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HARDENING TIMES FOR CASING CEMENTATION.*

By N. HEALEY, B.Sc., and S. L. PEASE, B.S., B.A., F.G.S.

THE ideal hardening time to be allowed for cement used in casing cementations is admittedly difficult to determine, and standing times actually applied are necessarily to some extent arbitrary. With increasing experience and accumulated empirical data, however, it has gradually been found possible to reduce standing times without any unfavourable effect on the efficacy of water shut-offs. At the same time, scientific testing of the cements used has led to the adoption of certain criteria as to the properties required as a basis for specifications, although the extent to which

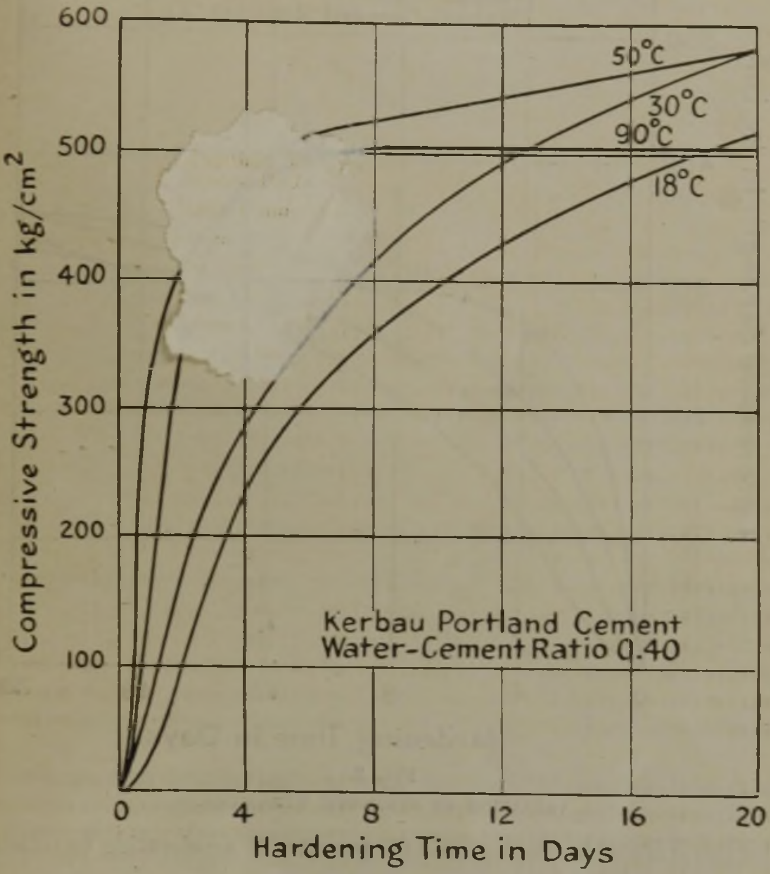

FIG. 1.

VARIATION OF STRENGTH WITH TIME

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* Paper received 8th October, 1941.

these criteria really represent what is required of the cements under subsurface conditions is not completely known.

Before discussing the actual hardening times to be adopted, the influence of various factors affecting the rate at which cement acquires its strength will be considered.

The principal of these factors are: (1) water-cement ratio of the slurry, (2) temperature of hardening, and (3) presence of accelerating or retarding agents in the mixing fluid.

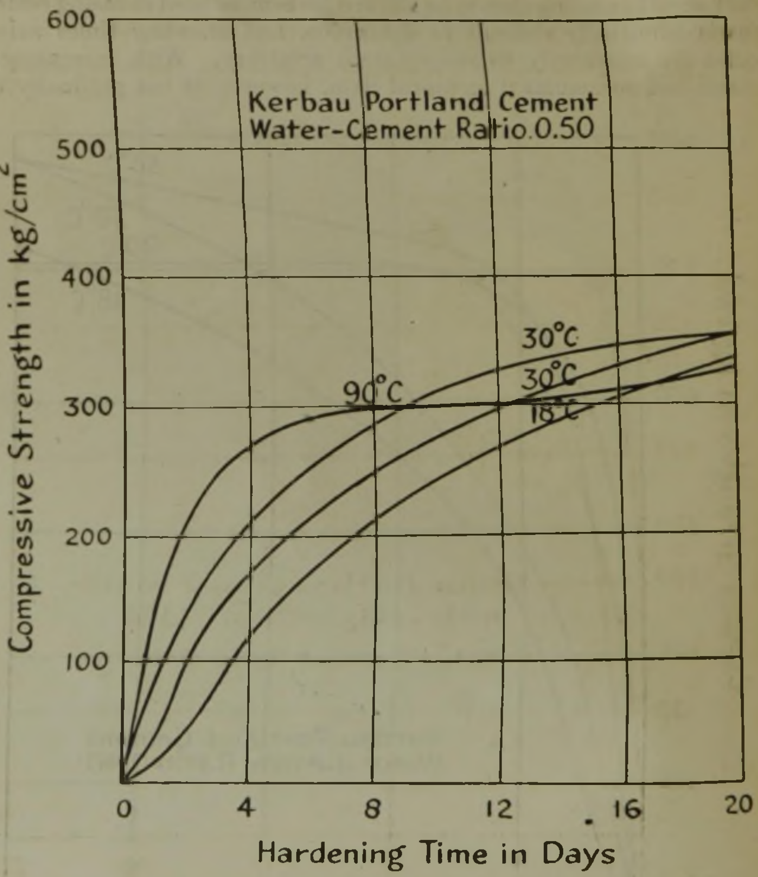

FIG. 2.

VARIATION OF STRENGTH WITH TIME.

The accompanying graphs show the influence which those factors have in the rate of increase of the compressive strength of the cement, which property has been found to be a satisfactory indication of the suitability of the cement for casing cementations.

Time Factor

The shape of all the strength–time curves (Figs. 1 and 2) shows that the rate of hardening is greatest initially, which is of course very advantageous, indicating that a high proportion of the final strength is obtained in the first day.

Water–Cement Ratio

The lower the water–cement ratio of a slurry the more rapidly it hardens. This is illustrated by a comparison of Figs. 1 and 2. Fig. 5 shows the variation of the compressive strength of " Kerbau " Portland cement for different water–cement ratios at temperatures of 50° and 90° C.

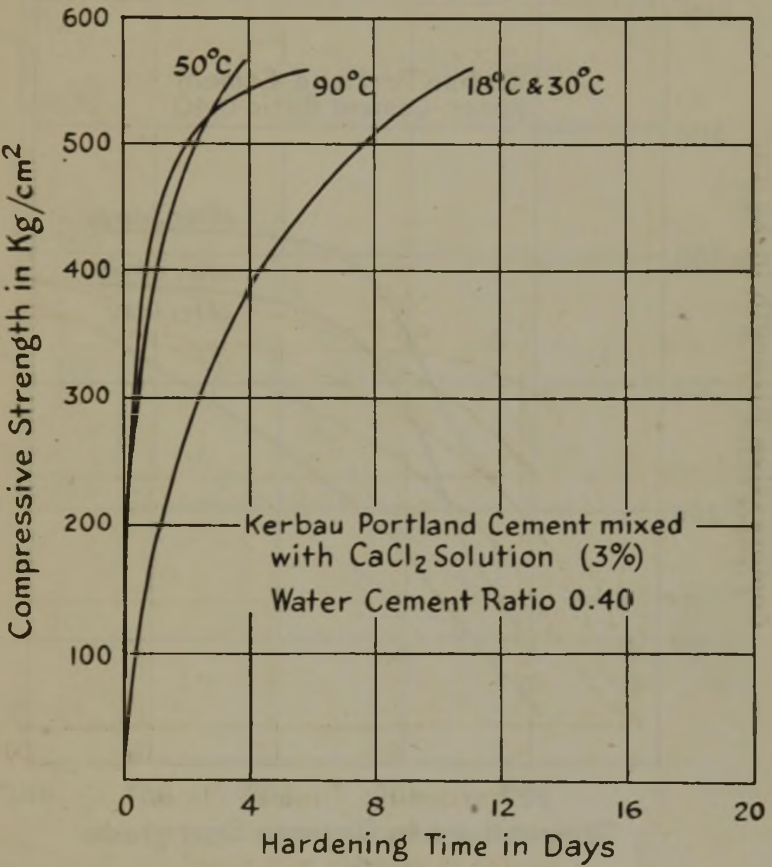

FIG. 3.

VARIATION OF STRENGTH WITH TIME

An average cement slurry for oil-field purposes has a water–cement ratio of 0·40 (S.G. 1·92), and, as Fig. 1 shows, such a slurry hardens very rapidly at 50° C., the temperature normally obtaining at a depth of about 2300 feet, according to the geothermal gradient.

Temperature

As shown by Fig. 4 and the time–strength graphs, an increase in temperature results in an acceleration of the hardening process. This effect is chiefly noticeable in the initial strength. (After long periods of hardening at high temperatures, the strength is often not as high as for the same period at lower temperatures—*e.g.*, 90° curves on Figs. 1 and 2.)

This temperature effect is important in oil-well cementations on account of the increase in temperature with depth. If the surface temperature is assumed to be 86° F. (30° C.), with a geothermal gradient of 1° F. per 64 ft., the temperature at 3000 feet will be 133° F. (56° C.). From Fig. 4

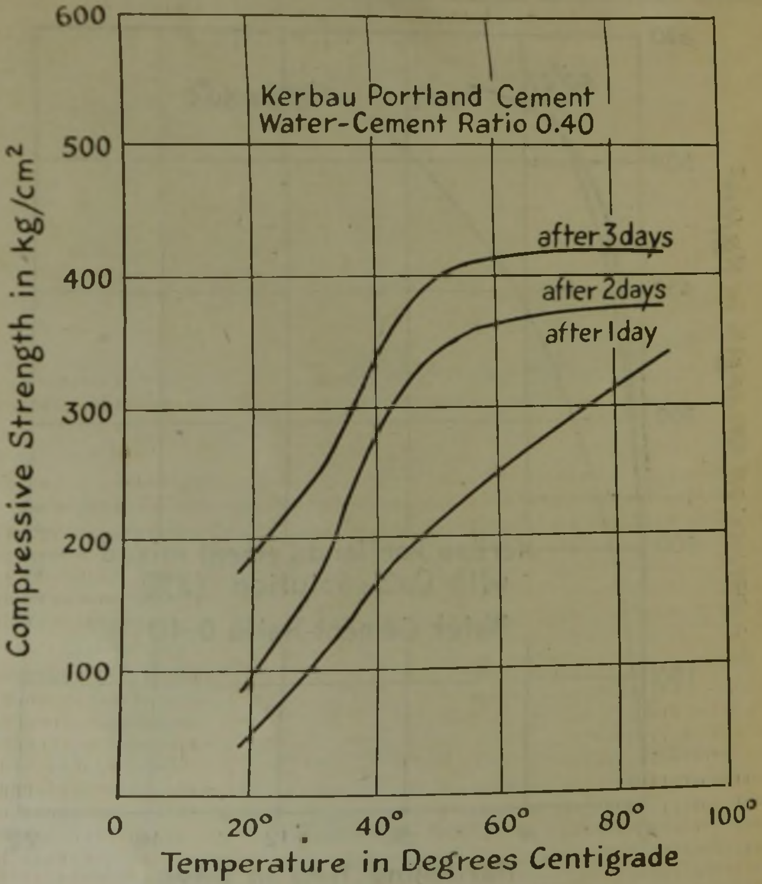

FIG. 4.

VARIATION OF STRENGTH WITH TEMPERATURE.

it can be seen that slurry with a 0·40 water–cement ratio has more than twice the compressive strength after one day at 50° C. than it has at 30° C. Therefore, at 3000 feet the cement will be more than twice as strong after one day as it would be at the surface.

The cement slurry, of course, does not immediately assume the geothermal temperature as it is pumped down the bore-hole, and this is a favourable condition for placing the cement, in that the time of initial set of the slurry is not unduly decreased by depth. This temperature lag probably does not last long enough to affect the strength, however, since the heat generated by the cement in setting also tends to raise the temperature of the thickening slurry.

Replotting the information on Figs. 1, 2, and 3 with the temperatures converted to depths according to the geothermal gradient, Fig. 6 was obtained.

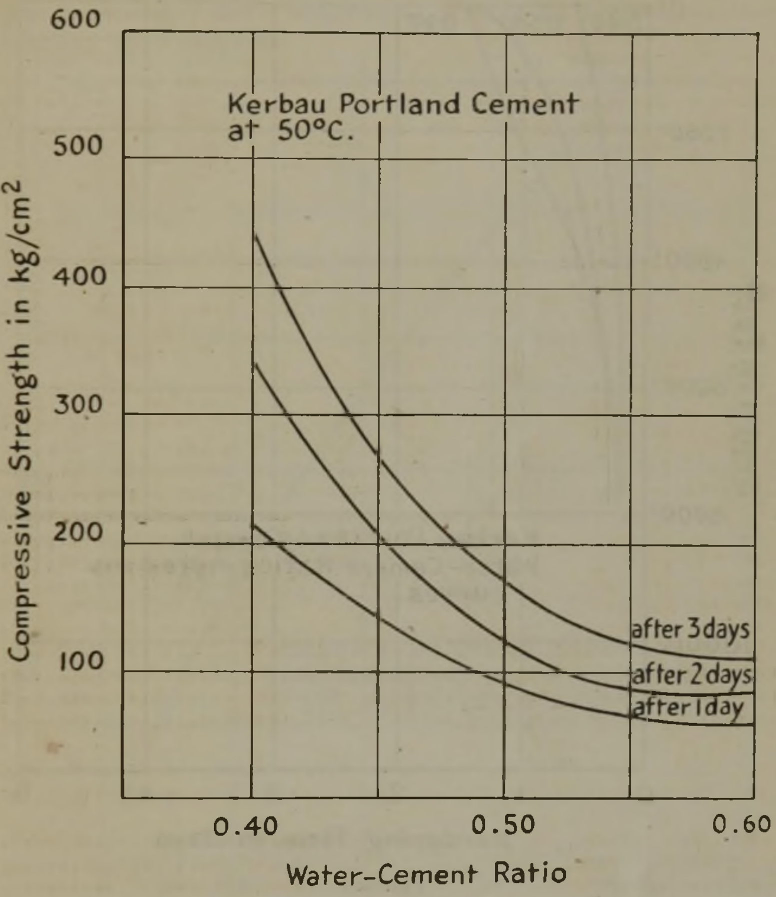

FIG. 5.

VARIATION OF STRENGTH WITH WATER–CEMENT RATIO.

These graphs show the time required for a slurry to attain a compressive strength of 50 kg./cm.^{2}.

Accelerators and Inhibitors

The effect of accelerators (*e.g.*, $CaCl_2$) is illustrated for a Portland cement by a comparison of Figs. 1 and 3. In every case the use of a 3 per cent. solution of calcium chloride as the mixing liquid results in an increase in the initial compressive strength. However, accelerators also have the unfavourable effect of decreasing the time of initial set, so they are not used if sufficient early strength is obtainable without them.

Inhibitors such as lead or zinc compounds, quebracho and boric acid retard the hardening of cements. They are not frequently used, however, because a slight excess may prevent the slurry from developing any strength at all.

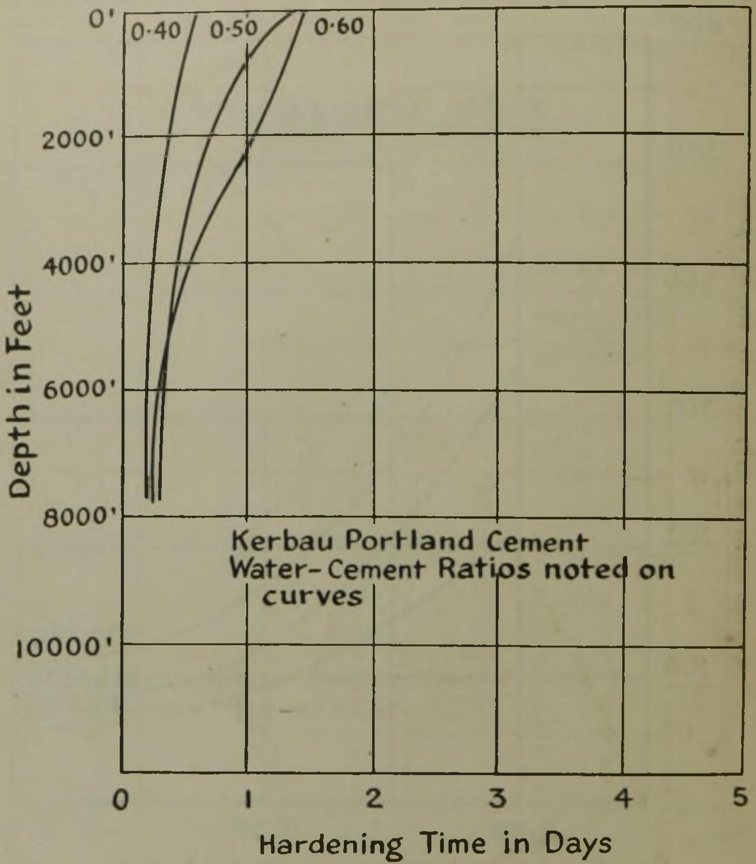

Fig. 6.

VARIATION WITH DEPTH OF TIME REQUIRED TO ATTAIN STRENGTH OF 50 KG./CM.^{2}.

Application of Principles to Oil-field Practice.

It is not known exactly what kind of strength requirements an oil-well cement has to meet, but it is reasonable to assume that resistance to shock is an important consideration, and that this is related to compressive and tensile strengths. A large number of tests indicate that compressive strength is probably a more reliable indication of this property than tensile strength.

Experience has shown that development of a certain compressive strength after a given time actually is a good criterion. The type of cement (Class III) used by the Shell Group for cementations above 3000 ft. has to meet the following specifications :—

Water–Cement Ratio.	Temperature.	Compressive Strength. After 1 day.	Compressive Strength. After 3 days.
0·50	30° C.	50 kg./cm.²	100 kg./cm.²

This type of cement has proved to be sufficiently strong after one day's setting to resist any shock occurring in drilling and to give permanently satisfactory water shut-offs.

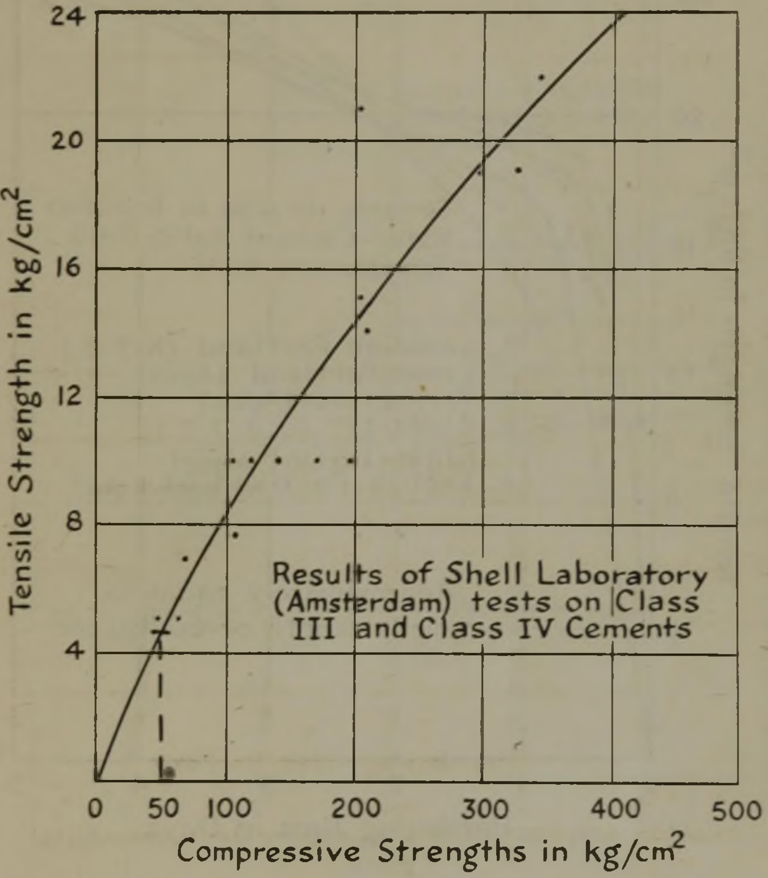

FIG. 7.

RELATION BETWEEN TENSILE AND COMPRESSIVE STRENGTHS.

The type of cement (Class IV) used below 3000 ft. has to meet the following specifications :—

Water–Cement Ratio.	Temperature.	Compressive Strength. After 1 day.	Compressive Strength. After 3 days.
0·60	50° C.	50 Kg./cm.²	100 Kg./cm.²

The strength requirements are the same but, allowing for a higher temperature, the strength must be obtainable with a higher water–cement ratio.

The cement is actually used at depths corresponding to geothermal temperature higher than 50° C. and with a water–cement ratio of about 0·40. Fig. 5 shows that after one day at 50° C. a cement with a water–cement ratio of 0·40 has a compressive strength more than three times as great as one with a ratio of 0·60 under similar conditions. If the cement

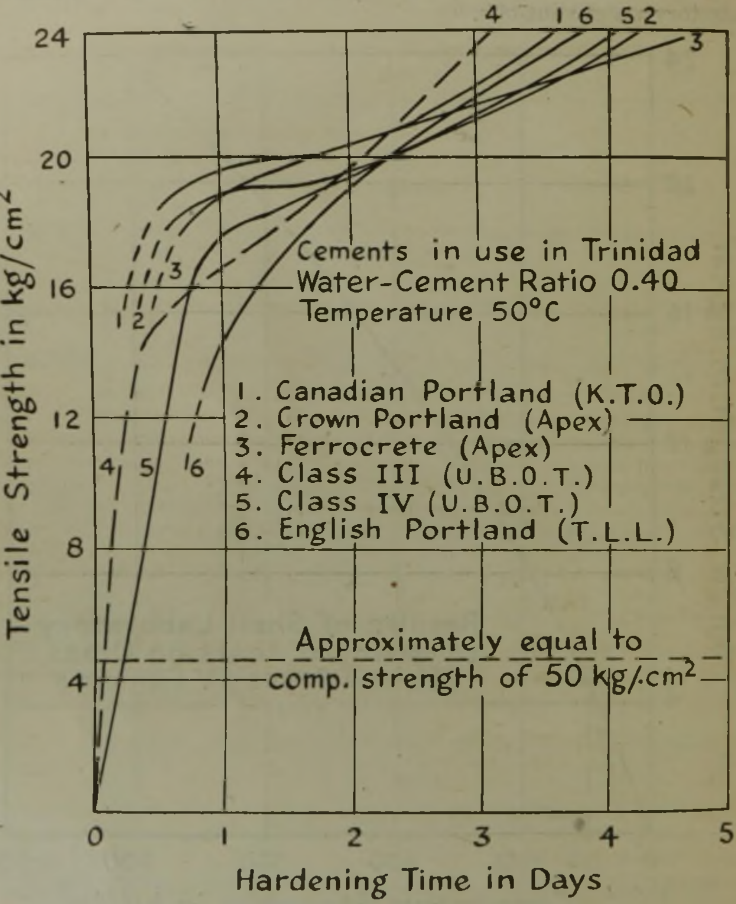

FIG. 8.

VARIATION OF STRENGTH WITH TIME.

meets specifications, therefore, we may assume that as used in the field, it will have a compressive strength of ÷150 kg./cm.^{2} after 1 day. This is about three times the strength which experience has shown to be necessary to allow drilling out after 1 day, and hence an allowable setting time of 1 day also below 3000 ft. appears to be safe and reasonable.

It follows from the foregoing that the desirable hardening time can be based on the attainment of a compressive strength of 50 kg./cm.^{2}, and

Fig. 6 shows that the time required to reach this strength at depths below 3000 ft. is considerably less than 1 day.

Quality of Cements in use in Trinidad

That oil-well cements in use in Trinidad at present are a good deal better than is required by the above specifications was proved by a series of tests made on samples collected from several companies. The results are shown on Fig. 8.

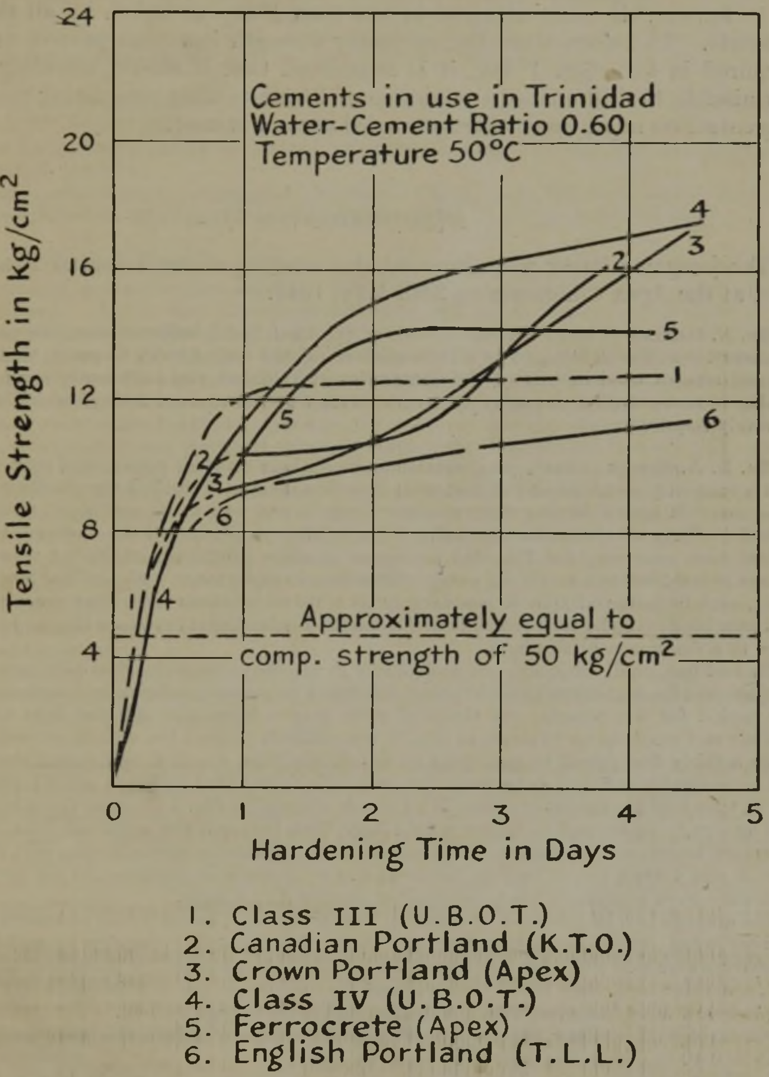

Fig. 9.

VARIATION OF STRENGTH WITH TIME.

Tensile strengths were determined for these samples, as no apparatus was available for determining compressive strengths, but an approximate relationship existing between the two properties is indicated by Fig. 7. The tensile strength corresponding to a compressive strength of 50 kg./cm.^{2} is seen to be about 5 kg./cm.^{2}.

In view of the location of the curves in relation to this value and of the grouping of the other curves about those for Class III and Class IV cement (Fig. 9) whose compressive strength has already been shown to be about three times stronger than specifications, it is evident that the requirement of 50 kg./cm.^{2} is easily attained in less than 1 day at 50° C. by all these cements. Therefore, since the necessary strength has been proved to be acquired in less than 1 day, it is considered that it should certainly be permissible to drill out at a minimum of 24 hours after completing casing cementations in all cases where a normal cement is used.

DISCUSSION.

The foregoing Paper was discussed at a meeting of the Trinidad Branch held at the Apex Clubhouse on 28th May, 1941.

Mr. N. Healey (United British Oilfields of Trinidad, Ltd.), before reading the paper, remarked that the title might be a little misleading, the object being to prove that the normal cement used by any of the Companies in Trinidad was sufficiently strong to enable it to be drilled out after 24 hours instead of the normal 3 days which were formerly required.

Mr. L. A. Bushe (Apex), congratulating the authors on their paper, said that they had apparently established the fact that cements used in Trinidad were sufficiently hard after 24 hours' setting time to allow work in the well to be continued without harmful effects on the water shut-off. Prior to the completion of the authors' tests, it had been necessary for Trinidad operators to allow minimum hardening times of 3 days below 3000 feet and 6 days above 3000 feet, in accordance with Drilling Regulations, and he believed that it was largely as a result of these tests that permission had now been given by the Government Petroleum Technologist to reduce the hardening time to a minimum of 24 hours.

He had one small criticism, not destructive in any way—namely, that although the authors had been at some pains to point out that 1 day was a sufficiently long hardening period for the cement, yet three of their graphs were only divided into 4-day periods and went up to 20 days, so that it was difficult to read the details accurately. With a fairly fine pencil he had tried to sub-divide Figs. 1 and 4, and found that he got considerable differences between the two. He found that in Fig. 1 after 1 day at 30° C. they had a strength of about 75 kg./cm.^{2}, whereas in Fig. 4 he made the strength 100 kg./cm.^{2} It seemed to him it would have been better if the scale had been considerably larger, so that they could discover exactly what the strength was, say, after 1, 2, 3, and 4 days, for, so long as the trend was an increase in hardness, he did not see that they were concerned what the result was after 3 or 4 days.

The authors had laid down a " yardstick " of 50 kg./cm.^{2}, and it would be interesting to hear what others present had to say about the strength necessary to make an effective water shut-off. He saw no reason to doubt the adequacy of the specification, and, accepting that, they found that with all the cements in use in Trinidad 1 day was ample below 3000 feet even with a water/cement ratio as high as 0·60.

Similarly with shallow depths it was only necessary to reduce the water/cement ratio to 0·40 to obtain the desired strength in 1 day.

As these results were obtained without an accelerator, he would like to ask the authors if they recommended the use of an accelerator at all. Did they know whether calcium chloride had a corrosive effect on steel casing ? It was not allowable, he believed, in many cases for use in reinforced concrete, as it was alleged that it corroded the steel reinforcing.

Had the authors any knowledge of what water–cement ratios actually were in use in Trinidad?

Finally, was the geothermal gradient of 1° in 64 feet correct for Trinidad? As a rough guide they had always talked of 1° in 100 feet, and it seemed to him that 1 in 64 was a little high.

Mr. Healey wished to apologize about the graphs, as the work had been done outside, and those were the graphs furnished. It was rather difficult to make out, as the graphs were reproduced roughly, but were they quite so much out as Mr. Bushe said?

The geothermal gradient given was a general average, but he thought from experience in the United States it was actually on the low side for oil-fields, 1° F. in 50 feet being normal.

As to the effect of calcium chloride, he said that his company had stopped using it now, and he could not see any real reason for using it on these results.

As for corrosive action of calcium chloride, he could not say that any had been noticed in practice.

The specification of compressive strength of 50 kg./cm.^{2} had been arrived at from experience in the field, and all specifications were based on this at the moment.

Mr. G. H. Scott (Apex) said he had intended to bring up the same point as to how the authors arrived at the empirical figure of 50 kg./cm.^{2} as the correct specification for cement. He felt that laboratory tests were so liable to be very much higher than the actual cement strengths underground. For instance, the cement was liable to contamination by mud, as well as to the possibility of aeration of the grout after placement; and also in test samples the excess water could settle out and rise to the surface, whereas underground it was liable to be trapped. He gave it as his considered opinion that water formed a vesicular structure in the cement which would affect both compressive and tensile strengths deleteriously. He wished to know in how far the safety factor of 3 could be decreased by the factors he had mentioned—that is to say, aeration of the grout, contamination of the mud, and excess water.

He had never seen before an actual curve that related compressive to tensile strength, and thought most cement manufacturers would definitely refuse to give any correlation between tensile and compressive strength. He enquired what others thought on how impact strength varied with compressive and tensile. Another thing was the shear strength, and it struck him, from his knowledge of what sheer forces could do underground, that 50 kg./cm.^{2} compressive was rather low if there was any weight on the casing string.

He wished to know further details of the cement specification, especially as to the limits of hydraulic modulus, and if they had any actual limits for viscosity with time in the placing of the cement.

Mr. Healey, replying to the question as to the effect of mud and free water, etc., said he did not really see how that affected one's taking 50 kg./cm.^{2} as a criterion in so far as results were actually based on field-scale tests after laboratory tests. It was found that a cement with this compressive strength was sufficiently hard under field conditions. Admittedly things could go wrong under exceptional conditions such as Mr. Scott suggested, but normally if a cement were taken which came up to this specification, a good cement job was normally obtained in the field.

Mr. Scott said that Reid and others recommended a tensile strength of 250 lb./sq. in. for cement grouts.

Mr. Healey replied that his company no longer had tensile strength in their specifications.

Mr. Scott remarked that, accepting Mr. Healey's 50 kg./cm.^{2} compressive as equivalent to 5 kg./cm.^{2} tensile, that was round about one-third of the tensile strength recommended by other authorities. In shear about 75 kg./cm.^{2} was usually recommended by people in the States.

Mr. Healey replied that the relationship drawn between tensile and compressive was purely empirical. As could be shown from the graph, a point corresponding to 5 kg./cm.^{2} tensile strength and 50 kg./cm.^{2} compressive strength had been taken, and a line drawn through this point and the origin. The mean of the points came pretty near to this.

As to the effect of mud on cements, laboratory tests had been made, and normal shale muds thoroughly mixed into cements up to 3 per cent. did not normally have any effect on hardening, but above 3 per cent. deleterious action was observed.

On the question of impact compared with tensile and compressive strengths, he did not think much was known about that. He thought it was more related to compressive than to tensile strength. The hydraulic modulus was the usual one for cement specifications, namely, 1·7–2·2 and the silicate modulus 1·2 to 4·0.

Mr. G. S. Taitt (U.B.O.T.) wished to emphasize that the paper was a rather good example of engineering practice because the authors had collected quite a lot of essential data and had related it to this very empirical figure of 50.

