing the tendency of the fluid in the reservoir to travel into the well-bore along these particular channels. If this process be continued to its logical conclusion by the injection of a sufficient amount of cement slurry, the more permeable parts of the formation (normally the water-producing zones) will become filled with filtered-out cement particles and clogged in a manner analogous to the clogging of the water-filter mentioned above. In filtering out through the various minute channels of flow throughout the producing formation, the cement will effectively plug these channels and cause the permeability of the portion involved to be greatly reduced. It may be open to question whether or not the cement will actually set in the flow-channels, as in the case of cementing casing, although this does appear to happen to some degree. However, appreciable benefits will be derived from the plugging of the formation by inverse filtration where actual cementation does not occur. Both processes of filtration and cementation are probably present in all cases, and the predominance of the importance of one occurrence over the other may well depend to a marked degree on the sizes of the channels of flow available for induction of the cement-laden fluid into the reservoir.

The total amount of cement which may be injected into a well by filtration formation cementing will vary greatly with the different producing formations encountered in various oil-fields, but will often be of such magnitude as to astonish a beginner in this type of work. The author once assisted in the formational cementing of an unconsolidated sand using this filtration method, in which case more than 1½ tons of cement were injected into the formation without any deposition of cement in the bottom of the well-bore.

It is, of course, possible to place the old-type bottom-hole plug of cement in the well-bore to supplement the effects of filtration formation cementing if such plugging back is unobjectionable. A. H. N.

1246.* Effects of Connate Water upon Ultimate Recovery. Part 1. W. F. Cloud. *Oil Wkly*, 22.9.41, **103** (3), 33.—The work of Hassler, Muskat, Botset, and their associates is reviewed together with Leverett and Lewis's experimental studies on the permeability of rocks to two-phase systems of fluids. From this review it is concluded that: (1) connate water content of only 15% or 20% will have very little effect on the relative permeability of a sand to oil, gas, or water; (2) viscosity has a small effect on relative permeability–saturation relations; (3) a small decrease in oil saturation causes a large increase in gas–oil ratios, higher ratios occurring with higher oil viscosity, provided the oil-saturation percentages are similar; (4) relative permeability as related to saturation is not a fundamental property of all sands, different sands having individual characteristics and gas–oil ratios at similar saturation; (5) different sands require different pressures to start the movement of fluids through them, and a certain pressure will remove only a certain amount of oil, depending on the number and size of capillary openings; (6) from 40% to 50% of the pore space may be filled with water, which remains fixed as oil and gas are produced; (7) the amount of water remaining fixed in a sand will depend on sand-grain size, specific permeability, and pressures applied.

The amount of water remaining in reservoir pore spaces after gas-expansion flow or gas-lift operations cease is a matter of prime importance when the application of gas injection or water-flooding is considered. The amount of this water must be determined from cores on a pore space percentage basis, and must be considered in calculating the amount of unrecovered oil in place before a field or lease can be intelligently subjected to secondary-recovery methods over a period of years. Laboratory investigations indicate that ultimate recovery of unsaturated oil is appreciably affected by the presence of various amounts of water existing as a coating on sand-grains and at their points of contact.

Experimental work on gas-drives is reviewed. The work of Mills, Krutter, and the author might be interpreted as indicating that, regardless of sand texture, porosity, compaction, and permeability, only approximately 50% of the original oil can be recovered by gas-drive under ideal conditions from either consolidated or unconsolidated sands, provided gas–oil ratios are disregarded and viscosities and temperatures are similar. A. H. N.

1247.* Sanding-up Problem Solved in New California Completion. G. M. Wilson. *Oil Wkly*, 29.9.41, **103** (4), 27–28.—A new method of completing a well which is characterized by having excessive amounts of fine sand is described and illustrated in detail. The equipment consisted of the following: A special set shoe was made up on the first joint of screen to be lowered into the hole. The shoe used contains a back-pressure valve, and has several holes in the bottom to enable fluid to be forced through it, permitting the liner to be jetted down past any obstruction that may be encountered in the open hole. The shoe also contains a pressure-tight connection, into which the tubing latches while the assembly is being lowered into the well, and which will release the string on rotating to the right.

The last section of liner to be run into the hole was hung in the rotary slips, and a single joint of tubing, with special latch-on tool made up on its lower end, was run in to the bottom of the set shoe, where four or five turns of the tubing to the left securely anchored it in the bottom of the shoe. Sufficient tubing was run to cause it to protrude 2 or 3 ft. above the top of the liner still hanging in the slips of the rotary table. A packer-setting tool was next made up on the top of the tubing. A section of tubing was then picked up with the elevators, and the packer pulled up over the section and held by the cat-line while the tubing was screwed up into the setting tool.

After setting the packer and circulating oil, the tubing can be removed without killing the well, as was necessary in the conventional methods. A. H. N.

1248.* Effects of Connate Water upon Ultimate Recovery. Part 2. W. F. Cloud. *Oil Wkly*, 29.9.41, **103** (4), 29.—When artificial water-flooding is first applied to partly depleted oil-sands no increase in oil production is immediately forthcoming, because the capillary " creep " of the water is very slow—perhaps less than 100 ft./year in the Bradford area. However, the rate at which water will move through sands will depend primarily on sand texture, pressure applied on the injected water, per cent. of remaining oil saturation, and the relative surface tensions of oil and water. It is characteristic for only oil and no water to be produced at recovery wells during the period when the oil is being pushed as a " bank " in front of the water network. The first appearance of water with the oil is usually accompanied by a marked reduction in oil production, after which the water production increases and oil decreases until the arbitrary economic limit of water–oil ratio is obtained. Regardless of whether the injected water permeates the sand-body as a circle, ellipse or lemniscate apex, the net result is the pushing of oil from several directions towards one pumping well, which is centrally located with respect to the surface pattern of well-spacing used. The mechanics of artificial flooding is probably two-dimensional and only slightly affected by gravity in most sandstones.

Factors which affect the entrainment or capillary retention of oil in sands after the gas has been depleted are the surface tension of the oil, the angle at which the oil makes contact with the sand-grains, the texture or uniform fineness of sand-grains, the surface area of sand-grains exposed to oil, and the relative densities of oil and water. The viscosity of the oil is not a prime factor, but if connate water is present at the points of contact of sand-grains, interfacial tension will be an important factor.

Laboratory procedure and results are reported on oil recovery. Water-flooding after gas-drive causes very little reduction in crude-oil gravity. There was no consistent relation between water-drive recoveries and water–oil ratios. Apparently recoveries by water-flooding are not correlative with porosity, but permeability seems to be directly related. Also, the rate at which water was injected portrayed no tangible effect in this sand except the time factor.

In all these tests the recovery by water-flooding was abnormally high, as compared with that of consolidated sandstones. This indicates that in highly permeable sands the capillary pressure is low, and all the forces acting at the contact points of sand-grains are subordinate to the hydrostatic pressure of the driving liquid. It is presumed that the 26·6% of the original oil remaining existed as a very thin film around each sand-grain, the amount of retention of each grain being dependent on capillary radius and grain-surface area. A. H. N.

1249.* Model for Study of Oil Recovery Problems. J. S. Levine, L. T. Bissey, and S. T. Yuster. *Oil Wkly*, 29.9.41, **103** (4), 34.—Although various models have been constructed to study fluid flow, they have dealt primarily with single, homogeneous fluids. A five-spot model has been designed and constructed for the purpose of studying the flooding of an unconsolidated sand. The apparatus is made of transparent Plexiglass, so that the actual flooding patterns can be seen during various stages of the flood, and the model is adaptable to various pattern arrangements.

The actual water-flooding of Pennsylvania crude oil from an unconsolidated sand is shown in a series of photographs taken during phases of the flood. They show the method of fluid migration from input to producing well, and also indicate the extent of the " dead areas " after the recovery period has ended. Curves are given to show the actual volumes of oil and water produced and the water–oil ratios during production.

The value of this experiment lies chiefly in the qualitative results obtained from the photographs of the flood. While not startling in themselves, they bear out theoretical conclusions as to the manner in which a five-spot pattern is flooded. The experiment also shows that most of the recovery is obtained in the early period of the flood, and that once water is produced, the oil production rapidly decreases. The results would also indicate that pattern rearrangement will produce little residual oil. However, this conclusion is not entirely valid, since it undoubtedly depends on the amount of residual oil present. In this case the initial recovery was high, so that but little oil remained. The recovery was higher than would normally be expected, and greater, in fact, than previous flooding of unconsolidated sand had produced.

The paper is well illustrated by the photographic results of the experiment, and the treatment is given in detail. A. H. N.

1250.* Easy Means Evolved for Constant Gas–Oil Ratio Checking. Anon. *Oil Wkly*, 6.10.41, **103** (5) 46.—In one pool in Oklahoma a constant check is maintained on the gas–oil ratio. Gas measurement procedure is solved by means of a pitot tube and differential recording orifice meter on a Sunray Oil Co. lease. The tube is bent in a curve at the upper end and inserted in a short section of 4-in. pipe. Gas is directed from the separator through a 25-ft. section of buried pipe and released at the vertical 5-ft. vent-line. A rubber hose connection is effective between the bent metal tube and the orifice meter. A 24-hr. continuous rotating chart is provided to record the changing differential.

An auxiliary 7-in. vent-line, 15 ft. in height, is available for exceptionally high gas capacities. The two vent-lines are joined at base to the common carrier underground, and a valve control has been inserted at base of larger vent-line. A. H. N.

1251.* Steel Lease Tanks. G. B. Nicholson. *Oil Wkly*, 13.10.41, **103** (6), 17.—This article is limited to steel tanks, and covers, in some respects, land operations only, being roughly divided into two sections as follows : (1) Tank specifications to consider before buying ; (2) suggestions for installation, operation, and maintenance. In view of the defence emergency and the accompanying steel scarcity, it is more important than ever to get the greatest amount of service out of tanks.

The various precautions to be taken in reducing evaporation losses are discussed individually. Recent practices in certain details regarding clean-outs and ventilation are given. An improvement which has been considered for tanks is a flat steel plate welded to the floor directly beneath the thief-hatch for a gauging plate, to simplify obtaining accuracy by assuring a level surface on which to rest the gauge-line plumb-bob. The plate usually extends higher than the floor level, but the gauge is not affected, as tanks are never completely emptied to the bottom during pipe-line runs. An additional advantage is offered by the plate in protecting the bottom of tanks from the point of the plumb-bob, which in many cases has weakened tanks in the area below the hatch opening and allowed the floor to be eaten out. Further accuracy in tank gauging is obtained by erecting a vertical interior-pipe, bolted firmly in place, with the top inside the thief-hatch, and its lower end, open and perforated, extending to a point below the fluid level. The liquid surface inside the pipe is free of surface agitation, lacking the foam that is ordinarily present. The gauge-line is run inside the pipe, and fluid-marks on the line give a true indication of the amount in storage.

Care must be taken to ensure that inside pipes give correct reading of oil and water contents. Below the hatch openings in modern tanks steel shelves are placed for the gauger's convenience.

Installation is similarly given in great detail. Concrete is recognized as the best foundation material, although it is not often used. However, if the tanks are expected to serve one lease over a long period, the additional expenditure will reap dividends in the future. Under ordinary conditions an earthen base is sufficient for support, as the load of a 16-ft. tank filled with oil seldom exceeds a ½ ton/sq. ft., and usually soil carries from 2–5 tons/sq. ft. without difficulty. In swampy territory it is sometimes wise to construct foundations with a wide concrete apron extending from under the tanks, to distribute the load over a broader area, and to add to the load-supporting capacity of the soil.

This extensive paper is well illustrated. A. H. N.

1252.* **Function of Relative Permeability in Water-Flooding.** L. C. Converse. *Oil Wkly*, 31.10.41, **103** (6), 28.—The six variable factors entering into the complex problem of fluid-flow as applied to water-flooding may be divided into two groups: (*a*) the reservoir conditions as found existing, over which the operator has no control, and (*b*) the variables over which the operator has control within definite limits.

The three incontrollable factors combine to make the important factor of relative permeability, the function of which is threefold: (*a*) as between reservoirs, (*b*) as between wells within the reservoir, and (*c*) between zones within the well-bore. Assuming oil present in commercial quantities, the application of the controllable values to the uncontrollable values makes the economics of any flooding project. Each of the factors is discussed separately. The uncontrollable factors are sand permeability and per cent. saturation (oil), and the viscosity of the oil. The controllable factors are pressure, distance (spacing), and diameter of input well.

In the modern concept viscosity is an integral part of specific permeability; however, the more obsolete idea gives emphasis to the point if we say that relative permeability is the variable of dry permeability plus the variable of per cent. of oil saturation plus the variable of viscosity as functioning between reservoirs. Since spacing has such large influence on the economics of a flood, and since viscosity has the largest influence on spacing, the importance of having this factor correct should be mentioned. The samples to be taken to the laboratory for viscosity determination should be taken at the wells from the last of the day's pumping in a pressure container with all air excluded. For interpretative use the viscosity should be run at the reservoir temperature. To get the true temperature an old well which has been static for a long time should be used.

Pressure and input well diameter, together with relative permeability, determine the spacing, and all of them put together determine the average take per foot of sand. The average take and the spacing determine the time interval necessary to displace the oil in the sand within the sphere of influence of the input wells. After the first few weeks of controlled flow the radial advance of the water would be far less than the optimum rate, even if the wells were taking 10 or 15 brl/day/ft. of sand. This being the case, take controls the economics of flooding, and instead of being limited, every advantage should be used to induce the maximum average take.

The average take per foot of sand/day for the Mid-Continent floods is less than 1·5 brl., which requires 5·5 years to displace the oil within a 330-ft. spacing pattern. This take gives an average radial advance of 1·36 in./day, which is obviously too slow for the average permeability of the sand and viscosity of the oil. The only change which would result if the take were increased to 4·5 brl./ft. of sand/day would be an economic one. With the spacing remaining the same, the time required would be reduced from 5·5 years to 1·8 years. Three times as much acreage could be developed and three times as much oil produced in the same period.

But, better still, if the wells averaged 4·5 brl./ft./day the spacing could be broadened to 440 ft. from like well to like well, and the time reduced to 3·5 years. Approximately a third would be saved in development cost, and two years in time. With much worse than average conditions the author has been able to introduce 5 brl./day/ft. of sand, whilst with better than average conditions he is now introducing 20 brl./ft./day.

Economics are further discussed. A. H. N.

1253.* Unusual Features in Successful Co-operative Repressuring of Loma Novia Field. T. Davison. *Oil Wkly*, 20.10.41, **103** (7), 17.—The first year of repressuring at Loma Novia shows promise of good final results. This project is particularly interesting for two reasons. First, it is unusual in that twelve operators having thirty small leases in a field can co-operate in a repressuring programme, disregarding property lines in the selection of key wells and input volumes. Second, the programme is unusual because only the excess power from the pumping engines is used to drive the compressors.

The location of the field and its development are discussed in some detail.

The injection of gas into an oil-producing formation not only forms a gas-drive, but also makes the oil more fluid. As the gas which was originally in the oil is spent, the oil not produced becomes more viscous and has less tendency to flow to the producing wells. Even in areas where the injection pressures are as low as 20 lb., the gas has an effect on the viscosity of the oil. At this low pressure not much of the gas can actually go into solution, but it is believed that the gas dissolves in the oil, making it less viscous and easier to drive or drain to the producing well.

After a long discussion the paper concludes thus : " A co-operative repressuring project can be successfully carried out even though there are small leases and many operators in a field.''

Mainly because of the lack of reservoir energy, and the large quantity of oil remaining in the sand, good results are shown and anticipated from the repressuring. Full utilization of the original power available is being made ; none of the operators have required additional power equipment to drive the compressors.

As periodic gas–oil ratio tests have been made and the injection volumes closely correlated with oil and gas production, none of the wells are in serious condition because of bypassing or channelling. The injection volumes required to show results are less than the produced gas volumes, although it is anticipated that more than the present produced gas volume will need to be injected to obtain the best results.

On all repressured leases the oil-production decline has been retarded. Some leases have shown a flattening of oil-production decline, and other leases have shown an increase in oil production in the past few months. The increase in ultimate recovery due to repressuring of the 220 wells in the co-operative area is estimated to exceed 800,000 brl., or 3640 brl./well. A. H. N.

1254.* Effects of Sand Grain Size Distribution upon Porosity and Permeability. W. F. Cloud. *Oil Wkly*, 17.10.41, **103** (8), 26.—The factors which affect the porosity of a sandstone are as follows : (1) the character and amount of cementing and colloidal materials, (2) the hardness or degree of compaction, (3) shape of grains, (4) arrangement of grains, and (5) the uniformity of grain size or distribution. Uniformity of grain size and shape are important factors. For example, it can be demonstrated both physically and mathematically that a gallon of No. 8 chilled shot will be just as porous as a gallon of No. 4 shot. But a 50–50 mixture of the two will have the least porosity.

Frequently very finely textured sandstones have a higher porosity than coarse sandstones, although the permeability of the latter will be much greater. Generally, if the grain shape is fairly similar throughout the various sizes and percentages of size distribution, porosity will increase and permeability will decrease as the range of finer sizes increases. For example, the average porosity of sandstones is 15·5% ; whereas that of silts and clays is 50%. If two sizes of similar sands are mixed, the porosity and permeability can be made to vary with each other as the per cent. of each component size is made to vary above or below a 50–50 mixture.

