

A NEW METHOD FOR THE DETERMINATION OF EQUIVALENT CRACKING CONDITIONS FOR COMMERCIAL CRACKING REACTIONS.*

By S. L. NEPPE (Associate Member).

SUMMARY.

The following new points have been brought out in this paper :

1. A chart is given showing that a straight-line relationship exists between the factor F_t for which velocity of cracking is doubled and the cracking temperature t . The relation can be expressed algebraically as $F_t = 0.04t - 10$.
2. An equation—

$$\frac{\theta_1}{\theta_2} = \left[\frac{0.04t_2 - 10}{0.04t_1 - 10} \right]^{17.32857}$$

(where θ_1 and θ_2 are the periods of cracking at temperatures t_1 and t_2 respectively), has been derived from theoretical considerations. This very closely defines the relation between time of cracking and temperature for ordinary commercial cracking under constant pressure for a definite yield of product.

3. Another chart has been constructed which can be utilized in a most simple manner for converting cracking conditions at any one temperature or period into equivalent cracking conditions at any other specified temperature or period.

THE following is a new method derived by the writer for correlation of the equivalent cracking conditions (temperature and time) during any commercial cracking operation.

According to Leslie,¹ the influence of pressure as such on the process of reaction is negligible. Similarly, the view of Cross² is that the primary importance of high pressure in cracking is the avoidance of evaporation, which otherwise would considerably decrease the temperature of the liquid.

The effect of pressure is therefore not discussed in this paper, the assumption being made that the theory is independent of pressure. Little error should be introduced, since the pressure during a run is generally kept approximately constant (say at 500 lb. per square inch), and variations are made mainly only in temperature and time of cracking.

It is generally recognized that cracking reactions follow approximately the well-known physical chemistry principle, that the velocity of reaction doubles itself for a rise of 18° F.

Owing to the fact that the cracking of an oil commercially is actually a combination of process, including polymerization, depolymerization, etc., it has been found by various investigators that as the temperature of cracking is increased a greater differential is required to achieve doubling of the reaction velocity than at lower temperatures.

Thus, Egloff and Nelson³ state that the rate of reaction is doubled for a change of approximately :

- 21° F. at 800° F.
- 26° F. at 900° F.
- 26° F. at 950° F.

* Paper received 12th May, 1941.

Similarly Keyes⁴ gives the following values :

- 21° F. at 750° F.
- 24° F. at 850° F.
- 28° F. at 950° F.

Geniesse and Reuter⁵ report that the reaction rate doubles for an increment of 25.2° F. at 842° F.

These results have been plotted graphically in Fig. 1. This shows that a straight-line relationship is the most reasonable reflection of the position. The point 26° F. at 950° F. has been neglected, as the same authorities report also the same value of 26° F. at a different temperature, 900° F. The latter value, however, falls exactly on the line, which also passes midway between the two values given in the two references^{3, 4} for the factor of 21° F. In addition, the point 25.2° F. at 842° F. falls off the line on the other side, so that the errors involved are for all practical purposes compensated.

Thus algebraically at any temperature *t*, we can say that the velocity of cracking reaction is doubled for a rise of *F_t* degrees Fahrenheit, where *F_t* can be written as *F_t* = *mt* + *c*.

From the solution of the curve, it is found that *m* = 0.04 and *c* = -10, so that

$$F_t = 0.04t - 10 \quad \dots \quad (1)$$

From the expression of the principle of reaction velocity it follows that

$$\begin{aligned} V_t + \delta t &= V_t \cdot 2^{\frac{\delta t}{F_t}} \\ &= V_t \cdot 2^{\frac{\delta t}{mt+c}} \quad \dots \quad (2) \end{aligned}$$

Now, since the velocity of reaction is inversely proportional to the time (*θ*), we get :

$$\frac{V_t + \delta t}{V_t} = \frac{\theta}{\theta + \delta\theta} \quad \dots \quad (3)$$

Substituting equation (3) in (2) we have :

$$\frac{\theta}{\theta + \delta\theta} = 2^{\frac{\delta t}{mt+c}}$$

Taking logs of either side

$$\begin{aligned} \log_e(\theta + \delta\theta) - \log_e \theta &= -\log_e 2 \cdot \frac{\delta t}{mt+c} \\ \therefore \log_e \theta \left(1 + \frac{\delta\theta}{\theta}\right) - \log_e \theta &= \log_e 0.5 \cdot \frac{\delta t}{mt+c} \end{aligned}$$

or

$$\begin{aligned} \log_e \theta + \log_e \left(1 + \frac{\delta\theta}{\theta}\right) - \log_e \theta \\ = \log_e \left(1 + \frac{\delta\theta}{\theta}\right) = \frac{\delta\theta}{\theta} = \log_e 0.5 \cdot \frac{\delta t}{mt+c} \end{aligned}$$

[since $\log_e(1+x) = x - \frac{x^2}{2} + \frac{x^3}{3} - \frac{x^4}{4} + \dots$

and when $x = \frac{\delta\theta}{\theta}$, x^2 and higher terms are negligible.]

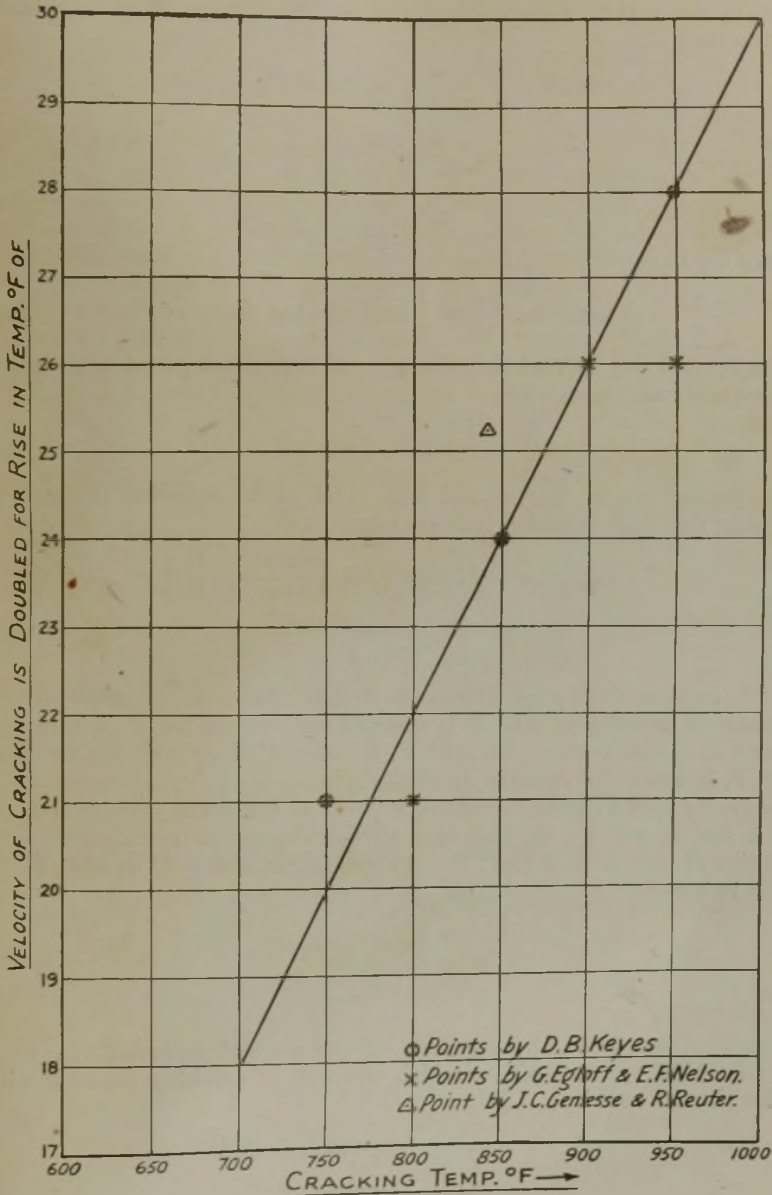


FIG. 1.

Integrating L.H.S. of this equation between limits θ_1 and θ_2 , we have :

$$\int_{\theta_1}^{\theta_2} \frac{d\theta}{\theta} = \log_e \frac{\theta_2}{\theta_1} \dots \dots \dots (a)$$

Integrating R.H.S. between limits t_1 and t_2 corresponding to θ_1 and θ_2 respectively :

$$\log_e 0.5 \int_{t_1}^{t_2} \frac{dt}{mt + c} = \log_e 0.5 \int_{t_1}^{t_2} \frac{dt}{w} \text{ say}$$

where
so that

$$w = mt + c$$

$$dw = m \cdot dt$$

and

$$dt = \frac{dw}{m}$$

Hence we have

$$\frac{1}{m} \log_e 0.5 \int \frac{dw}{w} = \frac{1}{m} \log_e 0.5 \left[\log (mt + c) \right]_{t_1}^{t_2} \dots (b)$$

From (a) and (b), we find that the general expression correlating time and temperature of reaction is :

$$\log_e \frac{\theta_2}{\theta_1} = \frac{1}{m} \log_e 0.5 \left[\log (mt + c) \right]_{t_1}^{t_2} \dots (c)$$

Substituting for $m = 0.04$ and $c = -10$, as in equation (1), and simplifying, the final equation reduces to :

$$\log_e \frac{\theta_2}{\theta_1} = -17.32867 \log_e \left[\frac{0.04t_2 - 10}{0.04t_1 - 10} \right]$$

or

$$\frac{\theta_1}{\theta_2} = \left[\frac{0.04t_2 - 10}{0.04t_1 - 10} \right]^{17.32867} \dots (4)$$

It is important to remember that if it is stated, for example, that the velocity of cracking at 900° F. is doubled for a rise of 26° F., it is incorrect to say that the velocity at 926° F. is twice that at 900° F., or that at 900° F. is twice the velocity at 874° F.

Actually 900° F. is the mean temperature at which the velocity is doubled for a rise of 26° F., so that the correct expression in this case is, the velocity at $900 + \frac{26}{2}$ or 913° F. is twice that at $900 - \frac{26}{2}$ or 887° F.

Thus in general :

$$\text{if } \frac{V_2}{V_1} = 2$$

$$\text{then } t_2 = t_1 + \frac{F_1 + F_2}{2} \dots (5)$$

As an example of the accuracy of the general equation (4), we can calculate the temperature at which the rate of cracking reaction will be twice that at 900° F.

$$\text{Then } \frac{\theta_1}{\theta_2} = 2 \text{ and } t_1 = 900$$

$$\therefore t_2 = 926.52^\circ \text{ F.} \dots (x)$$

By calculation from the equation to the curve in Fig. 1,

$$F_t = 0.04t - 10$$

we have

$$F_t = 0.04 \left(900 + \frac{F_t}{2} \right) - 10,$$

where F_t is the factor at the mean temperature of t_1 and t_2 , or $F_t = \frac{F_1 + F_2}{2}$.

$$\therefore F_t = 26.53$$

$$\text{or } t_t = 900 + F_t = 926.53^\circ \text{ F.} \quad (y)$$

The agreement between (x) and (y) is excellent.

Table I has been drawn up to show the relative rates of cracking reaction at various temperatures. This has been obtained by direct reference to Fig. 1 and utilizing the factor F_t at the mean temperature, as mentioned above. This curve can be utilized directly when $\frac{\theta_2}{\theta_1} = \text{power of 2}$.

For example, a time factor of unity was chosen at 800°, 820°, 840° F. etc., and the problem was then to determine the necessary temperature at which the velocity of reaction is doubled for each case, that is, the time halved, to achieve the same resultant effect. The method indicated in the above example was used except that F_t was obtained directly from the chart (Fig. 1). The results for a relative time factor of 2 were then 822.5°, 843.3°, 864.1° F., etc. Doubling the velocity again and again gives the temperatures at factors 4 and 8 respectively. The same procedure holds for determining also the corresponding temperatures for time factors 0.5, 0.25, 0.125, 0.0625, etc.

The precision is then dependent on the accuracy of reading the graph. At other ratios very accurate results can be obtained by calculation from the general expression equation (4).

TABLE I.

Relative time factor.	Cracking temperatures (° F.) corresponding to relative time factor.										
	Time factor = unity at										
	800° F.	820° F.	840° F.	860° F.	880° F.	900° F.	920° F.	940° F.	960° F.	980° F.	1000° F.
8	870.2	892.7	915.2	937.7	960.2	982.7	—	—	—	—	—
4	845.9	867.5	889.2	910.8	932.5	954.1	975.8	997.4	—	—	—
2	822.5	843.3	864.1	884.9	905.7	926.5	947.3	968.1	988.9	1009.8	1030.6
1	800.0	820.0	840.0	860.0	880.0	900.0	920.0	940.0	960.0	980.0	1000.0
0.5	778.5	797.7	816.9	836.1	855.3	874.5	893.7	912.9	932.2	951.4	970.6
0.25	757.8	776.2	794.7	813.2	831.6	850.0	868.5	887.0	905.5	923.9	942.4
0.125	737.9	755.6	773.4	791.2	808.8	826.5	844.2	862.0	879.8	897.5	915.2
0.0625	718.8	735.8	752.9	769.9	786.9	803.9	820.9	838.0	855.1	872.1	889.2
0.03125	700.5	716.8	733.2	749.5	765.9	782.2	798.5	814.9	831.3	847.7	864.1
0.0156	—	—	714.4	730.0	745.7	761.4	777.1	792.8	808.5	824.3	840.0

These results have been used in the preparation of Fig. 2, which is exceedingly useful for determining graphically the equivalent cracking conditions of any operation over a fixed period with varying cracking conditions, including coming on and off stream, variations in temperature due to endothermic nature of cracking reactions in general, or variations due to other causes, such as changes in furnace firing conditions, etc. With these curves it is possible to determine equivalent cracking conditions for any value of relative time factor, thus obviating cumbersome calculations.

For example, Fig. 3 shows four curves of cracking conditions (temperature v. time) for two cracks each on two topped crude oils A and B. Each run was carried out under constant pressure conditions of 500 lb. per square inch.

Without a method such as evolved here it would be impossible to say

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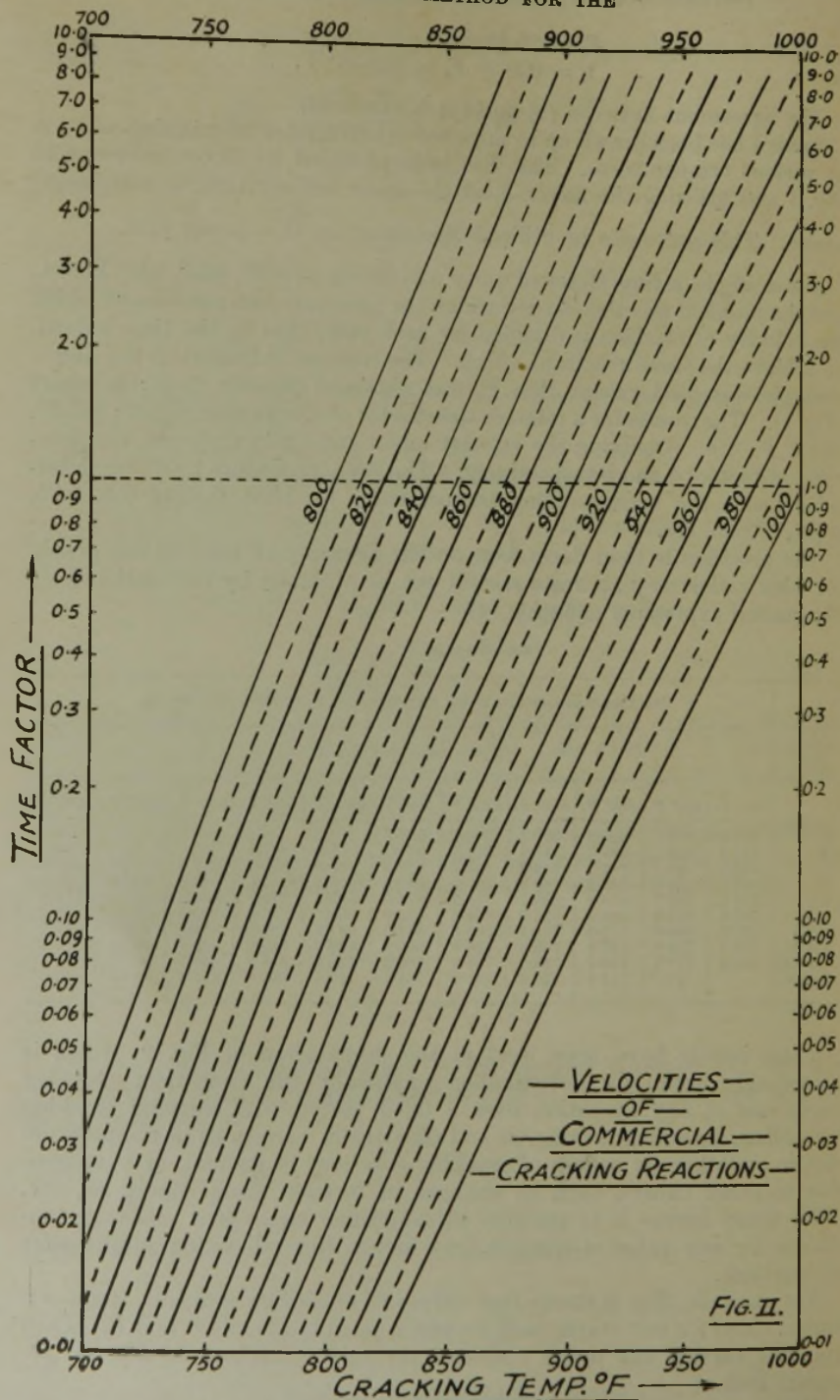


FIG. 2.

with any certainty what were the actual equivalent cracking conditions throughout the tests, even if comparatively regular curves had been obtained, and not curves of most inconsistent shapes, as illustrated here.