Mr. Scott had asked what the real value of that figure was. It was simply the result of experience in the Shell group, and it was found not by any calculated method that it would be a suitable strength, but that cements as used on the basis of past practice, purely from an empirical point of view, had a strength of about 50 kg./cm.^{2}, and so the whole question of the strengths of the cements actually used (up to 3 times the 50 kg. in many cases) were all related to empirical information.

He would like to bring out that they were really working rather in the dark as regards cement strengths, and they did not know whether tensile, or compressive, or what other strength, was the best criterion. It had been suggested that the main function of the cement was to act as a filler to prevent water infiltration, and that strength did not really matter, and it was not quite certain what properties actually were wanted. It had been suggested that cement of a very low strength but of a very good sealing power might be what was desirable.

Mr. Scott had brought out a point about the actual condition of the cement in the hole in comparison with the results in the laboratory. There was usually a good factor of safety, in comparison with the factor of 50, in the cements in use; but in any case he wished to mention that cement in open hole was very much harder to drill out as a rule than cement in casing. In the casing, water could not get out of a cement, with the result that the strength might be somewhat lower than in laboratory tests, whereas in open hole the water had a chance of escaping into porous formations and the strength of the cement was probably not much reduced below the laboratory criterion.

Mr. J. W. Knights (Apex) asked what mechanical means were used to obtain the water ratio to be sure of a steady grout.

Mr. Healey said he presumed Mr. Knights meant in the field; it was a matter of trial and error; the grout was weighed as it came through. But automatic feeders were now being developed in the United States and the water supply could be regulated so that the slurry came through at the required weight.

Mr. H. C. H. Darley (Trinidad Leaseholds Ltd.) asked if, when the authors spoke of a successful cement job, they meant that no subsequent trouble was experienced with water, or whether the job was able to stand some sort of test.

With regard to temperature gradient, he had found that mud temperatures varied as much as 10° F. or more for the same depth in different parts of the same field. He had known one well, where the bottom-hole temperature taken with a bottom-hole thermometer actually dropped some 20° F. on going deeper. He only mentioned this as a point of interest, since the subject had been brought up, and did not think it affected the authors' argument materially.

Mr. Pease replied that the success of a cement job was judged by subsequent results. Pressure tests applied were purely a matter of field experience, and were based on results. Test pressures were recorded, and if subsequently failures occurred, the company adopted higher test pressures.

Mr. Taitt said that the question of the hardening time, whether 1 or 3 days, was one which had only been obtained over a long period of time. He wondered whether any members could give information, based on the results going back as far as they could, as to what time, with cements normally used in the past, had been found suitable. Were there any findings as to what was a suitable time?

50 kg./cm.^{2} strength was based on experience in various parts of the world, but it was quite well known in the Shell group that there was no accurate information as to a fixed suitable time. The group had been making trials in various administrations with reducing the standing times, and as far as it had been out, it had been successful up to the present.

Could members give information as to where failures had occurred through cutting down times too much?

Mr. Bushe, in reply to Mr. Taitt, said that he had found the same thing—namely, that whereas in the past it had been usual to let cement stand for 3 or 4 days, in recent months standing times had been reduced to only 1 day and, as far as he knew, without any ill effects. It might be a point on which they could get together, and there was no reason why the Institute should not approach the Government, if they all accepted the fact that 1 day was sufficiently long.

Mr. Scott said that in a cementation the actual weakest point was the bond of the cement with the wall, and usually that was very much weaker than the wall of cement, even after 12 hours.

Mr. Healey replied that he believed one company in the United States had published something about this. They had been doing ordinary cementations with about 50 per cent. failures. Then they had started using wall scratchers on their casing, and had about one failure in fifty.

He believed also in the United States they were now cutting down standing time in certain cases to about 12 hours, and instead of normal cement slurry they were adding gypsum at the end, so that the gypsum was left around the shoe of the casing.

Mr. F. H. L. Tindall (T.L.L.) said that he agreed with Mr. Scott's statement that the bond of the cement with the wall was much more important than the strength of the cement itself. They had been testing their cementation to higher pressures than appeared to be the average in Trinidad, and had found, particularly with surface strings, that they had a large number of failures. The figure quoted by the authors—50 kg./cm.^{2}, *i.e.*, about 750 lb./sq. inch—referred to the strength of the cement, but they had found that the formation appeared weaker than the cement. They had cementation failures at pressures lower than 750 lb. and at depths down to 3000 feet. On occasion they had tried re-cementing, but without any better success. In only a very few cases had there been any signs of circulation returning to the surface, and if the cement itself had been unsatisfactory, then the circulation should have taken the weakest path and returned to the surface. The fact was that there was some portion of the formation which could not stand the test pressures being applied.

In reply to a question concerning Guayaguayare, Mr. Tindall said that he did not consider that conditions on that field were the same as elsewhere. The formation contained large thicknesses of sandy formation which might have some effect on cementation.

In reply to a question, he said that they were now drilling out cementations after 24 hours' setting time, and had not had any evidence of the cement itself proving defective. He attributed the breakdown of the cementation, when test pressures were applied, entirely to the formation and not to the cement.

Dr. J. E. Smith (U.B.O.T.) enquired as to the use of ice in tending to lower the temperature of cement for deep cementing jobs. He thought it had been used successfully—was it of any real advantage ?

Mr. Healey replied that the difficulty in deep cementations was that the time of placing was so long. If cement were moved after its initial set, it was very much weakened. Ice was used therefore to increase the period of initial set.

Mr. Scott added that it did also decrease viscosity tremendously.

The discussion then terminated.

MIXED-SOLVENT EXTRACTION.*

By A. V. Brancker, Ph.D., T. G. Hunter, D.Sc., F.Inst.Pet., and
A. W. Nash, M.Sc., F.Inst.Pet.

The Function of the Auxiliary Solvent.

Within recent years considerable development has taken place in the use of two or more solvents for solvent-extraction operations. The majority of such developments employ two solvents, and since this also represents the simplest case of multi-solvent refining, two solvent processes only will be dealt with here.

Processes employing two solvents have been divided into two main classes: mixed-solvent processes and double-solvent processes. In mixed-solvent processes both solvents are mutually soluble under the operating conditions—that is, the solvent employed is a homogeneous mixture of the components. In double-solvent processes the two solvents are immiscible or only partly miscible under the operating conditions. The operating temperature, type of stock treated, and relative proportions of the two solvents all affect to a certain degree the class into which any two solvents may be placed. Phenol and water, for example, depending on the temperature and relative amounts of the two components, may be classified as either a mixed or double solvent. These two classes may be further subdivided as follows :—

Mixed Solvents: Type 1.—A solvent mixture of two components in which one solvent is only partly miscible with the stock under the operating conditions, and in which the second solvent is completely miscible with both the first solvent and the stock under the operating conditions.

Type 2.—A solvent mixture of two components in which one solvent is only partly miscible with the stock under the operating conditions, and in which the second solvent is completely miscible with the first solvent, but only partly miscible with the stock.

The type into which a two-component mixed solvent falls will depend to a certain extent on the operating temperature and on the stock treated. A good example of Type 1 mixtures is the benzole–SO_2 process as normally operated. Type 2 mixtures are not so commonly employed as those of the first type; an example is phenol mixed with small quantities of water.

Double Solvents: Type 1.—The extraction with a solvent only partly miscible with the stock under the operating conditions where a second solvent, only partly miscible with the first solvent and completely miscible with the stock under the operating conditions, is employed.

Type 2.—The extraction with a solvent only partly miscible with the stock under the operating conditions where a second solvent, only partly miscible with the first solvent and also only partly miscible with the stock under the operating conditions, is employed.

As before, the type into which the double solvents may be classified will depend to a certain extent on operating temperature and on the stock treated.

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* Paper received 24th March, 1941.

This paper is concerned only with solvent-refining processes employing mixed solvents of Type 1. The first or primary solvent is only partly miscible with the oil at the operating temperature, whilst the second or auxiliary solvent is completely miscible with both the oil and the primary solvent at the operating temperature.

An auxiliary solvent of this nature may be employed for many reasons. The addition of an auxiliary solvent to a primary solvent which is solid at ordinary temperatures,[1] enables extraction to be carried out at lower and more economical temperatures, or at temperatures not practical with the primary solvent alone. In the refining of some heavy oils, particularly those of high viscosity, with a selective solvent, a considerable length of time may be required to obtain separation of the two phases. In these cases the use of an auxiliary solvent to reduce the time of separation and facilitate the sharpness of separation may be employed. The auxiliary solvent in this case is sometimes referred to as an "inert solvent" or "diluent." It has also been claimed that an auxiliary solvent, of the type considered here, in some cases actually improves the refining action of the primary solvent—for example, benzole has been claimed [2] to improve the refining effect of liquid SO_2.

Auxiliary solvents completely miscible with both primary solvent and oil at the operating temperature will be in the main low-boiling hydrocarbons such as propane, petroleum ether, benzole, toluole, and xylole. Auxiliary hydrocarbon solvents of a paraffinic nature, such as propane, may not be completely miscible with some primary solvents under certain operating conditions, and it must be emphasized that the discussion in this paper will not apply under such conditions.

The work described here was undertaken in order to study the effect on extraction brought about by the addition of a completely miscible auxiliary solvent to a primary solvent. The investigation was carried out in two sections. First, the action of an auxiliary solvent was studied for the separation by solvent extraction of a stock consisting of a mixture of two pure substances. In this case the extraction at constant temperature of this stock with a single solvent was ascertained, and then at the same temperature the extraction of the stock with the double-solvent mixture was investigated. Second, the action of an auxiliary solvent was studied on the solvent refining of a mineral oil. As before, extraction at constant temperature with a single solvent followed by extractions with a mixed solvent were compared.

The separation of a binary mixture by solvent extraction and the refining of an oil with a solvent at constant temperature have been shown [3] to be most conveniently studied by means of phase-equilibrium relationships plotted on triangular diagrams. The use of such diagrams enables all the desired variables to be explored quickly and accurately, and this method has been employed here. It has been shown elsewhere [4] that phase-equilibrium relationships at constant temperature for the solvent extraction of a binary stock with a binary solvent mixture—that is, a four-component system—may be adequately represented by means of a regular tetrahedron. It has also been shown [5] that the regular tetrahedron may be used for representing phase equilibrium in an oil mixed-solvent system. Although batch, multiple-contact, and counter-current extraction results can apparently be computed in an oil-solvent system by means of phase-equilibrium data represented on triangular diagrams,[3] it is not yet known that the tetrahedron diagrams for oil mixed-solvent systems can be used for either multiple-contact or counter-current computations. It is certain, however, that the tetrahedron diagrams can be employed for batch-extraction computations in oil mixed-solvent systems and for batch, multiple-contact, and counter-current extraction computations in four-component systems. The method of carrying out batch-extraction computations by means of such tetrahedron diagrams has been described in detail in another publication,[6] and the use of such diagrams enables the desired variables to be explored, and they have been employed here. All comparisons between single- and mixed-solvent systems have been made on the basis of batch extractions.

Pure-Component Systems.

The pure-component ternary system employed consisted of chloroform, acetone, and water, at a temperature of 25° C. At this temperature chloroform and acetone are completely miscible and represent the binary mixture to be separated by extraction. Water, the principal solvent, is partly miscible with chloroform and completely miscible with acetone at the selected operating temperature of 25° C. Acetic acid, the auxiliary solvent, is completely miscible with water, acetone, and chloroform. Mixtures of chloroform and acetone may be separated by extraction, with a solvent mixture of water and acetic acid at 25° C.

These systems were chosen, not for their industrial importance, but for ease in analysis in terms of individual components, and hence the convenient collection of accurate equilibrium data.

Equilibrium in the three-component system chloroform, acetone, and water at 25° C., and in the four-component system chloroform, acetone, water, and acetic acid at 25° C. was studied, and the detailed investigation of these systems has been described elsewhere.[4–5]

Employing these equilibrium data as a basis for calculation the effect of refining a constant stock with single and mixed solvent was determined. The constant stock selected consisted of 38·5 per cent. acetone, 61·5 per cent. chloroform. In this stock the acetone, by virtue of its miscibility relationships, must be the extracted component, and must be the undesirable component the removal of which is required. In consequence any decrease in acetone content of the raffinate obtained must indicate an improvement in quality.

The following data were computed :—

(1) The effect of solvent/stock ratio on the quality of the raffinate when using the principal solvent alone and mixed with varying amounts of the auxiliary solvent.

(2) The effect of solvent/stock ratio on the yield of raffinate when using the principal solvent alone and mixed with varying amounts of the auxiliary solvent.

The results obtained are given in Table I and shown graphically in Figs. 1 and 2. In Fig. 1, raffinate quality, as denoted by the acetone content of the raffinate, is plotted against solvent stock ratio for different percentages of auxiliary solvent in the solvent mixtures employed. In this and the remaining figures the principal solvent is referred to as S_1 and the auxiliary solvent as S_2.

TABLE I.

Solvent.	Solvent : Stock ratio.	Weight per cent. yield of raffinate.	Weight per cent. acetone in raffinate.
Water	0·33	94	35·0
,,	0·59	90	32·5
,,	1·00	85	29·5
,,	2·09	76	23·0
,,	2·62	73	20·5
Water 80%, acetic acid 20%	0·26	93	34·5
,, ,, ,,	0·77	90	33·0
,, ,, ,,	1·60	80	27·0
,, ,, ,,	3·78	67	21·0
,, ,, ,,	8·06	56	13·5
Water 61%, acetic acid 39%	0·33	94	36·0
,, ,, ,,	1·00	85	33·0
,, ,, ,,	2·09	69	27·0
,, ,, ,,	4·92	44	21·0
,, ,, ,,	10·50	32	15·0
Water 55%, acetic acid 45%	0·37	94	36·0
,, ,, ,,	1·11	81	33·0
,, ,, ,,	2·31	56	27·0
,, ,, ,,	5·45	17	21·0
Water 48·5%, acetic acid 51·5%	0·42	92	36·0
,, ,, ,,	1·26	69	31·5
,, ,, ,,	2·62	36	27·0
,, ,, ,,	3·09	23	25·5
,, ,, ,,	4·00	7	24·5
Water 47·6%, acetic acid 52·4%	1·29	55	33·0
,, ,, ,,	2·10	22	31·5

From Fig. 1 it is immediately apparent that better-quality raffinates are obtained at equal solvent/stock ratios for the single solvent than are obtained for any binary solvent mixture. That is, at constant-solvent stock ratio the quality of the raffinate is decreased with any increase in the amount of auxiliary solvent in the solvent mixture employed.

In Fig. 2, raffinate yield, expressed as a weight percentage of the total stock treated, is plotted against solvent-stock ratio for different amounts of auxiliary solvent in the solvent mixtures employed. From this figure it is evident that the yield of raffinate at any constant solvent/stock ratio is highest when extraction with the single solvent is employed. The addition of auxiliary solvent decreases the yield of raffinate obtained.

The extraction obtained using the single solvent may be compared with that obtained using the mixed solvent on the basis of both raffinate yield and quality at constant solvent/stock ratio by considering both Figs. 1 and 2 together. From such a comparison it will be seen that a higher yield of better-quality raffinate is obtained by extraction with the single solvent than by extraction with an equal quantity of mixed solvent. This is illustrated in Fig. 3, in which both yield and quality of raffinate are plotted against percentage auxiliary solvent in the solvent mixture employed at varying solvent/stock ratios.

The action of the single solvent, whereby a comparatively high yield of good-quality raffinate may be obtained, is definitely impaired by the addition of the auxiliary solvent.

These comparisons have been carried out at equal solvent/stock ratios—that is, equal volumes of single or mixed solvent per volume of stock treated have been employed. Comparisons between the action of single and mixed solvents are sometimes made on a different basis—namely, at equal primary solvent/stock ratios. For example, the results from the extraction of a stock with the principal solvent alone at a solvent/stock ratio of say 3/1 may be compared with the results from the extraction of the same stock with a solvent mixture of primary and auxiliary solvent at a total solvent/stock ratio of say 4/1, and with 25 per cent. of auxiliary solvent in the double solvent employed, but with the principal solvent/stock ratio still constant at 3/1. This method of comparison is very common in patent claims.

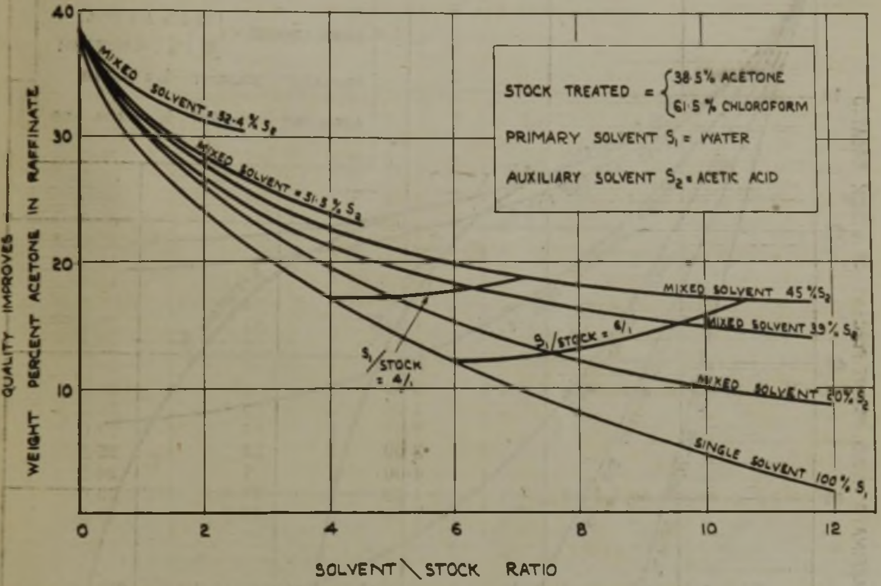

Fig. 1.

In Fig. 1 two curves are included showing comparisons between single-solvent and binary-solvent mixtures on this basis. In these two curves the primary solvent/stock ratio—that is the S_1/stock ratio—has been kept constant at 4/1 and 6/1. The total solvent/stock ratio employed under these conditions is given by the abscissa, whilst the raffinate quality, measured by the weight per cent. acetone in the raffinate, is obtained from the ordinate. These two curves cross the series of curves representing different solvent mixtures starting from the primary solvent curve labelled 100 per cent. S_1, and finally crossing the curve for the solvent mixture containing 45 per cent. auxiliary solvent, labelled 45 per cent. S_2. Consider, for example, the curve representing a constant principal solvent/stock ratio of 4/1, labelled S_1/stock = 4/1. The raffinate quality when the principal solvent is employed alone at this ratio may be readily ascertained from the 100 per cent. S_1 curve to be 18·0 per cent. acetone. The raffinate quality, when a mixed solvent containing 20 per cent. of auxiliary solvent is employed but in sufficient quantity to keep the principal solvent/stock ratio constant at 4/1, may be obtained from the intersection of the curve labelled S_1/stock = 4/1 with the curve labelled mixed solvent 20 per cent. S_2. Actually, as will be seen from the figure, this condition is satisfied at a total solvent/stock ratio of 5/1, and the raffinate quality is represented by 18·5 per cent. acetone.

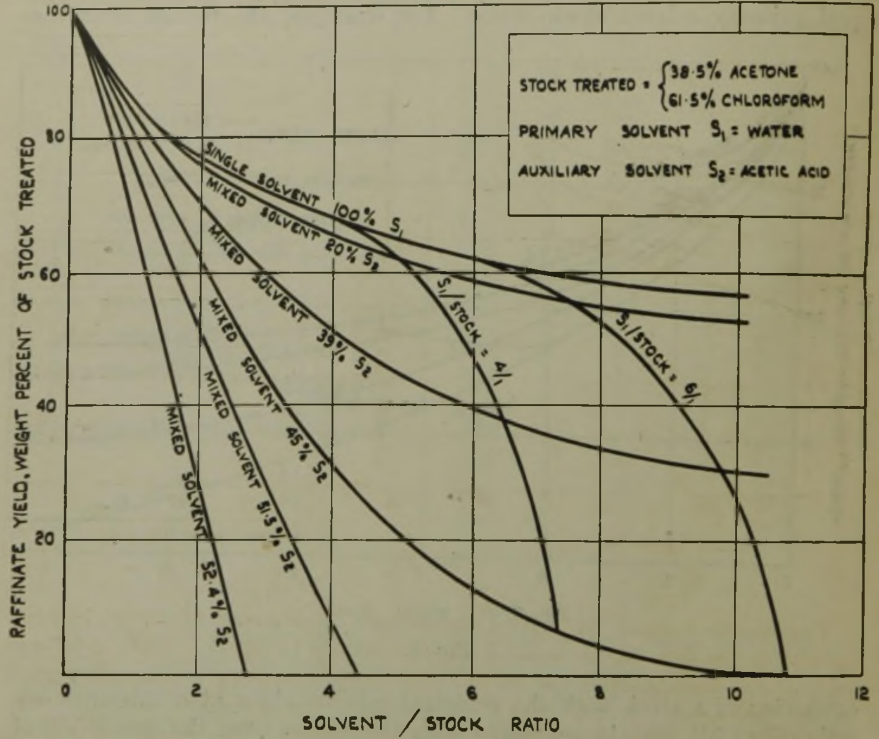

FIG. 2.

It is obvious from the two curves included in Fig. 1 that raffinate quality becomes poorer when auxiliary solvent is added to the principal solvent on this basis of comparison as well as on the basis of equal solvent/stock ratios.

Two similar curves have been incorporated in Fig. 2, from which it may also be concluded that by this method of comparison the addition of auxiliary solvent decreases the yield of raffinate.

These conclusions have been arrived at from a consideration of a system of four pure components, and it is desirable to decide whether they apply to the mixed-solvent refining of a complex material like a mineral-oil or a petroleum fraction. Oil single-solvent and oil mixed-solvent systems of similar type were therefore examined.

Oil Solvent Systems.

The single-solvent oil system studied was composed of Anglo-Iranian second cooled blue oil, V.G.C. 0·8553, with acetic acid as the solvent at 25° C. The equilibrium data were represented, in a manner previously described,[3] by means of an equilateral triangle, whereby a physical property is used to characterize the oil. The physical property employed in this case was V.G.C.

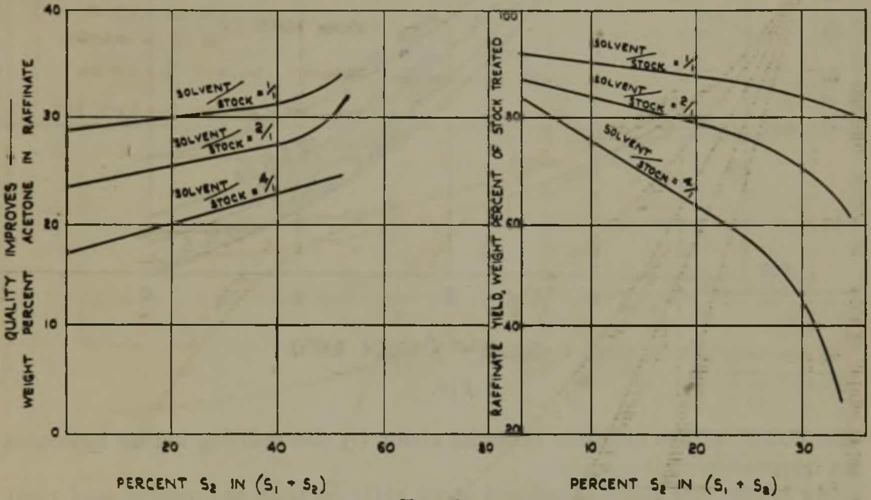

Fig. 3.

The double-solvent oil system investigated consisted of Anglo-Iranian second cooled blue oil, acetic acid and chloroform at 25° C. Acetic acid was only partly miscible with the oil at the selected operating temperature, and is the principal solvent, whilst chloroform, the auxiliary solvent, was completely miscible with both oil and acetic acid. The equilibrium data were represented by means of a regular tetrahedron with the oil characterized by V.G.C. This and the single-solvent system have been reported in detail in another publication.[5]

These two systems are not of any special industrial significance, but were selected for ease in the determination of equilibrium data. No significance is to be attached to the use of acetic acid and chloroform in the two cases investigated. Accurate methods of analysis of oil-acetic-acid and of oil-acetic-acid-chloroform mixtures were available, whilst raffinate and extract phases formed by the addition of these solvents to the oil separated readily without entrainment or hold up of droplets of one phase within the other. The equilibrium data obtained are believed to be accurate and reliable.

These data were used as a basis for calculating the effect of refining the second cooled blue oil with single and mixed solvents. Any decrease in

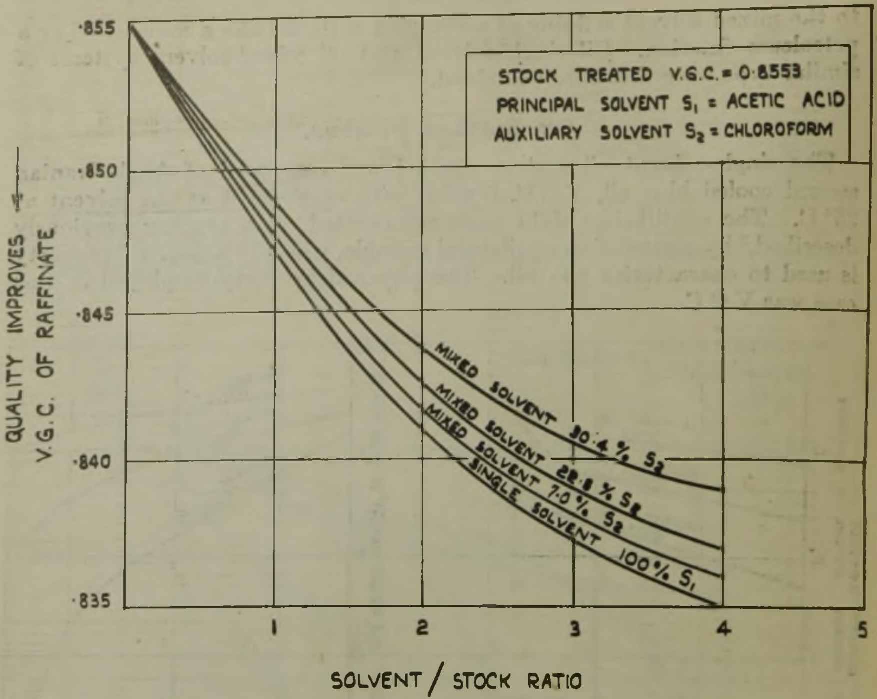

Fig. 4.

the V.G.C. of the raffinate brought about by the refining action indicates an improvement in quality.

As before, the effect of solvent/stock ratio on both the quality and yield of raffinate when using the principal solvent alone and mixed with varying

Table II.

Solvent.	Solvent : Stock stock.	Weight per cent. yield of raffinate.	V.G.C. of raffinate.
Acetic acid	1·0	92	0·8473
,, ,, ...	2·0	87	0·8408
,, ,, ...	3·0	85	0·8374
,, ,, ...	4·0	84	0·8351
Acetic acid 93%, chloroform 7% . .	1·0	90	0·8479
,, ,, ,, . .	2·0	84	0·8415
,, ,, ,, . .	3·0	79	0·8382
,, ,, ,, . .	4·0	75	0·8360
Acetic acid 77·2%, chloroform 22·8% .	1·0	86	0·8482
,, ,, ,, .	2·0	75	0·8426
,, ,, ,, .	3·0	66	0·8393
,, ,, ,, .	4·0	56	0·8370
Acetic acid 69·6%, chloroform 30·4% .	1·0	81	0·8485
,, ,, ,, .	2·0	63	0·8436
,, ,, ,, .	3·0	45	0·8406
,, ,, ,, .	4·0	27	0·8390

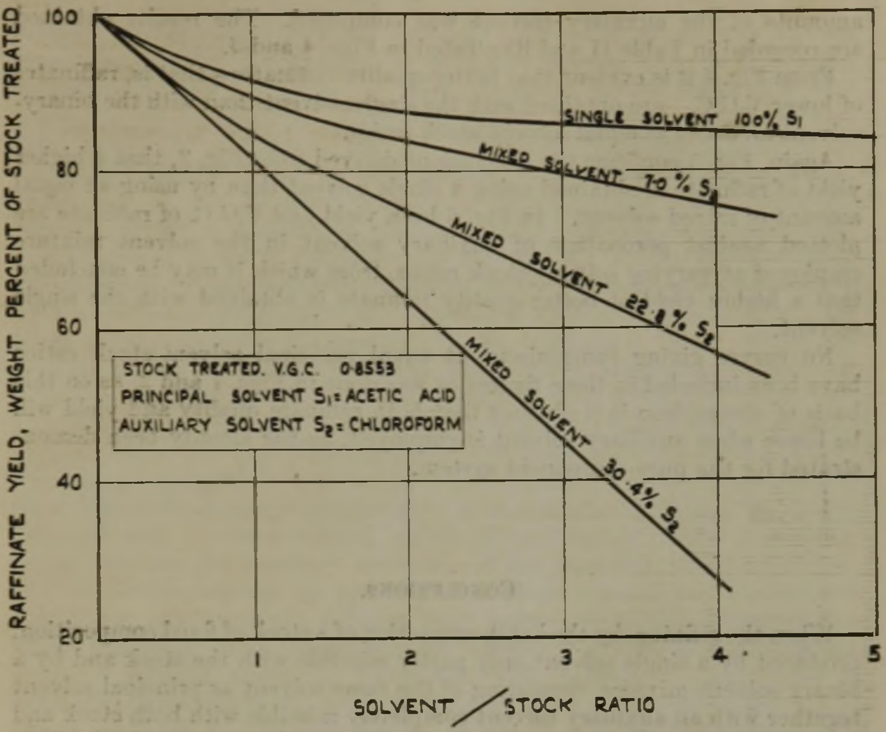
RAFFINATE YIELD, WEIGHT PERCENT OF STOCK TREATED
100
80
60
40
20
1
2
3
4
5
SOLVENT / STOCK RATIO
SINGLE SOLVENT 100% S_1
MIXED SOLVENT 7·0 % S_2
MIXED SOLVENT 22·8 % S_2
MIXED SOLVENT 30·4% S_2
STOCK TREATED. V.G.C. 0·8553
PRINCIPAL SOLVENT S_1 = ACETIC ACID
AUXILIARY SOLVENT S_2 = CHLOROFORM

Fig. 5.

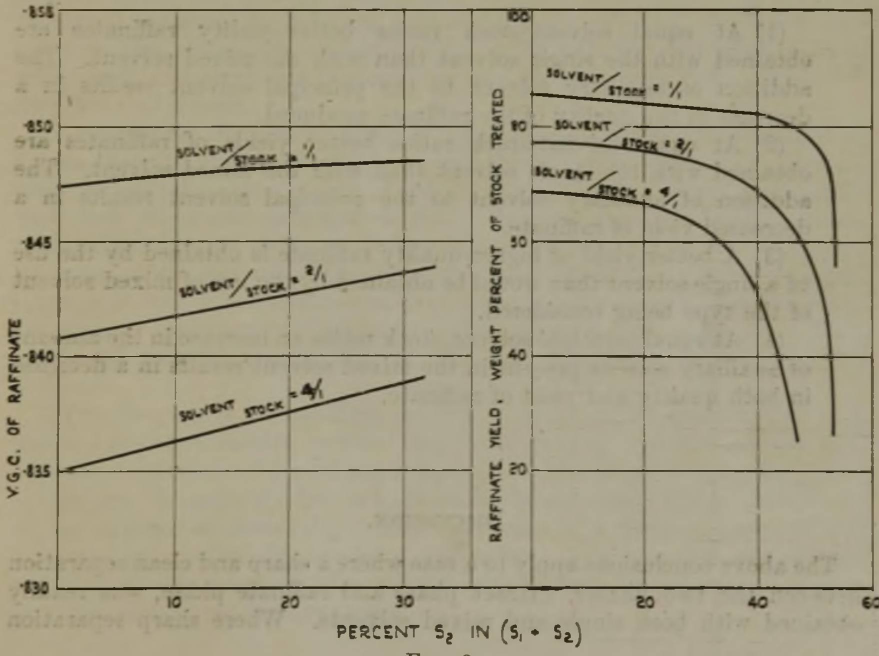
V.G.C. OF RAFFINATE
·855
·850
·845
·840
·835
·830
SOLVENT/STOCK = 1/1
SOLVENT/STOCK = 2/1
SOLVENT/STOCK = 4/1
10
20
30
RAFFINATE YIELD, WEIGHT PERCENT OF STOCK TREATED
100
80
60
40
20
SOLVENT/STOCK = 1/1
SOLVENT/STOCK = 2/1
SOLVENT/STOCK = 4/1
20
40
60
PERCENT S_2 IN (S_1 + S_2)

Fig. 6.

amounts of the auxiliary solvent was computed. The results obtained are recorded in Table II and illustrated in Figs. 4 and 5.

From Fig. 4 it is evident that better-quality raffinates—that is, raffinates of lower V.G.C.—are obtained with the single-solvent than with the binary-solvent mixtures at equal solvent/stock ratios.

Again, Fig. 5 confirms the conclusions derived from Fig. 2, that a higher yield of raffinate is obtained using a single solvent than by using an equal amount of mixed solvent. In Fig. 6 both yield and V.G.C. of raffinate are plotted against percentage of auxiliary solvent in the solvent mixture employed at varying solvent/stock ratios, from which it may be concluded that a higher yield of better-quality raffinate is obtained with the single solvent.

No curves giving comparisons at equal principal solvent/stock ratios have been included in these figures as was done in Figs. 1 and 2, as on this basis of comparison it is obvious that both raffinate quality and yield will be lower when auxiliary solvent is employed, as has already been demonstrated for the pure-component system.

CONCLUSIONS.

When the refining, by the batch extraction of a stock of fixed composition, produced by a single solvent only partly miscible with the stock and by a binary solvent mixture, consisting of the same solvent as principal solvent together with an auxiliary solvent completely miscible with both stock and principal solvent, is compared, the following conclusions are obtained :—

(1) At equal solvent/stock ratios better-quality raffinates are obtained with the single solvent than with the mixed solvent. The addition of auxiliary solvent to the principal solvent results in a decrease in the quality of the raffinate produced.

