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THE OIL-FIELDS OF WESTERN CANADA.

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WITH world history now being made on the grand scale, you will not wish to be burdened with a detailed account of the history of the oil-fields of Western Canada. Still, a few dates are necessary, both as a background and to afford perspective to the remarkable growth of the Albertan oil industry in recent years.

Apart from reference to the tar sands of Athabasca in 1788, the striking of natural gas in 1885 at Langevin, 40 miles to the north-west of Medicine Hat, and the drilling of the Lineham well at Pincher Creek in 1902, the history of the present oil industry dates only from 1914, when the Dingman well was successfully completed on the north bank of Sheep Creek in Turney Valley, some 40 miles south of Calgary. The Great War of 1914–18 put a stop to further developments, fortunately, perhaps, because, in the light of future experience, drilling technique was not sufficiently advanced in those days to have resulted in the successful development of the field. It was not until 1924, when the Royalite Company brought in its historic No. 4 well, at a depth of 3740 feet, with a flow of 500 barrels a day of naphtha, that Turner Valley focused public attention. From first to last, this well yielded over 900,000 barrels of naphtha, valued at over $3,000,000—say, £650,000—which was a very good return (seven barrels go to the ton). From 1928, when the Home Oil Company well No. 1 came in at 700 barrels a day, until June 1936, despite several notable naphtha-yielding wells being completed, the tempo of development slowed down. In that month Turner Valley Royalties Company brought in the first crude-oil well at a depth of 6825 feet. Up to that date, with the exception of Model well No. 1, which has been a consistent producer of crude oil since 1931, practically the entire production of Turner Valley had been "vapour-phase oil"—*i.e.*, naphtha derived from "wet gas." Since 1936 the development of the field has been one of continuing success, thanks largely to the very wise conservation measures taken to protect the field.

Whilst the above developments were taking place in Turner Valley, other fields were being proven, details of which will be given later.

Areal and Geological.

The chief possibilities for development of oil-fields in Western Canada lie in the great plains and eastern foothills of the Rocky Mountains, constituting a great triangular area, 800 miles along the International Boundary, and extending 1600 miles northward to the Arctic Ocean. This area, approximating 650,000 square miles, is underlain by 1000–13,000 feet—say, 1 mile—of sediments, largely marine in origin. The structure is basin-like, with the Alberta syncline occupying the deepest part. The sedimentary section as a whole thickens gradually from east to west across the plains and foothills, very great thickening occurring in the front ranges of the Rocky Mountains and farther west. The more important structural units within the southernmost part of this great belt are :—

1. The foothills belt.
2. The Alberta syncline.
3. The Sweetgrass arch.

Within this extensive, potentially petroliferous area, the geological column of formations, with their local names and approximate thicknesses in Turner Valley, is as follows :—

Tertiary		
Upper Cretaceous,	Edmonton sandstones	1500 feet.
,, ,,	Bearpaw Shales	100 ,,
,, ,,	Belly River sandstone	1500 ,,
,, ,,	Upper Benton shales	1600 ,,
,, ,,	Cardium sandstone	100 ,,
,, ,,	Lower Benton shales	750 ,,
Lower Cretaceous,	Blairmore sandstones	1150 ,,
,, ,,	Kootenay coal measures . . .	150 ,,
Jurassic,	Fernie shales	175 ,,
Carboniferous,	Mississippian—Madison limestone . .	1500 ,,
Devonian.		

To the newcomer the stratigraphy of the foothills belt presents a veritable nightmare. Versed as he may be in the study of faults, he finds himself disbelieving the evidence of his own eyes, for the whole area is intensively strike-faulted, and is further complicated by deep-seated sole-faulting. The magnitude of displacement or throw of these faults is often staggering, not infrequently exceeding 5000 feet. Thus, one well in the centre of Turner Valley ran into a repetition of the surface formation at a depth of over 7000 feet. Again, what may appear to be a straightforward anticlinal fold often proves to be the surface expression of deep-seated overfolding. Turner Valley may be cited as an example, and until this was appreciated its eastern flank was starred by wells which ran into overfolded beds and the sole-fault which underlies the whole field.

The formations in the foothills, or disturbed belt, consist largely of hard shales, etc., with layers of abrasive sandstones, which rapidly wear out the rock-bits. Thus, it is by no means unusual for bits to have to be replaced every foot or so drilled, sometimes even more frequently. Furthermore, the strata dip very steeply, and faults, sometimes of considerable displacement, are common, necessitating the greatest care in drilling, if a straight hole is to be ensured.

On the plains, however, the strata encountered in the wells consist mainly of less indurated shales, and, as such, present little or no drilling problems.

Oil-fields.

By far the most important oil-field yet struck in Western Canada, or for that matter anywhere in Canada, is that of Turner Valley. In fact, Turner Valley can rightfully claim to be one of the most remarkable oil-fields in the world. Apart from having produced 8,902,734 barrels of naphtha—say, 1,100,000 tons—from 1924 to 1936, it has since produced

38,815,079 barrels—say, 5,600,000 tons—of high-grade crude oil of 44° A.P.I. from 190 wells the average depth of which exceeds 7500 feet. All these flow under their own gas pressure, none has as yet been abandoned, and their gas–oil ratio is less to-day than it was a year ago. Furthermore, the closure of the liquid-phase oil zone—that is to say, the depth below the base of the vapour-phase or gas zone to edge water—exceeds 4000 ft., a depth unparalleled in any other oil-field.

Prior to 1936 the field was regarded solely as a vapour-phase oil producer—*i.e.*, one in which naphtha was derived from passing the wet gas first through separators, then through absorption plants to extract another gallon or so of naphtha, and finally scrubbed to desulphurize it before being piped to Calgary and other towns for lighting, heating, and other industrial purposes. Even so, the excess production, amounting to hundreds of millions of cubic feet daily, was burnt in huge flares, only a small proportion being piped back into the exhausted Bow Island and Foremost gas-fields with the object of repressuring and replenishing them as a future reserve against the time when the Turner Valley field is exhausted.

As already mentioned, drilling in Turner Valley calls for the exercise of the greatest care, so as to ensure a straight hole. In the old days it was not unusual for a well to diverge over 30° from the vertical. Now drilling contracts specify a tolerance of not more than 3°, and the Government lay down that the well shall be completed within the central 10 acres of the 40-acre spacing per well.

The heaviest types of rotary rigs are used. According to D. P. Goodall and G. A. Connell, the common practice is to drill a 9- or 10-inch hole to between 600 and 1000 feet, ream all or part of this to 16¼ inches, and then run and cement 13⅜-inch casing with about 225 sacks of cement. A 9-inch hole is then drilled to about 10 feet below the top of the Madison (Palæozoic) limestone, to which depth 7-inch or 6⅝-inch casing is run and cemented with from 250 to 600 sacks of cement. A 6⅛-inch hole is then drilled through the zones known as the upper and lower porous limestone, to approximately 10 feet below the top of the "dark or black lime," which is usually encountered about 450 feet below the top of the limestone. After drilling is completed, circulation is continued for about 45 minutes, to remove cuttings from the hole. Where mud is used for drilling fluid, the drill-pipe is then pulled to a point about 100 feet above the shoe of the production string, and the drilling fluid above this point is circulated out with water. The drill-pipe is then pulled, and a string of 2½-inch or 3-inch tubing is run to within a few feet of bottom, and the fluid displaced with oil, which, when high-pressure gas is not available from a near-by well, is swabbed down until the bottom-hole pressure is sufficient to lift the weight of the fluid column in the tubing. Setting a hook wall-packer in the shoe of the casing saves much time in swabbing.

Where high-pressure gas is available, oil and gas are introduced together into the tubing, and are circulated down the tubing and up the casing. As the gasified oil reaches the casing-head there is a noticeable vibration of the head, and the fluid from the well, which has previously been flowing into the suction pit, is turned into the separator. As soon as these first gasified returns are obtained, the oil-pump is slowed down, until finally, when the density of the fluid column in the well decreases sufficiently and the high-pressure gas alone has sufficient energy to flow the well, the oil-pump is shut off. After a while it may be possible to pinch off the input gas and allow the well to flow unassisted. This method of bringing in wells practically eliminates the loss of oil which accompanies swabbing and stage-lifting methods.

All wells are given at least one treatment of hydrochloric acid following completion. The wells are all completed in the limestone, and, whilst quite a good flow used to be obtained from the limestone, it was found that treatment of the wells with hydrochloric acid increased the porosity of the formation and resulted in a very greatly increased yield being obtained. The general procedure is to give each porous zone a " wash " treatment to remove any drilling fluid remaining on the walls of the hole. The well is " kicked-off " following this treatment and, after testing for a short period, the well is killed and a formation packer is set in the middle hard zone between the upper and lower porous zones. After testing the penetration rate in each zone, the method of treating the well is decided. In some cases one treatment in each zone is sufficient, while in others several treatments may be necessary. The well is " kicked-off " after each acid treatment, using the same method as that employed following completion of drilling. After completion of all acid treatments, the well's flow is switched from the casing to the tubing. The amount of acid used varies considerably, several thousand gallons of 15 per cent. hydrochloric acid sometimes being found necessary for the best results.

Present drilling depths range from 7000 to over 9000 feet. The record for fastest drilling was made by Royalite 57, in which 7765 feet of hole were drilled in 103 days, including all shut-downs, being an average of 75·4 feet per day. While no comparison can be made between the two fields, it is interesting to note that on the Gulf Coast it is routine practice for 11,000–12,000 feet wells to be drilled in 30 days !

On completion the wells are carefully tested under varying flow conditions, so as to determine their bottom-hole pressure and most economical gas–oil ratios. Early this year a new method of determining production allowables was introduced on the advice of Dr. Grainger Brown. This is based on an allowable production of twenty-five barrels of reservoir fluid per acre, the minimum Government spacing being 40 acres per well, account being taken of the liquefied volume of the free and dissolved gas as well as that of the oil at the recorded bottom-hole presure. Wells with a gas–oil ratio of over 30,000 cubic feet of gas per barrel are classified as gas-wells. So long as the oil produced represents a fairly large part of the reservoir fluid, satisfactory results may be obtained by gauging the rate of reservoir fluid withdrawal by the rate of oil production. But in those cases where the gas produced by the well represents the larger part of the volume of the reservoir fluid withdrawn, satisfactory operation can be best obtained by limiting the rate of reservoir fluid withdrawal on the basis of the rate of gas production.

In most cases the gas represents about 60 per cent. of the reservoir fluid volume when the gas–oil ratio exceeds about 2000 cubic feet of gas per barrel of oil. The rate of withdrawal of reservoir fluid volume is therefore defined and controlled by the rate of gas production.

The net result of the application of Dr. Grainger Brown's method of regulating optimum economic production is reflected in the steady reduction of the gas–oil ratio, which in June 1942 was 3220 cubic feet per barrel of crude oil as compared with 4150 cubic feet in June 1941, whilst in the same periods the oil produced was 26,693 barrels and 25,786 barrels per day, respectively.

The crude oil is pumped to the refineries in Calgary, together with the naphtha still being produced from some of the older wells.

The following tabular statement shows the production of Alberta to the close of 1941, expressed in barrels.

Year.	Production.	Year.	Production.	Year.	Production.
1914–21	56,599 bbl.	1928	489,531 bbl.	1935	1,263,750 bbl.
1922	15,853 ,,	1929	999,152 ,,	1936	1,320,442 ,,
1923	10,003 ,,	1930	1,433,844 ,,	1937	2,796,908 ,,
1924	14,049 ,,	1931	1,455,195 ,,	1938	6,742,039 ,,
1925	168,643 ,,	1932	917,622 ,,	1939	7,594,411 ,,
1926	219,598 ,,	1933	1,013,040 ,,	1940	8,495,207 ,,
1927	332,133 ,,	1934	1,265,940 ,,	1941	9,908,643 ,,

Total: 46,512,602 barrels, or 6,500,000 tons.

While the above is the production for the whole of Alberta, it may be taken as an index of the production of Turner Valley, since the latter is responsible for about 99 per cent. of the totals.

The number of crude-oil wells drilled in Turner Valley since June 1936, as distinguished from the vapour-phase oil wells drilled prior to that date, has been as follows:—

1936	2 wells.
1937	22 ,,
1938	36 ,,
1939	34 ,,
1940	35 ,,
1941	46 ,,
Total . . .	176 wells to the end of 1941.

While the first crude-oil well in 1936 was drilled on the west flank of the south portion of Turner Valley, and was followed by intensive drilling in that area, the outstanding development of the field in the past three years has been its northern extension. Here a succession of wells has been drilled since Home-Millarville No. 2 was completed in January 1939, and yielded 220,000 barrels in its first year. The whole field is now over 17 miles long, with an average width of 1 mile. Of the 190 wells producing in July 1942, thirteen are enjoying an allowable production of over 400 barrels a day, and many have produced over 500,000 barrels apiece. Some of the wells are allowed up to 800 barrels a day. The "allowable" production per well depends on the gas–oil ratio and the bottom-hole pressure and whether the well is truly drilled in the middle of the 40 acres. One of the objects of this conservation is that the market for oil in Western Canada is limited, and the oil cannot be sent to Eastern Canada, where the market is enormous. There is thus only a limited economic area within which these wells can compete with American production, the present rate of 27,000 barrels a day being practically the marketable limit.

Very high pressures are encountered in the wells in Turner Valley, several of which have come in with productions exceeding 2000 barrels per 24 hours. Recently, Foothills No. 9, in the north extension of the field, after an application of 4000 gallons of acid, responded with a flush flow of more than 3000 barrels a day, and a very low gas-oil ratio.

It is generally held that water-drive is not responsible for the large productions of the wells—in fact, the rate of edge-water encroachment has been scarcely noticeable, and in no way comparable with the recession of the fluid in the liquid-phase zone of the field. This circumstance lends emphasis to the imperative need for gas conservation in the vapour-phase zone or gas cap of the structure.

Such in brief is the history of the Turner Valley field up to date.

Outside Turner Valley, which is the sole field producing in the foothills zone, oil has been struck and is being developed in the following areas :—

	1941.		First half 1942.	
	Production.	No. of Wells.	Production.	No. of Wells.
Vermilion	22,051	7	26,731	14
Wainwright	11,733	6	6,981	6
Red Coulee	11,626	7	5,194	7
Taber	5,600	1	5,151	2
Princess	19,587	2	4,132	1
Tilley	Nil	—	3,285	1
Dina	2,894	2	2,880	—
Del Bonita	4,393	2	1,016	—
Lloydminster	416	1	572	—

There are, in addition to the above, many areas where test drilling has been or is taking place, several of which will, it is hoped, justify the expectations of their sponsors. As it costs about £50,000 to drill a well in the foothills zone, it takes much courage to go into a virgin area and start drilling. The fields in the plains have been neglected through no glamour attaching to them. Turner Valley, with its very sensational results, has always been in the limelight, and it has been comparatively easy to finance Turner Valley propositions.

Vermilion.

Oil is found in the Lower Cretaceous formation at depths of from 1600 to 1900 feet, some wells having been drilled in 36 hours and costing as little as $12,000. The oil produced is of 14° A.P.I. gravity with a sulphur content of 3 per cent., and as such it is only suitable as liquid fuel.

While many wells have flowed at the outset, pumping has invariably to be resorted to. The field was discovered in 1939, and constitutes one pool in the Vermilion–Wainwright–Dina–Lloydminster area, being about 100 miles east of Edmonton.

Wainwright.

Although discovered in 1923, it has not been intensively developed, owing to difficulty in shutting off the water which is found in close proximity to the oil-sand. The oil is struck at about 2200 feet in the Lower Cretaceous formation. The oil is black, contains a little wax, and is topped locally for engine distillate, fuel oil, and roofing asphalt.

Red Coulee.

This pool lies partly in Canadian and partly in American territory, and was discovered in 1930. Production comes from a sand in the Blairmore formation of Lower Cretaceous age encountered at a depth of about 2500 feet. The oil is of 30° A.P.I. and is locally refined. The field is spotty, due no doubt to variable permeability of the sand and the terrace-like character of the structure.

Taber.

This field is now very much in the limelight, since the productions obtained exceed those in other fields on the plains. The writer was responsible for the discovery of the field in 1931, when oil was struck at 3150 feet in the Cole–Hunter well. For years after, the prospects of the field were overlooked, and it is only in the last year that attention has again been focused on it. Some very good results have been obtained within the last few months.

Oil is encountered in the "Cut Bank" sand immediately overlying the Ellis (Fernie) shale. The "Cut Bank" sand is, in the opinion of Mr. Irvine, the same as the "Dalhousie" sand which has been a consistent crude-oil producer in Turner Valley, even though in most wells it was shut off in the early quest for the more productive Madison lime. The completion, in July of this year, of the Standard of British Colombia's Well No. 1, with a yield of 3400 barrels in the first nine days, was the signal for a miniature boom in oil leases at Taber. It is, however, too early yet to attempt to assess the value of the field, although the subsurface structure, as determined by geophysical survey, is encouraging.

Of the other fields in the plains little can as yet be said, since their productions are small, while the quality of the oil is not high.

Refining.

The principal refineries are in Calgary, where the Imperial Oil Company, the British American Oil Company, and the McColl–Frontinac Oil Company have thoroughly up-to-date refineries with a joint capacity of over 20,000 barrels a day. That is a very conservative estimate. The figure may be about 40,000 barrels a day. It is hoped to soon produce large quantities of 100-octane petrol, while in Turner Valley *iso*butane will be obtained from the natural gas, and an alkylate plant at the Imperial Refinery in Calgary will extract butylenes from the refinery gas.

Economic Aspects.

Despite the high cost of the wells in Turner Valley (£40,000–£50,000), the industry is flourishing. The cost of production is trifling, since all the wells flow, and thanks to the stringent conservation measures taken in recent years, the decline in production of the wells is very gradual. A long life to the field is therefore expected.

Owing to the high quality of the oil it realizes a good price—namely,

\$1.35 per barrel for 33–33·9° A.P.I., increasing 2 cents per degree up to \$1.97 for 64° or greater. As the crude averages about 44°, the field price is around \$1.55 per barrel. Naphtha from the absorption plants on the field commands \$2.28–2.44 per barrel.

Owing to the distance of the oil-fields in Alberta from the important markets in Eastern Canada, the industry is placed at a disadvantage, which can and will only be overcome when the production warrants the construction of a pipe-line to the Great Lakes. It is worth noting that the distance between Hudson's Bay, which is 1100 miles from Calgary, and Liverpool is considerably less than the distance between this country and Trinidad, the West Indies, or Rumania. In the opinion of those conversant with the geological prospects of the foothills zone, it is only a question of time for the construction of such an outlet being consummated. It is largely with this thought in mind that several of the largest companies have clubbed together to drill a deep well in Turner Valley to test the Devonian underlying the Madison lime. Farther west in the foothills, at Moose Mountain, the Devonian is petroliferous, and again in Fort Norman area it is furnishing a valuable supply of oil. Fort Norman is in the Arctic Circle. Hopes are therefore running high as to the outcome of this deep test, which will exceed 10,000 feet in depth.

Athabasca Tar-Sands.

Without question the most remarkable manifestation of oil in the world is that afforded by the tar-sands of Athabasca in the neighbourhood of McMurray. The areal extent of these is estimated at 10,000 square miles, but owing to the thickness of overburden being in the light of present technique, excessive, only some 20 square miles are considered workable under current operational conditions. Even so, this area is estimated to yield 500,000,000 barrels of oil, or about 70,000,000 tons of oil, as compared with one hundred thousand million barrels in the whole area. The world's consumption of oil for about 25 or 30 years could be supplied by this one enormous area.

An interesting feature about the tar, which is extracted by the simple process of boiling the sand, is that it is extremely susceptible to heat, and, as a result of mild digestion, its gravity is raised from 10° to 20–22° A.P.I., which makes it easy to handle. It has been suggested that the Athabasca tar-sands may be regarded as an intermediary ancestor of crude petroleum, and that, had heat and pressure conditions been present, the tar would have been converted into what we term crude petroleum. In other words, the tar represents a transitional link between the raw material and crude oil. It is, however, only in the last two years that the tar-sands have been worked on a commercial scale, and those qualified to speak about the results are confident that the crude can be cracked catalytically for the manufacture of 100-octane petrol and that buna-S synthetic rubber can be produced by cracking and alkylation.

The recent completion of the Edmonton Alaska highway opens up great prospects not only for the Athabasca tar-sands, but also for the further development of the oil-field near Fort Norman. Here a number of wells have been drilled into the Fort Creek shales in the Upper Devonian, and are producing several hundred barrels of excellent oil, which is refined locally, and finds a ready market among the many mining companies and river transport vessels.

Conclusion.

The subject of this paper is, like its areal extent, so vast that no matter how it is approached it cannot be adequately dealt with in the prescribed time. One thing stands out from the mass of information already available on the subject—namely, that the oil-fields of Western Canada, in conjunction with the tar-sands of Athabasca, are destined to play an increasingly important part in the economic development of the Dominion of Canada, and the sooner this is realized the more self-evident will it become.

Bibliography.

Apart from many informative articles in the Canadian and American technical Press, the subject of this paper has been very fully covered by bulletins issued by the Geological Survey Department of the Dominion of Canada ever since oil was first struck in 1914. Since 1924 Dominion geologists, under the able leadership of Dr. G. S. Hume, have carried out many surveys and published geological maps of the foothills and plains. These have been supplemented by excellent detailed statistical reviews by Mr. J. L. Irwin of the Department of Lands and Mines of the Province of Alberta, to whom the author is indebted for many of the photographs which illustrate this paper.

Among the many notable publications may be cited :—

(1) " Development of the Athabasca Tar Sands," by Max. W. Ball (*Canadian Inst. of Mining and Metallurgy*, Vol. XLIV, 1941).
(2) " Origin of McMurray Oil Sands," by J. C. Sproule (*American Association of Petroleum Geologists*, Vol. 22, No. 9).
(3) " Possible Future Oil Provinces in Western Canada " (*American Association of Petroleum Geologists*, Vol. 25, No. 8).
(4) " History of Alberta Oil," by F. K. Beach and J. L. Irwin.
(5) " Drilling and Completion of Oil and Gas Wells in Alberta," by D. P. Goodall and G. A. Connell (*Canadian Institute of Mining and Metallurgy*, Vol. XLV, 1942).

THE INSTITUTE OF PETROLEUM.

A Meeting of the Institute of Petroleum was held at the Junior Institution of Engineers, 39 Victoria Street, S.W.1, on Thursday, December 17th, 1942, at 4 p.m. The President, Mr. C. Dalley, occupied the Chair.

The following paper was read :—

"The Oilfields of Western Canada." By Campbell M. Hunter, O.B.E., M.A., A.M.I.C.E., F.R.G.S., F.G.S., F.Inst.Pet. (see pp. 75–83).

DISCUSSION.

The President, in opening the discussion, said he had been very interested in the author's remarks concerning the rock through which he had to drill. Reference was made in the paper, in order to provide a comparison, to the fact that on the Gulf Coast it was routine practice for wells of 11,000 to 12,000 feet to be drilled in 30 days, which was about 400 feet a day, whereas in the case of the Turner Valley, in the well where the drilling was fastest the average rate had been 75·4 feet per day. He did not think that statement was complete unless the number of rock-bits used was given. In his own principal experience of drilling through heavy rock the rate had been 5 feet per week, and in a well 7000 feet deep over £35,000 had been spent on rock-bits, and if the same conditions obtained in Turner Valley the £50,000 to which the author had referred would be almost spent on rock-bits alone.

The author referred to a well being killed but did not say how it was done, and he would like to know whether it was killed with heavy mud or what method was used.

Mr. T. Dewhurst said that the members were indebted to the author for the latest of a series of papers which from time to time had kept up to date their knowledge of developments in Western Canada.

The enormous oil-belt of Western Canada constituted only the northern half of the Rocky Mountain oil-bearing region, and that in turn represented only that eastern remnant of the Cordilleran geosyncline which had escaped the effects of the Laramide revolution.

A very wide range of the geological column was represented in the region in question, and in general it might be stated that the pre-Laramide formations were almost entirely marine, and that the younger formations were largely of brackish or fresh-water origin. In conformity with that source of origin, it might be inferred that the oil was pre-Laramide in age. The main oil-bearing stages would seem to be the Upper Devonian, the Upper Mississippian, the basal Jurassic, and the basal and lower parts of the Cretaceous. In any case it was probable that the main oil-forming stages were closely related to the major unconformities, the most important of which seemed to occur at the base of the Devonian, between the Palæozoic and the Jurassic, and also at the base of the Cretaceous. The earth movements associated with those and possibly other unconformities doubtless ushered in conditions suitable for the formation of oil, while later on the unconformities themselves would facilitate the subsequent migration of the oil. The extensive overlaps which occurred might have given rise to stratigraphic traps suitable for the accumulation and retention of the oil.