A discussion is given on sieve analysis and methods of reporting results.

Professor Cloud examined ten representative cores from ten different oil-fields located in widespread areas of the U.S. After the water and oil had been extracted, each core was dried, then drilled for a permeability sample. The scraps remaining were used for sieve analysis and porosity determination. Sieve samples were prepared by first crushing to pea size in a vise. Sieve separation of the coarse and fine particles at this stage provided coarser material for chemical separation by use of sodium acetate, and finer material for hand crushing or mild use of mortar and pestle. A binocular microscope was used to determine when complete grain separation had been accomplished. Several preliminary sieve sizings were necessary for most of the samples. Each prepared sample was weighed, then placed upon the coarse sieve in the conventional nest of eight sieves in the series. Each sample was shaken for 45 min., using a commercial machine designed for this work. Porosities were determined by using a modified Washburn-Bunting process. Permeabilities were determined in the conventional manner, using dried air at several differential pressures. The comparative results of all tests have been compiled graphically. The McClosky cumulative percentage curve is typical of colitic limestones. The permeability is very high, but the porosity is not what might be imagined unless it is recalled that there is a lack of correlation between these two properties. Of the entire group, the Woodbine sand shows the best correlation between high porosity and high permeability. This is typified on a block diagram by an appreciable coarse-size distribution and a broad " node " in the region of 65–150 mesh. The abnormal amounts of silt and colloidal material in the region of the 150-pan sizes of the Benoist, Bartlesville, Glenn, and California sand is indicative of higher than average (15·5%) porosity. On the contrary, the same conclusion is misleading for the Bradford sand, the cementing material of which is primarily secondary silica. Also the Bradford sand is too hard to be crushed accurately. The block diagram of the Layton sand portrays good porosity and fair permeability. One might expect low permeability through the Bradford, Bartlesville, and Blue Jacket sands after inspection of the curves and block plots. The Wilcox sand portrays perhaps the best " balanced " plot of the group.

As a result of these physical examinations, the author believes that for the average angular-grained sandstone of medium hardness, when the ratio of the sum of the two smallest size percentages to the percentage retained on the 100-mesh (region of normal node) is 0·50 or more, the permeability will be fair to good, and the effective porosity will be 20% or greater. A ratio lower than 0·50 will, of course, usually indicate a porosity less than 20% and low permeability, depending on grain shape and character of cementing material. A. H. N.

1255.* Critical Analysis of the Application of the Back-pressure Method in Studies of Gas Reserves. Part 1. J. W. Ferguson. *Petrol. Engr*, September 1941, **12** (13), 34.—The paper points out the correct mathematical methods of dealing with back-pressure curves. The characteristics of logarithmic scales are discussed as an introduction. The usual formula used is $Q = C_2(P^2)^n$ or written in logarithmic form: $\log Q = \log C + n \log (P)$.

The usual procedure employed to obtain a curve representing the performance of a group of natural gas wells is to choose certain values of P^2, such as 10,000, 20,000, 40,000, 80,000, and 100,000, or any others thought advisable. Then the value of Q corresponding to each of these values of P- for each well is calculated or read from the back-pressure curves, and tabulated. These values are then added, group by group, to obtain a composite value of Q corresponding to each value of P^2. These are then plotted, and the resulting curve is considered to be the composite curve for the group of wells.

Other methods are advanced elsewhere, due to the fact that the effective reservoir pressure is difficult to calculate. One of these methods was put forward by P. C. White, and the rest of the paper reveals errors in the reasoning of the method.

The effective formation pressure, together with the conventional composite curve, possess the advantage of the composite curves not being changed so long as the individual well-curves remain the same, and any changes in individual well-formation pressures will simply change the effective formation pressure; as it is impossible to predict with any degree of accuracy the changes in individual well pressures over a period of years, this effective pressure is as accurate a basis to begin from in predicting future effective pressures as is any other pressure that might be determined to be an " average " or " weighted average " pressure. A. H. N.

1256.* Progress of Intermittent Flow Devices for Producing Oil. Part 1. S. F. Shaw. *Petrol. Engr*, September 1941, **12** (13), 80.—The history of intermittent flow devices and methods is given. At the present time, the methods might be classified as follows:

1. No chamber, packer, or valve in the wall. Gas admitted to casing or tubing,

and flow is through the tubing or casing. Gas admission valve usually at the surface operated by: (*a*) manually, (*b*) tipping cylinder, (*c*) clock intermitter, (*c*) electric motor.

2. Valve in tubing; no chamber or packer (open type). Gas admitted through the casing and into the tubing through a valve operated by: (*a*) differential pressure, (*b*) wire line, (*c*) lifting or rotating the tubing.

3. Two tubing strings with chamber and standing valve; no packer in casing. (*A*) Gas admitted to annular space by (*a*) surface intermitter. (*B*) Gas admitted to the tubing and flowed through the annulus by: (*a*) manual operation, (*b*) tipping cylinder, (*c*) time-cycle intermitter, operated by clock movement, (*d*) electric motor and magnetic valve, (*e*) differential gas pressure, (*f*) lifting or rotating the tubing, (*g*) liquid-operated valve, controlled by gas pressure.

4. Packer and valve; no chamber (closed type). Gas admitted through the casing and then through ports into the tubing through valve operated by: (*a*) differential pressure, (*b*) wire-line intermitter, (*c*) lifting or rotating the tubing.

5. Packer, chamber, and valve. (*A*) Gas is admitted through the tubing and flowed through casing by surface intermitter. (*B*) Gas admitted through casing, entering chamber through valve operated by: (*a*) differential pressure, (*b*) wire-line intermitter, (*c*) lifting or rotating the tubing, (*d*) surface intermitter.

6. Plunger-lift.

Each type is discussed separately and illustrated.

This extensive paper concludes with the following general remarks: Surface injection of gas in intermittent flow does not necessarily require that a packer be set in the well, whereas injection from a point within the well usually includes the setting of a packer. With two tubing strings, as in Type 3, however, the admission of gas can be partly controlled by a valve operating on a differential pressure near the bottom of the well, and partly controlled by an intermitter on the surface.

When a packer is employed, the admission into the eductor may be made by means of a differentially-operated valve placed at a point close to the bottom of the well, or by means of a valve mechanically operated from the surface.

Each of the methods of positive control handled from the surface has its advantages and disadvantages. The wire-line method is less cumbersome and more easily operated than lifting of the tubing, but it is not readily adaptable to the handling of more than one set of valves. The frequent breaks when wire lines were operated in salt water have been materially reduced by the use of improved stainless steel wire lines when operating in corrosive fluids.

The method of lifting and lowering the tubing for intermitting involves the handling of a heavy string of tubing many times/day, and especially in a deep well, may gradually develop weakness in the coupling threads and cause parting of the tubing. On the other hand, it may be made to handle more than one set of valves when such becomes necessary.

Advantages of intermittent flow, more particularly when fluid levels are low, are those of increased production over the use of continuous gas-lift flow, and the use of less input gas/brl. of oil lifted.

Disadvantages of intermittent flow are those of more complication than in straight gas-lift, and the necessity of using moving parts in a well that gets out of order from time to time, and make a pulling job necessary. A. H. N.

1257.* Calculation of Theoretical Productivity Factor. H. H. Evinger and M. Muskat. *Petrol. Tech.*, September 1941, A.I.M.M.E. Tech. Pub. No. 1352, 1–13.—A method has been developed whereby the productivity factors of producing formations may be calculated from a knowledge of the reservoir conditions. Account is taken not only of the heterogeneous character of the gas–oil flow system, but also of the detailed variations with pressure of the shrinkage and viscosity of the oil, the solubility of the gas in the oil, and even the variability of the gas viscosity and the deviation of the gas from ideal behaviour. Curves give the results of numerical calculations on the production rate as a function of the pressure differential for a high-pressure and a low-pressure system, three values of gas–oil ratio being treated in each case. The curves show that even for a fixed gas–oil ratio and fixed behaviour of the fluids produced, the productivity factor is not a constant, but varies with the rate of production, as is actually observed in practice. The productivity factor depends not only on the detailed characteristics of the fluid and sand, but also on gas–oil ratio, pressure differential, and absolute pressure. Strictly there is no productivity factor that can be assigned to a gas- and oil-producing system with any range of validity, and a practical definition would be its restriction to the limiting slope of the rate of flow-pressure differential curve as the pressure differential is made vanishingly small.

Curves are also given showing the variation with distance from the well of the pressure, oil saturation, and permeability. The effect of connate water is briefly discussed in relation to the apparently large discrepancies between the calculated and observed productivity-factor values. G. D. H.

1258.* Natural Gas Hydrates. D. B. Carson and D. L. Katz. *Petrol. Tech.*, September 1941, A.I.M.M.E. Tech. Pub. No. 1371, 1–8.—Natural gases under pressure form crystalline hydrates with water. Experimental data are presented for the four-phase equilibrium for methane–propane–water, methane–pentane–water, and methane–hexane–water systems. Temperatures and pressures for equilibrium between gas, water-rich liquid, hydrocarbon-rich liquid, and hydrate were measured, as well as the percentages of methane and propane in the hydrate. The data indicate that natural gas hydrate behaves as a solid solution, and that pentanes and heavier hydrocarbons do not enter into the solid phase. Vapour-solid equilibrium constants are presented which permit estimation of the conditions for hydrate formation from the composition of a gas. G. D. H.

1259. Sampling Gas-condensate Wells. J. M. Flaitz and A. S. Parks. *Petrol. Tech.*, September 1941, A.I.M.M.E. Tech. Pub. No. 1374, 1–12.—Subsurface samples from gas-condensate wells are too small for the accurate determination of the heavier hydrocarbon components with normal equipment, and whilst an ordinary oil and gas separator will serve as a sampling device, phase relationships cannot be determined readily because of the difficulty of controlling temperature and pressure. However, if a sampling tube is introduced into the well tubing and material is drawn off at a rate which agrees with the velocity conditions in the tubing, a representative sample is obtained. A portable testing apparatus has been designed for use with the sampling tube.

The results of tests with a standard separator and the portable separator are tabulated. The maximum difference in condensate yield was 10%, but the deviation is much less on the basis of composite analyses. Curves show the relationship between separator pressure and the amount of separator condensate for six typical Gulf Coast fields at 100°, 80°, and 60° F., and data are plotted which can be used to predict the loss of condensate in the reservoir resulting from pressure reduction for the six fields. G. D. H.

1260. Use of Brine in a Kansas Field for Secondary Recovery of Oil. C. J. Wilhelm, S. S. Taylor, W. C. Holliman, and E. O. Owens. U.S. Bur. Mines. Rep. Invest. No. 3573, June 1941.—This report embodies findings of the Bureau of Mines in connection with the use of brine instead of fresh water in the secondary recovery of oil. It includes a detailed description of the flood project in Eastern Kansas, and North-eastern Oklahoma and sets forth general conclusions reached from an analysis of the data collected which it is suggested might be useful in initiating new projects.

The use of brine, when properly conditioned, is recommended as a flooding medium in areas where fresh water is limited or contaminated by brine produced in flooding. Its chemical characteristics should, however, be checked, together with those of brine in the formation to ensure that a mineral salt will not precipitate as a result of the two brines mixing in the formation.

Supersaturation of bicarbonates should be determined by chemical analysis and so reduced that precipitation will not occur in any part of the brine-distributing system. Moreover, oxygen content of the conditioned brine should be maintained at a minimum, since dissolved oxygen is a controlling factor in the corrosiveness of a brine to steel.

Such precautions having been taken, it was found on one lease that 8·7% of the original volume of oil was recovered before flooding and 21·3% by flooding. The average ratio of the volume of brine injected to the volume of oil produced was 14 to 1, and characteristics of oil recovered over a 20-month period showed only slight modification.

Further, results of a detailed survey showed that injected brine did not increase the salt content of the produced oil. H. B. M.

1261. Technical Research by the Bureau of Mines in Oil and Gas Production, Refining, and Utilization. H. C. Miller and G. B. Shea. U.S. Bur. Mines. Inf. Circ. No. 7173, August 1941.—The United States Bureau of Mines has a direct mandate from Congress to engage in research in oil and natural gas production, chemistry, refining, and utilization. It puts this mandate into effect through the Petroleum and Natural Gas Division, which studies technical problems of the industry, and the Petroleum Economics Division, which takes care of the statistical side.

This report indicates that research undertaken by the Bureau is not of a type usually carried out by industrial workers, although it embraces findings of a practical nature as well as those which do not appear to lead directly to the solution of immediate operating problems. The establishment of five field headquarters in major oil-producing areas, close co-operation with individual companies, groups of companies, industrial organizations, trade associations, and various States and State agencies and other factors have made unique the position of the Bureau of Mines as a fact-finding agency. Probably no other research agency has available to it so many facilities for the efficient conduct of research.

At the present time the production section is attaching great importance to the question of the fluid and energy relations in petroleum reservoirs, in order to indicate to the industry how best available energy can be utilized to obtain optimum recovery. In this connection problems concern gas–oil ratios of producing wells and fields, and the effect on ultimate recovery of changes in volumes of gas produced with oil; collection and examination of subsurface samples of crude oil to determine data on saturation changes, thermal contraction and changes in specific gravities of oils; physico-chemical properties of natural hydrocarbon mixtures, flow of air and gas through reservoir sands; and permeabilities and porosities of oil-bearing sands and rocks.

In its aim to establish more efficient utilization of petroleum through greater knowledge of its constitution and transformation into merchantable products, the chemical and refining section of the Bureau has paid special attention to the fractionation of crude oil by distillation at atmospheric pressure, vacuum distillations, and the use of solvents. Various petroleum fractions have been evaluated from the point of view of suitability for the manufacture of lubricating oils, diesel fuels, cracking stocks, etc.

In addition, the special chemical and engineering research branch of the Bureau has undertaken the study of a variety of problems connected with evaporation losses of petroleum and its products, contamination of potable waters by brines, use of cements and mud fluids in oil- and gas-wells, and mechanical, hydraulic, and chemical methods of cleaning oil-wells, etc.

Results of Bureau of Mines research in all these branches of the industry are made available through bulletins, technical papers, reports of investigations, information circulars, and special reports, some of which are classed as monographs. H. B. M.

1262. Petroleum Engineering Study of the Anahuac Field, Chambers County, Texas. C. B. Carpenter and H. J. Schroeder. U.S. Bur. Mines. Rep. Invest., No. 3579, August 1941.—The authors of this report state that their chief aim was to increase the accuracy of existing methods of estimating reserves by applying all the data collected during the modern development of an oil-field. The field chosen for detailed study—the Anahuac—ranks fourth among Gulf Coast oil-fields in estimated ultimate recovery, and presented many advantages from the point of view of collation of petroleum engineering data. The producing formation is very thick; every modern technique of drilling and development, including micropalæontological coring, electric logging, determinations of porosity, permeability and connate water, subsurface sampling of crude oil, and periodic depth-pressure measurements, has been applied; complete records of all operations, including detailed surface information, have been kept; the field has been developed systematically; and every effort has been made to utilize reservoir energy efficiently.

The conclusion is reached that the ultimate recovery of crude oil and natural gas from a field of the Anahuac type, which is heavily faulted, is most accurately estimated by the porosity-saturation method. This involves computation of net volume of the producing formation in the reservoir from subsurface records of wells, and determination of porosity, saturation, and shrinkage of oil by analysis or experiment.

Recovery which cannot be determined by analysis or experiment is based on records of depleted or nearly depleted fields having similar characteristics, or on theoretical considerations.

Thus estimated ultimate recovery of oil is calculated from the equation

$$R = \frac{7{\cdot}758\ Vpsy}{1 + x}$$

where R = recoverable oil (brl.); V = net volume of reservoir (acre-feet); p = effective porosity (%, expressed as a decimal); s = oil saturation of effective pore space (%, expressed as a decimal); x = volume increase of residual oil from 3235 lb. per square inch absolute to atmospheric pressure (%, expressed as a decimal): y = estimated oil recovery (%, expressed as a decimal), and 7758 = volume of 1 acre-foot expressed in brl. (42 gal.). H. B. M.

1263.* Laboratory Study of Water Encroachment in Oil-Filled Sand Columns. F. G. Miller. U.S. Bur. Mines Rep. Invest., No. 3595, October 1941.—The author of this report emphasizes the need for proper understanding of the phenomenon of edge-water encroachment if natural-water drives are to be used successfully in the recovery of oil from reservoir rocks.

At first the presence of edge-water was regarded as a necessary evil. More recently, however, it has come to be regarded as an integral part of the reservoir fluid and a source of energy for propelling hydrocarbon fluids through the reservoir and to the surface of the ground.

Many laboratory studies of edge-water encroachment were undertaken in earlier years which, although giving much valuable information, in general only yielded qualitative results. Thus, in view of the growing interest of the petroleum industry in the problem, the Bureau of Mines undertook an extensive laboratory investigation of water encroachment in oil-sands. The results of the first part of this research are the basis of this report, and are designed primarily to supply laboratory data on one aspect of the general problem, and not necessarily to supply information for field application.

These data concern relationship between rate of water encroachment and percentage of oil recovered by a water-drive from similar previously oil-filled sand columns; also to a lesser degree the influence of absolute sand permeability on recovery of oil by water drive.