(2) At equal solvent/stock ratios better yields of raffinates are obtained with the single solvent than with the mixed solvent. The addition of auxiliary solvent to the principal solvent results in a decreased yield of raffinate.

(3) A better yield of higher-quality raffinate is obtained by the use of a single solvent than would be obtained by the use of mixed solvent of the type being considered.

(4) At equal principal solvent/stock ratios an increase in the amount of auxiliary solvent present in the mixed solvent results in a decrease in both quality and yield of raffinate.

DISCUSSION.

The above conclusions apply to a case where a sharp and clean separation between the two phases, extract phase and raffinate phase, was readily obtained with both single and mixed solvents. Where sharp separation between phases cannot be easily obtained with the single solvent, but can be so obtained by the addition of auxiliary solvent, then it is possible for mixed-solvent extraction to show improved results compared with single-solvent extraction. Complete phase separation may be very slow, owing to inadequate gravity differential between phases, or to the high viscosity of one or both phases, at the operating temperature. Sometimes, if the oil being treated is very dark, the demarcation line between phases is difficult to observe clearly, and poor separation may result through errors in judgement by the operator. From the continued investigation of liquid-liquid equilibria and solvent-extraction processes over a period of years, it is the considered opinion of the authors that clean phase separation is a matter of some difficulty. Hence, either one or both phases, but more often both, may contain entrained droplets. A raffinate, obtained by the removal of solvent from a raffinate phase containing entrained extract phase, would be of inferior quality to the raffinate obtained from the same raffinate phase free from entrained extract phase. Further, it is possible for the results of solvent refining with a single solvent where phase entrainment has occurred to be less favourable than the results obtained with a mixed solvent where entrainment is absent. In many mixed solvents the auxiliary solvent is of low viscosity such as benzene, and its addition speeds up and improves phase separation. Under such conditions mixed-solvent refining may prove practically advantageous when compared with single-solvent refining. The reported improvement[7, 8] brought about by extraction with benzole–SO_2 compared to extraction with liquid SO_2 alone in the treatment of lubricants and heavy oils is probably due to this effect. In any entrainment free extraction process liquid SO_2 should always give better results than SO_2–benzole. In actual practice, by reducing entrainment the addition of benzole can improve the extraction of liquid SO_2. This fact has not always been recognized, and erroneous explanations as to the function of the benzole[2, 8] have been advanced.

In comparing the action of mixed solvents, care is not always taken to ensure that the mixed solvents compared are of similar type. The type or class investigated here is one in which the auxiliary solvent is miscible with both stock and principal solvent. For example, the mixed solvent aniline–benzene at ordinary temperatures comes within this category, whereas the double solvent aniline–petroleum ether at ordinary temperatures does not, since aniline and petroleum ether are usually only partly miscible at ordinary temperatures. Nevertheless such cases have been compared without recognition of the fact that their action may be different.

While the use of an auxiliary solvent of the type considered here in a mixed-solvent-extraction process may have certain practical advantages, such as reduction of operating temperature and improvement of phase separation, the general effect is to increase the solvent power of the solvent at the expense of selectivity. This gives rise to a decrease in yield and decrease in quality of resulting raffinates. Any practical advantages obtained by the addition of auxiliary solvent must be considered in conjunction with these disadvantages.

References.

[1] U.S.P. 2,084,471 (1937).
[2] U.S.P. 1,945,516 (1934).
[3] Hunter, T. G., "The Science of Petroleum," Vol. 3, 1818 (1938).
[4] Brancker, Hunter, and Nash, *J. Physical Chem.*, 1940, **44**, 683.
[5] Brancker, Hunter, and Nash, *Industr. Engng. Chem.*, 1941, **33**, 880.
[6] Hunter, T. G., *ibid.*, to be published.
[7] Thompson, "The Science of Petroleum," Vol. 3, 1856 (1938).
[8] Defize, J. C. L., "On the Edeleanu Process," pp. 142–206 (1937).

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University of Birmingham.

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.

1.* Possible Future Oil Provinces of the United States and Canada. A Symposium, edited by A. I. Levorsen. *Bull Amer. Ass. Petrol. Geol.*, Aug. 1941, **25** (8), 1433–1586. —Reserves in areas not fully explored, where big discoveries have yet to be made, are discussed, the criteria of possible oil occurrence being : (1) that there should be a thickness of at least 1000 ft. of sediments, especially of those which are marine, of contrasting types, and not metamorphic ; (2) that there should be oil- or gas-shows, or lateral continuity with productive structures ; (3) that there should be unconformities with pre-unconformity folding and weathering to produce oil-traps ; (4) that there should be wedge-belts of porosity suitable for reservoir rocks. On accompanying sketch-maps and geological sections a simplified system of symbols has been employed. The work is intended to show in what parts of North America most profit is likely to accrue from intensive exploration by geologists. A. L.

2.* Possible Future Oil Provinces in Alaska. P. S. Smith. *Bull. Amer. Ass. Petrol. Geol.*, Aug. 1941, **25**, 1440–1446.—In Alaska special attention is directed by Philip Smith to the Jurassic and probably Miocene rocks of the south coast at Katalla and Yakataga, where wells as shallow as 1000 ft. have already acted as producers. Alaska Peninsula has yielded shows of high-grade oil. In the north-west foreland folding in front of thrusting from the south-west gives a wide area of anticlines, varying in closure in a sandstone, shale, and oil-shale terrain. Here the Cretaceous alone is about 20,000 ft. thick. A. L.

3.* Possible Future Oil Provinces in Western Canada. Alberta Soc. P.G. *Bull. Amer. Ass. Petrol. Geol.*, Aug. 1941, **25**, 1447–1456.—Big developments are indicated in Western Canada in the Palæozoic and younger rocks, 1000–13,000 ft. thick, lying between the foothills of the Rockies and the Canadian Shield, in an area 1600 miles from north to south and 800 miles wide at the United States boundary. Underneath the unconformable base of the Middle Devonian prospects are poor, but that formation is generally petroliferous and bituminous, and is producing at Fort Norman on the Mackenzie River. The top of the Lower Carboniferous Limestone yields at Turner Valley and Steveville, in South-west Alberta, where porous zones due to weathering are present at an important unconformity, above which Jurassic and Cretaceous sands also contain quantities of oil and gas. Exploration is rendered difficult by gentle dips and widespread glacial drifts. In Northern Alberta the " Athabasca " Oil Sands, in which heavy oil coats the grains and acts as matrix as well as pore-filling, cover an area of 10,000–30,000 square miles, ranging up to 225 ft. in thickness. They constitute the McMurray formation (Lower Cretaceous), formed as a great sand delta from the Canadian Shield, and rest on planated Devonian. Dips are to south and west at

3–8 ft. per mile, and the oil has escaped the pressure and heat of highly folded zones. Sufficient oil to fill a billion barrels is available, to be obtained by mining on benches along valleys. A hot-water installation for separating oil from sand has undergone tests, and is expected to produce 350 brl. a day. Refining plant will give a complete line of products. Seepages in Queen Charlotte Island and on the mainland of South-eastern British Columbia, all from the Jurassic, also seem hopeful. A. L.

4.* Possible Future Oil Provinces in Pacific Coast States. Pacific Section A.A.P.G. *Bull. Amer. Ass. Petrol. Geol.*, Aug. 1941, **25**, 1457–1468.—In Washington State luxuriant vegetation, deep weathering and volcanic dykes, and the boulder clay of Puget Sound often render prospecting difficult. On the western side of the Olympic Peninsula seeps and yields from Oligocene and Miocene are promising, and organic shales of equal age elsewhere merit examination. In Oregon anticlines in the Coast Range and buried structures in the valleys between the Coast and Cascade Ranges are likely places, but there seems to be a deficiency of source-beds. Tertiary and earlier embayments on the Californian coast present laterally varying shale and sand deposits that call for skilled stratigraphical work in order that more oil-traps may be found. The Sacramento gas-field, and the Salton Sea area, with its mud volcanoes and volcanic history, may yet furnish oil at depth. A. L.

5.* Possible Future Oil Provinces in Rocky Mountain Region. Rocky Mountain A.P.G. *Bull. Amer. Ass. Petrol. Geol.*, Aug. 1941, **25**, 1469–1507.—East of the United States Rockies there are many fields, from the Canadian border down to Northern New Mexico. They present sequences from Lower Palæozoic onwards. In Montana the " Disturbed Belt," partly covered by thrusting, has many anticlines, most of which have not been explored to sufficient depth. Potential source-rocks are present above the Madison Limestone (Lower Carboniferous), which has a weathered top like that which acts as a reservoir at Turner Valley, Alberta. In North-eastern Montana low folding in exposures and the necessity for deep drilling have held up development; at present Upper Cretaceous sands are producing, and oil has been proved in Upper Palæozoics. Strata at depth vary from homotaxials in the basin edges, and palæogeography is unknown. In Southern Montana similar factors and absence of success in superficial anticlines have also been deterrents, although seeps and wells on the fringe of the Powder River basin indicate reservoirs at depth in the centre. Absence of marked deformation of the Tertiary cover is also a handicap in the Big Horn basin, Wyoming, and in the Wind River and Green River basins. The last may have oil in lenticular sands as well as at depth. In Colorado and Utah depth and marketing conditions are both adverse. The north part of the Black Mesa basin has dry beds, and oil occurrence may be synclinal at Carboniferous to Cretaceous horizons. In the San Juan basin, New Mexico, little exploration has been done below the Dakota Sandstone (Upper Cretaceous), apart from one marginal well—Rattlesnake—which produces from the Upper Carboniferous, other mainly marine beds occurring underneath. A. L.

6.* Possible Future Oil Provinces of Northern Mid-Continent States. Tulsa Geol. Soc. *Bull. Amer. Ass. Petrol. Geol.*, Aug. 1941, **25**, 1508–1526.—In the northern mid-continental fields of North and South Dakota the dominant feature of the stratigraphy is eastward thinning and overlap, so that many longitudinal wedge-belts of porous material must exist. When markets are obtainable and hindrances due to glacial deposits and loose surface sand can be overcome, production is to be looked for from the Ordovician upwards. The anticlinal uplift of Central Kansas is continued north-west into Nebraska, and overlaps of pervious strata, as well as upfolds and sand-lenses due respectively to earth movements and contemporaneous erosion during Palæozoic deposition, appear felicitous. Until many more trial borings have been put down, however, neither seismography nor palæogeography can see through the cover of later rocks which have been tilted in both pre-Cretaceous and post-Tertiary time. In the Salina and Forest City areas, north-east of the Central Kansas oil-pools,

the thickness of marine strata and their overlap against the Nemaha ridge point to productivity, but many dry wells have been drilled. Southwards from Central Kansas to the Amarillo buried ridge in Texas is a region with a geological column up to 2 miles deep. Around the borders oil has been found from rocks of Ordovician to Permian age. From present knowledge, inadequate as it is, of transgressions and lateral changes in deposition, 1000 linear miles of porosity wedges can be inferred. Exploration is difficult, however, since the surface beds do not lend themselves to precise mapping, and at shallow depths there are evaporites which upset geophysical observations. In Oklahoma and Arkansas the Ouachita Mountains are overthrust northwards on to a geosynclinal accumulation of great depth. The Choctaw thrust-plane conceals pre-Upper Carboniferous beds of shale, chert, and sandstone of low porosity, Ouachita type; but farther north the Ozark or Arbuckle type appears with marine shales and limestone and sands of "Wilcox" character in the Ordovician. Wedges in the Devonian under the Chattanooga Shale also offer opportunities for concentration. Gas is yielded, but high-carbon ratios in the local Upper Carboniferous coals have been regarded as a contra-indication against much oil. Further trial wells are needed that will penetrate the whole Carboniferous system and below it.
A. L.

7.* Possible Future Oil Provinces of West Texas. West Texas Geol. Soc. *Bull. Amer. Ass. Petrol. Geol.*, Aug. 1941, **25**, 1527–1538.—In the Llano Estacado, West Texas, best prospects are in the basal Permian dolomite and in arkosic washes from the flanks of uplifts. Older beds with a profound unconformity between Ordovician and Lower Carboniferous, and with early Upper Carboniferous folding, are also promising. A cover of Triassic red beds is unprepossessing. Edwards Plateau, north of the Rio Grande, has an overthrust belt on the south under which anticlines in the Cambro-Ordovician Ellenburger Dolomite, already known to contain gas, and in the Lower Carboniferous, may yield oil. Farther north wedges in Upper Carboniferous sands which thin out northwards are reasonably certain, and also in Permian beds showing lateral variation. All the Palæozoic formations and the overthrust are covered by the Cretaceous deposits which transgress from the south, and are gently folded so as to obscure the structures below. Near Del Rio lenticular sands, in the Cretaceous, are yielding oil. In the Trans-Pecos River province are complicated basins in which oil is present from Lower Ordovician to Quaternary. Formerly inaccessible, the oil in the north-west corner is now within reach of two pipe-lines that cross the Diablo Plateau.
A. L.

8.* Possible Future Oil Provinces of Eastern Canada. Geol. Survey of Canada, Quebec Bur. Mines, Newfoundland Geol. Survey. *Bull. Amer. Ass. Petrol. Geol.*, Aug. 1941, **25**, 1539–1562.—On the eastern side of the Continent it is found that the gently folded Ordovician to Devonian sediments of the James Bay area in Canada seem to yield no seepages. In Eastern Ontario similar marine beds reaching as high as the Richmond (late Ordovician) have yielded oil and gas from Trenton Limestone (Middle Ordovician) and a black bituminous shale above it, chiefly from the west and south sides of a down-faulted block. On the Ontario Peninsula most of the oil is from Middle Devonian limestones, while gas is obtained from the Silurian and Middle Ordovician. In Nova Scotia and New Brunswick two main synclinals contain Lower and Upper Carboniferous beds, among which non-marine deposits predominate. The only petroleum-producing field is at Stoney Creek, and is from the Albert formation (Lower Carboniferous), which also contains oil-shales. Workable oil-shale also occurs near the top of the Upper Carboniferous at New Glasgow. In the Prince Edward's and Magdalen Islands there is a terrestrial lithology—*e.g.*, soft red sandstones and silts, gypsiferous beds, and volcanic tuffs. No seepages have been noted. In the Gaspé Peninsula folds in the marine Ordovician to Devonian beds are of medium intensity, and unconformities separate Ordovician and Silurian, and possibly Silurian and Devonian. Bituminous shales and oil-soaked limestones occur at several horizons. A recent deep well ended in 1940 at a depth of 5995 ft., but this fell more than 1000 ft. short of reaching a possibly oil-saturated layer in the Silurian. Likewise in Eastern

Gaspé favourable structures remain untested by deep boring. Underground porosity may be unsuitable, but exploration may be worth while as far west as the Matapedia Valley. In the St. Lawrence Lowlands, mainly Ordovician beds dip at low angles in the north, but become highly complex on the south-east side of the river. Gas has been found below the surface clay, and parts of the Trenton are petroliferous. Helgi Johnson describes petroleum occurrences at two Ordovician localities in Newfoundland —Parson's Pond and St. Paul's. In addition, there are oil-shales at Grand Lake and Piliers Bay in the Carboniferous, and bitumen seepages. But, as elsewhere in Canada, a thick glacial coating often makes geological surveying somewhat speculative. R. C. W.

9.* Possible Future Oil Provinces in Eastern United States. Appalachian Geol. Soc. *Bull. Amer. Ass. Petrol. Geol.*, Aug. 1941, **25**, 1563–1574.—In the eastern part of the United States the Appalachian basin includes the Appalachian geosyncline and the Cincinnati arch. There are more than 10,000 ft. of sediments, and bituminous shales and marine magnesian limestones are conspicuous. Disconformities exist at the base of the Upper Carboniferous and beneath the Devonian. Beds which are yielding oil and gas include the Trenton (Ordovician), " Clinton Sand " (Lower Silurian), Newburg (Silurian), Oriskany (Lower Devonian). Upper Devonian to Upper Carboniferous pay-sands of the old Appalachian fields are now largely depleted. In North Cincinnati the possible oil area includes two major anticlines, the Cincinnati arch and the Kankakee arch separated by the Logansport sag. The sub-Trenton strata are insufficiently explored, and comprise, where the Cincinnati arch crosses the Ohio river, over 5000 ft. of sandstone, dark limestone, and dolomite. R. C. W.

10.* Possible Future Oil Provinces of South-Eastern United States. Mississippi Geol. Soc. *Bull. Amer. Ass. Petrol. Geol.*, Aug. 1941, **25**, 1575–1586.—In the South-eastern United States, in Georgia, several seeps are known, and oil-showings have been found in wells, but there is no commercial development, as few clearly defined structures have been worked out. Florida has thick marine sediments, mostly limestone, with large unconformities at the top of the Palæozoic and base of the Upper Cretaceous. Gas is reported in the Tertiary and more rarely in the Cretaceous, but no oil. Deeper Mesozoic and Palæozoic rocks are within reach of the drill. South Alabama has mainly marine sediments, with large pre-Upper Cretaceous unconformity. Gas is common, but dry wells on the Hatchetigee anticline and the Jackson fault have discouraged development. The Lower Cretaceous should be explored. North-west Alabama contains Cambro-Ordovician to Permian marine and lagoonal sediments, including much dolomite. There are asphaltic sands, and oil- and gas-shows, as, for example, in the old Fayette gas-field. The oldest shows are Ordovician. The deepest shows in Mississippi are also Ordovician, and an entire geological column of mainly marine origin is present, with pinch-outs, folding, and a few salt-domes. In Tennessee production has been obtained from many horizons. The Palæozoics of West Tennessee are, however, unexplored. Reasons for tardy exploration include: (1) loess surface cover, (2) fresh-water in Upper Cretaceous, (3) absence of younger Palæozoic in West Tennessee, (4) apparent lack of reservoir rocks above Knox dolomite (Cambro-Ordovician), (5) rapid decline of shallow Ordovician production, (6) restriction of present Ordovician and Mississippian production to small structures. R. C. W.

11.* Geology of British Oilfields. 1. The Geology of the Assam–Arakan Oil Region (India and Burma). H. M. Sale and P. Evans. *Geol. Mag.*, 1940, **77**, 337–363.—The Tertiary rocks of the Assam–Arakan region are almost unfossiliferous, and that, coupled with difficulties of access, has rendered classification very difficult.

Drilling began in Assam in 1866, but little oil was produced until after 1922. The only oilfields of importance which have been found are Digboi and Badarpur, and they represent a poor return for the time and money spent on prospecting.

The Lower Tertiaries are of two types. In the north-west sandstones, shales, thin coals, and some limestone occur, whilst the main development on the south-east side of the Assam valley and the Upper Surma Valley consists of shales, sandstones, and thin coals. The Upper Tertiaries rest unconformably on the Lower Tertiaries, and contain shales, sandstones, and pebble-beds.

The Tertiary belt of Assam–Arakan has been subjected to strong folding. In North-eastern Assam there is strongly developed thrusting. At the extreme south of the belt the long, narrow anticlinal folds disappear and are replaced by a much more complex structure.

Oil-seepages occur in beds from the top of the Lower Tertiaries through the lower half of the Upper Tertiaries. They are most numerous in Upper Assam, towards the head of the Surma valley, in the Boronga Islands, in Ramree Island, and in Cheduba Island.

The Digboi and Badarpur oilfields are on anticlines, and the same is true of many of the oil- and gas-seepages; but a number of Upper Assam seepages are closely associated with the overthrust strike faults of the Naga Hills. The asymmetrical Digboi fold is faulted on the steep flank. The Badarpur oilfield is developed on a small dome, also with a faulted steep flank. The very small productions of Boronga, Ramree, and Cheduba have been obtained from shallow wells drilled near to seepages, mostly on sharply folded structures. G. D. H.

12.* Geology of British Oilfields. 2. The Geology of the Oilfields and Some Prospective Oil Areas in Canada. G. S. Hume. *Geol. Mag.*, Jan.–Feb. 1941, **78** (1), 1–36.—On the Gaspé Peninsula the oil-bearing region is principally in the York and St. John River basins. Oil has been found in the Devonian, and a small production was obtained from wells drilled prior to 1902. Recently work has been renewed, and while there are favourable structures and petroliferous beds, the presence of suitable reservoir beds is still in doubt.

South of Moncton in New Brunswick, oil and gas have been obtained from the Albert formation (Mississippian) on the south flank of a fold. On the south-western peninsula of Ontario a little oil has been produced for eighty years. The basal arkose, possibly of Ordovician age, gives a little oil, and one field has been established in the Trenton (Dover). The latter may be due to faulting and fracturing having provided the necessary porosity. Gas and some oil are obtained from several Silurian horizons (Whirlpool, Cabot Head–Grimsby group, Guelph, and Cayugan). The Middle Devonian limestones are the most prolific sources of oil in Ontario, and in each Middle Devonian field the structure is an anticline of small closure.

Two wells yield oil in the Mackenzie River basin, 50 miles north of Fort Norman. Seepages of oil are common in the Upper Devonian, which is the productive horizon, and there are seepages in the Middle Devonian. The Middle Silurian is bituminous.

During 1939 96% of Canada's 7,743,000-brl. oil production came from Turner Valley in the foothills of Alberta. The structure of the foothills is complex, and the Mesozoic rocks, of which they are mainly composed, are highly faulted and folded, with great overthrust blocks in the Palæozoic. The Devonian yields oil in a well at Moose Mountain, and the overlying Mississippian contain limestones which provide the main oil- and gas-zones at Turner Valley. In the Southern Alberta foothills the Jurassic rests on the Mississippian, but to the east Triassic beds occur. In the lower part of the Blairmore of the Lower Cretaceous some oil and gas are found in a sand.

The soft beds of the Mesozoic show more complicated structures than the underlying more resistant Palæozoic limestones. Turner Valley is a fault-block cut off by major faults on both sides, with the Palæozoic limestone showing a westerly dip mainly. Gas has been found in the higher parts of the limestone, and oil to the west of the gas areas. The field is 17 miles long, and the northern limit is not yet known.

Several minor oil- and gas-fields occur in the plains of Alberta. At Steveville much gas and a little oil have been found in the Devonian, whilst Lower Cretaceous sands yield oil at Red Coulee.

The Palæozoic limestone is to be tested at Commotion Creek, British Columbia.
G. D. H.

13.* Geology of British Oilfields. 3. The Oilfields of Burma. P. Evans and C. A. Sansom. *Geol. Mag.*, Sept.–Oct. 1941, **78** (5), 321–350.—The Burma oilfields lie in the north–south Tertiary basin bounded on the west and east by the Arakan Yoma and the Shan Hills respectively, and most of the oil is obtained from fields lying on a single line of folding some 50 miles long. Hand-dug wells were giving an appreciable output in 1797, but the first mechanically drilled well was completed in 1889.

The stratigraphy of the Tertiary basin is described in some detail. The beds show a general tendency for a northward transition from marine to brackish and thence to fresh-water. The continental Irrawaddy beds rest unconformably on the Pegus in the oilfield region, and there is another unconformity within the Pegus separating Oligocene from Miocene beds.

The basin is affected by north–south and west-south-west–east-north-east folding trends, the latter dividing the main syncline into three basins which show stratigraphical differences. East of the main syncline is a belt of volcanic rocks.

Although the Tertiary rocks are supposed to have been laid down in a long, narrow gulf, bounded on the west by the Arakan Yoma and subdivided longitudinally along a line agreeing approximately with the volcanic belt, it is probable that in the earliest Tertiary the western shore was formed by remnants of Gondwanaland. Deposition kept pace with sinking until well into Oligocene times, when pronounced uplift occurred. In late Oligocene or early Miocene times there was transgression which may have involved some of the Arakan Yoma.

The Yenangyaung field is an elongated dome, slightly asymmetrical, with dip-faults. Oil is obtained down to 5000 ft. Singu is more asymmetrical, and the eastern flank is slightly overturned in places. It is faulted, and the most southerly fault has had an important bearing on oil accumulation. Apart from Yenanma all the other fields are on more or less asymmetrical domes or anticlines. The main producing fields give oil from the Oligocene (Pegu) chiefly, but there are Eocene and Miocene shows. In the main fields the oil is believed to have originated in the shales near the sands in which it is found, but there may have been fairly extensive lateral migration. G. D. H.

14.* California Production and Geological Conditions. Anon. *Oil Gas J.*, 30.10.41, **40** (25), A 38.—The following data are tabulated by fields, grouped according to districts: name of field; discovery month and year; number of producing wells at the end of September 1941; current daily average production; cumulative production to the end of August 1941; oil gravity; type of structure; average thickness of oil-zone; depth range. Maps show the locations of the fields, and there are detailed field-maps showing the distribution of wells in some of the San Joaquin Valley fields. G. D. H.

15*. Cross-Section and Field Data of Active Oil Areas—Southern San Joaquin Valley, California. Anon. *Oil Gas J.*, 30.10.41, **40** (25), 40 B.—The San Joaquin Valley lies between the Coast Ranges and the Sierra Nevada. Seepages of oil occur in the Jurassic, but during that period the rocks were intensely folded and intruded. Commercial quantities of gas occur in the northern part of the valley in the thick Cretaceous deposits, but depth precludes exploration except along the margin of the valley. From the Eocene onwards the valley was an area of sedimentation, with the oldest and youngest series predominantly continental. The Oligocene and Miocene are marine, with some of the Pliocene fresh-water or in the form of alluvial fans.

The valley has been a continuously subsiding area, giving a variety of structures of different ages, some of the folds being very recent.

The search for oil began on the margins of the valley, McKittrick being found on the western margin and Kern River on the east, followed by Coalinga and Midway–Sunset on the west. Fields now stretch right across the valley, and the discovery of those in the deeper parts was a consequence of geophysical work.

The oil-producing area embraces 3935 sq. miles, with 215 sq. miles proved for production. Nearly 2,400,000,000 brl. of oil have been produced, and the reserves are estimated at 2,100,000,000 brl.

A map shows the location of the oil- and gas-fields, and a cross-section indicates the stratigraphy, structure, and producing horizons. G. D. H.

16.* Natural-Gas Reserves Equal to Total Production to Date. Anon. *Oil Gas J.*, 30.10.41, **40** (25), A 48.—California has produced 7,837,582,539,000 cu. ft. of gas.

During the first half of 1941 only 3·6% of the gas output was wasted, a result due to gradually improving conditions in the past ten years. Most of the gas was obtained with oil, and whilst the Los Angeles Basin tops the list, the San Joaquin Valley group of fields will probably equal or surpass its output in 1942.

Dry gas is obtained from a number of fields and zones, but all dry gas does not originate in fields that produce dry gas exclusively. Rio Vista is the largest Californian dry-gas field. In the San Joaquin basin the gas comes from the Upper Pliocene as a rule. The Buena Vista Lake gas-field is on an anticline located by geophysics. Delano, another geophysically discovered dome, also gives gas from the San Joaquin clay series (Upper Pliocene). At Chowchilla gas was discovered at 8030 ft., 3800 ft. below the top of the Cretaceous contact. There is, however, a second gas zone at 2390–2800 ft. The Willows gas-field gives gas from the Cretaceous, but is not on commercial production. Marysville Buttes gas-field is on the south flank of the Sutter Buttes volcanic intrusion, and is productive from the Cretaceous. Buttonwillow is a gentle anticline with a closure of 250 ft. The McDonald Island gas-field lies on a dome discovered with the aid of the seismograph. Gas is derived from the Upper Cretaceous at Tracy, where the productive acreage is small. Vernalis, a recent discovery a few miles south of Tracy, has not yet had its possibilities fully determined. The Rio Vista production may be from the Eocene. Potrero Hills has not been put on commercial production. Goleta is an asymmetrical dome complicated by overthrust faulting, and giving gas from the Vaqueros.

Tables show the yearly gas production and its utilization, together with the oil output. A map gives the positions of some of the fields. G. D. H.

17.* Adequate New Reserves Found to Offset this Year's Output. L. P. Stockman. *Oil Gas J.*, 30.10.41, **40** (25), A 81.—Results of operations during the past three years indicate that operators should have found more than 230,000,000 brl. of new production annually, but they failed to do so, and hence crude-oil reserves have declined slightly during this period. Various factors affect production, and therefore reserves and ultimate recoveries.

The 1940 discoveries were Del Valle, the Pyramid Hills section of Kings County, and the Republic area in the Midway–Sunset district. Recently drilling on the extreme western end of the Del Valle structure has given several good wells, leading to the assumption that production may extend along the whole anticline from the Havenstrite section to the Videgain area. These areas are separated by a zone broken by folding and faulting.

The first discovery of 1941 was the Vernalis gas-field, followed by Panoche, Oak Canyon, Union Avenue, Raisin City, Helm, Jacalitos dome, Shafter, Dyer Creek, and Turnbull Canyon. The Panoche possibilities are undetermined, and success has not attended the second and third wells at Union Avenue. Estimates of reserves are apt to vary with the results obtained in a few successive wells ; hence Raisin City's reserve of 5,000,000 brl. may be revised in the light of the latest well with an initial flow of 1224 brl./day. Only one well has been completed at Dyer Creek. Oil is apparently accumulated in the Miocene against a fault. The Shafter discovery well encountered a thin, tight producing zone. Three pays have been found at Helm, in the Cretaceous and Lower Eocene at 8000 ft., and the Lower Miocene at 7448 and 7000 ft. A number of wells have been drilled at Jacalitos in the past 20 years, but the first commercial producer was not drilled until 1941. The Turnbull Canyon discovery is north of the Whittier fault. It may produce from the Puente. .

Although the Ford zone is not now being produced at Wilmington, it is possibly the most productive horizon of the field. Each fault-block at Wilmington is a separate unit. An Eocene shoreline accumulation has been developed east of the old East Coalinga field. Paloma is California's first distillate field. At Inglewood the Miocene is now being developed.

The crude-oil reserves and recovery per acre to date are tabulated by fields, and the production and demand in the period 1939–41 are given by months. G. D. H.

18.* California Crude-Oil Production from 1894 to Date. Anon. *Oil Gas J.*, 30.10.41, **40** (25), A 96.—The production, in barrels, year by year is tabulated for the various fields under the district headings San Joaquin Valley, Coastal district, Los Angeles Basin. G. D. H.

19.* Trenton Lime Production in Five Illinois Pools. Anon. *Oil Gas J.*, 30.10.41, **40** (25), 164.—The Trenton has given oil for a number of years from a few pools in South-east and South-west Illinois, and in 1940 and 1941 successful Trenton wells were completed at Centralia and Salem. Eighty-seven Trenton wells have been drilled at Salem, having been deepened from the Devonian. Trenton tests in a number of small pools have been unsuccessful, and so far it seems that Trenton production is limited to structures with considerable closure.

The first Trenton production in Illinois was in Kankakee County in 1900, but it was not commercial. The depth was 140 ft. Commercial Trenton production was discovered in 1910 at Westfield, a dome on the axis of the La Salle anticline. The 160 ft. of Trenton closure conforms closely to that of the overlying Mississippian. The permeability and porosity of the producing horizon were low, and hence the wells were small. Trenton production at Martinsville was obtained in 1921, but the two successful wells were small. At Waterloo and Dupo, on the northern extension of the Waterloo anticline, quite a number of Trenton wells have given oil.

The Trenton wells have been small, though long-lived, and the total Trenton crude obtained in Illinois is less than 1% of the State's total production. G. D. H.

20.* Well Logs and Field Data of Active Oil Areas, Upper Gulf Coast District, Texas. Anon. *Oil Gas J.*, 6.11.41, **40** (26), 144 B.—All the formations dip gulfward, and there is also considerable thickening of the older Tertiary beds, with the result that along the coast older Tertiary beds are now beyond the reach of the drill. The later formations are alternating continental and marine beds, with marine beds predominating in the middle of the section in the northern part of the area and throughout the whole section near the coast. The predominant structural features are a complex series of faults formed by slumping of blocks of sediment during the subsidence of the area, and a large number of salt-domes which have risen to various heights in the section. Recently there has been a search for local gentle structures forming small uplifts in areas of lensing sands.

Production began with the discovery of Spindletop in 1901, and during the next 25 years was largely confined to salt-domes and other fields discoverable by surface geology. The introduction of geophysics led to the discovery of many deep-seated domes and gentle structures on which many of the larger fields are located. There are more than 125 active fields in the district.

As older horizons have been found productive, prospecting has tended to spread northwards and deeper. It is now realised that the whole of the Wilcox may be oil-bearing, and recent tests have reported more than 1000 ft. of Wilcox sand, with almost one-third of the section showing some oil saturation.

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

21.* Venezuelan Crude Production of 648,762 Brl. Daily Sets New Peak. Anon. *Oil Gas J.*, 20.11.41, **40** (28), 29.—During September Venezuela's daily average production was 648,726 brl., about 18,300 brl. above the August figure. A slight decline took place in the eastern fields, but the rise of 20,685 brl./day in the Maracaibo fields more than offset this. The output was 33% above that of September 1940. Lagunillas contributed most to the rise in output in September 1941. The Santa Barbara field yielded 4510 brl./day, against 2045 brl./day in August. Most of the new production from Eastern Venezuela is derived from comparatively new fields in Anzoategui–Santa Ana, San Joaquin, El Roble.

The output for September 1940 and for August and September 1941, is tabulated by fields and companies, and the exports by various companies are given for August and September 1941. G. D. H.