The graphical method of solution consists of deciding on a fixed temperature (say 850° F. for first crack : oil A) at a position shown on the curve. Mark off small intervals of time on the curve as shown, and treat each small section independently. Determine the average temperature and time for each increment, and determine the point on the 850° F. line, in this case, which is on the vertical from the temperature under consideration. For example, the 800° F. vertical meets the 850° F. line at a point 0.22 time factor, or the 890° F. line meets the 850° F. at a point 3.00 time factor. This means that 1 minute at 800° F. is equivalent to 0.22 minutes cracking at 850° F., and that 1 minute at 890° F. is equivalent to 3.00 minutes at 850° F. Multiplying the factor found in this way by the appropriate time interval gives the actual equivalent time at the assumed standard temperature of 850° F., say, for that particular increment of time.

Naturally, the higher the effective temperature at any point on the curve, the shorter should be the time interval that must be chosen, so that accuracy is not sacrificed for expediency. It is immediately evident from the curve that the error in taking fairly large time intervals at the lower temperatures when coming on and off stream is small, especially if the test conditions are such that the initial rise and final fall are carried out as rapidly as possible.

By the addition of the results for each interval at 850° F., the conclusion may be obtained that the conditions are equivalent to, say, 84.5 minutes at 850° F. This can be converted into any other condition very simply by means of the same chart, Fig. 2—*e.g.*, if the equivalent temperature is desired, say, for 60 minutes' cracking, refer to the ratio

$\frac{84.5}{60} = 1.41$ and determine the intercept of this ratio on the 850° F. line.

The corresponding temperature reading on the abscissa is 863.5° F. Similarly, what is the equivalent cracking period at a temperature of 910° F. ?

The time is $\frac{1}{5.2} \times 84.5$ minutes—*i.e.*, 16.25 minutes.

Table II illustrates clearly that, although the four curves represented in Fig. 3 appear to be widely different, there is actually no great variation in the equivalent cracking conditions for each run.

In order that there should be no misunderstanding, the writer wishes to emphasize that the theory of this work would be totally unaffected if the results of the authorities (3), (4), and (5) selected are shown not to hold exactly for all types of cracking reactions using any crude.

For example, W. L. Nelson,⁶ in a discussion on the "Theory of Cracking," has accumulated a large amount of data from the work of Leslie and Potthoff,⁷ and Keith, Ward, and Rubin,⁸ in addition to results by Geniesse and Reuter.⁵ These have all ventured to give definite statements regarding the rate at which the velocity of cracking changes with temperature. These results have been represented graphically by Nelson in a composite curve for liquid, mixed and vapour-phase cracking. He has shown that

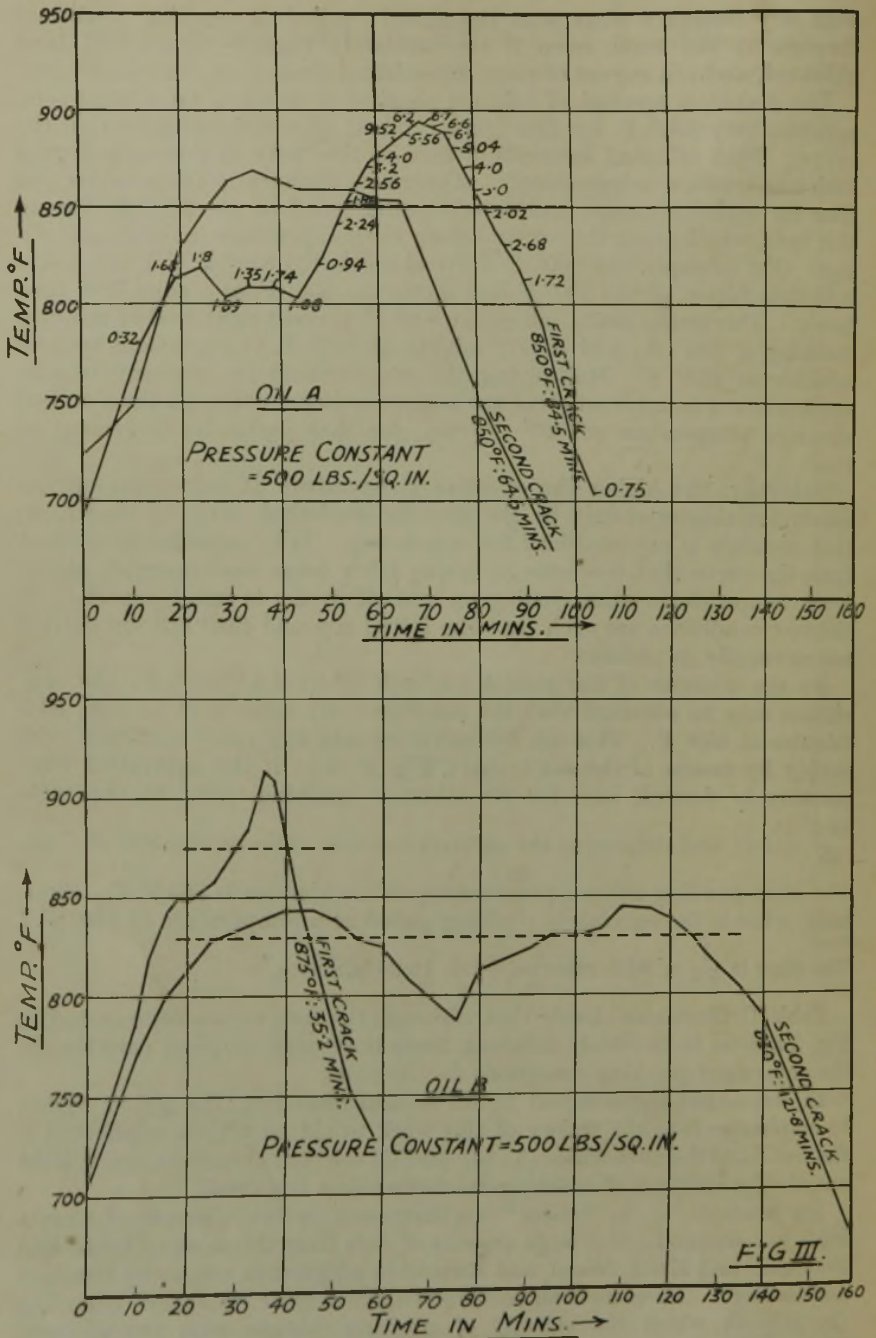


FIG. 3.

although the data of these various workers display apparently many inconsistencies, it is nevertheless possible to get an idea of the qualitative effect of temperature on the rate of cracking.

TABLE II.
Equivalent Cracking Conditions.

Temp., ° F.	Oil A.		Oil B.	
	First crack, mins.	Second crack, mins.	First crack, mins.	Second crack, mins.
850	84.5	64.6	—	—
875	—	—	35.2	—
830	—	—	—	121.8
Mins.	Temp., ° F.	Temp., ° F.	Temp., ° F.	Temp., ° F.
60	863.5	853	857	854.5
20	903.5	893	897	894.5
10	929.5	919	923	920.5
5	956.5	946	951	948.0

A most careful consideration of all the results concerned over the range 700–1000° F. has been made by the writer, who has arrived at the conclusion that the values reported by the authorities (3), (4), and (5), and used as the basis of Fig. 1 of this paper, probably reflect the true position as accurately as could possibly be determined, especially when due regard is paid to the experimental difficulties encountered in such determinations.

A definite mathematical substantiation of this statement is that if moments be taken about the line $F_t = 0.04t - 10$ decided on by the writer, the algebraic sum of the moments of all points considered by Nelson and in this discussion is found to be almost exactly zero.

Actually, if the line chosen in this paper to represent $F_t = mt + c$ is proved by others to be, say, $F_t = m_1t + c_1$, or even an expression of the type :

$$F_t = a + bt + ct^2 + dt^3 + \dots$$

the only alteration in the theory would probably be negligible changes in the actual figures used in Fig. 2.

References.

- ¹ Leslie, *vide* Sachanen and Tilicheyev, "Chemistry and Technology of Cracking" (The Chemical Catalog Co., N.Y., U.S.A.).
- ² Cross, *ibid.*
- ³ Egloff, G., and Nelson, E. F., "The Modern Cracking Process," *Trans. Amer. Inst. Chem. Engrs.*, 1936, **32**, 249.
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- ⁶ Nelson, W. L., "Petroleum Refinery Engineering" (McGraw-Hill Book Co., N.Y.), 1936, pp. 328–329.
- ⁷ Leslie and Potthoff, *Industr. Engng Chem.*, 1926, **18**, 776.
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HOMBRE PINTADO, VENEZUELA *

By G. W. HALSE, B.Sc., A.M.Inst.C.E. (Associate Member).

VENEZUELA occupies a position unique in the development of the world's oil resources. The first commercial oil-well there was completed in 1914. The present Venezuelan oil-fields were at that time in unmapped, unknown, almost uninhabited regions, without roads or other means of access. Notwithstanding this, such a tremendous amount of development was done that by 1928 Venezuela was the world's second largest producer of petroleum. To achieve this position in the space of 14 years in spite of the great natural difficulties and lack of local resources was a remarkable accomplishment.

The most important oil-fields of Western Venezuela are also near, or actually in, Lake Maracaibo. A most efficient technique and special equipment have been developed for drilling in the lake, and derricks may now be seen many miles from the shore, in water up to 70 feet deep. Even the low-lying land surrounding the lake has its own problems, mostly due to the swampy nature of the country. At Lagunillas, on the eastern shore of Lake Maracaibo, an extremely interesting and most unusual problem had to be met. The land in that region was sinking. This necessitated the building of extensive bunds or dykes, otherwise the lake would have encroached far inland over the steadily sinking, flat, low-lying, alluvial shore.

North-east of Lake Maracaibo is the State of Falcon. In early Tertiary times, Lake Maracaibo and Falcon were part of the same big sedimentary basin, but in the late Tertiary they became separated and developed as two different units.

In Falcon, folding and erosion have resulted in a low-lying east-west coastal strip, giving place southwards to foothills, and then to mountain ranges (see Fig. 1). South of the Falcon ranges is the depression of Lara, which forms the basin of the River Tocuyo, and south of this again the main range of the Venezuelan Andes.

These large-scale alternations of plains with mountain ranges have strongly affected the climate. The north-east trade winds, charged with moisture, pass over the northern plains, where they drop very little rain. In the foothills the rainfall increases, and takes the form of very heavy showers of short duration. Farther south again, in and near the main range of Falcon, which rises to a height of 7000 feet at its western end, full tropical rainfall is experienced.

The southern side of the main Falcon range drops with astonishing abruptness a mile or more in elevation to the plains of Lara. This striking physiographic change causes an equally striking meteorological one; the mountains are covered with full tropical vegetation, yet 2 or 3 miles south the vegetation is sparse, and consists mainly of cactus and the thorny bushes which characterize semi-arid areas here. This semi-arid climate continues south until the foothills of the main range of the Venezuelan Andes are approached.

* Paper received 19th January, 1942.



FIG. 1.
NO. 5 WELL, 500 FEET
ABOVE THE VALLEY.



FIG. 2.
ROAD BUILDING WITH
TOPOGRAPHY OF THIS
NATURE IS DIFFICULT.

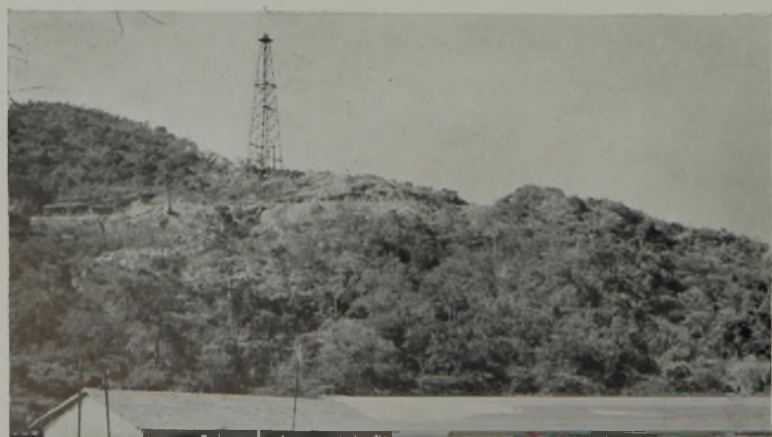


FIG. 3.
WORKMEN'S
HOUSES BUILT
BY B.C.O., LTD.

FIG. 4.
THE RAILWAY TO WELL
NO. 22, SHOWING THE
"DEAD MAN" AT THE
TOP.

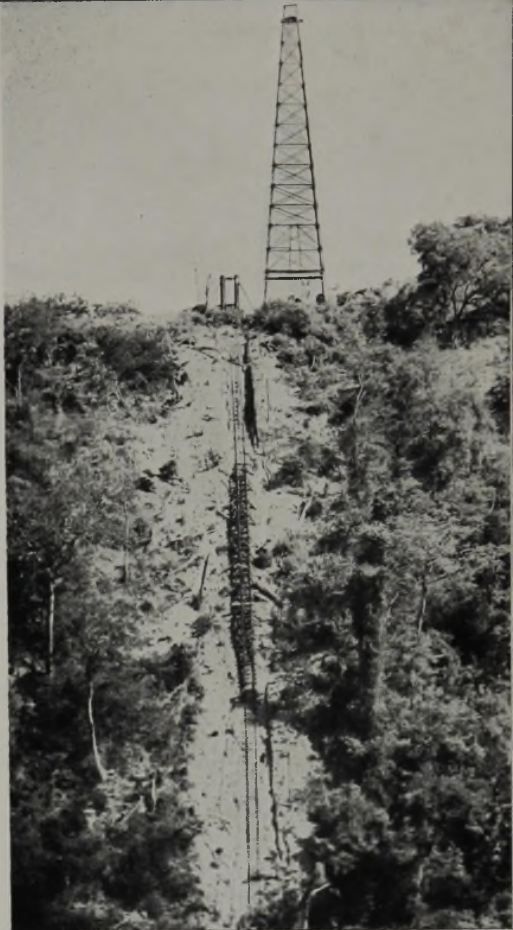


FIG. 5.
A GROUP OF
WELLS AT
HOMBRE
PINTADO.