The author had referred to the very serious difficulties in the way of prospecting for oil in Western Canada. In the foothills belt those difficulties were due to complications of structure, involving low-angle thrust faults. The test drilling which had been carried out within the foothills belt in Canada and also farther south, in Montana, had as yet failed to disclose the existence of another Turner Valley oilfield.

With regard to prospecting in the plains, the great difficulty of detecting the presence of extremely gentle and closed structures was increased by the presence of glacial overburden, and it was much to be hoped that those difficulties would in time be resolved by geophysical methods of exploration. In that connection it might be presumed that the Athabasca tar-sand deposit was what he might term the corpse of what might have been an enormous oilfield, and it would be interesting if the author would indicate whether he regarded this unique deposit as being due to gentle doming of the strata or to a terrace on a great monocline or perhaps to the presence of a stratigraphic trap. In any case, the existence of the deposit suggested that other deposits of oil, more deeply buried but nevertheless less moribund, might still lie undetected within the eastern homoclinal belt.

In conclusion, he would like to express his own thanks as a geologist, and no doubt the thanks of other geologists, who could not be present, to the author for his paper, and he would also like to wish the author every success in his strenuous efforts to develop the oil resources of the great Dominion of Canada.

Mr. R. J. Ward asked the author whether the extension in the north-western area of Turner Valley was still being developed, and whether he could state the type of oil that was obtained there.

The author had mentioned that the site of each well was 40 acres, and that one condition for increased allowables was that the well should be near the centre of the 160-acre area allotted. It did not necessarily follow that that would be the best site for the well, and he wondered whether the Companies developing the field were tied to the centre of the 160 acres, particularly in view of the axis of this extension running north-west–south-east and drilling areas had been divided into squares running north and south.

Mr. S. H. Chapman said the author stated that the common practice in Turner Valley was to drill a 9-inch or 10-inch hole and then ream out to 16½ inches. He would like to ask whether this practice of drilling a comparatively small hole followed by 7½ or 6½ inches of reaming was adopted because it was found easier to keep the hole straight, and also cheaper than drilling, say, a 14-inch hole, leaving only 2 inches to be reamed.

With regard to the limestone, he would like to know what proportion or percentage of it contained oil, and what was the porosity and permeability of the oil-bearing limestone.

Mr. C. T. Longcroft said the author had mentioned, when showing his slides, that in the Turner Valley oilfield an overfold had been encountered in a well which was drilled down to 7000 feet, and that the well had had to be abandoned. Surely overfolding did not necessarily preclude the presence of oil beneath the formations which were first encountered and then met with again in the reverse order. If he remembered correctly, "we used to encounter similar conditions in the Boryslaw field of Poland, but this did not prevent our finding oil beneath the overfold." He would be very glad if the author, as a geologist, could clear up that point.

Mr. E. H. Cunningham-Craig, in a written contribution read by the Honorary Secretary, said he was glad that the Institute was in ordinary session again, with a geological paper being read by one who was almost worthy of the title of "old timer," for Mr. Campbell Hunter had spent much time and done much hard work in exploring the delectable Province of Alberta, and was yet ready to seek for new marvels.

He thought that the author and he would probably agree fairly well as to the different stages into which they would divide the geological exploration of the oil-bearing lands. Possibly the author would give more attention to actual drilling and engineering problems, shows and productions of oil, while he himself would confine his studies for the first year or two almost entirely to geological structure. He would therefore date the commencement of the systematic search for petroleum some years earlier than most people would.

He did not know when it was that Dr. Dowling first took the field in Alberta; it was not before 1908, but he must have had a start of at least four years over anyone following him. Why had Dr. Dowling been apparently forgotten, instead of his sound geological methods being keenly followed? He could say with confidence that if Dr. Dowling had been followed, at least half the wells drilled in Alberta without oil being found would not have been drilled at all, or, to put it more fairly to all parties, exploration with the drill would have been delayed for a few years, until the complexities of the geological situation had been more thoroughly and scientifically studied.

At the beginning of 1912 there were only the pioneer geological maps of Dr. Dowling's to rely upon, and those were on the scale of one mile to half an inch, which was far too small a scale for the mapping of such intricate structures as those encountered in the foothills of Alberta. Consequently there were mistakes both in stratigraphy and in structure even in those maps, but with large-scale maps to work on Dr. Dowling would have made no mistake at all. The point was that Dr. Dowling provided the keys to nearly all the problems and points of difficulty in the foothill regions of Alberta. The strong but often somewhat concealed asymmetry, the thrust-planes, with their riders, the general stratigraphy, could all be found in map and section in Dr. Dowling's work.

Those who came after Dr. Dowling, working on the six-inch scale—twelve times larger than his—made many mistakes in the first two or three years, but, correcting their errors as they went along, they gradually proved the truth of the most startling facts as shown on Dr. Dowling's maps and sections, made such emendations as were necessary, and now had a clear and consistent story of hundreds of square miles of the foothill country between the Athabasca tar-sands and the U.S.A. frontier which any geologist could read with ease.

He was sure that every geologist who had studied the foothill country by the only certain method—*i.e.*, large-scale mapping—would readily admit his debt to Dr. Dowling, who was a great geologist and had not been equalled, far less surpassed, by any of the official geologists who had had to tackle in recent years the somewhat difficult country in question.

It was perhaps unfortunate that the two strikes of oil in the Dingman well had been made so early in its history, for, although the oil was very highly filtered and gave a great stimulus to practical development, a very senseless boom was caused. Much confusion in geological ideas was also caused. The people of Western Canada were keen, enterprising, and anxious for quick results.

On the other hand, large-scale geological mapping took a long time. The natural results followed. It was well that the war of 1914–18 soon slowed up the budding oil industry. It carried on in a small way still, producing filtered oil: every new well brought in causing new encouragement. But geological work went on all the time, with declines and recrudescences, and bit by bit the story of Alberta's oilfield was pieced together.

Many wells were drilled, and nearly all were failures; certainly Western Canada got a bad name, although numerous stout hearts never gave up hope. It became the fashion to drill through thrust-planes or to attempt to drill into beds below where even the driest gas could be found. The same mistakes were made again, and would be made once more. Nothing could stop it.

At last, in 1929, the last particle of evidence that was wanted came to light, and the secret of Turner Valley was a secret no more. It was disclosed to only a few. But the brave men who would take the risk of drilling, drilled, within six years, and proved with one well all the real Turner Valley, north and south, as far as it had been followed. They deserved the title of discoverers, for they had worked out logically why the oil must be there, why it could be nowhere else, and why it must be of the quality it was. It was quite a romantic story.

He agreed with the author that there were still many untested chances for oil production in Western Canada, but, on the other hand, a very great deal was now known about the geology of Western Canada.

Much land that looked promising a few years ago must now be rejected. One or two localities had still great chances. Everyone wished Western Canada well, but qualifications to warrant careful examination were likely to be raised much higher than formerly. There was still much need for large-scale mapping.

Mr. A. P. Catherall, referring to the question of well spacing, asked whether the figure of one well to 40 acres or sixteen wells to the square mile was based on any scientific fact with regard to drainage area or whether it was just an arbitrary Government regulation.

Mr. Campbell Hunter said it was an arbitrary Government regulation.

Mr. Catherall said that on the last page of the paper it was stated that some 20 square miles of the Athabasca tar-sands were considered workable. With sixteen wells to the square mile, there would be about 320 wells, and they were to yield 500,000,000 barrels of oil, which would be about 1,500,000 barrels per well. That seemed to be a rather high figure.

Mr. Campbell Hunter replied that it was not a question of producing by wells; it was a tar-sand proposition, the average content being about 19 per cent. bitumen.

Mr. A. E. Chambers asked whether the Turner Valley had proved itself to be a commercially attractive proposition. It seemed to him that it was very much limited by its geographical situation, as had been pointed out, and it would be easy to get over-production with so many wells. Perhaps the author in his reply would touch on the broad commercial aspect of Turner Valley.

Mr. Campbell Hunter, in replying to the discussion, said the question raised by Mr. Chambers was obviously a very important one. His difficulty in dealing with it concisely was due to the way in which the Turner Valley field had been financed. The cost per well was such that in most cases a well was regarded as a unit of finance and was financed in different ways. In the old days it was financed by the promoters selling stock. Nowadays, except in the case of the Standard Oil Company and the larger companies, it was usually financed on a royalty basis, a certain number of royalty units being sold. The value of the unit was determined according to the probability of oil being struck in the site in question. The company holding the acreage would sell 50 units, say, at 5000 dollars per unit, which would bring in 250,000 dollars, a sum estimated to be sufficient for drilling the well. The promoters would retain the other 50 units for themselves and the overriding royalty owners. Therefore the dividends paid by the different companies represented only a very small proportion of the financial return which Turner Valley was making to its sponsors. He could only say that the proof of the pudding was in the eating, and as forty to fifty wells were being drilled per annum he considered it was fair to conclude that drilling in Turner Valley was a commercial proposition.

In answer to Mr. Ward, he explained that the 40-acre lot, known as a legal subdivision, was taken as the unit for locating wells. It was not based on any geological grounds.

In reply to Mr. S. H. Chapman, he stated that the porosity of the limestone varied considerably, and for that reason the limestone was treated with hydrochloric acid to increase its porosity.

The consumption of rock-bits varied enormously. When drilling through hard shale one could drill 120 or 130 feet, or even more, per rock-bit, and he had known 200 feet being drilled without the rock-bit being changed. When hard sandstone was encountered, the rock-bit might have to be changed after only 6 inches had been drilled. The rock-bits cost about $100 (about £20) each, and, speaking from memory, he thought in Turner Valley about 200 rock-bits were used per well.

So far as the killing of wells was concerned, they were killed with oil and not with mud; otherwise the process of cleaning out would be delayed a great deal.

Mr. Cunningham-Craig's remarks were very interesting. He thought that Mr. Cunningham-Craig could also claim to be a real "old timer" himself, as he had met him in Canada in 1914. He could not say that they had always agreed, but one learned much more by disagreeing with a person than by agreeing with him. There were undoubtedly going to be many pleasurable surprises and many heart-breaking disappointments. The foothills belt must not be considered as represented only by Turner Valley. Finance had been attracted to visible results, and when one tried to finance a likely structure elsewhere, the first question asked was: "Is it near Turner Valley?" If the answer was "No," people were not disposed to help to finance the proposition.

The President, in proposing a vote of thanks to Mr. Campbell Hunter for his excellent paper, which had provoked a very good discussion, said that he himself already envisaged a scheme whereby the surplus gas from the Turner Valley would be injected into the Athabasca tar-sand as a method of recovery in place of the laborious system of extraction from the sand.

The vote of thanks was accorded with acclamation, and the meeting then terminated.

In a written contribution Mr. I. A. Stigard said that there seemed to have been few developments in Canada during the last quarter of a century, although Mr. Campbell Hunter had not touched on the subject of potential oilfields in British Columbia.

He had visited the "High River" district, a few miles south of the Turner Valley, which had had very favourable reports and where concessions had been taken up and borings projected. At first sight, the field looked like an anticlinal valley with escarpments on either side dipping about 30° and 35° in the Upper Cretaceous series (which are, of course, unconformable on the Lower oil-bearing series). This structure seemed to have formed the basis of the section, but an investigation in the gorge at the bottom of the valley soon disclosed beds of the Lower Cretaceous series, exposed in nearly vertical beds dipping 75–85° in either direction. There was, of course, a big unconformity in the Cretaceous above the petroliferous series, and there was no relation in the structures of the two series.

Turner Valley had sometimes been exemplified as a typical anticlinal valley, but was probably much more complicated. He had, many years ago, given the opinion that the strata of the foothills were, in general, too much disturbed to provide good results, but that when deeper drilling became possible good results would be obtainable in the region where the prairie merges into the foothills, where the Cretaceous lies at great depth.

He did not know whether Mr. Campbell Hunter had given any attention to the region of the upper part of the Peace River Basin, in the part where British Columbia extended over the watershed to the eastern side of the Rockies, as this region seemed to have a more favourable structure than any other in the foothills.

The Wainwright Field had given rise to high hopes in 1920, but seemed to have shown disappointing results.

The Athabasca Tar Sands, which extend for over 10,000 sq. miles in a nearly horizontal position, seemed so far to have been exploitable only by distillation, but more development might be done in this direction. When struck at depth, however, the bitumen was found to be in a viscous condition, and became less inspissated with increasing depth. The gas which was always associated with these sands at depth (*e.g.*, Pelican at 600 ft.) was, however, exploitable, and was present over an enormous area in almost unlimited quantities.

Mr. Campbell Hunter had not alluded to experiments carried out by a Calgary engineer for the distillation of oil in wells in the "Tar Sands." Concessions had been obtained and attempts had been made to form a syndicate to carry these experiments into practice, but he had heard no results although the plan seemed to be open to wide possibilities.

Fort Norman and the Mackenzie Basin were a different story, although a boring at Pelican passed through the "Tar Sands" into the Devonian where traces of oil were found.

In conclusion, he did not think it was purely fortuitous that the International Boundary should divide a country with the greatest production in the world from one which, while larger in area, had a relatively poor production. He considered that the reason for this was financial rather than geological, and that it had been brought about by a lack of capital and enterprise.

OIL—AN ADDITIONAL BASIC MATERIAL FOR THE BRITISH PLASTICS INDUSTRY.

Extract from an Address before the Institute of the Plastics Industry, London Section, on Wednesday, 13th January, 1943.

By Dr. G. Tugendhat, M.Sc.Econ.

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Introduction.

The big and ever-growing family tree of the synthetic plastics and resins has its roots in many fields. Coal and coal-tar derivatives such as phenols, formaldehyde, urea, and many of the acetylene derivatives, fermentation products such as alcohols, and organic materials such as casein and cellulose have also contributed to its growth.

In the beginning of the industry many of these materials were considered to be of little industrial use, and were even regarded as waste products. In course of time the industry has called other materials, such as asphalt and bitumen and the large range of products derived from naphthalenes, glycerine, and other chemical materials, to its aid to act as fillers, extenders, and plasticizers. Many products, such as cellulose acetate, which entered the plastics industry in a subsidiary capacity, have, in the course of time, become of prime importance to the industry.

The rapidly expanding demand for plastics has raised its original raw materials to the rank of essential products. Until the outbreak of war few people questioned that the traditional sources of supply would be sufficient to meet the demands of the industry. However, due to war developments, these sources of supply are proving, in many cases, insufficient, and the industry is looking round for new raw materials. Already phenols are synthetically produced from benzol, and new sources are being opened up for the production of benzene, styrene, acetone, alcohols, and other solvents—to name only a few. Many of these bodies are being produced from oil in the U.S.A. in rapidly increasing quantities. This is a natural development, as all plastic materials contain hydrocarbons and petroleum is one of the cheapest sources of hydrocarbons known to man.

Before the war the total production in Great Britain, U.S.A., and Germany was estimated at not exceeding 200,000 tons per annum, of which England and the U.S.A. accounted for about 135,000 tons. If the Plastics Age is to become a reality, much larger quantities of plastics will have to be produced, and in many cases at lower prices than prevail to-day.

The oil industry presents the plastics industry with an abundant supply of relatively cheap raw materials. Furthermore, it offers new materials, many of them making possible new chemical synthesis.

I have been asked by your Committee to discuss to-day the following questions:

(1) The economics of oil refining in Britain instead of close to the oil-fields.

(2) A comparison between refining in England and the present set-up in the U.S.A.—could Britain expect costs to be roughly equivalent to the American?

(3) Which of our raw materials could be obtained from oil for:

(*a*) The older plastics, for instance, phenol—is it possible to give any indications of how costs would compare with materials produced by present methods?

(*b*) The newer plastics which some of us regarded as being essentially oil derivations and therefore economically almost U.S.A. preserves.

In order to discuss the economics of oil refining in Great Britain as compared with oil refining close to the oil-fields, it is necessary first of all to give a picture of the English market. In 1938, the last year for which full figures are available, the total consumption of liquid and solid petroleum products in Great Britain amounted to just over 11 million tons. About 40 per cent. of the consumption consisted of petrol, nearly 33 per cent. of fuel and diesel oil, 6 per cent. of gas oil, 4 per cent. of lubricating oil, the remainder being made up of kerosene and other refined products. Allowing for the difficulties of reconciling trade and consumption statistics, I would say that refinery production based on imported crude oil contributed about 1·8 million tons, or just over 15 per cent. to the total.

The main source of supply of finished products consumed in this country was the American Continent, which accounted for nearly 70 per cent. of the total imports—nearly 35 per cent. coming from the Dutch West Indies, 20 per cent. from the U.S.A., 9 per cent. from the British West Indies, and the balance from the Central American States. The distances these imports had to travel were from 3000 to 5000 miles. By comparison, the U.S.A. consumed in 1938 almost sixteen times as large a quantity of petroleum products as the U.K. in practically the same proportions. In other words, the break-up of the crude for England and America was almost identical. The task of the refining industry here and in the States working on similar crudes would, therefore, be pretty well the same.

As I have said before, we are importing the bulk of our finished products over an average distance of 3000 to 5000 miles. What is the position in the U.S.A.? The State with the biggest crude-oil production is Texas, which is several times the size of Great Britain. The main centres of consumption lie in the Eastern States in a triangle between Philadelphia, Boston, and Chicago. There are oil-fields in this area too, but, in order to meet the demands, 50 to 60 million tons per annum, or over 130,000 to 160,000 tons of crude oil and petroleum products, have to be imported every day of the year from the Gulf seaports. I do not know what the proportions of crude oil to finished products were ten years ago—at the end of 1940 over 70 per cent. of the daily imports consisted of crude oil, distillates, and fuel and less than 30 per cent. of fully refined products, mainly in the form of simple distillates. The distance from the Gulf ports to the Eastern seaboard is between 1800 and 2000 miles. From the point of view of proximity to the oil-fields the refinery manager in New York or Philadelphia is therefore not very differently placed from the refinery manager in the Manchester or London area. There are over 500 refineries listed in the U.S.A. to-day, and the break-up of this figure into simple refineries or topping plants and complete refineries shows that 78 per cent. of the complete refineries are right in the centres of consumption,* the remainder being at the meeting-points of the great waterways and the sea. The Gulf Coast, the gathering point of the world's largest and most prolific oil-fields, shows the smallest number of

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* U.S. Department of the Interior, Report of Investigation R.I. 3616, February, 1942, p. 34.

complete refineries compared with the big centres of consumption in the industrial triangle in the north-east. By " complete refinery " I understand a plant fully equipped to produce all the commercial oil fractions meeting the most up-to-date specifications and to utilize the gases by means of modern synthetic processes.

The building of refineries in the oil-fields continues, but apart from the special refining industry which is arising in connection with the utilization of natural-gas wells, the plants are mainly of a simple kind, not expensive to build, and designed to produce standard products from the particular crude oil which they are working. Complete refineries in the centres of consumption are specially constructed to process many different types of crude, and it would be a waste of elaborate machinery to make it dependent on one oil-field alone.*

A refinery is primarily an instrument for the separation of crude oil into its various commercial fractions. The proportion of these fractions and the chemical constitution of the crude oil vary with the different types of crude, and it is the claim of these modern, or what one may call complete refineries, that they break up any type of crude according to market requirements. There is only one limiting factor—due to technical considerations, it is not possible to work a refinery of this type economically below a certain capacity, which to-day may be put at about 500,000–750,000 tons annual throughput. There are refineries in the U.S.A. with an annual capacity of well over 2 million tons, and the biggest are located just outside New York. It is held by many that only a very small saving, if any, accrues from these mammoth refineries. Be this as it may, even a 2-million-ton refinery could be regarded as covering only 20 per cent. of Great Britain's pre-war market.

How would the British refinery manager's task as far as erection and running costs are concerned compare with that of his American colleague? *Prima facie* there should be no difference. The equipment of a refinery consists of boilers, pipe-stills, various types of vessels, a lot of storage tanks, and many pumps, pipe-lines, cables, and instruments. Calculated on the throughput, the steel and other material requirements are small. Taking it all in all, there should not be much difference between the erection costs of a refinery in Great Britain and in the U.S.A. Quotations which I saw before the war bear out this statement. There is the fact that American steel manufacturers and certain Continental concerns have concentrated for many years on the production of special refinery equipment. Not much has been done on these lines in this country, but given equal concentration of effort, competitive prices for construction material, etc., I fail to see why erection costs in this country should differ materially from those of the U.S.A., especially after the first experimental work has been carried out.

The running of a modern complete refinery comprises, broadly speaking, the working of the following processes: straight distillation, treating, blending and extraction, cracking, and synthetic processes. Distillation is the only technical process I know of where, apart from the cost of fuel, you

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* Most of these modern complete refineries work in close co-operation with the main chemical firms of the U.S.A., such as du Pont, Monsanto, Allied Chemicals, Commercial Solvents, Carbide & Carbon, etc.

can as it were unscramble your eggs as often as you like—if you pump all the fractions coming out of the distillation unit into one tank you would have the crude oil as before. The crude distillates are, however, not fit to meet modern fuel and lubricating specifications; furthermore, as their proportions are dictated by nature, the quantities very rarely conform to market requirements. To balance their proportions is the primary object of the cracking plant. Its original purpose was to crack the heavy and medium fractions into gases, petrol, fuel oil, and/or coke, and thus to increase the output of petrol from any given crude.

A synthetic department was added in order to utilize the gases and to produce from them new materials, the best known of which are *iso*-octane and similar compounds with an octane rating of 100 or more. To-day, by means of a number of operations such as hydrogenation, dehydrogenation, alkylation, isomerization, cyclization, not forgetting polymerization and reforming, the proportion of gases to liquids and the quality and quantity of gases can be varied within very wide limits by changes of operation, charging stock, and by different cracking processes. By these means the range of new chemical bodies produced from oil is steadily increasing. I might add that until a few years ago these very cracking gases were considered waste which could at best be used for heating purposes.

In the treatment and blending department the products from the fractionation and synthetic departments receive their final polish and adjustment to modern specifications. By employing physical methods of solvent extraction, aromatic bodies are separated from paraffins and naphthenes, or paraffins from aromatics and naphthenes. The latter processes are to-day mainly employed in the production of high-grade lubricating oils, kerosenes, and diesel oils; the former are becoming of increasing importance in the preliminary treatment of the petrol fractions. Although the solvent methods have largely displaced the old methods of chemical refining with sulphuric acids, acid treatment still plays an important part. I should also mention the various filtering and purification processes such as sweetening, clay treatment, dewaxing, and wax production.

Fuel, electricity, cost of the catalysts, chemicals, the replacement of corroded and eroded material, and provision for depreciation form the biggest items on the expense sheet of a refinery, on which the cost of labour represents only a comparatively small proportion. Again I do not see why the cost of fuel, heat, power, and chemicals in this country should be appreciably higher than in the U.S.A. In other words, given equal efficiency of operation, there should not be much difference between the two countries.

In this connection there remains one point to be discussed. It is the question of refinery waste, which looms so large in all discussions on refinery location in the centres of crude-oil production versus the centres of consumption. According to the laws of nature, the sum total of what is put into the refinery must be equivalent to the sum total of the products which come out. Waste is, therefore, a word which requires closer definition. In practice all physical refinery accounts show a certain shortage, due to evaporation and unavoidable errors in bringing a number of products down to a common denominator, etc. However, this refinery shortage is small—the physical balance sheet of all U.S.A. refineries gives for 1940 a figure of 7½ million barrels on a total refinery throughput of 1300 million barrels, or just over one-half of 1 per cent. It is obvious that such a small figure can hardly affect the considerations of refinery location. Indeed, what is loosely termed "refinery waste" does not in fact represent a physical shortage, but refinery products which are unsaleable. Anybody who has had anything to do with refinery management here or in the U.S.A. will confirm that the waste of yesterday has, to a very large extent, become the necessity of to-day. The cracking gases have not only become the main source of aviation-fuel blending stock, but also of an increasing number of primary, intermediate, and finished chemical bodies. Over 300 chemicals are produced from them, covering such important materials as acetone, various types of alcohols, aldehydes, esters, ketones, toluene, glycerine, and glycol, not to mention butadiene and styrene. The production of acetone from petroleum in the United States is said to be 100,000 tons per annum and to account for almost two-thirds of their total acetone production. According to various official announcements, the petroleum industry has undertaken to produce the ingredients—butadiene and styrene—for nearly 600,000 tons of the 700,000-ton synthetic rubber programme, a quantity representing only a fraction of the industry's theoretical capacity. The extracts from the various solvent processes, particularly of the heavy fractions, were largely unsaleable on account of their high content of aromatics and unsaturates. It is just the presence of these bodies which makes them interesting starting materials for chemical synthesis. Even the acid sludges which have so long defied the attacks of the chemist are beginning to yield, and interesting bodies are in course of preparation.