22.* Well Logs and Field Data of Prospective Oil Areas—North Section Permian Basin—West Texas. Anon. *Oil Gas J.*, 20.11.41, **40** (28), 52 B.—The north section of the Permian basin comprises an area of about 20,000 sq. miles between the productive part of the basin in West Texas and New Mexico and the Panhandle gas- and oil-field. Very few wells have been drilled in the area, and correlation between them has been difficult. The granite and schist basement of pre-Cambrian age was covered in the southern and eastern parts of the basin by Ellenburger–Arbuckle and Simpson deposits. Silurian and Devonian deposits came in from the south-west. Mississippian and Pennsylvanian deposits cover the margins of the basin, but do not appear to have extended as far north as did the Ordovician beds. In the Permian a great thickness of limestone was deposited in the Texas section, followed by continental deposits. Salt, anhydrite, and gypsum beds were also laid down, probably behind limestone reef barriers analogous to the limestone mass of El Capitan, and these reefs have given most of the oil in West Texas.

In North-west Texas alternations of marine and evaporite deposits are most frequent, adding to the number of possible pay horizons and rendering discovery more difficult. The pays at Wasson and Slaughter are generally considered to be of San Andres age; that at Lubbock is probably of Clear Fork age, as in the Panhandle.

Pre-Permian production seems unlikely, and the massive limestone deposits of the older West Texas producing district appear to be absent. The seaward sides of the barriers, which gave the many evaporite series, provide possibilities for oil and gas accumulations.

A series of well logs is appended. G. D. H.

23.* Colombian Wildcat Produces at Rate of 480 Brl./Day. Anon. *Oil Wkly*, 20.10.41, **103** (7), 64.—Casabe 1 on the Yondo concession produced at the rate of 480 brl./day in a test. It lies on the left bank of the Magdalena, opposite the Barranca Bermeja refinery. Oil sands were reported at 6748–6993 and 7435–7602 ft. The depth is 8280 ft. G. D. H.

24.* Venezuela Output Reached New Peak in August. Anon. *Oil Wkly*, 20.10.41, **103** (7), 64.—The 19,769,000 brl. of oil produced in August was Venezuela's record output for any month, and 30% above the January figure. The Lake fields, Cabimas, Lagunillas, Tia Juana, and Bachaquero, had an increase of 33%, in spite of a material fall at Bachaquero. Mene Grande's output rose by 24%. 38% more oil was produced at Oficina, Jusepin, San Joaquin, and El Roble than in January. Mulato 1 on the Amana concession has proved a gasser, giving 1,200,000 cu. ft. of gas/day from 4100 ft. The closed-in pressure was 1575 lb./in.^{2}. There was a small show of oil.

Roble 5 gave 42·5° oil from 9805–9850 ft. at the rate of 1128 brl./day, and Roble 6 has had showings of oil and gas at 8900 ft. Mercedes 2 was making a drill stem test at 4616 ft. G. D. H.

25.* Alberta Basin Become Important Factor. F. R. Henry. *Oil Wkly*, 27.10.41, **103** (8), 40–42.—The Alberta basin, which lies principally in Alberta but has its southern tip in Montana, has yielded more than 100 million barrels of oil, 40 million from Turner Valley, and 68 million from Kevin-Sunburst, Cutbank, and Pondera. 46,000 brl./day are obtained, 27,000 being from Turner Valley. Recently a well on the Twin River structure of Southern Alberta has been giving 100 brl./day from 3900 ft. by pumping. The Madison was penetrated and showed porosities of 10–25%.

Twin River, Del Bonita, Spring Coulee, and Ross Lake are domes on the flank of the geanticline of which Kevin-Sunburst forms the crest. Kevin-Sunburst and Cutbank are flat structures with thin oil zones, giving small wells and a low yield per acre. The Alberta structures are more basinward and have steeper dips and greater closures. The oil zones are thicker and the reservoir pressures higher.

None of the Southern Alberta structures has yet produced from the sands of the Lower Blairmore, which are productive at Cutbank. Two wells at Spring Coulee showed these sands to be oil saturated. The Devonian, which underlies the Madison, affords deep possibilities.

The west flank of the Alberta basin is sharply folded and complexly faulted, and Turner Valley is the only field yet discovered in this area. G. D. H.

26.* Modern Prospecting a Broad and Complex Science. W. L. Baker. *Oil Wkly*, 3.11.41, **103** (9), 97.—The use of geology in prospecting for oil did not amount to much until about 1912, when the geologist's work was strictly surface structural mapping, a technique which continued to be the dominant prospecting method until the early 1920's. Thereafter it declined in importance, due to exhaustion of areas suitable for its application and the appearance of other successful methods. Stratum contouring, the search for surface indications, and the following of trends preponderated in the geological work, although there was still much random drilling based on seepages and other surface evidences. Aerial photography, introduced since 1920, has added to the capabilities of surface mapping.

The sharp increase in consumption and the scarcity of new surface indications in the early 1920's caused more attention to be paid to subsurface geological methods. The correlation of well logs to provide subsurface maps and the development of ideas about favourable structures for oil accumulation came to the fore. The core-drill was of great value. Subsurface methods were at their peak between about 1925 and 1930, since when they have declined in importance as a discovery method.

The first salt-dome and oil-structure discovered geophysically was the Nash dome in Texas in 1924. This was followed, when it proved productive in 1926, by an intensive campaign of torsion-balance surveys, especially in the salt-dome country. The seismic refraction method gradually supplanted the torsion balance, and was highly successful in the Gulf Coast salt-dome region from 1924 to the early 1930's. About 1931 the reflection method came into use on the Gulf Coast, and is the leading exploratory method to-day. The gravimeter has almost replaced the torsion balance, and attained an all-time high in 1940. The use of the magnetometer has increased, although it is still but little employed. Electrical methods have received some attention, especially where the reflection method is inapplicable.

Appreciation of the possibilities of stratigraphic traps called for a revisal of prospecting methods which sought structural traps only, and the determination of palæogeography from detailed well studies and other data began to develop. Electrical logging has proved of great value in this connection, and has recently been supplemented by gamma-ray well-logging for cased holes. Core analyses have provided additional information on the porosity, permeability, fluid content, and age of the rocks, and various drilling records are proving helpful.

Geochemical prospecting claims to be able to discover structural and stratigraphic oil accumulations. G. D. H.

27.* Twin River Wildcat Shows for Production. Anon. *Oil Wkly*, 17.11.41, **103** (11), 62.—Twin River No. 1 in Alberta is giving 50–60 brl. of light crude per day from a limestone at 3969 ft. The well is 50 miles south of Lethbridge and 6 miles north of the Montana border. It is 10 miles north of the Reagan Tribal well of Montana, which found a flow of 5,000,000 cu. ft. of gas and a spray of oil in the Madison. G. D. H.

28.* Exploratory Activities in Brazil. Anon. *Petrol. Engr*, Oct. 1941, **13** (1), 75.—A small commercial output of oil has been found in the coastal area of Brazil around Bahia. Oil was first discovered in 1939 at Lobato at a depth of 700 ft. Since then at least ten wells have been drilled, of which two or three are commercial producers. The producing wells are slightly less than 2000 ft. deep, but some exploratory wells have been taken to 7000 ft. The oil is obtained from Cretaceous beds in a narrow belt of sediments some 20 ml. wide, with Quaternary and Tertiary beds resting on Cretaceous to Triassic beds.

Other areas of petroleum interest in Brazil are the Parana basin, Acre, and Para. A number of wells have been drilled in the Parana area, south of Rio de Janeiro. The Acre area is relatively near to the Aguas Calientes field of Peru, and there are seeps in Peru near the Brazilian border. The few wells drilled in the Para area gave little information on the oil prospects. G. D. H.

29.* Development of Aguas Calientes, East of the Andes, is Most Interesting Current Activity in Peru. Anon. *Petrol. Engr*, Oct. 1941, **13** (1), 96.—Five well have now been completed at Aguas Calientes at depths of about 1200 ft., with productions of 250–2500 brl./day. The temperature of the oil is 165° F., and the wells flow by water-drive with no gas. A 45-mile pipe-line may be built to carry the oil to the Ucayali River, and a small topping plant is to be constructed.

The structure runs north-west–south-east for about 15 miles, and it is about 7 miles wide. The crest is flat and relatively wide, and the north-east flank has dips as steep as 25–30°. Oil is obtained from sands in a series of interbedded shales, sands, grits, and volcanic ash.

About 80% of Peru's oil comes from the Negritos district, and 139 wells were completed there in 1940. Most of the wells were in proved areas, although some were drilled to horizons not previously exploited, and a few were wildcats. The oil is obtained from the Eocene, but a deep test has been drilled to the Upper Cretaceous.

During the past year the output of the Lobitos area probably declined by about 10%. The old Zorritos field has about 60 wells, with a production of approximately 200 brl./day. G. D. H.

30.* Drilling and Production Activity in Foreign Fields. Anon. *Petrol. Engr*, Oct. 1941, **13** (1), 150.—Argentina's 1940 production of 20,610,000 brl. was 11% above the 1939 output. 70% of the oil came from Comodora Rivadavia. A deep test to 7715 ft. in the old central area found no production below the zones previously known. A wildcat in the southern part of the new El Tordillo area will be kept as a reserve for future development. 90 miles south-west of Comodoro Rivadavia, a well drilled to 6139 ft. found no productive formations, and two wells south of Comodora Rivadavia in San Jorge gulf were also unproductive. Some of the wildcats in the Plaza Huincul district had oil and gas showings. The Tupungato production has increased. Production is obtained at 7220–7890 ft. in the Lunlunta field.

25,600,000 brl. of oil were produced in Colombia in 1940, an increase of 7% over the 1939 output. 84% of the oil came from Infantas and La Cira. There are now approximately 100 producing wells in the Petrolea field, only one being on the south dome. There are three producers at Carbonera and ten at Rio de Oro. A small producer was completed at 3960 ft. at Tres Bocas, and a deep test has had slight showings.

Oil impregnation has been found in cores at various depths from 4900 to 6050 ft. in Casabe 1, across the Magdalena from Barranca Bermeja. Last year several wildcats were abandoned in the Magdalena Valley from south of Gamarra to Honda.

75% of Ecuador's production last year came from Ancon.

186,134,000 brl. of oil were produced in Venezuela in 1940, 9·4% less than the high of 1939. 73% of the oil came from the Maracaibo basin. In Eastern Venezuela both Santa Barbara and Socororo can now be considered proved fields.

The 1940 production of Iran, Iraq, Bahrein, Saudi Arabia, and Turkey is estimated at 122,800,000 brl. Burma produced 7,979,000 brl. of oil in 1940, and India's production was 2,250,000 brl. In 1940 the Netherlands East Indies produced 60,830,000 brl. of oil, Sarawak and Brunei 7,047,000 brl., and Japan 2,639,000 brl. G. D. H.

31.* Drilling Operations in the Philippine Islands. W. A. Sawdon. *Petrol. Engr*, Oct. 1941, **13** (1), 150.—Five wells have been drilled to depths of about 1000 ft. on the Bondoc peninsula of the Island of Luzon without finding oil production. A well has been drilled to 6000 ft. on the Daan Bantayan Peninsula of Northern Cebu, and this is to be deepened. The structure is a symmetrical anticline with a thick oil-bearing series, according to cores. In some areas of the Phillippines the marine Miocene and Pliocene beds are stratigraphically equivalent to the producing horizons of Borneo. In addition to the structures at Bondoc and Daan Bantayan, there are other folds with oil possibilities. Seepages are found in a number of places in the islands, particularly on the Bondoc peninsula. Shallow holes in an outcrop on the west coast of Cebu, 60 miles south of the Daan Bantayan location, have given oil. An exposed tar-sand on the island of Leyte has been mined for paving material.

The paper also describes the difficulties in transportation and haulage experienced owing to the lack of equipment. Details are given of the rig and methods used.
G. D. H.

32.* Elements of Argentine Petroleum Geology. Anon. *World Petrol.*, Sept. 1941, **12** (9), 77.—Commercial accumulations of oil and gas have been found in structures developed in the Sierras Subandinas in Salta and Jujuy, in folds which flank the Cordillera of the Andes in Mendoza, in anticlines along the northern limit of the Patagonian Massif in Neuquen, and in complexly faulted anticlines in Chubut within the Cuenca de San Jorge. Numerous oil-seeps, asphalt, etc., occur in these and other areas. The age of the producing rocks ranges Devonian to Tertiary.

In northern Argentina the fields of Aguas Blancas, San Pedro, Rio Pescado, Tartigal, and Lomitas-Tranquitas give oil from closely folded anticlines trending generally north–south. The outcropping formations are largely shales and sandstones of Cretaceous and Tertiary age. Production is usually limited to the axial parts of the folds, and at Vespucio and Tranquitas the producing sands are probably of Lower Tertiary age. Rio Pescado obtains oil from younger Tertiary sands, and Aguas Blancas from the Devonian.

Four important oil areas exist in Mendoza—Cacheuta, Tupungato, Lunlunta, and Ranquil Co. Cacheuta is on a plunging anticlinal nose, and the producing formations (Rhætic) outcrop near asphalt deposits. Tupungato is anticlinal, and originally yielded oil from shallow Tertiary beds, but the main production is from the Rhætic at about 5850 ft. Oil is obtained from very fine grained sandstones and from joints in interbedded volcanic ashes. Beds of Rhætic age on one of the domes on an anticline are productive at Lunlunta. At Ranquil Co. oil is obtained from Lower Cretaceous dolomitic limestones on an anticline.

Rapid lateral changes in lithology and structural complexities make the Neuquen geology difficult to unravel. There are at least three important post-Triassic unconformities. Oil indications are numerous. Although the five oil-pools are related to east–west folds, porosity and truncation are important locally in forming traps. Production is chiefly from the Jurassic.

Chubut is the most important oil-producing province, oil having been discovered in 1907 when drilling for water. The Comodoro Rivadavia area obtains oil from four zones of Upper Cretaceous sandstones and lenses which are partly continental, at depths of 1800–5850 ft. Lenticularity dominates the oil distribution. There are accumulations in places on complexly faulted anticlines trending east–west.

G. D. H.

33.* Petroleum Development against Historic Background of Ecuador. H. K. V. Tompkins. *World Petrol.*, Sept. 1941, **12** (9), 80.—Eastern Ecuador has favourable structures and Cretaceous beds are present, but the isolation will be a problem if oil is discovered there. In the lower portion of the plateau country, between the two mountain ranges, seepages are present, but the intense folding and fracturing are unfavourable features. The coastal area involves Tertiary beds from which oil is produced, and towards the mountains there are Cretaceous possibilities. Although there are seepages and suitable structures in various areas, production is limited to the Santa Elena peninsula. In the shallow wells in the seepage area, oil comes from fractures. Oil is obtained from two Eocene horizons at 1200 and 3800 ft. Wells are erratic, and output from the wells depends on the amount of fracturing of the sandstones. Many of the deeper wells are long-lived. Water is absent in the shallow horizon and there is little gas.

During the past two years there has been an increase in exploratory activity, and the whole of the coastal area is covered by concessions for exploration or exploitation. Off-shore from Cabo San Francisco, there appears to be an important seepage.

Some description is given of the country and its people, and the main points of the mineral and hydrocarbon laws are noted. G. D. H.

34.* Growing Export Demand Stimulates Drilling in Venezuela. Anon. *World Petrol.*, Sept. 1941, **12** (9), 84.—In the first half of 1941 Venezuela's oil production averaged 563,766 brl./day, as compared with 508,000 brl./day in 1940. 27,000 brl./day of the increase was due to the Maracaibo fields, and 20,000 brl./day to Oficina. There are now 30 oil-fields in Venezuela, Santa Barbara and Guario having been added to the list this year.

Of the thirty-four wildcat operations in 1940, ten were abandoned, seven were brought in as producers, and nine were still being drilled at the end of the year. Four were being tested or cored.

30,000,000 brl. of oil were processed in Venezuelan refineries in 1940, 98·25% more than in 1939.

In the west the most important operations at present are in the Netick field, 42 miles north-east of Totumo. A well has been brought in for 500 brl./day of 28·1° A.P.I. oil. Las Ollas 1 in Central Venezuela may be completed as a distillate well. Rincon

No. 1, drilled to more than 9600 ft., has been completed as a producer. The Santa Ana field to the north has two producers giving 500–600 brl./day, while still farther north, at San Joaquin, 8000 brl. of oil/day are being obtained from fourteen wells. Guario has two producers and two wells ready for testing. Four wells are yielding 6000 brl. of oil/day at El Roble, and Santa Rosa provides 500–600 brl./day from one well.

60,000–70,000 brl./day are being shipped from Oficina by the 16-inch pipe-line. Early this year a 4000 brl./day producer was brought in at Santa Barbara.

G. D. H.

35.* Government Endeavours to Check Decline in Peruvian Production. Anon. *World Petrol.*, Sept. 1941, **12** (9), 88.—The Zorritos field gave 5500 brl. of oil during 1884 and had produced 3,287,000 brl. of oil up to the end of 1940. The producing sands lie at depths of 300–1700 ft. To the south are the Restin–El Alto and Lobitos fields, which have yielded more than 49,060,000 brl. of oil. There the producing horizons are at 1500 ft. and 2800–3200 ft., and a third horizon is being explored below 5000 ft. The most important Peruvian oil area is the La Brea–Parinas estate still farther south. Commercial production began about 1890, and up to the end of 1940, 211,962,000 brl. of oil had been obtained. Quaternary beds partly cover Tertiary sandstones, shales, and conglomerates, interbedded with which are oil-sands. The broadly folded rocks have been affected by many faults, giving rise to numerous blocks dipping at 5–35°, and commonly towards the east. Oil occurs at various horizons from 300 to 5000 ft. There are unconformities, with the consequent masking of the structure of the older beds in places.

From 1906 to 1915 some 286,000 brl. of oil were produced in the Pirin field of the Lake Titicaca district. Five wells have been drilled in the Agua Caliente area of eastern Peru, and initial outputs of 500–2000 brl./day were obtained from a depth of about 1100 ft.

The total oil output of Peru has declined since 1937.

The history of some of the oil development is briefly outlined, and the economic position and some of the activities of the oil companies are described. G. D. H.

36.* Tempo of Development Maintained in Colombia. E. Ospina-Racines. *World Petrol.*, Sept. 1941, **12** (9), 94.—From 1st Jan., 1939, to 30th June, 1941, twenty-eight wildcats were drilled in Colombia. Fifteen were abandoned, and of the six which found oil, only one exceeded 50 brl./day. Casabe No. 1 had oil and gas showings.

Tables give the wildcats drilled between 1st Jan., 1939, and 30th June, 1941, and the results obtained; the numbers of wells on the Barco and De Mares concessions; the production and disposal of the oil from these two concessions in 1940 and the first half of 1941; some of the properties of the oils from the Barco and De Mares concessions; the oil industry's contributions to the Colombian Government in 1939; the cost of locating a drilling rig in the Upper Magdalena Valley and of exploration and drilling in certain concessions. A map shows the concessions. G. D. H.

37.* Two Thousand Four Hundred Brl. Well 30 Miles North of Coalinga Opens Important New California Area. Anon. *World Petrol.*, Sept. 1941, **12** (9), 100.—In June 1941 a test in a well near Raisin City gave oil at a rate of 2400 brl./day from a Miocene sand at 5021–5049 ft. After sand trouble the well was finally finished with an output of 750 brl./day of 23·5° A.P.I. oil. The drilling followed intensive geological and geophysical studies. The first well was drilled to 6429 ft., and plugged back for 15,000,000 cu. ft. of gas/day from the Miocene at 5005–5045 ft.

The Raisin City anticline trends north-west, and lies on the east side of the main San Joaquin Valley syncline. Continental sands and clays form the first 3800 ft. of beds, followed by 600 ft. of rather coarse marine Miocene sands. From 4400 to 6000 ft. there are continental Miocene green and brown mottled clays with thin sand streaks, and the present production is from sands at about 660 ft. below the top of this interval. The Kreyenhagen shales lie at 6000–6300 ft., and below are Eocene sands.

G. D. H.

Drilling.

38.* Well-Drilling Methods. J. J. Conry. *Oil Wkly*, 3.11.41, **103** (9), 63.—This issue of the *Oil Weekly* reviews the petroleum industry over the last twenty-five years, and in this paper drilling methods and their modification in twenty-five years are discussed.

Even a casual backward glance over the past twenty-five years in oil-well drilling recalls two conflicting situations. One is the striking contributions of the scientist and the engineer to remarkable improvements in drilling equipment and methods. The other is the unmistakable fact that fundamentally methods have not been changed, merely refined. A typical example illustrating both points is the cable-tool rig.

Progress in cable-tool and rotary rigs and in mud systems is reviewed. A. H. N.

39.* Drilling Equipment. Anon. *Oil Wkly*, 3.11.41, **103** (9), 77.—In an extensive paper the development in drilling and production equipment over the last twenty-five years is reviewed. Derricks, prime movers, hoisting equipment, rotation mechanism, drilling strings, rotary mud systems, drilling control equipment, cable-tool drilling, directional drilling, coring improvements, cavings, etc., are studied separately.

In cementing, recently, a device for measuring and recording the irregularities and cavities in open holes has proved helpful in determining the amount of cement required to fill a given distance behind the casing. Some surprising variations in diameter of holes have been found in some formations, which probably accounts in many instances for the previous failure of cement to rise behind the casing as far as calculated.

In recent years there has been a growing use of gravel packing as a means of protecting screens against clogging, crushing, or excessive cutting action. Gravel packing is applicable either with perforated casing or screens, or by prepacked liners that have made their appearance on the market.

A recent innovation in completion practices has been the use of acid-soluble and drillable pipe sections. Set opposite upper producing zones, they provide a means of easily and efficiently opening them up for production at later dates.

In production similar treatment is given to various items of equipment. Several new pumping methods have been introduced. One is a hydraulically-operated rodless pump that is gaining much favour in the last few years. Oil pumped under pressure from the surface down a small tubing string actuates a bottom-hole pump. Submergible electrical centrifugal pumps, in which a motor placed in the hole is supplied with electric power through special cables from the surface, have been developed and used successfully in many regions. A. H. N.

40.* Fluorescence Analysis of Drill Core has Wide Possibilities. J. de Ment. *Oil Wkly*, 17.11.41, **103** (11), 62.—Petroleum and a variety of mineral species may be detected by the fluorescence they exhibit as ultra-violet light. Recently scheelite (calcium tungstate) was detected by the fluorescence of cores obtained in prospecting an antimony deposit in Idaho.

Petroleum generally fluoresces a characteristic blue or shade of blue; zinc minerals vary in their fluorescence, but uranium is practically always characterized by a yellowish-green response. The fluorescent test is very sensitive.

Some details are given of the fluorescence shown by tungsten, zinc, uranium, and mercury minerals, and by petroleum and its derivatives. G. D. H.

41.* Improvements Continue in Drilling and Production Practices in California. T. P. Sanders. *Oil Gas J.*, 30.10.41, **40** (25), A 30.—In an extensive paper drilling and production practices of California are reviewed. California uses the world's largest drilling equipment. One rig, owned by the Superior Oil Co., makes use of five 130-h.p. locomotive-type boilers which deliver superheated steam at 500-lb. pressure. It is believed that this is the first instance in which steam pressures of more than 350 lb. have been used in the drilling industry. At 500 lb. pressure the saturated steam temperature is 467° F., and with 100° of superheat the steam is hot enough to char wood. Under heavy firing the five boilers are capable of delivery power to the hoist-engine and pumps at the rate of about 1500 b.h.p.

Continental Oil Co. uses a large unitized steam-generating plant consisting of two marine-type water-tube boilers with complete facilities for condensing all the exhaust steam for return to the boilers. The water-tube boilers are 13 ft. in over-all height and 8 ft. wide, but each is guaranteed to deliver at least 17,500 lb. of steam/hr. at 350 lb. pressure. Based on heating surface alone, each boiler is rated at 175 b.h.p., but under efficient firing the rating is exceeded by 310%, and with excessively heavy firing even more power could be developed. The plant is given in detail. Other systems of steam-generating plants are also described.

One new type of screen for removing sand and cuttings makes use of a large drum which is wrapped with wire around the outside to form fine slots. It is rotated and vibrated by an electric motor. Mud enters the inside of the drum through a hopper-like arrangement and passes through the mesh into a lower trough. Rollers at the top of the drum, made of rubber and fabric, force cuttings that become lodged in the slots back into the drum, so that they can be discharged from the interior with the other cuttings.

A number of California rigs now use a type of centrifugal desander in which the fluid is pumped in at high velocity by a motor-driven centrifugal pump located outside the mud-chamber. In circulating within the chamber the sand is driven to the outside, so that it finds its way downward to the bottom of the cone-shaped vessel, where it is taken off through an orifice of selected size. A small jet of water just above the orifice helps to wash the sand from the mud. A small but steady stream of sand, so fine that it has passed through the vibrating screens, is thus removed from the bottom of the chamber with little escape of mud. Testing and pumping mud are described in some detail.

A new type of derrick is widely used in California and in those foreign fields for which equipment is ordinarily purchased in California. It is a 136-ft. derrick with a bulge on one side extending from the third girth to a point above the fourble board. This bulge makes it possible to place three or four more rows of drill-pipe back of the finger-board. Thus the 136-ft. derrick provides about as much pipe-racking space as the 150-ft. derrick of standard design.

Weight control, use of internal-combustion engines, electric rigs and types of bit and hole size are discussed separately, new practices being pointed out. Bulk cementing, a new process, and new methods of improving cement bonds are given.

A new completion method is described where gas oil is squeezed under 900 lb./sq. in. into the formation. After completion of the washing and squeezing operation, the well was swabbed in the tubing for nearly 12 hrs. During this swabbing the casing pressure built up to 500 lb., and flow through the tubing started against a back pressure of 140 lb. The well was found capable of flowing unaided at a rate of 100 brl./day of 31-gravity oil through a 10/64-in. surface choke—a considerable improvement on the former production. Thus it appears that a new practice has been developed which make take its place beside acidizing and shooting as a means of increasing production.

Other production practices are given. A. H. N.

42.* Causes and Prevention of Drill-Pipe and Tool-Joint Troubles. Part 1. R. S. Grant and H. G. Texter. *Oil Gas J.*, 6.11.41, **40** (26), 161. *Paper Presented Before American Petroleum Institute.*—It is stated that true twist-offs, spiral tears, and tension failures have been practically eliminated by improved pipe manufacturing and drilling practices. Failures at the last-engaged thread and leakage through threads have also been practically eliminated through improvements in design and in installation methods.

Fatigue breaks are the most common type of drill-pipe trouble to-day. They may be pure fatigue failures, but more often are accelerated by notches or scars and by corrosion. Fatigue breaks may be greatly reduced by the use of adequate drill-collar weight, and this is probably the most important recommendation that can be made to increase the life of drill-pipe.

Troubles arising from worn pipe can best be prevented by keeping the pipe straight. Pipe is usually made crooked by running the string in compression. Collapsed pipe, although rare, usually occurs while making drill-stem tests. Wall eccentricity, internal erosion, and magnetism, although often discussed, have never been proved to be causes of drill-pipe failures.

Longitudinal splitting of the pipe-ends of tool-joints has been practically eliminated by the use of upset forgings. Splitting or swelling of the pin and box-ends can be prevented by the use of special lubricants. Galling and wobble failures are the two most common tool-joint troubles to-day. The former can be prevented by careful breaking in and adequate lubrication.

Wobble failures result from operation of the joint while loose, and aggravated by the modern practice of running drill-strings in tension. The best method by which these can be prevented is by adequate tonging and by care in handling to prevent damage to shoulders.

Tool-joint wear cannot be prevented, but the effects and costs entailed can be minimized by the use of easily replaceable tool-joints, oversize tool-joints, or wear-subs, and by resleeving or hard-surfacing of either the tool-joints or subs. A. H. N.

43.* Drill-Pipe and Tool-Joint Troubles—Their Causes and Prevention. Part 3. R. S. Grant and H. G. Texter. *Oil Gas J.*, 20.11.41, **40** (28), 51. *Paper Presented Before American Petroleum Institute.*—This forms the conclusion of the paper. The discussion on handling and correct use of drill-pipe and tool-joint is concluded by a series of summarized hints and advice collected from field experience and observation.

A point often forgotten is that a drilling string may sometimes be subjected to abuse merely in one well, or by only one crew, and later used normally ; but troubles may continue to develop throughout the rest of its life. A simple example would be where one crew, being very careless in stabbing, damaged a number of the tool-joint box shoulders. This could lead to a succession of wobble failures and mud cutting throughout the whole string. A. H. N.

44.* Plugging-Back by Squeeze-Cementing in Open Limestone Formation. I. V. Tuyl. *Petrol. Engr*, Oct. 1941, **13** (1), 29–30.—This type of work has hitherto been hampered owing to the lack of a cement retainer that would remain " tight " when set in an open formation. The success obtained in the method now being employed is largely dependent, therefore, on the improved cement retainer designed for this type of cementing. This improved retainer has now been used on a total of six jobs without a single failure on the part of the retainer itself.

The retainer designed for the initial trial described in this paper consisted of a rubber element 5¾ in. in diameter and 30 in. long, to be run in a 6¼-in. hole. This packing element is collapsed vertically and expanded horizontally by raising the tubing when the retainer is at the desired depth in the well. A mandrel above the packing element causes the slips to expand horizontally, thus engaging the formation.

When a packing element is collapsed by the weight of the tubing, the total force is limited by the dead weight of the pipe in the medium in which it is suspended. When collapse is obtained by raising the tubing, as in the retainer, the force limit is determined only by the tensile strength of the pipe. For example, in a 3900-ft. well employing 2-in. external-upset tubing, the total weight available for collapsing the conventional packer is approximately 18,000 lb. in air or 15,600 lb. in water. On the other hand, the strength of Grade D (A.P.I.) tubing is 37,000 lb., assuming a safety factor of 2½. Also, when a packing element is collapsed by tensile stress in the tubing, any pressure applied below the element will cause it to set more tightly, rather than to move upward, as in the conventional packer.

An additional and important advantage is that no anchor is required below the retainer, and consequently the cement plug may be drilled out with greater ease.
A. H. N.

45.* Directional Drilling as a Routine Method of Development. W. A. Sawdon. *Petrol. Engr*, Oct. 1941, **13** (1), 36.—Operations in a tide-water lease lying entirely under the Pacific Ocean at Huntington Beach, California, are described. The average elapsed drilling time per well has been 34 days. Regardless of the depth, it has been found that it takes approximately the same number of days to drill any well on this particular lease. The reason is that the deeper wells extend over a greater horizontal distance and require greater angles ; in building up the higher angles, more weight has to be applied, and in using greater weight, faster hole is made. In drilling some of the wells the rate of penetration has averaged 150·8 ft./8-hr. working day. In drilling the thirty-eight completed wells there has been a gain of 4878 ft. of oil-sand, or an average of 128 ft./well.

All holes are drilled with a gradual build-up to the maximum angle of deviation, and every change in angle or direction is made with a smooth curve, to eliminate any chance of "dog-legs" that might eventually make trouble in running casing, or cause wear on rods and tubing when the well is put on the pump. This necessitates constant attention to the instrument that indicates and records the weight on the bit, the speed of rotation, the mud pressure, and the torque on the drill-pipe, as control of the drift angle is made possible by regulation of these factors.

Whipstocks are used mainly to change direction, as regulation of weight on the bit, speed of rotation, and pump-speed will definitely control the drift-angle. In this field it is the natural tendency of formations to control direction of drift and to raise and lower the angle from vertical. When building up the angles, the hole tends to go to the right; when lowering the angle, it tends towards the left.

In some wells only one whipstock has been necessary, all other controls being obtained with weight, table speed, and pump. The whipstock employed is of the removable type, and in drilling thirty-eight wells, 168 of these whipstocks have been set, an average of 4·4 per well. The average depth drilled per whipstock has been 1102 ft. In drilling at an angle of 52° from vertical the maximum turn-off from a whipstock is approximately 5° in direction, but in drilling these high-angle wells the average turn-off taken is about 3°, in order to make sure that no abrupt bends will result and cause friction.

The wells that are to bottom at sand locations closest to shore are drilled vertically to 750 ft. and the surface string there cemented. The first whipstock is then set at approximately 820 ft. The wells drilled farther out below the ocean are kept vertical to only 200 or 225 ft. and a whipstock is there set to start deflection. These holes usually build up to 12° from vertical before the surface string is run at approximately 750 ft. In all wells the drift angle is built up to the maximum within the first 2400 ft. of depth. In doing this it is endeavoured to build 2° 30′/100 ft. of depth.

The tools used in building up to maximum angle consist of the bit, a 5-ft. reamer, and an 8-ft. drill-collar. After reaching the maximum drift-angle the drill-collar is increased to approximately 30 ft., as this length will hold the maximum angle better.

Tabulated data give many exact details required in successful directional drilling.

A. H. N.

46.* Cementing and Completion Methods in Trinidad. P. E. T. O'Connor. *Petrol. Engr*, Oct. 1941, **13** (1), 83.—The excessively high pressures encountered in Trinidad at relatively shallow depths necessitate the use of drilling mud weighing as much as 135 lb./cu. ft., and occasionally as high as 140 lb./cu. ft. when drilling to the Lower Cruse sands. Even in the Forest and Upper Cruse sands it is often necessary to carry mud weighing 120–130 lb./cu. ft. Mud technique in Trinidad has therefore had to be developed to a very high order. All the major companies employ a mud specialist, with the required number of assistants, who is responsible for research as well as routine tests on drilling mud at the wells. Central mud plants are installed in all active areas where muds of various specifications are reconditioned and supplied to the drilling wells through a system of pipe-lines.

Viscosity control of these heavy muds is the principal problem, but with proper supervision even the heaviest muds employed can be maintained at a viscosity of 25–50 sec. (Marsh funnel, 1000 c.c. in and 500 c.c. out). The maintenance of low viscosity has proved to be the greatest single factor in reducing gas-cutting and the risks of blow-outs, and the saving in barytes consumption has been enormous.

The most general completion method adopted at present is to cement 6⅝-in. casing through the oil-zone and gun-perforate at the selected points. The 6⅝-in casing is run in 8⅝-in. or 8½-in. hole, and it is also usual to run 28-lb. pipe opposite all sands that are likely to be gun-perforated later, irrespective of depth.