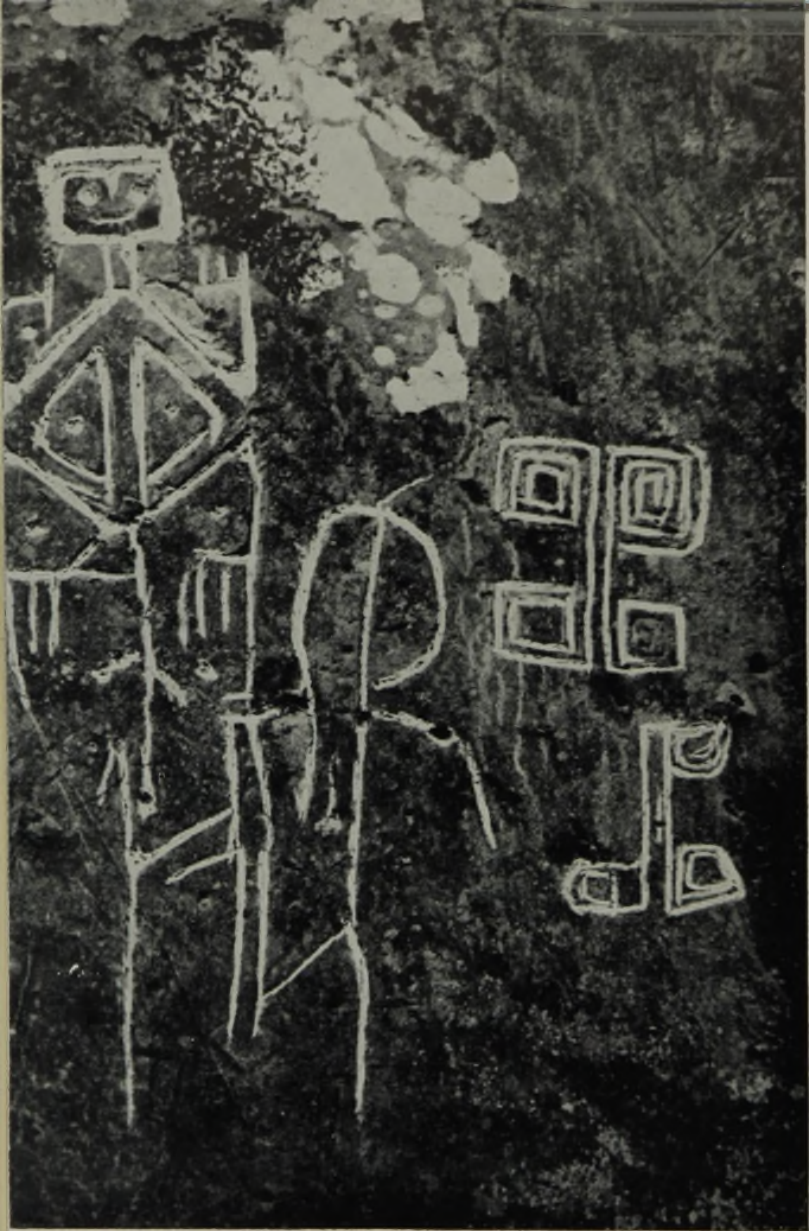


FIG. 6.

"HOMBRE PINTADO," AN
ABORIGINAL INDIAN DESIGN
CUT IN A SANDSTONE CLIFF.

Thus the effect of topography on the north-east trade winds causes the repetition twice over of the cycle :—

- (i) Plains with little rainfall.
- (ii) Foothills with medium rainfall.
- (iii) Mountains with full tropical rains.

This twice-repeated cycle takes place in a north-south distance of 125 miles.



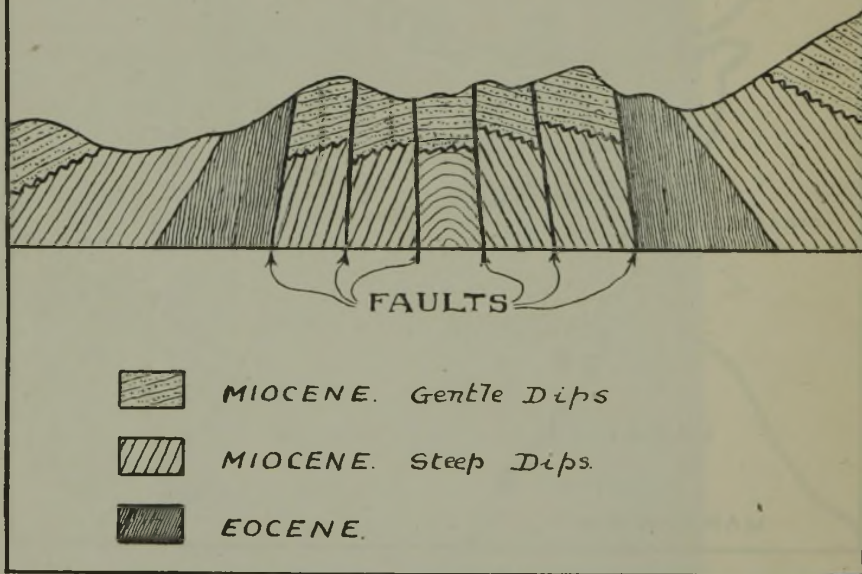
The Hombre Pintado oil-field operated by the British Controlled Oilfields, Ltd., lies in the intermediate region of foothills, 25 miles from the north coast. These foothills have been uplifted by comparatively recent crustal movement, and are in an early phase of the cycle of erosion. They rise to a maximum height of 2500 feet in the immediate vicinity of the oil-field. Although the rainfall is only moderate in total amount, the showers are extremely heavy, and the vegetation is not thick; consequently erosion is tremendously active. The result of this is precipitous and inaccessible topography (see Fig. 2).

In 1926 British Controlled Oilfields, Ltd., drilled the first well at Hombre Pintado. The only possible approach was up a stream gorge, often with

vertical sides. The road frequently crossed and re-crossed the stream. Oil was obtained in sufficient quantity to encourage further drilling.

In 1927 and 1928 the Standard Oil Co. of Venezuela drilled four wells, one of which has produced over a quarter of a million barrels of oil. An idea of the topographic conditions may be gained from the fact that well No. 5 (see Fig. 1), although close to No. 4, is 500 feet above it in elevation. No. 2 is less than a mile from No. 3, yet the road between them is over 6 miles long, because it has to go round some precipitous and impassable hills.

DIAGRAMMATIC SECTION



No more drilling was done for 9 years, until in 1937 British Controlled Oilfields resumed operations. Surface geology had been mapped as a fairly simple anticline in the form of the crown of a structure sheared off from its flanks. This crown has been downdropped some thousands of feet, bringing Miocene rocks of the arch level with Eocene rocks of the flanks, but in itself it appeared to have remained intact and more or less unbroken. It therefore offered scope for further drilling for oil. Cores and electric logs subsequently obtained provided the additional information that there is a concealed angular unconformity, and that the structure is cut into a number of blocks by faults which were undoubtedly formed

as part of the movement of collapse subsequent to very strong folding. This block-faulting has had a most important effect on the final distribution of the oil, which has probably re-migrated more than once.

Drilling has given positive proof that the fold axes are old and established, and that each new folding movement has been super-imposed along a pre-existing axis. In El Mene, for instance, there is a strong post-Eocene fold, a medium post-Oligocene fold, and a gentle post-Miocene fold. There is angular unconformity both between the Eocene and the Oligocene and between the Oligocene and the Miocene. These unconformities imply periods not only of complete cessation of the folding forces, but also of subsidence. Notwithstanding this, and regardless of the competence and loading of the subsequently deposited beds, new folding took place exactly along the old axis each time.

Drilling in 1937 and 1938 at Hombre Pintado was carried out at reasonably accessible sites (see Fig. 3). As the nature of the structure clarified, however, it became evident that some inaccessible areas were geologically favourable. The idea of inaccessibility, therefore, was no longer tenable, and B.C.O. engineers were faced with the problem of getting to apparently impossible places the large amounts of heavy equipment necessary for drilling. Various seemingly fantastic schemes were discussed, amongst them that of leaning a light railway against the hillside and hauling all equipment up on a flat car. This, in fact, was the scheme actually adopted for various locations.

Directional drilling was one of the first possibilities to be considered. All production so far obtained, however, is at less than 2000 feet depth, which leaves insufficient room for deviation except with excessive angles. In addition to this, the concealment of the structure by unconformity, together with the erratic distribution of the oil due to the effect of the fault mosaic, made accurate forecasting of oil horizons an impossibility. For these reasons directional drilling was thought to be impracticable.

The first well with a railway was No. 22 (see Fig. 4). The railway is 2 feet 6 inches gauge, and was laid in sections with steel ties already attached. The well is 245 feet above the valley, and the distance is 520 feet, which gives an average slope of 1 in 2.1. Actually, it is steeper than this, because the initial slope is gentle for over 100 feet.

On account of the steepness of the slope, it was necessary to provide against the railway-track slipping down under its own weight and buckling. This was done by tying the track to the ground at points where there was rock or other suitable foundation.

The power for hauling up the flat car was provided by an old, heavy production winch, situated at the foot of the track. From this a casing line, double the length of the track, passed round a pulley anchored to a "dead man" at the top of the railway-line and back to the car. Guide-pulleys for the wire-line were set up at convenient points.

Although it was at first thought that leaning railways against hillsides was not feasible, it soon became routine work and called for no comment (see Fig. 5). It entails the disadvantage of extra handling of over 100 tons of equipment for each well, as compared with direct transport by truck or tractor. Another drawback is that production pulling winches cannot be driven to these wells. These smaller matters, however, do not appear

formidable once the major problem of drilling at an apparently inaccessible site has been solved.

Hombre Pintado means "Painted Man," and the name is derived from some aboriginal Indian designs incised on a vertical sandstone outcrop in the Hombre Pintado stream (see Fig. 6). The principal figure is about life size, and its centre is now 12 feet above the bed of the stream. This presumably means that erosion has cut the stream-bed down some 12 feet since the figure was made, which would represent a relatively short time interval, possibly not more than 200 or 300 years, under the local conditions of rapid denudation. But for oil, this region would have remained almost exactly as it was when inhabited by primitive Indians.

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Geology and Development

132.* Regional Stratigraphy of Mid-Continent. R. H. Dott. *Bull. Amer. Ass. Petrol. Geol.*, September 1941, 25 (9), 1619-1705, including bibliography.—The Mid-Continent is taken as extending from South Dakota and Iowa to the north part of Texas. Maps are provided indicating the surface and underground occurrences of different formations. The influence of buried ridges, folds of various ages, and lateral variation of

facies, in determining oil distribution, is fully outlined, with numerous references to authors. Pre-Cambrian (? Algonkian) rocks appear in the Sioux Falls uplift, South Dakota, which stretches underground into Iowa. They form buried cores in the Cambridge anticline and Chadron dome, Nebraska, and in the Nemaha ridge, which trends south-west into North-central Kansas, intersecting almost at right angles the Central Kansas uplift, under the oil-fields of which there is a floor of pre-Cambrian granites and schists. Another such ridge runs north-south near the western boundary of Missouri, and pre-Cambrian rhyolites break the surface in the St. Francois Mountains. The Spavinaw district, Oklahoma Ozarks, has small ancient outcrops; peaks in granite and domes may yield oil—*e.g.*, Cushing Field. Pre-Cambrian has also been penetrated in North-west Arkansas at 2485 ft. The line of uplift in Southern Oklahoma, with pre-Cambrian exposed in the Arbuckle and Wichita Mountains, continues underground both east-south-east and west-north-west. The Amarillo oil-fields, in the north corner of Texas, lie on this strike. Pre-Cambrian approaches the surface in the Pecos and Red River uplifts, and it has a shelving descent from outcrop in the Llano district, Texas.

The Cambrian is very extensive, usually beginning with conglomerates and sandstones, sometimes glauconitic, and passing up into thick limestones and dolomites, within which, as in the case of the Ellenburger and Arbuckle formations, lies the Cambro-Ordovician boundary. Only in the Ouachita Mountains of Oklahoma and Arkansas is the Cambrian notably shaly. There the graphitic Collier muds are succeeded by the Crystal Mountain sandstone, and in subsequent Palæozoic deposits a distinctive shale and chert facies persists. The Cambrian is absent apparently in the Sioux Falls area, over the Nemaha ridge, in part of Western Missouri, in the Spavinaw district, and at least in places in West Texas. Economically Cambrian sandstones yield water for many towns.

The Ordovician is still more widespread. In the Llano uplift only Lower Ordovician occurs, but elsewhere nearly complete successions are found. Except in the Ouachita basin, which is continued underground into North-east Texas, the typical column comprises dolomites, limestones, sandstones, and shales. The Ordovician is to some extent planed off by pre-Mississippian erosion in North-east Oklahoma and South-east Kansas, and is partly removed by pre-Pennsylvanian erosion in Western Kansas. On the Red River arch and other Texan "highs" it is entirely denuded by pre-Pennsylvanian erosion. The formation is prolific of oil and gas, especially in Kansas, in the "siliceous lime" of the Arbuckle Group (Lower Ordovician), which produces most when separated by Simpson beds (Middle Ordovician) from the Pennsylvanian unconformity, and in Oklahoma in the "Wilcox" sand, a probably diachronous sandy facies, as well as at other horizons, in the Simpson Group. Yields are likewise obtained in North and West Texas. The Viola limestone, of Trenton age, thins rapidly northward from the Arbuckle Mountains, but limestone of equivalent date reappears in the Falls City field, South-east Nebraska, and has yielded some oil. More persistent over the Mid-Continent is the Fernvale limestone, of Richmond age (Upper Ordovician), valuable for structural mapping, and often confused with the Viola.

Silurian and Devonian are both absent in the Llano uplift and in the Wichita Mountains. They are relatively restricted and thin, and are very incomplete compared with the standard New York section, but thicken towards Iowa and Missouri. Numerous limestones are present, though not in the Blaylock sandstone and unfossiliferous Missouri Mountain slate of the Ouachitas. In Oklahoma oil is obtained from the "Hunton," a term that represents both Silurian and Devonian. The "Hunton" underlies most of Central and Western Oklahoma, except in "highs" along the Central Oklahoma uplift. In part of the Greater Seminole area, where not removed by denudation, it is an important producer. It also yields, as in the Salina basin, in Kansas, and in the Forest City basin, opened commercially in 1939, in South-east Nebraska. There is Silurian over much of the latter State, though not on the Chadron and Cambridge anticlines, whilst the Devonian seems to wedge in only in the east.

In the Llano uplift the basal part of the Mississippian is missing, and the Chappel limestone, of Osage age, is only a few feet thick, resting on Ellenburger, and disconformably succeeded by the Barnett shale, in the upper strata of which there are Pennsylvanian fossils. In the Wichita Mountains no Mississippian outcrops. In the Ouachitas the Upper Talihina chert, synchronous with Upper Arkansas novaculite,

belongs to the Lower Kinderhook, at the bottom of the Mississippian, and there follows an interval of non-deposition. Elsewhere the Mississippian is well represented. It begins with irregular sandstones, Sylamore and Misener, the latter of which in Oklahoma, Kansas, and at Falls City, Nebraska, gives a varying quantity of oil. These sandstones occur locally at the base of the black, fissile, Chattanooga shale, a richly organic "oil mother," which rests on planated older rocks from Middle Devonian down to Ordovician. The United States Geological Survey treat the Chattanooga as "Devonian (?)," but it is more convenient to put it in the Kinderhook. North of the Ozarks the Mississippian is rich in limestones, whereas southwards from them, in Oklahoma and Arkansas, many limestones grade into dark shale, and changing facies-faunas render correlation difficult. In Oklahoma and Kansas there is much production from the "Mississippi lime." While in Kansas and North-east Oklahoma this is white and cherty, similar to the Boone limestone and chert, of Osage and Lower Meramec age, in Central Oklahoma it becomes a black, gritty, argillaceous limestone, called "Mayes" by those who correlate it with only the Meramec division of the Mississippian. The Boone itself, in the Tri-State zinc and lead-mining district, of Missouri, Kansas, and Oklahoma, contains numerous seeps of asphaltic oil. Meramec beds in North-west Oklahoma and South-west Kansas have been explored in recent years, and are now yielding oil in Scott County, Kansas, for which State a detailed microscopic study of the Mississippian has been published. The richly limy facies is also well developed underneath the Pennsylvanian over most of Nebraska, Iowa, and Missouri, except on the tops of major structural features like the Cambridge anticline and Nemaha ridge.