In the course of investigations described in the report, specially prepared oil-filled columns of unconsolidated sand were flooded with water at flooding rates of the same order as rates of edge-water encroachment in actual reservoirs. The conclusion reached of principal interest to petroleum engineers is that, under certain idealized laboratory conditions and within a definite range of low water-encroachment rates, the percentage of oil recovered increases with the rate of water encroachment. Further, it is concluded that the influence of rate of water encroachment on oil recovery is more pronounced at lower than at higher rates.

It is suggested that much additional fundamental laboratory research is needed before the principles underlying the behaviour of encroaching edge-water in oil-productive formations will be understood; also that investigations of the rate and manner of edge-water movement in petroleum reservoirs should be continued in order to correlate laboratory studies with actual reservoir performances. H. B. M.

1264.* Technical Contribution to Petroleum Conservation. F. Penn. *World Petrol.*, October 1941, **12** (10), 42–45.—A brief review of conservation concepts and its lack in early production practices is given. In the modern concept of well-completion it is usual to consider one or more, and sometimes all of the following steps in completing a well efficiently as a preparation for applying the principles of conservation throughout the entire useful life of the well:

> The setting of one or more strings of casing to prevent the migration of fluids from one formation to another, whether they contain oil and gas, potable waters or other fluids.

The use of electrical logging and sidewall sampling, or other coring devices to investigate thoroughly every possible oil- or gas-producing horizon that might have been passed in drilling.

The use of the more recently developed method of γ-ray logging, either to correlate formations or to determine the success of the cementing operation when cement containing radio-active material has been employed.

The use of acid or other chemicals for the various purposes of (*a*) increasing the porosity of limestones and more recently of sandstones, (*b*) making the surface tensions of oil and water more nearly comparable, so that natural flow can be more easily established, and (*c*) for a general cleaning up of the producing formation to increase the productivity of the well.

The scraping of walls or the underreaming of a hole in order to increase the effective area of the producing formation.

The use of gravel-packing as a means of combating the tendency of loosely consolidated sand formations to slough-off and fill the well-bore.

The list could be added to indefinitely if each minor variation were to be mentioned, but the above are examples of the methods coming into use every day, all with the sole objective of increasing the efficiency whereby oil-wells are prepared for the all-important task of producing oil with as little underground waste as possible.

Conservation is also practised in improving the methods of producing and treating oils and emulsions. Thus the author carries the concept into the domain of refining and cracking as methods of conserving oil. A. H. N.

1265. Patents on Production. A. M. Gurley. U.S.P. 2,253,780, 26.8.41. Appl. 30.10.39. Hydraulic pumping unit for deep wells.

P. G. Exline. U.S.P. 2,254,006, 26.8.41. Appl. 10.11.38. Apparatus for testing well-samples.

C. S. Crickmer. U.S.P. 2,254,060, 26.8.41. Appl. 20.4.39. Packing element for an oil-well packer.

C. S. Crickmer. U.S.P. 2,254,061, 26.8.41. Appl. 30.10.39. Adjustable kick-off valve for flow devices.

L. V. Hull. U.S.P. 2,254,148, 26.8.41. Appl. 18.10.40. Pump-jack bearing.

A. Boynton. U.S.P. 2,254,207, 2.9.41. Appl. 28.11.38. Bellows-type stage-lift for wells.

G. E. Ostrom. U.S.P. 2,254,443, 2.9.41. Appl. 14.6.38. Method of treating wells with mono-chloracetic acid together with magnesium and phosphorus pentachloride to increase production.

G. L. Thompson and L. A. Cejka. U.S.P. 2,254,554, 2.9.41. Appl. 10.4.39. Well-pump with gas-line to control a valve.

C. V. Temple. U.S.P. 2,254,631, 2.9.41. Appl. 2.9.37. Gas-lift valve with a spring tending to open the valve.

Q. J. Penick. U.S.P. 2,254,752, 2.9.41. Appl. 25.9.37. Well-head assembly with retractable supporting means.

C. A. Ricou. U.S.P. 2,254,979, 2.9.41. Appl. 9.10.39. Screen cleaning gun.
A. H. N.

Transport and Storage.

1266.* Gas Storage at Low Temperature Increases Effective Capacity of Spherical Tanks. A. F. Davis. *Petrol. Engr*, July 1941, **12** (11), 100.—A gas-storage project is described in which three steel spheres are equivalent in capacity to 150 conventional gas-holders. The unique feature is the reduction ratio of 600 to 1 in liquefaction and the extremely low temperature (248–250° below zero) at which the gas is stored.

Each sphere consists of an outer shell containing 3 ft. of cork insulation on which the inner sphere "floats." The erection represents a new industrial advance made practicable by welding, and a large part of the article is devoted to details of the construction job of the alloy steel plate multi-segmented spheres, utilizing the shielded arc process. J. C.

Gas.

1267.* Safety Standards of Liquefied Petroleum Gas Industry. G. L. Brennan. *Oil Gas J.*, 14.8.41, **40** (14), 49.—A brief graphical review of the development of the liquefied petroleum gas industry is followed by a description of the method of preparation of safety standards in the industry and their adoption by the National Board of Fire Underwriters. A list is given of the more important publications with details of the basic rules in pamphlet No. 58 covering odorization of gases, examination and listing of equipment and systems, construction of cabinets, location of containers and regulating valves, container valves and accessories, hose specifications, safety devices, filling densities, and transfer of liquids. C. L. G.

Cracking.

1268. Refining Oil—Synthesis Primaries. Anon. *Chem. Tr. J.*, 10.10.41, **109**, 174.—Reference is made to a paper given by H. Velde before the German Society for Mineral Oil Research published in *Oel und Kohle*, in which a description is given of a modified catalytic process developed by Ruhrchemie A.-G. for the production of synthetic gasoline by thermal cracking. The process consists of single-stage cracking of the crude gasoline separated into different fractions, thereby raising its octane number from 55 to 65. The reactions include isomerization of straight-chain to branched compounds and of olefins (shifting of double bond from the end towards the middle of the molecule). Work has also been carried out on the polymerization, isomerization, aromatization, and catalytic cracking of fractions of synthesis products. The primary gaseous products are also polymerized with phosphoric acid catalysts at 60–80 atmospheres and temperatures below 250° C. to gasoline. Saturated gases are either used as fuel or dehydrogenated for subsequent polymerization. New catalysts for isomerization, that give considerable branching of the carbon skeleton, are claimed. C. L. G.

1269. Cracking Patents. J. G. Alther. U.S.P. 2,253,007, 19.8.41. Appl. 27.10.39. Improvement in the catalytic conversion of hydrocarbon oil wherein vapours are contacted with a cracking catalyst in a reaction zone maintained at cracking temperature. Hydrocarbon oil is passed through a heating zone independent of the reaction zone, and heated to cracking temperature. The heated oil is then passed in indirect heat exchange with the vapours and catalyst in the reaction zone, and the whole separated into vaporous hydrocarbons and residue. The vaporous hydrocarbons are then introduced into the reaction zone for catalytic conversion.

C. L. Thomas. U.S.P. 2,254,553, 2.9.41. Appl. 11.1.39. Conversion of hydrocarbon oils which are heavier than gasoline by contacting the charging oil with an alumina–chromia catalyst under conditions designed to effect conversion of paraffins in the oil into normally liquid olefins. Thereafter the olefins are separated from the normally gaseous products and cracked in the presence of a silica-alumina catalyst at a temperature below the optimum cracking temperature of the charging oil. In this way lower-boiling hydrocarbons are produced from the olefins.

P. Subkow, E. W. Gard, and R. E. Haylett. U.S.P. 2,255,399, 9.9.41. Appl. 29.10.35. Conversion of hydrocarbon gases and liquids into gasoline-like fractions having high anti-knock characteristics by subjecting normally gaseous hydrocarbons to cracking conditions. Afterwards a portion of the cracked gases are subjected to higher pressures to effect polymerization of the gases. The products of polymerization are then mixed with normally liquid petroleum hydrocarbons and with the remainder of the cracked gases and the whole passed into a heated cracking and polymerization zone under substantial pressures. In this way reforming of the added hydrocarbons and polymerization of the mixed materials are achieved. Finally the products are fractionated to yield normally liquid materials in the gasoline boiling range.

H. B. M.

Hydrogenation.

1270. Hydrogenation Patents. Standard Oil Development Co. E.P. 537,532, 25.6.41. Appl. 23.2.40. In the combined dehydrogenation and cyclization of hydrocarbons a catalyst is used consisting of a mixture of aluminium oxide and an oxide of a metal from the left side of Group VI of the periodic system. The catalyst is formed by co-precipitating the mixture from a common solution containing salts of these minerals, separating the co-precipitate so formed and drying.

H. E. Potts. E.P. 538,225, 25.7.41. Appl. 6.11.39. Preparation of an iron catalyst suitable for use in the high-pressure hydrogenation of oils in the liquid phase. Compact iron is treated with oxidizing gases at high temperatures and for a length of time sufficient substantially completely to convert the iron into iron oxide, without melting of the iron of the iron oxide formed. Thereafter the iron oxide so formed is reduced to metal by treatment with gases.

C. L. Thomas. U.S.P. 2,254,555, 2.9.41. Appl. 9.2.39. Method of treating paraffinic gasoline fractions which includes contacting it with a catalyst under dehydrogenating conditions. In this way the oil is converted predominantly into an olefinic product, which is afterwards subjected to cracking in the presence of a catalyst of different composition from the dehydrogenating catalyst, and which is selective in the breaking of carbon-to-carbon bonds.

W. A. Yarnall. U.S.P. 2,257,082, 23.9.41. Appl. 18.3.39. Dehydrogenation of normally gaseous hydrocarbons of 2 to 4 carbon atoms and low-boiling normally liquid hydrocarbons, to form olefins. The hydrocarbons are contacted at low pressures and at temperatures between 350° and 600° C., in vapour phase and in the presence of a substantial amount of carbon monoxide, with a mixture of catalysts. These catalysts include a dehydrogenating catalyst consisting of aluminium and chromium oxides, and a catalyst strongly promoting the interaction of carbon monoxide and hydrogen, consisting of the oxides of cobalt, magnesium, and thorium. H. B. M.

Polymerization and Alkylation.

1271.* Finish Year's Operation of New Type of Polymerization Unit. J. D. Waddell. *Oil Gas J.*, 28.8.41, **40** (16), 45).—The first catalytic polymerization unit licensed by the Polymerisation Process Corporation to be built in a Mid-Continent refinery recently completed its first year of operation. The relatively low investment incurred in assembling the equipment as a result of utilizing discarded cracking chambers as catalyst drums, and the subsequent favourable operating results might make this installation interesting to refiners generally.

The unit includes essentially four catalyst drums, a heater, a fractionator, pump-house, and a centralized control panel. The normal daily charge is 1500 brl., consisting of 90% C_3 and C_4 hydrocarbons, contains about 30% unsaturates, and is free of pentanes and heavier hydrocarbons. The vapours of the liquid charge preheated to about 410° F. enter the first of the series of four catalyst drums, an inlet pressure of 900 lb./sq. in. being maintained on the hot gases. These gases leave the drums at pressures ranging from 700–750 lb./sq. in.

The stream is then cooled to 200° F. and enters the plant stabilizer operating at a pressure of 200 lb./sq. in., a top temperature of 175° F., and a reboiler temperature about 385° F. The polymer product is inhibited as it leaves the cooler for storage. It usually has an end-point of 430° F., gravity 65° A.P.I., O.N. about 83·5 A.S.T.M., or 95/96 by 1939 Research Method.

The catalyst consists of copper pyrophosphate in pelleted form, and is mixed with charcoal in the proper proportions.

Arrangements are made to bypass an exhausted catalyst drum to enable it to be flushed and cooled for the removal of the spent material. D. L. S.

1272. Polymerization and Alkylation Patents. Standard Oil Development Co. E.P. 537,589, 27.6.41. Appl. 18.4.40. Process for the production of normally liquid hydrocarbons substantially completely saturated in character. A mixture containing at least one paraffinic hydrocarbon and olefinic hydrocarbons is reacted in the presence of fluorsulphonic acid. It is claimed that many of the disadvantages attaching to the use of sulphuric acid in the process of alkylation are overcome by substitution of fluorsulphonic acid.

Standard Oil Co. E.P. 537,705, 3.7.41. Appl., 19.10.39. Improved method of catalytically converting normal paraffins in a hydrocarbon mixture containing aromatics into isomeric saturated branched-chain hydrocarbons. The aromatics are removed from the hydrocarbon mixture prior to conversion of the normal paraffins.

Dow Chemical Co. E.P. 537,894, 11.7.41. Appl. 10.1.40. Process for preparing monoalkyl benzenes by reactions of olefins with benzene in the presence of an alkylation catalyst of the Friedel–Crafts type. The alkylating agent is contacted in successive stages with reaction liquors, each of which comprises an aromatic compound and a Friedel–Crafts catalyst. Aromatic compound and fresh catalyst are continuously introduced into the reaction liquor of the last stage which the alkylating agent contacts. At least a portion of the reaction liquor from each stage except the first is withdrawn and introduced into the preceding stage. Reaction liquor and suspended catalyst are continuously withdrawn from the first stage which the alkylating agent contacts, and a large part of the suspended catalyst so withdrawn returned to the first stage for re-use. The desired alkylated product is separated from the remainder of the withdrawn reaction liquor.

Standard Oil Development Co. E.P. 538,307, 29.7.41. Appl. 19.1.40. Production of normally liquid saturated hydrocarbons boiling within the gasoline range from normally gaseous saturated hydrocarbons containing at least one tertiary carbon atom and normally gaseous mono-olefins. The invention also includes similar alkylation of paraffinic hydrocarbons containing at least one tertiary carbon atom with mono-olefins, either or both components having up to six carbon atoms.

G. A. Boyd and C. H. Seeley. U.S.P. 2,253,607, 26.8.41. Appl. 19.6.37. Preparation of high anti-knock motor fuel by subjecting substantially sulphur-free gaseous hydrocarbons to controlled oxidation by contacting with steam and a nickel catalyst at 1200–1500° F. Carbon monoxide and hydrogen thus produced are mixed with substantially unpolymerizable hydrocarbons and the mixture subjected to hydrocarbon synthesis. From the synthesized hydrocarbon gases a fraction is separated containing substantially unpolymerizable fixed gases, and the fixed gases recycled to the aforesaid controlled oxidation to produce additional carbon monoxide and hydrogen. A second fraction containing polymerizable gaseous hydrocarbons is then polymerized to form hydrocarbons boiling within the motor-fuel boiling range. The polymerization product is then fractionated to recover at least one fraction comprising unpolymerized hydrocarbons and the carbon monoxide and hydrogen resulting from oxidation admixed with it. The mixture is then passed to the hydrocarbon synthesis process.

C. G. Gerhold. U.S.P. 2,254,522, 2.9.41. Appl. 8.3.39. Improved method of polymerizing olefins in the presence of sulphuric acid at polymerizing temperatures above atmospheric. In this way there is formed a polymer liquid containing sulphuric acid esters. The polymer liquid is then boiled to vaporize the lighter components. The improvement lies in supplying the heat for this boiling by direct introduction of steam to the liquid, thus preventing decomposition of the esters. The liquid is then treated with additional steam in the presence of alkali to hydrolyse and separate the esters.

H. J. Welge. U.S.P. 2,255,302, 9.9.41. Appl. 30.8.38. Polymerization of mono-olefins by subjecting a mono-olefin in gaseous state to contact with a catalyst consisting of a bisulphate of an alkali metal in solid form. The reaction is carried out at a temperature between approximately 100° C. and the melting point of the bisulphate, and in the presence of water vapour in sufficiently small proportion to avoid substantially the presence of free water in liquid state at that temperature.

D. R. Carmody. U.S.P. 2,255,843, 16.9.41. Appl. 7.12.39. Production of a high-octane-number fuel by contacting a branched-chain paraffinic hydrocarbon with methyl chloride in the presence of a metallic halide alkylation catalyst under conditions adapted to promote alkylation of the branched-chain paraffinic hydrocarbon with the organic radical of the methyl chloride.

A. R. Goldsby, E. F. Pevere, L. A. Clarke, and G. B. Hatch. U.S.P. 2,256,450, 16.9.41. Appl. 18.6.38. Alkylation of *iso*paraffins by treating olefins and an excess of low-boiling *iso*paraffins with strong sulphuric acid. In this way the *iso*paraffins are alkylated by the olefins. Afterwards the used acid is separated from the reaction products and at least part of it contacted with substantially olefin-free *iso*paraffins to strip the acid of absorbed olefins. The mixture of *iso*paraffins and hydrocarbons stripped from the acid is then passed to the alkylation operation.

A. R. Goldsby and J. C. Van Gundy. U.S.P. 2,256,880, 23.9.41. Appl. 20.4.40. Process for the continuous alkylation of *iso*paraffin hydrocarbons with olefin hydrocarbons by contacting with a liquid alkylation catalyst. Stages in the process consist in continuously passing a hydrocarbon feed containing *iso*butane, normal butane, and olefins to a series of reaction chambers, wherein the hydrocarbons are contacted with the catalyst to form alkylated hydrocarbons. The reaction mixture is continuously withdrawn from each stage and separated into a normally gaseous hydrocarbon phase rich in *iso*butane, a normally liquid hydrocarbon phase containing normal paraffins, and a catalyst phase. The normally liquid hydrocarbon phase is withdrawn and the catalyst phase returned to the stage from which it was withdrawn. The gaseous hydrocarbon phase is returned to the reaction for further contact with olefin hydrocarbons. Finally at least part of the normally liquid hydrocarbon phase is discharged and the remainder passed to the stage preceding that from which it was withdrawn.