This string of casing is invariably run with a down-whirler cement shoe and a cement float-collar, or some form of back-pressure valve one joint above the shoe. The use of wire wall-scratchers and other forms of centring device on the casing has not been generally adopted, but various trials of such equipment have been made. Most companies operate their own cementing truck equipped similarly to those of cementing companies in the United States. There is also one privately owned cementing company that operates two units. This company serves several of the smaller operators and wildcat wells, and also obtains a good deal of work from the larger companies during busy periods.

Cement is mixed through a hopper by pumps mounted on the cementing truck, and is pumped down by the drilling pumps. In placing the cement, some operators accurately measure the mud pumped behind the cement from specially installed tanks; others merely rely on the stalling of the pumps as an indication that the plug has reached bottom. A Halliburton measuring line is, however, run on practically all jobs.

The technique of squeeze cementing has proved very effective in Trinidad, and squeeze jobs of various types are carried out to shut off water, either as an initial completion practice or in later repair work. Owing to close proximity of the oil and water sands and the lack of good shale-breaks, it is considered good practice in many instances to carry out a squeeze job on any doubtful section of the hole immediately after the original cement job has set. A. H. N.

47.* Mechanical Rigs Well Adapted for Hazardous Foreign Service. W. A. Sawdon. *Petrol. Engr*, Oct. 1941, **13** (1), 90.—A great many wells being drilled in various countries are exploratory wells. Considering the transportation facilities to these wells, diesel engines are probably more widely used than gasoline engines, because diesel fuel is more easily transported and handled. There is a tendency at present to use for foreign operations engines that are convertible from diesel fuel to gas, gasoline, or butane. Butane has not yet been used extensively because it can seldom be obtained, but the advantage of changing over to gas or gasoline is obvious when the engine is put into service where such fuels are economically available. When a wildcat well drilled with diesel power becomes a discovery well, the equipment is then available for development purposes with whatever fuel is most economical. Mechanical rigs originally exported for development work in proved fields will obviously be powered by engines using the most economical fuel.

Air transportation is briefly mentioned. The mobility of a modern mechanical rig is its most outstanding feature.

There is an inclination to rate a power-rig by the horse-power of the prime movers. Although this may be considered as an index, it must be remembered that the transmission and brake capacity are definite factors in determining the capacity of the rig. Circulation requirements will vary under different conditions, and different pump capacity must be provided. Reserve power may sometimes be necessary for draw-works performance as well as for driving additional pumps. Additional engines can be installed to meet certain operating conditions at one location, and may advisably be removed during the drilling of another well. By proper compounding, the power of any one, of all, or of any number of the engines may be applied to the draw-works or to the pumps, and the power thus distributed to meet the requirements at any period during drilling operations. A. H. N.

48.* Methods of Conducting Marine Operations on Lake Maracaibo. W. A. Sawdon. *Petrol. Engr*, Oct. 1941, **13** (1), 101.—The derricks at all the Lago's lake locations are supported by reinforced-concrete piles (either square, solid, or round caisson type), but the derrick floor, with a cantilever extension for the engine, is very much like that of an ordinary land location. All other facilities for drilling the well, however, are provided by barges. As soon as a well has been rigged up, a drilling barge is moved alongside and anchored with its forward end parallel to the side of the floor of the derrick. At the stern of this barge are four 300-lb. boilers which supply steam to the engine through a hose connection between barge and derrick. The mud-pumps, generally two 15½ by 7¾ by 20, which are on the barge directly ahead of the boilers, are also supplied with steam from the barge boilers.

The forward part of the barge has two decks, the upper serving as a pipe-rack, from the front of which a ramp extends to the derrick floor. Below the upper deck are storage compartments for drilling mud and fuel oil. Around the lower deck is a steel settling ditch, through which the returns pass after coming from the well through a large-diameter hose. A shaker screen is so arranged that it can be put in or taken out of the mud-stream as desired.

A mud-barge equipped with two 250-brl. tanks is used to replenish the mud supply on the drilling barge when needed, and for carrying back to land any spent mud containing oil or any other foreign matter that might contaminate the lake-waters.

This mud-barge and a similar barge carrying fuel oil is towed to the drilling operations by a power-boat or launch. A separate barge (35 ft. by 80 ft.) is used for cementing operations. It has a sheet-iron house to provide protection for the cement while the barge is being towed to a job. A belt conveyor runs through the centre of the house and transfers cement in bags to a platform. A knife in the platform automatically slits the paper bags, and the loose cement is deposited in a mixing hopper that feeds the 12 by 6¾ by 14 slurry pumps. Three of the slurry pumps are mounted on the barge, any two of which can be compounded to discharge at a pressure of 1100 lb./sq. in.

In operation the cement barge is moored alongside the drilling barge, and the steam-head on the drilling barge is connected by a flexible hose connection to the steam-header on the cementing barge. The discharge header on the slurry pumps is connected by a drilling hose to the well. After the slurry has been pumped into the casing, it is displaced with drilling mud by the mud-pumps on the drilling barge.

Other barges and equipment are described. A. H. N.

49.* Drilling and Production Methods in Western Canada. H. E. Denton. *Petrol. Engr*, Oct. 1941, **13** (1), 140.—An historical sketch is given. Drilling, since the discovery of crude oil in Turner Valley, has been almost exclusively with heavy-duty steam rotary rigs with 136-ft. derricks. Water supply is very abundant from three rivers originating in the mountains. This water is excellent boiler-water, and consequently a minimum treating expense is necessary. High-pressure gas is also plentiful from the separators of producing wells.

An average time of 6 months is required to drill and complete one of these wells, and during that time an average of 200 rock-bits are used to the lime and thirty-five to forty while drilling the lime. The usual tool-joint replacement per well is 33⅓% and, with proper care, drill-pipe, before abandonment, can be expected to drill 40,000 ft. of hole. Beyond that point the limit of fatigue is exceeded, resulting in an excessive number of twist-offs. This short life of drill-pipe and tool-joints is explained by the extremely hard formations from the surface down and the large number of trips per well. Because of the large number of trips, the hoist and other corresponding moving parts are subjected to much wear.

The casing programme consists in normal cases of 600–700 ft. of 13⅜-in. surface casing, cemented solid to the surface, and a string of 7-in. O.D., 26-lb. production casing set on top of the limestone cemented to approximately 3000 ft. from bottom up. In the drilling of the 9-in. hole into which the 7-in. casing is set, little trouble is experienced with regard to casing, sloughing, etc.

The mud problem is quite simple. The only mud added to the circulating system is that at the time of beginning the hole and setting surface casing. From then on the bit makes its own required mud. No weighting material is needed because of the depth at the time the producing horizon is penetrated.

Many completed wells produce no oil, nor will they build up any gas pressure until given a series of acid treatments. A total of 10,000–20,000 gals. of acid is usually used in a series of acid treatments; in some extreme cases more than 40,000 gals. have been used. The average well, after final acidization, usually produces 500–900 brls./day as flush production and is capable of maintaining a steady daily rate of 30–40% of this initial flow. Most wells, however, do produce a little oil before acidization, but a very small flow is expected, perhaps 100–200 brl. The percentage of completions that result in dry holes is extremely low, although many wells are relatively small.

Following the final acidization most wells flow very steadily and with a gas–oil ratio of about 1000 cu. ft./brl. This gas–oil ratio gradually increases proportionately with the total oil withdrawn. The rate of withdrawal also has a pronounced effect on gas–oil ratio.

The wells are tubed to bottom with either 2½-in. or 3-in. upset tubing, and the well control heads, for the most part, are made up of the consolidated-type equipment with flanged connections, and are usually 4000-lb. test. The tank-farms are equipped with high-pressure separators, enough storage to provide gauging facilities, gas-meters for measuring the tail-gas, a "dog-house" in which the meters are installed and records kept, and a boiler for heating purposes. The oil is heated only to 70° or 80° F. before delivery to the pipe-line. As there is no water in the oil, the only heat required is that necessary to meet pipe-line specifications. The object is to maintain constant temperature on the line all the year round. A very satisfactory oil gathering system is available. A. H. N.

50.* Methods of Plugging Wells with Cement in Iraq and Syria. M. W. Cook. *Petrol. Engr*, Oct. 1941, **13** (1), 160.—The Kirkuk field lies approximately 75 miles south-east of the city of Mosul and 150 miles north of Baghdad. In this field there are three domes on the crest of the anticline, two of which, the Baba Gurgur and Avanah, produce oil; the third, Khurmala, produces gas. The two oil-domes are considered to be continuous, and form a structure approximately 60 miles long and 4 miles wide. The wells can produce as much as 130,000 brl./day flowing through 6-in., 4-in., or 3-in. flow-lines with a hydrostatic pressure of approximately 200 lb./sq. in. The depths of the wells range from 1700 to 2700 ft. As the entire field is controlled by one company, operations have been designed to produce the oil as efficiently and economically as possible. Although wells to determine the limits of the field have been drilled, production has been confined to a small area on the crest of the main dome, and the other wells have been used as observation and control wells. The few wells produced were fully adequate to provide maximum capacity of the pipe-lines to the Mediterranean coast. How much oil is being produced and transported through the pipe-lines at present is not known.

A few months before the war began it was ordered that all but two wells in the Mosul area be cemented. None of the wells in this area was equipped with tubing; the wells were produced through the casing. Another advantage to the cementing operations was that the lime formation took fluid at 50–1000 lb./sq. in., and so eliminated the use of a portable derrick and the running of tubing to displace the cement-plug. Consequently, a plug-holder cement-head was built to hold two top plugs. One plug was released and followed by a batch of cement slurry consisting of about 10 sacks. The top plug was then released on top of the cement and displaced with water to within 50 ft. of the bottom of the casing. The cement was allowed to set for 3 days, after which the master gates were opened to test the plug. If it was found to be holding, the well was bailed by hand to a point 10 ft. below the master gate. Here another top cement-plug was pushed down to the top of the fluid, and was followed with enough cement to fill the casing to the master gate. When this operation was finished, the master gate was removed and a solid iron plate bolted to the casing flange.

Arab crews, under the supervision of Roumanian and Polish drillers, followed behind the cement crew and filled in the rig cellars to obliterate all traces of an oil-well. Flying over these locations some months later, the majority of the sixty-one wells thus treated were not discernible from the air. A. H. N.

51.* Current Methods of Driving Concrete Piles at Lake Maracaibo. W. A. Sawdon. *Petrol. Engr*, Oct. 1941, **13** (1), 165.—As drilling operations in this area are done in the lake-pile, supports are used. Until a little more than two years ago all piles employed for this purpose were of the solid, square, reinforced-concrete type; but as development of the lake fields continued wells have been located farther from the lake shore and in deeper water. The solid concrete piles have been used successfully in depths as great as 60 ft., the piles being as long as 133 ft. The true lake bottom, which is hard shale, is covered with a mud silt that varies in thickness from practically nothing to more than 100 ft., and in order to overcome the conditions found in deep water a tubular or caisson type of pile was developed. To date, this type of pile has been used for derrick foundations only, as other structures on the lake have not been constructed in the deeper water.

All piles are pre-cast at a plant at La Salina situated in the northern part of the lake fields. The solid, reinforced piles are made in three sizes: 16 in., 20 in., and 24 in., the 16 in. for lengths up to 70 ft., the 20 in. for lengths of 70–100 ft., and the 24 in. for lengths greater than 100 ft. The piles are transported to the location on barges, and are there driven by a pile-driver. For derrick foundations there are three piles—two plumb and one batter—at each corner. The number and arrangement of piles for other structures depend on the size and loads to be supported.

The pile-driver crane has a capacity of 59 tons on a 30° angle. The leads can swing 90°, thus providing for the driving of batter piles front, back, or on either side. Only one move of the driver barge is necessary in driving an entire derrick foundation. The piles are picked up from the carrying barge by a crane on the driver barge.

Operations are performed with steam supplied by boilers on the barge, which are fired with fuel oil.

After the piles are driven, they are stripped to elevation and capped with reinforced concrete. On this cap a 24-ft.-square steel base is set and grouted-in and the derrick erected.

Derricks in deep water built on caisson-type foundations have one of these tubular-type piles at each corner. The hollow piles are 60 in. in diameter and are cast in 15-ft. sections. Each section consists of a steel inner lining encased in a 5-in. sheath of concrete strengthened by spiral steel reinforcement. The steel inner liner is made up of two half-cylinders welded together longitudinally to form a cylinder, which is centred in a cylindrical concreting form. The annulus between the steel cylinder and the form is poured with concrete after the spiral reinforcement has been set in place, the section being on end and the concrete subjected to vibration during pouring to ensure complete and smooth placement. After removing the form and curing the concrete, the number of sections required to provide a desired length of pile are welded together at the steel and grouted at the concrete. At the bottom of each pile thus made is a concrete shoe 5 ft. in length and conical in shape, that forms a point to facilitate passage through the mud and penetration into the harder formation at the bottom of the lake. A. H. N.

52. Patents on Drilling. L. C. Beers. U.S.P. 2,255,754, 16.9.41. Appl. 8.3.39. Multiple record electrologging of wells.

R. A. Lillich. U.S.P. 2,256,119, 16.9.41. Appl. 21.10.38. Back-pressure valve in combination with a drill-stem.

T. J. Crawford. U.S.P. 2,256,455, 16.9.41. Appl. 30.3.40. Oil-well casing of a thin-walled type.

E. J. Turner. U.S.P. 2,257,080, 23.9.41. Appl. 10.10.39. Drill-pipe cleaner for cleaning the inside of drill-stems.

A. Boynton. U.S.P. 2,257,101, 30.9.41. Appl. 30.6.39. Threadless drill-pipe.

P. E. Harth. U.S.P. 2,257,114, 30.9.41. Appl. 22.8.36. Application of drilling fluids containing surface-treated iron particles resistant to oxidation.

C. A. Lundeen. U.S.P. 2,257,120, 30.9.41. Appl. 3.10.39. Well-pipe support in an elevator.

S. Evans and R. S. Grant. U.S.P. 2,257,335, 30.9.41. Appl. 5.5.40. Tool-joint welding.

G. Knutson. U.S.P. 2,257,418, 30.9.41. Appl. 31.3.38. Detachable bit rock-drill.

W. R. Coleman. U.S.P. 2,257,733, 7.10.41. Appl. 29.10.38. Apparatus for drilling terrestrial bores.

D. Scaramucci. U.S.P. 2,257,765, 7.10.41. Appl. 30.9.39. Cementing device for well-casings.

L. C. Chamberlain. U.S.P. 2,258,001, 7.10.41. Appl. 23.12.38. Subterranean boring into calcareous formation by means of hydrochloric acid.

A. C. Catland. U.S.P. 2,258,352, 7.10.41. Appl. 27.11.39. Core-drill for use on tubular rotary wells drilling strings.

S. Evans. U.S.P. 2,258,751, 14.10.41. Appl. 27.4.40. Method of making welded tool-joints.

J. S. Morgan. U.S.P. 2,258,785, 14.10.41. Appl. 29.4.39. Draw-works.

J. C. Fortune. U.S.P. 2,258,887, 14.10.41. Appl. 5.2.40. Stuffing-box.

R. O. Laird. U.S.P. 2,258,934, 14.10.41. Appl. 7.11.40. Oil-well rack device in combination with a derrick.

N. D. Allen. U.S.P. 2,259,191, 14.10.41. Appl. 27.9.39. Stem for core-drills.

A. R. Hopkins. U.S.P. 2,259,206, 14.10.41. Appl. 20.2.39. Cathead for drilling apparatus.

A. J. Hodge. U.S.P. 2,259,223, 14.10.41. Appl. 15.2.39. Rotary machine.

A. J. Hodge. U.S.P. 2,259,224, 14.10.41. Appl. 22.1.40. Drill-stem drive device.

A. L. Stone. U.S.P. 2,259,232, 14.10.41. Appl. 17.8.38. Well pipe-joint.

D. G. Hefley and J. G. Standt. U.S.P. 2,259,419, 14.10.41. Appl. 23.10.37. Well drilling with a drilling fluid.

W. P. Holland. U.S.P. 2,259,564, 21.10.41. Appl. 2.7.40. Means and method of removing casing from wells.

R. A. Perkins. U.S.P. 2,259,775, 21.10.41. Appl. 3.2.41. Cement bag cutting means in combination with a pair of tables.

B. F. McNamee and F. Rieber. U.S.P. 2,259,904, 21.10.41. Appl. 17.1.38. Method and apparatus for lagging bore-holes.

J. E. Hoffoss. U.S.P. 2,260,320, 28.10.41. Appl. 23.11.40. Coring apparatus with a latching mechanism for a wire-line core-barrel.

W. L. Childs. U.S.P. 2,260,366, 28.10.41. Appl. 12.3.40. Reamer for rotary well-drilling.

F. L. Scott. U.S.P. 2,260,487, 28.10.41. Appl. 27.2.40. Fluid deflector for well-drills to deflect fluids away from the bearings of cutters.

F. B. Williams. U.S.P. 2,260,499, 28.10.41. Appl. 16.5.38. Application of mud-laden or drilling fluid.

L. Dillon. U.S.P. 2,260,562, 28.10.41. Appl. 13.12.37. Process and apparatus for core sample orientation.

H. W. Cardwell. U.S.P. 2,260,604, 28.10.41. Appl. 27.10.38. Well-drilling machine which is portable and comprises a tractor.

I. S. Salnikov. U.S.P. 2,261,292, 4.11.41. Appl. 25.7.39. Method for completing oil-wells.

L. A. Layne. U.S.P. 2,261,441, 4.11.41. Appl. 4.2.39. Cementing machine with a concrete mixer and conveyor, including a centrifugal pump.

A. B. Lore. U.S.P. 2,261,501, 4.11.41. Appl. 3.3.41. Bearing destroyer for rock-bit cutters.

W. W. Gipson. U.S.P. 2,261,546, 4.11.41. Appl. 8.12.39. Shrouded drill-bit.

S. Robichaux and G. J. Barrett. U.S.P. 2,261,564, 4.11.41. Appl. 9.5.40. Method of removing stuck-pipe from wells.

H. W. Russell and H. A. H. Pray. U.S.P. 2,261,566, 4.11.41. Appl. 31.5.40. Protector ring or coupling for pipe joints.

W. M. Schultz. U.S.P. 2,261,570, 4.11.41. Appl. 11.7.39. Cothead.

D. Hering. U.S.P. 2,262,934, 18.11.41. Appl. 10.6.39. Well-surveying method for determining the path of a bore-hole.

R. W. Stuart. U.S.P. 2,263,108, 18.11.41. Appl. 16.7.40. Logging wells during drilling using ultra-violet light on the mud stream to detect oil which may be present.

E. J. Protin. U.S.P. 2,263,223, 18.11.41. Appl. 12.3.40. Thread protector.

G. A. Nichols. U.S.P. 2,263,364, 18.11.41. Appl. 23.10.39. Cementing bracket in the form of a well-casing elevator.

A. H. N.

Production.

53.* Voluntary Crude-Oil Curtailment in California Effective. A. H. Bell. *Oil Gas J.* 30.10.41, **40** (25), A 46.—Proration problems are discussed and the " uniform formula " is given as the engineer's answer to these problems. It recognizes the marginal well; it recognizes, too, that a prolific flowing well can bear a greater percentage of curtailment than can a small settled well; and that there is a maximum limit more than which no well should produce.

With the minimum depth allowable, the marginal well is permitted to produce without restriction. The Conservation Committee designates the marginal well as one the potential of which is less than the total exemption provided under the minimum formula for the particular depths, the exemption itself having been developed after consideration of several factors. The most important of these is the average lifting cost, which is relatively high on a per-barrel basis, since all of these wells are pumpers, so that the exemption provides a " living wage " for many wells which would otherwise be forced off production, with the resultant loss of reserves.

The minimum-allotment provision of the uniform formula gives each well not less than 10 brl./day, if it is capable of that amount of production, and, in addition, gives each well an allotment based on depth. The depth minimum now provides for an allotment of 5 brl. for the first 1000 ft. of depth; 5 brl. plus 0·75 brl. for the second 1000 ft.; 5·75 brl. plus 0·75 brl. or 6·50 brl. for the third 1000 ft., and so on. In the actual application of the depth minimum, fractions are discarded and whole numbers are used, a table being constructed so that the wells within a given depth range receive the same minimum. For example, a well at 5583 ft. would receive 37·5 brl./day under the formula, whilst one at 5695 ft. would receive 38·5. The tables give wells between these two depths 38 brl. minimum allotments.

The second step in the formula is commonly known as the sliding-scale-percentage curtailment, and is the curtailment applied to the potential remaining after the minimum allotment is deducted. This curtailment is applied to all intermediate wells, which are defined as those wells falling between marginal and top classifications, on the same principle as that of income taxation—namely, that the percentage of curtailment increases as the production increases, on the theory that prolific wells are best able to bear the burden of curtailment, as wealthy individuals are of taxation. This method is a refinement of the straight percentage method, and avoids the tendency of the latter method to allocate a disproportionate share of the total allotment to flush-wells.

The third step in the uniform formula is the application of the top allowable, which is arbitrarily set by the committee at its monthly meetings, and which has been reduced from 250 brl. per well in June 1939, when the formula went into effect, to 143 brl. in October 1941. This allotment is given to each well capable of earning it under the formula. A. H. N.

54.* Improved Method of Installing Liners at Raisin City Field. T. P. Sanders, *Oil Gas J.*, 30.10.41, **40** (25), A 92.—A new method, developed to meet severe sand conditions, has been evolved after several failures. The patented method used for the final successful completion is unique in that the liner is run on tubing. Following this step, and without removing the tubing, the bottom of the hole is washed out, the well is washed in by circulating fluid or gas around the liner, the packer at the top of the liner is expanded inside the casing shoe, the christmas tree is installed, and the tubing is hung in final position, all without killing the well,

The method is illustrated schematically and described in detail. A. H. N.

55.* New Method of Washing Gravel-Packed Liners in Wilmington Completions. T. P. Sanders, *Oil Gas J.*, 30.10.41, **40** (25), A 95.—Completion methods are described, as these help in understanding the procedure of washing the gravel-packed liners. The washer is made up on the end of the drill-pipe, using $2\frac{7}{8}$-in. flush-joint drill-pipe as a tail on the $3\frac{1}{2}$-in. string, so that the washer can be run to the bottom of the liner. Placement of the swab rubbers on the washer is a matter of choice, but the interval between the opposed rubbers is usually 1 ft. This 1 ft. interval in which the fluid is discharged is placed opposite the lowest perforations of the liner, and the pump at the surface is started. Circulation is carried on for 1 min. before the drill-pipe is raised to take in a new interval. If the pressure recorded on the gauge at the surface is considered too high, circulation is carried on for a longer period, to see if the differential pressure through the gravel pack can be reduced by thorough washing.

The pipe is raised 6 in. at a time, so that no intervals can be missed. It is, of course, necessary to shut down the pump before attempting to raise the drill-pipe, as otherwise the swab rubbers would adhere to the liner. It has been noted that much less pressure builds up while washing a liner if the walls of the hole have been previously scraped by the formation scratchers. Thus the washer has served to show the effectiveness of an instrument which would otherwise be very difficult to evaluate.

A regular 7¼ by 14 in. slush-pump is generally used for circulation of the fluid, but sometimes a cementing truck is employed for the sake of convenience or because greater pressures are required. In nearly all cases water is used as the circulating medium while washing prepacked liners, although light mud is more likely to be used when the formation scratchers are being applied to the open hole.

After washing of the liner has been completed, it is standard practice to raise the washer well above the top of the liner and replace the water in the casing with mud, which is intended to hold the well under control while the tubing is run and the christmas tree is assembled.

Time required for washing depends on liner length and the depth, but a few examples of actual jobs are as follows : for cleaning 836 ft. of prepacked liner in the Upper Terminal zone, 13½ hr. were required, including running in, washing, and placing the mud-cap in the casing. For cleaning 661 ft. of liner in the Ford zone (total depth 5400 ft.) 12 hr. were required for the job. For cleaning 256 ft. of liner in the Ranger zone, 8½ hr. were required. A. H. N.

56.* Review of Multiple-Zone Production in California. R. F. Cory. *Oil Gas J.*, 6.11.41, **40** (26), 88. *Paper Presented Before American Petroleum Institute.*—When several productive zones are present in a field, the wells should be drilled so that the production from each zone can be controlled without affecting other zones. The differences between zones in pressures, gravity, and value of the oil, gas–oil ratio, edge-water conditions, sand production, and other factors make this desirable.

The conditions necessary to insure the practicability of multiple-zone wells are fairly rare. In general, California practice indicates that separate wells to each zone are to be preferred to multiple-zone wells because of additional recovery and fewer operating difficulties.

The primary reasons for the use of multiple-zone wells, in almost all cases, have been limited space, offset requirements, and increased potentials per well.

In general, multiple-zone wells are recommended : (1) when most of the recovery will be by natural flow (perhaps aided by repressuring), the pumping life short, and the field deep ; (2) when the energy of one zone can be used as a natural gas-lift for oil from another zone ; (3) when space is limited and the number of wells is restricted ; (4) when the establishing of high gas or oil potentials per well is important.

In most cases in which a multiple-zone well is desirable, a two-zone well is to be preferred to a three-zone well. The advantages of a three-zone well over a two-zone well are likely to be more than offset by the difficulties inherent in the more complex installation.

The methods and procedures used to drill, complete, and produce a multiple-zone well must be varied to suit the field and even the location. The following is a brief statement of the chief considerations : a two-zone well is relatively simple ; a three-zone well is much more complex, expensive, and troublesome.

The chief problem in drilling a multiple-zone well is the separation of the zones by cement outside the liner. The best method of cementing depends on the special conditions found in the field and well. Recementing is sometimes necessary, but the majority of the cement jobs give no trouble. The production problems are more serious. Packers give trouble by leaking or failing to set. When sand is produced, sand-blasting of tubing and casing will occur. Also, a few feet of packed sand can almost prevent removing a packer.

Repairs are difficult and expensive. In short, although multiple-zone wells may be economically desirable, they are troublesome mechanically.

The production history of multiple-zone wells is given. A. H. N.

57.* Control of Gas–Oil and Water–Oil Ratios by Chemical Treatment. H. T. Kennedy. *Oil Gas J.*, 6.11.41, **40** (26), 92. *Paper Presented Before American Petroleum Institute.* —This paper describes typical chemical treatments for reduction of gas– and water–oil ratios by the plugging of selected portions of the producing formations, and mentions briefly similar treatments applied to cable-tool drilling wells to shut off excessive water. Records of six water-plugging treatments, chosen to represent various successful treating methods, and eleven gas-plugging treatments are included. The latter group consists of all the applications up to the present time of chemical plugging methods to the wells of two major companies in the Goldsmith Pool, Ector County, Texas. Conditions essential for successful application of chemical plugging methods are discussed.

A survey of the present status of chemical formation plugging indicates that these methods have useful and economical application in three distinct fields: first, in treating cable-tool drilling wells to shut off excessive water; second, in treating producing oil- and gas-wells to cut down pumping costs and avoid back pressure on producing formations; and, third, in the lowering of gas–oil ratios in producing formations underlying gas-caps. The Goldsmith pool is the first location where a sufficient number of wells have been treated for gas–oil ratio control to determine the operators' chance of success, and in that field 82% of the wells treated were brought substantially to or below the penalty limit of 5000 cu.ft./brl. A. H. N.

58.* Oil-Well Tests Suggest New Rating Standards. H. E. Dralle and E. H. Lamberger. *Oil Gas J.*, 6.11.41, **40** (26), 98. *Paper Presented Before American Petroleum Institute.* —In oil-well pumping there are many known variables which directly affect the design and application of equipment used in the economical production of oil. To ascertain the individual effects of these variables on the performance and ratings of oil-well equipment and to augment the many theoretical considerations already given to them, Phillips Petroleum Co., Sargent Engineering Corp., and Westinghouse Electric & Manufacturing Co. jointly made a series of more than 200 tests, extending over a continuous period of six months.

The actual tests included independent variation of the speed, stroke length, counterweighting working-barrel size, tubing diameter, and type of prime mover. Under these varying conditions, oscillographic film was used to show fourteen simultaneous records of instantaneous loads and displacements occurring during a pumping cycle.

Instruments were placed in the incoming power line, in the low-speed gear shaft, on the pitman, at two different points on the walking beam, on the polished rod, and at two different points in the sucker-rod string. Correlated with these were polished-rod dynagraph charts and bottom-hole dynamometer records.

The paper covers that part of these tests which suggests the development of new formulas for predetermining, from a known set of well conditions: (1) peak polished-rod load; (2) pump plunger stroke; (3) peak crankshaft torque.

These new formulas, with supporting data, are given, and results from their use compared with those obtained from existing formulas and with actual test results. Suggestions are also made that other perplexing problems incident to oil-well pumping may be solved conveniently with these same basic and fundamental test data.

It is concluded that: (1) stroke length on a well using either beam or rotary counterweights to give practically equal power peaks on the up- and down-stroke is not appreciably affected by the type of prime mover; (2) peak polished-rod loads, under the same conditions of counterbalancing, are also unaffected to any practical degree by the type of prime mover; (3) peak torques on the crankshaft do vary with the prime mover, being greatest with the normal-slip motor. There was no observable difference in peak torque between the high-slip motor and the engine, unquestionably because both have speed-torque curves that result in appreciable speed drop with load increase and because of flywheel effect in the mechanical system. A. H. N.

59.* Leak Resistance of Casing Joints in Tension. P. D. Thomas and A. W. Bartok. *Oil Gas J.*, 6.11.41, **49** (26), 147. *Paper Presented Before American Petroleum Institute.* —This paper consists essentially of two parts: (*a*) tension-leak tests; (*b*) photo-elastic study of stresses in casing joints.

Leakage tests were made on casing joints subjected simultaneously to internal pressure and increasing tensile load. The loading under pressure was continued until full leakage was obtained. Pressure was then removed and the joint pulled to destruction.

Results indicated that the standard eight-pitch round-thread casing joint had leak resistance in tension beyond that required in service. Yield strength of the joint was apparently the controlling factor. Long-thread joints had a higher leak resistance than short-thread joints, although it was questionable if this extra tightness was of practical value. Thread lengths intermediate to A.P.I. long and short threads appeared advisable. Thread make-up was a critical factor, three threads pulling being the optimum. Differential in taper lowered leak resistance, but this tendency was overcome by proper make-up.

Photo-elastic study developed fundamental information concerning stresses in casing joints, supplementing and explaining the results of tension-leak tests. The usefulness of the photo-elastic method in analyzing stresses in casing joints was pointed out.

The similarity of tension and make-up stresses in the last-engaged thread areas was confirmed by the fact that distortion of threads in make-up was in the same direction, although less than that found in pulled-out joints. With tension and make-up stresses being additive, the possibility of preloading and overloading a joint by make-up was demonstrated. In the tension-leak tests, leak efficiency fell off with make-ups over three threads. The lowered leak resistance was explained by the combined make-up and tension stresses preloading the casing specimens sufficiently to cause yielding at reduced loads. Consequently, lower leak points and joint efficiencies developed. The early yielding took place at the points of highest stress concentration.

The essential difference between tension and make-up stresses lay in the point of concentration—tension stresses concentrating under the open root, make-up strssses under the closed root of the last engaged thread. With this difference present, the maximum stresses produced by each were not directly additive, but the similar stresses combined with each other directly according to the stresses that existed at identical points. A. H. N.

60.* Critical Review of Methods for the Determination of the Porosity, Permeability, and Saturation of Core Samples. M. D. Taylor. *Oil Gas J.*, 20.11.41, **40** (28), 40.—In view of the published methods of core analysis used for the determination of the porosity, permeability, and saturation of oil-field core samples, it was become increasingly evident that the particular method to be adopted depends on the type of samples to be analyzed, the speed with which an individual result is required, the number of samples to be handled, and the degree of accuracy needed. The methods of analysis which have been found most useful are briefly described and the conditions for which they are most adaptable are stated.

For porosity determination without crushing, the sample is extracted and dried, the bulk volume is determined either by the displacement of a liquid which does not penetrate the sample or by saturating the sample and displacing a liquid with the saturated sample, and either the grain volume is measured by the displacement of a gas or a liquid, or the pore volume is measured by determining the amount of liquid necessary to saturate the sample. An alternative method of obtaining the grain volume which may be used for approximate work is simply to divide the dry weight of the sample by 2·68, since the density of the rock-grains will seldom deviate more than 3–5% from this figure. Six methods of accomplishing the same results but with different degrees of accuracies and speeds are described.

Porosity measurements which involve crushing the samples are briefly discussed.

Permeability measurement with dry air is discussed, note being taken of Klinkenberg's findings regarding the variation of permeability with mean pressure.

The methods for the determination of liquid saturation usually consist of analyzing the sample for water and measuring the total loss of weight on extraction and drying. The quantity of oil present is then calculated by subtracting the weight of water found from the total loss in weight. The determination of water by distillation, by the critical solution temperature method, using ethyl or *iso*propyl alcohol to extract the water and then determining the temperature equal volumes of alcohol solution and kerosine become totally soluble, and finally by the titration method, is discussed in some detail. A. H. N.

61.* Air–Gas Proves Good Stripper Area Recovery Agent. F. R. Cozzens. *Oil Wkly*, 17.11.41, **103** (11), 47.—More than 70% of the eastern stripper-field producers are located in areas where gas must be piped in from outside sources, the cost of this and various other factors making its use prohibitive as a recovery measure. Many producers in such areas have been experimenting during the past five years with air and gas combined. In summarizing results thus obtained, ample proof is found that when an air–gas ratio not lower than 3 to 1 (three parts air, one part gas) is maintained, the producer gets full benefits of air pressure plus a reconditioning of the sandy body resulting from the use of gas. Cost is 40–60% less than when gas is used alone, which places the method within the economic range of small operators.