Pennsylvanian strata, striking, on the average, a little east of north, are exposed from North-central Iowa to the Llano uplift. In Oklahoma and Kansas the sequence is specially thick and complete. It may be divided into Morrow, Des Moines, Missouri, and Virgil, each of which succeeds an unconformity. During or just after Morrow time the following structures were rejuvenated or originated—Llano uplift, Concho arch, Red River uplift, in Texas; Criner Hills, Hunton-Tishomingo uplift, initiation of Ardmore basin, probably of Arbuckle anticline, and Central Oklahoma uplift, in Oklahoma; Wichita-Amarillo Mountains, in Oklahoma and Texas; Nemaha ridge and Central Kansas uplift, in Kansas; and many oil-producing structures. In the basins into which the area was divided, the Des Moines sediments were laid down. The unconformity between the Missouri and Virgil seems to mark the early period of orogeny in the Ouachita-Marathon range, the margin of overthrusting lying to south and east of the Llano foreland. Contemporaneously the western Arbuckle Mountains anticline and the Ardmore basin were accentuated, and there was growth of the Arbuckle, Wichita, and Amarillo Mountains. The Morrow, in which Cromwell sand and "Wapanucka lime" are notable yielders, and the Des Moines, only a little wider in distribution and containing the Booch, Bartlesville-Glenn, Burbank, Prue-Calvin, and Oswego and Big lime horizons, are present in Texas, Oklahoma, and Arkansas, whilst the Missouri and Virgil occur, unless removed by recent erosion, throughout the Pennsylvanian outcrop and underground to west of it. The principal producers in North Texas, South and South-east Oklahoma, North-west Arkansas, and West Missouri, belong to the Pennsylvanian. In Northern Texas a new Lampasas "Series" has been proposed, between the Morrow and Des Moines. It includes famous pay-zones of the so-called "Caddo Lime" and also deeper pays in coarse sand in Montague County. The Texan upper part of the Des Moines is the Strawn which covers most of the earlier Carboniferous structural developments with the exception of the Amarillo uplift. The K.M.A. and Hull-Silk fields of Wichita and Archer Counties yield mostly from sandstones in the Strawn. Canyon (Missouri) and Cisco (Virgil) Series are also productive.

Between the Virgil with its red beds and the Permian System above it, the transition is a gradual one. The Permian of South-west Texas includes the Wolfcamp, Leonard, Guadalupe, and Ochoa Series, identified mainly by marine fossils. In North Texas and Oklahoma the section comprises a great thickness of red beds with gypsum and salt basins and deltaic fans of sandstone. These and other localised phenomena, like arkosic washes from the Arbuckle Mountains and even, in one place, a calcareous and dolomitic sand interpreted as an offshore bar, do not lend themselves to lateral correlation, but both to north and south there is interdigitation of marine beds, so that marine equivalents can be surmised. Subterranean Permian is ubiquitous west of the outcrop, and in West Texas there is a buried, deep basin of several thousand

feet of, in descending order, salt, anhydrite, dolomite, and limestone. The chief salt bed in Kansas and Texas rises in the stratigraphical column as it is traced to the south-west, but beneath it the general sequence is maintained, oil being found in the anhydrite, dolomite, and limestone, and in intercalated sands. In the Texas panhandle, the anhydrite and underlying dolomite are lumped together as the "Panhandle big lime." In Oklahoma Permian gas becomes important, and in the Oklahoma panhandle and Hugoton field, Kansas, mostly gas is yielded.

In the western parts of Texas, Oklahoma, and Kansas, the Trias, represented by the upper Triassic Dockum, composed entirely of non-marine red-beds famous for vertebrate fossils, including phytosaurs, overlies the Permian with probable unconformity. It is overlain unconformably by the Jurassic, but also by Cretaceous on the margin of the High Plains, and by Tertiary in the Texas panhandle. The Jurassic is terrestrial with dinosaurs. 2000 ft. of salt and red beds in the sub-surface in Ouachita County, Arkansas, have recently been assigned to it by Imlay. They thicken southward in Louisiana into a marine suite of 7000 ft.

In North-west Louisiana and Arkansas, Comanche strata (Lower Cretaceous) produce oil and gas in several fields. In Marshall County, Oklahoma, the same formation yields from shallow wells in the so-called "Arbuckle" sand in the Trinity Group, and in Central Texas there is a good deal of oil obtained from the Fredricksburg Group which succeeds the Trinity. The Gulf Series (Upper Cretaceous) rests with unconformity on the Comanche, and the Woodbine sand at its base is the chief producer in the Mexia fault zone and Van pool, in North-east Texas and in the eastern Texas field. Yields are also obtained from higher horizons—Blossom-Tokio (Austin Group), Buckrange and Ozan (Taylor), and the Nacatoch (Navarro) sands in North-east Texas and adjacent parts of Arkansas and Louisiana. Cretaceous oil production is thus restricted to the southern Mid-Continent, though in the north, in Nebraska, Iowa, and Kansas, the Dakota sandstone forms the base of the Upper Cretaceous.

A. L.

133.* Amount of Source Bed Required to Furnish Oklahoma City Oil Pool. R. L. Ginter. *Bull. Amer. Ass. Petrol. Geol.*, September 1941, 25 (9), 1706-1712.—The Cherokee shale is used as a hypothetical sole source for the Oklahoma City oil reserve of 600 million brl. The Cherokee was laid down on porous, permeable, pre-Pennsylvanian rocks, entirely burying a land-surface of Mississippian down to Arbuckle beds. When the overburden was supplied, the resulting compaction of the shale presumably moved the primordial crude oil into the porous beds under the unconformity. The oil would then migrate upward through the top beds of this old land-surface and probably laterally across the beds near the top of the structure, the porosity features being sufficiently large to provide for gravity separation of oil and water. Originally the pool probably had a common water-table, and contrary evidence seems to be due to unequal rates of withdrawals.

By using certain assumptions about the original organic content of the source sediment (taken as 35%), proportion of organic matter converted to crude oil (4.5% suggested), percentage of generated oil lost during migration (estimated at 50%), percentage of shale compaction (taken at 60%), and a reasonable figure for the original amount of oil in the oil-pool; the distance of migration to the Oklahoma City reservoir is calculated to be no more than 7.86 miles and the volume of mother shales to be 3.5 cu. miles.

J. T.

134.* Peru—Production Continues Decline, Refining Slumps. Anon. *Oil Gas J.*, 13.11.41, 40 (27), 26.—During the first half of 1941, Peru's crude output was 5,419,162 brl. against 6,078,481 brl. in the same period of 1940. The natural gasoline production was 475,946 brl.

A table lists the output of various products during the first half of 1940 and of 1941.

G. D. H.

135.* Venezuela—Discovery of New Field Likely at Ultramar Test. Anon. *Oil Gas J.*, 13.11.41, 40 (27), 26.—2 Mercedes in the State of Guarico has penetrated the uppermost series of oil-sands at a depth of 4358 ft. Drill-stem tests are reported to have been made, and the top of the sand is said to have been proved gas-bearing. The

second sand yielded 30° Be oil. The area lies about 90 ml. west of the newly opened Ollas area, and 125 ml. west of the El Roble field.

In the San Joaquin field of Anzoategui, 3 Guarío is coring below 10,768 ft., and 4 Guarío is fishing at 6843 ft. 1 Anaco, in the El Roble district, is testing at 11,294 ft.

During August the Standard of Venezuela completed four wells at Jusepin at an average depth of 4537 ft. and for an average output of 605 brl. each/day. Two wells were completed at Oficina for 470 brl. each, and one at Leona for 688 brl./day at 7750 ft.

G. D. H.

136.* Major-field Need Demands Outpost-Area Exploration. W. V. Howard. *Oil Gas J.*, 11.12.41, 40 (31), 30.—An increase in price of oil encourages wildcatting, and drilling proceeds in areas where a high yield is not expected. Discoveries in such areas do not greatly increase the reserves. Exploration may be based on previously defined concepts regarding oil-accumulation sites, or after a random discovery there may be an intensive search for similar fields.

The chances of major discoveries are less in the older areas than in the newer areas. The most spectacular successes of the past seem to have come by combining known conditions in one or more sections and trying to find them in a nearby area, but the record of development in areas which start with rank wildcats is usually very spotty.

G. D. H.

137.* Increased Exploration Required by Declining Discovery Rate. W. V. Howard. *Oil Gas J.*, 27.11.41, 40 (29), 26.—Estimates of discoveries of oil reserves fall into two classes—namely, those found in the early development of fields, and those found in the same fields at some later date. It appears that the amount credited to fields during the first year averages 40–60% of the total which will eventually be allocated to those fields in the first period of development.

Reserves are added to old fields mainly by reason of the discovery of deeper pays, and it is impossible to predict the date at which deeper development will take place. In a normal year about 3% of the total reserve comes from additions to old fields.

Early estimates are generally conservative, and in most cases the revision is upwards, and this may constitute 4% of the total reserves annually.

The discovery rate is unpredictable as far as additions to reserves are concerned.

Reserves may be appraised in terms of years' supply, and so show if the rate of discovery is likely to meet future requirements, although it is realized that in most instances the oil could not be produced in the time set out. The optimum reserve, the balance between shortage and unsettling flush production, appears to be approximately thirteen times the current annual production.

Although there is no immediate danger of shortage, provided no sharp increase in consumption occurs, the reserves added in the past two years through new fields is insufficient to meet the immediate needs for flush production.

Tables present data on the allocation of the new oil found and on the discovery requirements in the period 1935–41.

G. D. H.

138.* Venezuela—Standard and Lago Complete Seven Wells—One Gas, Six Oil. Anon. *Oil Gas J.*, 4.12.41, 40 (30), 24.—In the Mulata area, a gas-well was completed at 1,200,000 cu. ft./day from 4100 ft. Four oil-wells in the Tia Juana area had an average initial output of 1094 brl./day from 3600 ft., one at Jusepin gave 100 brl. initially, and that at Lagumillas 470 brl./day.

G. D. H.

139.* Well Logs and Field Data of Active Oil Areas—Western and Central Kansas. Anon. *Oil Gas J.*, 4.12.41, 40 (30), 48b.—The dominant feature of Western Kansas is the Barton arch, on the flanks of which many of the pre-Middle Pennsylvanian beds thin. In the Lower Permian the area formed part of the great Permian basin running into Texas, and in it salt and gypsum were laid down.

The oil and gas are largely associated with unconformities. In the periods when the granite was exposed, basal conglomerates and sandstones were formed, especially in the Cambrian and Lower Pennsylvanian, and both these basal formations are productive. The productive "Misener" sand below the Mississippian shales is also a basal sand.

The bulk of the Western Kansas production is along the Barton arch, and occurs in three main areas where cross-trends traverse the arch. These cross-trends may extend into the basin to the south-west. It is possible that oil may be found in eroded limestones below unconformities, and, indeed, oil is found in the Arbuckle on the crest of the arch beneath the Pennsylvanian. The Viola produces on the south flank.

A map and series of well logs are included.

G. D. H.

140. Résumé of Oil-field Operations in 1938. R. D. Bush. *California Oil-fields, Summary of Operations*, Vol. 24, No. 3, 1939.—A résumé of California oil-field operations in 1938 has recently been published, wherein it is shown that the total production of oil for that year was 249.4 million bbl., an increase of 11.9 million bbl. over 1937. Estimated closed-in production was increased during 1938 from 172,507 bbl. in January to 204,850 bbl. in December. Total crude and refined petroleum in storage in Pacific Coast territory by the end of 1938 was 158.9 million bbl., representing an increase in storage of 30.8 million bbl., as against a decrease of 3.3 million bbl. registered for 1937. Total crude and refined oil shipped to Atlantic Coast ports during 1938 was 4.8 million bbl., or nearly 1 million bbl. less than 1937 shipments. Four new oil-fields were discovered in the year under review: East Coalinga Extension, Fresno County; Wasco and Canfield Ranch, Kern County; Aliso Canyon, Los Angeles County. New productive areas were developed at Wilmington, Torrance, Rosecrans, Dominguez, Huntington Beach Tidelands, all Los Angeles County; at Coles Levee, Ten Section, Round Mountain, Kern County; also at Rio Vista Gas field, Solano and Sacramento Counties. Finally, deeper oil producing zones were penetrated in Montebello field, Los Angeles County, and in Greeley field, Kern County. Details of all these operations are given.

H. B. M.

Drilling

141.* Drill-Pipe and Tool-Joint Troubles—Their Causes and Prevention. Part II. R. S. Grant and H. G. Texter. *Oil Gas J.*, 13.11.41, 40 (27), 50. *Paper Presented Before American Petroleum Institute.*—Fatigue and corrosion are studied in detail. The whole vicious circle of corrosion fatigue might be thought of as follows: (1) The chemical effects produce a minute pit. The electro-galvanic effect between scale, steel, and fluid produces another pit, or deepens the first one. (2) Then, as the pipe metal is bent, or stretched, the stress is concentrated at the bottom of the pit, just as at the bottom of a notch. This creates a difference in potential between the highly stressed bottom and the unstressed edges of the pit, and an electric current is set up which further deepens the pit. (3) Then, in a deeper pit the stress concentration increases still further, the electro-potential difference is greater, and the current becomes more effective in making the pit still deeper, and so on. Small wonder, then, that corrosion plus fatigue can so greatly reduce the life of drill-pipe, as compared with what either factor alone could do.

So far there is no accepted method for preventing corrosion fatigue—although, as stated, practical study of the problem currently is being undertaken. Removing scale from the inside wall might be the first step, but is probably only a short step. The real solution would seem to be coating the inside of the pipe so as to entirely prevent corrosion. However, the problem of finding a coating which could be readily applied, without pin-holes, absolutely impervious to all drilling fluids ordinarily encountered, and with sufficient ductility to withstand tension, bending, hammering, and erosion by the mud stream, is not an easy task. The same problem has long been studied on sucker rods, with none too great success. Alloy steels have proved disappointing. Chemical treatment is still in the experimental stage.

The paper deals with a large variety of troubles, including hydrogen sulphide embrittlement, eccentric wear on pipes and tool-joint troubles.

A. H. N.

142.* Better Pulling Methods Permit Greater Recovery of Casing. O. H. Stormont. *Oil Gas J.*, 27.11.41, 40 (29), 54.—With the use of modern pulling equipment and improved methods of recovery, it is now not uncommon to obtain 100% of the casing from wells more than 4000 ft. deep. In shallower wells casing-shoes were being

pulled with monotonous regularity, and in one 4700-ft. well 100% of the casing was recovered.

After the pulling machine is placed over the well and guyed down, the hydraulic jacks are set up. They are connected to the pump by fitted lengths of pipe and hammer-type unions. The jacks are linked together with two steel arched bars, and upper and lower spiders equipped with sub-rings to fit standard A.P.I. slips. It is highly important that the jack foundation be level and the spiders be centred, in order to place a straight pull on the casing. A short piece of casing is run through the spiders and, by use of a swedge, if necessary, screwed on to the casing-string. The slips are then placed, and pulling is ready to start.

In loosening the pipe the amount of pull placed on the casing is largely governed by the length of the string and the age and weight of the casing. In a 1650-ft. well 15 or 20 years old, and equipped with 20-lb. lap-weld casing, a maximum pull of 85,000-90,000 lb./sq. in. is exerted. If 22 lb., eight round-thread seamless casing is being pulled, maximum strain of 175,000-250,000 lb. will usually not endanger the pipe.

The pressure is applied slowly until the maximum estimated safe pull is reached; the jacks are then lowered. This intermittent application and removal of tension tends to free the pipe from the surrounding formations and makes for greater recovery. It is continued until the amount of "stretch" obtained remains fairly constant at maximum safe load. When this point is reached, the contractor is able to estimate the amount of pipe that will be recovered.

Experience has shown that in pulling old 20-lb. lap-weld casing, a stretch of $\frac{3}{4}$ in. indicates 100 ft. of casing recovery. In newer 22-lb. seamless casing each 100 ft. of recovery is indicated by 1- $\frac{1}{4}$ in. of stretch. Thus in a 1600-ft. well equipped with 20-lb. lap-weld casing, if an 11-in. stretch was obtained it would indicate that recovery of about 1500 ft. might be expected.

To recover the casing a small shot of solidified nitroglycerin is run in on a wire line. It is spotted at the first collar above the depth to which the casing is expected to be recovered. This is done by means of "feelers" placed on the wire line with the shot. The feelers are expanded when they reach the correct depth and then pulled up a few feet until they strike the first collar. The shot is then fired by dropping a weight, or by any of several other common methods.

The use of mud and of olive oil to increase recovery is briefly discussed.