H. B. M.

Refining and Refinery Plant.

1273.* Refining Pennsylvanian Oils with Furfural. F. T. Mertens. *Oil Gas J.*, 7.10.1940, **39** (26), 47).—A description is given of the plant and process used for the solvent extraction of Pennsylvanian oils with furfural at two refineries in Pennsylvania, with details of the products obtained. The conventional method of processing involves dewaxing of the wax distillate and reduction to neutral oil, followed by clay treatment, and clay treatment of the cylinder stock bottoms followed by centrifuge dewaxing and removal of dilution naphtha. With furfural refining the crude charge is split into the same two products ; if no solvent dewaxing is to be carried out, the solvent extraction preceding the reduction and clay treatment of the wax distillate, and being the first stage of the cylinder stock treatment. If solvent dewaxing is carried out after solvent extraction, the crude charge is distilled to a higher viscosity distillate, giving the neutral oil on finishing. A typical treatment consists of preheating to 140–180° F. and charging to the middle of the vertical counterflow extraction tower, at the top of which furfural at 200–280° F. is introduced. The refined oil solution is removed from the top of the tower, heat exchanged, and stripped in a vacuum flash and stripping tower. Extract and solvent from the base of the tower are flashed in an atmospheric column which removes 30–40% of the solvent, and then in a pressure-flash section, followed by a vacuum steam stripper. Furfural is removed from condensate water by taking advantage of the formation of a constant-boiling mixture with water.

A yield of 90·1% of raffinate of 101·5 V.I. is obtained from zero pour point 94·4 V.I. dewaxed Penna 600 stock, and of 89·8% of raffinate of 109·6 V.I. from − 10° F. pour point 93·5 V.I. Penna Neutral. Furfural refining is claimed to improve the stability and sludging tendency of these oils, and has reduced percolation filter costs by increasing the filter yields from 50% to over 300%. C. L. G.

1274.* (Shell Operating) First Solutizer Treating Plant at Wood River. L. E. Border. *Oil Gas J.*, 7.11.40, **39** (26), 55.—A description is given of the operation of the first solutizer treating plant at a Wood River Refinery. The plant has a capacity of 15,000 brl. per day handling a blend of straight-run, cracked, and reformed gasoline. The solutizer used is composed of 6N-KOH, plus 3N-potassium *iso*butyrate, and is prepared by neutralizing with *iso*butyric acid one-third of the KOH in a 9N-KOH solution. The plant consists of an extraction section and a regenerating section (flow-sheet given). Gasoline cooled to 85° F. is passed to the foot of the 58-ft. extraction tower which contains a 30-ft. section of carbon-ring packing and baffles. The sweetened gasoline from the top of the tower contains 0·02% of solutizer solution, 90% of which is removed in a settler and the balance in a steel-wool coalescer, no further treatment being required. The spent solution contains 1% of suspended and 0·5% of dissolved gasoline, the latter being liberated on dilution with stripped aqueous condensate from the regenerator. The diluted solution is heated to 255° F. and passed to the stripping column, where part of the mercaptan removal takes place, the remainder being removed in the reboiler. The solutizer treatment reduces the mercaptan sulphur and total sulphur from 0·09% and 0·12%, respectively, to 0·0004% and 0·03% respectively, the octane number being increased from 69·5 to 70.

The untreated gasoline requires 0·65 and 2·20 c.c. of T.E.L. per gallon to increase the O.N. to 75 and 80, respectively, whereas the treated gasoline only requires 0·38 and 1·30 c.c., respectively. An overall saving of 5 c. per brl. over conventional doctor treatment is claimed. C. L. G.

1275.* Refining Characteristics of Mississippi Crude. D. Read, Jr., and G. Egloff. *Oil Gas J.*, 31.7.41, **40** (12), 148.—The Tinsley field of Yazoo County, Miss., now ranks among the major oil-fields. The reserve pressure in the field is relatively low in all sands, and approximately half the 200 wells at present in production are on artificial lift, but this does not greatly affect the recoverable reserve estimate.

At the moment approximately 62% of production moves to Louisiana for transhipment and refining, 15·5% goes to Illinois, direct shipments to Kentucky and Tennessee refiners account for 9 and 5%, respectively, whilst about 8·5% is refined within the State.

A 34·2° A.P.I. gravity representative sample of this crude was distilled in a 10-in. laboratory Hempel column to produce 15% gasoline, 10% naphtha, 12% kerosine, 8% diesel fuel, 40% heavy gas-oil, and 15% asphalt bottoms. In additional break-ups the crude was fractionated to produce 400° F. end-point gasoline, 525° F. end-point kerosine, and topped and reduced crudes.

Both a 40% gas-oil fraction and a 25·4° A.P.I. topped crude were thermally cracked to determine the yield and quality of the products obtainable.

Tinsley crude is similar to Mid-Continent material in gasoline content and gravity. Detailed properties of the crude and laboratory distillation analyses are given in tables included in the paper. Although the sulphur content of the crude is 0·79%, the light straight-run fractions were each sweet, and contained only small amounts of sulphur. The distillate fractions were high in paraffinic compounds, as shown by low specific gravities and relatively low octane numbers. The crude yielded 27·6% of 390 O.N. 400° F. end-point gasoline or 14·9% 52·5 O.N. spirit, indicating that the light gasolines would be unsuitable as aviation base stock. The kerosine was of good quality, whilst the diesel fuel (cetane number 57) would be satisfactory for high-speed engines. The asphalt bottoms after removal of the 40% gas-oil fraction had a penetration at 77° F. of 40.

As a result of cracking the gas-oil fraction 58·6% of 68 O.N. gasoline was produced, as against 50–53% when using a topped crude. The sweetened gasoline from the gas-oil cracking gave an O.N. of 77·5 by the addition of 3 c.c. T.E.L. per gallon, whilst that obtained from the topped crude gave under the same conditions a 75·5 O.N. product. C. L. G.

1276.* Greatly Improve Lead Response by Desulphurizing Gasoline. W. T. Ziegenhain. *Oil Gas J.*, 28.8.41, **40** (16), 42.—The octane value of the straight-run gasoline produced in the 2000-brl. plant of Malco Refineries, Inc., located at Artesia, N.M., has been greatly improved by the recent installation of desulphurizing equipment.

The plant processes crude from the Artesia and Maljamar fields, and the gasoline was formerly sold as third-grade motor fuel. By treatment using the Perco catalytic desulphurization process, the sulphur content of the gasoline has been reduced by 95%, its O.N. increased by about 3 units and with 1 c.c. of T.E.L. by about 7 units. With higher additions of lead the improvement is even more marked.

When base-stock for ethyl gasoline is required, about 10% butane-free natural gasoline is added to the feed-stock to be treated, and a fuel is obtained which, with slightly less than 2 c.c. T.E.L., has O.N. of 80.

The paper includes a simplified flow-sheet and a brief description of the process.
D. L. S.

1277.* Refinery Piping—Providing for Expansion in Hot Lines. R. G. Lovell. *Petrol. Engr*, July 1941, **12** (11), 27.—A general analysis from a practical viewpoint of the problem of providing for expansion in refinery hot pipe-lines. A curve of the linear expansion of steel pipe against temperature is shown, and a discussion is included of bursting stress, creep, and plastic flow. Various expedients, such as pipe-bends and expansion joints for above-ground pipe-lines, are described. The theory of expansion phenomena for underground pipe-lines is considered incomplete and a new theory is developed to agree with practice. The protection of valves by concrete anchors and means for obtaining leak-free threaded joints, with a table for determining thread specifications, are given. J. C.

1278.* Submerged Coolers for Refinery Service. D. E. Fields. *Petrol. Engr*, 1941, **12** (12), 98.—With tubular condenser banks of the usual construction, the removal of tubes which require replacement is an operation which demands a considerable amount of end-space, and entails lifting the entire bank of tubes from the condenser box.

The form of construction here described makes it practicable to remove any tube or all the tubes from the bank without removing the latter from the box, provided about 2 ft. of space is available between the cooler and the sides of the box. The tubes are supported at either end by means of two tube-sheets, the intermediate support being given by horizontal rollers. U-shaped spacers are slipped over alternate vertical rows of tubes, straddling the rollers, the spacers and rollers being locked in position.

The tubes are readily removed by unlocking and removing the spacers and rollers, and withdrawing the tubes through the side of the bank, " springing " them out of the end tube-sheets. C. G. G.

1279.* Rerun Unit Designed to Operate with Heating Medium and Exchangers. Anon. *Refiner*, September 1941, **20** (9), 386–389.—A departure from the conventional distillation practice is in the method of evaporation. Instead of charging the distillate to direct-fired tube-stills, an enclosed system was developed through which a separate heating medium is circulated at controlled temperature and volume, using shell-and-tube exchangers in conjunction with the heat medium circuit, and fractionating column to evaporate the pressure distillate.

The fractionating tower was designed especially for re-running the pressure distillate. It is 13 ft. in diameter and 48 ft. 6 ins. high, equipped with twelve fractionating bubble trays and six stripping plates, all of which are installed on 24-in. spacing, and has clean-out manholes at each tray. The 18-in. vapour line at the overhead outlet is flanged directly to a shell-and-tube vapour-to-charge exchanger which contains 1720 sq. ft. of tube surface. Two heat medium exchangers heat the feed to the column, the first having 710 sq. ft. and the second 1500 sq. ft. of tube surface. The second exchanger is located in a vertical position close to the tower, with a single pass through the tubes to permit of nearly complete vaporization of the feed without excessive pressure drop.

The heat medium is a 32–33° A.P.I. gas oil, which is picked up from a 9 ft. × 12 ft. horizontal surge-tank by a steam-turbine-driven centrifugal pump, and discharged with a pump pressure of 60 lbs./sq. in. to direct-fired tube-stills in which about 40,000,000 B.t.u./hr. are liberated. The outlet or transfer line of the heat medium heater is maintained at 610° F. and the pressure of 48 lb./sq. in. to the various exchangers included in the heating circuit.

Laboratory as well as operational data are included in the description of the operation of the plant. A. H. N.

1280.* Combination Charging Stock Yields High Octane and Extended Run. Anon. *Refiner*, October 1941, **20** (10), 411–412.—Through an uninterrupted run of 2561 hr.

one refinery obtained an overall liquid yield of 94·45%. In this yield was 60·85% overhead distillate, which was fractionated to an end-point of 395° F., having a gravity of 61·7° A.P.I. The octane value of this product was 68, research method, which, with the addition on 1 c.c. T.E.L., was raised to an octane value of 75.5. The charge to the fractionating tower during this 106-day run consisted of a mixture of reduced crude and fresh crude.

This plant was built as a straight skimming plant. A single-furnace Dubbs cracking unit built in 1939 had a capacity of 1000 brl./day, to operate as a full flashing, selective cracking unit. In 1940 the plant was increased to its present capacity of 2000 brl. by adding a second furnace and the necessary pumps and instruments for adequate operation and control. Certain details of the plant are described.

A. H. N.

1281.* Qualified Welding in Refining. W. L. Archer. *Refiner*, October 1941, **20** (10), 413–416.—To-day welding is being performed in conformance with rules and regulations of apparently haphazard nature but of real importance and significance. The paper deals with each factor separately, explaining their significances. The subjects discussed cover process, base metal, filler metal, position, preparation of base material, nature of electric current, size of welding tip, nature of flame, method of welding (backhand or forehand), welding technique, cleaning, defects, peening, treatment of underside of welding groove, preheating, heat treatment, and tests required.

The paper is the first of a series on welding. A. H. N.

1282.* Steam Generating Unit Also Improves Fractionation and Condensation. Anon. *Refiner*, October 1941, **20** (10), 417–418.—By installing equipment for generating steam by heat exchange with streams of flash-chamber and the main fractionating column, one company has augmented its boiler-feed as well as improved operation of the fractionating column. Before being returned to the column for reflux the light oil-stream operates in steam generation, with the result that a smaller quantity is required for maintaining the proper top temperature for the column. The heat reduction in the residuum stream from the flash-chamber is reduced by 300° F. in its heat exchange, with the result that less water is used for condensation.

The steam generating unit produces an average of 4500 lb. of steam/hr. at 125 lb./sq. in.

Residuum from the flash-chamber is withdrawn at 805° F., which in conventional operation is water-cooled to required storage temperature. In the main fractionating chamber the light oil-stream has a temperature of 560° F. Taking advantage of the temperature of both streams, facilities were recently installed for steam generation. The details are given briefly. A. H. N.

1283*. Caustic-Methanol Mercaptan Extraction Process. F. W. Field. *Refiner*, October 1941, **20** (10), 419–420.—A radically new refining process, developed by the Atlantic Refining Co., removes mercaptans from gasoline and substantially improves its lead susceptibility. Octane rating suffers no loss in any gasoline treated by this process, and in many gasolines is increased.

Mercaptan removal is brought about by extraction with an aqueous solution of caustic soda and methanol. The caustic is continuously regenerated, and the methanol almost entirely recovered. The process is based on existing patents and a considerable number of recent applications.

The tetraethyl lead saving caused by the elimination of octane loss, and the increase in lead susceptibility produced by caustic-methanol extraction, will usually pay all costs of operating the process, and in some instances yield a profit.

Advantage can be taken of the higher finished octane and lower sulphur content obtainable by caustic-methanol extraction in any of three ways: (1) By using less tetraethyl lead and selling a product of the same quality as before installation of the process. (2) By using approximately the same amount of lead and selling a better product. (3) By using a higher proportion of sour crudes. If a product of the same octane rating as before the installation of caustic-methanol treating is marketed, the lead savings are substantial. Few gasolines will show a saving of less than 0·25 c.c. tetraethyl lead/gal., whilst in some the savings run to as high as 1·0 c.c.

The flow of the process is described. Laboratory test results are given to substantiate the claims made with regard to the octane rating and response of treated gasolines. A. H. N.

1284.* Skimming Heat from Cracking Unit. Anon. *Refiner*, October 1941, **20** (10), 425–426.—The skimming side of the refinery is separate from the cracking section, but dependent on it for heat. Instead of a skimming pipe still, as in conventional plants, the crude passes through several exchangers and two salt-settling drums before it is flashed to one of two bubble towers for the manufacture of straight-run gasoline. The first bubble tower in the skimming section removes only straight-run gasoline, whilst the second tower is restricted to naphtha, kerosine, diesel-fuel distillate, and topped crude.

The fresh crude is pumped through an exchanger on the kerosine stream and passes through the second bubble tower overhead vapour exchanger to the first salt-settling drum. Without further application of heat, the charge enters the second salt drum, and from this vessel exchanges heat with overhead vapours from the cracking plant first fractionating column, and goes to the first bubble tower of the skimming section. Gasoline is produced and fractionated to end-point with condensate pumped back over the top, and, to increase the recovery of this material, the bubble tower is equipped with a base heater, or reboiler, the heat of which is obtained from the cracking plant residuum exchanger and products cooler.

The cracking plant is next described with some detail of the operations. A. H. N.

1285. Patents on Refining and Refinery Plant. Standard Oil Development Co. E.P. 538,697, 13.8.41. Appl. 25.4.40. Method of carrying out catalytic reactions involving periodic regeneration of the catalyst. The invention is particularly adapted to the catalytic treatment of hydrocarbon oils such as cracking, purifying, and refining in the presence of a solid contact mass.

Standard Oil Development Co. E.P. 538,747, 14.8.41. Appl. 12.8.40. Improved process and apparatus for dewaxing petroleum distillates by means of which it is possible to secure optimum heat transfer and hence improved operating efficiency. The waxy distillate is chilled by the vaporization of a refrigerant therefrom. Thereafter waxy constituents are removed from the chilled oil and the dewaxed oil contacted with the vaporized refrigerant to condense it.

W. Mendius. U.S.P. 2,252,020, 12.8.41. Appl. 11.5.38. Improvement in the fractionation of petroleum stocks by means of towers into which a stream of the stock is discharged after being heated to vaporize a substantial part thereof. A liquefied fraction which has been withdrawn from the tower is reintroduced at a point below that at which it was withdrawn. The fraction being cooled is passed in indirect heat exchange with the vapours and liquids flowing through the tower in a region below the point at which it is reintroduced.

F. L. McKennon. U.S.P. 2,253,638, 26.8.41. Appl. 15.12.39. Method of removing acid reacting materials from a hydrocarbon liquid by treating with an aqueous solution of a strong base containing a substantial amount of an urea dissolved in it. Conditions are adjusted to effect extraction of the acid reacting materials from the hydrocarbon liquid and leave it substantially free of undesirable acid reacting materials.

P. J. Gaylor. U.S.P. 2,254,364, 2.9.41. Appl. 9.6.38. Method of treating petroleum oil by contacting it with a normally solid aromatic ester of a phthalic acid at a temperature below the complete miscibility temperature of the oil and the solvent, but above that at which the solvent solidifies. After such treatment the raffinate and solvent extract phases are separated.