The air–gas method differs but slightly from regular air-pressuring, except that gas in required amounts is fed through a jet to the intake of an air compressor, and that traps are placed on the producing wells so that the air–gas mixture can be saved for re-use. On small leases, regular oil-storage tanks are used for air–gas storage. There is no set rule which determines the amount of gas fed to the air under pressure. The richer the mixture, the more speedy is its effect on the sand-body ; but the cost of gas and its limitations must be reckoned with, so that the average producer generally adheres to the 3 to 1 ratio. A. H. N.

62.* Treating Water for Disposal in Surface Channels. C. H. Rankin. *Petrol. Engr*, Oct. 1941, **13** (1), 27–28.—When the fluid comes from the wells in the proportion of about 1 brl. of oil to 10 brl. of water, it separates readily when heated, except for a residue of about 1%, which remains suspended in the water as an emulsion. This emulsion can be broken down with the Treto-lite compound recommended for the purpose, but it must be allowed to settle in large pits before the separation is complete. The oil can then be skimmed from the pits and the water discharged through surface channels.

Almost every known method has been tried in this field to obtain complete removal of the last traces of oil from the water. At one time the water was run into large open pits having porous bottoms, and attempts were made to skim off clean oil. At another time the water from the settling pits was run through a series of hay-tanks in an effort to skim off the oil. These and many other methods that were attempted proved unsuccessful.

It has been suggested that the chemical should be added before the oil enters the heater—a practice commonly followed in many other treating systems. This suggested practice has been tried, but without success. Emulsion was carried over into the stock-tanks.

Treating costs in this field have run as high as 5 cents/brl., although at present they are less than half that amount. The Wellington field now produces 200 brl. of oil daily, with 1800 brl. of water from eleven wells that average 4500 ft. in depth. All wells are equipped with standard rig fronts and pump 24 hr./day. A. H. N.

63.* Effect of Velocity on the Mixing of Liquids in Porous Media. V. V. Hendrix and R. L. Huntington. *Petrol Engr*, Oct. 1941, **13** (1), 48.—In this investigation five different sizes of porous media were studied. Two miscible liquids were used simulating gases under high pressures. Two sizes of tubes, a $\frac{1}{2}$-in. and a 1-in. tube, served as packed reservoirs. The porous medium in the tube was saturated with carbon tetrachloride, which was then displaced by normal hexane, injected into the bottom of the vertical tube. The amount of mixing was determined for different rates of flow. It was found that a Reynolds' number near a value of 1 (in consistent units) gives the least mixing, which is a desirable condition for such operations.

The sand was saturated with carbon tetrachloride as it was being packed into the tube. After the tube was packed it was inverted and attached by means of a union to a pressure bomb containing normal hexane. A constant-pressure head was maintained on the hexane in the bomb by placing natural gas pressure on the upper surface of the hexane. The pressure on the gas main was 30 lb./sq. in., allowing considerable freedom in the rate of producing the mixture. After the packed tube was in place, the gas pressure-valve was opened ; then the valve separating the pressure bomb and the packed tube was opened. The needle valve at the top end of the packed tube was then adjusted until the desired rate was obtained. This process amounts essentially to washing out the carbon tetrachloride with the hexane. Consecutive samples of produced liquid were taken during each run.

The produced liquid was analyzed first by means of a pycnometer and a chainomatic balance. Some of the densities were taken with a Westphal balance. Sample sizes depended on the amount of carbon tetrachloride in place. It was impractical to continue the test until all carbon tetrachloride had been recovered. The tests were terminated when the volume of hexane injected was equal to twice the original volume of the carbon tetrachloride in place. As there was no shrinkage of liquids on mixing, the amount of hexane injected was volumetrically equal to the amount of liquids produced. A. H. N.

64.* Centralized Control of Closed Gathering System in Arabian Field. D. Nix. *Petrol. Engr*, Oct. 1941, **13** (1), 93.—One of the most interesting features of operations in Arabia is the oil-gathering system used in the Damman field. Briefly, the system consists of: (1) individual flow-lines from each well to (2) a central gas-trap setting, from which oil flows to (3) a stabilizer, and is discharged into (4) field-tanks. The system is then given in some detail.

The author believes that the system described is unusual in that it allows complete control of the flow-rates of all wells in the field from one location and a closed system from well to field-tanks that includes gas separation, individual well-gauging, stabilization, and H_2S removal. It might be pointed out that the system is not considered an experimental one; it has been functioning satisfactorily for about two years.
A. H. N.

65.* Drilling and Production Activity in Foreign Fields. W. A. Sawdon. *Petrol. Engr*, Oct. 1941, **13** (1), 150–152.—Of the oil-producing areas of the world outside the North American Continent it appears that the greatest increase in activity in the near future will be in South America. There is still a lag due to the loss of markets caused by the war in Europe, but there now appears to be a growing demand for South American petroleum products for British use. An indication of this prospect is the recent increase in orders for oil equipment and the probability of larger orders to provide stores for long operating periods. In some instances ordering for 1942 is already in progress.

There is also a likelihood of increased activity in the East Indies, Burma, and possibly India, as those areas will have to maintain production even though they may not greatly increase the amount of oil produced. Expansion of petroleum developments in the Near East will be delayed until after the war, but it can be assumed that when hostilities are over plans held in abeyance will be put into effect. In the Near East to-day, however, several strings of drilling tools are running. Western Europe and Russia seem to be out of the picture at present so far as exploratory work or expansion of development operations is concerned.

A brief review is given of activities in South America, Argentina, Colombia, Ecuador, Venezuela, Trinidad, the Near East, Europe and Russia, India and Burma, and the Far East. A. H. N.

66. Patents on Production. F. N. Osmun. U.S.P. 2,255,857, 16.9.41. Appl. 4.10.38. Hydraulic-power transmitter control.

H. R. Downs. U.S.P. 2,255,918, 16.9.41. Appl. 16.2.40. Well-pump comprising a gas-driven motor.

L. Hegy. U.S.P. 2,255,924, 16.9.41. Appl. 6.4.40. Pneumatic displacement pump.

H. E. Drake. U.S.P. 2,256,552, 23.9.41. Appl. 19.3.40. Retrievable formation tester adapted to be mounted in drill-pipe.

C. E. Moseley. U.S.P. 2,256,567, 23.9.41. Appl. 2.2.40. Well-pump of the reciprocating type.

G. W. Taylor. U.S.P. 2,256,599, 23.9.41. Appl. 4.12.39. Well-pump operating apparatus.

R. W. Bier. U.S.P. 2,256,605, 23.9.41. Appl. 3.6.39. Counterbalancing apparatus for well-pumps.

L. R. Thrasher. U.S.P. 2,256,659, 23.9.41. Appl. 25.6.40. Deep well-pump motor of the submersible type.

C. S. Crickmer and J. J. Lane. U.S.P. 2,256,704, 23.9.41. Appl. 17.10.38. Flow device for gas-lift tubings.

W. H. Brenot. U.S.P. 2,257,225, 30.9.41. Appl. 3.9.40. Sub-casing-head take-off for wells.

H. C. Marsh and W. M. Quilter. U.S.P. 2,257,269, 30.9.41. Appl. 7.10.40. Tubing plug.

I. J. McCullough. U.S.P. 2,257,270, 30.9.41. Appl. 14.11.39. Gun perforator for well-casings.

I. J. McCullough. U.S.P. 2,257,271, 30.9.41. Appl. 10.2.40. Perforating gun with serial firing means.

J. F. Maloney. U.S.P. 2,257,344, 30.9.41. Appl. 11.1.40. Screen-pipe with gravel between two perforated pipes.

C. A. Combs. U.S.P. 2,257,523, 30.9.41. Appl. 14.1.41. Well-control device for wells having a casing with tubings arranged therein.

N. F. Brown. U.S.P. 2,257,784, 7.10.41. Appl. 26.8.38. Plug for use in wells to force material through a pipe.

R. B. Barnes. U.S.P. 2,257,997, 7.10.41. Appl. 27.11.40. Breaking petroleum emulsions of the water-in-oil type.

L. C. Chamberlain. U.S.P. 2,258,000, 7.10.41. Appl. 15.3.37. Treatment of wells producing mineral fluid to reduce the flow of water.

T. G. Myers. U.S.P. 2,258,064, 7.10.41. Appl. 27.5.38. Sealed electric motor adapted to be submerged into a well liquid.

F. E. Scheider. U.S.P. 2,258,103, 7.10.41. Appl. 9.7.38. Well-pumping apparatus with hydraulic engine and sucker-rods.

C. R. Neilon. U.S.P. 2,258,190, 7.10.41. Appl. 4.9.40. Unitary packing and gland structure for casing-heads and the like.

R. P. Miller. U.S.P. 2,258,299, 7.10.41. Appl. 15.8.38. Automatic pumping in wells fitted with tubing strings.

J. F. Kendrick. U.S.P. 2,258,614, 14.10.41. Appl. 28.2.38. Method of treating and producing oil-water wells.

J. F. Kendrick. U.S.P. 2,258,615, 14.10.41. Appl. 28.2.38. Apparatus for the treatment and producing of oil-water wells.

J. F. Kendrick. U.S.P. 2,258,616, 14.10.41. Appl. 8.7.39. Treatment and producing of oil-wells.

R. H. Carr, K. A. Covell, and C. F. Terrell, Jr. U.S.P. 2,259,019, 14.10.41. Appl. 7.6.39. Apparatus for pumping oil-wells.

W. H. Wineman. U.S.P. 2,259,020, 14.10.41. Appl. 9.12.38. Apparatus for pumping wells.

W. H. Wineman. U.S.P. 2,259,021, 14.10.41. Appl. 9.12.38. Apparatus for pumping oil-wells.

K. E. Moehrl. U.S.P. 2,259,262, 14.10.41. Appl. 12.11.40. Means for well-cleaning through annular screen to surrounding strata.

P, G. Shelley. U.S.P. 2,259,428, 14.10.41. Appl. 23.4.40. Treatment of wells to remove paraffin and the like.

D. M. Simmons. U.S.P. 2,259,429, 14.10.41. Appl. 1.8.39. Method of treating wells with a fluid treating agent.

L. T. Monson and W. W. Anderson. U.S.P. 2,259,704, 21.10.41. Appl. 12.5.41. Process for resolving petroleum emulsions.

F. A. Bent and A. G. Loomis. U.S.P. 2,259,875, 21.10.41. Appl. 9.9.36. Method fo treating oil- and gas-wells.

M. P. Burke. U.S.P. 2,259,949, 21.10.41. Appl. 21.4.38. Fluid-lift apparatus for wells.

C. F. Bonnet. U.S.P. 2,259,995, 21.10.41. Appl. 30.1.41. Breaking petroleum emulsions of the water-in-oil type.

W. F. Tebbetts, Jr. U.S.P. 2,260,127, 21.10.41. Appl. 11.3.40. Deep-well pumping mechanism.

D. O. Sproule. U.S.P. 2,260,347, 28.10.41. Appl. 22.7.37. Echo-sounding apparatus with a device for measuring and indicating the time periods between the emission of sound-pulses and the reception of the echo pulses.

F. D. Stanley. U.S.P. 2,260,544, 28.10.41. Appl. 20.10.39. Polish-rod clamp.

D. E. Humphrey. U.S.P. 2,260,669, 28.10.41. Appl. 8.8.40. Well-pump in combination with a tubing string which can be rotated from the surface.

D. E. Humphrey. U.S.P. 2,260,671, 28.10.41. Appl. 4.10.40. Well-pump in combination with a tubing string which can be rotated from the surface.

C. J. Wolff. U.S.P. 2,260,696, 28.10.41. Appl. 5.8.38. Hydraulic pump for wells operated by fluid pressure.

H. Richter. U.S.P. 2,260,789, 28.10.41. Appl. 29.7.39. Outflow regulator for petroleum separators.

T. A. Rial. U.S.P. 2,260,916, 28.10.41. Appl. 5.12.40. Electric heating device for oil- and gas-wells.

R. W. Erwin. U.S.P. 2,261,057, 28.10.41. Appl. 15.7.40. Emulsion treating and brine injection system for oil-wells.

R. W. Erwin. U.S.P. 2,261,100, 28.10.41. Appl. 25.7.41. Brine injection method for oil-wells.

R. W. Erwin. U.S.P. 2,261,101, 28.10.41. Appl. 25.7.41. Emulsion treating apparatus for the closed type.

A. Boynton. U.S.P. 2,261,135, 4.11.41. Appl. 8.12.39. Differential stage lift-flow device for wells.

A. N. Porter. U.S.P. 2,261,180, 4.11.41. Appl. 6.9.38. Rocker bearing for an under-pull jack.

L. A. Layne. U.S.P. 2,261,440, 4.11.41. Appl. 4.2.39. Well-head control.

R. L. Harter. U.S.P. 2,261,468, 4.11.41. Appl. 24.6.40. Friction-activated sleeve-valve for foot-valve pumps.

R. L. Harter. U.S.P. 2,261,469, 4.11.41. Appl. 26.8.40. Sleeve-type foot-valve for pumps.

N. W. Buckner. U.S.P. 2,261,752, 4.11.41. Appl. 24.1.40. Fluid pressure motor.

C. A. Ricon. U.S.P. 2,261,859, 4.11.41. Appl. 9.10.39. Oil and gas production gun perforator.

A. Boynton. U.S.P. 2,262,750, 18.11.41. Appl. 28.11.38. Flow intermitter for controlling wells.

A. Boynton. U.S.P. 2,262,751, 18.11.41. Appl. 31.1.39. Pneumatic piston pump, differential type.

A. Boynton. U.S.P. 2,262,752, 18.11.41. Appl. 31.1.39. Pneumatic piston pump, differential type.

C. C. Cole. U.S.P. 2,262,925, 18.11.41. Appl. 7.8.39. Projectile and barrel for gun-type perforators.

J. E. Hall. U.S.P. 2,263,086, 18.11.41. Appl. 15.5.40. Fluid motor.

C. N. Scott. U.S.P. 2,263,144, 18.11.41. Appl. 18.4.39. Pump for deep wells having two plungers.

R. E. Franklin. U.S.P. 2,263,267, 18.11.41. Appl. 22.6.40. Tubing-joint breaker for connecting and disconnecting oil-well tubing coupling.

A. L. Armentrout. U.S.P. 2,263,412, 18.11.41. Appl. 30.9.40. Method and means of perforating pipe.
A. H. N.

Transport and Storage.

67.* New Developments in Painting of Tanks and Other Structural Steel. A. T. Saunders. *Oil Gas J.*, 1941, **40** (17), 44.—The American national defence programme has resulted in the virtual disappearance of aluminium paints from civilian use in the U.S.A.

Since no pigment has been found which possesses powers of resisting water permeation equal to those of aluminium flake, new paints for tanks, steelwork, etc., are being formulated to make use of anti-corrosive priming coats. These primers frequently make use of the known protective properties of the chromate and phosphate ions. The continued slight solubility in water of zinc chromate, and the immunizing effect of the solution on the metal surface, make this pigment of great value as a component of such primers. A content of 15–25% of the pigment is recommended.

Recently developed light-coloured finishing coats are generally based on very opaque rutile types of TiO_2, with or without ZnO, in an oil vehicle reinforced with high-mol. wt. synthetic resin.
C. G. G.

68.* Cathodic Protection of Montana Power Company's Pipe-Lines. C. R. Davis. *Oil Gas J.*, 2.10.41, **40** (21), 45.—At the time of construction of this Company's pipeline system, electrolysis was controlled by insulation, the approved method of the time. Three years later alvanic action, etc., had caused faults where there were imperfections in the coatings, and in 1936 a programme to place the entire system under cathodic protection was initiated. After a complete survey of pipe to ground potentials, the first rectifying unit was installed in 1937, and by the end of 1940, 90% of the transmission system, 80% of the distribution system and the storage tanks, well-casings, etc., of the producing company were under cathodic protection. The various systems are described in detail, four types of units being employed—viz., copper oxide rectifiers, motor generators, wind generators, and gas-engine-drive generators, of which the first has proved most dependable.

A photographic recording voltmeter has been developed for use with the wind generators, and the instrument is described. Results given by this and by other test instruments indicate that the better the pipe coating the longer the effect of polarization, and that the latter will increase the effectiveness of a wind generator by at least 20%.

A variety of ground-bed installations are in use, and are described, whilst the article concludes with a discussion of operating costs.
J. C.

Crude Petroleum.

69.* Practical Suggestions for Improving Quality of Crude Oil. F. R. Cozzens. *Petrol. Engr*, 1931, **12** (13), 98.—Various difficulties which may arise through the use of unsuitable equipment or through faulty handling of crude oil under field storage conditions are very briefly discussed.

Methods used for the reduction of evaporation, and for the removal of troublesome sludge and colloidal matter before pumping to the lines, are sketched in outline.
C. G. G.

Gas.

70.* City Gas. W. L. Jones and F. E. Vandaveer. *Industr. Engng Chem.*, 1941, **33** (7), 852.—The causes and effects of the smoke problem in urban communities are reviewed and the economics of the supply of smokeless fuel discussed. Data are given on the properties and combustion of gaseous fuels. Special reference is made to the part gas has taken in the smoke-abatement problem in the St. Louis metropolitan area.
J. W. H.

Cracking.

71.* Unusual Properties of Houdry Cracked Products Revealed. H. P. Broom. *Oil Gas J.*, 27.3.41, **39** (46), 164.—Houdry cracked gasolines from commercial units using natural clay catalysts have octane numbers (A.S.T.M. or motor method) of 77–80, but the newly developed synthetic catalysts produce gasolines of 78–81 O.N. The ability of Houdry gasolines to meet modern engine requirements is indicated by their research method octane numbers, which vary from 86 to 92, the road octanes by the Union town method having been shown to be nearer the research method than the motor method. Curves showing the influence of speed on the motor-knocking tendencies of various fuels of similar octane number indicates that the Houdry gasoline provides more than the maximum power requirement throughout the entire range, whereas a leaded straight-run gasoline falls off badly at low speeds. Houdry gasolines also have a flat octane distillation curve, so that in a multi-cylinder engine perfect distribution of the vaporized and unvaporized fractions is not required to eliminate knock. Lead susceptibilities are good, the sulphur content being low and paraffin content high, 1 c.c. of TEL per gallon increasing the O.N. (A.S.T.M.) from 77·4–80·9 to 82·7–86·2, and 3 c.c. of TEL to 84·9–90·1. The blending value with straight-run and cracked fuels of about 70 O.N. is relatively high and is almost arithmetical. Doctor-sweetened Houdry gasoline has an exceptionally low stability (10-hr. induction period in the oxygen bomb). In view of the high octane number of the heavy ends, it is not necessary to reduce the end-point, particularly as the product has ample front-end volatility.

The catalytic gas-oil or recycle stock can be thermally cracked, blended with heavy fuels, cut to specification furnace oils, or used as low-speed diesel-engine fuels. On cracking, the gas-oil gives similar yields to fresh stocks of similar gravity distillation characteristics (*e.g.*, a 73·5% yield of gasoline of 74·3 O.N. by Houdry, followed by thermal cracking, as compared with a 65·9% yield of 71 O.N. gasoline by thermal cracking alone). A further point is the catalytic reduction in sulphur of the charging stock. The dry gas produced over a 10-lb. Reid gasoline may contain more than 50% of C 4 fractions, 80–85% of the butane being *iso*butane, useful for alkylation. Butylenes vary from 10% of the C 4 cut when reforming or cracking light oils to more than 50% when cracking reduced crudes or residues. The cracked tar may be viscosity broken, coked, blended with thermally cracked tars to reduce viscosity, reduced to asphalt and binders, or burnt as fuel.
C. L. G.

72.* Use of Stress-Rupture Data in Inspecting Cracking-Still Tubes. C. L. Clark. *Oil Gas J.*, 2.10.41, **40** (21), 39.—As a basis for design, and for the inspection of cracking-still tubes after each operating cycle, stress-rupture tests are said to be the most useful laboratory procedure.

Stresses are greater than in the creep test and specimens are carried to actual fracture, loads being adjusted so that fracture occurs after widely differing times.

Stress *versus* rupture time is plotted, and with logarithmic co-ordinates straight lines result. With the standard 5 CrMo-type steel a discontinuity occurs in the straight line at 1200° F. and higher, due to surface scaling. These relationships give stresses corresponding to definite fracture times at each temperature considered, and by plotting stress *versus* temperature, and by extrapolation, a series of constant-fracture time curves results. The use of these curves in inspecting cracking-still tubes is demonstrated by an actual example showing how it is possible to determine the extent to which the tube-metal temperature can rise before the operating cycle must be discontinued. J. C.

73. Patent on Cracking. Standard Oil Development Co. E.P. 540,408, 16.10.41. Appl. 31.1.40. Method of cracking hydrocarbon oils by admixing therewith an absorbent solid catalyst and passing the mixture through a cracking zone. Thereafter the catalyst is separated from the cracked products and the latter fractionated to obtain a normally gaseous fraction, a motor-fuel distillate fraction, and a higher-boiling fraction. The normally gaseous fraction is further fractionated to obtain a light fraction consisting chiefly of hydrogen, methane, and ethane, and a heavier fraction consisting principally of hydrocarbons having 3–4 carbon atoms. The lighter or heavier fraction is recycled to the cracking zone. H. B. M.

Polymerization and Alkylation.

74. Patents on Polymerization and Alkylation. Anglo-Iranian Oil Co. E.P. 540,449, 17.10.41. Appl. 10.3.41. Production of saturated hydrocarbons by the alkylation of *iso*butane or *iso*pentane by condensation with one or more lower olefins in the presence of concentrated sulphuric acid. After alkylation the alkylate is washed with fresh concentrated sulphuric acid under agitation for the removal of sulphur. Finally the alkylated product is subjected to distillation.

Texaco Development Corporation. E.P. 540,459, 17.10.41. Appl. 19.4.40. Method of alkylating hydrocarbons by reacting an olefin with an *iso*paraffin hydrocarbon in the presence of a liquid catalyst consisting of a boron trifluoride–water complex containing 21–29% by weight of water.

K. Korpi and A. R. Goldsby. U.S.P. 2,260,943, 28.10.41. Appl. 25.6.37. Manufacture of normally liquid hydrocarbons boiling within the gasoline range by reacting low-boiling polymers with an *iso*paraffin selected from the group consisting of *iso*butane and *iso*pentane in the presence of concentrated sulphuric-acid catalyst. By maintaining a substantial excess of the *iso*paraffin in the reacting mixture, alkylation of the *iso*paraffin is effected and a substantially saturated liquid reaction product is produced.

A. R. Goldsby and K. Korpi. U.S.P. 2,260,944, 28.10.41. Appl. 29.7.39. Alkylation of a normally liquid cracked naphtha fraction to increase its anti-knock value. The cracked naphtha fraction is treated with added *iso*butane in the presence of concentrated sulphuric acid under alkylating conditions. In this way *iso*butane reacts with the normally liquid olefins originally present in the cracked naphtha fraction to produce alkylation products.

K. Korpi and A. R. Goldsby. U.S.P. 2,260,945, 28.10.41. Appl. 18.6.37. Manufacture of normally liquid hydrocarbons boiling within the gasoline range by reacting low-boiling olefins with a low-boiling *iso*paraffin in the presence of concentrated sulphuric acid catalyst while maintaining alkylating conditions. H. B. M.

Synthetic Products.

75.* Reaction Products of Olefins with Sulphuric Acid. R. F. Robey. *Industr. Engng Chem.*, 1941, **33** (8), 1076.—The reaction products of *n*-butene with sulphuric acid are shown to be alkyl sulphuric acid (30–40%), and the remainder is considered to be in the form of the alcoxonium ion. In the light of the observations, a criticism of the reported values of the heat of reaction between butene and sulphuric acid is given.

J. W. H.

Refining and Refinery Plant.

76.* **Nomograph for Selecting Electrical Heaters.** J. J. Serrell. *Industr. Engng Chem.*, 1941, **33** (7), 961.—A nomograph is given enabling the selection of a suitable heater for petroleum products in a continuous system to be made easily from a knowledge of the working temperature range, density, and flow-rate. J. W. H.

77.* **Use of a Third Component to Improve the Fractional Distillation of Binary Liquid Mixtures.** D. B. Keyes. *Industr. Engng Chem.*, 1941, **33** (8), 1019.—The basic requirements for the effective use of a third component in the fractional separation of an azeotropic binary mixture are reviewed. Examples are also given of the addition of a third component to form an azeotrope with one of the components of the binary mixture to facilitate the separation. J. W. H.

78.* **Alignment Chart for Optimum Amount of Water in Heat Exchangers.** R. D. Douglass and D. P. Adams. *Industr. Engng Chem.*, 1941, **33** (8), 1082.—The construction of the chart is described and the method of estimating the optimum amount of cooling water is illustrated by an example. J. W. H.

79.* **Early Plant for the Preparation of Toluene from Petroleum.** J. B. Terry and C. K. Parker. *Nat. Petrol. News*, 23.7.41, **33** (30), R.234.—The authors describe, in reminiscent vein, the early difficulties in the preparation, in 1915, of toluene by a pyrolytic cracking process. Compared with modern practice the plant was crude, but in view of the absence of background experience, speciality materials, and recording instruments the results obtained were highly commendable. In the final plant twelve retorts, arranged in pairs on a common base, consisted of 18-in.-diameter cast-steel tubing containing a nickel oxide catalyst and maintained by external heating at 700° C. Oil was sprayed in under slight vacuum for 35 min., air being passed for the remaining 25 min. in each hour for the purpose of removing carbon deposits. The gases were discharged through a series of " tar-pots " to a pressure condenser. The crude distillate was fractionated according to current coal-tar refining practice, the residue after the removal of naphthalene being used as a paint-base or as fuel. H. G.

80.* **Mercaptan Removal By Extraction with Caustic Soda and Methanol.** Anon. *Nat. Petrol. News*, 1.10.41, **33** (40), R.316.—H_2S-free gasoline is fed to the base of a packed column. Methanol is introduced in the middle of the column and aqueous NaOH at the top. The NaOH–methanol solution is drawn off from the bottom and passed to a stripper for the recovery of the methanol. The caustic is regenerated. Almost complete mercaptan removal is claimed. Complete economic and operating data are not yet available, but the process is said to be very promising. H. G.

81.* **Refineries in North America.** D. H. Stormont. *Oil Gas J.*, 27.3.41, **39** (4), 54, 167, 189.—A brief survey of growth of refinery capacity in U.S. and Canada is given with a table of the capacity, number, and type of plants in operation and shut down in each State. The personnel of refineries and details of the crude oil and cracking capacity and type of refinery of each of the refineries in the U.S., Canada, and Mexico is also given. C. L. G.

82.* **Chemistry in Petroleum Refining.** L. N. Leum. *Oil Gas J.*, 27.3.41, **39** (46), 85.—A brief review is presented of the systems of nomenclature of hydrocarbons, including general names, names in the substitution system, and names on the Geneva system. The fundamental chemistry of various new processes is briefly discussed by means of equations based on single hydrocarbons. C. L. G.

83.* **Turner Valley Natural Gas and Crude Oils—a Refinery Evaluation.** D. Read and G. Egloff. *Oil Gas J.*, 27.3.41, **39** (46), 142.—Detailed analyses are given of Turner Valley natural gas, the natural gasoline derived from it, the crude oil and products obtained from it by laboratory distillation, and the products obtained by cracking the topped and reduced crude in a Dubbs pilot plant. The natural gas yields 0·35 gal. of 20-lb. Reid gasoline per 1000 cu. ft. It contains 0·63–0·74% of *iso*butane, 0·99–1·09% of butane, and 0·29–0·36% of *iso*pentane. It is estimated that 75,500,000 gal. per year of butanes are available from the natural gas and 45,500,000 gal. per year could be produced from cracking operations. The butanes could be processed to yield high-octane gasoline by (1) pyrolysis and non-selective polymerization, (2) catalytic dehydrogenation followed by selective polymerization and hydrogenation, (3) fractionation with *n*-butanes for catalytic dehydrogenation and *iso*butanes alkylated by the preceding olefines, and (4) polymerization of olefines in cracked gases from various cracking, reforming, etc., operations. From method (2) 5000 brl./day of 95–100 octane aviation fuel could be produced.

Two samples of Turner Valley crude have been analyzed, the lighter yielding 21·7% of 250° E.Pt. gasoline of 68 O.N., or 47·5% of 400° E.Pt. gasoline of 53 O.N., and the heavier crude very slightly less gasoline. The topped crude has a pour-point of 50° F. and a viscosity S.U. at 100° F. of 52·9 sec., and after removal of 26·8% of gas-oil the reduced crude has a pour-point of 80° F. and a viscosity of S.U. at 100° F. of 144 sec. On cracking the crude oil, topped crude, and reduced crude, yields were obtained of 82%, 63·1%, and 59·8% of gasoline of O.N. 64, 68·5, and 70, respectively. The cracked residues meet the S.C. 2 grade road-oil specifications of the Asphalt Institute, as well as the No. 6 fuel-oil specification. A cracked side-cut oil is suitable for use in low-speed diesel engines (cetane number 35), or could be distilled to produce a tractor distillate of 49 O.N. Catalytic polymerization of cracking plant and stabilizer gases, alkylation of the butylenes with *iso*butane, and polymerization of the residual gas from alkylation added to alkylate bottoms would yield 4·3%, 5·0%, and 2·4% of gasoline, respectively, on the crude. Doctor and copper-sweetened straight-run and cracked gasolines show a satisfactory lead response, 1, 2, and 3 c.c. of TEL/gal. increasing the O.N. from 63 to 70, 73·5, and 76, respectively. Satisfactory storage stability and gum content are obtained by inhibiting, but dyeing is required owing to its poor colour, unless additional refining, such as clay treatment, is provided. C. L. G.

84.* Laboratory-Controlled Reflux Distillation Apparatus. R. W. Harkness and R. E. Bland. *Oil Gas J.*, 27.3.41, **39** (46), 148.—A description is given of a controlled reflux distillation apparatus suitable for laboratory control of full-scale or pilot-plant yields of gasoline from cracked or reformed distillates. The apparatus has a capacity of 3 or 5 litres, and is constructed of interchangeable glass parts, with the exception of the reflux condenser of coiled copper tubing in an insulated metal bath. The method of heating preferred is a glass fabric mantle in which heating coils are embedded, surrounding the glass distillation flask. The fractionating column is $1\frac{1}{2}$ in. in diameter and 18 in. long, and is surrounded by a vacuum jacket, silvered on the inside. The tower packing consists of $\frac{3}{16}$-in. stainless steel helices of 0·016-in.-diameter wire. The automatic reflux regulator is electro-magnetically controlled, and can be adjusted by an electric timing device for different reflux ratios. The reflux condenser over the column is cooled by water, the product condenser by refrigerated ethylene glycol–water at 0° F., and the vapour condenser by dry ice–spirit at − 60° F. A complete distillation takes 4 hr. (50% yield). The degree of separation obtained with the laboratory distillation is about the same as that in the plant. Tables of properties and distillation curves of representative distillation runs are included.

C. L. G.

85.* Finish 20 Tons of Wax Daily Without Using Sweat Pans. D. A. Young. *Oil Gas J.*, 1941, **40** (11), 34.—A descriptive account of the Sinclair Refining Co's new solvent-dewaxing and wax-finishing plant at Houston.

The dewaxing solvent consists of M.E.K.–benzene–toluene (45 : 40 : 15). The flow-sheet given is of normal type. Cooling is obtained by direct expansion of NH_3. The filters employed are of the rotary-drum continuous type.

The wax-cake is passed through a two-stage stripping process to recover the adhering solvent, the resulting slack wax then being given a second solvent treatment in lieu of the customary sweating process. In the second solvent treatment the solvent–wax ratio is high (15 : 1 by vol.).

After filtration, washing on the filter, and removal of solvent, the resulting " crude scale " wax is given one of two further treatments, according to whether " finished semi-refined " or " finished fully-refined " wax is ultimately required.

For production of semi-refined wax, the crude scale is given acid and soda treatments, followed by water washing, deodorizing with superheated steam under vacuum in a small bubble-tower, and earth percolation.

For production of fully-refined wax, the scale is given a third solvent extraction before the finishing treatment, which is the same as that described for the semi-refined grade. The great bulk of the wax is processed to 130–132° F.

In all stages of the process where solvent vapour is present the gaseous phase is diluted with CO_2 to prevent the formation of explosive mixtures with air.

The article is liberally illustrated with photographs, and the full flow-sheet is shown.

C. G. G.

86.* Continental Adds Four Types of Solvent Units to Separate Dewax Lube Oil Stocks. W. T. Ziegenhain. *Oil Gas J.*, 7.8.41, **40** (13), 30.—Four different types of solvent units have been placed in full-scale operation at the Ponca City, Okla., plant of the Continental Oil Co. These include two for treating the oil—furfural and Duosol plants—and two for dewaxing—M.E.K. and Bari-Sol plants.

The furfural plant receives daily about 1200 brl. of light-wax distillate, S.U. viscosity of 75–80 sec. at 100° F. The raffinate is freed of solvent, sent to the M.E.K. plant for dewaxing, and then re-run to make a 180 viscosity motor-oil base. The asphaltic portion is cracked after removal of solvent.

The Duosol unit receives daily about 1600 brl. of heavy vacuum-distilled lube bottoms, which is contacted with liquid propane and " selecto " at 300 lb./sq. in. The oil raffinate is dewaxed in the M.E.K. plant, while the asphaltic fractions are cracked.

The refinery also produces about 550 brl. daily of a heavy overhead cut of oil of 500 viscosity at 100° F. This is segregated, and may be processed by either of the extraction units, being subsequently dewaxed and reduced to produce an S.A.E. 30-grade motor oil.

The Bari-Sol plant is used primarily to dewax residue oils in the manufacture of very heavy pale-lube stocks. One of the principal products of this process is a zero cold-test oil of 160 viscosity at 210° F. The feed oil, viscosity 350 at 210° F., is mixed with ethylene dichloride and benzene and chilled to − 20° F., when the wax separates.