A. H. N.

143.* Methods of Determining Value of Native Clays Used as Drilling Muds. V. B. Zacher. *Oil Gas J.*, 27.11.41, 40 (29), 60. *Paper Presented Before American Petroleum Institute.*—The author suggests the use of a "merit index" for muds which combines the results of different significant tests. These are: (a) for average or heavy muds;

Index = $\left(\frac{1000W}{LTR}\right)$, where W = mud weight (lb./cu. ft.) at 30 sec. visc.; L = water loss (c.c.) at 78 lb./cu. ft., 185° F.; T = cake (mm.) at 78 lb./cu. ft., 185° F.; R = reaction to T.S.P.P. (from 30 sec. visc. at 1 lb./brl. or 1.7 g./600 c.c.); (b) for light or colloidal muds, Index = $\left(\frac{1000Y}{LTR}\right)$, where Y = yield brl./ton. at 30 sec. visc., $\frac{222}{W - 62.4}$ W at 30 sec. visc.; L = water loss (c.c.) 30 sec. visc., 185° F.; T = cake (mm.) 30 sec. visc., 185° F.; R = reaction to T.S.P.P. (from 30 sec. visc. at 1 lb./brl. or 1.7 gm./600 c.c.).

It is specified that (1) all clays are thoroughly banded and mixed in a gear-pump or equivalent mixer; (2) all viscosities are read at 500 c.c. in, 500 c.c. out, using a $\frac{3}{16}$ -in. orifice; (3) all filter tests are taken at 100 lb./sq. in. from zero to 15 min. using a 3-in. diameter cell.

The tests are briefly discussed.

A. H. N.

144.* Reverse Circulation Speeds Completions at Cromwell. H. F. Simons. *Oil Gas J.*, 4.12.41, 40 (30), 34.—Reverse circulation of the drilling fluid is obtained by installing a pack-off head capable of rotation on the casing string, and then directing the flow of mud down the annulus and up through the tubing to which the bit is

attached. The purpose of the reverse-circulation method is to obtain a better completion at less cost. Debris and mud-cake on the producing zone can be removed from the hole by circulating oil and a normal well completed in 24-36 hr. after moving in. Where a well is shot it requires 3-5 days to drill in, shoot, clean out after the shot, and give the well a production test. The completion of small holes with cable-tools is tedious and often produces complications which add to the time and expense. Use of the reverse circulator results in substantial savings over both slim-hole and regular-hole cable-tool completions. Contamination of the sand is avoided if mud and water are eliminated during completion. Use of oil and ordinary circulation have not been successful because of the high fluid velocity required for such a light fluid to remove cuttings from the hole. By reversing circulation and pumping oil down the annular space and up through the drill-stem, a very high velocity prevails during the trip to the surface.

The increase in velocity of the upward stream is proportional to the area of the annulus and tubing. Where normal circulation gives a velocity of 125 ft./sec. in the annulus formed by 2-in. tubing inside 4½-in. casing, reversing circulation will give approximately four times that velocity in the tubing. Actual fluid velocity with one 4½- by 6-in. pump operating at 60 s.p.m. is 500 ft./min. through the tubing. As the carrying power of a stream is a geometric function to its velocity, this increase has a great effect on the size and density of particles which can be brought to the surface. Even large pieces of steel can be removed from the hole. In one case a reverse-circulating crew recovered a set of steel bearings which had been lost in the hole when a cutter element came off a rock-bit. Time for cuttings to come to the surface from 4500 ft. is less than 10 min.

Details are given of the whole operation.

The reverse-circulation method has been tried for cleaning out old wells, but where the formation pressure is low it is not yet entirely successful, because of the difficulty in maintaining circulation. On new completions, little, if any, oil escapes into the pay-zone, and it can be recovered. On old wells the loss is substantial, and the main objective—removing accumulated debris—is not realized. A number of plugging agents have been employed, the most successful of which is flake mica. There is, however, some question about reopening of sand-pores after they have been deliberately plugged. Reverse circulators are consistently used only on new wells or old ones which still have appreciable bottom-hole pressure.

A. H. N.

145.* Field Transportation and Especially Developed Equipment. S. H. Grinnell. *Oil Wkly*, 10.11.41, 103 (10), 33-34. *Paper Presented Before American Petroleum Institute.*—The equipment discussed are divided into two classes: (1) portable equipment defined as "that equipment which is moved daily on the highways, and which conforms to all state, county and city laws"; (2) mobile equipment, defined as "that equipment which is moved every two or three weeks, and which does not necessarily conform to any laws and requires permits if moved on the highways." Practically all drilling equipment is of the mobile type and, when moved from one geographical location to another in the State, it is so designed that it can be broken down in size and be readily moved by trucks or shipped by rail. When in use in any area, the smaller shipping units are assembled in a master unit which is generally "over-weight," "over-height," and "over-width," thereby necessitating permits, and it must be moved on special transportation equipment.

As an illustration, moving derricks in California is discussed in detail. Moving is accomplished either by putting track-laying wheels or rubber-tyred dollies under the derrick and towing by tractor or truck. There is a steel I-beam protruding from two corners of the derrick; the derrick is jacked-up and the track-laying wheels are slipped on—the protruding I-beams being used as axles. Directly opposite these two wheels is placed a steel I-beam equivalent to 12 in. on top of the steel foundation, making a total of 24 in. of 79-lb. steel to give additional support; a sway-backed dolly made of track-laying wheels is placed under the centre of this I-beam. The advantage of three-point suspension is that, at all times, there are three points of contact with the ground, whereas with four-point suspension there is a possibility of high spots on the two diagonal corners which would cause rocking of the derrick, and also the possibility of an undue strain on members of the derrick. When the derrick is moved, some operators hang a plumb-bob from the centre of the

derrick at the water-table; so long as this plumb-bob hangs free within the derrick, the centre of gravity is such that there is no danger of upsetting.

Other items discussed include the cost of moving various equipment. A. H. N.

146.* Drilling Activity is Maintained at High Level. Anon. *Oil Wkly*, 10.11.41, 103 (10), 55.—Although a number of factors have been conducive to a reduction in drilling, the completions for October and the number of rigs drilling on 1st November show no slowing down in drilling for the country as a whole. The average for October was 102 completions/day, against 102.2/day for September and 82.4/day in October 1940.

Tables give the completions by states in October 1940, and September and October 1941, the type of well and the initial production, the cumulative completions for the first ten months of 1940 and 1941, the total rigs in operation on 1st November, 1940, 1st October and 1st November, 1941, with details of the field activity on 1st November, 1941. G. D. H.

147.* Co-ordination and Planning Reduce Drilling Time. G. M. Wilson. *Oil Wkly*, 1.12.41, 103 (13), 15-17.—An average total of from 7 to 10 days/well from spudding to pumping into the tanks has been maintained in a string of wells, averaging between 3100 and 3500 ft. deep, recently completed in the Wilmington field of California. Despite the fast time, no special equipment was used; in fact, some of the drilling conditions were far from ideal, as compared with those usually encountered in other fields.

Credit for this accomplishment is largely due to at least two very important factors: (1) unusually thorough planning of all phases of the drilling of each well before a bit was spudded, and (2) perfect co-ordination between the men and equipment, as well as between the management and the facilities of the supply and well-servicing companies.

The wells were drilled along a 21-ft. strip of property, flanked by a railroad right-of-way on one side and by a river flood-control channel on the other. Details of drilling and completing operations are given. These details show the way time was saved by planning operations such as well conditioning, cementing, etc.

The efficient development of this particular 7-well lease was directly reflected in the relatively low drilling costs. The total prorated cost of each well was only approximately \$20,000. This figure includes all drilling costs, casing, tubing, rods, pumping units, and all fittings. This cost compared with the somewhat higher figure of \$35,000-\$40,000, which is considered to be the approximate average in this field for drilling under similar conditions. Labour and prorated salaries for each well average only \$2100. A. H. N.

148.* Design of Casing Strings. Part 1. E. N. Kemler. *Oil Wkly*, 1.12.41, 103 (13), 20.—This is the first of a series of papers intended to give an exhaustive analysis of the problems met in casing design. In this part the subjects discussed are external or collapsing pressures, internal or bursting pressures, tensile loading, and buckling loads. The paper is well illustrated by charts giving pressures of different types *versus* depth.

When casing is first installed and cemented in a well, it is subjected to the pressure from the fluid in the producing formation on the inside, and the pressure from the mud in which it was run or the pressure from any porous fluid-bearing formations on the outside. Since these two pressures for a new well under static conditions are practically equal if the internal fluid is a liquid, the casing is subjected to very little load from this source. If, however, the well is bailed down so that there is no pressure on the inside, then the external pressure gives the load, which is called the collapsing pressure. Also as the well is depleted, and if the producing formation pressure decreases to a relatively low value, the casing will then be subjected to the unbalanced external or collapsing pressure. This pressure can be calculated from the equation, $p = 0.433sl = 0.00694p_m l = 0.052W_m l$, where l = well depth in ft., s = specific gravity of fluid, p_m = mud weight in lb./ft.³, W_m = mud weight in lb./gal., p = pressure due to mud column in lb./in.²

Internal pressures may exceed the safety limits in such cases as squeeze cementing

or where gas or distillate pressure at the top of the casing is excessively high and unbalanced by external pressure, and will result in a burst. When casing is full of liquid and closed at the top, the thermal expansion of the liquid may also result in excessive internal pressure.

When casing is being run in a well to the required depth it is subject to an axial load resulting from its weight. During this process the weight to be carried under static conditions will be equal to the casing weight less the buoyant effect of the mud in which it is run. If the casing is run open-ended this buoyant effect will be equal to the difference in density of the steel and of the mud, multiplied by the volume of the steel. This can be expressed in equation form as, $L_w = lw \left(1 - \frac{P_m}{P_s} \right)$, where

L_w = total tensile load on the casing due to its weight, l = length of casing suspended, w = weight of casing/ft. in air, P_s = density of steel = 0.2833 lb./in.³, P_m = density of drilling mud = 0.03613 × specific gravity of mud = lb./in.³

When the casing is cemented a change in temperature results in a change in tensile loading, due to expansion and contraction. The change of load is $L_t = a\Delta tAE$, where L_t = increase or decrease in load due to temperature decrease or increase, a = coefficient of expansion of steel 6.9×10^{-6} , t = change in temperature in degrees F., a = area of pipe in in.², E = modulus of elasticity of steel = 30×10^4 lb./in.²

Poisson's effect is studied, and is given by $L_p = S_c A \sigma$, where L_p = change in load due to tangential stress, S_c = tangential stress due to internal or external pressure, A = area of pipe in square inches, σ = Poisson's ratio = 0.26 for steel.

S_c is given by $S_c = \frac{PD}{2t}$, where P is the internal pressure in lb./in.²; D is pipe diameter in inches; t is wall thickness of pipe in inches.

Buckling loads are given by the usual Euler's equation $L_c = \frac{\pi^2 EI}{l^2}$, where $I = \frac{\pi}{64}(D_1^4 - D_2^4)$. A. H. N.

149.* New Methods Tame Wild Gas Well. Anon. *Oil Wkly*, 1.12.41, 103 (13), 44.—Unusual methods, believed to be tried for the first time, were recently used to control a wild well near Chickasha, Oklahoma. Casing was set through water and gas sands and cemented—all done while the well was blowing an estimated 40 million cu. ft. of gas daily from 3800 ft. and in danger of cratering.

The well had 151 ft. of 10-in. surface pipe cemented, and at top of the casing 12 ft. of 10-in. flow-line with no connections were welded. Below the bottom of the surface pipe were a number of water-sands, and below these, at approximately 2400 ft., were several depleted gas-sands. Drilling had progressed to 3800 ft. when a stray sand was encountered.

Operators started to pull the drill-pipe out of the hole in order to put on a blow-out preventer, but before this could be done the well blew out. Acting quickly, the kelly was put back on in an attempt to kill the flow. This plan not being successful, and in order that more mud could be pumped in the hole, the drill-pipe was shot at 3400 ft. Added volume from mud-hogs killed the flow. As there was no gate at the top, the well again blew out. Thus it was necessary to plug the well, shoot the drill-pipe at different points, and cement a casing string. The operations are given in detail. A. H. N.

150.* Portable Cooling Tower Improves Rotary Mud Properties. G. M. Wilson. *Oil Wkly*, 8.12.41, 104 (1), 30.—By cooling the mud on wells 8000–10,000 ft. in depth in California improved mud-pump operation, more satisfactory viscosity control, a thinner mud-sheath, and a greatly reduced filter loss are obtained. Mud temperature, which, without the cooler, would ordinarily range between 135° and 145° F. at these depths, is now being lowered to and held at between 110° and 115°, through the use of a skid-mounted portable cooling tower, which in most outward appearances closely resembles an ordinary water-cooling tower. The mud is, however, circulated through a closed system of small piping which is cooled by a combination of water spray falling from an overhead sprinkling system, together with a forced draught created by a 4-ft. propeller-type fan mounted in a metal hood in one end of the tower.

A small steam engine supplies the economical power which drives the fan and centrifugal water-circulating pump. Details of the cooling tower are given.

An important result was found from a 1-hr. test, which showed that cake-thickness was reduced from $\frac{1}{8}$ in. to $\frac{1}{16}$ in. Approximately 27% reduction in filter loss, based on the 1-hr. test, is therefore possible by cooling the mud from 140° to 105°. A thinner sheath was also noted.

A later field test was made which further substantiated this percentage figure. On two similar wells with like conditions at approximately 8000 ft., the fluid loss in the suction pit was measured for a $\frac{1}{2}$ -hr. period by shutting off water and chemical in the ditch at each well. With a flow-line temperature of 138° in Well A, the fluid loss in $\frac{1}{2}$ -hr. was 2 $\frac{2}{3}$ brl. With a flow-line temperature of 110° in Well B, the fluid loss in $\frac{1}{2}$ -hr. was only 2 brl. This represents a saving of approximately 25% in the fluid loss caused by the higher mud temperatures encountered at depth.

The operation of the mud-pumps has also been measurably improved. The temperatures have been lowered to points which correspond to the specifications recommended by the manufacturers of the rubber sleeves, which ordinarily is less than 120°. As a result, pump-strokes are smoother, and a much higher pumping efficiency is being obtained.

The lowering of mud temperatures directly affects the problem of properly controlling the viscosity of the mud by means of chemicals. It was found that through the use of a cooler, such chemical treatments were rendered much more effective.

A. H. N.

151.* Design of Casing Strings. Part II. E. N. Kemler. *Oil Wkly*, 8.12.41, 104 (1), 36.—When a tube or string of casing is subjected to external pressure it will, up to a certain pressure, contract uniformly as the pressure is increased, like any elastic body under stable equilibrium conditions. For higher pressures, the tube becomes unstable and failure results because of buckling of the tube. The method of failure is similar to that of a slender rod subjected to an axial load. If a slender rod is loaded axially it will, up to a certain load, deflect proportionally to the load. When the load reaches a certain critical value, the rod will buckle, and failure will occur without warning. The rigorous mathematical treatment of failure of a tube subject to external pressure for all conditions is very difficult and involved.

The equation for determining the load at which failure due to instability will result is often called the elastic curve. The basis of the elastic curve given by the A.P.I.

is the formula $P = \frac{62.6 \times 10^6}{D \left[(D/t - \frac{1}{2})^2 \right]}$, where P = pressure at which collapse will occur in lb./in.², D = pipe diameter in inches, t = pipe-wall thickness in inches.

A discussion of this curve is given, together with other equations as given by different workers.

The strength of joints in tension is becoming increasingly important as deeper wells are drilled. By working on electrically welded joints it was found that the joint strength in tension was, within experimental limits, a function of the yield strength of the material in tension, and generally independent of the ultimate strength of the material. The curves of load *vs.* wall thickness were essentially straight lines which intersected the zero load line at a wall thickness of from 0.070 to 0.080 in. This range represents the wall thickness used by the threads, or the thickness at which no metal would be left under the roots of the threads.

For failure by bursting pressure the recommended form is more conservative than the one generally used. It is given as $P = \frac{2 \times 0.875 S_y t}{D}$, where P = bursting pressure in lb./sq. in., S_y = the minimum yield strength in tension, in lb./sq. in., t = nominal wall thickness in in., and D = outside diameter in in.

As a result of certain studies minimum values for casing strengths and criteria were set. The minimum collapse strength was set at 75% of the average collapse pressure as given in present A.P.I. Bulletin 5-c-2. Minimum joint-strength values were set at 80% of the average ultimate strength values as now given in Bulletin 5-c-2. The minimum bursting strength was made 87 $\frac{1}{2}$ % of the values now given in Bulletin 5-c-2. These values are tentative and are necessarily subjected to revision as more data and information becomes available.