E. J. Houdry. U.S.P. 2,255,060, 9.9.41. Appl. 2.8.39. Process for producing clean distillate stock from liquid or liquifiable hydrocarbons. The hydrocarbon charge is heated to at least 800° F. to provide a mixture of vaporized and unvaporized material, which is subsequently fed to an enlarged coking zone. A vaporizing medium is used to minimize formation of material within the gasoline boiling range. The liquid material in the coking zone is agitated by feeding at least part of the fluids entering the zone to the lowest part. In order to effect rapid decomposition of the liquid material into vaporized material and coke, the whole of the coking zone is maintained at a temperature above 800° F. The rate of feed to the coking zone is controlled in such a way that vaporized material remains there for less than 50 sec. Production of material in the gasoline boiling range is limited to not more than 5% by weight of the hydrocarbon charge.

H. O. Forrest. U.S.P. 2,255,283, 9.9.41. Appl. 21.11.38. Method of refining a heavy petroleum oil to produce lubricating oil. A residual lubricating-oil stock containing uncracked heavy components and resins is fractionated into at least one viscous oil fraction having a viscosity at 210° F. below 300 sec. Saybolt and a resin fraction having a viscosity at 210° F. of more than 300 sec. Saybolt. The resin fraction is then diluted with a hydrocarbon diluent heavier than propane, but lighter than the removed viscous oil fraction. The diluted resin fraction is contacted with clay in the absence of the separated viscous oil fraction and the latter separately treated to improve its colour and quality. Finally, at least a portion of the clay-contacted resin fraction is blended with the treated viscous oil fraction to improve the quality of the viscous fraction.

W. A. Schulze. U.S.P. 2,255,394, 9.9.41. Appl. 9.11.38.—Production of sweet motor fuel from crude petroleum oil by first subjecting it to a medium-temperature flashing operation to produce stabilized crude oil and a low-boiling straight-run gasoline; then subjecting the stabilized crude oil to distillation to produce straight-run gasoline and topped crude; subjecting the topped crude to cracking to produce a gaseous fraction containing some gasoline hydrocarbons and a fraction consisting of cracked gasoline; processing the gaseous fraction to recover the gasoline content, and separating the cracked gasoline into a low-boiling fraction containing seven and less carbon atoms per molecule and a higher-boiling fraction containing more than seven carbon atoms per molecule. The improvement lies in sweetening the cracked gasoline fraction containing more than seven carbon atoms per molecule by treating with a cupric chloride solution, followed by sodium sulphide stabilization. The remainder of the gasoline fractions are sweetened by passage with dissolved air over a solid adsorbent reagent impregnated with a solution of cupric chloride.

C. Ellis, T. C. Whitner and W. V. Keegan. U.S.P. 2,255,417, 9.9.41. Appl. 3.12.38. Method of sweetening sour petroleum oil containing mercaptans by converting the latter into oil-soluble mercaptides of a heavy metal. Afterwards the oil containing the mercaptides in liquid phase is treated with a salt of a halogenated monocarboxylic acid and the salt reacted with the mercaptides to form oil-soluble derivatives which can subsequently be removed from the oil.

W. A. McMillan. U.S.P. 2,256,405, 16.9.41. Appl. 5.12.39. Process of recovering normally gaseous petroleum hydrocarbons, including propane, from a gas mixture. The hydrocarbons are continuously absorbed in an absorbing oil to produce an enriched oil, which is then passed to a still and subjected to distillation to remove absorbed hydrocarbons. The oil from which the hydrocarbons have been removed is withdrawn and a liquefied fraction consisting predominantly of propane segregated from the removed absorbed hydrocarbons. At least a portion of the absorbed oil is mixed with the segregated fraction in an amount sufficient to precipitate tarry constituents. The mixture is maintained at a temperature substantially above atmospheric and the resulting precipitate removed. The remaining solution of purified absorption oil is mixed with the enriched oil passing to the still, and the mixture subjected to distillation to effect simultaneous vaporization of normally gaseous hydrocarbons from both the purified oil and the enriched oil. The lean oil, including that from which the tarry constituents have been removed, is returned to the absorption cycle.

G. W. Duncan. U.S.P. 2,257,547, 30.9.41. Appl. 17.3.39. Process for the solvent treatment of mineral oils which comprises contacting a petroleum lubricating oil in a counter-current treating system with phenol at a temperature between 90° and 250° F., and under conditions designed to form a solvent extract phase and a raffinate phase. The solvent extract phase is separated and extract oil recovered therefrom.

5–20% of water is added to the raffinate phase at a temperature at which the raffinate phase separates from a phenol–water phase. The raffinate oil is separated and the phenol completely removed from it. The phenol–water phase is then separated and returned to the counter-current treating system at a plurality of stages between the point of introduction of the oil-feed and the point at which the raffinate phase is withdrawn. H. B. M.

Chemistry and Physics of Petroleum.

1286.* Measurement of Flame Gas Temperatures. W. T. David. *Engineer*, **172**, 4471, 186–187.—The author discusses the agreement which may be expected between the measured temperatures by well-known methods and the ideally calculated temperatures of combustible gas–air mixtures.

The accuracy of the sodium-line reversal method is shown to be susceptible to the degree of mixing and to the effects of sodium salts present in the mixture.

Flame-gas temperature measurements carried out with platinum and platinum-rhodium wires showed that provided the wire is quartz-covered, substantially correct results can be expected when measuring temperatures of flame gases resulting from the combustion of carbon monoxide–air and hydrogen–air mixtures. E. F. C.

1287.* Thermal Conductivity of Twelve Industrial Chlorinated Hydrocarbons. O. K. Bates, G. Hazzard, and G. Palmer, *Industr. Engng Chem.*, 1941, **33** (3), 375.—The thermal conductivity and temperature coefficients of conductivity are given for methylene chloride, chloroform, carbontetrachloride, dichloroethylene Di-48, dichloroethylene Di-60, β-trichloroethylene, tetrachloroethylene, ethylene dichloride, trichloroethane, tetrachloroethane, pentachloroethane, and propylene dichloride. J. W. H.

1288.* Diffusion, Thermal Conductivity and Viscous Flow. R. E. Powell, W. E. Roseveare, and H. Eyring. *Industr. Engng Chem.*, 1941, **33** (4), 430.—A general theory of viscosity, diffusion, thermal conductivity, and ionic conductivity is developed in terms of the statistical mechanical theory of reaction rate. These properties are shown to be quantitatively expressed by equations which are in terms of measurable thermodynamic properties. These equations include the case of the interdiffusion of molecules of different sizes. J. W. H.

1289.* Heat and Vapour Transfer in a Wetted-wall Tower. W. A. Barnet and K. A. Kobe. *Industr. Engng. Chem.*, 1941, **33** (4), 436.—Heat-transfer data were obtained from the operation of a wetted-wall tower with countercurrent flow of a mineral oil and air. Simultaneous heat and vapour transfer data were obtained by operation with air and water. The results of these experiments showed that in all cases the gas film controlled the rate of heat transfer, whether or not simultaneous vapour transfer occurred. The data are correlated by the Nusselt, the Chilton–Colburn, and the Arnold theories. The Arnold and Colburn theories are better correlation between heat and vapour transfer than the Nusselt theory. The heat-transfer coefficients for direct contact with gas and liquid, as determined in this investigation, are considerably larger than those normally obtained when the fluids are separated by a metal wall; for which reason heat transfer between gas and liquid should be carried out whenever possible by direct contact. J. W. H.

1290.* Simplified Calculation of Diffusional Processes. A. P. Colburn. *Industr. Engng Chem.*, 1941, **33** (4), 459.—Equations are derived which, when represented graphically, enable the number of theoretical plates required for a given separation to be calculated with an accuracy of 2–9% for absorption, distillation, and countercurrent liquid–liquid extraction processes. The simple equations are extended to apply to cases when there is curvature in the operating or equilibrium lines or both. Four examples are given showing the method of evaluating the number of transfer units and theoretical plates required for a given separation. J. W. H.

1291.* Calculation of the Effect of Reflux Ratio in Batch Fractionation. A. Rose and H. H. Long. *Industr. Engng Chem.*, 1941, **33** (5), 684.—This paper summarizes the results obtained by calculation of the effects of reflux ratio on the distillation curves of binary mixtures for different values of vapour-pressure ratio (a) and the number of plates (n). The principal conclusions are as follows :

1. The magnitude of the effect of reflux ration (R) depends, in order of importance, on α, R, and n.
2. The effect of increasing R is proportionately greater for a small value of R and for given values of α and n, and in many cases there is an insignificant increase in the sharpness of separation for increased values of R beyond a certain point.
3. Where α is small, R has little effect on the sharpness of separation, unless n is large.

J. W. H.

1292.* Calculation of Theoretical Plates Required for Separation of Two Normal Liquids by Batch Fractionation. A. Rose. *Industr. Engng Chem.*, 1941, **33** (5), 594.—Equations and graphs are given for the estimation of the number of theoretical plates (n) at minimum, optimum and maximum reflux ratio (R) required for a standard separation of two similar normal liquids with normal vapour–liquid equilibrium relationships and in cases when the usual simplifying assumptions of distillation and negligible hold-up are justified. The separation selected is that the first 40% distillate, 50–50 mixture is to have an average purity of 95 mol.-%. For optimum conditions

$$n = \frac{2{\cdot}85}{\operatorname{Log}_{10} a} = R$$

in which a is the vapour-pressure ratio of the two components undergoing separation.

J. W. H.

1293.* Design of Fractionating Columns for Very Dilute Solutions. Tzeng-Jiueq Suen. *Industr. Engng Chem.*, 1941, **33** (5), 656.—When the concentration of one of the components of a binary mixture is very low, the construction of a McCabe and Thiele diagram is laborious, due to the large number of steps required at the ends of the separation. For very dilute solutions it is shown that the vapour–liquid equilibrium is practically linear and the use of an algebraic method based on this property, analogous to the Browns absorption factor, is explained. J. W. H.

1294.* Nomographs for Thermal Conductivity of Gases and Vapours. D. S. Davis. *Industr. Engng Chem.*, 1941, **33** (5), 675.—Three nomographs are presented illustrating the conductivity–temperature relationships of some thirty-two substances, including ten hydrocarbons. In addition a nomograph is given relating H_2 with conductivity for mixtures of H_2, CO_2, N_2O, and N_2 at 32° F. J. W. H.

1295. Petroleum Bases. II. Amino- and Hydroxy-Derivatives and a Contribution to the Chemistry of Diazo-Oxides. L. R. Modlin, Jr., and A. Burger. *J. Amer. chem. Soc.*, 1941, **63**, 1115–1118.—This paper gives an account of the preparation of various amino- and hydroxy-derivatives from the kerosine base, 2 : 3 : 8-trimethylquinoline. The conversion of 2 : 3 : 8-trimethylquinoline-6-diazo-5-oxide into 2 : 3 : 8-trimethylquinoline-5 : 6-quinonedioxime by means of hydroxylamine represents a reaction hitherto unknown for *o*-diazo-oxides. R. D. S.

1296. Polymerization of Olefins. III. Polymeric Olefins from Methyl*iso*propylcarbinol. F. C. Whitmore and W. A. Mosher. *J. Amer. chem. Soc.*, 1941, **63**, 1120–1123.—The authors studied all the products of the reaction of 75% sulphuric acid with methyl*iso*propylcarbinol at 80° C. and, incidentally, confirmed the findings of Drake, Kline, and Rose (*J. Amer. chem. Soc.*, 1934, **56**, 2076), who found only two decenes : 3 : 4 : 5 : 5-tetramethyl-2-hexene (A) and 3 : 5 : 5-trimethyl-2-heptene (B), among the products of reaction. The following is a complete list of the products identified, together with their yields. Trimethylethylene, 1% ; 3-methyl-2-pentene, 3% ; methyl*iso*propyl ketone, 1% ; di*iso*butylenes, 1% ; 2 : 3 : 4 : 4-tetramethyl-1-pentene,

2%; other nonenes, 1%; decene (A), 45%; decene (B), 35%; higher polymers, 5%; intermediates, 5%. The authors synthesized 3 : 5 : 5-trimethyl-3-heptanol by the action of ethyl magnesium bromide on 4 : 4-dimethyl-2-hexanone. It was first dehydrated with copper sulphate and, secondly, with 75% sulphuric acid at 80° C. The ratio of the resulting isomers was different in each case. The relation of this dehydration to the structure of the polymers is discussed. Ethyl Grignard reagent would not add to 3 : 4 : 4-trimethyl-2-pentanone, nor would methyl Grignard reagent add to 4 : 5 : 5-trimethyl-3-hexanone, enolization being the chief reaction in each case.
R. D. S.

1297. Chromium Oxide Gel Catalysts for Dehydrocyclization of *n*-Heptane. J. Turkevich, H. Fehrer, and H. S. Taylor. *J. Amer. chem. Soc.*, 1941, **63**, 1129–1131.—The authors prepared chromium oxide gel catalysts by the following methods, with a view to examining their characteristics in the dehydrogenation-cyclization of *n*-heptane and determining the composition of the liquid product in olefins and aromatics: (*a*) the standard gel, by slow precipitation with dilute ammonia from dilute chromium nitrate solutions; (*b*) formation from a chromium oxide jelly; (*c*) from chromic acetate; (*d*) as amorphous chromium oxide by reduction of chromic acid by alcohol and other organic reducing agents. Catalysts prepared by alcohol reduction of chromic acid were found to be highly active and readily prepared in bulk. The catalysts prepared by partial reduction of chromic acid with oxalic acid were also readily prepared, and found to possess high aromatizing activity, but only moderately active products were obtained by the reduction of chromic acid by sugar solutions. During the dehydrogenation of heptane, it was found that a fall in activity steadily occurred which reduced catalyst activity for subsequent dehydrogenations of *cyclo*hexane.
R. D. S.

1298. Thermal Stability, Poisoning, Revivification and Reactivity of Chromium Oxide Gel Catalysts for Dehydro-Cyclization. D. J. Salley, H. Fehrer, and H. S. Taylor. *J. Amer. chem. Soc.*, 1941, **63**, 1131–1133.—This paper records the characteristics of the chromium oxide gel catalysts used in the experiments reported in the previous paper. It was found that water can be desorbed from gels between 300° and 550° C. Negligible amounts of hydrogen are desorbed above 350°, but a small amount is removed between 300° and 350° C. The colour of the gel is no criterion of the harmful " glow " phenomenon, but indicates the state of oxidation of the surface; thus, black indicates an oxidized surface and green a reduced surface. During dehydrogenation and dehydrocyclization the catalyst becomes spent but can be revivified by passing oxygen–nitrogen mixtures over the surface, which is cleansed by oxidation of the carbonaceous products. Poisoning and revivification can be repeated continuously without affecting the efficiency of the catalyst. The conditions for revivification are given. Water vapour acts as a poison, temporarily retarding dehydrogenation. The gel is stable up to temperatures of 600° C. and over when properly controlled. R. D. S.

1299. Thermal Data on Organic Compounds. XXI. Some Heat Capacity Entropy and Free Energy Data for the Four Methylnonanes. G. S. Parks, T. J. West, and G. E. Moore. *J. Amer. chem. Soc.*, 1941, **63**, 1133–1135.—The paper tabulates specific heats and corresponding heats of fusion between 80° and 298° K. The entropies in the liquid state at 298·16° K. have been calculated therefrom. In addition, the calculated free energies of 2-methyl- and 5-methyl-nonane were found to be lower than *n*-decane.
R. D. S.

1300. Determination of Critical Temperature from Index of Refraction. S. W. Wan. *J. phys. Chem.*, 1941, **45** (6), 903.—A linear relation between the critical temperature (T_C) and molecular refraction (R) of the form $T_C = K_1R + K_2$ is derived for compounds belonging to specific chemical groups. The values of the constants for hydrocarbons, alcohols, ethers, carboxylic acids, esters, and nitriles are given. The agreement between the calculated and experimental values of T_C is good. J. W. H.

1301.* Chart to Provide Approximate Correction for Temperature and Deviation from Boyle's Law. A. D. Brokaw. *Petrol. Tech.*, September 1941, A.I.M.M.E. Tech. Pub. No. 1375, 1–3.—The chart was prepared by interpolating for the desired values in the data of Burke and Keyes, and Kvalnes and Gaddy on the compressibility of methane, after adjusting their results from 0° C. to 60° F., and combining the correction factors for compressibility and temperature into a single multiplier, which, applied to the product of pressure and reservoir volume, gives at once the volume at one atmosphere and 60° F. Correction factors or multipliers at intervals of 0·05 from 0·55 to 1·40 have been plotted.

The computation applies strictly only to pure methane, and for natural gas composed of mixed hydrocarbons the estimates will be low, because of the greater compressibility of such gases. Brown has worked out approximate corrections for mixtures of hydrocarbon gases, and a table gives the amounts to be subtracted from the pressure and temperature to change the origin of the chart to give an approximation to Brown's results when the specific gravity of the gas is known.

Two examples are worked out, and it is indicated that the accuracy of the method is higher than that likely to obtain in estimating the reservoir volume. G. D. H.