An important adjunct to these processes is the use of additives. In the highest-quality oils methyl dichlor-stearate is used as an oiliness dope, and a small quantity of " thialkene " is added. This is a sulphonated olein made at the refinery, and it is claimed that its use improves the oxidation characteristics of the oil. D. L. S.

87.* Liquefaction and Degasification of Lighter Hydrocarbons. F. W. Laverty and W. C. Edmister. *Oil Gas J.*, 1941, **40** (17), 35.—Up to the present, very little attention has been paid to the thermodynamic properties of the hydrocarbons usually handled by industrial liquefaction plants. The authors point out that for efficiency in the design and operation of such plants, accurate knowledge of the entropies and enthalpies of the hydrocarbons is required, in addition to the details of vapour pressures, boiling points, dew points, and critical points.

A thermodynamic survey of methane, propane, butane, propylene, and three mixtures of light hydrocarbons was carried out, using the reduced thermodynamic data afforded by Edmister's method, together with experimental calorimetric and vapour-pressure or phase-diagram data. The results were incorporated in Mollier diagrams, showing enthalpy *versus* pressure (on log. scale) with temperature, entropy, and volume parameters.

These diagrams furnish a great deal of useful data for the design and power provision of liquefaction and refrigeration plants generally. Extended examples of their applications are given.

A general description of the natural-gas liquefaction and storage plant now being operated by the E. Ohio Gas Co. at Cleveland is given.

The article is illustrated with the relevant Mollier diagrams. A photograph and diagrams of the plants discussed are also included. C. G. G.

88.* New Refinery Processes. T. B. Leech. *Oil Gas J.*, 2.10.41, **40** (21), 40.—Refinery processes developed during the last few years are concisely surveyed.

Two new vapour-phase developments are described. In the first, topped crude, distillate, or naphtha at high temperature and at pressures of 200 lb./sq. in. is submitted to pyrolysis and to further reaction with some uncracked charge. A large yield of high-octane gasoline is given, and, in certain conditions, this may contain 6–8% of toluene. The second process, distinguished by higher pressure, lower temperature, and the omission of the second reaction, operates on naphtha and produces a high-octane fuel, which may be fractionated to yield an aviation cut.

Training-grade aviation fuels may be produced by debutanizing natural gasoline, removing the pentane, and blending back the depentanized natural gasoline with *iso*pentane, obtained by fractionation of the pentane cut. The yield may be leaded to 90 octane, and the remainder of the natural gasoline can be blended into motor fuel or can be alkylated or polymerized.

By alkylation, high-octane products are obtained from *iso*paraffins and olefins. A simple type of reaction is the combination of butene and *iso*butane to *iso*-octane by the sulphuric-acid catalyst process. At higher temperatures unsaturates may be polymerized into octylene, which is an excellent blending fuel, or may be hydrogenated to *iso*-octane. An outstanding alkylation process is the formation of neohexane from ethylene and *iso*butane. Neohexane has an octane rating of 94 and can be leaded to 115, and the reaction is of particular importance from the standpoint of U.S.A. resources, since it utilizes a lighter gas than is usually considered feasible for commercial alkylation. If it is economically desirable, butane may be isomerized, thus increasing the raw stock of *iso*paraffins available for alkylation.

n-Butane and *iso*butane may be converted into *n*-butene and *iso*butene by dehydrogenation at temperatures of 975–1025° F., at pressures of 15–25 lb., using chromium oxide or alumina as a catalyst. The yield may be polymerized using a solid phosphoric-acid or a sulphuric-acid process to give high-octane fuel or octylene, which latter may be hydrogenated at 75° F. and at 5–50 lb. pressure, over a nickel oxide catalyst, to *iso*-octane.

Catalytic-cracking plants in general use, operating on crude residual oil, distillate or naphtha, yielding gasoline of 77–81 octane rating, have a daily capacity of some 250,000 brl. A second process of this type operates catalytically on naphtha and hydrogen and gives a yield of 80% when the octane rating is raised by 30–40. The product contains 40–50% of aromatics and 15–20% of toluene. A notable advance in this branch of refining is the use of a movable catalyst, which is fed into the vapour, removed from the reacted products, rejuvenated, and returned to the system.

These processes are important in the U.S.A. national defence programme, and the article concludes with a statistical discussion of available refining capacity in relation to present emergency needs, to normal consumption and exports, and to the probable demands of the near future. J. C.

89.* High-Pressure Absorption of Natural Gasoline. E. J. Squire. *Oil Gas J.*, 2.10.41, **40** (21), **48**.—Natural-gas wastage is already much reduced in quantity through controlled production, gas injection, depletion of reserves, and increased demand. Further conservation measures are still, however, necessary, and the present condensed and non-technical article deals briefly with the conversion of the Ventura plant of the Shell Oil Co. from low-pressure to high-pressure absorption. This plant, built in 1926, operates at 30 lb., but associated companies, who take 80% of the gas, compress it to 250–400 lb. pressure. The gas-fuel available will be diminished, depending on the quantity of butanes and propane required as liquid products. J. C.

90.* Gasoline Plant Employs Two Fractionators in Series. J. C. Albright. *Petrol. Engr*, 1941, **12** (13), 27.—Many plants which are producing more than one grade of natural gasoline use only one column, and consequently batch processing is required.

A new plant near Cunningham, Kansas, is now producing two grades of natural gasoline by means of a continuous process in which two columns are employed in series.

Low-pressure and high-pressure gas, from older and newer producing wells, respectively, are fed to two sets of absorbers in parallel operating at 50 lb./sq. in. and 600 lb./sq. in., respectively. The absorption oil from the high-pressure absorbers is pumped directly into one of the low-pressure absorber columns, with two attendant advantages. Duplication of "fat-oil" pumps is eliminated, and venting the high-pressure oil into the low-pressure column serves to remove unwanted ethane and other low-boiling constituents without the necessity for recompressing and recovering desirable fractions. Raw gasoline of R.V.P. 55–60 lb./sq. in. is recovered from the wash oil, and is then separated by means of a two-stage pressure fractionation into natural gasoline of R.V.P. 12 lb./sq. in. and "Liquefied Petroleum Gases" (L.P.G.) of R.V.P. 80 lb./sq. in. Working details of the distillation system are given for these products. C. G. G.

91.* Laboratory Tests of Cathodic Protection of Steel in Various Corrosive Solutions. W. R. Hill. *Petrol. Engr*, 1941, **12** (13), 51.—A laboratory investigation was carried out to determine the significance in cathodic protection of steel of each of the factors: (*a*) concentration of electrolyte; (*b*) ionic constituents of electrolyte; (*c*) p_{H} value; (*d*) time of contact; (*e*) current density and metal-solution potential relationships.

It was found that variations of (*a*), (*b*), and (*d*) had little or no effect on the minimum current density required to ensure complete protection. On the other hand, solutions of low p_{H} value appear to require augmented current density as compared with neutral solutions. In general, complete protection is attained at a current density of about 10 mA./sq. ft., but $0{\cdot}001N$-H_2SO_4 ($p_{\mathrm{H}} = 4$) showed appreciable corrosive action even at 35 mA./sq. ft. Protective conditions are usually, but not invariably, attended by some polarization.

Full details of apparatus and technique are given, and the experimental results are shown in graphical form. C. G. G.

92.* Rates of Flow and Heat Loss in Refinery Steam Piping. R. G. Lovell. *Petrol. Engr*, 1941, **12** (13), 59.—Charts from the Crane Co.'s publication, "Engineering Data on Flow of Fluids in Pipes," are reproduced, and their application to steam-flow and heat-loss problems is illustrated by means of examples.

It is pointed out that the rate of discharge of steam from a high-pressure system to a system at lower pressure increases as the lower pressure is reduced down to 58% of the higher pressure; thereafter the rate does not change with increasing pressure difference. The use of this effect for controlling rates of steam supply is suggested.

The following subjects are discussed: rates of flow of steam through valves, piping, and orifices; heat losses from bare steam piping. C. G. G.

93.* Review of the Fundamentals of Hydraulics. R. W. Machen. *Petrol. Engr*, 1941, **12** (13), 126.—An elementary exposition of the quantitative aspects of fluid-flow through pipes and orifices, and over full-width, end-contracted, and triangular weirs.

Tables of discharge coefficients are given for full-width and end-contracted weirs discharging water. C. G. G.

94.* Reabsorber in Gasoline Plant Controls Pressure or Entire Distillation System. Anon. *Petrol. Engr*, 1941, **12** (13), 142.—A brief description, with photographs, of the new natural gasoline plant built by the Del Valle Gasoline Co., near Saugus, Cal.

A novel feature of the plant is that, with the exception of the main absorber, all vessels and vent-tanks throughout the distillation and condensate system are pressure controlled by means of a single back-pressure controller on the reabsorber.

C. G. G.

95. Patents on Refining and Refinery Plant. Standard Oil Co. E.P. 539,385, 9.9.41. Appl. 4.10.39. Process for conversion of relatively heavy hydrocarbon oils into lower-boiling hydrocarbons by subjecting the vaporized oils to the action of a catalyst consisting of silica gel, the internal pore surface of which is coated with a thin layer of thorium compound.

Standard Oil Co. E.P. 539,844, 25.9.41. Appl. 4.9.40. Method of recovering oil adhering to the spent catalyst obtained from a hydrocarbon conversion process. The catalyst is treated with hot normally gaseous hydrocarbons at a temperature the same as or slightly below that at which the conversion process was carried out. The treatment can be applied to spent catalysts from catalytic cracking, reforming, dehydrogenation, aromatization, alkylation, isomerization, polymerization, etc.

N.V. de Bataafsche Petroleum Maatschappij. E.P. 539,867, 26.9.41. Appl. 4.4.40. Process for the removal of weakly acid-reacting substances from water-insoluble neutral or weakly basic organic liquids with the aid of an aqueous solution of a strong base. Treatment with the base is carried out in the presence of a salt of a non-aromatic dicarboxylic acid having from 5 to 11 carbon atoms in the molecule, and in which the carboxyl radicals are separated by at least two carbon atoms.

Standard Oil Development Co. E.P. 540,287, 13.10.41. Appl. 15.11.39. Catalytic treatment of hydrocarbon oils. The oil is contacted with a solid catalyst which becomes fouled with carbonaceous matter during the process. Accordingly the operation is interrupted from time to time and the catalyst regenerated. The throughput of the oil and the temperature of the reaction in the cracking zone are kept constant, and the length of the cracking operation is progressively reduced as the activity of the regenerated catalyst becomes depreciated.

S. R. Merley. U.S.P. 2,257,914, 7.10.41. Appl. 7.12.39. Process for the neutralization of sulphuric-acid-treated mineral oils and removal of oil-soluble soaps without the use of caustic alkali solution. The acid-treated oil is further treated with an excess of a solution of normal alkali metal sulphite.

W. W. Johnstone. U.S.P. 2,258,249, 7.10.41. Appl. 27.4.39. Method of sweetening hydrocarbon distillates containing mercaptans by treating with sodium plumbite solution and a quantity of elementary sulphur in excess of that required to convert the mercaptans into lead mercaptides. Afterwards the distillate is treated with a solution of an alkali metal hydroxide containing a relatively small amount of a low-boiling mercaptan. This solution is used in sufficient amount to remove the excess sulphur from the distillate, which is then recovered without further plumbite treatment.

T. F. McCormick. U.S.P. 2,258,512, 7.10.41. Appl. 6.7.38. Method of purifying a cracked petroleum hydrocarbon oil by intimately mixing and reacting therewith a straight-run sulphuric-acid sludge to form a mixture of partially purified oil and cracked acid sludge. Afterwards the purified oil is separated from the cracked acid sludge.

H. B. M.

Metering.

96.* New Apparatus for Calibrating Gasoline Displacement Meters. E. W. Jacobson. *Nat. Petrol. News*, 6.8.41, **33** (32), R.254.—It is stated that a meter must always be calibrated with the liquid on which it will be used. In the apparatus described this liquid, gasoline or burning oil, is confined over water and passed by hydrostatic pressure through the meter into an accurate measuring device. Adequate precautions to eliminate errors due to evaporation, temperature change, and air entrainment are taken.

H. G.

Chemistry and Physics of Petroleum.

97. Polymerization of Olefins. IV. Nonenes from the Dehydration and Copolymerization of *tert.*-Butyl and *tert.*-Amyl Alcohols. F. C. Whitmore and L. W. Mixon. *J. Amer. chem. Soc.*, 1941, **61**, 1460–1462.—Dehydration of an equimolar mixture of the alcohols with 65% sulphuric acid at 80° C. gave a 17% yield of nonenes. Satisfactory separation of the isomeric nonenes could not be obtained by repeated fractionation through a column equivalent to twenty-three theoretical plates; but it was effected by ozonolysis to 2 : 3 : 4 : 4-tetramethyl-1-pentene, 50%; 2 : 3 : 4 : 4-tetramethyl-2-pentene, 10%; 3 : 5 : 5-trimethyl-2-hexene, 23%; 3 : 5 : 5-trimethyl-3-hexene, 5%; and 2 : 4 : 4-trimethyl-2-hexene, 10%. The mechanism of the reaction is discussed. The yields indicate that 88% of the nonenes are formed by the addition of a *tert.*-butyl fragment to an amylene or its equivalent, as compared with 12% formed by the addition of a *tert.*-amyl fragment to *iso*butylene.

R. D. S.

98. Catalytic Dehydrogenation of Hydroaromatic Compounds with Benzene. H. Adkins, L. M. Richards, and J. W. Davis. *J. Amer. chem. Soc.*, 1941, **63**, 1320–1325.—A method has been developed for catalytic dehydrogenation in the liquid phase in a closed system. Such a reaction is reversible without the presence of a hydrogen acceptor or oxidizing agent, and it was found that benzene, which is readily available, stable against polymerization, highly unsaturated, and reacts irreversibly with hydrogen under these conditions, was excellent for the purpose. Although benzene reacts with hydrogen to give *cyclo*hexane, the latter does not suffer dehydrogenation to any appreciable extent in these reactions. Nickel catalysts were employed chiefly. Nickel on chromium oxide was found to be the most active for the dehydrogenation of those saturated hydrocarbons which are particularly resistant to reaction. Supported on kieselguhr or alumina, however, it was better employed for the dehydrogenation of substituted *cyclo*hexanols, as the tendency for condensation was not so great. Platinum was sometimes more active than nickel at lower temperatures, but gave lower yields of phenols. The process consisted in heating the hydroaromatic compound at 300–350° C. in the liquid phase under nitrogen in the presence of benzene and catalyst. Results are given for twenty-eight hydrocarbons, alcohols, ketones, and ethers containing a completely or partly saturated benzene, naphthalene, or phenathrene nucleus. R. D. S.

99. Nitrogen Compounds in Petroleum Distillates. XXI. Isolation and Synthesis on 2 : 3 : 4-Trimethyl-8-*i*-Propylquinoline. L. M. Schenck and J. R. Bailey. *J. Amer. chem. Soc.*, 1941, **63**, 1364–1365).—This material is one of six bases occurring in California kero base of b.pt. 320–330° C. and n_D^{20} 1·5698. Its boiling point is 327° C. The structure was determined, as usual, by chromic acid oxidation to the known 2 : 3 : 4-trimethylquinoline-8-carboxylic acid, and was confirmed by synthesis from methylacetylacetone and *o*-cumidine. R. D. S.

100. Nitrogen Compounds in Petroleum Distillates. XXII. Isolation and Synthesis of 2 : 3-Dimethyl-4 : 8-Diethylquinoline (I) and 2 : 3-Dimethyl-4-Ethyl-8-*n*-Propylquinoline (II). L. M. Schenck and J. R. Bailey. *J. Amer. chem. Soc.*, 1941, **63**, 1365–1367.—Isolation of bases (I) and (II) complete the segregation of the six bases present in the 320–330° C. fraction of the kero base from California petroleum mentioned in the preceding abstract. An admixture of the two was precipitated in acetone–ether solution as nitrates which were converted into picrates. Base II was separated by precipitation from I as acid sulphite. Degradation and synthesis were employed to confirm the structures. R. D. S.

101. Hexabenzylethane. S. A. Hill, W. C. Nelson, R. L. Dunnell, and L. S. Moody. *J. Amer. chem. Soc.*, 1941, **63**, 1367–1368.—The authors have prepared 2 : 2 : 3 : 3-tetrabenzyl-1 : 6-diphenylbutane (hexabenzylethane) by treating tribenzylmethyl bromide in dry ether, and in dry benzene, with sodium, with mercury, and with zinc. The best yield was given by heating with zinc to 50° C. for 48 hrs. in dry benzene. 2-Benzyl-1 : 3-diphenylpropene appeared as an oil, which was decanted from the solid hexabenzylethane. The latter was characterized by nitration to hexanitrohexabenzylethane. R. D. S.

102. III. Two-Component Gel Catalysts Containing Chromium Oxide for the Aromatization of *n*-Heptane. H. Fehrer and H. S. Taylor. *J. Amer. chem. Soc.*, 1941, **63**, 1385–1386.—The dehydrogenation–cyclization of *n*-heptane has been studied in the presence of gel catalysts containing, in addition to chromium oxide, (*a*) the dehydrogenating metals, copper, nickel, and palladium ; (*b*) the dehydrogenating metal oxides of manganese, zinc, and molybdenum ; (*c*) oxides such as silica, zirconia, and stannic oxide. The results have been compared with those obtained on standard chromium–oxide gel catalysts published previously (*J. Amer. chem. Soc.*, 1941, **63**, 1129–1131 ; *J. Inst. Petrol.*, **27**, 1941, Abstr. No. 1297).

Of class (*a*), palladium–chromium oxide yielded only that quantity of gas expected from the oxide content. The hydrogen content of the gas was increased, but the conversion to aromatics was below the standard yield. Nickel gave cracking. Copper gave rates higher than those deduced from the oxide content, lower than those with an equal quantity of standard gel. The gas produced was higher in hydrogen content than standard, and the aromatic content of the liquid lower. The catalysts containing the hydrogenating oxides favoured low olefin content with a given production of aromatics. Incorporation of silica does not materially increase gel stability, but produces greater availability of the chromium oxide surface. Owing to their slower rate of poisoning, catalysts containing zirconia and stannic oxide were superior to the standard gel. They are sensitive to the revivification procedure and lose activity. Pure zirconia has dehydrogenating-cyclizing activity towards paraffins at 475° C. R. D. S.

103. IV. Mechanism of Reaction and of Poisoning in the Dehydroaromatization of *n*-Heptane. H. S. Taylor and H. Fehrer. *J. Amer. chem. Soc.*, 1941, **63**, 1387–1392. —Data are presented on the comparative rates of reaction of *n*-heptane, heptylene-1, and methyl*cyclo*hexane from the standpoint of yields and poisoning, and, in addition, data on the effect of poisoning by ethylene as a typical olefin. The authors found that initially heptylene-1 cyclizes more rapidly than *n*-heptane, but during the dehydrogenation extremely rapid poisoning of the catalyst occurs. From the reaction of a mixture of 85% *n*-heptane and 15% heptylene-1 it was observed that the presence of the heptylene-1 markedly reduced the conversion rate. The reaction rate of methyl*cyclo*hexane was greater than that of *n*-heptane or the initial stages of heptylene-1, but no poisoning occurred. Ethylene had a pronounced poisoning effect on the dehydrogenations, but the presence of hydrogen suppressed this effect, presumably by rapid hydrogenation to ethane. The effect was due to deposition of carbonaceous material on the surface, and the poison was removable only by oxidation. Poisoning affected much more seriously the aromatic formation than the dehydrogenation of the paraffin to olefin. A general discussion on the mechanism of these reactions is given. R. D. S.

104. Use of Sulphuric Acid in Purifying Saturated Hydrocarbons : its Action on 2 : 4 : 4-Trimethylpentane. F. C. Whitmore and H. H. Johnson, Jr. *J. Amer. chem. Soc.*, 1941, **63**, 1481–1482.—After treating *iso*-octane with cold 95% sulphuric acid for 10 days the authors found that over half othe starting material had been changed to other products. Although this is a prolonged treatment, and therefore an extreme case, they question the desirability of this method for the purification of saturated hydrocarbons. R. D. S.

105.* Dielectric Properties of Organic Compounds. S. O. Morgan and W. A. Yager. *Industr. Engng Chem.*, 1940, **32** (11), 1519.—The dielectric constants of a large number of hydrocarbons, halogen compounds, ethers, ketones, esters, and alcohols are given. The relationship between chemical composition, physical structure, and dielectric constant is discussed. The determined dielectric constant of many polar liquids do not agree with the results calculated from chemical constitution, due to association or molecular interaction. In the solid state where simple theory predicts a low dielectric constant, there are many cases of high values. In the case of plastics this phenomena has been more fully investigated, and a correlation is found between the presence of polar groups and the value of the dielectric constant. J. W. H.

106.* Electrical Conduction in Dielectric Liquids. R. W. Dornte. *Industr. Engng Chem.*, 1940, **32** (11), 1528.—The current-voltage relations at high electrical gradients are given for dry, gas-free heptane and benzene at 23° C. Measurements have been made in uniform and non-uniform electrical fields in cells of different types fitted with different electrodes. The experimental results do not agree with the thermionic emission theory of conduction. The experimental slope was generally greater than calculated value. It was suggested that this lack of agreement is due to the nature of the electrode surfaces. Cold cathode emission of electrodes is suggested as a mechanism for the electrical conduction in dielectric liquids. J. W. H.

107.* Phase Equilibrium in Mixed Solvent Extraction. A. V. Brancker, T. G. Hunter, and A. W. Nash. *Industr. Engng Chem.*, 1941, **33** (7), 880.—The tetrahedral and right-prism methods of representing the phase equilibrium between four components are discussed. Experimental data are given for the systems chloroform–acetone–

acetic acid–water at 25° C. and oil–acetic acid–chloroform at 25° C. in which the oil is regarded as two components of the system. J. W. H.

108.* Liquid Films in the Viscous Flow Region. J. F. Friedman and C. O. Miller. *Industr. Engng Chem.*, 1941, **33** (7), 885.—Experimental data are given for the flow of fluids down wetted wall-towers. Measurements of the film thickness and velocity have been made at various flow-rates in glass tubes of 1·00 and 0·626 in. dia. with oil, kerosine, toluene, and water as the fluids. The data from these experiments have been correlated with Reynolds number and friction factor. It is considered that in the flow of liquid films bounded by solid and static air interfaces, a third type of flow, named pseudo-streamline, exists between Re 25 and Re 1500. This type of flow is characterized by the appearance of waves in the liquid film and a much higher gas–liquid interfacial velocity than that predicted by the streamline flow equations. The Reynolds number–friction factor relationship for true streamline flow is applicable in this region. The change from streamline to pseudo-streamline is a function of Reynolds number and is independent of the tube diameter. J. W. H.

109.* Calculation of Partial Pressures of Binary Mixtures. R. M. Levy. *Industr. Engng Chem.*, 1941, **33** (7), 1928.—Equations are developed which enable the vapour–liquid equilibrium to be calculated for binary mixtures from a knowledge of the total pressure of the system and the vapour-pressure temperature relationship of the components. Experimental and calculated values of the vapour liquid equilibrium are given for examples which obey and which deviate from the ideal solubility laws. The equations can be applied to the soluble portions of partly miscible liquids.
J. W. H.

110. Olefine Production from Ketones. Anon. *Chem. Tr. J.*, 17.10.41, **109**, 188.—A method of producing olefines from aldehydes and ketones is described in E.P. 538,353 of 1941 granted to the Gas Light & Coke Co. and R. H. Griffith. An aldehyde or ketone (*e.g.*, dipropyl ketone) is treated at *ca.* 400° C. and at atmospheric pressure with an excess of hydrogen in the presence of a deoxygenating catalyst, consisting of a compound of vanadium, tungsten, or molybdenum, preferably the oxides or sulphides. With a catalyst space of 1 litre, 1000 litres of hydrogen/hour are passed through with 1 litre/hour of the ketone. The oxygen in the aldehyde or ketone is removed in the form of water, but saturation of the double bond does not take place unless temperature or hydrogen concentration is too high or time of treatment too prolonged. Satisfactory results are obtained when 10% of the aldehyde or ketone is unchanged. The quantity of hydrogen should be about ten times the theoretical, this being reduced at low throughputs or high temperatures to reduce saturation of the double bond. Increasing the pressure also has the effect of increasing formation of saturated hydrocarbons. The position of the aldehyde or keto-group generally determines the position of the double bond, unless isomerization occurs (which may result from the secondary activity of the substance used as catalyst support). From dipropyl ketone a mixture of C.7 hydrocarbons results, most having one double bond in the molecule. Water, heptanol 4, and fully saturated hydrocarbons are also formed. C. L. G.

See also Abstract No. 82.

Analysis and Testing.

See Abstract No. 118.

Motor Fuels.

See Abstract No. 71.

111. Patents on Motor Fuels. S. B. Grundy. E.P. 539,285, 3.9.41. Appl. 8.3.40. Manufacture of addition agents for incorporation in motor spirits. Naphthalene and a proportion of graphite are mixed together, and during the process of mixing xylidine (amidodimethylbenzene) is incorporated in the form of a fine spray. The resultant powder is then compressed into the form of tablets.

Standard Oil Company. E.P. 539,297, 4.9.41. Appl. 15.12.39. Conversion of saturated straight-chain normally liquid paraffin hydrocarbons into saturated branched-chain paraffin hydrocarbons. The saturated straight-chain hydrocarbons are treated with a catalyst selected from the group comprising aluminium chloride, aluminium bromide, and their hydrocarbon complexes, and a halogen-containing promoter for such catalyst, at elevated temperature, and pressure, and in the presence of one or more normally gaseous saturated paraffin hydrocarbons having at least two carbon atoms per molecule.

Standard Oil Development Co. E.P. 539,383, 8.9.41. Appl. 13.10.40. Treatment of crude petroleum oil to obtain motor fuel of high anti-knock value. The oil is separated into a number of fractions of different boiling ranges. These are then vaporized individually, and a solid pulverulent contact material is suspended in each fraction. The suspensions are then passed through separate reaction zones and maintained under conditions designed to convert the oil fractions into high-grade motor fuel.

Standard Oil Development Co. E.P. 539,480, 12.9.41. Appl. 13.11.39. Production of normally liquid hydrocarbons suitable for use as motor fuel of the kind in which an olefin and an *iso*paraffin are reacted to produce alkylated hydrocarbons. According to this method there is introduced into the reaction mixture a fraction of a previously formed product of such reaction, consisting of hydrocarbons boiling below the final product and hydrocarbons boiling above the final product.

V. G. Strickland. E.P. 539,792, 24.9.41. Appl. 16.3.40. Method of running internal-combustion engines with easily inflammable fuels. The fuel is stored in the form of an emulsion, and is separated from the emulsion only on its way to the engine. It is claimed that fuel stored in this way is is not liable to explode and is particularly suitable for use in aircraft engines, submarines, etc.

M. H. Arveson. U.S.P. 2,257,723, 7.10.41. Appl. 26.1.38. Conversion of petroleum oil into high anti-knock motor fuel by fractionating it into naphtha, virgin gas oil, and reduced crude. Thereafter the reduced crude is thermally converted into tar and light products, including gases and gasoline. The virgin gas-oil is catalytically cracked, and the products therefrom, together with the products from thermal conversion, catalytically cracked to separate gasoline and gases from a first cycle gas-oil. Hydrogen and methane are separated from these gases to obtain a C_3–C_4 hydrocarbon fraction, which is admixed with the first recycle gas-oil. Finally, the mixture is catalytically converted to form a second cycle gas-oil and a high anti-knock gasoline characterized by branched-chain structure.

D. R. Stevens and W. A. Gruse. U.S.P. 2,258,368, 7.10.41. Appl. 19.1.38. Manufacture of a motor fuel consisting substantially of di*iso*butylene and tri*iso*butylene. *iso*Butylene is taken up in 60–65% sulphuric acid solution and polymerized while maintaining the concentration of the sulphuric acid on a hydrocarbon-free basis substantially constant. During polymerization the apparent acidity of the *iso*butylene–sulphuric acid solution is approximately 45 gm. 95 H_2SO_4/100 c.c. of *iso*butylene–sulphuric acid solution. In this way about 90% of the *iso*butylene is polymerized.

R. M. Melaven and R. V. Shankland. U.S.P. 2,258, 787, 14.10.41. Appl. 25.1.39. Conversion of heavy hydrocarbon oils into gasoline by vaporizing the oils and subjecting the vapours at a temperature between 700° and 1050° F. to the action of a catalyst consisting essentially of silica gel promoted by titanium. The catalyst is made by treating the gel with a titanium compound in an acid solution and afterwards washing and drying.

H. V. Atwell. U.S.P. 2,258,839. 14.10.41. Appl. 10.10.37. Conversion of normally liquid and normally gaseous hydrocarbon products of the reaction of carbon monoxide and hydrogen. A fraction predominating in normally liquid constituents, and including at most a minor proportion of hydrocarbons boiling above the gasoline range, is separated from the reaction products, and a substantial porportion of normally gaseous hydrocarbons mixed with it. The resultant mixture is subjected to elevated conditions of temperature and pressure to effect conversion of normally liquid and normally gaseous constituents thereof to gasoline of high anti-knock value.

E. L. D'Ouville. U.S.P. 2,260,279, 21.10.41. Appl. 21.12.38. Preparation of a motor fuel containing a large proportion of branched-chain paraffin hydrocarbons from a naphtha containing substantial amounts of aromatic and straight-chain paraffin hydrocarbons. The naphtha is heated to produce therefrom a hydrocarbon mixture containing straight-chain paraffin hydrocarbons, but not more than 2% by volume of aromatic hydrocarbons. The mixture is then subjected to the action of an aluminium halide catalyst and an activator affording a hydrogen halide under conditions effective to convert straight-chain paraffin hydrocarbons into branched-chain paraffin hydrocarbons.

Le R. G. Story. U.S.P. 2,261,004, 28.10.41. Appl. 27.5.39. Manufacture of high anti-knock gasoline hydrocarbons by dehydrogenating normally gaseous hydrocarbons predominating in paraffins containing between two and five carbon atoms, to form a hot mixture of paraffins and olefins. The hot mixture is then contacted with liquid products from an alkylation process, and the liquids thus vaporized to form an alkylate and a normally gaseous hydrocarbon fraction containing olefins and paraffins. The gaseous portion is then fractionated to produce a fraction rich in olefins and a fraction rich in paraffins. The olefin-rich fraction is charged to the alkylation operation, where the olefins are alkylated with *iso*butane in the presence of an alkylation catalyst. The paraffin-rich fraction is returned to the dehydrogenation operation. H. B. M.

Gas, Diesel, and Fuel Oils.

112. Home Fuels for Diesels. Anon. *Gas Oil Power*, July 1941, **36** (430), 144; Aug. 1941, **36** (431), 161.—This is a summary of a report with particular reference to the use of indigenous fuels in road-vehicle oil engines, published by the Diesel Engine Users' Association.

In some general comments on the problem of using home-produced fuels in high-speed diesels, it is pointed out that the S.I.T. of coal oils is higher than those of petroleum-base oils; thus the former are more difficult to ignite in an engine. Dopes have been tried out to overcome this deficiency, including ethyl nitrate, amyl nitrate, and nitrite, and two dopes patented by the Gas Light & Coke Co. and the Low-Temperature Carbonization Co. respectively.

The test fuels used for this work comprised :—

(*a*) 0/100% reference blend : *a* methyl naphthalene/Kogasin II.
(*b*) 0/100% blend : H.-T. creosote/petroleum diesel fuel.
(*c*) 0/100% blend : L.-T. diesel oil/petroleum diesel fuel.
(*d*) Blenders : Diesoline, Esso-Diesel, Scotch shale oil and high-ignition-quality gas oil.

The bench tests were carried out at the Gas Light & Coke Co's Beckton Research Experimental Station on a single-cylinder Lister engine, compression ratio 19 to 1 for starting from cold and 15·25 to 1 for normal working, rated at 9 B.H.P. at 1000 r.p.m.

Results have been plotted in the form of a graph showing the relation between the critical ignition temperatures of the various fuel blends and the engine compression ratio under running temperature conditions. The following indications can be obtained from the graph :—

(i) Proportion of high-temperature or low-temperature creosote diesel fuel which can be blended with a commercial petroleum-base fuel for use in a diesel engine of known compression ratio and temperature limits.

(ii) The minimum compression ratio required to enable a given blend of creosote diesel fuel to be used. Since the compression ratios of standard makes of engine are known, the graph will indicate what engines can run on a given blend.

It was found that the high-temperature creosote blends require a higher temperature of ignition than either the reference or the low-temperature blends. Conversely, a given engine will require a higher percentage of high-grade fuel in the blend than would be necessary if either the reference or low-temperature creosote blends were being used.

It is concluded that:—

1. Straight H.-T. creosote cannot be satisfactorily used in present commercial transport engines.
2. Doping this fuel improves its performance, the effect of 4% dope being equivalent to a 40% addition of petroleum diesel fuel.
3. Although bench tests allow up to 50% H.-T. creosote in a fuel, in practice 20% creosote probably represents the limit. Even then a dual fuel system is necessary for starting from cold.
4. Under some conditions straight L.-T. creosote can be used and doping gives satisfactory results.
5. With L.-T. creosote 50% blends are more or less satisfactory.

D. L. S.

113. Patent on Gas, Diesel, and Fuel Oil. E. T. Scafe. U.S.P. 2,261,003, 28.10.41. Appl. 5.12.39. Preparation of an unrefined light fuel oil of gas-oil nature inhibited against the formation of sediment by oxidation under normal conditions of storage by the addition of small amounts of di*cyclo*hexylamine. H. B. M.

Lubricants and Lubrication.

114.* Anti-Friction Bearing Lubricants. O. L. Maag. *Nat. Petrol. News*, 1.10.41, **33** (40), R.313.—The author advocates the introduction, for industrial lubricants, of a classification system similar to the S.A.E. system for motor oils. The relative merits of oils and greases are discussed and a specification for an all-the-year-round grease for army use is suggested. H. G.