A. H. N.

152.* Completions Under Month Ago but Above Year Ago. Anon. *Oil Wkly*, 8.12.41, 104 (1), 45.—In November the U.S.A. completions averaged 97.6/day, against 101.3/day in October and 102.2/day in September. Drilling was curtailed in November in Oklahoma, Kansas, North Texas, West Texas, New Mexico, North Louisiana, and Mississippi, but in other districts there was little change.

At the beginning of December 1941, 4746 rigs were in operation.

Tables give by states the completions in November 1940 and October and November 1941; details of the wells drilled in 1941; the cumulative completions for the first eleven months of 1940 and 1941, and details of the wells completed in 1941; the number of rigs in operation on 1st December, 1940, 1st November and 1st December 1941, and the status of the rigs.

G. D. H.

153.* Automatic Release Hanger Lessens Heavy Tong Chores. Anon. *Oil Wkly*, 15.12.41, 104 (2), 30.—A simple type of hook, featuring automatic release of the tongs when required, has been worked out by one company, in which gravity is used as the actuating force to free the tongs and permit ready swinging of the tool back to engagement with the string of pipe.

The usual hanger stand is used as basis for the fastening, with a nipple of 1-in. pipe, some 4 in. in length, being welded vertically to the draw-works side of the stand, with the base of the nipple some 36 in. above the floor. Up through this nipple is slipped a 24- or 26-in. long $\frac{3}{4}$ -in.-diameter steel bolt, the head engaging against the bottom of the nipple if raised to highest elevation possible. The upper portion of the bolt is heated and bent at a point some 16 or 18 in. from the head, being bent sharply through 90° to form a shoulder which will abut on the top of the vertical nipple. The outer end of the bolt is then again bent upward, to form a hook with slight slope toward the angle at its base. The hooked end is about 4 in. in length, to provide ample engagement for the eye of the back-up tongs.

To hang tongs with this hanger, they are swung back into the general direction of the support, the eye riding above the height of the hook in the bolt when the latter is in its lowest or dropped position. To engage the hook in the eye with one hand while guiding the swing of the tongs with the other is a comparatively simple operation, the bolt having a space of some 14 in. vertically through which it may be moved to engage the hook, whilst the offset permits a lateral swing through a circle with a radius of around 12 in.

Details of operations and advantages accrued are given.

A. H. N.

154.* Designs of Casing Strings. Part III. E. N. Kemler. *Oil Wkly*, 15.12.41, 104 (2), 33.—This part deals with failure due to a combination of stresses studied in the first two parts. Formulae for calculating maximum stress values engendered by a combination of various types of loadings are given and discussed.

The design of a specific string of casing involves many factors, some of which are difficult to evaluate. Fortunately most of these factors are decided by the company policy and as a result of operating practices over a long period. Because of the considerable amount of money involved, the engineer must constantly study the casing programmes, in order to be able to take advantage of any local or market conditions and changes in production practices. To-day the national emergency has introduced a further problem in supply and materials, which will require constant changing of casing programmes. The operating factors which will affect the design of casing programmes are drilling practices, producing practices, and finally future well conditions.

In areas where casing failures may occur because of corrosion, or for other reasons, it may be desirable to make provision for running an emergency string to permit continued production. If a well must be cleaned out or shot, or if liners must be pulled or run, the oil-string should be of sufficient size to permit running of necessary tools.

The producing practices or requirements are the controlling factor when future well conditions do not have to be considered. The type of pool, amount of fluid to be handled, probable loads which will be encountered and allowable production will determine initial and final tubing sizes. The requirements or restrictions for taking potentials on wells may also influence casing sizes. Since failures of sucker rods and

tubing are always possible, provision must be made for fishing and clearance allowed for fishing tools.

The drilling practices will dictate the size of hole which can be drilled through a given string. Again company practice will dictate the size casing which it is safe to run in a given size of hole. The size may vary with the type of formation to be drilled and the amount of open-hole carried. Another factor which must be considered is availability in sizes, weights, and grades. In the designing of any casing programme, it is always possible to reduce the weight of steel required by using the calculated required weight. Practically, it is not feasible to have a wide range of weights and sizes, because of high cost of manufacturing and stocking of casing. Local conditions frequently are such as to make a new size or weight desirable.

A. H. N.

155.* Some Factors Controlling the Pumping Time of Oil-well Cements. G. R. Neighbors and S. Cromer. *Petrol. Tech.*, November 1941, A.I.M.M.E. Tech. Pub. No. 1399, 1-6.—The effects of temperature and pressure on the setting times of cement were examined in a paddle-type consistometer. The cement slurry was rapidly mixed and poured into the instrument. The pressure was raised to the required value, the temperature adjusted, and the test commenced within 2 min. of mixing the cement. Readings of time and the torque exerted were recorded at intervals until a fluidity equivalent to 100 poises was reached, at which stage the test was stopped.

The results show that increase in temperature markedly increases the rate of stiffening of the cement slurry, probably due to an accelerated rate of hydration on heating. The rate at which the cement becomes heated while it is being pumped in the well is uncertain, and many believe that it may not exceed 170° F. during placement, although in squeeze-cementing operations it seems likely that it may reach the formation temperature approximately.

The time to reach a fluidity equivalent to 100 poises was 15-25% less at 3000 lb./in.² than at atmospheric pressure, a result which conforms with other experimental work.

A high water-cement ratio reduces the pumping time, but such slurries are easily contaminated, subject to sedimentation, and give a cured cement of very low strength. The cement after storage in tight metal cans for 3 months gave slurries with a longer setting time for a given concentration and temperature than when first used.

More data on temperatures attained during cementing are required, and an instrument capable of tests at pressures up to 12,000 lb./in.² is needed.

G. D. H.

156.* Chemical Treatment of Bentonitic Suspensions and the Relationship to the Heaving-shale Problem. H. H. Power and C. R. Houssiere. *Petrol. Tech.*, November 1941, A.I.M.M.E. Tech. Pub. No. 1401, 1-16.—In attacking the heaving-shale problem, it is evident that a knowledge of the physical and chemical properties of the shales and how such shales are affected by the addition of chemicals is essential. Consequently, investigations were carried out on suspensions prepared from Wyoming bentonite. The effects of added electrolytes on viscosity and filtration were determined. The following points were noted for relatively low concentrations of electrolytes. In general, small amounts of added reagents (HCl, NaCl, KCl, Na₂SO₄, etc.) reduced the viscosity, while larger amounts increased it. There was a similar general effect as regards the amount of filtrate in 30 min. It was generally observed that the effective ion absorption was in the order: Na, K, H. The effects of combined 1N-KCl-1N-HCl did not correspond with those of the separate reagents. In some instances it appears that the assumption of the presence of ionic structures may furnish a partial explanation of viscosity changes when filtrate rates remain constant. Enmeshment of water apparently results from treatment with NaOH, but not with NaCl. Using salts, it appears that the reduction of viscosity is due to the number and kinds of ions present. The viscosity varies in inverse proportion to particle size. In a study of filtration characteristics, "bridging" of particles was shown to be important, and particle-size distribution rather than high viscosities apparently accounts for low filtration rates. The change of p_H is retarded as particle sizes decrease. If viscosity change is due primarily to adsorption of ions from solution, a

variation in p_H results. Thus, the degree of viscosity change is reflected in the change of p_H , except in so far as the viscosity changes are not always due to adsorption of ions alone.

G. D. H.

157.* Tool Joint-Drill Pipe Connection. R. I. Gardner. *Petrol. World*, October 1941, **38** (10), 26.—This paper is written with the object of giving a qualitative rather than a quantitative analysis of the problems, advantages, and limitations of the various designs of tool-joints now available. One of the critical sections of the rotary drill-stem is the connection between the A.P.I. Standard tool-joint and the drill-pipe. Correct mating within the specifications is essential.

When making up the pipe end-joint a number of conditions must simultaneously be met. (1) The mating parts should truly be in contact at all points, to prevent any looseness while in service. Any looseness will inevitably develop a fatigue-type failure if the joint does not either unscrew or wash out beforehand. (2) Sufficient frictional resistance must be developed to prevent the joint from unscrewing while in service. (3) A leakproof seal must be developed to prevent washing out of the threads. In order to effectively seal the threads and to lubricate the mating parts, a good grade of metal-base thread lubricant is applied in a thin uniform coating over the threads of both box and pin. Interfacial contact pressures as high as 17,500 lb./sq. in. are developed between mating parts.

Although specifications for bucking-up tool-joints usually include the range of torque necessary to produce a satisfactory connection, mention is seldom made of the limiting number of turns allowable after "hand-tight." If, however, excessive amounts of lubricant are used, it is not possible to attain sufficient torque without permanently deforming the thread elements.

With the usual proportions of the pipe end-joint, the highest unit stresses are found in the inside surface of the pin-end. These are hoop-stresses, resulting from the radial compression of the pin by the box as the former is screwed into the latter. There are, of course, tensile hoop-stresses in the tool-joint, or box, but these are usually unimportant because of the relatively higher strength of the tool-joint material. When singles are put together with "regular" couplings, it becomes necessary to determine the hoop-stresses in the coupling as well as in the pipe.

If the usual joint is made up beyond the number of turns which will stress the pin-end to its yield-point in compression, the end of the pin will be permanently deformed. The originally carefully cut pitch-cone will be altered, resulting in an increased non-uniform taper. The bad effects of this will be evident on the next tool-joint made up.

Another reason why high compressive hoop-stresses are detrimental to strength at the last engaged thread is that a press fit acts much the same as an integral shoulder under rotating beam-type loading. This effect approaches that of the integral shoulder as the stress induced by the press-fit is increased.

The paper deals extensively with calculations and improvements of A.P.I. joints.

A. H. N.

158.* Californian Equipment and Methods. N. A. D'Arcy, Jr. *Petrol. World*, November 1941, **38** (11), 61.—Much of the equipment described has recently been recounted in the literature, such as the comparatively new bulk-cementing method, the three-cylinder slush-pump, marine-type full-condensing boilers, steam-operated casing tongs, wall calipers used to predict volumes of gravel or cement required, heavy portable drilling units—Abstracts in the 1941 *Journal* may be consulted. The paper is extremely well illustrated.

Amongst the equipment described is an 87-ft. derrick unit complete with crown block, travelling block, draw-works, rotary machine, and internal-combustion engine, all mounted on a special sub-base to which Athey Trak wheels are permanently attached. This draw-works unit is moved over the rolling Poso Hills in perfect safety, as the centre of gravity is only approximately 16 ft. above the ground. It is said to be an interesting sight to see this unit travelling over the roughly graded roads, leaning at an extreme angle.

In addition to the derrick unit, there is a slush-pump unit with its internal-combustion prime mover mounted on another Athey wagon, which may be moved from one location to another merely by disconnecting the discharge line from the

pump and raising the suction line. When the drill-pipe is laid down at the completion of a hole, it is laid directly on a special drill-pipe transporting rack, also mounted on Athey wheels, and is ready to move when the last piece has been laid down. Even the doghouse on this unit is mobile. This unit has been moved over the Poso Hills road a distance of $2\frac{1}{2}$ miles in 10 hr.

Another interesting feature is temperature control of muds. The temperature of the mud in these fields is, of course, high, and a special mud-cooler is in operation. This cooler consists of a forced-draft cooling-tower, through which the mud is pumped. It is reported that the temperature of the mud can be reduced from a normal discharge temperature of 150° to approximately 105° .

Two interesting new instruments are also in use in the Dominguez field. The Mud Logger charts a 24-hr. graphic recording of the viscosity of the mud in centipoises and the weight of the mud. This chart provides a picture of the condition of the mud and enables the operator to detect dangerous portions of the drilling fluid. The chart will indicate the time-cycle required to circulate non-uniform mud, and this will enable the operator to add chemicals or weighting materials at the exact point most needed.

The Drillogger is another new instrument now operating at Dominguez. This instrument makes a continuous graphic record of the rate of penetration, weight on the bit, table speed, pump pressure, and rotary torque. Correlation of these five curves, together with a knowledge of the formation being drilled, enables the experienced operator to establish a more suitable drilling technique for a particular formation. Where the formation is not known, a continuous chart of the rate of penetration is of value in correlating core data and electric log information in establishing various strata.

A. H. N.

159. Patents on Drilling. M. Hokauson. U.S.P. 2,262,001, 11.11.41. Appl. 21.8.39. Drill-bit for percussion drilling systems with several cutting and reaming edges.

S. Pennella. U.S.P. 2,262,041, 11.11.41. Appl. 7.1.41. Tube-cutter adapted to be inserted and rotated inside the tube to be cut.

G. A. De Vlieg. U.S.P. 2,262,099, 11.11.41. Appl. 3.3.39. Machine for sharpening rotary cutters.

E. J. Roe. U.S.P. 2,262,117, 11.11.41. Appl. 19.1.39. Well-plugging device with a pipe in sections and an expansible sleeve.

J. L. Downes. U.S.P. 2,262,171, 11.11.41. Appl. 6.7.38. Hose-coupling device to be used manually.

A. L. Stone. U.S.P. 2,262,210, 11.11.41. Appl. 25.9.39. Method of building up tubular joint members.

A. L. Stone. U.S.P. 2,262,211, 11.11.41. Appl. 18.3.40. Composite tool-joint for well-pipe.

A. L. Stone. U.S.P. 2,262,212, 11.11.41. Appl. 20.3.40. Method of making composite tool-joint members and the like.

L. F. Athy and H. R. Prescott. U.S.P. 2,262,419, 11.11.41. Appl. 9.4.38. Method of electromagnetic logging.

I. T. Minaryard. U.S.P. 2,262,694, 11.11.41. Appl. 25.7.40. Cathead for drilling rigs fitted with a clutch.

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D. H. Weinstein and L. H. Metzner. U.S.P. 2,265,093, 2.12.41. Appl. 8.1.38. Angle measuring device for surveying instruments.

H. G. Campbell. U.S.P. 2,265,472, 9.12.41. Appl. 14.9.40. Reamer for straightening an earth-hole.

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Production

160.* **Practical Application of Flow-Valve Installation Principles.** J. E. Halferty. *Oil Gas J.*, 27.11.41, 40 (29), 46.—The conclusion reached in this long paper is that most of the difficulties encountered in the selection and installation of gas-lift equipment have resulted from an insufficient knowledge of the necessary technical data of the well's characteristics. There is little doubt that a complete survey of a prospective gas-lift well, strict adherence to the proved principles governing submergence, spacing, type of valve, and type of installation, test-rack data on the mechanical status of the valve, and a follow-up flowing gradient to determine the valve's operation, would eliminate a large number of unsatisfactory flow-valve installations. A high degree of satisfactory gas-lift operation is at hand for the operator who will demand that such information be accurately obtained and carefully examined before and after flow-valves are run in his wells.

The following conclusions are condensed from the body of the article and tabulated for convenience: (1) *Type of Valve*.—Differentially operated, spring-loaded with a minimum of different settings, of which a 125-lb. reopening, 150-lb. blow-down close, 150,000–175,000 cu. ft. of gas passage, double-seated type has been found satisfactory, particularly for high-fluid level wells. Typical unloading type single-seated valves are frequently run on top of a long string and intermitting-type valves are run on bottom. (2) *Submergence*.—Top valve should be placed approximately 150 ft. deeper for oil and 75 ft. deeper for water than the fluid load necessary to reopen the valve. Factors effecting submergence are: casing pressure, fluid gradient (lb./sq. in./ft. of depth), valve setting and volume of gas valve will pass. (3) *Spacing*.—Depends entirely in reopening pressure of valve and maximum weight of fluid to be lifted. For 125-lb. reopening differential pressure, space approximately eight tubing singles (31-ft. length) if water is present, and eleven tubing singles where well makes pipeline oil. Spacing too far will stymie; too close spacing will cause "interference" and inefficient operation. (4) *Depth of Bottom Valve*.—Determined by working fluid level in casing, production rate desired, and estimated decline of wells, bottom-hole pressure. Working fluid level is determined from productivity index, daily production rate, and fluid gradient. (5) *Flowing Friction*.—Conservative figure to use is 0.1 lb./sq. in./ft. in flowing water. Oil or aerated water column will have a proportionally smaller friction loss/ft. (6) *Semi-closed Installations*.—Used in small "tight"

wells with high maximum closed-in bottom-hole pressure (fluid level), or any small well with maximum bottom-hole pressure sufficiently high to elevate fluid a height above bottom flow-valve to create necessary pressure differential with respect to well's casing pressure and cause valve to reopen and operate. Tubing standing valve is not used in semi-closed installation. Perforated seating chamber above packer, and removable blank drop-valve, if used, enables operator to unload casing annulus without unseating packer if fluid should leak through valves into annulus during a shut-in period. (7) *Auxiliary Equipment Recommendations*.—Test-rack for testing new and removed flow-valves. Gas-line scrubber. Proper supply gas regulation. (8) *Payout*.—Average flow-valve installation in moderately corrosive area should pay out in one year or less, using 10 cents/brl. saving on flow-valve operation over pumping equipment, and assuming 10% depreciation and 5% interest charge on difference in initial investment cost between pumping and flow-valve installation. Daily allowable of 25 brl. is assumed. Where corrosion or sand conditions are severe, the saving/brl. using flow valves would probably be greater than 10 cents/brl. Conversely, where compression or supply gas costs are high, the saving will be correspondingly less.