Whilst I hesitate to generalize, I would say that the weight of liquid and solid materials leaving a modern refinery to-day for which there is no market is less than 2 per cent. In any case it is, I believe, small enough not to affect the question of refinery location. I hope I have made it clear that the gases, far from being waste, are to-day not only required to adjust the output of a refinery to market requirements, but are also essential for the production of high-grade aviation fuel and an increasing number of chemicals.

I have not bothered about transport costs, because as long as England has no crude oil resources worth speaking of, oil products must be imported in the crude or refined form. There is one thing to be said here in favour of crude, and that is that its contamination does not matter; it may even be imported in the bottoms of merchant ships. On arrival in England the crude oil could be pumped from the tanker through pipe-lines to the refineries to be erected in our big cities at an average cost of about 3*s*. to 4*s*. per ton for 100 miles, allowing for interest and depreciation on the pipe-line. At approximately the same rates, the refinery pipe-lines could also convey the bulk of the finished liquid products from the refinery to the principal centres of consumption, whilst the gases could be either converted on the spot or, where possible, transported in liquefied form by road or rail-car.

As I said before, hard facts, not theory, support the statement that the best location for a complete refinery is in the centre of consumption, Indeed, looking at the papers published by the U.S.A. Department of Mines on refineries inside and outside the U.S.A., I have not been able to find out what is termed a complete refinery in the modern sense of the word anywhere near the centres of crude-oil production, although one or two exist in the big Gulf ports, and there are some which may be termed semi-complete near some of the big oil-fields in the world.

I think the best way of answering your third question will be to give a physical balance sheet, as it were, of a modern refinery. To date there exists, as far as I know, no complete refinery in this country, the bulk of the existing plant being asphalt refineries. Let us therefore assume that this country has decided to import 50 per cent. of its requirements in the form of crude oil and to erect refineries with a total capacity of, say, 5 million tons per annum and a cracking capacity of, say, 3 million tons. The synthetic units of these refineries would be equipped with every modern device for hydrogenation, dehydrogenation, alkylation, aromatization, polymerization, and all necessary treatment plants for the production of aviation fuel, high-grade commercial spirit, high-grade lubricating oils, waxes, etc. The great flexibility of these plants would enable their managements to buy crude oil from the most convenient and cheapest source and to work it up into proportions and qualities required by the market.

It is, of course, impossible to forecast post-war market requirements in this country, but in view of the great, I may say almost miraculous flexibility of the modern plants, I can confidently predict that any conceivable post-war demands for individual products could easily be met by the industry, and would in no way affect what I have just said about the economics of refining in this country. Furthermore, these plants could and would concentrate on the production of highest grade fuel, lubricants, dopes, and chemicals for the synthetic organic chemical industry. The balance of required imports would consist of the cheaper standard commercial products which it will undoubtedly be possible to buy on advantageous terms from the refineries near the oil-wells. I can even visualize the importation of cheap petrol for such motor-cars as we shall be allowed to run after this war, and the cracking of home-produced motor spirit into gases for the production of butadiene, aviation fuel blending stock, and similar high-grade materials. I think it is unnecessary for me to stress the advantages for our balance of payment and our trade policy that may be gained from buying crude oil instead of finished products, particularly high-quality products or chemicals.

To return to our probable refinery balance sheet. As I have said before, I cannot predict post-war demands, and in view of the ever-increasing flexibility of the plant, anything I may say to-day about possible products may to-morrow be out of date. However, to give you an idea of the products to be expected from British refineries with a total annual throughput of 5 million tons and a cracking capacity of 3 million tons, I will now give you one of many possible production programmes. Crude oil, as most of you probably know, is a liquid which contains a blend of thousands of hydrocarbon compounds, from the simplest structure, such as methane and ethane, down to the solids and semi-solids, such as asphalt, bitumen, and the paraffins. The last two have been the friends of the plastics industry almost from its inception. Chloro- and nitro-paraffins are newcomers, but are rapidly gaining an important position for themselves.

In addition to over 4 million tons of liquid and solid products, there would be between 240,000 and 500,000 tons of gases. Without dehydrogenation or aromatization the yields of unsaturates, mainly ethylene, propylene, and butylenes, would be between 120,000 and 200,000 tons. These yields would be considerably increased by dehydrogenation. By a new aromatization process which has been developed in this country, using naphtha or gas oil as starting material, it would be possible to produce from each 100,000 tons of feeding stock approximately 25,000 tons of unsaturated gases, ranging from ethylene to butylenes, 30,000 tons of low and medium boiling pure aromatic liquids, such as benzol, toluene, xylene, naphthalenes, etc., the remainder being methane and ethane and a small fraction of heavy tar and coke.

Looking at these materials from the point of view of the plastics industry, I may say that it would be possible to produce many tens of thousands of tons of thiokol, polyvinyl chloride, styrene, methacrylates, glycols, glyptal resins, benzol for phenols, etc., not forgetting butadiene, acetone, acetic-anhydride and a goodly number of various solvents, plasticizers, varnish bases, and drying agents. Who shall say which unknown hydrocarbon fraction of to-day will not be one of the reigning monarchs of the plastics world to-morrow ?

As crude oil contains only traces of oxygen, no nitrogen, and only a very small proportion of sulphur, which can easily be removed on cracking or by chemical treatment, it is comparatively simple to produce pure products free from these adulterating compounds. As hydrocarbons are present in every fraction of crude oil from the gases to the solids, every part of petroleum offers the possibility of chemical synthesis, and may be regarded as a potential brick for the plastic chemist.

I hope I have made it clear that the oil industry is capable of supplying large quantities of most of the starting materials for the plastics industry, not only the olefins, but also the full range of aromatics which were hitherto the preserve of the coal-tar industry. I should mention that it is also possible to produce from refinery gases formaldehyde and ammonia. This is already being done in the United States.

I believe that the only question your Committee has put to me which I have not answered is the question : "At what cost is it possible to produce the raw materials for the plastics industry ? " As they all come out of the same cask, the allocation of the cost of individual items is, as many of you well know, practically impossible.

As a refinery manager I shall sell my products for what the market will pay for them. In so far as they are used for heating purposes their value will be mainly determined by their B.T.U. value, handling, and transport costs. Before the war the U.S.A. refineries were selling cracking gases for heating purposes at fuel oil prices, *i.e.*, 80 cents per barrel or $5 per ton, or less than one-fifth of one cent per lb. *iso*-Octane was and is produced from these cracking gases. Ten years ago one American gallon was claimed to be worth $500, and I believe there was not one gallon in the whole world. To-day U.S.A. refineries are selling 100 octane fuel at 11 to 13 cents per gallon allowing for profit and amortization of the plants within three years.

On the basis of this calculation, *iso*-octane should be worth about .17 cents per gallon. Therefore there is no reason to assume that the cost of other materials produced from cracking gases will not, on large-scale production, come down to similar lower levels.

It is claimed in the scientific books which I have read on the subject of plastics that the chemist of to-day not only knows how to build from simple substances complex molecules from which to form plastics, but that he is also able to determine beforehand most of the properties of the resulting material. There is no doubt that the physical chemists and chemical physicists are, with their mathematical formulas, increasingly transforming the old and homely methods. The industry has embarked on the great and adventurous journey of creating products designed to meet specified needs with maximum effect and minimum waste. There is no sphere in human industry or life in which plastics do not tend to play an increasingly important part. Dissatisfied with the limitations set upon its products by the very nature of the existing starting materials, the plastics industry is aiming at pushing its boundaries farther and farther afield. It is anxious to compete in heat and cold, ductility, elasticity, tensile strength, modulus and hardness, colour, beauty, touch, and resistance to wear and tear, with everything with which nature has provided us.

In practice all this poetry boils down to this. If the industry is to achieve its ambition, it must provide its workers with, I would say, almost unlimited supplies of cheap raw materials from which to build by large-scale production, old and new molecules. The chemist's hands must not be shackled by restricting him to a certain range of raw materials—nothing, to my mind, is more conducive to the creation of a new industry than the feeling that it can wallow in raw materials. It is, I believe, an unchallenged fact that it is practically impossible to meet the requirements of this country in petrol and other liquid fuels from coal by the known methods of hydrogenation: this quite apart from the fact that 4 to 5 tons of coal are required to produce 1 ton of petrol, and the cost of conversion is £10 to £12 per ton against £1 to £2, which is the cost of producing petrol from crude oil. The elimination, or even a considerable reduction, of our importations of petroleum products is, therefore, simply not practical politics, if the industry of this country is to be maintained on an efficient level. Therefore, the development of a synthetic chemical industry based upon oil does not raise the problem of importing new raw materials, but simply requires the substitution of refined products by crude oil which may be bought anywhere in the world.

In the U.S.A. a number of products which can be produced from oil are still being produced from coal in increasing quantities, thus proving that coal can hold its own against oil. In fact, recent research has, as far as can be judged from the meagre information given these days, paid great attention to the isolation and production of special hydrocarbons, oxygen, and nitrogen bodies from coal or coal-tar which should be of special interest as building bricks for the synthetic chemical industry, plastics, drugs, and dyes production.

There are bricks in coal and there are bricks in oil; there are, for that matter, bricks in a good many other places which I should have liked to mention, but which, as they do not form part of this address, I have reluctantly left out. In fact there are bricks everywhere, and only intensive research, experience, and the application of methods of large-scale chemical engineering can and will prove the advantages of one God-given raw material over another for this or that process. Of one thing, however, I am certain—as certain as I am of anything in this life—and that is that unless we apply our minds to everything that nature has given us, we must, and we undoubtedly shall, fall behind those who are not content to restrict their minds and their labours to the scraping out of narrow corners, but have set their ambitions on exploring the whole world.

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.

Geology and Development.

253. Crude Oils of New Mexico. E. C. Lane. *U.S. Bur. Mines Report of Investigations*, No. 3660, August 1942.—It is reported that the first important discovery of oil in New Mexico was made in 1909 near Dayton, Eddy County. Although wells were drilled in 1911 and 1912 in McKinley County, commercial production did not in fact begin until the discovery of Hogback Field, San Juan County, in 1922. It is only since 1930 that the State has ranked as one of the large producers, being sixth or seventh as compared with other States in recent years. Table 1 of this report shows production by years from 1924 to 1940, the figures being taken from the *Bureau of Mines Mineral Year Book*. Table 2 gives information as to the discovery of well production for 1940, and cumulative production for each field reported. A further table summarizes data showing sources of samples and some of the characteristics of crude oils from New Mexico. H. B. M.

254.* Regional Geology of Dakota Basin. N. Ballard. *Bull. Amer. Ass. Petrol. Geol.*, October 1942, **26** (10), 1557–1584.—The broad Dakota syncline is bounded on the east by the pre-Cambrian outcrops in Minnesota and the Sioux uplift, and on the west by the Black Hills pre-Cambrian and the Baker–Glendive anticline. It is wider and less deeply folded than the comparable Powder River basin in north-eastern Wyoming, and less elongated in a north-west to south-east direction.

Alluvium of re-worked shales and gravel may be the western and southern equivalent of northern boulder-clays. Silts of glacial Lake Agassiz along the Red River reach 100 ft. thick. Glacial drift (up to 500 ft.) thins westward, and does not reach beyond a north–south line west of the Missouri River.

The Tertiary includes White River (Oligocene) volcanic ash, pinkish clays, and calcareous sands (0–400 ft.), Fort Union sandy clays and lignitic sands (0–1200 ft.), and the Lance comprising the marine Cannonball and the lignitic Ludlow (together 0–300 ft.), as well as the very lignitic Hell Creek (up to 600 ft.), which at its base has small pebbles from the underlying Fox Hills (Cretaceous).

The Fox Hills formation (approx. 350 ft.) has, in its highest beds, many shells of *Ostrea glabra*, and passes with gradation downwards into the Pierre shale (1200–2000 ft.), in which the Eagle sand is a potential yielder in North Dakota, while the Shannon sandstone already produces oil in eastern Wyoming. Corresponding sands yield gas in the Baker–Glendive field, Montana. The Niobrara contains 200–325 ft. of impure chalk, grading into grey shale. Below it the Benton (about 250–1910 ft.) is of shales and some thin aragonitic fossiliferous limestones. The oil-bearing Wall Creek and Newcastle sands in Wyoming form part of the Benton. The sandstones of the Dakota group (0–725 ft.), above and below the Fuson grey to maroon shale member, yield oil in Wyoming and gas locally in the Dakotas. The base rests with major unconformity on the Jurassic.

The Canadian facies of the Jurassic contains grey marine shales in addition to red to maroon shales with anhydrite. It includes the Morrison (0–220 ft.) and Sundance (up to 735 ft.), and overlaps on bevelled edges of strata ranging down to the Devonian. The Triassic is represented by the Spearfish (up to 830 ft.) of red muddy sands. The Permian consists of the Minnekahta purplish grey finely crystalline limestone and dolomite with bituminous smell (40–60 ft.), and the Opeche ruddy shales and silts (60–160 ft.) with anhydrite. The Opeche–Minnelusa contact seems to be gradational.

The Minnelusa (Permo–Pennsylvanian) is up to 1335 ft. thick and comprises limestone, chert, dolomite, anhydrite, coaly and red shales, and grey to red sands of varying coarseness. It provides oil in the Williston basin of the Dakotas, and in Wyoming. It rests with great unconformity on the Big Snowy series (500–1450 ft.), which is mainly of grey limestone finely crystalline or oolitic. These beds are probably Upper and Middle Mississippian, and towards the west appear to contain the 6700 ft. oil-zone of the Baker–Glendive area. The Pahasapa limestone (Lower Mississippian) merges upwards into the Big Snowy group and downwards into the Englewood (Kinderhookian), which has Chattanooga-like shale with conodonts below it. Exposures at Wind Cave, Black Hills, show no discordance of dip between the Englewood and underlying Deadwood (Cambrian). Siluro-Devonian lithographic dolomite with streaks of leached green shale occur in south-eastern South Dakota;

and in Williams County, North Dakota, it is believed that 635 ft. of these beds have been penetrated. In the eastern half of South Dakota, Devonian dolomite with round frosted grains of quartz overlaps the Ordovician.

The Ordovician includes Whitewood limestone, Decorah shale, and St. Peter (?) sandstone. Beds of Beekmantown age (Lower Ordovician) are not recognized. The Deadwood (Cambrian), which ranges from 233 to approx. 500 ft., includes glauconitic fucoid-bearing sandstone, shales, and dolomitic limestone with basal conglomerates.

The undermentioned epochs of tilting and folding are indicated :

Post-Oligocene.
Post-Fort Union.
Possibly post-Fox Hills, pre-Lance.
Post-Morrison, pre-Lakota.
Post Spearfish, pre-Sundance.
Post-Chester, pre-Pennsylvanian.
Post-Devonian, pre-Mississippian.
Post-Silurian, pre-Devonian. } Near or in
Post-Galena, pre-Silurian. } area of
Post-Beekmantown, pre-Chazy. } Sioux uplift
Post-Deadwood, pre-Decorah.
Pre-Cambrian folding.

Pre-Cretaceous and pre-Pennsylvanian palæogeological maps are provided.

A. L.

255.* Interbasin Pennsylvanian Correlations, Illinois and Iowa. J. M. Weller, H. R. Wanless, L. M. Chine, and D. G. Stookey. *Bull. Amer. Ass. Petrol. Geol.*, October 1942, **26** (10), 1585–1593.—A 350-ft. Pennsylvanian section in adjacent parts of Illinois and Iowa has been correlated bed by bed. At the bottom, the composite Seahorne cyclothem (Middle Cherokee) of western Illinois is equivalent to the Munterville limestone of southern Iowa. Succeeding coals, and fusulinid and other marine as well as non-marine limestones are readily linked up, and cover the whole of the Des Moines series. At the top, the Trivoli limestone, in Illinois, is synchronous with the Hertha limestone, in Iowa. The Hertha has the earliest specimens of *Triticites*, and is the lowest limestone of the Missouri series. The Trivoli, albeit without fusulines, lacks characteristic Des Moines fossils such as *Mesolobus* and *Prismopora*. Several of the sandstones are of a channel-filling nature. A. L.

256.* Chester Sandstones Producing Oil and Gas in Lower Wabash River Area, with Special Reference to New Harmony Field, Illinois and Indiana. G. V. Cohee. *Bull. Amer. Ass. Petrol. Geol.*, October 1942, **26** (10), 1594–1607.—The New Harmony field, discovered in June 1939, lies along the lower Wabash River. It has developed rapidly, and, by the end of 1941, covered 5000 acres with 647 wells which had then produced 11,700,000 brl. crude oil. Future reserves are put at 20 million brl. If we include the Keensburg field the productive area is about 18 ml. long from north–north-east to south–south-west and from ½ to 2 ml. wide, and occurs on a broad, slightly folded anticline. Oil and gas usually occupy local highs, but productive areas in individual sands depend more upon sand characteristics than on tectonic structure.

The main yield is from Chester (Upper Mississippian) sandstones, including the Bethel, productive over 3300 acres ; the Aux Vases, productive over 2640 acres ; the Cypress, productive over 2000 acres ; while the Waltersburg, Tar Springs, and Paint Creek-Bethel yield from 750, 480, and 440 acres respectively. Other production is from the basal sandstone of the Lower Pennsylvanian, and from the Fredonia (= McClosky) limestone of the Ste. Genevieve formation (Lower Mississippian).

The Chester sands are mainly fine-grained, usually with siliceous cement, but the Aux Vases (= Rosiclare sandstone of Hardin County) has varying amounts of calcareous matrix, which may be so abundant as to render parts of the sandstone impermeable. In the southern area of the field, Aux Vases wells are shot with 600 or more quarts of nitroglycerine.

These fine sands were apparently deposited near shore in advancing Chester seas, and may have been supplied from a low-lying land mass by large streams of low gradient. Current and wave action contributed to re-work unconsolidated alluvial material. Sandbars and irregular sand deposits, formed as lenticular and disc-shaped bodies—cf. C. Bower, *Bull. A.A.P.G.*, June 1928—which grade laterally into siltstone and shale, were preserved by later sedimentation in the transgressing sea. A. L.

257.* Crocker Flat Landslide Area, Temblor Range, California. R. R. Simonson and M. L. Krueger. *Bull. Amer. Ass. Petrol. Geol.*, October 1942, **26** (10), 1608–1631.—In the Crocker Flat–Recruit Pass area of the Temblor Range, north-east of the San Andreas fault-zone, structures previously described as a low-angled overthrust sheet, and succeeding fanglomerate lenses containing granitoid and schistose boulders, are shown to be due to large-scale landslips which took place during the Upper Miocene.

Following late Antelope orogeny which exposed sands and shales of the Vaqueros (Oligocene) and Temblor (Lower Miocene) as well as Gould shale (Middle Miocene) along an uplifted axis corresponding with the San Andreas fault-zone, slipping due to gravity brought a crumpled sheet of these earlier Tertiaries to rest upon the McDonald and Antelope shales (Upper Miocene).

Erosion followed this primary Crocker Flat landslip, and there was also uplift of much older basement rocks on the south-west side of the San Andreas fault. From the upraised massif, Santa Margarita (Delmontian = highest Upper Miocene) sediments were derived which rest everywhere on an unconformity. Towards the south-west they consist of: (1) the coarsest types of talus, which give place north-eastwards to (2) conglomerates in a sandy matrix, which in turn interdigitate with (3) finely bedded, punky diatomaceous shales which are interleaved with lensing cobble-beds. (2) and (3) buried the "fossil Crocker Flat landslide."

Later folding and erosion isolated the slumped Temblor–Vaqueros shales and the boulder-beds from their sources. Uplift on the north-east side of the normal Recruit fault, to which elevation of the Temblor Range is largely due, has also left much of the travelled material now in a higher position than that of the eroded stumps of the hills from which it was derived. A. L.

258.* Payton Pool, Pecos and Ward Counties, Texas. R. E. Gile. *Bull. Amer. Ass. Petrol. Geol.*, October 1942, **26** (10), 1632–1648.—Discovered in November 1937, by September 1, 1940, Payton Pool had yielded 1,700,000 brl., or 1280 brl./acre, from 134 producing wells. The oil is from upper and lower pay-zones, separated by a 60-ft. dolomite, in the Yates formation (240 ft.), of the Guadalupe series (Permian). The oil-sands are interbedded in red and green shale. A north-west–south-east elongate dome controls the presence of gas or oil, but lateral gradation eastward from sand into sandy shale and anhydritic sand determines production. Improvement is usually obtained by shooting the wells with nitroglycerine.

The earlier wells yielded from 35 to 305 brl./day of natural flow. Originally there was a gas-cap under high pressure, and the bottom-hole pressures in the upper and lower pays respectively were 1014 and 1132 lb./sq. in. By September 1940, after production of 2844 brl. per lb. drop in bottom-hole pressure, the average was 412 lb./sq. in. Water encroachment has not kept pace with withdrawals, so that gas-expansion is mainly responsible for moving the oil to the borings. In September 1940, forty wells had natural flow, twenty-nine were on gas lift, fifty were being pumped, and ten were defunct.

Ultimate recovery, based on cumulative production and rate of decline of pressure, is estimated at 3,500,000 brl. or 100 brl. per acre-foot of saturated sand. A. L.

259.* Amoura Shale, Costa Rica. P. P. Goudkoff and W. W. Porter. *Bull. Amer. Ass. Petrol. Geol.*, October 1942, **26** (10), 1647–1655.—Foraminifera from samples of shale on the Amoura River, a few metres from the mouth of Uscari Creek, Talamanca Province, on the Caribbean side of Costa Rica, are of Oligocene or Lower Miocene date, and are older than the Uscari formation as known in the works of Olsson and Woodring. Abundance of *Orbulina*, *Planulina*, and *Robulus* indicates deposition in temperate waters "at a depth above the continental shelf and under open-sea conditions." There are marked affinities with the microfauna of Mante, Ecuador, and also with the Zemorrian stage (Oligocene or Lower Miocene), California.

At the tip of the Nicoya peninsula, between Cape Blanco and Ballena Bay, on the

Pacific coast, gently dipping littoral beds rest on a basaltic basement. Samples of siltstone and clay with rounded fragments of molluscan shells and pebbles contain relatively brownish-stained Foraminifera—*Uvigerina gardnerae*, *Nonion*, *Planulina*, *Pyrgo*, *Robulus*—which are probably re-worked from Eocene or Oligocene sediments. There is also a much more abundant indigenous fauna, all of a white colour, consisting of *Amphistegina*, *Bolivina*, *Elphidium*, *Eponides*, and *Quinqueloculina*, which indicate Miocene of a younger date than the assemblage from the Amoura shales. *Amphistegina* and *Elphidium* suggest warm, shallow waters. A. L.

260.* Preparation of Lantern-Slide Copy. C. A. Moore. *Bull. Amer. Ass. Petrol. Geol.*, October 1942, **26** (10), 1656–1671.—Familiar defects in lantern-slides are: (1) lettering too small; (2) figures and lines, including grid-lines, too crowded; (3) lack of contrast between lines and background; (4) lettering copied from typescript not solid black, but consisting of separated impressions of threads of a typewriter ribbon; (5) too much glaring white background and margin which cause contraction of the pupil and so reduce visual appreciation.

According to the ophthalmological charts of the American Optical Company, letters of 1·75 in. in height are visible to normal eyes at a distance of 100 ft. The ratio of height to distance for visibility is thus

$$\frac{1{\cdot}75}{1200},$$

or 0·0015 (approx.). From this Arthur Knapp has derived his formula for determining the minimum size of lettering required on slides:

$$h = 0{\cdot}0015\,\frac{Ac}{P},$$

where h = height of letters in inches, A = maximum distance of audience in feet, c = width of original copy in inches, and P = width of projection on screen in feet. For instance, on the assumption that the rearmost onlooker is to be 50 ft. away, that the original copy is 20 in. wide, and that the width of projection is 7 ft., the minimum height of the letters should be 0·21 in.