115.* Patents on Lubricants and Lubrication. Standard Oil Co. of California. E.P. 539,293, 4.9.41. Appl. 15.11.39. Preparation of a hydrocarbon lubricating oil having incorporated therein a metal phenate and a salt of an organically substituted acid of phosphorus. It is claimed that oils of this character improve lubrication and operation of internal-combustion engines.

B. H. Lincoln and G. D. Byrkit. U.S.P. 2,257,750, 7.10.41. Appl. 24.5.39. Preparation of a lubricant consisting of a major proportion of a lubricating oil and a minor proportion of an organo-metallic salt of a sulphur-bearing organic acid.

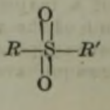
B. H. Lincoln and G. D. Byrkit. U.S.P. 2,257,751, 7.10.41: Appl. 5.7.41. Preparation of a lubricant consisting of a major proportion of a lubricating oil and a minor proportion of a tin salt of a sulphurized carboxylic acid. The carboxylic acid is sulphurized by treatment with sulphur chloride.

B. H. Lincoln and G. D. Byrkit. U.S.P. 2,257,752, 7.10.41. Appl. 5.7.40. Preparation of a lubricant consisting of a major proportion of a lubricating oil and a minor proportion of a salt of a quaternary ammonium base and a sulphur-bearing organic acid.

R. G. Sloane. U.S.P. 2,257,890, 7.10.41. Appl. 3.10.33. A sufficient quantity of an aromatic compound containing only the elements carbon, hydrogen, and sulphur is combined with a highly viscous mineral oil to reduce the tendency of the oil to form acidic material through oxidation.

H. M. Fraser. U.S.P. 2,257,945, 7.10.41. Appl. 24.5.40. Removal of entrapped air from lubricating grease by dividing the grease into a number of small streams and subjecting to a vacuum. In this way air is quickly removed from the grease streams.

C. M. Loane and B. H. Shoemaker. U.S.P. 2,257,969, 7.10.41. Appl. 18.5.39. Preparation of a lubricant containing a small amount of an organic sulphone of the general formula



$$R-\overset{\overset{\displaystyle O}{\|}}{\underset{\underset{\displaystyle O}{\|}}{S}}-R'$$

R and R' are radicals selected from the group consisting of aliphatic radicals, alicyclic radicals, aromatic radicals, and hydrocarbon substituted aliphatic, *cyclo*aliphatic, and aromatic radicals.

L. G. Burns. U.S.P. 2,258,202, 7.10.41. Appl. 16.5.40. Preparation of a lubricant having incorporated in it graphite (2 parts per 100), bentonite (98 parts per 100), and sufficient water to render the mixture of graphite and bentonite free flowing.

A. J. Morway and A. Beebower. U.S.P. 2,258,301, 7.10.41. Appl. 11.5.38. Preparation of an anhydrous grease consisting of a soda soap of a fatty acid, lubricating oil, and a small amount of plasticizing agent comprising a non-distillable, substantially neutral saponifiable material obtainable as a by-product of the oxidation of paraffin wax. The amount of this neutral by-product is less than half that of the acid used in making the soap.

J. C. Zimmer. U.S.P. 2,258,309, 7.10.41. Appl. 7.4.38. Preparation of a lubricant consisting of an aqueous emulsion of a mineral lubricating oil to which has been added a filler consisting of a polyvalent metal salt of an acid selected from the class consisting of phosphoric, boric, and hydrosulphuric acids. This salt is substantially insoluble in both oil and water.

F. R. Moser and A. J. Dijksman. U.S.P. 2,258,591, 14.10.41. Appl. 27.11.39. Preparation of a compounded mineral lubricating oil of improved anti-corrosive properties and containing a small amount of the zinc salt of di-*iso*propyl salicylic acid.

M. Pier and F. Christmann. U.S.P. 2,258,806, 14.10.41. Appl. 19.1.35. Preparation of a lubricant consisting of a synthetic product of high molecular weight prepared by condensation, by means of a catalyst of the Friedel–Crafts reaction, a mixture of an organic compound selected from the class consisting of unsaturated and halogen-containing compounds having a long hydrocarbon chain, and a substance selected from the class consisting of elementary sulphur and reactive organic sulphur compounds possessing anti-oxidant properties.

H. G. Berger, W. H. James, and D. E. Badertscher. U.S.P. 2,259,452, 21.10.41. Appl. 2.8.39. Preparation of an improved mineral-oil composition consisting of a mineral-oil fraction and a small amount of a compound selected from the group consisting of an aromatic *ortho*-phosphite-carboxylic acid chloride and derivatives thereof.

E. F. Engelke. U.S.P. 2,260,303, 28.10.41. Appl. 8.5.39. Preparation of a lubricant consisting of a hydrocarbon oil and a condensation product of an organic phosphine formed in the presence of sulphur and containing at least two organic phosphine radicals in the molecule.

E. F. Engelke. U.S.P. 2,260,304, 28.10.41. Appl. 15.9.39. Preparation of a lubricating composition consisting of a lubricating oil to which has been added a small proportion of a nitrogen-free organic chlorophosphine oxide in which chlorine is directly attached to phosphorus.

J. E. Schott. U.S.P. 2,260,341, 28.10.41. Appl. 5.4.38. Manufacture of a lubricating composition consisting of hydrocarbon oil of suitable viscosity compounded with approximately 1% by weight of aluminium stearate and a quantity of hydroxy butyloxy-ethyl ether, sufficient to improve the lubricating efficiency of the oil. The ingredients of the compounded oil are subjected to a heat treatment at an elevated temperature and for sufficient length of time to produce a resulting product which has substantially the viscosity and fluidity characteristics of the uncompounded oil.

P. A. Asseff. U.S.P. 2,261,047, 28.10.41. Appl. 28.7.41. Preparation of a lubricating composition consisting of a major proportion of a hydrocarbon oil to which has been added a small amount of the zinc salt of an acidic reaction product obtained by reacting phosphorus pentasulphide with an alkylated *cyclo*hexanol in which substantially all of the alkyl groups have less than six carbon atoms.

H. B. M.

Asphalt and Bitumen.

116.* Mechanics of Granular and Granular-Plastic Materials, with Special Reference to Bituminous Road Materials and Subsoils. V. A. Endersby. *Proc. 43rd A.M., A.S.T.M.*, 1940, **40**, 1154–1173.—This paper is a study of the mechanical stability of bituminous mixes by evaluation with the Mohr circle diagram, of results obtained in the triaxial test on road-mix samples. It is shown that, in correlating tests with practical conditions, the absolute dimensions and composition of the specimen, the maximum particle size, the temperature, and the speed must be considered.

Friction-deformation and void-deformation curves for various aggregates, and Mohr diagrams for bituminous mixes, showing the effect of the factors mentioned above, are given. J. F. T.

117.* Measurement of the Deformation Properties of Asphalts. T. F. Ford and K. G. Arabian. *Proc. 43rd A.M., A.S.T.M.*, 1940, **40**, 1174–1181.—The inadequacy of the penetration tests and other empirical tests in evaluating the deformation properties of asphaltic bitumens, particularly those which are elastic as well as viscous, led the authors to investigate the value of a rotating-cylinder viscosimeter. This instrument is provided with conical bases to the cylinders to eliminate end effects. Results of viscosity determinations using different shearing stresses and varying clearance between the cylinders were in good agreement when examining petroleum resins. Deformation–deformation rate curves for Mexican-blown bitumen show that the deformation obtained by the penetration test bears no direct relation to viscosity, and that capillary viscosimeters are unsuitable for the examination of deformation behaviour.

A simpler type of rotating cylinder viscosimeter is described, consisting of two concentric rings, of which the outer one is stationary and the inner one is rotated by weights on a fish-line round the driving pulley, both rings being removable, so that the clearance area and, hence, the shearing stress can be varied. The viscosities of petroleum resins of penetration 12–257 determined on this instrument compared with results obtained by the coni-cylindrical viscosimeter show agreement varying between 1% and 4%.

From an analysis of the deformation curves for Mexican-blown bitumen it is concluded that the minimum data from which such curves can be prepared necessitates a knowledge of three properties such as viscosity, elasticity in shear, and rate of slip. J. F. T.

118.* Rheological Interpretation of Asphalt Tests. R. N. Traseler, H. E. Schweyer, and J. W. Romberg. *Proc. 43rd A.M., A.S.T.M.*, 1940, **40**, 1182–1194.—The relation between the rheological properties of asphaltic bitumen and its colloidal nature, together with problems arising out of the elasticity and thixotropy of the bitumen, is discussed in order to show the unsatisfactory nature of the penetration, ring-and-ball softening point, and ductility tests in evaluating the flow properties of bitumen. From data and curves relating the consistency in absolute units with these three empirical factors, the penetration test is considered to be of little value, the ring-and-ball softening point test is shown to be satisfactory in the case of steam-refined and air-blown bitumens, although not for vacuum or steam-refined bitumen with high-temperature susceptibility, while the ductility test, owing to the effect of temperature and variations in the rate of shear, is considered to bear no relation to any specific property.

In conclusion, the authors urge the substitution of empirical tests by rheological methods of which the rotating cylinder viscometer with variable rates of shear is recommended. J. F. T.

119.* Study of the Recovery of the Bitumen from Soft Asphalt Cements by the Bussow Method. C. Bussow. *Proc. 43rd A.M., A.S.T.M.*, 1940, **40**, 1201–1205.—In order to examine the influence of the maximum temperature of distillation on the penetration of the bitumen recovered by the Bussow method, details of which are given, nine bitumens of penetration 49–270 were recovered, using maximum recovery temperatures of 225°, 250°, 275°, and 800° C., and the penetration, loss on heating, and penetration after heating of the recovered bitumens determined. The results, when compared with the original figures, indicated that a maximum temperature of recovery of 250° C. is suitable for all these bitumens except for that with a penetration of 270.

The paper concludes by comparing the Abson and Bussow methods, and offers an explanation, based on the difference in solubility of the various components of the bitumen, for the loss in ductility of bitumens recovered by the Abson method.

J. F. T.

120.* Corrosion of Bituminous-Coated Metal Surfaces. A. O. Beckman, R. M. Badger, E. E. Gulletson, and D. P. Stevenson. *Industr. Engng Chem.*, 1941, **33** (8), 989.—Electro-osmosis and ionic diffusion are shown by a series of experiments to be almost negligible factors in the type of corrosion encountered in practice. Data given on wetting angles between bitumens and aqueous solutions indicate that imperfections of the order of 0·1 mm. in radius in some bituminous coatings will permit the intrusion of water through an appreciable thickness of film. It is concluded that it is the presence of these small fissures in the coating which is the dominant factor governing corrosion. J. W. H.

121.* Permeability and Absorption Properties of Bituminous Coatings. A. P. Anderson and K. A. Wright. *Industr. Engng Chem.*, 1941, **33** (8), 991.—Although bituminous coatings are shown to be permeable to water and oxygen by molecular diffusional processes, the rate of permeation is so slow as to give rise to a negligible rate of corrosion. It is concluded that asphalt will be effective in preventing the corrosion of coated metal pipes as long as the asphalt coating is macroscopically intact. J. W. H.

122.* Study of Bituminous Mixtures on Road-Testing Machines. C. Mack. *J. Soc. chem. Ind.*, 1941, **60**, 111–120.—The necessity of surfacing a vast mileage of secondary roads in North America has led to the use of low-cost materials which must stand a range of – 30° F. to 100° F. in the shade. Bitumens of consistency 70–100° F. (R. & B.) have been found suitable and difficulties in summer overcome by the use of graded aggregate. Owing to the continual presence of water, the adhesion between bitumen and aggregate must remain high for the roads to be satisfactory. The paper deals with the problem of increasing this adhesion, which has been correlated with the stability of paving mixtures when tested on road-testing machines under various operating conditions. The author discusses the theory of adhesion between bitumen and aggregate and describes a method of measuring adhesion by allowing the powdered solids to settle freely in a 40–60% solution of the bitumens in benzene. It is pointed out that a factor overlooked by many investigators is the presence of the exchangeable sodium and potassium ions. These form soaps with the acids in the bitumen, and water penetrating through will wash off the bitumen. It has been found that heavy metal soaps, particularly lead, added to the bitumen increase the adhesion, as do additions of hydrated lime to acidic aggregates and inorganic heavy metal salts, particularly lead nitrate, to aggregates with exchangeable sodium and potassium ions. Owing to the difficulty of precoating with heavy metal salts, the use of the double salts of heavy metals containing organic radicals of low and high molecular weight was developed—*e.g.*, lead acetate–naphthenate. It requires the presence of high-molecular-weight organic acids or their metal soaps to make it soluble in bitumen. The use of road-testing machines with the pavement kept drenched affords a practical method of testing adhesion as well as the effect of temperature, traffic, etc. The two machines used are described in detail; one has a single traversing wheel, while the other has four overlapping traversing wheels. Careful temperature control during the tests was found to be essential, while decreasing temperature increased the stability of a test paving mixture. The addition of the adhesion-increasing agents described above was found to give a considerable increase in the life of a bituminous-test paving mixture with both the road-testing machines. The effect of temperature on the relative improvement obtained by these adhesion-increasing agents was found to be much more pronounced on one machine. Increasing the speed of the wheel was found to result in an increase of stability which was higher than would correspond to the ratio of the speeds. The results have been correlated between the two machines, and for the same paving mixture the comparison seemed to indicate that the stability was influenced by (1) temperature,

(2) the adhesion of bitumen to aggregate, (3) the speed of the wheel, (4) the amount and distribution of the traffic, (5) the surface contour of the pavement, and (6) the scuffing action of the wheel. Other factors still remain to be investigated. In view of the difficulty in controlling all of the factors affecting the stability of a pavement on the road, it seemed to the author to be impossible to correlate road results with those obtained on the machines, and that considerably more knowledge must be obtained before this could be achieved. H. G. W.

Special Products.

123.* Electrical Insulating Oil Deterioration. J. C. Balsbaugh, A. H. Howell, and A. G. Assaf. *Industr. Engng Chem.*, 1940, **32** (11), 1497.—Two series of related samples of insulating oils have been studied for their oxidation and electrical stability. The samples in these series represent different degrees of solvent refining and finishing treatment of a given stock. The results show that the stability depends on the initial chemical constitution and the refining treatment. Full details of the experimental technique employed, together with details of the effect of oxidation time on the electrical stability, are given. J. W. H.

124.* Liquid Dielectrics. J. D. Piper, C. C. Smith, N. A. Kerstein, and A. G. Fleiger. *Industr. Engng Chem.*, 1940, **32** (11), 1510.—Various compounds representing types of sparingly soluble oxidation products formed during the service degradation of insulating oils have been added to liquid paraffin in proportions to form homogeneous or heterogeneous systems with change of temperature. The power factor, dielectric constant, and conductivity of the system were measured at different temperatures. Homogeneous systems gave low power factors and conductivities. Liquid heterogeneous systems gave higher power factors, which were much higher than that predicted by the Wagner concept of a heterogeneous dielectric. Crystalline heterogeneous systems showed no increase of power factor over the corresponding homogeneous system. J. W. H.

125.* Electrical Stability of Oil-Impregnated Paper. C. E. Trautman and W. N. Arnquist. *Industr. Engng Chem.*, 1940, **32** (11), 1535.—The relationship between the properties of the impregnating oil and the resulting electrical stability of the oil-impregnated paper have been investigated for oils representing various degrees of refining treatment of a Texas Coastal oil. For these oils the power-factor stability and high-voltage life of the paper were found to be related to the specific dispersion. No general relationship between specific dispersion of other oils and electrical stability has been found, and it is assumed that this is due to the presence of small amounts of materials which have no effect on the specific dispersion or Waterman analysis. The addition of an anti-oxidant to the refined oils improved the power-factor stability. J. W. H.

126.* Synthetic Chemicals in Fuels and Lubricants. W. G. Whitman, *Industr. Engng Chem.*, 1941, **33** (7), 865.—A general review is given of synthetic petroleum products under the headings anti-knock agents, anti-oxidants, metal deactivators, cetane improvers, pour-point depressors, anti-lacquers, and extreme pressure improvers for lubricating oils and aviation-fuel blending components. J. W. H.

127.* Plastics and Chemicals from Petroleum Bases. R. L. Wakeman. *Nat. Petrol. News*, 23.7.41, **33** (30), R.226–R.232, R.237.—The past 20 years have seen very rapid strides in the growth of a chemical industry within the petroleum world. This progress has been made possible by the great advances made in the technique of refining and by the widespread introduction of cracking processes which have made " cracked " gases available in large quantities. The list of products prepared from raw materials of exclusively petroleum origin is large, at least as large as that of materials derived from coal-tar products.

It is estimated that in 1940 the total of organic chemicals prepared from the former source exceeded that from the latter by more than twice. These figures may, however, refer to America only. The list includes a wide range of plastics, solvents, dyestuffs, detergents, wetting agents, and pure organic chemicals. The five principal ways in which the paraffinic constituents of petroleum and natural gas are converted into chemicals are: Pyrolytic cracking followed by chemical reaction, oxidation with steam, CO_2 or atmospheric oxygen, chlorination, nitration, and sulphonation. Ethylene is probably the most important raw material. A wide variety of plastics and intermediates is made from it. The chlorination of pentane leads to amyl chloride and mono-, di-, and tri-chlorpentane. 1 : 3-Dichloropropane is prepared as an intermediate for *cyclo*propane, a promising anæsthetic. The production of nitromethane, nitroethane, and nitropropane by vapour phase nitration is now possible on a large scale. The present scope of their application is not relatively large, but rarely has a new group of chemicals been made available without their ultimately filling an important place in industry or commerce. H. G.

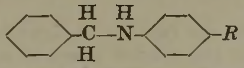
128. Patents on Special Products. Standard Oil Development Co. E.P. 539,252, 2.9.41. Appl. 9.5.40. Manufacture of alkyl halides by the reaction of olefins with hydrogen halides. The reaction is conducted in the presence of a solution of an aluminium halide catalyst in an inert solvent. The catalyst is sufficient to effect the reaction, but does not exceed 2%.

Shell Development Co. E.P. 540,004, 1.10.41. Appl. 27.2.41. Production of aliphatic dicarboxylic acids by the oxidation of an alicyclic hydrocarbon or cyclic ketone with a nitric acid solution. Operating conditions, and particularly the nitric acid concentration, are controlled by a novel procedure, so as to obtain high yields of the desired aliphatic dicarboxylic acids with minimum consumption of nitric acid.

N.V. de Bataafsche Petroleum Maatschappij. E.P. 540,022, 2.10.41. Appl. 28.3.40. Production of aromatic hydrocarbons from mixtures of paraffins and *cyclo*paraffins having more than 6 and less than 12 carbon atoms in the molecule by catalytic cyclization and/or dehydrogenation to increase the octane number. *cyclo*Paraffins with a non-hydroaromatic character, especially *cyclo*pentane homologues, are substantially removed from the initial material before cyclization or dehydrogenation.

Standard I.G. Co. E.P. 540,045, 3.10.41. Appl. 6.2.40. Preparation of paraffin–olefin mixtures by incomplete dehydrogenation of paraffins or paraffin–olefin mixtures of low olefin content. The original hydrocarbons are subjected to temperatures above 500° C. in the presence of a hydrogen halide. 1–10 mols. of hydrogen halide are employed to 1 mol. of paraffin.

C. E. Trautman. U.S.P. 2,257,869, 7.10.41. Appl. 22.3.40. Preparation of a transformer oil composition consisting of transformer oil and a small amount of a dissolved compound represented by the structural formula



where *R* is selected from the class consisting of methoxy and ethoxy groups.

C. E. Trautman. U.S.P. 2,257,870, 7.10.41. Appl. 31.10.40. Preparation of an electrical insulating-oil composition consisting of a petroleum oil having a stabilizing amount of an alkali-insoluble 2 : 4 : 6-trialkylated monohydroxyphenol and a stabilizing amount of *N*-tetrahydrofurfuryl-*p*-aminophenol dissolved therein.

C. E. Trautman. U.S.P. 2,257,871, 7.10.41. Appl. 9.11.40. Incorporation of a small amount of triphenyl phosphate in petroleum oil used as a dielectric and cooling medium in the operation of electrical transformers. The addition of triphenyl phosphate substantially inhibits oxidational changes which would otherwise take place in the oil during normal conditions of use.

C. E. Trautman. U.S.P. 2,257,872, 7.10.41. Appl. 9.11.40. Improvement in transformer oil by the addition of relatively small amounts of trithiophenyl phosphate and of 2 : 6-di-*tert.*-butyl-4-methylphenol. The oil is claimed to be highly resistant to sludging and to other oxidational deterioration under service conditions.

A. N. Sachanen and R. C. Hansford. U.S.P. 2,257,920, 7.10.41. Appl. 20.1.39. Production of alkyl aromatic hydrocarbons boiling below 300° C. from a petroleum tar comprising a substantial amount of alkyl aromatic hydrocarbons entirely of petroleum origin. The alkyl aromatic hydrocarbons are treated with benzene in the presence of a metal halide catalyst at a temperature between 80° and 200° C.

L. T. Monson and W. W. Anderson. U.S.P. 2,259,704, 21.10.41. Appl. 12.5.40. Process for breaking petroleum emulsions of the water-in-oil type. The emulsion is subjected to the action of a demulsifying agent consisting of a mixture of an acylated amino-ether, a blow fatty oil, and a sulphonated fatty body substantially neutral to methyl orange indicator.

W. K. Griesinger and B. Bettmann. U.S.P. 2,259,885, 21.10.41. Appl. 6.4.38. Manufacture of a water-soluble petroleum carbocyclic aminosulphonic acid having at least one nuclear side-chain substituent containing from 3 to 12 carbon atoms. To prepare this acid a petroleum distillate fraction is treated with sulphuric acid to effect sulphonation of at least part of the distillate. Unreacted distillate is then separated from acid sludge and the latter treated with a nitrating agent. Nitrosulphonic acids are extracted from the nitration mixture with an organic solvent and the aqueous solution of acids neutralized with sodium hydroxide. Finally the sodium nitrosulphonates are treated with a reducing agent to reduce them to aminosulphonates.

C. F. Bonnet. U.S.P. 2,259,995, 21.10.41. Appl. 30.1.40. Process for breaking petroleum emulsions of the water-in-oil type. The emulsion is subjected to the action of a demulsifying agent containing a nitroso-aromatic compound selected from the group consisting of nitroso-phenols and nitroso-aromatic carboxylic acids.

A. Pott and H. Broche. U.S.P. 2,261,075, 28.10.41. Appl. 3.6.38. Method of treating dry pulverulent bituminous coal extract to improve its use for motor fuel. The softening point is lowered and ignition temperature lowered by treating with oxygen containing gas at high temperatures. H. B. M.

Detonation and Engines.

129.* Instrument for Measuring Ignition Quality of Diesel Fuels. W. H. Browne. *Soc. Aut. Engrs J.*, 1941, **48** (4), 148–153.—This paper describes the development and use of the Caterpillar cetane valve, an instrument for measuring cetane ratings by throttling the intake air of a single-cylinder test engine. The valve consists of a straight-edged gate sliding across an orifice of varying width. The shape of this orifice is such that a straight-line calibration exists between gate movement and cetane number. Thus, only two reference fuels are needed for standardization. The method of use is to close the orifice gradually until a misfire occurs. When the instrument has been calibrated this misfire point gives the cetane rating of the fuel. As it is important to traverse the gate at a uniform rate, a small electric motor is used.

It is claimed that an operator can rate six to eight fuels an hour on the Caterpillar engine. On the C.F.R. engine the misfire point is not sufficiently definite for the present design of cetane valve to be applied. K. A.

Coal and Shale.

130.* Electrostatic Charges on Coal Particles in Oil. J. E. Hedick, A. C. Andrews, and J. B. Sutherland. *Industr. Engng Chem.*, 1941, **33** (8), 1055.—Under the impress of an electric current, coal particles in oil suspension show a line of force arrangement. Both positive and negative charges exist in the same suspension, not only on different particles, but on different areas of the same particle. These charges are produced by the friction during grinding. Stabilizing addition agents are of two types, surface-acting compounds which prevent flocculation by their electrical effects and mechanical agents which hold a particle in suspension by the formation of gel structures. The mobilities of suspended coal particles have been determined, and are shown to lie between 1·0 and 7·7 $\times 10^{-5}$ cm./sec./volt. J. W. H.

131.* Hydrogenation of High-Volatile Bituminous Coals. L. L. Hirst, R. L. Boyer, A. Eisner, I. L. Pinkel, and H. H. Storch. *Industr. Engng Chem.*, 1941, **33** (8), 1068. —The results are given of liquid phase hydrogenation of assays of four bituminous coals in the Bureau of Mines experimental plant. A summary of similar data obtained for eight bituminous coals, three sub-bituminous coals, and two lignites is also given. J. W. H.

BOOK REVIEW.

Possible Future Oil Provinces in the United States and Canada. By the American Association of Petroleum Geologists. Pp. 154. A.A.P.G., Tulsa, Okla. Price $1.50.

This volume, of only 154 pages, records the results of a symposium conducted by the Research Committee of the American Association of Petroleum Geologists in April 1941. Despite its small size, the volume constitutes a peak even on the high plateau of achievement of this leading association of petroleum geologists.

The project of obtaining and recording a bird's-eye view of the main undiscovered petroleum resources of the United States and Canada was characteristically bold in conception, and the volume under review bears ample testimony to the excellence of its execution. The contributors to the symposium include five geological societies, the Alberta Society of Petroleum Geologists, the Pacific Section of the A.A.P.G., the Geological Survey of Canada, the Quebec Bureau of Mines, and the Chief Alaskan geologist, U.S. Geological Survey. These organizations are responsible for their respective contributions to the volume, and behind them are the best specialists in the United States and Canada. Each and every article in the volume therefore bears the stamp of the highest authority.

Nine main petroliferous provinces are dealt with, but a few regions have been omitted, as present information regarding them is too meagre to allow of authoritative presentation of the evidence.

The description of the petroliferous provinces is preceded by a characteristically thoughtful foreword by the Chairman and Editor, who is probably the leading exponent of the philosophy underlying geological exploration. He sets out four fundamental criteria which form the basis of the articles, and which should be satisfied if a province or region is to rank as being capable of supporting many deposits of oil of commercial size.

The first criterion is the volume and character of the sediments. Volume of sediments is doubtless of the first importance in estimating the petroleum possibilities of any country or province, and it would seem to be specially applicable to the United States, which is unique in that practically every system in the geological column is petroliferous. The disposition of the sediments with respect to the general geological structure is important as, owing to this factor, different provinces and also different parts of a single province may have quite different prospects, which are by no means proportional to the respective volumes of the sediments. The character of the sediments is an important consideration, as is shown by the fact that some of the areas described in the volume under review contain a considerable proportion of continental deposits, the prospects of which are relatively slight or non-existent. However, provided that the succession in a province includes formations that could have functioned as source-rocks, reservoir-rocks, and cap-rocks, the criterion of volume of sediments is of fundamental importance.

The second criterion is that of evidences of oil and gas. This criterion is obviously of the greatest importance, and the gas and oil indications should be studied closely in relation to possible source-rocks and cap-rocks, as this relationship may throw much light on the extent of lateral and vertical migration of the oil and gas, and thus on the stratigraphical positions of possible accumulations of oil in structures and in stratigraphical traps.

The third criterion is the presence of unconformities, which are of great importance in relation to the creation of conditions suitable for the formation of oil, and for its subsequent lateral migration and accumulation in structures and stratigraphical traps.

The fourth criterion is the existence of regional wedge-belts of porosity, which are specially important in the case of extensive shore-line deposits which have been effectively concealed by the unconformable overlap of younger formations.

A deep and large basin, trough, or synclinorium, constituting the whole or a portion of a geosyncline, provides the best general geological setting for the preservation of an enormous volume of sediments, and also for the extensive lateral migration of oil and gas in all directions to the usual marginal and occasional interior structures, and also to any stratigraphical traps that may be present on the foreland side of the original geosyncline. Moreover, the considerable temperatures and high pressures resulting from the burial of sediments to great depths in such basins and troughs probably aided the migration of oil and gas. Indeed, the burial of thick argillaceous sediments may have had some bearing even on the later stages of the formation of oil. These considerations lead to the possibility that the four criteria of the foreword are among the usual and interrelated consequences of the deposition of sediments in a geosyncline. Discussion of the total results of sedimentary deposition in this environment might lead to the detection and formulation of subsidiary criteria, and might even show that all the criteria are so interlocking and consilient as to leap together in the unity of a single and simple hypothesis. In any case, further discussion of the best working criteria for the appraisal of the prospects of large areas or provinces would be of the greatest interest and value to petroleum geologists.

It is impossible in a brief review to attempt to do justice to the individual articles of the volume. They are excellently well presented and amply illustrated by maps and sections. It is possible that one or two of them show slight effects of an attempt to squeeze a quart into a pint-pot, but considerations of space doubtless rendered such compression unavoidable. The articles are perhaps more uniform in quality and method of treatment than might have been expected in a series of articles on different provinces by different authorities; the slight and unavoidable differences in the presentation of evidence and in the approach to the subject of prospects being negligible in view of the great value of the volume as a whole.

Although space precludes special reference to particular areas, attention must be directed to the very striking circumstance that many of the areas dealt with are the interior or central parts of basins, the marginal structures of which support oil-fields. These areas present a difficult and important problem in the science and art of discovery as, owing to the very thick succession of deposits, the absence of any signs of structure in the superficial formations, the presence of concealed unconformities, and the great depths to known oil-bearing horizons, very great difficulties exist in the way of locating suitable deep structures and stratigraphical traps.

The oil measures of the United States are unique in respect of their very wide geological range and their extensive geographical distribution. It is therefore fortunate that the great opportunities provided by these features have been matched by the enterprise of the pioneers and later prospectors, with the result that the number of proved oil-fields is legion. The student of the petroleum geology of the United States is therefore usually perplexed, and even overwhelmed, by the magnitude and complexity of the data with which he is confronted, with the result that he is unable to see the wood for the trees. This small volume, dealing as it does with fundamental considerations only, presents a bird's-eye view in which the outlines of the forests are clearly defined, so that each wood and even the striking individual trees fall into their proper places and are seen in true perspective. For this reason alone the book is an indispensable preliminary guide to the study of the petroleum geology of the greater part of North America. It is true that the authors had no intention of producing a volume that would be useful as a guide, but nevertheless they have provided the indispensable skeleton to which all the other parts can be fitted.

By the publication of this volume the American Association of Petroleum Geologists has performed an outstanding service to petroleum geology, and has placed all petroleum geologists in its debt. The volume is a stimulus to the study of the philosophy of geological exploration, and provides much comprehensive data by means of which this philosophy may be enriched. Moreover, since the avowed purpose of the symposium was to outline the major undiscovered petroleum resources of the United States and Canada, it follows that the volume provides a valuable and indispensable preliminary guide to all who are in any way interested in these possibilities.

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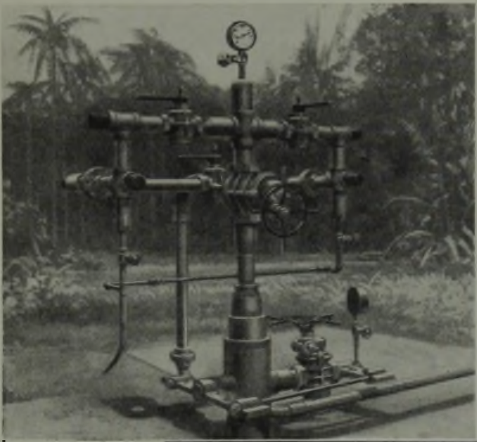

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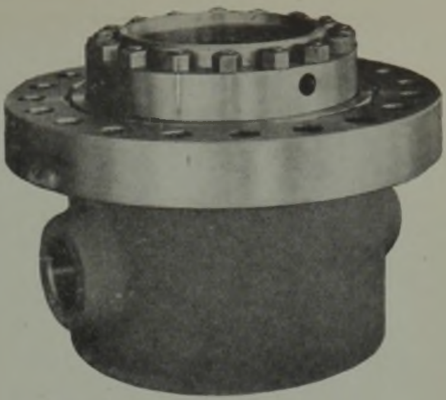

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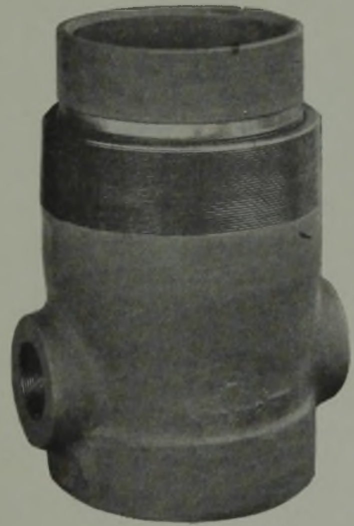

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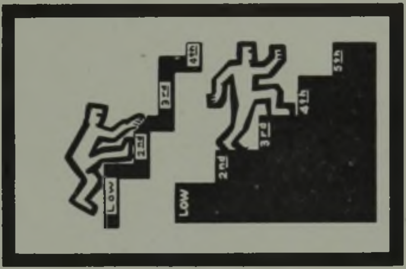

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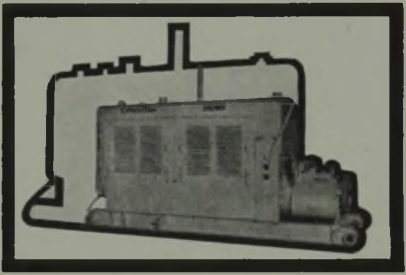

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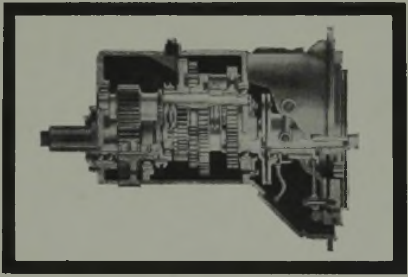

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