1302.* Chemical Conversions of Lighter Hydrocarbons. G. Armistead, Jr. *Refiner*, September 1941, **20** (9), 327–336.—A national emergency, with its extra demands for special synthetic fuels and numbers of other products, including pure hydrocarbons and their derivatives, increases the importance of petroleum and natural gas as a chemical raw material. As such they have advantages, including abundance and wide distribution, ease of transportation, and a make-up almost wholly of carbon and hydrogen. The most important hydrocarbons for chemical conversions so far have been the lighter ones up to the octanes (C_8), chiefly because of the type and current demand for their derivatives, the fact that many of them lie within the gasoline boiling range, and the relatively low number of isomers. The paper summarizes the various types of conversions applicable to these hydrocarbons, which now are or have prospect of being of particular commercial importance.

The processes briefly outlined under separate headings are: (1) Catalytic polymerization. (2) Thermal polymerization. (3) Gas Reversion (Polyforming). (4) Thermal alkylation. (5) Catalytic alkylation. (6) Isomerization. (7) Dehydrogenation. (8) Fischer–Tropsh process. (9) Hydroforming and other aromatization. (10) Rubber substitutes from petroleum. (11) Miscellaneous chemicals from petroleum. All these processes have the common denominator of applying to the conversion of the lighter aliphatic hydrocarbons to specific other compounds or classes of compounds by more or less clearly defined reactions.

Under "Miscellaneous Chemicals from Petroleum" come the products of cracked gases. These gases, with their substantial olefine content, are a primary source of chemicals, starting with the sulphuric acid absorption of the olefines, followed by hydrolysis and other reactions producing a variety of alcohols, ketones, ethers, and other products. Acetone is being prepared from propylene by first converting it to *iso*propyl alcohol and then dehydrogenating to acetone. Ethyl alcohol is prepared from ethylene. Amyl alcohol and its derivatives are prepared from the chlorination of pentane. By chlorination of ethylene, followed by other reactions, ethylene glycol is prepared by Carbide and Carbon Chemicals Corporation. Recently, Shell Development Co. has announced a process for making glycerine from propylene, employing a high-temperature chlorination step developed by them. A plant has recently been erected for the nitration of paraffin hydrocarbons. Shell Chemical Co. is cracking natural gas at high temperatures to separate hydrogen for subsequent use in a high-pressure ammonia synthesis. A. H. N.

1303.* Pyrolysis of Several Lower Hydrocarbons in the Presence of Methyl-Chloride. H. C. Lu and R. L. Huntington. *Refiner*, September 1941, 20 (9), 390–393.—Pyrolysis of the lower hydrocarbons in the presence of methyl chloride can be explained by the existence of free radicals. The removal of hydrogen in the form of hydrogen chloride succeeds to a certain extent in obtaining unsaturated hydrocarbons, but in order to make this process industrially feasible, further experimentation is necessary.

The present paper reports experiments with propane, ethane, and ethylene in presence of methyl chloride or natural gas, calcium phosphate being used as a catalyst.

Experimental procedure is described as well as the results obtained. Pyrolysis of methyl chloride was studied under non-catalytic conditions and also in the presence of several types of catalysts. The products of decomposition, besides a small amount of unsaturated hydrocarbons, consist of carbon, hydrogen, hydrogen chloride, and methane.

Comparison has been made between the cracking of mixtures of methyl chloride with ethane, propane, and ethylene, and similar mixtures of natural gas in the place of methyl chloride. In these experiments a greater yield of unsaturated hydrocarbons in the cracking of CH_3Cl mixtures was noticed. By examining the results of the experiments, several possible types of reactions have been suggested for the thermal decomposition of methyl chloride.

The low yield of olefine, and the rapid decomposition of methyl chloride into carbon and hydrogen during its pyrolysis, make the process unattractive at least at the present for the purpose of obtaining unsaturated hydrocarbons from methyl chloride. A. H. N.

1304.* Action of Sulphur on Hydrocarbons Under High Pressure. W. Friedmann. *Refiner*, October 1941, **20** (10), 395–406.—From results of experiments conducted on normal heptane, *iso*-octane, and *iso*decane, the following general conclusions are reached. (1) The normal hydrocarbons change into branched systems, especially those which, under the directional influence of sulphur, tend to form a five-membered ring with sulphur in the bridge. The latter, obtained during a mild reaction, are generally regarded as thiophanes. (2) The branched hydrocarbons give simultaneously thiophanes and sulphides, CH_3–S–CH_3, which are formed when, for example, the quaternary carbon atom of the branched hydrocarbons (*iso*-octane) cause a slight disintegration of the molecule, after which the fragments of the branched molecule react with sulphur. (3) Thiophanes react further with sulphur forming: (*a*) thiophenes with partly dehydrogenated products as intermediate compounds, from normal paraffins; (*b*) thiophthenes (probably thiophthanes, also) from normal heptane and from normal octane; (*c*) polythiophanes or thiophane polysulphides, from *iso*-octane; (*d*) dithienyls (probably hydrogenated dithienyls as an intermediary product) from *iso*decane. Experimental data are given under separate sections dealing with the three hydrocarbons studied.

It is argued that it is a mistake to regard a certain predetermined sulphur content in an oil fraction as detrimental and demanding its complete removal. The thiophenic sulphur is practically harmless, and therefore a much higher percentage of this form of sulphur can be tolerated—*e.g.*, in gasoline—than the thiophanic sulphur. According to these experiments the last-mentioned sulphur compound, when added in a concentration of 0·1% S to a normal heptane-*iso*-octane mixture of 65 C.F.R. M.M. rating, will completely neutralize the anti-knock effect of the addition of 3 c.c. tetraethyl lead/gal. of such mixture. On the other hand, the thiophene sulphur added in the same concentration (0·1% S) will lower the above anti-knock rating by three octane points only. A. H. N.

1305.* Nomograph for Density Corrections of American Oils. A. H. Nissan. *Refiner*, October 1941, **20** (10), 407–410.—Based on the data studied by Stott for American petroleum oils, a monogram is presented for their density variation with temperature. A. H. N.

Analysis and Testing.

1306.* Rapid Method for the Determination of Mercaptan Sulphur in Refinery Caustic Soda Scrubbing Solutions. Anon. *Refiner*, September 1941, **20** (9), 393.—A rapid method utilizing the reagents and apparatus found in a small laboratory has been developed. This method can also be used on refinery or natural gases for the determination of mercaptans, by passing a known volume of the gases through a caustic-soda solution and then proceeding in the usual manner. The method outlined in this paper is essentially the reverse of the scrubbing operation in the plant. The mercaptans are forced into the hydrocarbon phase, where they are determined by one of the two commonly accepted methods for mercaptans in gasoline.

Spent caustic-soda solutions were analysed by an adaptation of the method of Willard and Fenwick and by the method in question. The comparison of the results

of the two methods is not in close agreement, but is accurate enough for ordinary control work. However, if the reagents are chilled, much better agreement is obtained.
A. H. N.

1307.* Portable Unit Measures Gas for Gasoline Content. Anon. *Refiner*, September 1941, **20** (9), 394.—Mounted in the coupé back of the driver's seat are a gas scrubber, a two-stage compressor (consisting of a vacuum pump and a high-stage cylinder), gas meter, pressure gauges, mercury manometer, filter, and condenser.

After a metered quantity of gas has been processed through the plant and the gasoline extracted and collected in a graduate, the liquid is heated by means of car-engine temperature to the standard 60° F. and the volume in cubic centimetres at that temperature read off.

The accuracy of the apparatus is claimed to be very high. A. H. N.

1308.* Prediction of Ignition Points of Diesel Fuels in the Laboratory. G. Vorberg. *Refiner*, October 1941. **20** (10), 423–424.—The following indices for ignition characteristics have been employed and compared in forty-two oil tests of various origins: (1) content of hydrogen; (2) aniline point; (3) diesel index; (4) cetene value (determined by Marder's density method); (5) cetene–cetane number, determined in I.G. test motor; also in C.F.R. test motor, as a comparison for above four tests.

Summarizing the results of forty-two oil tests, it has been shown that the diesel index and the cetane value (by Marder) are well adapted to laboratory methods for determining the fuel or ignition characteristics of diesel fuels, which are widely distributed and used in commerce and industry. A. H. N.

1309.* Short-Cut Analysis. B. G. Adams. *Refiner*, October 1941, **20** (10), 426.—A brief description is given for four tests which, it is claimed, are extremely quick to perform. The tests are for determination of (1) doctor treatment improvements—mercaptan; (2) lead; (3) sulphur; and (4) specific gravity of gases. A. H. N.

1310.* Samples of Gas-borne Particles. Anon. *Engineering*, 1941, **152** (3945), 141 and (3947), 181.—The apparatus and technique for the analysis of gases for suspended solids and oil mists are described. It is concluded that Stillite filters are suitable for particles of diameter greater than half a micron, but an electrostatic precipitator is required for particles of smaller size. The design of baffles capable of rendering the gas–dust system homogeneous for sampling or mixing purposes is discussed.
J. W. H.

Motor Fuels.

1311. Motor Fuel Patents. Phillips Petroleum Co. E.P. 538,645, 12.8.41. Appl. 20.12.39. Improved catalytic methods of treating petroleum oils, such as straight-run and cracked gasolines, pressure distillates, naphthas, polymerized gasolines and natural gasolines, to produce an improved type of motor fuel. The gasoline stock is contacted in the vapour form at a pressure between atmospheric and 100 lb. per square inch, with a bauxite catalyst impregnated with a solution of chromium compound subsequently converted to the oxide. The treated vapours are split into two streams, one of which is recycled back into heated raw vapours prior to entry into the catalyst chamber. Decomposed impurities are separated from the other stream, also the light gas fraction containing a substantial proportion of hydrogen gas. In this way hydrocarbons boiling within the gasoline range and having improved anti-knock characteristics are obtained.

Standard Oil Development Co. E.P. 538,715, 14.8.41. Appl. 6.11.39. Method of production of saturated hydrocarbons by the reaction between saturated hydrocarbons containing tertiary carbon atoms and olefins. The invention relates particularly to the embodiment of this reaction in the production of hydrocarbons boiling within the gasoline range and containing a considerable amount of *iso*-octane and fractions suitable for aviation gasoline.

P. Miller. U.S.P. 2,252,089, 12.8.41. Appl. 27.12.39. Preparation of a motor fuel consisting of a hydrocarbon fuel base blended with sufficient of an *N*-alkylated aromatic amine to improve substantially anti-knock characteristics. The amine contains in the aromatic nucleus an aliphatic substituent radical in which oxygen is linked to carbon as in an ester group, and boils within the boiling range of the hydrocarbon fuel base.

L. Heard and A. G. Oblad. U.S.P. 2,252,927, 19.8.41. Appl. 31.3.39. Production of high anti-knock motor fuels from a low anti-knock gasoline by incorporating at least one nitro-aromatic hydrocarbon in the gasoline in sufficient amount to yield a quantity of aromatic amine which will substantially increase the knock rating of the gasoline. Simultaneously the low anti-knock gasoline is dehydrogenated and the nitro-aromatic hydrocarbon converted into an aromatic amine.

R. Rosen. U.S.P. 2,256,627, 23.9.41. Appl. 31.10.39. Preparation of a motor fuel consisting of a major proportion of gasoline hydrocarbons and an unsaturated ether selected from the group consisting of divinyl ether and dimethallyl ether. The ether is blended with the hydrocarbons in sufficient amount to improve the octane value.

A. R. Goldsby. U.S.P. 2,257,074, 23.9.41. Appl. 8.7.39. Manufacture of high anti-knock motor-fuel hydrocarbons by catalytically converting a mixture of carbon monoxide and hydrogen to a synthetic hydrocarbon mixture composed mainly of hydrocarbons having from 1 to 10 carbon atoms per molecule. These hydrocarbons are composed largely of normal olefins, and are comparatively free from aromatic and naphthenic constituents. Gasoline hydrocarbons boiling up to about 390° F. are separated from the mixture and reacted with a paraffin hydrocarbon fraction comprising *iso*butane, in the presence of sulphuric acid, and in the absence of *iso*butylene and aromatic hydrocarbons. In this way *iso*butane is alkylated to produce normally liquid saturated hydrocarbons having a high anti-knock value and boiling within the motor-fuel range.

Le R. G. Story. U.S.P. 2,257,079, 23.9.41. Appl. 4.2.37. Preparation of an anti-knock gasoline, stabilized against gum formation by subjecting cracked hydrocarbons containing unsaturated constituents to contact with a solid absorption catalyst under polymerizing conditions of temperature and pressure and in the presence of a phenol. The phenol is caused to react with at least a portion of the unsaturated constituents, and forms an anti-oxidant reaction product, together with hydrocarbons of gasoline boiling range.

R. Rosen. U.S.P. 2,257,194, 30.9.41. Appl. 18.10.39. Preparation of a motor fuel consisting of a gasoline hydrocarbon fuel to which has been added a minor proportion of a hydrocarbon borine-amine product.

J. W. Teter. U.S.P. 2,257,434, 30.9.41. Appl. 17.8.37. Preparation of a motor fuel consisting of gasoline and a small proportion of a compound of the group consisting of 4-nitroso-2-methyl phenol, 4-nitroso-2-ethyl phenol, and 4-nitroso-2 : 5-dimethyl phenol.

H. B. M.

Lubricants and Lubrication.

1312.* Temperature and the Lubricating Properties of Greases. D. Tabor. *Engineering*, 1941, **152** (3946), 178.—A method of analysis of the friction forces between moving surfaces has been developed. The principle involved is that of sliding a metal plate against a loaded stationary hemisphere. The frictional force is measured by the deflection of an arm attached to the hemispherical surface by means of a moving film camera. Two types of motion are found to occur : (*a*) continuous smooth sliding, and (*b*) a series of jerks. It is shown by photomicrographs that when the latter motion occurs, considerable wear of the sliding surface takes place. With this apparatus it is possible to measure the frictional conditions at temperatures and loads similar to those encountered in practice and to examine the effect of dopes on greases.

J. W. H.

1313.* Lubricating Oil Addition Agents. O. M. Reiff. *Industr. Engng Chem.*, 1941, **33** (3), 351.—Wax-substituted hydroxy-aromatic hydrocarbons formed by the condensation of a hydroxy aromatic hydrocarbon with a chlorinated paraffin wax by the Friedel and Crafts reaction are the starting materials used in the synthesis of multi-functional lubricating-oil addition agents. Details of the method of synthesis of these compounds are given and their structure is discussed. The wax phenols are shown to be good pour point depressants. The introduction of metal substituents into the wax-substituted hydroxy-aromatic hydrocarbon results in an improvement in the pour point depressant value and a highly effective anti-oxidant action is imparted. For example, the addition of $\frac{1}{8}$% of a " wax phenol " lowers the pour point of an oil by 20° F. and the addition of the corresponding wax cobaltous phenate results in a 35° F. lowering of the pour point. Tests in a C.F.R. engine showed that the latter compound greatly decreased the ring-sticking tendency, lowered the carbon deposits, and decreased the neutralization number. The synthesis of metal derivatives of the wax-substituted phenolcarboxylic acids are discussed, and it is shown that these compounds are similar to the metalloxy-compounds in their pour point depressing action and their oxidation inhibiting properties. In addition, these metalloxy derivatives are V.I. improvers. J. W. H.

1314. Contact of Colliding Surfaces and the Influence of Lubricant Films. F. P. Bowden and D. Tabor. *J. Counc. Sci. Ind. Res. Austral.*, 1941, **14** (2), 152–160.—The condenser discharge method has been used to measure the contact period of colliding metallic solids, while measurement of electrical conductance between the metal surfaces has been utilized to study the nature and area of contact. When the surfaces are separated the conductance is zero, and as they come together the conductance rises to a maximum. The conductance at any instant is a measure of the area of contact. A cathode-ray oscillograph was used to record the changes. The break is much more rapid than the make, indicating that plastic flow of the metal takes place. With specially hardened tool steel and small velocities of impact, the collision is more nearly elastic. The presence of a lubricant such as a fatty acid may have little or no influence on the time or area of contact, provided the viscosity of the lubricant is low. If a lubricant of higher viscosity is used it may prevent metallic contact. The time of impact is so short that the oil is not able to escape from between the surfaces. Although the surfaces do not touch, the forces transmitted through the oil film may be sufficiently great to cause plastic flow and permanent deformation of the metal surface.
T. C. G. T.

1315.* Better Lubrication with " Roughened " Motor Bearings. Anon. *Nat. Petrol. News*, 20.8.41, **33** (34), R. 262.—Whereas formerly engine crankshaft bearings have been finished to " mirror smoothness " in which surface irregularities had a maximum depth of 5–6 micro (10^{-6}) inches, one plant has now standardized a " rough " finish in which the surface irregularities have a maximum depth of 60 micro inch. The composition of the shaft, bearing, and oil have been unchanged, but better lubrication, longer life, and less wear are stated to have resulted. Tests showed that an advantage was gained up to 60 micro inch " roughness," after which bearing wear again increased. The effect is explained in the assumption that the scratches which constitute the roughness function as tapered grooves to facilitate the transfer of oil to sites of high bearing pressure. H. G.

1316.* Oil Company Developed Process for Etching Bearing Surfaces. Anon. *Nat. Petrol. News*, 20.8.41, **33** (34), R. 264.—Steel bearing surfaces are etched by treatment in a bath consisting of 50%-wt. NaOH and 1%-wt. S at 250° F. Certain constituents of the steel—for instance, ferrite—are dissolved selectively to produce depressions approximately 80 micro inch deep. Data on film strength and wear as obtained from laboratory dynamic testing machines indicate that such etched surfaces show an advantage from the point of view of all desirable characteristics. These observations have been confirmed by tests under service conditions. H. G.