A. H. N.

161.* Loco Hills Pressure-Maintenance Project Placed in Operation. D. H. Stormont. *Oil Gas J.*, 11.12.41, 40 (31), 48-49.—Pressure maintenance is being applied on a major scale by the operators in the Loco Hills field of Eddy County, New Mexico. The project is a co-operative effort which includes practically all the lease owners in the pool. The plant facilities and certain other details are given.

The Loco Hills field was discovered in January 1939, and although some drilling continues on inside leases, the productive limits have been fairly well established on all sides. Development has been one well to 40 acres. Production throughout most of the field is from a 2800-ft. pay. However, on the south-west side production is from a sand slightly lower than the main pay. Original bottom-hole pressure varied from 600 to 1000 lb., with the average estimated at 900 lb. The average reservoir pressure at first fell off rapidly, but during the past eight months, with daily oil withdrawals ranging from 6000 to 7500 brl., the decline has been about 8 lb./month. In August, when the most recent survey was run, the average pressure was about 661 lb. The average gas-oil ratio early in 1940 was about 800 : 1, but it has since increased to the present ratio of 1500 cu. ft./brl.

The field's main pay averages about 20 ft., with regional dip to the south and east. Analyses of cores have shown the pay to have a porosity of about 20%, with connate water content ranging from 15% to 25%. Under primary recovery methods it is estimated that ultimate oil yield would have been 4500 brl./acre. Under pressure maintenance, however, due to the highly favourable conditions for such operations, it is expected that ultimate recovery will be raised to 9000-10,000 brl./acre.

A. H. N.

162.* Red River Field Offers Example of Value of Repressuring. D. H. Stormont. *Oil Gas J.*, 18.12.41, 40 (32), 32.—In the Red River field of Tillman County, Oklahoma, a 270-acre repressuring project has been under way for more than 12 years. Despite natural barriers of lenticular sands and the fact that the repressured area is located in a river-bed, the project offers an excellent example of the value of repressuring. Oil production has fallen off steadily for the past 10 years, and has now reached a point where it is expected that operations will be abandoned within the next few years. Since the project is nearing depletion, it is possible to show what has actually been accomplished by repressuring.

The geology and field structure are given, together with the sand condition of the producing formation.

At the start of gas injection, vacuum of from 20 to 26 in. was being applied at the well-heads. Experience has shown that any reduction in vacuum resulted in an immediate loss in oil production. Therefore, the vacuum was removed in stages, the time between and the amount of each cut being governed by daily oil production, so that the vacuum was not entirely eliminated until almost one year after the start of repressuring. Since then reservoir pressures have slowly increased, and to-day injection pressures vary from 10 to 30 lb. A surprisingly small loss of daily production was noted when the vacuum was removed from the wells.

A noticeable result of the vacuum removal was an increase of the gravity of the oil produced. While vacuum was being used the average oil gravity in the field was 39°, but after the vacuum had been eliminated the average gravity was 41°, with many tanks running 42°. After the input gas had built up a pressure in the sands, the gravity fell slightly, the 42° phase being eliminated. Simultaneously with the cut in vacuum and the rise in gravity of the oil, there was a distinct drop in the gasoline content of the casing-head gas taken from the wells. The history of injection operations under different conditions is given.

The present oil output of about 275 brl. daily is being produced by some seventy oil and fifteen key-injection wells, or an average of approximately 4 brl./well/day. Many of the edge wells, however, produce in the neighbourhood of only $\frac{1}{2}$ brl. daily. Economic limit of the field is estimated to be approximately 100 brl./day, thus it is probable that the field will be abandoned in 3 or 4 years. Should it prove profitable to continue operations through 1946, a total oil recovery of 7,492,000 brl. will have been produced, or a yield of about 27,700 brl./acre. As ultimate recovery under primary and vacuum operations would have totalled an estimated 5,729,000 brl., the repressuring project, by the time of abandonment, will yield an additional 1,763,000 brl. of oil.

A. H. N.

163.* Future of Oil Production Methods. D. R. Knowlton. *Oil Gas J.*, 18.12.41, 40 (32), 35.—Since the discovery of oil in 1859, more than a million wells have been drilled in the United States, ranging in depth from a few feet to 15,504 ft., as the deepest well ever drilled, and 13,206 ft., as the deepest well now producing.

At present there are approximately 380,000 producing wells in the United States, with the daily average production exceeding 4,000,000 brl. It is estimated that 30% of this production flows naturally from the reservoir, and 70% is pumped.

Most oil is pumped without the assistance of secondary recovery methods, such as gas injections or water-flooding. The equipment in use varies from wooden pumping-rods in the old areas to very efficient and highly engineered individual pumping units.

The author predicts that it is in the control of reservoir energy and methods of optimum utilization of production principles that the future methods will excel. Making equipment lighter than their present weights, the advancement of hydraulic pumping, the adaptation of electrical submersible pumps to small well-pumpings, and the more effective use of wide spacing are other steps in the advance of production methods.

A strong plea is made for unitization in producing oil-fields.

A. H. N.

164.* Closer Association between the Production Engineer and His Operating Co-Worker. D. R. Knowlton. *Oil Wkly*, 1.12.41, 103 (13), 38. *Paper Presented Before American Petroleum Institute.*—The development of petroleum engineering as a distinct and independent profession is discussed. The principal types of administrative organizations in general use by the oil companies are briefly explained. It is stated that the effectiveness of the association between a production engineer and an operating co-worker is in some degree directly proportional to the mutual respect and confidence which exist between them. By the selection and proper development of capable men for the jobs, by definitely instructing them as to their responsibility and authority, and by requiring joint and concerted action by them, the association of the production engineer and his operating co-worker will be more harmonious, more efficient, and more profitable.

A. H. N.

165.* Fluid Back Pressure Checks Sand Caving. G. B. Nicholson. *Oil Wkly*, 8.12.41, 104 (1), 15-16.—The production from the particular field discussed was hindered by presence of apparently unlimited quantities of sand bearing fine shale particles which made producing the wells almost an impossibility. Ordinary production methods resulted in frequent sanding-up, screen-washing, and clean-out jobs, which entailed considerable expense and made economic operation doubtful, and the operators resorted to artificially flowing the wells, employing methods with which they had experience in other localities.

By lifting the fluid from a high level, the operators now hold back-pressure on the

formation by means of a heavy fluid column which supports the sand. Weight of the hydrostatic head prevents the heaving or infiltration of sandy mush which formerly followed a material lowering of the fluid column.

As an abundant supply of high-pressure natural gas was not available in the Louise field, it was decided to build a compressor station to inject air into the wells for lifting the fluid. The plant has been in operation for several months, with production records tabulated since completion verifying the efficiency and economy of its performance. A small corrugated-iron building houses the compressor, which consists of a single, 2-cylinder, 2-cycle engine of 90-horse-power capacity set on concrete flooring and using lease-gas for fuel. Water for the engine is supplied by a lease water-well, which flows prolific quantities artificially lifted by air from the compressor, whilst in a nearby location a large steel storage tank is equipped with a cooling tower which maintains the water at a suitable temperature for the engine. Near the engine-house a special tank is provided for storage of natural gas should it become available in quantities adequate for gas-lift, and the engine is adapted for conversion to compress gas instead of air.

Details of the system are given. Nine wells are joined with the air-lift system, and are staggered in operating to avoid exhausting pressure supply or constantly keeping requirements at a maximum. Each month approximately 16,000 brl. of fluid are lifted, of which 6000 brl. are oil and the remainder water. In ordinary operation, about 500,000 cu. ft. of air are used daily to lift this fluid, with a calculated air-fluid ratio slightly exceeding 900 to 1. Operators regard the lifting cost represented as extremely low, and while a slight emulsion occurs due to agitation by air, treating costs amount to only $\frac{1}{2}$ cent/brl. A. H. N.

166.* Portable Pump System Handles Output of Distillate Field. E. Sterrett. *Oil Wkly*, 8.12.41, 104 (1), 26.—In the Chapel Hill distillate field the nature of the production imposes wide spacing, with the high gas-oil ratio affording relatively small daily liquid output/well. Due to this type of production and to its high gravity, usual methods of handling the output into pipe-lines are not applicable, nor advisable, on account of the possibility of high fluid loss unless continuous supervision be present to detect and guard against leakage, line-break, or shutdown of the pumping unit.

Since but one pipe-line serves the field for gathering the liquid production, pumping problems have been simplified and constant supervision assured by fitting out a portable pumping plant which, taken to the various leases in rotation, empties the lease-tanks, then moves to the next lease and repeats. Under this system only one lease can be on the line at any time, and possible overloading through the attempt to run a number of pumps simultaneously is avoided.

A duplex plunger pump, with integral gear reduction, is mounted on the rear end of a 1½-ton truck, with the fluid end extending across the normal rear member of the pump-frame and carried on a welded extension to carry a heavy bumper out behind all pump connections.

The layout and operations of various items of the equipment are described and illustrated. A. H. N.

167.* Co-operative Water Disposal Planned for East Texas. Anon. *Oil Wkly*, 15.12.41, 104 (2), 24.—The paper discusses the plans of a large co-operative programme which may solve the increasingly serious problem of how to handle the growing volume of salt water being produced in the East Texas field, by injecting it back into the producing formation, and thus also checking the decline in reservoir pressure. Not only would this be the world's largest salt water disposal system, but probably the largest co-operative operation of any kind ever undertaken in the industry's history.

At stake is an estimated 200 to 800 million brl. of oil in ultimate recovery, a threatened increase in lifting cost as declining bottom-hole pressures force additional wells on the pump, and possible elimination of legal difficulties arising from disposal of the water by means of surface evaporation pits. The volume of salt water produced in East Texas has increased steadily and rapidly during the past year, and currently the volume is in excess of 400,000 brl./day.

The financial aspect is discussed and the setting up of a company capitalized at \$4,000,000 is proposed.

Investigations to determine the most desirable method of returning East Texan field salt water to the formation led to the formulation of three methods whereby this might be accomplished, each being developed in detail to cover a section of the field which was considered as representative. After dividing the field into sections, choosing as basic boundaries those established as head-right surveys, the engineering committee of the East Texas Salt Water Disposal Group selected that portion designated on their map as Section 3-A, which comprises a strip with Kilgore approximately on a median line between northern and southern boundaries, and extending from the easternmost portion of the field westward to the vicinity of the Smith County line.

Working first from close investigation of conditions as developed within this sample or typical section, recommendations were extended to cover the East Texas field, and to provide for a daily salt water volume of in excess of 400,000 brl. Between the three sets of data worked up by the engineering committee no choice was made, all three plans being submitted for such action as might be taken.

The three plans are detailed with some discussion, together with conclusions reached on the types of treating plants and gathering systems recommended.

A. H. N.

168.* Possibilities of Secondary Recovery for the Oklahoma City Wilcox Sand. D. L. Katz. *Petrol. Tech.*, November 1941, A.I.M.M.E. Tech. Pub. No. 1400, 1-22.—The Oklahoma City Wilcox sand, discovered in March 1930, has produced 394 million brl. of oil and 819,000,000,000 cu. ft. of gas up to 1st July, 1941. A pressure of 2600 lb./in.² existed in early days, and there were 100,000-brl. wells, but the reservoir pressure is now substantially atmospheric and the output 75,000 brl./day of oil from 466 pumping wells. Early estimates of the crude-oil content of the Wilcox sand indicated that about 600 million brl. of oil would remain after the pumping wells ceased to produce economically.

A brief summary is given of data obtained in examining the possibilities of a secondary recovery project for the Wilcox sand. From the reservoir conditions at various dates it is concluded that the initial residual crude oil was 1072 million brl., which accords well with sand volume and porosity information. Core data from some of the newly drilled wells show the oil saturation of the gas zone to range from 1.0 to 25.9% and that of the oil zone to be 52.7-92.8%, and a possibility of 1% or even no connate water is indicated.

Displacement pressure tests on the Wilcox sand indicate that it may not be differentially wet by the Wilcox water. The low connate water content is in accordance with this finding, and also with the lack of beneficial results from natural water-flooding. It suggests that water-drive might not recover the desired crude oil.

A gas-injection project in the south end of the Wilcox sand has given favourable results. A gas injection and unitization plan has been worked out to recover 80 million brl. more oil than is predicted from the decline curves, and the estimated production, costs, earnings, etc., under this plan are tabulated.

Legislation to authorize the unitization is still lacking.

G. D. H.

169.* Radioactivity Logging Through Casing. L. C. Beers. *Petrol. World*, November 1941, 38 (11), 95.—The instrument consists of two parts. The lower part is an ionization chamber filled with gas. γ -rays originating in the formation produce a minute current in this chamber. The strength of this tiny current is strictly proportional to the number of γ -rays passing through the chamber/second. This ionization current is tremendously magnified by the amplifier in the upper chamber, and is transmitted up the cable to the recording equipment at the surface. Here it is further amplified and transmitted to an automatic pen recorder, which registers on a paper chart the γ -ray intensity of the formations opposite the sub-surface instrument.

The paper chart is moved in synchronism with the depth of the instrument in the hole, with the result that when the sub-surface instrument is raised, a continuous depth log is traced which shows the radioactivity of the formations outside the pipe.

It is important to note that the kind of fluid in the hole, or the presence or lack of fluid in a well, has no effect on the accuracy of radioactivity logs. The radioactivity of each formation is a permanent lithological characteristic of the rock itself.

Comparison of radioactivity logs with the previously determined stratigraphy of

both cased and uncased wells has revealed a definite tendency for sands to appear on the logs as radioactive lows and for shales to be relatively high in radioactivity. Limestones are of intermediate strength. Anhydrite, coal, and salt beds are usually low in γ -ray intensity, whilst certain black marine shales and potash beds are much more radioactive than ordinary shales. In contrast to electrical logs, which show nearly all shales to have a uniform resistivity value, the radioactivity logs show the shales to have a wide range of radioactive values. This makes it possible to discern radioactive markers or zones in otherwise monotonous shale sections which can be correlated in detail by radioactivity logs.

The radioactivity of sediment rocks, as measured by this method, is not limited to the uranium-radium series alone. Penetrating γ -rays are also emitted by minerals containing thorium and actinium and their by-products. Potassium is also slightly radioactive, and is sufficiently abundant to be an important factor in differentiating strata by this method.

Radioactivity logging is compared with electrical logging.

It is concluded that these surveys have a distinct application in guiding plug-back and perforating programmes, and are capable of revealing structural features of old fields that will be useful in planning deepening programmes. The most effective method of employing radioactivity logs is to evaluate the radioactive properties of the strata in a given area by running the radioactivity log first in a key well where complete and stratigraphic information is available, and then correlating out across the area to locate the precise depths in old wells at which the horizons of interest occur.

A. H. N.

170.* What Shall Be Done about Proration. Part III. O. W. Willcox. *World Petrol.*, November 1941, 12 (12), 44-49.—In this series of paper the proration system practised on a world-wide basis in the sugar industry is described as a model for the petroleum industry. The system is summarized: The system is made nation-wide, and takes in (as charter members) every visible primary producer and every visible processor. Both wings of the industry are separately organized, and join in creating a central association which negotiates with the public authorities on behalf of the industry, distributes the business proratably among the primary producers and the processors, keeps out unneeded newcomers, takes charge of the product from the points of origin of the raw material to the ultimate distribution points of the finished goods, and collects a legally fixed price from the consumers which is prorated back to the producers on a legally determined basis that will ensure the economic survival of all elements of the industry. It is to be remembered that the terms of the industry's charter were first democratically thrashed out in a plenary conference of the whole industry, and were presented to the Government as the considered opinion of what the industry needed, wanted, and was prepared to do. Thus the industry elected its executive committees and boards and ran under a charter virtually written by itself.