"Negative slides" with white lines on a black background give best visibility, since with such slides the retinal opening is least contracted by glare, and ocular fatigue is reduced to a minimum. Unfortunately, where projection of the same slide is continued for a considerable period, such slides absorb too much light and heat from the bulb, so that usually they are only suitable where the slides are changed in quick succession. A. L.

261.* Late Palæozoic Age of the Morehouse Formation of North-eastern Louisiana. R. W. Imlay and J. S. Williams. *Bull. Amer. Ass. Petrol. Geol.*, October 1942, **26** (10), 1672–1673.—The Morehouse formation, comprising 1190 ft. of dark silty shale and thin siltstones of carbonaceous, siliceous, or finely micaceous, less commonly calcareous, nature, occurs at depth under the Eagle Mills salt, anhydrite, and red shales. On the evidence of a sponge, Imlay (1941) placed it in the Jurassic, but fifty external and internal moulds of molluscs have now been obtained which have a late Palæozoic aspect.

Special importance is attached to a member of the Bellerophontacea, identified as *Patellostium* sp. The genus ranges from Devonian to Permian, but the Morehouse specimens have distinctive ornament like that of *P. montfortianum* Norwood and Pratten, which has recently been made the genotype of *Cymatospira* Brookes Knight. This resemblance suggests that the age is not greater than Pennsylvanian.

The Morehouse appears to introduce us to deposits of the southern part of the Ouachita geosyncline. Such Palæozoics are less favourable for oil than the local Mesozoic strata. A. L.

262.* Petroleum Development in Canada. Part 2. F. K. Beach *Petrol. Engr*, November 1942, **14** (2), 54.—Outcrops of bituminous sand extend for 65 ml. along the Athabaska River, and for perhaps 40 ml. to the south-west. In places they are 200 ft. thick. These sands, possibly of Cretaceous age, rest on Middle Devonian limestones, and may be of deltaic or estuarine origin. The bitumen impregnation is irregular, but the total estimated bitumen content is probably such as to make the sands the greatest single oil reserve in the world. Commercial development of the sands was attained only in 1941, when 20,000 brl. of oil were separated, and fractionated into products ranging from gasoline to fuel oil. In working, the sand is shattered by explosives and conveyed to vats, where the addition of hot water allows the removal of much of the sand, while dilution of the oil with a light oil enables most of the remaining inert matter to be extracted. The oil has about 5% of sulphur which is not in a corrosive form. Tests are being made on the production of bitumen for paving.

Geophysics and shallow drilling are being used to search for favourable structures in Alberta, for most of the province has a mantle of glacial drift. The magnetometer method has not proved successful, but the gravity meter may be useful. The presence of glacial drift has made the interpretation of seismic work difficult, due to uncertainty about weathering corrections in some areas. So far the discoveries in the plains have been mainly in the Mesozoic. Production is dependent on local conditions in continental beds, and not on the usual structural trapping features. Better results may be obtained in the underlying Palæozoic beds.

Alberta's main oil production comes from Turner Valley in the foothill belt. The first distillate production from the Palæozoic limestone was obtained in 1924, but it was only in 1936 that the first crude-oil producer was completed well down the western flank of the structure. Now there are 192 oil-wells, and the field is 20 ml. long and up to 1½ ml. wide, with the gas-cap on its eastern margin. At present the production is about 27,000 brl./day. Up to the end of 1941 33,500,000 brl. of oil had been produced, with an overall gas/oil ratio of 3500 cu. ft./brl. The individual gas/oil ratios depend on the position and treatment of the wells.

Details are given of the drilling and completion practices.

The porosity and permeability of the reservoir limestone are erratic. Two or three porous zones are present in some parts of the field. The depletion characteristics of the wells are better criteria than the reservoir porosities from which to estimate reserves. G. D. H.

263.* Well Completions Drop off During October. Anon. *Oil Wkly*, 9.11.42, **107** (10), 142.—Well completions, after having risen above the 400-per-week level in September, dropped slightly below 400 per week in October. There were considerable decreases in the numbers of completions during October in Kansas, Mississippi, Ohio, New York, Pennsylvania, and West Virginia.

The 18,004 wells completed in the first ten months of 1942 were 32% below the corresponding figure for 1941, but it seems likely that the year's total will appreciably exceed the 19,000 set by the Government as necessary to sustain the U.S. producing ability.

On 1st November, 1942, 2185 wells were drilling, compared with 2124 on 1st October, 1942. This increase was largely due to California, Illinois, Indiana, and Kentucky, where restrictions have been relaxed. The wildcat total is smaller than desired.

Tables give by States the drilling activity on 1st November, 1941, 1st October, and 1st November, 1942; details of the completions in October 1942, and of the cumulative completions in the first ten months of 1942. G. D. H.

264.* New Oil- and Gas-Fields and New Pay Horizons Discovered in the United States in October. Anon. *Oil Wkly*, 16.11.42, **107** (11), 48–52.—The discoveries are grouped according to States, and subdivided according as they represent new fields or new pay horizons. The data are presented in tabular form, and include the name of the field, the county, the location of the discovery well, and the name of the company which drilled it; its distance from the nearest field and pipe-line; the date on which the well was spudded, and the date on which it was completed; the total depth of the well; the type of structure and the method of discovery; the name, nature, and age of the producing formation; the depth of the pay; the method of initial production and the amount of oil obtained in 24 hr.; the oil gravity and a preliminary estimate of the ultimate production. G. D. H.

265.* Wildcatting Results Fall Short of Expected Required Drilling. Anon. *Oil Wkly*, 16.11.42, **107** (11), 52.—During October the results of wildcatting in the U.S.A. fell materially below the development hoped for in the programme of the minimum necessary drilling for 1942. Of the 19,000 wells expected to be drilled it was calculated that 4000 should be wildcats, of which 624 should produce oil and 116 gas, while the remainder failed. These figures are equivalent to an average of 333 wildcats per month, with fifty-two giving oil and ten gas. Only 235 wildcat wells were completed in October. Thirty-two new oilfields were discovered, one new distillate field, and twelve new pays in established fields. Five new gas-fields were found. Over half the new oilfields were in Oklahoma, Kansas, and Illinois, where discoveries are commonly pools of limited area and importance. The three States furnished respectively seven, five, and five new fields. Texas had seven new fields, Kentucky, Michigan, and Montana two each, and Indiana and South Louisiana one each. A new gas-field was found in each of the following areas : Indiana, Kansas, New Mexico, South Louisiana, and the Lower Texas Gulf Coast. Five new pay horizon discoveries were made in Texas, three each in Illinois and Oklahoma, and one in Wyoming.

Relatively few of the discoveries were in districts commonly supposed to have possibilities of yielding important fields. G. D. H.

266.* Location of Reserves Big Factor in Supply Deficiency. Part 2. W. V. Howard. *Oil Gas J.*, 26.11.42, **41** (29), 18.—In October the Illinois–Indiana–Missouri area had a deficiency of 218,000 brl. of crude/day with regard to its normal demand of 500,000 brl./day. On 1st July, Illinois had estimated reserves of 5·1 years' production calculated on the basis of the output during the first half of 1942. At the current reduced rate of production the reserve in terms of years' supply has been slightly increased.

Oklahoma, Kansas, and Nebraska produced 332,000 brl. of crude/day in excess of refinery needs in October 1942. During 1941 and the first half of 1942 the Kansas output was at the rate of one-ninth of its estimated reserves annually, but since July the discovery rate has fallen, and the present production rate is $\frac{1}{7 \cdot 3}$ of the estimated reserve. There seems to be little possibility of increasing the production rate of Oklahoma's present fields, and recent discoveries have not been of major importance.

The North Louisiana production rate has risen nearly 20% since October 1941, but most of this gain has been offset by a reduced output in the Louisiana coastal region. North Louisiana's hopes of increased production centre round deep pays in such fields as Haynesville, and added discoveries at the eastern end of the Wilcox trend. Coastal Louisiana's decline is almost entirely due to transportation difficulties. The Lower Cretaceous and Jurassic possibilities of Arkansas and North Louisiana are far from exhausted.

Texas and New Mexico have nearly 60% of the U.S. reserves, but provide only 37% of the current production. 20% of the Texas output is from districts (Laredo, San Antonio, East Central, West Central, and North Texas) with wells averaging less than 12 brl./day, and except for Laredo these districts cannot be expected to give much additional production. The East Texas field gives most of the East Texas district oil, and no increased production can take place there until an adequate water-disposal scheme is in operation. The rate of production in the Texas coastal fields could be increased. Since October 1941 the output of West Texas and New Mexico has fallen 100,000 brl./day, but this production could be restored and a further 150,000 brl./day could be added with safety and maintained for two years. Major discoveries may be expected in the Permian Basin and South Texas.

The reserve situation in Colorado and Montana is good, and their production could be increased, though not sufficiently markedly to affect the national output. Wyoming has many undrilled structures, and lack of markets has held back much potential production.

The estimated future relationship between refinery runs and production is tabulated for the various districts.

Unless additional drilling is encouraged any sudden increase in demand would cause a production crisis with far-reaching effects. G. D. H.

267.* October Completions Down 51·2% from Last Year. Anon. *Oil Gas J.*, 26.11.42, **41** (29), 180.—The U.S.A. well completions numbered 1451 in October, ninety-one fewer than in September 1942, there being 830 oil-wells and 172 gas-wells. There were 2242 active rigs and drilling operations. Drilling in California has steadily increased during the past few weeks, and the October total of ninety-nine completions was the highest since January. This increase is partly due to renewed drilling in old shallow areas such as Coalinga, Midway-Sunset, Kern River, and Belridge.

A table summarizes the operations in October 1942 by States, with data about depths, type of well, etc. G. D. H.

268.* California Operators Turn to Old Shallow Fields for New Oil. L. P. Stockman. *Oil Gas J.*, 3.12.42, **41** (30), 12.—The December allowable for California is 815,000 brl./day, calling for the production of 45,000 brl. of natural gasoline and distillate, and 770,000 brl. of crude/day. It is likely that the 1943 demands will be substantially higher than this, and, when the maximum efficient rate of production has been reached, further increases in output will call for additional drilling or the ignoring of the matter of efficient rates of production.

While the number of discoveries has been maintained, the productivity of the fields found in the last four years has been negligible, and few deep zone discoveries have been made. (While the Stevens zone discovery at Elk Hills is important, it will be held back by the Navy Department.)

Lately there has been widespread development in the older fields where additional drilling is justified. Most of the present drilling in the San Joaquin Valley is in shallow fields. At South Belridge a number of wells have been completed in the 800-ft. zone in less than a week, yielding oil from Pleistocene beds or from the Pleistocene–Pliocene contact. Fifteen new wells with an aggregate output of 1209 brl./day have been completed at Kern Front. The thirteen new wells at East Coalinga have a total output of 2139 brl./day. Seventeen rigs are active at Midway-Sunset, and increased drilling is going on at Mount Poso and Round Mountain. G. D. H.

269. November Completions Lowest since Spring. Anon. *Oil Wkly*, 14.12.42, **108** (2), 41.—During the five weeks ended 28th November, well completions averaged 370 per week, the lowest figure since April. The weekly rate of completions in November fell in California, Colorado, Montana, Wyoming, New Mexico, Arkansas, Kansas, South Louisiana, Oklahoma, North, East, and West Texas, Illinois, Indiana, Michigan, and Pennsylvania. There were increased weekly averages in Kentucky, Ohio, New York, West Virginia, North Louisiana, and all southern and coastal districts of Texas. It seems likely that the Government's objective of 40% curtailment of drilling in 1942 will be achieved.

Tables give by States and districts details of drilling operations on 1st December, 1941, and 1st November and 1st December, 1942; also the completions, types of completions and footage drilled in November 1942, with the well totals for November 1941, October 1942, and for the first eleven months of 1942. G. D. H.

270. Kentucky's New Burbank Field Producing 8000 brl. Daily. W. R. Jillson. *Oil Gas J.*, 17.12.42, **41** (32), 18.—On 7th August, 1942, the exploratory well 1 Burbank was completed in north-west Henderson County as an important producer in both the Cypress and the McClosky. After four months of development twenty wells (seventeen producers) have been completed, and the field's flush production is over 8000 brl./day. The wells have ranged 250–800 brl./day initially, with an average of about 500 brl./day from depths of 2300 ft. The discovery well was credited with 150 brl./day from the McClosky at 2674–2683 ft., and about 300 brl./day from the Cypress at 2303–2320 ft.

Beneath the alluvium Pennsylvanian beds extend to a depth of 1500 ft. The underlying Chester (Mississippian) limestones, sandstones and shales occur and include the principal oil and gas horizons of western Kentucky and southern Illinois. Beneath are Middle and Lower Mississippian beds, some Devonian, Silurian in places, and Ordovician. The oil-producing possibilities of the Middle and Lower Palæozoic are unknown, due to lack of exploration.

The normal dip of the Palæozoics between Henderson and Union County is 25–30 ft./ml. to the north-west, but there are local flexures which frequently control oil and gas accumulation. There may be a local anticline at Burbank, for synclines occur to the north and south, and they run together at Smith Mills. This belief is supported by the wells drilled so far. G. D. H.

271. November Completions Show Steady Decline in Drilling. Anon. *Oil Gas J.*, 24.12.42, **41** (33), 60.—In November 1353 wells were completed, considerably fewer than in the previous four-week period, for there were sixty-five fewer oil-wells and twenty fewer gas-wells. Compared with November 1941 the drilling was down by 51·6% and the number of oil-wells down by 59·7%.

A table summarizes by States and districts the completions during November 1942, giving the numbers of completions in each category (oil, gas, or dry), the footage, and the numbers of wells in various depth ranges. G. D. H.

272. Chinese Open Oilfield far Behind Battle Lines. Anon. *Oil Wkly*, 28.12.42, **108** (4), 48.—An oilfield has been located by surface geology and seepages at an undisclosed spot far behind the battle front in China. The wells are drilled to a depth of about 1500 ft. They show little gas, but considerable hydrostatic pressure is reported. Glacial drift up to about 150 ft. in thickness covers the area. G. D. H.

273. Turner Valley Reaches Peak this Year. Anon. *Oil Wkly*, 28.12.42, **108** (4), 48.—Turner Valley gives 97% of the Canadian oil output, and in 1942 it will surpass all its previous records. In the first ten months of 1942, Alberta produced 8,478,354 brl. of oil, and it is estimated that the total for 1942 will be 10,478,354 brl. The Alberta output has risen rapidly since a prolific oil-flow was found in the South Turner Valley limestone in June 1936.

Vermilion, the most productive field outside Turner Valley, gave 6979 brl. from fourteen wells in October, Taber 6086 brl. from two wells, Red Coulee 839 brl. from seven wells, Wainwright 1347 brl. from seven wells, Princess 1384 brl. from one well, Del Bonita 391 brl. from one well and Tilley 236 brl. from one well. G. D. H.

274. Unsatisfactory Exploration Status Demands Attention. E. De Golyer. *Oil Wkly*, 28.12.42, **108** (4), 15.—The U.S.A. exploratory effort, as measured by the number of wildcats and by the number of geophysical crews and core-drill crews operating, is an all-time high. More than 3000 wildcats were completed in 1941, and in the first ten months of 1942 some 222 seismic crews and twenty-nine core-drill crews were in the field. Intelligently directed exploratory effort is being more widely expended than ever before, but the results obtained are inadequate. For the past four years new discoveries appear to have been at the rate of 500,000,000 to 600,000,000 brl./year, against an annual consumption of substantially more than 1,000,000,000 brl. Proved reserves are of the order of 20,000,000,000 brl., and if they were suitably located and recoverable at the required rate, they would meet the war programme, but this is not so. Even now the excess producing capacity is largely in areas with inadequate transport facilities.

This unsatisfactory condition is mainly due to the failure to find large fields at the same rate as in the past. From 1934 to 1938 an average of 121 new fields were found annually, with an average estimated reserve of 15,000,000 brl. each. For 1939 to 1941 inclusive, the average was 242 fields/year, with an average estimated reserve of less than 3,000,000 brl. each, due to the absence of the 100,000,000 and 200,000,000 barrel fields which had raised the average reserve in the previous period. While the number of fields found annually has been increasing since 1934, their average reserve has been falling.

Up to the present, the bulk of the scientific and technical skill has been concentrated on finding structural traps. It appears that the structures now being found in known petroliferous provinces are very small. This suggests that the discovery of stratigraphic traps must be depended on to maintain production, unless prolific new areas are opened. The discovery of a stratigraphic trap generally requires much more drilling than the discovery of a structural trap. Thus, since many of the new pools will probably be stratigraphic traps, extensive wildcatting is needed. Every possible method of discovery must be employed. Existing geological and geophysical data must be re-examined and re-appraised; greater risks must be taken. Areas which seem favourable for accumulation must be explored for structural prospects, and there are quite a number which have not been covered by detailed surveys of the highest resolving power. This condition exists in producing as well as in non-producing States.

The future discovery cost of stratigraphic and structural traps may easily be at least twice as high as the present cost of 20–35c./brl. shown by some successful companies. G. D. H.

275. Four Attacks Proposed to Enhance Oil Exploration. E. De Golyer. *Oil Gas J.*, 24.12.42, **41** (33), 13.—See preceding abstract. G. D. H.

276. World Oil Industry Has Weathered Impacts of a Year's Global War. S. Norman, *Oil Gas J.*, 31.12.42, **41** (34), 38.—Tanker losses and lengthened supply lines have been the chief reasons for the most radical changes in production, but lack of steel has also played a part. While reliable data are lacking, Germany's reserves are believed to be being seriously depleted. Venezuela's output has fallen by over 78,000,000 brl., due to shortage of marine transport.

Trade agreements have been concluded between Mexico and U.S.A., which should improve the position of the oil industry in the former country. Argentina's production has risen 8–9%. Trinidad has discovered one new field since war began, but the bulk of its 75,000–100,000 brl./day production is from its old fields.

Rumania's 1942 production may not exceed 30,000,000 brl., compared with 43,231,000 brl. in 1941, while her exports to Germany may have fallen 10–15% to 20,000,000 brl. The Lipse field of south-west Hungary is reported to be giving 2,500,000 brl./year. Operations are said to have been accelerated at Zisterdorf, Gbelly, Pechelbronn, Kutina, and Saint Marcet, oilfields within the territory now occupied by Germany.

Some sources state that several large refineries in north France are being removed to the interior of Germany to make them less vulnerable to air attack.

A table gives the estimated oil production of the various countries in 1942, and sets out the 1941 figures for comparison. G. D. H.

277. Reduction in Oil Production Caused Entirely by Warfare. J. P. O'Donnell, *Oil Gas J.*, 31.12.42, **41** (34), 42.—During 1942 the world oil output probably amounted to 2,056,900,000 brl., 170,225,000 brl. less than in 1941. This is the largest decline in history. While 75,000,000 brl. were lost as a result of destruction in the south-west Pacific area and at Maikop, 125,000,000 brl., almost all of it in the western hemisphere, were lost as a result of lack of transport. Venezuela's output fell by nearly 80,000,000 brl., entirely due to lack of transport, while the potential output has increased.

Widespread destruction in Burma and much of the East Indies has certainly reduced the production of those countries to small proportions.

During 1942 Colombia's production was only 43% of the 1941 figure, the rate having fallen from 83,500 brl./day in February to 6500 brl./day in October. This decline is due to lack of outlets.

The loss of the Maikop fields has no doubt increased the rate of exploitation of the Ural–Volga fields, and it seems unlikely that the Soviet loss of oil or of means of transport on the Volga has been sufficient to impair their ability to resist or to take the initiative.

Hungary's production is estimated at 12,000 brl./day, and probably shows the greatest rise in oil production among those countries controlled by Germany. Rumania's output is believed to have declined again in 1942.

Production has increased in the Near East, demands for oil from this region having risen since the loss of the Far East fields. Production also rose in Trinidad, Peru, and Argentina, while it fell in U.S.A., Mexico, and Colombia. G. D. H.

278. Colombia's Casabe Field Showing Major Caliber. E. Ospina-Racines. *Oil Gas J.*, 31.12.42, **41** (34), 60.—The Infantas and La Cira sands of the De Mares concession, due east of the Casabe structure, range 50–200 ft. in thickness. The lenticular Casabe sands are several times thicker. 5 and 6 Casabe have been brought in with natural flow of 1200 brl./day and 1000 brl./day respectively.

The El Doce test, located 125 ml. from the Caribbean, was abandoned in the basement rocks at a depth of 10,046 ft. On an adjacent tract El Dificil has encountered considerable gas pressure.

750 ml. inland, in the Llanos region, are the Culimba and Braval tests, which penetrated the Cretaceous without positive showings of oil or gas. In this area a number of structural holes have also been drilled. Extensive geophysical work has been carried out.

In the middle Magdalena valley the MacCarthy well was abandoned at a depth of 5438 ft. No. 1 Cimitarra showed some gas and oil. On the Gutierrez tract just north of the Yondo block, two unsuccessful tests were drilled. The Infantas and La Cira structures have been completely delimited by drilling, over 298,441,666 brl. of oil having been produced since 1921.

The Petrolea field of the Barco concession has 137 wells, which have fully delimited the structure. The Socuavo structure may develop into Colombia's largest field. Two wells have been completed and a third begun. The Tres Bocas field also shows good promise.

The Sagoc pipe-line may ultimately be able to transport 26,000,000 brl. of oil/year. It is estimated that within ten years Colombia's oil production may be doubled, and so equal 50,000,000 brl./year, provided that the oil discoveries are suitably located and that a crude-oil market is available. 87·5% of the 1941 output was exported.

Tables give data about the wildcats drilled since the passage of and under Law 37, details of which are given; about the decline in oil production in the first ten months of 1942; and about the oil concessions as of July 1942. G. D. H.

279. Argentina's Increasing Oil Production Big War Asset. Anon. *Oil Gas J.*, 31.12.42, **41** (34), 66.—Argentina's 1942 oil output will be about 3,840,000 metric tons, compared with 3,499,757 metric tons in 1941, when 64% of the total was Government production.

Argentina has over 3000 oil-wells and about 100 gas-wells. 364 new wells were drilled in 1941, 228 by the Government. The nineteen refineries have an annual capacity of about 4,800,000 metric tons. The country possesses thirty-one tankers with a total tonnage of some 85,000 tons.

Argentina is ninth on the list of oil-producing countries, but it has to import crude oil and refined products. In 1934 two-thirds of the country's output was in the hands of private owners. Now the position is reversed, and the Government wells provide two-thirds of the output. The cash value of the oil imports fell by 36% between 1929 and 1939.

The principal oil-producing regions in Argentina are Comodoro Rivadavia, Mendoza, Plaza Huincul, Salta, and Jujuy. Comodoro Rivadavia produced 1,450,000 metric tons of oil in 1931, and 2,100,000 metric tons in 1940.

In 1941 14·91% of the country's oil was imported. 799,000,000 cu. m. of natural gas were produced in 1941. The war has restricted oil imports, leading to shortages, and the Government is now being urged to drill additional wells on the reserved lands in order to increase the national oil production. G. D. H.

280. Extensive Development Plans Launched in Northern Canada. Anon. *Oil Gas J.*, 31.12.42, **41** (34), 103.—Tentative plans are being made for drilling about 50 ml. north of Fort Norman. Also, additional production may be developed at Fort Norman, and a 400-ml. pipe-line laid westward to Whitehorse, where a refinery would be built. This would ease the oil problem for activities in Alaska.

Production was developed in the Fort Norman area over twenty years ago, but its isolation prevented much expansion. The wells are east of the Mackenzie river, and near a seep. The oil is in Upper Devonian beds, the first well being completed at a depth of 990 ft. The second well was completed at a depth of 1602 ft. in 1925. The rate of production has been determined by the needs of local mining operations, and in 1939 about 20,000 brl. were produced. A new topping plant capable of handling 800 brl./day is planned. G. D. H.

281. Agua Caliente Field in Peru Could Deliver Oil via Amazon. Anon. *Oil Gas J.*, 31.12.42, **41** (34), 107.—There is a potential daily production capacity of 2500 brl./day at Agua Caliente, east of the Andes and 2800 ml. from the mouth of the Amazon. Owing to war conditions it has not been possible to get barges for transporting the oil down the Amazon, which is the easiest route for moving the oil from the field.