1317.* Tests Showed Matt Finish Provided Best Lubrication. H. Shaw. *Nat. Petrol. News*, 20.8.41, **33** (34), R. 266.—The author describes a series of experiments designed to illustrate the advantage of matt surfaces in bearings as opposed to a mirror finish and to demonstrate his theory that when a matt finish is produced by normal service the mechanism of the etching action is attrition, due to turbulence in the lubricant stream set up by slight random irregularities in the surface. It is concluded that a matt finish for bearing surfaces provides the most efficient lubrication, but that the action of heavy loads is to polish out this finish except under certain prescribed conditions. H. G.

1318. Lubricants and Lubrication Patents. Standard Oil Development Co. E.P. 537,615, 30.6.41. Appl. 27.12.39. Preparation of a grease composition particularly suitable for use at temperatures above 300° F. Raw rapeseed oil or the acids obtained therefrom are saponified with caustic soda in the presence of mineral lubricating oil while heating to dehydrate the mixture. Additional mineral lubricating oil is added and the mixture stirred and heated to 480–520° F. The mixture is then cooled. During dehydration a small amount of an oil-soluble alkali metal, is incorporated.

Standard Oil Co. E.P. 537,816, 8.7.41. Appl. 3.10.39. Preparation of a lubricant consisting of a hydrocarbon lubricating oil in which is incorporated a metal phenate with a phenolic radical having more than ten carbon atoms. It is claimed that the composition is more stable to heat and resistant to deterioration at high temperatures than the original oil. It is specially suitable for use as a heat transfer fluid where it is desirable to prevent the formation of a deposit on the metal surface from or to which heat is being conveyed.

C. C. Wakefield & Co. E.P. 538,159, 23.7.41. Appl. 18.11.39. Preparation of a lubricating composition, particularly suitable for use under extreme pressure conditions, consisting of a lubricating oil and a minor proportion of an organic compound containing at least two halogen atoms and at least one nitro-group in the molecule, and which may be further substituted only by oxygen-containing groups.

Standard Oil Company of California. E.P. 538,474, 6.8.41. Appl.15.11.39. Preparation of a lubricant consisting of a hydrocarbon lubricating oil in which is incorporated a heavy metal salt of a substituted oxy-acid of phosphorous containing an organic substituent. Preferred acids are substituted orthophosphoric acids, and preferred salts comprise the aluminium, calcium, barium, and chromium salts of these acids.

Armour & Co. E.P. 539,186, 1.9.41. Appl. 7.12.39. Preparation of a mineral lubricating-oil composition containing, as a pour point depressor, an acylated indene wherein the acyl group contains at least twelve carbon atoms.

E. A. Ocon. E.P. 539,191, 1.9.41. Appl. 24.2.40. Method of recovering high-grade lubricating oils from inferior stocks by subjecting the stocks to a de-asphaltizing process, dewaxing the oil which has been de-asphaltized, and selectively separating from it a relatively more paraffinic fraction. The extracted constituents are subject to differential separation. In this way desirable lubricating-oil constituents of cyclic and unsaturated character are obtained.

C. F. Prutton, A. K. Smith, and D. R. Frey. U.S.P. 2,251,953, 12.8.41. Appl. 6.3.39. Preparation of a lubricating composition consisting of a major proportion of a mineral oil and a small amount of an oil-soluble, phosphorus-containing product resulting from the reaction of PCl_3 with a compound of the class consisting of lactic acid, esters of lactic acid, and salts of lactic acid.

J. G. McNab and W. T. Watkins. U.S.P. 2,252,087, 12.8.41. Appl. 20.9.38. Preparation of a lubricant consisting of a mineral lubricating oil, a soluble soap of a polyvalent metal of the second to the eighth group of the periodic table, and the acids produced by the air oxidation of petroleum oils and waxes. The lubricant is substantially free of oxy-organic impurities of the class consisting of esters, lactories, lactides, and free acids of the type used in preparation of the soap. In addition, 0·25–1·5% of a free saturated fatty acid selected from the class of stearic and margaric acids is added.

C. F. Prutton. U.S.P. 2,252,674, 12.8.41. Appl. 23.3.38. Manufacture of a lubricating composition consisting of a mineral lubricating oil and an amount up to 20% of a composition selected from the following class: the reaction product of a complex organic wax of mineral origin and a phosphorus- and halogen-containing reagent in which the phosphorus has a valence of three or less; the reaction product of a complex organic oil of mineral origin and a phosphorus- and halogen-containing reagent in which the phosphorus has a valence of three or less. The total amount of phosphorus in the lubricating composition is less than $\frac{1}{10}$%.

C. F. Prutton, A. K. Smith, and D. R. Frey. U.S.P. 2,252,675, 12.8.41. Appl. 6.3.39. Manufacture of a lubricating composition consisting of a major proportion of a mineral oil and a minor proportion of an oil-soluble product resulting from the reaction of a hydroxy-ester with a phosphorus- and halogen-containing compound of the type in which the phosphorus is present in the tri-valent form.

W. A. Whittier. U.S.P. 2,254,337, 2.9.41. Appl. 23.9.38. Preparation of a lubricant consisting of mineral lubricating oil, a phosphorized fatty oil, and a stable highly halogenated aliphatic hydrocarbon having a boiling point not much lower than 180° C.

E. Lieber. U.S.P. 2,254,433, 2.9.41. Appl. 9.9.38. Preparation of a lubricant consisting of a lubricating oil to which has been added not more than 2% of a pour point depressing polyester formed from a polyhydroxy aliphatic alcohol with a long hydrocarbon chain and a polycarboxylic aromatic acid.

J. M. Musselman. U.S.P. 2,254,490, 2.9.41. Appl. 7.7.39. Preparation of a lubricant to which has been added a small amount of a diarylethylenediamine compound of a halogenated carboxylic acid having at least six carbon atoms.

E. Segessemann. U.S.P. 2,254,756, 2.9.41. Appl. 18.6.38. A sulphurized unsaturated aliphatic alcohol having at least eight carbon atoms is used as a sulphur carrier for lubricants.

C. F. Prutton and A. K. Smith. U.S.P. 2,255,085, 9.9.41. Appl. 21.11.41. Preparation of a lubricating composition consisting of a major proportion of a mineral lubricating oil and a minor proportion of a halogen and oxygen-bearing compound of the class consisting of halogen-bearing aromatic acids, halogen-bearing esters of aromatic acids, and halogen-bearing salts of aromatic acids.

O. M. Reiff. U.S.P. 2,256,442, 16.9.41. Appl. 9.3.40. Preparation of a lubricating composition consisting of a mineral lubricating oil and a small proportion of an oil-miscible condensation product of a wax-substituted hydroxyaromatic acid in which at least two wax-substituted aryl nuclei are interconnected by at least one atom of an element from the group consisting of sulphur, selenium, and tellurium.

U. B. Bray. U.S.P. 2,257,328, 30.9.41. Appl. 7.12.37. Preparation of a lubricating oil containing 0·6–2·5% of an oil-soluble metal soap of organic acids containing at least ten carbon atoms and adapted to overcome valve and ring-sticking tendencies. Since the oil contains naturally occurring non-corrosive sulphur, it overcomes the corrosive tendencies of the soaps and imparts extreme pressure characteristics.

H. G. Vesterdal. U.S.P. 2,257,627, 30.9.41. Appl. 29.12.37. Preparation of improved oxidation and sludging resistant lubricating oils by treating a previously refined lubricating oil substantially free from unsaturated materials with a small amount of a boron halide. H. B. M.

Asphalt and Bitumen.

1319. Asphalt and Bitumen Patents. N.V. De Bataafsche Petroleum Maatschappij. E.P. 537,563, 26.6.41. Appl. 8.3.40. Production of bituminous materials with plastic properties and consisting of a mixture of asphaltic bitumens and mineral and/or non-mineral fillers. The asphaltic bitumens have a low-temperature susceptibility, a penetration at 25° C. above 50, and a penetration index above + 7.

J. G. Fife. E.P. 537,567, 26.6.41. Appl. 14.3.40. Manufacture of compositions particularly suitable for road-construction purposes and consisting of sand, clay (with or without the addition of stone chippings), water, and bitumens. Asphaltic residues are employed as bitumens, originating from mineral oils or mineral-oil products, and containing at least 2% by weight of solid paraffin wax. Alternatively, they may originate from tars containing at least 1% by weight of solid paraffin wax.

International Bitumen Emulsions, Ltd. E.P. 538,690, 13.8.41. Appl. 28.3.40. Method of incorporating a rubber latex mix and bituminous material in textile fabrics. The fibres or yarn or fabric are impregnated with a bituminous emulsion, and then with latex or a mixture of bituminous emulsion and latex. For example, a white jute canvas may be coated with an emulsion consisting of 15% of oxidized bitumen (20 pen., softening point R. and B. 180–200° F.), 15% of oxidized bitumen (200 pen.), 10% casein, 2% ammonia (880), 55% water, 1% preservative (*e.g.*, cresylic acid), and 1% insolubilizer (*e.g.*, hexamine).

A. H. Batchelder, U.S.P. 2,252,111, 12.8.41. Appl. 12.11.38. Manufacture of asphalt from a charging stock containing asphaltenes, oily constituents, and asphaltic resins. The oily constituents are separated out and air-blown. In this way additional asphaltenes are formed without converting the asphaltic resins in the charging stock into asphaltenes. Afterwards these additional asphaltenes are mixed with those obtained from the charging stock, also with the asphaltic resins. H. B. M.

Special Products.

1320.* Aromatics, Gas, and Coke from Heavy Petroleum Residues. E. L. Hall. *Chem. Met. Engr*, September 1941, **48** (9), 100–105.—Processing of petroleum for the production of aromatics is essentially a destructive distillation of high-molecular-weight hydrocarbons into new groupings of simpler structure, accompanied by side reactions and polymerization. Expressed simply, the cracking of petroleum (principally paraffins and naphthenes) follows somewhat this progression : High-molecular-weight paraffins—olefines—(such as acetylenes, naphthenes, polycyclic compounds)—benzol, toluol, xylol, and higher homologues.

It is also true that in any one group the higher-molecular-weight compounds tend to split into lower-molecular-weight compounds, with scission of a radical. For example, butylene–propylene–ethylene, or xylol–toluol–benzol. However, this general trend is also accompanied by alkylation and/or polymerization to produce higher molecular weight compounds—*i.e.*, benzol—naphthalene, or benzol—ethylbenzol.

The effects of temperature, time, pressure, and concentration are treated simply.

Production of gas from oil is similarly studied with the addition of a historical survey of the industry. After describing the work of the company in which the author is chief engineer, the following conclusions are reached :

The gas industry is a logical collaborator of the oil-refining industry for the most advantageous and economic processing of petroleum, a fact which is true principally for two reasons : (1) the gas industry can process petroleum advantageously at operating temperatures suitable for the production of aromatics, since the production of large quantities of gas does not constitute a limitation. (2) The petroleum industry, however, can process petroleum advantageously only to a point where the residues are sufficiently fluid for transportation. If the oil is processed to coke, the local market must be depended on in view of freight limitations. Only in favoured locations are the local markets large enough to absorb the quantities involved.

Thus it seems apparent that the gas industry can with advantage carry on the processing of petroleum from a point where the oil industry leaves off. To be sure, the petroleum industry can produce aromatics by selective extraction of materials containing small quantities of aromatics or by the catalytic cracking of selected hydrocarbons, but it is not believed that such methods can compete with aromatics produced by the gas industry from the heaviest petroleum residues. A. H. N.

1321.* Green Cotton Wax. Anon. *Chem. Tr. J.*, 3.10.41, **109**, 159.—The U.S. Dept. of Agriculture reports the possibility of obtaining high-melting-point waxes from green lint cotton which contains up to 17% of wax, as compared with 0·5% in ordinary cotton. An experimental area of 5 acres is now under cultivation in South Carolina. The cotton has been grown in the south for many years and is used for home spinning

and handicraft work. Exposure of the green lint to sunlight converts it into a dull-brown colour. After removal of wax, the fibre provides a high-grade cellulose.
C. L. G.

1322.* New Products from Naphthenic Acids. Anon. *Chem. Tr. J.*, 3.10.41, **109** 160.—The methyl, ethyl, and *iso*propyl esters of naphthenic acids of acid value 302 and apparent molecular weight 186 have been prepared by Le Roy, Weatherby, and Schiller of the chemical laboratory of the University of S. Carolina.

1000 g. of the acid are refluxed for 3 hr. with a 50% excess of the alcohol and 100 c.c. of conc. H_2SO_4, giving a yield of 85% of the theoretical. The distillation ranges of the three esters were 340–540° F., 365–543° F., and 290–345° F. respectively. Further work is in hand on the reduction of the naphthenic esters to naphthenyl alcohols, and their use in the preparation of emulsifiers and detergents. C. L. G.

1323. Special Products Patents. Standard Oil Development Co. E.P. 537,468, 1.6.41. Appl. 13.10.39. Method of extracting olefines having three and four carbon atoms from mixtures containing these and saturated hydrocarbons. The mixture is contacted with a cuprous halide under conditions designed to ensure that the partial pressure of the olefines in the mixture is greater than the dissociation pressure of the addition compound formed by the reaction between the olefine and the cuprous halide. The residual mixture is then separated from the addition compound.

Standard Oil Development Co. E.P. 537,497, 24.6.41. Appl. 13.10.39. Improvements in the absorption and separation of olefines having two to four carbon atoms to the molecule from mixtures of olefines and paraffins. The invention is designed chiefly to facilitate removal of the heat of formation and supply of heat of dissociation. It also enables time of contact required to absorb an olefine in a cuprous halide to be materially reduced.

Armstrong Cork Co. E.P. 539,077, 27.8.41. Appl. 30.3.40. Manufacture of a tile comprising a filler and a binder in which the binder has a cloud-point between 20° and 100° C., and comprises mineral oil and at least one resin of the class consisting of coumarone resins, indene resins, styrene resins, etc. Mineral oil comprises about 30% of the composition. Suitability of the oil for different resins is judged on the basis of its aniline point.

G. A. Lloyd and E. C. Hermann. U.S.P. 2,252,082, 19.8.41. Appl. 7.3.39. Production of heating oils of increased stability by separating from a cracked distillate boiling in the range 350–650° F. 40–60% of the relatively lower boiling constituents. These are then subjected to an acid treatment of about 2–5 lb. of sulphuric acid (88–98% strength) per brl. of oil. The treated lower-boiling constituents are afterwards blended with the untreated higher-boiling constituents.

E. V. Murphee and E. B. Peck. U.S.P. 2,256,622, 23.9.41. Appl. 29.5.40. Method of controlling the reaction temperature in a process for the manufacture of hydrocarbons containing more than one carbon atom in the molecule from oxides of carbon and hydrogen. A synthesis gas mixture is passed through a plurality of alternate catalyst reacting and cooling zones, and a cooling liquid passed through the cooling zones. The temperature of the gases is maintained within a predetermined range by contact with the cooling liquid. H. B. M.

Detonation and Engines.

1324. Combustion Research in the U.S.A. E. F. Fiock. *Aircr. Engng*, August 1941, **13** (150), 221–224.—A survey is given of combustion research in the direction of improved power output and economy. The author divides the subject under the following headings: (1) The finding of new mixtures which are inherently more powerful or more economical. (2) The finding of new methods of altering the mass rate of burning, the completeness of combustion, and hence the rate of increase in pressure. (3) The prevention of preignition in spark-ignition engines and the promotion of ignition in compression-ignition engines. (4) The suppression of detonation.

The paper is illustrated by extracts from recently published work. J. G. W.

1325. Combustion of Tar and its Products. W. Kirby. *Engineer*, 22.8.41, **172** (4467), 122–123.—The difficulties encountered in burning tars and pitches are discussed and various burners are described which are suited to these types of fuel. Some details are given regarding the specification of the products which can be handled by the equipment described. J. G. W.

1326.* Home Produced Fuels for Oil Engines. Report of Home Fuels Sub-Committee of the Diesel Engine Users Assoc. *Engineer*, 29.8.41, **172** (4468), 138–140.—The results of bench and road tests are given, from which the following conclusions are reached : (1) The present designs of transport diesel engine do not readily utilize a straight H.-T. creosote fuel. (2) The addition of a small percentage of one dope improved the suitability of this fuel, 4% being equivalent to the addition of 40% petroleum diesel fuel. (3) A road test with 20% H.-T. creosote blended in petroleum gas oil gave satisfactory performance. (4) Whilst difficulties arise in connection with starting up on L.-T. fuel it is possible to run certain types of engine on this product. (5) Dopes in L.-T. fuel are equally encouraging. (6) Up to 50% L.-T. fuel can be used satisfactorily in blend. (7) Sludging of blended fuels can be avoided by a patent de-sludging process. (8) The quantity of L.-T. crude immediately available is of the order of 1,050,000 gal. per annum. J. G. W.

1327.* New Method of Testing the Knocking Qualities of Motor Fuels. Anon. *J. Inst. Fuel*, August, 1941, **14** (79), 253 (abridged from *Oel und Kohle.* Reprinted from *World Petroleum*, May, 1941).—The C.F.R. method of testing fuels will rate them correctly as far as concerns the C.F.R. engine, but the ratings will not necessarily be the same in other engines or in the same engine under different operating conditions. Road tests developed in the U.S.A. for rating fuels are often far from agreeing with the octane numbers obtained on standard single-cylinder engines.

The octane number as a measure of the knocking of a fuel takes in only a fraction of the time range, and thus the author, with the support of the German authorities, embarked on research to visualize knock throughout its entire extent. An electro-acoustic method was devised in which a microphone attached directly to the engine picked up the noise which could be made visible in a Braun tube or photographed for later examination. An arrangement was incorporated for screening out foreign noises. Besides this, another apparatus was invented by which the intensity of noise could be measured, and it was then practicable to construct and compare knock curves of a test gasoline and a standard reference fuel.

The investigation has demonstrated that it is possible to show the behaviour of each cylinder in a multi-cylinder engine on the same picture.

The author emphasizes that it should be the object of engine-builders to create engines that are less prone to knock instead of fuel producers straining to produce fuels of higher octane rating. He suggests standardization on a 74 O.N. fuel.

Work on this new method for rating fuels has now crystallized in the construction and demonstration of a portable instrument that without difficulty can be used on any type of automobile. A photograph of this apparatus is included and its method of attachment illustrated. The chief result of the road tests so far carried out is to confirm that the cylinders in a multi-cylinder engine may not be behaving in a similar manner with regard to knocking phenomena. Thus adjustments may be made and the overall efficiency of the engine improved. D. L. S.

1328.* Automatic Control of Internal-Combustion Engine Temperatures. W. A. Sawdon. *Petrol. Engr*, July 1941, **12** (11), 19.—In some recent installations of I.-C. engines in the oil industry, temperature control has been obtained by regulation of the flow of air through the radiator, and not by the usual method of thermostatic control of the liquid circulation system. Such engines operate under widely varying loads and at extremes of atmospheric temperature, and the requirements are not merely to cool the engine under maximum heat-producing conditions, but to maintain the desired engine temperature at all times. Control of the flow of air, giving positive results, has been effected by automatically varying the pitch of fan-blades, applying the principles used in controllable pitch propellers of airplanes. The control is effected by a thermostat mounted in the hub, the thermostat containing a special liquid selected for suitability at the predetermined temperature. A power saving is obtained over conventional fans, and the seriously detrimental effects of over-cooling upon both oil and engine are avoided. Further, since the temperature control is by air-flow regulation, there is constant circulation in the liquid system, and hence there is no hazard of cracking the cylinder block by a sudden inrush of cold water. Actual examples are quoted and illustrated, showing benefits obtained by using variable pitch fans—viz., a power-generating plant in Los Angeles, an oil-well pumping engine, an engine used in bailing service, etc. J. C.

1329. Diesel Engines Underground. III.—Effect on Exhaust-Gas Composition of operating Engines in Mixtures of Normal Air and Natural Gas. M. A. Elliott, J. C. Holtz, L. B. Berger, and H. H. Schrenk. *U.S. Bur. Mines, Rep. Invest.*, No. 3584, September 1941.—It frequently happens that diesel engines have to operate underground where composition of the atmosphere differs from that of normal air because of the presence of exhaust gas or, alternatively, of hydrocarbon gases given off by the strata in the underground workings. This report deals specifically with the effect on exhaust-gas composition of operating two 4-stroke diesel engines in mixtures of normal air and natural gas. Concentrations of natural gas used in the course of experiments ranged from 0·2 to 4·7% by volume, and the engines were operated at different speeds and power outputs within the normal operating range of each engine. Concentration of natural gas in the intake was maintained lower than that corresponding to the lower inflammable limit in air at atmospheric pressure and temperature.

It was found that when natural gas was introduced, concentrations of carbon monoxide, aldehydes, and oxides of nitrogen in the exhaust gas generally were much greater than when the intake consisted of normal air. Further, greatest increases in concentration of carbon monoxide were observed when the engines were running at full throttle—*i.e.*, at the maximum fuel–air ratio in the normal operating range. Carbon monoxide concentration was also increased when natural gas was added to the intake with the engines running at constant speed and power output—*i.e.*, at a constant ratio of reacting fuel to air.

Conclusions reached as a result of these experiments indicate that the concentration of natural gas in the intake of the engines could reach 0·5% by volume without necessitating an increase in the quantity of air required for ventilation under normal atmospheric conditions.

While admitting the somewhat limited scope of this report in so far as studies of combustion in the engine are concerned, the authors nevertheless suggest that the addition of combustible gases to the intake may be a valuable experimental technique in studying combustion in the diesel engine, and in obtaining data on the inflammable limits of combustibles under conditions existing in internal-combustion engines. It is suggested that such possibilities should be further investigated, and also that the addition to the intake of other gases, such as carbon monoxide and hydrogen, in concentrations lower than that corresponding to the lower limit of inflammability, should be studied in relation to combustion in the diesel engine. H. B. M.

BOOK REVIEW.

Regulation of Pipe-lines as Common Carriers. By William Beard. 1941. Columbia University Press (English agents : Oxford University Press). 184 pp. 13*s*. 6*d*.

The regulation of American pipe-lines as common carriers, on the analogy of the common carrier status of railways, dates back to legislation of 1906. Intermittent disputes between railroads, large oil corporations, small independents, and landowners had been going on since 1885, and by 1905 had grown into a demand for Government intervention. In 1906 the position was clarified to some extent by Congress legislation, which placed the responsibility for the regulation of certain aspects of pipe-line operation upon the Interstate Commerce Commission. The Commission is primarily concerned with railroad regulation, and the railroad concept of transportation came to be applied to both carriers, on the theory of similarity in function. At first the Commission was concerned only with accounting procedure. Subsequently its control was extended to rate-fixing, definition of status, regulation of services at collecting and delivery points, and co-ordination with rail and sea transport. In 1938 the mileage of oil pipe-lines recognized by the National Government as common carriers and reporting to the I.C.C. was 95,973 out of an approximate total mileage (excluding natural gas lines) of 115,000.

Whether the application of the historic concept of the common carrier to a modern instrument of technology to which it is poorly adapted is justified or not is a matter of opinion. Mr. Beard puts forward no personal views, but ably summarizes the pros and cons of the common-carrier status. The extraordinary fact is that the evolution of the industry has been such that :

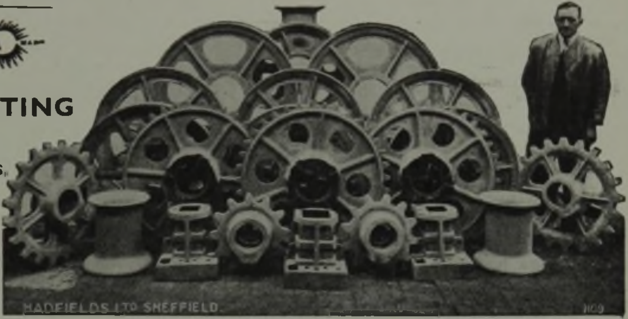
> " Though tens of thousands of miles of pipe lines serving the mineral industries have become common carriers on paper, they are only to a very limited extent common carriers in fact. Some such pipe lines are entirely devoted to moving fluids owned by the interests controlling the lines, while other facilities carry only a small percentage of freight for outsiders, meaning the public generally. True, there are lines that are operated largely or exclusively as common carriers for the general public, but these independents are of decidedly secondary importance in the total situation."

From the fact that only two formal complaints regarding pipe-line rates and services have been filed with the I.C.C. between 1906 and 1939, it appears that the best form of legislation has been one of benevolent non-interference.

On the one hand, pipe-lines can be regarded as transportation agencies moving freight in competition with carriers by rail and water. This view has predominated in public policy. On the other hand, lines may be regarded as an extension of the plant facilities of an integrated company. This view prevails in fact, and makes for efficiency in processing and ultimate public benefit.

The author's treatment throughout is on legal and historical lines ; but he does not lose sight of the implications of possible future technical developments. For example, the introduction of alternative freights, such as synthetic alcohol, hydrogenated coal, or pulverized coal suspended in a liquid medium, are discussed as possibilities that may radically alter the present status of the pipe-line. His book is an unbiased and well-documented chronicle of conflicting policies and enactments during the past 35 years. It is topical as bearing on the national defence programme of U.S.A. ; and it is deserving of study in any other country that may be faced with problems of pipe-line regulation.

S. J. ASTBURY.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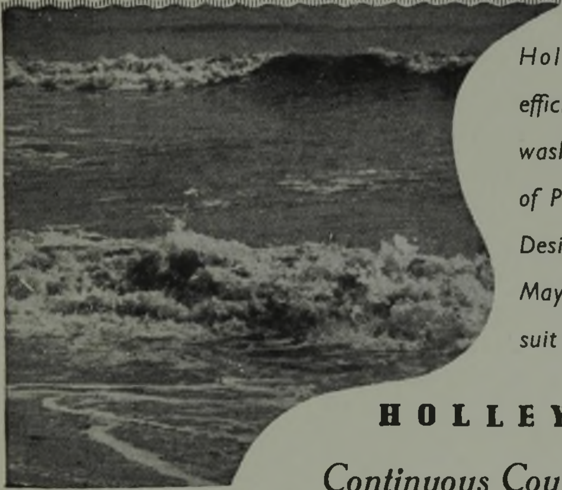

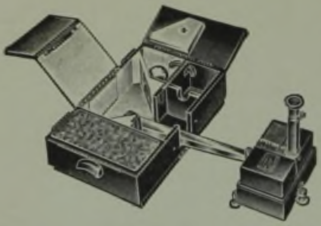

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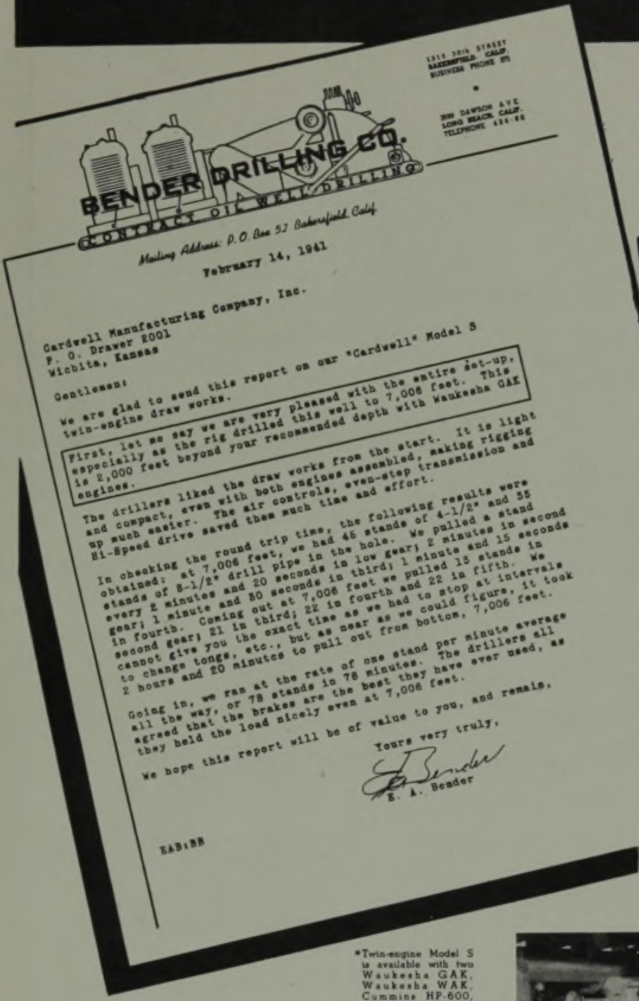

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TELEPHONE 434-60

February 14, 1941

Cardwell Manufacturing Company, Inc.
P. O. Drawer 2001
Wichita, Kansas

Gentlemen:

We are glad to send this report on our "Cardwell" Model S twin-engine draw works.

First, let me say we are very pleased with the entire set-up, especially as the rig drilled this well to 7,006 feet. This is 2,000 feet beyond your recommended depth with Waukesha GAK engines.

The drillers liked the draw works from the start. It is light and compact, even with both engines assembled, making rigging up much easier. The air controls, even-step transmission and Hi-Speed drive saved them much time and effort.

In checking the round trip time, the following results were obtained: at 7,006 feet, we had 45 stands of 4-1/2" and 35 stands of 5-1/2" drill pipe in the hole. We pulled a stand every 2 minutes and 20 seconds in low gear; 2 minutes in second gear; 1 minute and 30 seconds in third; 1 minute and 15 seconds in fourth. Coming out at 7,006 feet we pulled 13 stands in second gear; 21 in third; 22 in fourth and 22 in fifth. We cannot give you the exact time as we had to stop at intervals to change tongs, etc., but as near as we could figure, it took 2 hours and 20 minutes to pull out from bottom, 7,006 feet.

Going in, we ran at the rate of one stand per minute average all the way, or 78 stands in 78 minutes. The drillers all agreed that the brakes are the best they have ever used, as they held the load nicely even at 7,006 feet.

We hope this report will be of value to you, and remain,

Yours very truly,

E A Bender

E. A. Bender

EAB:BB

TWIN-ENGINE MODEL S FEATURES

"Cardwell" five-speed, even-ratio transmission drives to the drum and rotary table through friction clutches.

Friction clutches are air-controlled.

Air-controlled Hi-Speed drive operates outside of transmission for quick "kick-up" of block.

Power take-off friction clutches are air-controlled.

Draw works can be moved complete without removing engines.

When rotating, the drum may be engaged and the drill pipe lifted without stopping the rotary table.

Dual safety, self-energizing brakes

Heat-treated brake flanges have water-trough for quick cooling

Sand line drum is available with rig or for field installation at later date.

*Twin-engine Model S is available with two Waukesha GAK, Waukesha WAK, Cummins HP-600, Cummins HPS-600 (Supercharged) or "Caterpillar" D13000 engines.

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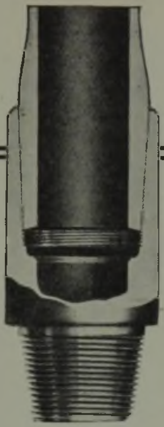

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These features assure a doubly-positive sealed joint, prevent rocking and minimize effects of whipping. All the advantages of shoulder-welding without any of the disadvantages.

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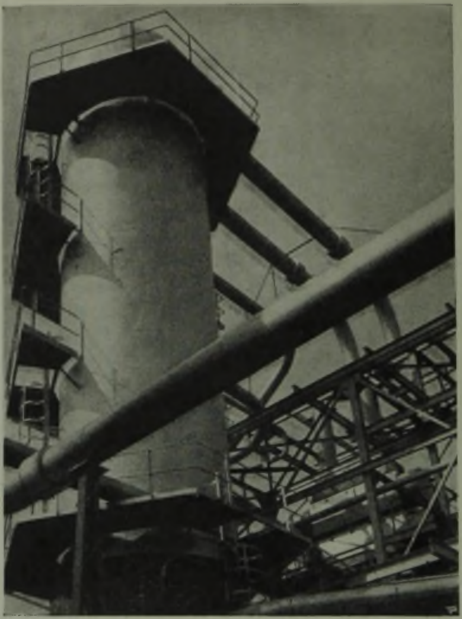

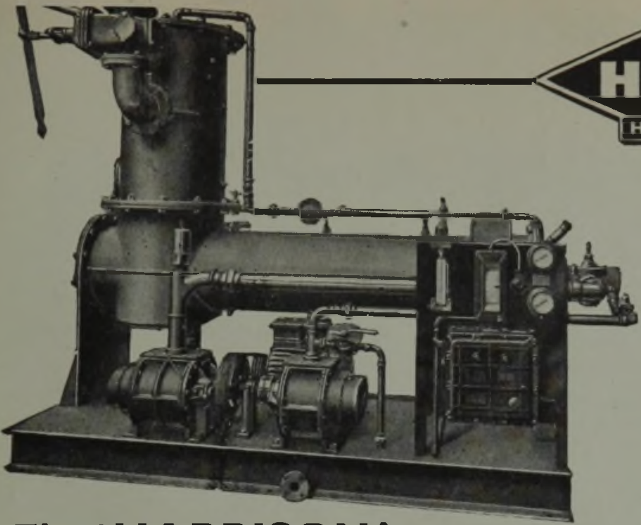

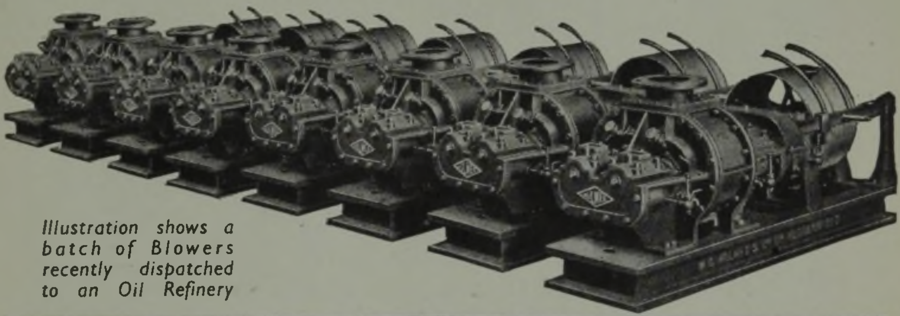

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