Brazil holds the key to the successful operation of this field, since Brazilian law requires all refining and exploratory operations to be carried out by Brazilian nationals, and it is uncertain whether this ruling applies also to transportation through Brazil.

The Agua Caliente series of sandstones and shales outcrops on the crest of the structure. It is probably of upper Middle Cretaceous age, and it includes the oil-zones. Six wells have been drilled to prove about 640 acres. G. D. H.

282. Tres Bocas–Socuavo Wildcats Open New Colombian Production. Anon. *Oil Gas J.*, 31.12.42, **41** (34), 121.—The cessation of export-crude movements stopped production almost completely at Petrolea. Encouraging results have been obtained in wildcat operations on the Tres Bocas–Socuavo structure, north of the Petrolea field. Two wells testing the Cretaceous at depths of 9000–10,000 ft. found some distillate production. Socuavo 1 on the crest of the northern part of the structure is not rated as a commercial well, but A-2 Tres Bocas, 8 ml. to the south and west of the crest, flowed at the rate of more than 1000 brl./day. Two tests of the Tertiary in the 4000–5000-ft. range have been drilled on the same structure. Socuavo 2 on the west flank, 4 ml. north of Socuavo 1, produced 200 brl./day, and No. 3 Tres Bocas, about 14 ml. south of 2 Socuavo, and on the east flank, pumped a smaller amount of oil mixed with water. G. D. H.

283. Bolivia is Expanding All Phases of Oil Operations. Anon. *Oil Gas J.*, 31.12.42. **41** (34), 128.—Bolivia's four oilfields are to be rehabilitated and developed, and exploration for further reserves is to be undertaken, with a view to trebling the country's output in the next two years. The present production is about 1900 brl./day, over half of it coming from the Bermejo field. Earlier in 1942 two wells were giving 500 brl./day at Camiri, and seven wells 380 brl./day at Sanandita. Pipe-lines are to be built to make the oil available for industrial and mining operations. A 2000-brl./day refinery is to be built at Oruro to provide oil products for mining operations. The capacity of the Camiri topping plant will be increased to 500 brl./day.

Camiri produces 53·1-gravity oil from the Devonian at a depth of 3200 ft. 640 acres have been proved, while the total productive area may be 5000 acres. 200 acres have been proved at Sanandita, and this field may cover 1800 acres. Camatindi has been shut in since 1931. 3200 acres are potentially productive, although only 1120 acres have been proved. Bermejo has three pays at depths of 2200 ft., 2850 ft., and 3600 ft. It covers 2560 acres, and may extend to 11,500 acres. A contract has been signed for the production of 1000 brl./day from Bermejo for Argentina.

G. D. H.

Geophysics.

284. Progress in Exploration. Anon. *Oil Gas J.*, 31.12.42, **41** (34), 172.—There are indications of a revival in the use of magnetic and electrical prospecting methods, but the reflection seismograph and gravimeter are by far the most widely employed instruments, and more parties have operated in the past year than for some time previously. A direct-current electrical method is in use for taking observations which give the resistivity at increasing depths. An alternating-current method makes use of the fact that the depth of penetration decreases rapidly with increasing frequency. Hence the effect of deep horizons may be eliminated by increasing the frequency, and with fixed electrodes a form of vertical exploration is possible.

There have been great advances in mechanical well logging, and this aids in the interpretation of electrical logs. Neutron logging, gamma-ray logging, mud logging, drilling-time logging, etc., are also being carried out. Caliper logging has proved valuable in several ways.

An electrical method is available for determining the dip of the strata by the use of three electrodes set 120° apart, which give three self-potential curves. Knowledge of the orientation of the electrodes by means of a photoclinometer permits the changes in the three self-potential curves to be employed to give the dip and dip direction of the beds. G. D. H.

Drilling.

285.* Drilling Fluid Technology. Part 1. L. C. Uren. *Petrol. Engr*, October 1942, **14** (1), 42.—In rotary drilling, the circulating fluid has a number of important functions to perform. Prompt and continuous removal of the material loosened by the drill prevents accumulation of drill-cuttings and " freezing " of the drill-pipe. Deposition of clay on the walls of the well and within the pores of the wall rocks minimizes the tendency of the walls to cave; lubricates the drill-pipe, reducing frictional power loss; prevents loss of fluid into very porous, low-pressure formations, so that circulation of drill cuttings to the surface will not be interrupted, and seals off high-pressure gas- and water-yielding horizons, so that fluids from them cannot enter the well, thus preventing destructive blowouts. The drilling fluid also prevents destruction of the drilling-bit and drill-pipe by absorbing the heat caused by friction of revolving steel on the bottom and walls of the well. These are matters of prime importance, especially in deep drilling, and failure of the fluid to meet any one of these requirements might prevent successful completion of the well. The paper treats each important function separately.

In raising drill-cuttings from the bottom of the well to the surface, effective action of the drilling fluid depends chiefly on maintenance of a proper fluid density and viscosity, and a rate of flow that will maintain a suitable ascending velocity in the annular space between the drill-pipe and the wall of the well. The size and density of the drill-cuttings are also important factors.

Part 1 further deals with sealing the formations by a clay sheath controlling high-pressure fluids, and with "gas-cut" drilling fluids. Gas-cutting may result in serious blowouts. The fluid must be treated to release the bubbles. This may be accomplished by passing the fluid through a vibrating screen, through a suitably designed trap in which the fluid will be spread out in a thin film over metal surfaces, or by diluting with water, subsequently thickening the fluid to proper density after the gas is released. Addition of chemical reagents to reduce the viscosity of the fluid will also promote release of gas. A. H. N.

286.* Diesel-Electric Drilling Rig Designed for Simplicity. J. P. Van Vorst. *Petrol. Engr*, October 1942, **14** (1), 46. The basic idea in designing and building diesel-electric rigs is to make the system as simple and as free from complicated electrical devices as possible. The rig described was designed with this in mind as well as to have the generating units as compact as possible, facilitating transportation and erection. With this arrangement, perfect alignment and levelling are desirable, but not necessary, as the engines and generators are connected as units, and the generators and exciters are not driven by belts, as is the case in some earlier diesel-electric rigs. The rig is described in some detail, the chief component being illustrated and relative data of capacities and dimensions given. A. H. N.

287.* Methods of Marine Exploitation Differ Throughout the World. Anon. *Petrol. Engr*, October 1942, **14** (1), 76. Marine exploitation has been practised at many places distributed over the surface of the earth. Among these marine exploitations are the vast Lake Maracaibo operations in Venezuela, the wells drilled in the Gulf of St. George at Comodoro Rivadavia in Argentina, the recovery of oil from below the Irrawaddy River in Burma, the tide-water drilling into the China Sea at the Seria field on the island of Borneo, the developments along the Gulf Coast of Louisiana and Texas, the channel drilling around the Long Beach harbour, and the tide-water operations along the Pacific Coast of California. The methods employed for drilling and producing such areas are obviously governed by conditions, and include the use of barges, the building of piers, and controlled directional drilling from both piers and locations on shore. The paper discusses in separate sections the practices employed on Lake Maracaibo, along the Gulf Coast in Argentina, in Borneo and Burma, and along the Pacific Coast.

Production methods are also discussed. The methods employed in producing oil through individual slant-hole wells from below a body of water and discharging it at a land or pier location are similar to those followed in producing the wells of a land field. Multiple-well locations, however, sometimes require ingenuity to facilitate their production and servicing, particularly when they are on the pump. The three wells drilled from a pier in the Elwood field, California, for example, are equipped with separate pumping beams, one beam extending in the opposite direction from the other two. Each beam is powered by its own engine, and any one, two, or all wells can be pumped at any time.

Each well of those comprising the groups in the Huntington Beach field mentioned is pumped with its own electric motor-driven unit, the wells having been spaced far enough apart for this purpose. To facilitate servicing the wells, however, tracks were set in a concrete floor laid around each group and a production derrick placed on rollers on these tracks, so that the derrick can be moved to any well needing service, the one derrick thus being used for four or five wells, depending on the number in the group. A. H. N.

288.* Deep-Hole Cable-Tool Drilling Lines. A. S. Rairden. *Petrol. Engr*, October 1942, **14** (1), 138.—The mechanism of breakdown of a cable-tool drilling line is given as follows : As an oil- or gas-well progresses in depth, the accumulated weight of the cable-tool drilling line added to the weight of the stem, jars, tools, etc., will eventually reach a value at which the suspended weight on the drilling-line clamp will be so severe as to cause rapid deterioration of the line. The applied wire-rope load at the clamps eventually becomes so great that extremely severe radial pressures of the outer strands are imposed on the hemp core, resulting in the cutting and pulverizing of the hemp fibres in the core, and also in a severe compression of the hemp core into a more solid mass. All this causes a loss in effective foundation of the hemp core to the outer surrounding strands. A natural result is the distinct lengthening of the rope lay or pitch, which in turn reduces the very necessary elasticity or resilience of the rope, an important quality in a cable-tool drilling line, that enables the rope to absorb easily the shock-loads of the drilling motion. Loss of foundational qualities of the hemp core also causes a reduction of the outer diameter of the wire rope. This diameter reduction finally causes the drilling clamps to grip the rope inadequately, resulting in the line slipping through the liners in the clamps.

The critical loading of the line at the clamps, causing this sequence of deteriorating conditions, are all related and additive, so that when the critical depth and loading are reached in the progress of drilling a well, the complete deterioration of the wire rope at the clamps occurs very rapidly. Usually this deterioration occurs after a well reaches a depth greater than 7500 ft., when the factor of safety on the cable-tool line begins to reach a value equal to 3 or less.

Calculations are given to justify these statements. Whipping of the line may increase the loads by 50% of the deadweight static load. A. H. N.

289. Thermal Characteristics of High-Temperature Oil-Well Cements. E. E. Byrd and F. W. Jessen. *Industr. Engng Chem.*, 1942, **34** (10), 1142.—An investigation has been made on the total heat of hydration and the rate of heat evolution and pumpability for five cements at temperatures of 150°, 175°, and 200° F. In the absence of addition agents, it is shown that the setting times and quantity of heat liberated are a function of the chemical composition and the fineness of the grind. J. W. H.

290.* The Nature of Hastings Drilling Mud by Supercentrifuge and X-Ray Analysis. G. H. Fancher and S. C. Oliphant. *Petrol. Tech.*, November 1942, **5** (6), A.I.M.M.E. Tech. Pub. No. 1531, 1–12.—Two samples of drilling mud were taken from wells in the Hastings field, the muds having been formed from the formations encountered in drilling, and the properties of these muds were examined (viscosity, density, *p*H, filtration rate, total solids, etc.). The size distribution of the solid particles was determined by screening for particles greater than 44 μ in diameter, sedimentation for particles between 1 μ and 44 μ, and by means of the Sharples supercentrifuge for the smallest particles. During the whole series of tests about 12% of the original solids were lost. This total loss was uniformly distributed over the whole size range. The particle sizes calculated from the conditions of separation agreed well with the sizes measured directly with the slit ultramicroscope. 50% of the total solids was made up of particles less than 5 μ in diameter. The size-frequency distribution curves show two peaks, one at about 0·9 μ and the other at 150–200 μ. The mud (Curkeet) which was taken after the well had penetrated the Oligocene shales showed fewer coarse particles than that (Edwards) taken while the well was still in the sandy Basal Miocene. The lower filtration rate and higher viscosity of the Curkeet mud were in accordance with the presence of more fine particles than in the Edwards mud.

The distribution of minerals in many of the size fractions was determined by X-ray analysis, with an accuracy of 5–10%. This revealed the presence of more silica in the Edwards than in the Curkeet mud. For the Edwards mud the bulk of the fractions less than 0·3 μ average diameter the principal mineral was illite, while in the coarser fractions silica with calcite and felspar were the dominant minerals. These determinations were in agreement with the observed decrease in density of the particles with decrease in particle size. Felspar occurred only among the coarser particles, but silica was distributed over a wide range, and showed two peaks in its frequency curve.

The large amount of illite in the Curkeet mud was no doubt due to the penetration of the Oligocene shale. The calcite may have been derived from thin limestone streaks in the beds, or it may have been precipitated in drilling. The absence of montmorillonite is of interest. Illite is less plastic and swells less than montmorillonite.

Only 7–8% by weight of the mud solids was within the generally accepted range of colloidal dimensions (0·5 μ equivalent diameter or less). Thus the material larger than the colloidal range is quite as important as the colloids in determining the properties of a mud and its susceptibility to chemical treatment. G. D. H.

291.* Calibration and Control of the Supercentrifuge for the Fractionation of Oil-Well Drilling Muds. S. C. Oliphant, C. R. Houssiere, and G. H. Fancher. *Petrol. Tech.*, November 1942, **5** (6), A.I.M.M.E. Tech Pub. No. 1530, 1–7.—The calculation of the size of particles separated by the Sharples supercentrifuge depends on the assumptions: (1) that the flow parallel to the axis of rotation is streamline, and (2) that Stokes' law holds only for dilute suspensions. Continued refractionation with the centrifuge operating under constant conditions results in the deposition of only a very thin film on the liner, and the solid particles are found to be distributed along the bowl in a mono-dispersed film in accordance with a definite equation, the value of the size in relation to the distance along the bowl being unique for given operating conditions.

Charts have been constructed and are given, which permit the selection of operating conditions in order to separate particles between definite size limits, but the charts must be constructed for each centrifuge. They show the rate of feed, rate of rotation, and the air pressure necessary to give the required rate of rotation.

The reliability of the method for determining the size of particles separated by the Sharples supercentrifuge under controlled conditions has been tested by examining fractions with the slit ultramicroscope. The latter device has various sources of error, but on the whole it was deemed that the indications were such as to confirm the reliability of the sizing carried out in the supercentrifuge. G. D. H.

292. Patents on Drilling. H. J. Woolslayer, E. A. Campbell, and C. J. Jenkins U.S.P. 2,300,480, 3.11.42. Appl. 11.8.41. Folding derrick base for portable oil-well derricks.

J. W. O'Brien. U.S.P. 2,300,590, 3.11.42. Appl. 4.6.41. Conditioning of drilling mud to increase its specific gravity and maintain the viscosity within a normal range by adding celestite and a viscosity reducing chemical.

C. R. Atky. U.S.P. 2,300,763, 3.11.42. Appl. 28.10.41. Portable well derrick with telescopic mast.

T. W. Pew. U.S.P. 2,300,805, 3.11.42. Appl. 13.1.41. Drilling bit.

A. D. Whitman U.S.P. 2,300,823, 3.11.42. Appl. 18.12.39. Indicating device for well-drills.

P. A. Wolff. U.S.P. 2,301,001, 3.11.42. Appl. 14.11.40. Well superstructure (apparently to take the stresses on a depth-measuring wheel).

L. Yost. U.S.P. 2,301,105, 3.11.42. Appl. 1.5.41. Safety collar for drills in a turbine-driven well-drilling unit.

T. E. McMahan. U.S.P. 2,301,307, 10.11.42. Appl. 14.1.42. Means for orientating tools in bore-holes.

C. E. Reistle, Jr. U.S.P. 2,301,326, 10.11.42. Appl. 3.11.39. Process for obtaining temperature gradients in bore-holes.

H. J. Craig, H. C. Brown, and D. Ragland. U.S.P. 2,301,377, 10.11.42. Appl. 29.9.41. Rotary releasing socket.

R. F. Farris. U.S.P. 2,301,389, 10.11.42. Appl. 22.8.40. Apparatus for cementing wells consisting of spring-bars which shear the cement in its flow in the casing but allow the plugs to pass through.

H. Salvatori. U.S.P. 2,301,458, 10.11.42. Appl. 31.10.40. Seismic well-logging.

W. A. Abegg. U.S.P. 2,301,495, 10.11.42. Appl. 8.4.39. Method and means of renewing the shoulders of tool-joints.

G. A. Smith. U.S.P. 2,301,757, 10.11.42. Appl. 27.3.41. Well-surveying instrument with an electrically operated recorder.

J. Neufeld. U.S.P. 2,302,247, 17.11.42. Appl. 22.4.40. Well-surveying method and apparatus using radioactivity.

C. A. Peufield. U.S.P. 2,302,249, 17.11.42. Appl. 26.3.40. Pipe spinner in combination with a pipe-tongs.

G. L. Kothney. U.S.P. 2,302,330, 17.11.42. Appl. 6.3.42. Apparatus for orientating tools and removal of whipstocks.

L. K. Heiner. U.S.P. 2,302,692, 24.11.42. Appl. 14.7.41. Well-drilling pump unit.

W. H. Hamon. U.S.P. 2,302,856, 24.11.42. Appl. 10.8.40. Releasable joint for rotary well strings.

J. M. Lilligren. U.S.P. 2,302,996, 24.11.42. Appl. 12.10.38. Sampler for well drillings from the stream.

W. H. Martin. U.S.P. 2,302,998, 24.11.42. Appl. 14.10.40. Pipe-tongs.

G. C. Maddox. U.S.P. 2,303,085, 24.11.42. Appl. 20.3.40. Device for removing samples from fluid streams adapted for well-drilling muds.

A. Pranger and S. A. Guilerson. U.S.P. 2,303,090, 24.11.42. Appl. 8.11.38. Pressure drilling head with packer element.

R. R. Schweitzer. U.S.P. 2,303,178, 24.11.42. Appl. 24.2.41. Well-drilling apparatus with rotary drill-pipe.

W. F. Sheffield. U.S.P. 2,303,312, 24.11.42. Appl. 11.4.41. Well pipe-jack.

A. H. N.

Production.

293.* Progress in Reservoir Technology. Part 3. M. Muskat. *Petrol. Engr*, October 1942, **14** (1) 35–36.—This part of the paper deals with secondary recovery methods. It is explained that by simple gas cycling no more oil would be produced than that yielded by primary production were they continued into the high gas-oil ratios and uneconomically low rates. In contrast to the simple secondary recovery method of gas cycling, the injection of gas into a gas-cap for the purpose of pressure maintenance is based on sound technical principles. Here the segregation of the gas above the main oil-pay permits the former to exert a driving action on the oil, rather than a sweep or drag, as obtains in the simple gas-cycling method. Because of the higher oil saturations in the sand surrounding the producing wells, the permeability to the oil is maintained and at the same time the growth in gas permeability is retarded. Hence if the regional pressure gradients within the oil-pay near the gas-oil interface can be held below those corresponding to the gravity differential between the gas and oil, bypassing and channelling of the gas through the oil-saturated section can be prevented.

From the physical point of view the secondary recovery method of water-flooding is well founded and inherently efficient. As previously indicated, the residual oil saturation in a sand that has been traversed by a water-flood is very materially lower than that remaining in a sand subjected to a gas-drive, even when the latter is continued to high gas–oil ratio conditions. When the residual oil saturation at the close of the primary production phase is sufficiently high, and the producing zone is not lenticular, and is of reasonable uniformity in permeability, water-flooding offers promise for materially increased oil recovery. These are the primary criteria for success, and such factors as well-spacing and flooding pattern do not appreciably affect the physical efficiency of the operations. The latter are of real significance only in determining the economies of the problem. It is pointed out, however, that in certain cases controlled production under a water-drive may be more advantageous than rapid production followed by water-flooding.

Condensate reservoirs and retrograde phenomena are discussed and the necessity of maintaining the pressure made evident. Gas cycling for this purpose is the simple solution. Although the development of this method was based largely on the idea that the single-phase bearing formation constituted the whole of the so-called condensate reservoir, this restriction is necessary neither from a theoretical nor a practical viewpoint. On the contrary, in order for the single-phase fluid to undergo condensation on a drop in pressure, it must be at its dewpoint—*i.e.*, saturated with the heavier and condensable liquid hydrocarbons. This means that it must have been at some time in equilibrium with a liquid phase having a composition the same as that which drops out as soon as the pressure is lowered. In the light of generally accepted views on the origin and accumulation of oil, it seems highly probable that at the time of discovery, the single-phase fluid is still in equilibrium with a heavy liquid phase. A. H. N.

294.* Treating Plant for Heavy Oil Production. W. A. Sawdon. *Petrol. Engr*, October 1942, **14** (1), 25–26.—The oil being treated comes from a field in California. The oil from this area ranges in gravity from 8 to 17·5° A.P.I., with the wet oil averaging 15° A.P.I. This oil has a high viscosity even for its gravity, and the measured viscosity of some of the wet oil has been as high as 200,000 seconds Saybolt at 80° F. The viscosity of the wet oil being treated ranges from 20,000 to 30,000 seconds Saybolt at 100° F.

The treating plant at present consists essentially of eight electric dehydration units, four heaters, two pumps, and necessary tankage and piping. It is illustrated by a diagram. It is entirely automatic in operation. The net quantity of oil being taken from the dehydrators is approximately 10,000 brls. daily. When expanded, the plant will have twelve units with a gross capacity of 22,000 brls. daily. Only the wet oil from the field passes through the plant. The average cut of this oil is 32%, and the gas is taken off by low-pressure separators in the field. The vapour pressure is 25 lb. at 190° F. The dry oil from the dehydrators averages 1·5% cut.

The electric dehydrators are completely automatic. They operate on a current of 28,000 volts, and the installation includes double transformer hook-ups. The shell of each unit is 10 ft. in diameter, and provides for 36 lb./sq. in. working pressure. It is important in this plant to keep the pressure relatively high, to prevent any gas leaving the oil during dehydration, and a working pressure of 34 lb./sq. in. should be maintained at all times. The shells are insulated, because the density or gravity of the oil is very close to that of water, and it is important to keep the heat constant. This temperature control keeps conditions in the unit constant, permitting complete separation to take place, which might not be the case with fluctuating temperatures.

The dehydrating units are equipped with multiple-field, concentric-ring electrodes, and have a wide lower field with low gradient voltage across it. The dry oil is removed continuously from the top of the units, and the separated water is drawn off intermittently by means of automatic electrically controlled valves.

Recirculation is practised. A. H. N.

295.* Surface Energy Relationships in Petroleum Reservoirs. H. K. Livingston. *Petrol. Tech.*, November 1942, **5** (6), A.I.M.M.E. Tech. Pub. No. 1526, 1–6.—A technique has been developed which makes it possible to determine the spreading pressure of liquids on solids for simple systems. Data on the surface tensions, interfacial tensions, spreading pressures, and contact angles for water, heptane, and silica are tabulated. These data can be applied in evaluating the capillary rise and displacement pressure in a petroleum reservoir. Equations are given for calculating the capillary rise and displacement pressure, and their application is discussed.

The presence of surface-active substances affects both capillary rise and displacement pressure, and also seems to influence the rate of fluid flow. G. D. H.

296.* Reservoir Analysis and Geologic Structure. J. M. Bugbee. *Petrol. Tech.*, November **5** (6), A.I.M.M.E. Tech. Pub. No. 1527, 1–12.—An effective water-drive appears to be the most desirable reservoir production mechanism. Water-drive may result either from the expansion of edge-water or from the artesian flow of edge-water extending to the outcrop. Thus the extent of the reservoir has an important bearing on both the rate and ultimate quantity of water influx into an oil-pool.

Lens-type reservoirs are generally recognized, and in such reservoirs only the expansion water-drive can operate, but the complete structure of the more important domal types, in which possible crestal and synclinal faulting may limit the effective extent of the reservoir, is not well understood. The delineation of the structure of the domal types is becoming increasingly more accurate due to the introduction of coring, electrical logging, etc., although the absence of drilling in the synclinal areas prevents such complete delineation of the faults in these areas.

Inferences drawn from cores and electrical logs, coupled with scattered well data and geophysical data for the synclines, and a consideration of the dynamics of folding and faulting, may be applied to determine the complete picture of the geological structure. Since faulting on the domes and in the synclines may effectively seal, and thus limit, the size of a reservoir, thereby barring additional water influx, the consideration of the geological structure and its possible effects is essential to a complete analysis and prediction of reservoir performance. G. D. H.

297.* Effect of Casing Perforations on Well Productivity. M. Muskat, *Petrol. Tech.*, November 1942, **5** (6), A.I.M.M.E. Tech. Pub. No. 1528, 1–10.—Analytical calculations have been carried out on the effect of casing perforations on the productivity of wells, and formulæ have been derived for general types of perforation patterns. Numerical calculations show that the resultant well productivity is essentially independent of the perforation pattern, but is determined mainly by the total perforation density. Thus a density of three perforations per foot of casing reduces the well productivity to one-third of that of the uncased well for a perforation radius of ⅛ inch, and to approximately one-half for a perforation radius of ¼ inch, regardless of the detailed manner in which the perforations are distributed over the casing surface. The reduction is slightly greater for 6-inch-radius casing than for 3-inch-radius casing.

The analytical theory is also extended to include wells completed with slotted liners. The reduction in productivity due to such liners is relatively small compared with that due to perforated casing.

While it is felt that the calculations indicate the correct magnitude of the effect of casing perforations on well productivity, it is not to be assumed that the predicted effects will necessarily be observed in field practice. The actual productivity of a well is the resultant of a great many factors, only one of which is the type of casing perforations, if any. Variations in these other factors—sand permeability, fluid saturation distribution, gas–oil ratio, cleanliness of sand face, etc.—may well counterbalance and mask completely the limited effect of the casing perforations in making comparisons between cased and open-hole completions, even in the same field. The calculations are based on idealized assumptions, and have no greater validity than these assumptions. The analysis was carried through for a homogeneous fluid system. G. D. H.

298.* Analysis of Reservoir Performance. R. E. Old. *Petrol. Tech.*, November 1942, **5** (6), A.I.M.M.E. Tech. Pub. No. 1529, 1–13.—Quantitative methods are available for the identification and determination of the magnitude of water encroachment, for the estimation of the original oil in place, and for the calculation of the pressure behaviour in oil reservoirs. These methods have been applied in a study of the Jones sand of the Schuler field. The initial oil content of the reservoir was estimated in two ways, the results agreeing closely, and with two years of pressure-production records as a background, the pressure behaviour for the following three years was calculated and compared with the actual measurements, satisfactory agreement being obtained.

It is clear from this and similar studies that the use of the material balance and water-drive equations, when properly applied to field data, gives a fundamental tool for the evaluation of reservoir performance. In particular, the pressure behaviour may be predicted. Critical rates of production may be established for water-drive fields, and rates and quantities of injected water to supplement natural encroachment may be pre-determined. The effect of gas injection can be predicted before the injection is undertaken. Consequently, the effects of various production programmes can be safely evaluated beforehand, and when these determinations are combined with core-analysis saturation data, the economics of recovery under each can be analyzed, and the most profitable programme selected.

The calculations can be made when reservoir pressure measurements, production records of oil, water and gas, and bottom-hole sample analyses are known. The determination of the structural dimensions, using porosity, connate water content, and permeable thickness from core analyses, will aid in earlier application and increased accuracy of the results.

Complete and accurate pressure and production records are essential. The reservoir pressure is affected as much by the withdrawal of equal volumes of water and gas as by oil, so that the extra effort of measuring and recording these quantities is well justified in view of the increased knowledge of reservoir performance that may be gained by their use. G. D. H.

299. Patents on Production. G. W. Ayers, Jr. U.S.P. 2,300,393, 3.11.42. Appl. 29.5.40. Method of increasing fluid permeability of earth or rock formations which are siliceous in nature.

F. J. Spang. U.S.P. 2,300,438, 3.11.42. Appl. 10.2.40. Well-packer with expansible element and slips.

M. De Groote and B. Keiser. U.S.P. 2,300,554, 3.11.42. Appl. 12.5.41. Process for breaking petroleum emulsions of the water-in-oil type by means of a demulsifier.

M. De Groote and B. Keiser. U.S.P. 2,300,555, 3.11.42. Appl. 12.5.41. Process for breaking petroleum emulsions of the water-in-oil type by means of a demulsifier.

F. E. Carlberg. U.S.P. 2,300,648, 3.11.42. Appl. 13.7.42. Well-pump of the sucker-rod reciprocating type.

G. A. Smith. U.S.P. 2,300,709, 3.11.42. Appl. 10.1.41. Electrical prospecting method to determine the porosity characteristic of strata traversed by a well.

H. Allen and M. T. Works. U.S.P. 2,300,854, 3.11.42. Appl. 24.6.40. Tubing bottom with a back-pressure valve.

A. Boynton. U.S.P. 2,301,190, 10.11.42. Appl. 4.10.38. Well-testing tool of the pump-packer type.

A. Boynton. U.S.P. 2,301,191, 10.11.42. Appl. 28.10.38. Well-testing tool, rat-hole type.

C. M. Peters. U.S.P. 2,301,319, 10.11.42. Appl. 15.11.41. Plunger for use in cylinders of deep-well pumps.

A. F. Spengler. U.S.P. 2,301,340, 10.11.42. Appl. 27.12.38. Motor or the like for actuating a well-pump unit.

A. L. Armentrout. U.S.P. 2,301,355, 10.11.42. Appl. 9.4.40. Flow-bean.

G. L. Adams and A. Shapiro. U.S.P. 2,301,494, 10.11.42. Appl. 11.3.41. Treatment of oil-wells to prevent emulsification.

C. F. Bonnet, U.S.P. 2,301,609, 10.11.42. Appl. 30.1.41. Breaking petroleum emulsions of the water-in-oil type by means of a demulsifier.

C. K. Holt. U.S.P. 2,301,624, 10.11.42. Appl. 10.8.40. Tool for use in wells to place fluids therein.

H. H. Holmes. U.S.P. 2,301,875, 10.11.42. Appl. 25.1.40. Method of treating oil-wells in calcareous formations.

J. D. Nixon. U.S.P. 2,302,391, 17.11.42. Appl. 22.10.40. System and apparatus for lifting fluid from wells.

F. E. O'Neill. U.S.P. 2,302,567, 17.11.42. Appl. 13.12.37. Method and means of perforating well-casing and the like by means of a stream of fluid carrying abrasive solids.

T. L. Jarvis. U.S.P. 2,302,774, 24.11.42. Appl. 27.3.42. Electric heater for oil-wells.

J. N. Downs. U.S.P. 2,302,905, 24.11.42. Appl. 24.5.40. Well-packer.

C. J. O'Donnell. U.S.P. 2,303,134, 24.11.42. Appl. 17.2.41. Means for packing wells with a prepacked liner.
A. H. N.

Gas.

300.* Corrosion of Metals and Alloys by Flue Gases. L. Shnidman and J. S. Yeaw. *Industr. Engng Chem.*, 1942, **34** (12), 1436.—The corrosion behaviour of metals and alloys when exposed to flue gases has been examined. The fuels used for this examination included two natural gases. The effect of sulphur is given on the amount of corrosion experienced under various conditons of flue-gas temperature. From the data obtained, the maximum life of 22 different sheet metals of 20 gauge thickness has been estimated.
J. W. H.

Cracking.

301. Patents on Cracking. Standard Oil Development Co. E.P. 548,760, 23.10.42. Appl. 2.12.40. The cracking characteristics of hydrocarbon oils are improved by pretreatment which involves selectively removing substantially only hydrocarbons of high specific dispersion. These are in fact the condensed ring aromatic constituents of the oil.

P. K. Frolich. U.S.P. 2,303,076, 21.11.42. Appl. 18.5.38. Improvement in the method of catalytic cracking of hydrocarbon oils which involves a bank of catalytic converters containing a mass of cracking catalyst which is subjected to periodic regeneration *in situ* to remove carbonaceous deposits, and wherein the cracking and regeneration periods in the individual converters are arranged in staggered relationship one to another. The improvement lies in initially passing the oil to be cracked through the converter in the later stages of the cracking period, and afterwards passing all vapour products from this converter to a converter in the earlier stages of the cracking period. In this way the oil is contacted with partly spent catalyst and afterwards with a catalyst which has been subjected to cracking treatment for a substantially shorter period.

W. L. Benedict. U.S.P. 2,304,070, 8.12.42. Appl. 25.11.40. A conversion process in which a hydrocarbon oil is thermally cracked, and the resultant products are fractionated. The reflux condensate therefrom is then subjected to catalytic cracking in contact with a first catalyst bed. Simultaneously a second catalyst bed previously used in processing, is subjected to exothermic regeneration. Insufficiently converted hydrocarbons are separated from the catalytically cracked products, and at least part of them are passed in indirect heat exchange relation with the first and second catalyst beds. Subsequently they are passed to the thermal cracking process.

R. F. Ruthruff. U.S.P. 2,304,083, 8.12.42. Appl. 28.2.40. Relatively low-boiling olefinic hydrocarbons are contacted at a high temperature with a catalyst having as an essential ingredient cobalt pyrophosphate. In this way the low-boiling olefinic hydrocarbons are converted to hydrocarbons boiling within the gasoline range.

E. H. McGrew. U.S.P. 2,304,189, 8.12.42. Appl. 30.9.39. In a conversion process, hydrocarbon oil is subjected to thermal cracking, and from the resultant products a reflux condensate heavier than gasoline, a gasoline distillate, and a normally gaseous fraction containing polymerizable olefins are separated. The last fraction is subjected to polymerization and a polymer fraction is separated which boils substantially within the gasoline range. This polymer fraction is then subjected to the action of a cracking catalyst at a temperature between 500° and 900° F. under conditions designed to effect substantial saturation of the polymers by the transference of hydrogen thereto from the reflux condensate.

C. O. Tongberg. U.S.P. 2,304,289, 8.12.42. Appl. 2.12.39. In a process for cracking hydrocarbon oils, the oil is first treated with a selective solvent capable of removing aromatic constituents. The treatment is controlled in such a way that a solvent extract phase is obtained which consists principally of condensed ring aromatics having a specific dispersion above 190. The raffinate phase is substantially free of condensed ring aromatics but contains substantial amounts of single-ring aromatics. After separation the raffinate phase is subjected to cracking treatment to produce lower boiling hydrocarbons. H. B. M.

Hydrogenation.

302. Patent on Hydrogenation. F. E. Frey. U.S.P. 2,303,118, 24.11.42. Appl. 12.10.39. Process of catalytic non-destructive hydrogenation of relatively volatile normally liquid olefin hydrocarbons boiling in the motor-fuel range. The liquid hydrocarbons, together with recycled hydrogenated hydrocarbons and hydrogen, are fed into the upper part of a vertical hydrogenator containing a supported hydrogenation catalyst. The process is operated without substantial removal of heat by a cooling medium in indirect heat exchange relationship with hydrogenator. Temperature and pressure are so controlled that a substantial amount of the hydrocarbon material at the top of the hydrogenator is in liquid phase, and that there is a progressive increase in temperature from top to bottom of the hydrogenator. Hydrogenated and vaporized hydrocarbons are withdrawn from the lower part of the hydrogenator, and afterwards these are separated from unused hydrogen by condensation. H. B. M.

Polymerization and Alkylation.

303. Patents on Polymerization and Alkylation. Standard Oil Development Co. E.P. 548,525, 14.10.42. Appl. 14.2.41. In the catalytic reforming of hydrocarbon oils boiling within the gasoline boiling range in the presence of a gas rich in free hydrogen, gaseous products of reaction are continuously recycled to provide the gas. The improvement claimed lies in heating the oil and gas or recycled gaseous products in separate heating zones prior to their introduction into the reaction zone. The entire stream of products leaving the reaction zone is passed to a fractionation process without any indirect cooling.

Dorman, Long & Co., Ltd. E.P. 549,516, 25.11.42. Appl. 31.3.41. Process for the refining of solvent naphtha for the production of xylene therefrom. The naphtha is first washed with caustic alkali to remove materials such as phenols, which would inhibit thermal polymerization of the unsaturateds. Afterwards, the washed material is submitted to fractional distillation in a still fitted with a fractionating column and condenser, with consequent thermal polymerization of the unsaturateds and their retention in the still as the xylene fraction distils over.

R. Pyzel and E. R. Kanhofer. U.S.P. 2,304,654, 8.12.42. Appl. 19.10.39. After subjecting normally gaseous hydrocarbons to polymerization, all of the products except gases boiling below propane, are absorbed in a polymer liquid consisting of materials boiling within the gasoline range. The resultant enriched polymer liquid is stabilized to separate from it a fraction consisting essentially of three-carbon atom gases and a fraction consisting essentially of four-carbon atom gases. Regulated quantities of the former fraction are returned to the polymerization process and part of the stabilized polymer liquid is passed to the absorption process as absorber oil.

H. B. M.

Synthetic Products.

304. Petroleum Resins. Anon. *Chem. Tr. J.*, 29.1.43, **112**, 102.—Reactive distillates from the cracking of, *e.g.*, propane or butane at high temperature and pressure form a useful source of petroleum resins. When treated with aluminium chloride, condensation and polymerization takes place to a hard, amber-coloured resin, melting at about 100° C. It is still quite unsaturated and reactive, and oxidizes readily when exposed in a thin film, accelerating the gelation of tung and other varnish oils. It can be combined with drying or semi-drying oils for special purposes, or used directly in a varnish kettle for producing quick-drying varnishes. Many types of resins are produced from distillates differing in chemical composition or by the use of different catalysts. While the main outlet is in the paint industry, they are also used in the production of printing ink, plastic tile, linoleum, laminates, and impregnated fibres.

C. L. G.

Refining and Refinery Plant.

305.* Condensation of Vapours from Non-condensing Gases. J. C. Smith. *Industr. Engng Chem.*, 1942, **34** (10), 1248.—The previous method for the design of condensers to handle vapours in non-condensing gases, proposed by Colburn and Hougen, neglects part of the heat loss from the condensate layer in calculating the temperature gradient along the condenser. Data obtained on actual condensers showed that a higher rate of heat transfer was obtained than that predicted by the theory in the case of organic liquids of low latent heat. The new theory proposed makes full allowance for the cooling of the condensate, and an actual example worked out by both methods shows that the new method gives a surface area which is 14% less than that calculated from the old.

J. W. H.

306.* Liquid Capacity of Bubble-Cap Plates. A. J. Good, M. H. Hutchinson, and W. C. Rousseau. *Industr. Engng Chem.*, 1942, **34** (12), 1445.—In large-diameter bubble-plates, or moderate-diameter plates operating at high liquid loads, the hydraulic gradient set up across the plate becomes an important factor in determining the maximum liquid load which can be handled by the plate. Previously it has been customary to express this load in terms of the rate of liquid flow per unit cross-sectional area of plate. This is not a satisfactory method of expressing this factor, and it is better considered as the rate of liquid flow per unit mean width of plate. From the results of data obtained on an experimental bubble-plate graphs are given which enable the effect of the variables in bubble-cap design on the liquid loading of the plate and the pressure drop to be estimated. The use of these data is illustrated by the solution of an actual problem.

J. W. H.

307. Patents on Refining and Refinery Plant. Houdry Process Corp. E.P. 549,547, 26.11.42. Appl. 10.2.41. The patent embodies a two-stage process for the refining of naphthas and like hydrocarbon stocks of gasoline boiling range, carried out in the presence of catalysts. Total products from the first stage are passed to the second stage. In the first stage the naphtha is subjected to a splitting reaction in the presence of silica–alumina catalysts. The second-stage products of this reaction are immediately subjected to a dehydrogenation reaction in the presence of metallic catalysts.

Standard Oil Development Co. E.P. 549,699, 3.12.42. Appl. 6.8.40. The water content of hydrocarbon fluids is reduced by treating with an inorganic dehydrating agent. The fluid is first treated at a relatively high temperature with the dehydrating agent in a relatively high degree of hydration. In this way part of the water is removed. The partly dried fluid is then treated with the dehydrating agent at one or more successively lower degrees of hydration, and at successively lower temperatures. The final stage is carried out with the dehydrating agent in a form having a dissociation pressure lower than the partial vapour pressure exerted by the desired final water content in the fluid at the temperature of operation.

F. M. Watkins. U.S.P. 2,302,281, 17.11.42. Appl. 18.5.39. Method of refining a petroleum oil containing a small proportion of organic nitriles formed *in situ* in the oil by conversion of the organic acids and esters to nitriles. The oil is subjected to the action of substantially anhydrous ammonia at a temperature below that at which substantial cracking of the oil occurs.

R. W. Henry and J. V. Montgomery. U.S.P. 2,302,319, 17.11.42. Appl. 11.9.39. Method of refining and purifying mineral oil to separate the asphaltic and other undesirable bodies from the paraffinic portion of the oil. Commercial pyridine is added to the oil as the selective solvent in an extraction zone. A constant-boiling-point mixture of water and pyridine is added to the solution in the extraction zone as a precipitant to cause a refluxing action. In this way are obtained a raffinate phase and an extract phase. The extract phase is withdrawn and fractionated to obtain a constant-boiling-point mixture of water and pyridine, and it is afterwards returned to the extraction zone for further refluxing.

H. G. Schutze. U.S.P. 2,302,352, 17.11.42. Appl. 4.8.40. Petroleum oil which has been sweetened with a copper-containing reagent can be stabilized by treatment with anthranilic acid. In this way an insoluble complex copper-containing compound is precipitated from retained copper salts reacted with the anthranilic acid.

E. M. Dons and O. G. Mauro. U.S.P. 2,302,429, 17.11.42. Appl. 15.6.40. During the separation of petroleum oils and waxes, both oil and wax are dissolved in a solvent comprising over 25% *iso*propyl acetate and less than 75% methylene dichloride. The solution is cooled to a temperaure at which the *iso*propyl acetate and the methylene dichloride will selectively dissolve the oil and reject the wax. The selected oil solution is afterwards separated from the rejected wax.

E. M. Dons and O. G. Mauro. U.S.P. 2,302,657, 17.11.42. Appl. 26.12.41. During the process of dewaxing oils and de-oiling the wax, a settling zone is maintained in communication with a counterflow de-oiling zone. While the oil is being dewaxed in the settling zone, wax is being de-oiled in the counterflow zone.

E. M. Skinner. U.S.P. 2,302,916, 24.11.42. Appl. 26.7.40. Salt is removed from crude petroleum by heating the oil to a temperature sufficient to remove substantially the water associated with the salt and reducing the salt to a dispersed solid.

A. P. Giraitis. U.S.P. 2,303,077, 24.11.42. Appl. 6.2.40. Method of refining white oils which involves exhaustively treating a petroleum oil with concentrated sulphuric acid, separating the sludge, neutralizing the oil with an alkaline solution, washing the oil to remove sulphonate soaps, and finally chemically stabilizing the oil by treating with an essentially dry, alkaline-earth basic compound.

W. T. Hancock. U.S.P. 2,303,547, 1.12.42. Appl. 18.6.40. Petroleum hydrocarbons are refined by a process which includes passing a stream of such hydrocarbons through a cracking zone; subsequently passing the vapours from this zone to a conversion zone containing a foraminate body of material so as to subject the hydrocarbons to cracking and polymerization. The vapours are then introduced into a body of condensate maintained within the lower interior of the conversion zone. Thus mixed liquid and vapour fractions are subjected to intimate contact with this material by upward displacement of the condensate, and the liquid fractions constantly wash the material in the presence of hydrocarbons undergoing cracking, and polymerization vapours are removed from the conversion zone, and the condensate and its contained polymers are afterwards separately removed.

S. C. Carney. U.S.P. 2,303,609, 1.12.42. Appl. 10.6.40. Method of stabilizing crude oils which involves passing the oil through a series of desorbing zones of successively lower pressures to remove the methane. The methane gas which is separated in each succeeding desorber is compressed and injected without cooling into the preceding desorber. The partly demethanized crude oil from each desorber is cooled prior to pressure reduction and injection into the respective succeeding desorber. The demethanized crude oil is passed through a rectification process to remove an overhead fraction consisting of polymerization feed-stock and natural gasoline. This fraction is then condensed to produce liquid polymerization feed-stock and natural gasoline. By removal of the condensed fracton the crude oil is stabilized.

D. G. Brandt. U.S.P. 2,303,721, 1.12.42. Appl. 9.5.33. Method of separating wax or petrolatum from mineral-oil lubricants. The original oil is mixed with a low-boiling hydrocarbon at a temperature of approximately 100° F., and then slowly cooled to a temperature between 25° and 45° F. Afterwards it is rapidly chilled to about − 40° F. by vaporizing a portion of the low-boiling-point hydrocarbon. Finally precipitated wax is separated from the chilled mixture.

R. L. Gholson. U.S.P. 2,303,835, 1.12.42. Appl. 9.5.39. Sour petroleum distillates are sweetened in the following manner. A catalyst is provided, consisting of ferric sulphate salt and sodium chloride in equilibrium solution with air. An absorbent body of granular character is saturated with the catalyst, and the whole subjected to a temperature of 140° F. After moisture has been removed from the absorbent mass, the distillates under treatment are passed through it. H. B. M.

Chemistry and Physics of Hydrocarbons.

308. Vapor-Pressure Chart for Volatile Hydrocarbons. R. V. Smith. *U.S. Bur. Mines Information Circular*, No. 7215, August 1942.—During investigations of the physical properties of petroleums and natural gases in the Laboratories of the Bureau of Mines at Bartlesville, the author of this report had to make frequent reference to published data on the vapour pressures of volatile hydrocarbons. It was found that such data were widely scattered throughout the literature, and also that they frequently referred to uncommon units of pressure and temperature. Subsequently an endeavour was made to collate such data and to refer them to commonly used units of pressure and temperature.

The chart reproduced in this report was constructed by plotting collected data on semi-logarithmic co-ordinate paper on which the ordinate is the logarithm of vapour pressure and the abscissæ is the reciprocal of degrees Kelvin (degrees centigrade absolute). To facilitate use of the chart in low-temperature distillation analyses, a millivolt scale is provided for users of 3-element copper constantan thermocouples.

Pressure and temperature ranges covered by the chart provide space for plotting the vapour pressures of all hydrocarbons up to *n*-dodecane with the exception of pressures for methane below 15 millimetres of mercury. Vapour-pressure data are incomplete for *iso*pentane below pressures of 50 millimetres of mercury. Available critical constants for neopentane at the time of construction of the chart were apparently in error, as two lines were obtained with slightly different slopes. Data for *iso*butane are inconsistent in trend between pressures of 300 and 760 millimetres of mercury. H. B. M.

309.* The Halogenation of Aliphatic Hydrocarbons. G. Egloff and M. Alexander. *Oil Gas J.*, Part I, 20.8.42, **41** (15), 41; Part II, 27.8.42, **41** (16), 39; Part III, 3.9.42, **41** (17), 34.—This is a series of three articles discussing the halogenation of straight-chain hydrocarbons which commonly occur in petroleum or are produced during the processing of petroleum and its fractions by modern refinery methods. A digest of the methods employed and results obtained by research workers is given under the headings mentioned below, and appropriate literature references are provided. Theories of the mechanism of the reactions involved as advanced by various workers are given, and are critically reviewed.

Part I deals with the halogenation of the alkanes under four main headings covering the methods employed, which are (1) thermal, (2) catalytic, (3) photochemical, (4) indirect by reaction of alkyl halides with suitable inorganic halogen derivatives. The fourth method is normally employed for the preparation of fluorine derivatives.

Part II deals with the preparation of halogen substitution and addition products from alkenes by reaction with the halogens, and also the formation of addition products by reaction with hydrogen halides. Effects of reaction temperatures, catalysts, solvents, etc., are discussed.

Part III covers the following preparations : (1) Alkene addition compounds through the medium of halogenated reagents other than halogens and hydrogen halides. (2) Alkene addition compounds formed by reaction of alkenes with halogens and hydrogen halides in the presence of catalysts such as certain metals, metallic salts, and organic compounds. (3) Addition compounds formed by reaction by alkenes with halogens and hydrogen halides by photochemical methods. (4) Alkadiene addition compounds formed by reaction of alkadienes with halogens and hydrogen halides. (5) Substitution and addition compounds formed by reaction by alkenynes with halogens and halogenated reagents. R. A. E.

310.* The Nitration of Aliphatic Hydrocarbons. G. Egloff, M. Alexander, and P. Van Arsdell. *Oil Gas J.*, Part I, 15.10.42, **41** (23), 39; Part II, 22.10.42, **41** (24), 49.—Nitroparaffins were first prepared some 70 years ago, but it was not until 1940 that production on a commercial scale was commenced in the U.S. Physical properties of the lower members of the series produced commercially are tabulated. Nitroparaffins are valuable materials for use as solvents for a wide variety of purposes and as raw materials for preparation of explosives, lachrymators, amines, etc.

A commercial process for producing nitroparaffins consists of : (1) high-temperature nitration of propane in vapour phase, (2) separation of reaction products and recovery of unreacted materials for recycling, (3) fractional distillation and purification of the nitroparaffins. In addition to 1- and 2-nitropropane, nitro-methane and nitro-ethane are produced by this method.

The alkanes are the most difficult aliphatics to nitrate, especially the lower members of the series, for which vapour-phase nitration was found to be the solution. The four general methods of nitration are : (1) vapour-phase nitration with nitric acid, by which method mononitro-compounds can be produced practically to the exclusion of dinitro- and more highly nitrated compounds ; (2) vapour-phase nitration with nitrogen tetroxide, which yields both mono- and dinitro-compounds ; (3) liquid-phase nitration with nitric acid and nitric-sulphuric acid mixture, applicable to alkanes of 5 or more carbon atoms. Increased concentration of acid increases both oxidation and nitration and produces relatively greater amounts of di- and poly-nitro-derivatives ; (4) catalytic. Certain nitrates have been found useful catalysts in processes already mentioned, and promote reaction of alkanes with nitric oxide at high temperatures.

Part II deals with the nitration of alkenes and alkynes. Nitration of the alkenes may be accomplished by (*a*) nitric acid, (*b*) nitrogen oxides, (*c*) catalytic methods, (*d*) electrochemical methods. R. A. E.

311.* Phase Equilibria at High Temperatures. R. R. White and G. G. Brown. *Industr. Engng Chem.*, 1942, **34** (10), 1162.—A complete description is given of an apparatus for determining the liquid-vapour phase equilibrium at temperatures up to 820° F. and at pressures up to 700 p.s.i. Essentially this apparatus consists of a pipestill preheater and a flash-pot which embodies a Hagen separator, to ensure that no liquid is carried over with the vapour, and a liquid level controller to ensure that no vapour is passed out with the equilibrium residue. This liquid level controller is of special design, and depends on the change in capacitance between the liquid and vapour phases. This liquid level indicator will operate satisfactorily to a reduced pressure condition of 0·95 at the critical temperature. Using this apparatus, liquid-vapour equilibria have been investigated for petroleum fractions boiling between 95 and 750° F. up to the pressures and temperatures given above. From the data obtained the vaporization constants have been calculated, and these constants include values in the critical and retrograde condensation regions for complex hydrocarbon mixtures. J. W. H.

312.* Nomograph for Calculating Reduced Temperature. D. S. Davis. *Industr. Engng Chem.*, 1942, **34** (10), 1174.—A nomogram is given which enables the reduced temperature to be rapidly estimated. The critical temperature scale is also marked with a number of common hydrocarbons. J. W. H.

313.* Nomographs for Mean Driving Forces in Diffusional Problems. E. C. Scheibel and D. F. Othmer. *Industr. Engng Chem.*, 1942, **34** (10), 1200.—The construction and use of nomograms are given which enable the mean driving force in diffusional problems to be rapidly estimated. These nomograms greatly facilitate the use of the equations given by the authors for the solution of diffusional problems in *Trans. Amer. Inst. Chem. Engrs*, 1942, **38**, 339. The use of the nomograms is illustrated by examples of absorption, distillation, and extraction problems. J. W. H.

314.* Composition of the Dew Point Gas of the Methane–Water System. R. H. Olds, B. H. Sage, and W. N. Lacey. *Industr. Engng Chem.*, 1942, **34** (10), 1223.—The composition of the dew-point gas of the system methane–water has been investigated over the temperature range 100–460° F., and at pressures up to 10,000 p.s.i. Comparison of these data with similar results for the systems hydrogen–water and nitrogen–water shows that the systems are not ideal, and that the behaviour of such systems must be determined experimentally. J. W. H.

315.* Surface Tension–Viscosity Nomograph for Organic Liquids. D. S. Davis. *Industr. Engng Chem.*, 1942, **34** (10), 1231.—A nomogram is given which relates the surface tension to the viscosity of 32 organic liquids, which include a number of paraffin and aromatic hydrocarbons. J. W. H.

316. Densities of Liquefied Petroleum Gases. Technical Committee, Natural Gasoline Association of America. *Industr. Engng Chem.*, 1942, **34** (10), 1240.—The densities of propane, *iso*butane, *n*-butane, and *n*-pentane in the liquid phase have been investigated over the temperature range − 50° to 140° F., and for propylene and *l*-butene over the range 0–60° F. In addition to these determinations for the pure hydrocarbons, the densities of equimolecular mixtures of propane-*iso*-butane and *n*-butane–*n*-pentane have been determined over the temperature range 20° to 100° F. These densities determinations agree generally with the data previously published. The new densities are somewhat lower for *iso*butane and propylene and higher for *n*-butane. The two mixtures investigated do not appear to deviate appreciably from ideal solutions. J. W. H.

317.* Nomograph for Pressure Drop in *iso*Thermal Flow of Compressible Fluids. G. W. Thomson. *Industr. Engng Chem.*, 1942, **34** (12), 1485.—In *Industr. Engng Chem.*, 1942, **34**, 821, equations were given for the estimation of the pressure drop under the above conditions. The present article gives a nomograph which enables a rapid solution of the equations to be obtained. J. W. H.

318.* Nomographs for the Absorption Factor Equation. S. Chase. *Industr. Engng Chem.*, 1942, **34**, 1499.—Nomographs have been constructed which enable a rapid solution of the Souders and Brown equation for the absorption of gases to be made. From these nomographs the number of theoretical plates required for a given component can be estimated from a knowledge of molal ratio of the gas and absorbent and the equilibrium constant. J. W. H.

319.* Phase Equilibria in the Methane–Decane System. H. H. Reamer, R. H. Olds, R. H. Sage, and W. N. Lacey. *Industr. Engng Chem.*, 1942, **34** (12), 1526.—The specific volumes of five mixtures of methane and decane have been determined over the temperature range 100–460° F. and at pressures up to 10,000 lb. p.s.i. From these data the bubble and dew-point pressures and properties of the co-existing phases have been established. J. W. H.

320.* Binary Mixtures for Testing Fractionating Columns. Correspondence in *Industr. Engng Chem.*, 1942, **34** (12), 1543.—Carlson and Colburn have written a criticism of Bragg and Richards' work on the relative volatility (α) of the binary mixture benzene–ethylene dichloride (*ibid.*, 1942, **34**, 1088). The writers show that, from thermodynamic considerations, the new data are not tenable, and recommend the use of the ideal values of α, calculated from the Smith and Matheson vapour-pressure data, until the experimental technique can be improved, and any deviations from Raoult's law demonstrated with certainty. In reply, Bragg and Richards maintain that, although individually the determined values of a are subject to large experimental errors, there is overwhelming evidence in favour of the data published. J. W. H.

Analysis and Testing.

321. A Rapid Infra-Red Analytical Method for Hydrocarbon Mixtures and a Routine Spectrophotometer for Plant Control. R. R. Brattain and O. Beeck. *J. appl. Phys.*, 1942, **13** (11), 699.—A description is given of two spectrophotometers which operate in the infra-red region and are suitable for the analysis of hydrocarbon mixtures. One is a simple unit for use at 1186 cm.$^{-1}$ wave-band, and is suitable for the analysis of *iso*butane. The other is a more versatile instrument, and is designed to operate in the 2–15 μ region. In this instrument, provision is made for seventeen fixed spectral positions. These instruments consist essentially of a Nernst filament forming a source of infra-red radiation, a rock-salt prism for wave-length separation, and a compensated thermophile and galvanometer for receiving and measuring the intensity of the transmitted radiation. The accuracy of routine analyses for *iso*butane by this method is ± 0·5%. The average time required for an analysis is 15 mins., but a single operator has analysed thirty-eight samples in 6 hours, including the necessary calculations and other operations incidental to the actual analyses.
J. W. H.

322.* The Electron Microscope. C. J. Burton, R. B. Barnes, and T. G. Rochow. *Industr. Engng Chem.*, 1942, **34** (12), 1429.—Methods of calibrating electron microscopes are discussed, and it is recommended that the calibration range be extended well into the optical microscope range so that comparative experience may be gained in the appearance and interpretation of the inspection under the optical and electron microscopes. The electron microscope used by the authors had a range of 200–15,000 diameters, but accurate focusing became difficult at more than 10,000 diameters. A description is given of an attachment to the microscope which enables the range of magnifications to be extended without redesigning the magnetic lense system.
J. W. H.

Motor Fuels.

323. Patents on Motor Fuels. Standard Oil Development Co. E.P. 549,075, 5.11.42. Appl. 3.9.40. Preparation of a motor fuel consisting of a hydrocarbon fuel and an organo-substituted borine compound having one or more hydrocarbon groups directly attached to the boron atom, or a nitrogen-base addition compound of the borine compound.

M. W. Kellogg Co. E.P. 549,570, 27.11.42. Appl. 20.8.40. Method of converting a naphtha charging stock rich in aliphatic hydrocarbons into a motor-fuel component rich in aromatic hydrocarbons. The charging stock is contacted in vapour phase with an aromatization catalyst, in the presence of added hydrogen. The net produced hydrogen is afterwards removed.

E. E. Solomon. E.P. 549,908, 14.12.42. Appl. 18.8.41. Production of motor fuels given during the retorting of tar mixed with animal or other fats, alcohol, benzene rectified, acetone, and paraffin oil. After this process the oil is drawn off, leaving the watery part. This watery part is mixed with the residue in the retort with naphthaline crude, sodium nitrate powdered, and dry nitric acid, dry hydrochloric acid, sulphuric acid or other substances like resinous oils, to obtain suitable oil for motor fuel.

Standard Oil Development Co. E.P. 549,963, 16.12.42. Appl. 14.3.41. Process for the catalytic reforming in the presence of hydrogen of hydrocarbon oils containing both saturated and unsaturated hydrocarbons. The activity of the catalyst, and therewith the production of hydrogen, decreases the proportion of saturated hydrocarbons to unsaturated hydrocarbons in the feed-stock.

M. C. K. Jones. U.S.P. 2,303,050, 24.11.42. Appl. 31.10.40. A safety motor-fuel composition of high oxidation resistance and high flash-point consists of a gasoline hydrocarbon boiling substantially within the range 100–350° F., substantially free from molecular oxygen, and containing carbon dioxide in an amount above 100% by volume at about atmospheric temperature.

R. V. Shankland. U.S.P. 2,303,663, 1.12.42. Appl. 30.12.38. Method of producing motor-fuel constituents from a substantially saturated normally gaseous hydrocarbon mixture containing considerable proportions of normal butane and *iso*butane. The mixture is first fractionated in a fractionating zone to form a fraction rich in normal butane and a fraction rich in *iso*butane. A part of the former fraction is dehydrogenated to produce butylenes and hydrogen. The butylenes are introduced with the fraction which is rich in *iso*butane into an alkylation zone containing a catalyst, and are maintained under conditions suitable for the reaction of butylenes and *iso*butane to form branched-chain octanes. The products are removed from the alkylation zone, a normally liquid fraction containing octanes is separated, also a normally gaseous fraction. The normally gaseous fraction is introduced into the fractionating zone. The remaining part of the fraction rich in normal butane is isomerized in the presence of a catalyst of the aluminium chloride type to produce a further quantity of *iso*butane for use in the alkylation zone.

A. R. Goldsby. U.S.P. 2,303,735, 12.1.42. Appl. 10.2.40. Method of improving the anti-knock value of a narrow-cut gasoline fraction of relatively low anti-knock value having an end boiling point not more than 25–75° F. higher than its initial boiling point, and containing substantial proportions of normally liquid olefin and straight-chain paraffin hydrocarbons.

T. A. Mangelsdorf. U.S.P. 2,303,944, 1.12.42. Appl. 16.9.39. To produce high anti-knock gasoline, a hydrocarbon oil is subjected to catalytic cracking in the presence of a solid catalyst adapted to promote conversion into lower-boiling hydrocarbons. Simultaneously another stock is subjected to thermal cracking to effect conversion into lower-boiling hydrocarbons without the aid of a catalyst. Hot products from the catalytic and thermal cracking processes are combined, and the resultant mixture is maintained in a reaction zone in the absence of a catalyst, at a temperature of the order of 900° F. to effect further conversion into hydrocarbons of the gasoline boiling range. The resultant cracking products are separated into vapours and residue. Then the vapours are mixed with charging stock to effect condensation of part of the vapours. The resultant mixture is passed to the thermal cracking zone, and the uncondensed vapours are subjected to further fractionation to separate a reflux condensate from lighter products. The reflux condensate is directed to the catalytic cracking zone.

R. F. Marschner. U.S.P. 2,304,187, 8.12.42. Appl. 8.11.39. A high octane-number motor fuel is produced from a relatively low knock-rating naphtha of wide boiling range in the following manner. The naphtha is fractionated into a number of fractions, including a light naphtha fraction, an intermediate fraction, and a heavy naphtha fraction. The light fraction is contacted with a catalyst under conditions designed materially to increase its octane number. The heavy fraction is contacted with a dehydro-aromatization catalyst to convert the hydrocarbons of lower boiling range intermediate between the light fraction and the heavy fraction. The dehydro-aromatization products are fractionated into a gasoline fraction and a heavier fraction. The gasoline fraction is blended with the high octane-number products of the light naphtha fraction to produce the desired fuel.

C. W. Hussey. U.S.P. 2,304,639, 8.12.42. Appl. 31.8.39. To produce yields of gasoline of relatively high olefin content a hydrocarbon oil is subjected to thermal cracking treatment. The resultant products are separated into vapours suitable for catalytic cracking and non-vaporous residue. The vapours are separated into at least two streams, one of which is catalytically cracked to increase the total gasoline content and decrease the olefin content. Resultant cracked products are fractionated to form reflux condensate and to recover therefrom aviation gasoline fractions. The reflux condensate is combined with another vaporous stream, and an automotive gasoline is separated from the mixture. This gasoline has a higher olefin content than the aviation spirit.

H. B. M.

Gas, Diesel and Fuel Oils.

324.* Indian Vegetable Fuel Oils for Diesel Engines. Anon. *Gas Oil Pwr*, May 1942, **37** (440), 80.—This article is concerned with a report issued by the Department of Scientific and Industrial Research Bureau, India, which describes the work of four Indian engineers.

India is one of the principal seed-producing areas of the world, the annual production in 1938 being eight million tons. The most important Indian oils are cottonseed, rape, sesame, coconut, groundnut, and castor.

Previous reports on this subject include papers published by Gautier in France in 1928, 1933, and 1935, papers in German by A. W. Schmidt in 1932 and 1934, some preliminary work by Chinese investigators 1936, and an article in *Gas & Oil Power* by J. Walton, 1938. The Indian report contains a section devoted to the general requirements of diesel fuels, these being divided into : (*a*) handling, storage, pumping, and atomization of fuels, and (*b*) ignition and combustion of the fuel after injection. Section (*a*) covers flash point, specific gravity, viscosity, setting point, and impurities, while (*b*) covers calorific value, chemical constitution, and carbon residue.

The test equipment used for these investigations included a single-cylinder Lister unit 8 B.H.P. at 1200 r.p.m., with bore and stroke 4½ in. and 4⅜ in. respectively. The engine appears to have been of standard design, with Bosch fuel-pump and single-hole injector, and was provided with a dual-chamber combustion arrangement with starting compression ratio 19 : 1 and operating value 15 : 1. Care was taken to maintain the intake air at constant temperature. The engine was run for 25 hours at approximately three-quarters full load and normal rated speed before the preliminary trial runs were made. Experiments were then made with mineral diesel fuel and a few vegetable oils, with a view to establishing the normal operating conditions under which the various fuels might conveniently be subjected to extended comparative tests. In the preliminary runs general operating characteristics, such as startability, operation stability, nature of exhaust, and maximum output, were determined. Prolonged runs of 50 hours under full load followed, during which average power output, specific fuel consumption, brake thermal efficiency, deposits on engine parts, and corrosion of engine parts were studied.

Results are summarized in detailed tables. It was shown that in comparison with mineral fuels, vegetable oils in general gave comparable average power output, somewhat high fuel consumption, and rather superior thermal efficiency. The deposits were somewhat greater, and in some cases harder. Corrosion on the whole was greater, but varied for the different vegetable oils. The lowest consumption and highest efficiency of all oils including the mineral oil in these 50-hour tests were obtained when using cottonseed oil, and this was confirmed in short-duration check tests.

The results of these experiments and a review of the literature on this subject indicate that from purely technical considerations the use of vegetable oils as diesel fuels holds considerable promise, but that there still remains a number of intricate technical problems to be solved. However, it would appear that several of the oils tested could be used under expert guidance to relieve India's fuel problem at the present time. D. L. S.

325. Patent on Gas, Diesel, and Fuel Oils. G. H. Cloud. U.S.P. 2,304,242, 8.12.42. Appl. 22.3.39. Preparation of a compression-ignition fuel consisting of a hydrocarbon oil boiling between 400° and 700° F. and a small proportion of an essentially hydrocarbon unsymmetrically substituted hydrazine compound selected from the group consisting of dialkylhydrazines, phenylhydrazine, diarylhydrazines, alkylarylhydrazines, quinalylhydrazine, acetylphenylhydrazine, 3-amino-phthalhydrazine. The added compound is an ignition promoter and stabilizing agent. H. B. M.

Lubricants and Lubrication.

326.* Viscosity Characteristics of Lubricating Oils Saturated with Natural Gases at High Pressures. J. D. Swearingen and E. D. Redding. *Industr. Engng Chem.*, 1942, **34** (12), 1496.—A description is given of a capillary-type viscometer for the determination of the viscosities of liquids under pressure. By the use of this apparatus the viscosities of saturated solutions of four mineral lubricating oils and a sample of castor oil with a natural gas consisting of 90% methane have been determined in the temperature range 80–190° F. and over the pressure range 0–3000 p.s.i. From these data it is shown that castor oil is unique, in that two phases are formed at high pressure and that the viscosity is considerably greater than in the case of the mineral oils. From the data on mineral oils it is shown that the addition of a light oil to a heavy oil to produce an oil of intermediate viscosity substantially reduces the drop in viscosity with subjection of the oil to natural gas under pressure. J. W. H.

327. Patents on Lubricants and Lubrication. W. Helmore. E.P. 548,390, 8.10.42. Appl. 4.4.41.—A lubricant especially suitable to carry high bearing loads at elevated temperatures is prepared from a lubricating-oil base and a small proportion of an oil-soluble organic compound of tin, an organic compound containing trivalent phosphorus, and an organic compound containing a phosphate radical. The total amount of addition agents does not exceed 10% by weight of the lubricating-oil base. Lubricants of this description are claimed to exhibit a marked degree of resistance to oxidation and to the formation of carbonaceous and gummy deposits at high operating temperatures.

Standard Oil Development Co. E.P. 548,723, 21.10.42. Appl. 17.4.40. Production of lubricating compositions by chemically condensing a lubricating oil containing cyclic constituents with an acyl halide of a naphthenic acid in the presence of a Friedal–Crafts catalyst.

Standard Oil Development Co. E.P. 549,040, 4.11.42. Appl. 14.10.40. A lubricating grease has incorporated therein 50–90% by weight of a mineral lubricating oil having a Saybolt viscosity at 210° F. of at least 60 secs.; 10–20% by weight of a sodium soap obtained by saponifying a mixture of equal parts of stearic acid and rosin; and a vegetable wax having a free acid number of less than 20.

Imperial Chemical Industries, Ltd. E.P. 549,296, 16.11.42. Appl. 12.4.41. Preparation of a lubricant consisting of a hydrocarbon lubricating oil to which has been added a minor proportion of a polyvalent metal acid, normal or basic salt of a hydroxyphosphoric acid of the formula $RR'C(OH)PO(OH)_2$. R and R′ represent aliphatic or alicyclic groups in which the total number of carbon atoms is not less than 6.

E. I. De Pont de Nemours. E.P. 549,524, 25.11.42. Appl. 21.5.41. Mineral oils, and particularly viscous petroleum oils, are stabilized against deterioration in colour by the incorporation therein of a small proportion of an oil-soluble ester or amide of an N : N′-alkylene-di(β-amino-crotonic) acid free of acidic substituents.

J. W. Johnson, U.S.P. 2,302,552, 17.11.42. Appl. 7.4.38. Lubricating oil can be purified, and an effective concentration of addition agent maintained therein, by means of a special device which comprises, in series, a porous filtering medium and a porous absorbent medium impregnated with an organic addition agent soluble in lubricating oil in relatively low concentrations.

S. Musher. U.S.P. 2,302,708, 24.11.42. Appl. 23.4.40. The tendency of lubricating oils towards sludge formation can be decreased, also their tendency to cause corrosion of metal surfaces, by treating them with a relatively small amount of a combination of molasses and a phosphatide at a high temperature.

G. H. Schoenbaum. U.S.P. 2,303,068, 24.11.42. Appl. 27.4.40. Preparation of a lubricant suitable for heavy mechanical equipment, such as tractor roller bearings which are exposed to dust and dirt during use. The lubricant consists of 50–90% of a mineral oil having a viscosity between 200 and 250 secs. Saybolt at 210° F., and a flash point of at least 600° F.; 1–25% of a finely divided fibrous solid suspended in the mineral-oil base stock; and 5–40% of petrolatum having a melting point not lower than 110° F. The amount of petrolatum should be sufficient to stabilize the composition against separation of the fibrous solid during storage.

H. G. Greger. U.S.P. 2,303,546, 1.12.42. Appl. 8.8.39. Impurities are separated from lubricating oils by mixing with them a compound of the guanidine series and afterwards filtering the mixture. H. B. M.

Asphalt and Bitumen.

328. Patent on Asphalt and Bitumen. H. E. Cier. U.S.P. 2,303,023, 24.11.42. Appl. 19.12.40. Asphalts having improved susceptibility characteristics to temperature changes are prepared by fluxing a reduced crude with a low-viscosity hydrocarbon fraction boiling within the lubricating-oil range. The mixture is diluted with a liquefied gaseous hydrocarbon, and the temperature is so adjusted that an asphalt is precipitated from it. Precipitated asphalt is separated from the portion which is soluble in the diluent, and finally the asphalt is stripped free of light hydrocarbons. H. B. M.

Special Products.

329.* Cryoscopic and Viscosity Studies of Poly*iso*butylene. A. R. Kemp and H. H. Peters. *Industr. Engng Chem.*, 1942, **34** (10), 1192.—Cryoscopic and viscosity data have been determined for solutions of various poly*iso*butylene polymers in various solvents. The constant in the molecular weight–viscosity equation has been determined for various degrees of polymerization. The cryoscopic deviation from Raoult's law begins when the molecular weight of the polymer exceeds 2300, corresponding to a chain length of 80 carbon atoms. *n*-Hexane is the best solvent for the viscosity–molecular weight measurement of poly*iso*butylenes. J. W. H.

330.* Low-Temperature Flexibility Behaviour of Vinyl Elastomers. R. F. Clash and R. M. Berg. *Industr. Engng Chem.*, 1942, **34** (10), 1218.—A description is given of an apparatus for the measurement of the flexibility of elastomers at temperatures down to – 75° C. In this apparatus a strip of the elastomer, at a controlled temperature, is subject to a torsional stress which can be measured. By means of this apparatus the flexibility–temperature relationship has been established for samples of vinyl copolymer resins to which have been added various amounts of different plasticizers. J. W. H.

331.* Spraying Solutions in Liquefied Gases for Insecticidal Aerosol Production. L. D. Goodhue. *Industr. Engng Chem.*, 1942, **34** (12), 1456.—The spraying of insecticides, such as pyrethrum extract and nicotine, from solutions in liquefied gases results in much more finely divided mists than those produced by most spraying methods. These mists settle more slowly than sprays, and measurements of the rate of settling are given. Suitable non-inflammable gases for this type of spraying are methyl chloride and dichlordifluoromethane. J. W. H.

332.* The Effect of Sulphur and Nitrogen Compounds on Liquid Dielectrics. J. D. Piper, A. G. Fleiger, C. C. Smith, and N. A. Kerstein. *Industr. Engng Chem.*, 1942, **34** (12), 1505.—Measurements have been made of the power factors, conductivities, and polar contents of systems of liquid paraffin with sulphur and nitrogen compounds selected to represent types found in insulating oils, or formed from them as the result of deterioration in service. Sulphur and nitrogen compounds of the types occurring in natural petroleum had low power factors and conductivities even when present in high concentrations. The presence of soluble salts resulting from the reaction between nitrogen bases and carboxylic acids can cause high power factors, but not when present in the quantity comparable with nitrogen content of insulating oils. Sulphonic acids, such as lauryl sulphonic acid, result in high power factors which are greater than those produced by the concentrations of asphaltic deterioration products. J. W. H.

333. Patents on Special Products. J. G. Fife. E.P. 548,733, 22.10.42. Appl. 21.4.41. Process for the separation and recovery of hydrocarbons of a lesser degree of saturation from hydrocarbons of a greater degree of saturation contained in hydrocarbon vapour mixtures of relatively narrow boiling range. The vapour mixture is contacted with a liquid solvent of the group consisting of acetonitrile, propionitrile, nitromethane, nitro-ethane, and nitropropane, to dissolve selectively the hydrocarbons of lesser degree of saturation. The residual gas is separated from the liquid solution containing these hydrocarbons, which are afterwards recovered.

J. G. Fife. E.P. 548,734, 22.10.42. Appl. 21.4.41. Process for the recovery of hydrocarbons of a lesser degree of saturation from hydrocarbons of a greater degree of saturation contained in hydrocarbon vapour mixtures of relatively narrow boiling range. The original mixture is contacted with a liquid solvent mixture consisting of 5–55% by weight of water and 95–45% of a compound of the group consisting of morpholine, dioxane, acetone, methyl ethyl ketone, acetonitrile, and lactonitrile, to dissolve selectively the hydrocarbons of lesser degree of saturation.

Anglo-Iranian Oil Co., Ltd. E.P. 548,901, 29.10.42. Appl. 2.4.40. Process for the isomerization of a normal hydrocarbon having at least four carbon atoms in the molecule. The normal paraffin, or paraffins, or mixtures of hydrocarbons containing such normal paraffins, are contacted, in the absence of hydrogen, with a catalyst consisting of an oxide and/or sulphide of a metal of Group VI of the periodic table.

R. M. Barrer. E.P. 548,905, 29.10.42. Appl. 24.2 41. Method of separation of straight-chain hydrocarbons from mixtures containing straight-chain hydrocarbons, branched-chain and/or cyclic hydrocarbons. The mixtures are contacted with crystalline natural or synthetic zeolites having rigid three-dimensional anionic networks and having interstitial dimensions sufficiently large to absorb the straight-chain hydrocarbons, but small enough to exclude the branched-chain and/or cyclic hydrocarbons.

Kodak, Ltd. E.P. 548,907, 29.10.42 Appl. 21.3.41. A process for scrubbing coal gas and other gases with a mineral oil in which there has been incorporated one or more of the organic substances: xylenols, phenolic ethers, naphthols, hydroquinone, pyrogallol, coal-tar distillates boiling within the range 140–300° C., and pine and other soft-wood phenols and oils.

Kodak Ltd. E.P. 548,908, 29.10.42. Appl. 21.3.41. A process for scrubbing coal gas and other gases with a mineral oil in which an aminophenol has been incorporated.

Anglo-Iranian Oil Co., Ltd. E.P. 549,003, 3.11.42. Appl. 2.10.40. Method of conversion of normal saturated aliphatic hydrocarbons, such as *n*-butane or *n*-pentane, into substantial proportions of the corresponding branched-chain hydrocarbons. The conversion is carried out in the presence of an aluminium halide and a solvent selected from carbon disulphide or a chloro-paraffin such as tetrachloroethane.

Standard Oil Development Co. E.P. 549,233, 12.11.42. Appl. 3.7.40. In the isomerization of normal paraffin hydrocarbons the normal paraffin is subjected at a temperature of 30–400° F. to the action of a metal such as will, with a halogen-containing compound, form a Friedel–Crafts type catalyst, and a halogen-containing compound capable of reacting with the metal to form metal halide. In this way a nascent Friedel–Crafts catalyst is prepared *in situ*.

Standard Oil Development Co. E.P. 549,702, 3.12.42. Appl. 2.12.40. Preparation of a composition consisting of a mineral oil or a petroleum hydrocarbon and a relatively small amount of a tertiary alkyl ether of a mono-hydroxy phenol having at least two alkyl groups attached to the ring nucleus, and in which two of the alkyl groups are attached to the nucleus by a carbon atom having a hydrogen atom attached thereto, or in which one of the alkyl groups is a tertiary alkyl group and another is a primary or secondary alkyl group containing at least two carbon atoms.

Standard Oil Development Co. E.P. 549,829, 14.12.42. Appl. 24.7.40. A liquid-phase process for the isomerization of normal paraffins containing at least four carbon atoms into *iso*paraffins. The catalyst employed is of the Friedel–Crafts type, and is maintained in an amount of at least 100% by weight of the amount of feed-stock in contact with it at any given moment.

J. T. Rutherford. U.S.P. 2,302,655, 17.11.42. Appl. 18.12.39. Process for preparing a homologous mixture of heterocyclic secondary amines having a basic dissociation constant higher than $1{\cdot}0 \times 10^{-4}$. An initial mixture of petroleum nitrogen bases being substantially free of hydrocarbons and petroleum-derived impurities insoluble in an excess of 50% H_2SO_4 is recovered from petroleum. The mixture is then subjected to the action of hydrogen under reducing conditions, in the presence of a sulphur-active hydrogenating catalyst and an active sulphur carrier. Secondary amines thus produced are separated from the normally liquid reaction mixture by adjusting the pH of the mixture to approximately 9·5. H. B. M.

Coal and Shale.

334. The Physical Properties of Cokes from Bureau of Mines—American Gas Association Tests at 800° and 900° C. D. A. Reynolds and C. R. Holmes. *U.S. Bur. Mines Report of Investigations*, No. 3650, June 1942.—The carbonizing properties of sixty-six American coals and a number of coal blends have been determined by means of the Bureau of Mines, American Gas Association (BM-AGA) test. Many of the coals were carbonized at 800° and 900° C. in two sizes of retort. Because the quality of the coke was found to be affected by the size of the retort, this report was prepared to show the average physical properties of coke from two sizes (13- and 18-diameters).

Conclusions reached as a result of such tests are as follows. Cokes from the two sizes of retort do not differ appreciably either in apparent specific gravity or hardness. The 800° cokes from the two sizes have about the same $1\frac{1}{2}$-inch shatter and 1-inch tumbler indexes. The 900° cokes from the 18-inch retort generally are stronger; they have higher $1\frac{1}{2}$-inch shatter and 1-inch tumbler indexes than cokes from the 13-inch retort made at the same temperature. The physical properties of the coke were found to be related to the rank of coal carbonized. As more coals were carbonized at 900°, comparison of the properties of cokes on the basis of carbonizing temperature was not entirely valid. The $1\frac{1}{2}$-inch shatter index was definitely higher for the 800° cokes from all ranks of coal, whereas differences for the 1-inch tumbler index were small, with no definite trend for this index to be higher at either carbonizing temperature. H. B. M.

BOOKS RECEIVED.

Correlation of Certain Properties of Oil-Well Drilling-Mud Fluids with Particle-Size Distribution. G. L. Gates and C. P. Bowie. U.S. Bureau of Mines, Report of Investigations, R.I. 3645, May 1942.

British Electrical and Allied Industries Research Association. Twenty-second Annual Report. 1st October, 1941, to 30th September, 1942.

La Elaboracion del Pirogalol y la Destilacion por Arrastre con Liquidos no-Acuosos. G. A. Fester and A. R. Collados. University of Santa Fé.

La Geoquimica de los Filones Vanadiferos. G. A. Fester, V. Lombardozzi, and M. A. Solchaga. University of Santa Fé.

INSTITUTE NOTES.

March, 1943.

CANDIDATES FOR ADMISSION.

The following have applied for admission to the Institute. In accordance with the By-laws, the proposals will not be considered until the lapse of at least one month after the publication of this *Journal*, during which time any Fellow, Member, or Associate Member may communicate by letter to the Secretary, for the confidential information of the Council, any particulars he may possess respecting the qualifications or suitability of the candidate.

The object of this information is to assist the Council in grading the candidate according to the class of membership.

The names of candidates' proposers and seconders are given in parentheses.

Ernste, Jan Willem, Manager, B.P.M. (*John A. Oriel ; R. I. Lewis.*)

Greenberg, Leander, Research Chemist. (*Dr. A. H. Nissan ; C. E. Wood.*) (Application for transfer from Student to Associate Member.)

Noble, George, Assistant Manager, Agwi Petroleum Corporation, Ltd. (*H. D. Demoulins ; Prof. F. H. Garner.*)

Rosenfeld, Ludwig, Research Engineer, Institution of Automobile Engineers. (*C. G. Williams ; E. A. Evans.*)

CONTRIBUTIONS TO THE *JOURNAL*.

In view of the fact that the orbit of the Institute has now been widely extended, it was decided at a recent meeting of the Publication Committee to invite contributions to the *Journal* from members, not only on purely scientific and technical topics, but on those matters that might be of general interest. The Editors are particularly anxious to have papers dealing with exploration, so that many members of the Institute who are quite unacquainted with the amazing pioneering hardships and difficulties which geologists, geophysicists, and surveyors have had to contend with since the inception of the industry may hear of what their fellow-members have achieved. These papers should be confined to information of general interest, and should be illustrated by photographs if possible.

STANLOW BRANCH.

Since the formation of the Stanlow Branch in 1940, nineteen meetings have been held, and the current session has seen the following papers read :—

"Aero Engine Performance in relation to Fuels." By Dr. C. G. Williams.

"Butadiene and Synthetic Rubber Developments." By K. L. Butcher.

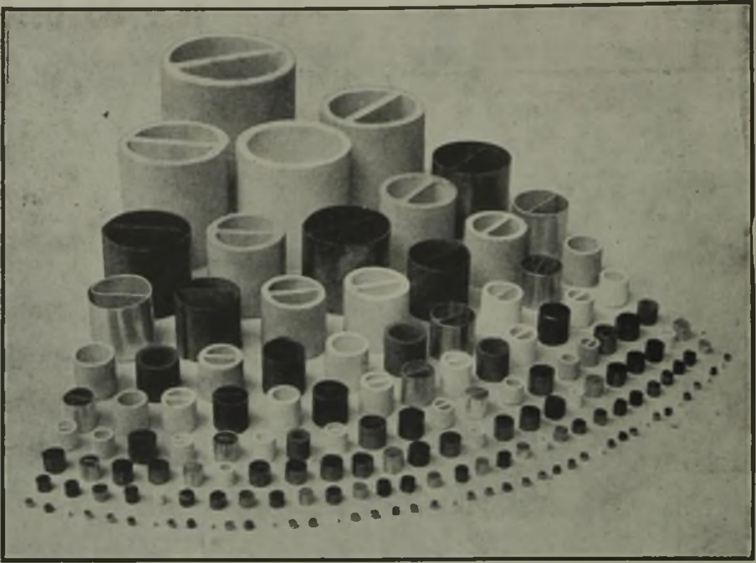
"Cracking and Related Processes—Developments in 1942." By J. C. Wood-Mallock.

"Varieties of Asphaltic Bitumens." By W. W. Goulston.

In addition, an informal social function held on 19th January last was attended by forty-one members and nine guests from H.M. Forces and local industry. On this occasion a petroleum "Brains Trust" was formed from amongst the members and their unrehearsed answers to the not always serious questions submitted during the evening were much appreciated. The remaining meetings scheduled for the 1942–43 Session are on 24th March, when Dr. Ter Meulen will read the paper on "Solvent Refining of Lubricating Oils," recently given to the Institute of Chemical Engineers, and on 28th April when the Annual General Meeting will be held.

The membership of the Branch has, after reaching a peak in 1941–42 at 135, declined somewhat owing to National Service calls, and stands at the moment at 121, of whom 36 are members of the parent Institute. The attendance at meetings averages about 40.

ARTHUR W. EASTLAKE,
ASHLEY CARTER,
Joint Honorary Secretaries.



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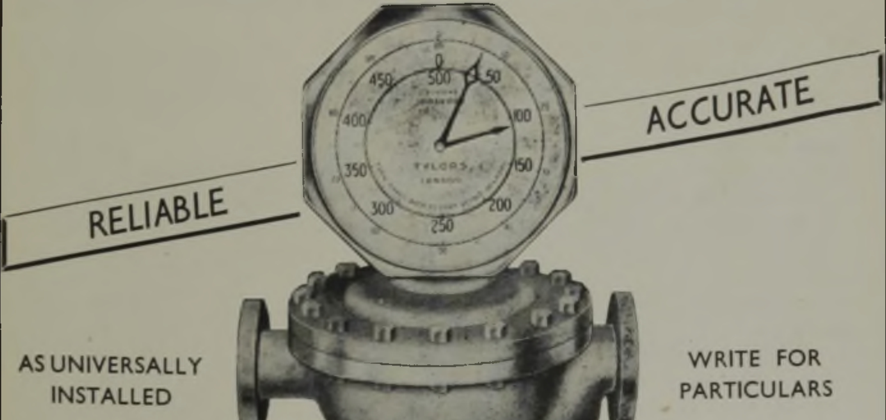
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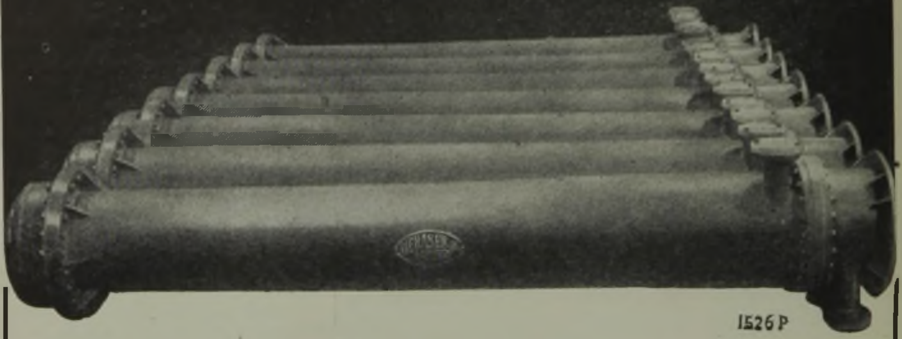
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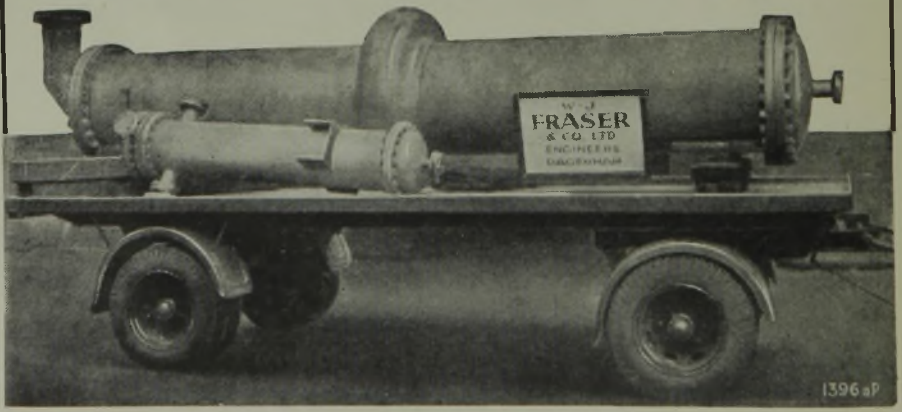
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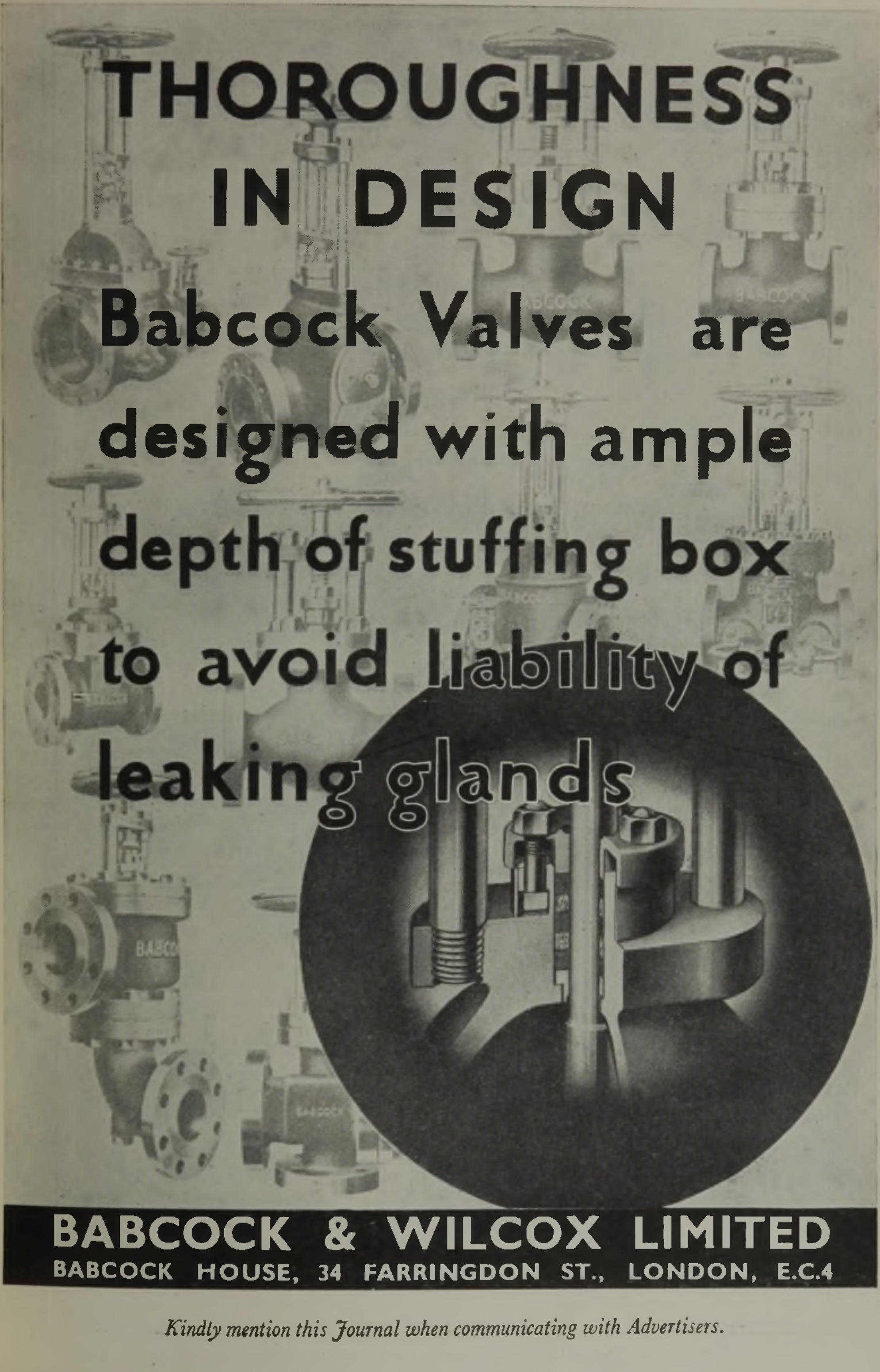
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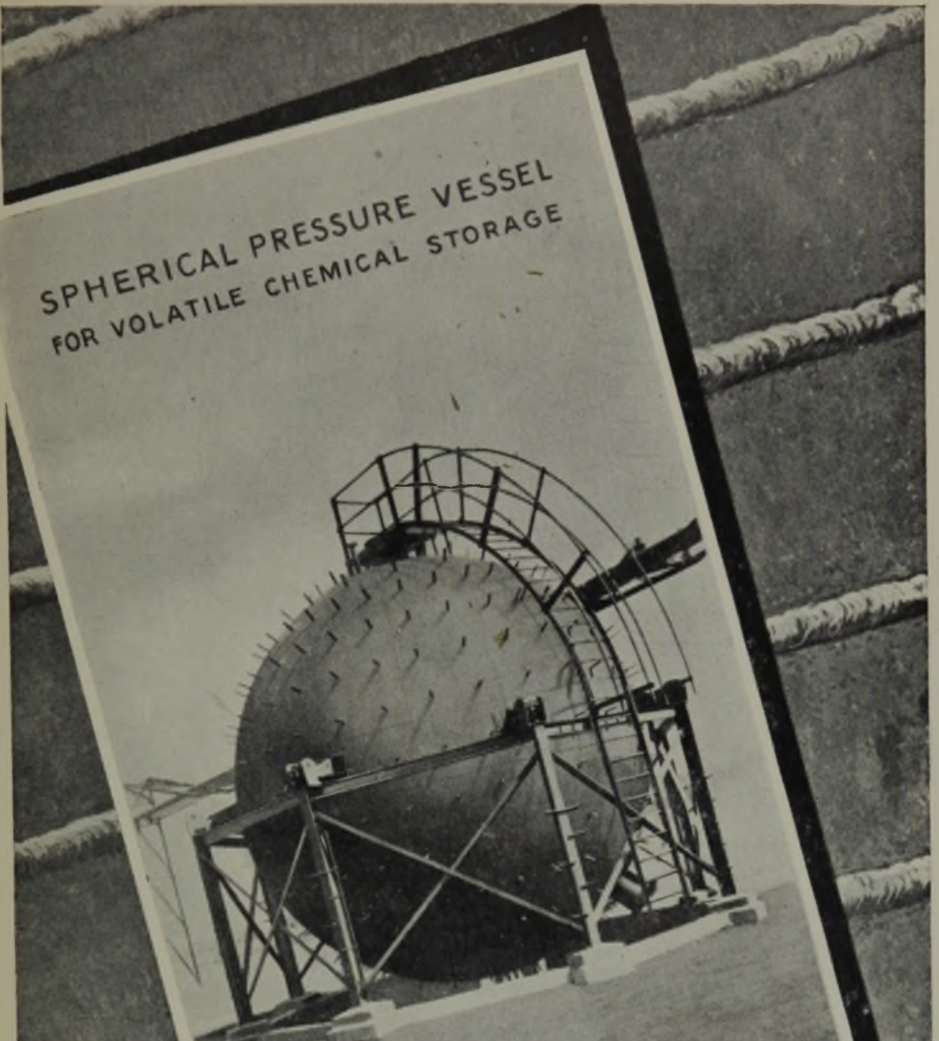
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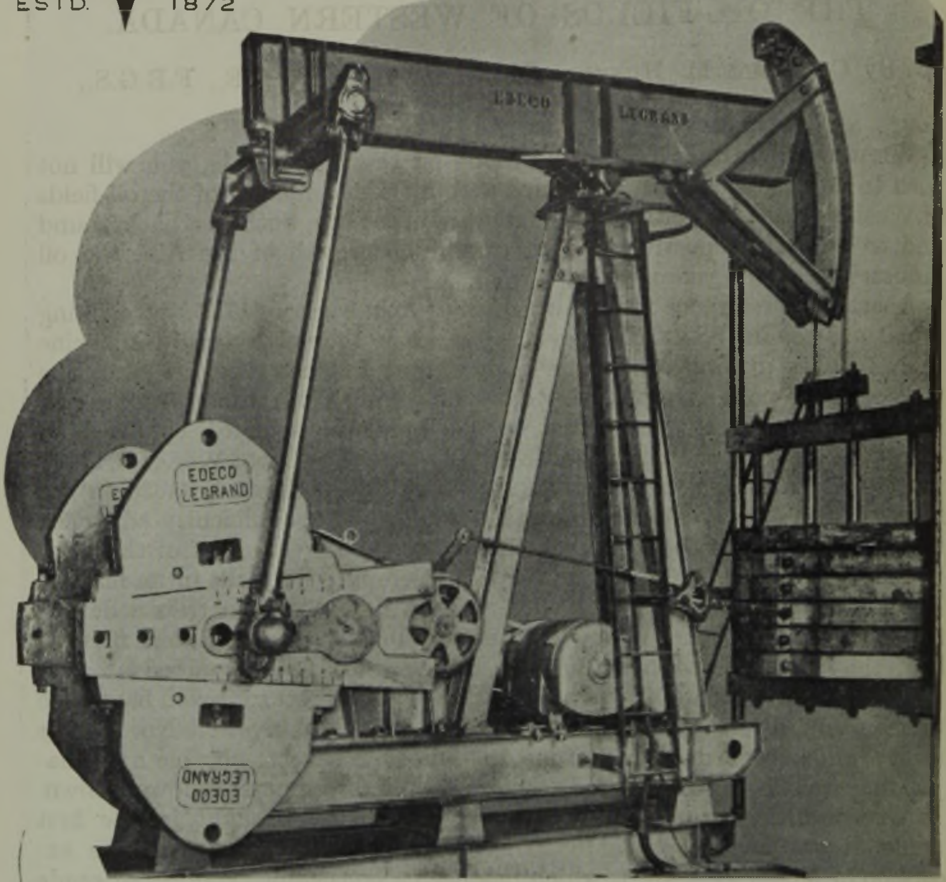
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