The rest of the paper deals with the advantageous results accruing from the hypothesis that such a system was adopted by the industry. The author discusses the relation of the industry with the Government and with other industries and consumers in such cases.

A. H. N.

171. Patents on Production. H. De Groote, B. Keiser, and C. M. Blair, Jr. U.S.P. 2,262,357, 11.11.41. Appl. 27.6.40. Process for breaking petroleum emulsions.

M. De Groote and B. Keiser. U.S.P. 2,262,358, 11.11.41. Appl. 27.6.40. Process for breaking petroleum emulsions.

W. T. Lietz. U.S.P. 2,262,428, 11.11.41. Appl. 21.5.38. Process for the treatment of oil- or gas-wells.

W. St. M. E. Crake. U.S.P. 2,262,490, 11.11.41. Appl. 12.11.40. Casing-head structure for supporting a constant portion of the weight of inner casing strings.

H. R. Hogaboom. U.S.P. 2,262,535, 11.11.41. Appl. 30.9.40. Counterbalance crank for rotating shaft.

M. De Groote and B. Keiser. U.S.P. 2,262,736, 11.11.41. Appl. 27.6.40. Process for breaking petroleum emulsions.

M. De Groot. U.S.P. 2,262,737, 11.11.41. Appl. 11.10.40. Composition of matter and process for preventing water-in-oil type emulsions resulting from acidization of calcareous oil-bearing strata.

M. De Groot. U.S.P. 2,262,738, 11.11.41. Appl. 11.10.40. Composition of matter and process for preventing water-in-oil type emulsions resulting from acidization of calcareous oil-bearing strata.

M. De Groot. U.S.P. 2,262,739, 11.11.41. Appl. 11.10.40. Composition of matter and process for preventing water-in-oil type emulsions resulting from acidization of calcareous oil-bearing strata.

M. De Groot. U.S.P. 2,262,740, 11.11.41. Appl. 11.10.40. Composition of matter and process for preventing water-in-oil type emulsions resulting from acidization of calcareous oil-bearing strata.

M. De Groot. U.S.P. 2,262,741, 11.11.41. Appl. 11.10.40. Composition of matter and process for preventing water-in-oil type emulsions resulting from acidization of calcareous oil-bearing strata.

M. De Groot. U.S.P. 2,262,742, 11.11.41. Appl. 11.10.40. Composition of matter and process for preventing water-in-oil type emulsions resulting from acidization of calcareous oil-bearing strata.

M. De Groot. U.S.P. 2,262,743, 11.11.41. Appl. 12.5.41. Process for breaking petroleum emulsions.

J. P. Walker. U.S.P. 2,262,744, 11.11.41. Appl. 18.2.39. Method of recovering well-fluids.

A. Boynton. U.S.P. 2,263,565, 25.11.41. Appl. 28.11.38. Flow intermitter to control discharge of fluids from well-tubing.

G. H. Williams. U.S.P. 2,263,910, 25.11.41. Appl. 11.7.38. Standing valve-puller for valves with upward projecting stems.

W. D. Mounce. U.S.P. 2,264,450, 2.12.41. Appl. 15.4.39. Gun perforator.

P. O. Webb. U.S.P. 2,264,600, 2.12.41. Appl. 22.6.39. Paraffin scraping and oil-saving device.

G. L. Monighan. U.S.P. 2,265,082, 2.12.41. Appl. 26.7.38. Breaking up water and oil emulsions.

W. F. Bettis. U.S.P. 2,265,098, 2.12.41. Appl. 28.10.39. Release for pressure bombs for oil-wells.

R. L. Chenault. U.S.P. 2,265,099, 2.12.41. Appl. 20.12.38. Apparatus for timing well-pumps and the like.

J. A. Lyne. U.S.P. 2,265,379, 9.12.41. Appl. 26.7.39. Pumping mechanism with a pair of cranks out of phase with each other.

S. W. Long. U.S.P. 2,265,660, 9.12.41. Appl. 6.12.39. Swabbing valve for use in a well having spaced production zones.

H. C. Lawton, D. A. Limerick, and A. G. Loomis. U.S.P. 2,265,759, 9.12.41. Appl. 6.6.39. Oil-well treating fluid.

W. R. Godsey. U.S.P. 2,265,835, 9.12.41. Appl. 15.4.40. Intermittent valve for admitting gas to a liquid conduit.

W. R. Godsey and W. Horn. U.S.P. 2,265,836, 9.12.41. Appl. 15.4.40. Flow-valve for gas lift apparatus.

J. S. Normand. U.S.P. 2,265,923, 9.12.41. Appl. 17.11.38. Method of treating oil- and gas-wells to increase production.

F. A. Bent and A. G. Loomis. U.S.P. 2,265,962, 9.12.41. Appl. 9.9.36. Method of treating oil- and gas-wells for sealing off water-bearing formations by means of an alcoholate of silicon.

A. H. N.

Transport and Storage

172.* Investigate Abnormal Conditions To Improve Cathodic Protection. H. White. *Oil Gas J.*, 18.9.41, 40 (19), 106.—Eight months after installing cathodic protection for a gasoline plant, the El Paso Natural Gas Co. found that in one section pipe to soil potential was zero and 200–250 mv. less negative than the rest of the plant piping. Attempts to remedy this condition by adding carbon anodes to the iron anode system already in operation failed, whilst no improvement was yielded by replacing these carbon anodes by iron anodes. Small-scale experiments were then carried out with soil from the abnormal, corrosive area and also normal soil. The abnormal soil was shown to contain unusually large quantities of soda ash and sodium sulphate, and the increase in electrical resistance to be caused by polarization. Various chemicals, known to be depolarizers, such as sodium chloride, potassium chromate, and nitric acid, were added to the soil in attempts to eliminate this over-voltage effect, and excellent results were finally obtained by adding calcium chloride around the anodes. In the field installations perforated iron pipes were used as anodes, filled with solid calcium chloride, water poured on top, and as the calcium chloride dissolved it spread into the soil surrounding the pipe. J. C.

173.* Graphic Corrosion-Leak Record Guides Pipe-line Protection. R. Wardwell. *Oil Gas J.*, 18.9.41, 40 (19), 116.—A flexible system of graphic corrosion-leak charts has been kept by the General Petroleum Corporation for 5 years and, coupled with field inspection data, supplies a basis for determining which sections of line need protection. A complete record of leaks, type, repair, cost, etc., is kept both chronologically and according to location. Location charts show insulating flanges, which are used to terminate sections under cathodic protection, and also indicate changes in soil conditions. Time charts (one of which is illustrated) are graphs of leak location plotted against time of failure. By means of these charts future leak occurrence can be anticipated to some extent and troublesome portions of line may be defined clearly. These sections are coated or otherwise protected, thus saving much expense and making it economically possible to carry out intensive work on the affected parts. The mode of protection used varies with the district and the type of the corrosive soil. J. C.

174.* Prevention of Pipe Corrosion Highly Developed Technique. S. Thayer. *Oil Gas J.*, 25.9.41, 40 (20), 60.—Recent improvements in pipe protection are divided into three groups—viz., improvement in the quality of coating compositions, replacing of hand painting by coating machinery, and cathodic protection of uncoated or poorly coated pipes.

In dealing with existent unsatisfactorily coated pipe-lines, operators have to decide whether to rebuild the corroded sections or to instal cathodic protection. The planning of new pipe-lines in unknown soils is a more complicated undertaking. To apply a good protective coating to the entire line is safe but expensive. To define the corrosive areas and treat them only means, in general, reliance on soil-resistance measurements. Occurrence of restricted areas of corrosive soil types in apparently bland soils leads to unexpected leaks, and when this occurs it is considered best to use cathodic protection for the affected parts.

The following conclusions are reached :—

1. In planning a new line do not try to define the corrosive areas too closely.
 2. Use every available practical means to determine these areas.
 3. Use the best protective coatings in bad areas.
 4. Do not use extra wall thickness to prolong pipe-life, since steel is the poorest as well as the most expensive of coating materials.
 5. Prospects for operators planning new lines are bright.
- J. C.

175. Temperatures of Natural-Gas Pipe-lines and Seasonal Variations of Underground Temperatures. W. M. Deaton and E. M. Frost, Jr. *U.S. Bur. Mines. Report of Investigations*, No. 3590, October 1941.—It is pointed out in this report that operating pressure in a pipe-line may be determined easily and is usually available from records

of operation, but that temperature is seldom known. Formation of gas hydrates in natural-gas pipe-lines is, however, dependent on temperature as well as on pressure and the presence of condensed water. Consequently, the Bureau of Mines, in co-operation with the American Gas Association, conducted a pipe-line-temperature survey and studied underground temperatures at depths at which pipe-lines are ordinarily buried, with a view to acquiring information of assistance to engineers in designing and operating natural-gas pipe-lines.

A 22-in. pipe-line extending from a point near Amarillo, Texas, north-westward through Mexico into Colorado was chosen for study, also a 16-in. pipe-line extending southward from Amarillo. In making the survey two types of temperature-measuring equipment were used—recording thermometers and thermocouples—and where data on several temperatures were desired, multiple-pen or a number of single-pen thermometers were used. At the more important installations, recording thermometers fully compensated for ambient temperatures were employed.

Survey of temperature records thus compiled reveals that ground temperatures at depths of 3 ft. or over are not affected materially by the daily fluctuations in temperature, and a lag of 2 or 3 days in temperature response may be expected following an abrupt change in atmospheric temperatures. At a depth of 6 ft. or over, the ground temperature responds only to seasonal temperature variations or to extended periods of abnormal temperatures. Yearly temperature records show that the highest temperatures at depths greater than 3 ft. usually occur in September, whereas the lowest temperatures at the same depths usually occur in March.

Temperature of the pipe-lines and gas therein is essentially the same as the temperature of the ground at a depth corresponding to that of the centre of the pipe, unless there are disturbing influences, such as compressor stations, river crossings, or abrupt changes in depth of the pipe-line.

H. B. M.

See also Abstract No. 179.

Crude Petroleum

176.* Density of Crude Oils Saturated with Natural Gas. M. B. Standing and D. L. Katz. *Petrol. Tech.*, November 1941, A.I.M.M.E. Tech. Pub. No. 1397, 1-7.—The densities of naturally occurring liquid hydrocarbon mixtures are important in many petroleum engineering computations, of which the calculation of the shrinkage of a sub-surface sample of crude oil as the natural gas is evolved is an example. Density data are given for fifteen saturated hydrocarbon liquids in the range 35–250° F. and 1000–8220 lb./in.² The apparent liquid densities of methane and ethane are shown to vary with the density of the system in which they are present. A method is proposed whereby the densities of liquid hydrocarbon mixtures containing both methane and ethane in solution may be computed at elevated temperatures and pressures within the accuracy of usual engineering computations. A method is outlined by means of which the shrinkage of crude oils may be calculated from the gas-oil ratio, gas analysis, and crude gravity.

G. D. H.

177. Analyses of Crude Oils from Some Fields of Oklahoma. II. Southern Oklahoma. E. L. Garton. *U.S. Bur. Mines. Report of Investigations*, No. 3592, October 1941.—This report is a continuation of the study of Oklahoma crude oils being made by the Bureau of Mines Petroleum Experiment Station, Bartlesville, Oklahoma, and refers to that part of the State lying south-west of the Arbuckle Mountains, and embracing the counties of Carter, Cotton, Garvin, Jefferson, Kiowa, and Stephens.

Analyses are given of twenty-seven samples obtained from twenty-one different fields in the area, and the physical and chemical characteristics of these crude oils are briefly discussed.

In addition to the usual analytical data, correlation index figures are included. These, taken in conjunction with all other available data, form the basis of conclusions reached as to possible uses of these oils. At first sight it seemed that the prospect of obtaining good-quality gasoline was uneconomic, owing to the relatively high sulphur content of the oils. However, improved methods of desulphurization may prove technically and economically practicable. Moreover, if the sulphur were removed, it is believed that certain of these gasolines would be found to have exceptionally good anti-knock values.

H. B. M.

Gas

178. Natural Gasoline and Liquefied Petroleum Gases. G. R. Hopkins and A. T. Coumbe. *U.S. Bur. Mines. Minerals Yearbook, Review of 1940, with Final Statistics for 1939*.—In spite of the fact that a new record production of 2,320,458,000 gal. of natural gasoline was established in the United States in 1940, the industry as a whole did not experience a particularly profitable year compared either with 1929, when the previous record was reached, or with 1939. This was due to the fact that the average value of gasoline at the plants fell from 7.1 cents a gallon in 1929 to 4.2 cents in 1939, and then to approximately 3.0 cents in 1940—an abnormally low price for refinery gasoline.

As a result probably of reduction of yield of gasoline in favour of fuel oils, there was a loss in refinery deliveries of natural gasoline during the year 1940, although the proportion used in refinery gasoline showed little alteration. This position, together with the gain in production, resulted in a considerable gain in stocks, as compared with a nett withdrawal in 1939.

The industry was further depressed by a continued fall in exports as a result of the war. Only 71,694,000 gal. were exported in 1940, compared with 172,662,000 gal. in 1939. Most severe cuts in shipments were those to the Netherlands West Indies—from 63,177,000 to 4,362,000 gal.; United Kingdom—from 33,629,000 to 8,361,000 gal.; and Japan—from 7,611,000 to 213,000 gal. The decline was attributable chiefly to the United States ban on exports of materials suitable for aviation fuel. H. B. M.

179. Natural Gas. F. S. Lott and G. R. Hopkins. *U.S. Bur. Mines. Minerals Yearbook, Review of 1940, with Final Statistics for 1939*.—Defence programme demands during 1940 were reflected in an 8% increase in marketed production of natural gas in the United States. Estimated consumption (marketed production less exports) was 2,667,010 million cu. ft., as opposed to 2,473,765 million cu. ft. in 1939. With the exception of petroleum refineries and electric power-plants, all major classes of consumers used more gas in 1940 than ever before. Domestic consumption also increased, largely owing to unusually cold weather in the early part of the year.

Exports to Mexico increased by 61% and totalled 4900 million cu. ft., while natural gas piped to Ontario, Canada (mixed with manufactured gas), amounted to 90 million as compared with 76 million cu. ft. in 1939. No natural gas was imported into the United States during 1940.

2382 gas-wells were completed during the year, representing an 11% increase, and reversing a declining trend which had been evident since 1937. Moreover, greater drilling activity was reported in eleven States, and moderate declines only in five.

The year 1940 was also noteworthy for the construction of the first large-scale equipment for storage of natural gas in liquid form. This involves a process of liquefying the gas by refrigeration to -250° F. and construction of auxiliary equipment to store and regasify the liquid as required. As 1 cu. ft. of liquefied gas is equivalent to approximately 600 cu. ft. in gaseous form, construction of such equipment in fact provides storage for a volume of gas which could not be conserved above ground by any other known method.

Investigations concerning transportation and storage of natural gas in liquefied form reveal certain marked tendencies: dehydration processes are being more widely employed to prevent trouble from gas hydration and moisture in high-pressure lines; more gas companies are utilizing butane and propane to supplement gas supplies; and the importance of natural gas in defence and other industries is growing, both as a source of controlled heat and as a raw material for such commodities as plastics, textile fibres, and explosives. H. B. M.

See also Abstract Nos. 176 and 199.

Cracking

180.* Houdry Process Occupies Important Place in National Defence. Anon. *World Petrol.*, 1941 Ann. Refinery Issue, 12 (11), 52.—An outline is given of the development of the Houdry Process and modern improvements, and of its present status and possi-

bilities for providing fuel for national defence. Sixteen Houdry units are now in operation, having a combined catalytic cracking capacity of over 200,000 bbl., and producing aviation and motor gasolines of 78-81 A.S.T.M. and 87-90 research octane numbers. The problem of revivification of the catalyst has been solved by incorporating perforated tubes in the catalyst bed which conduct air and oil into the bed and reaction products and regeneration gases from all parts of the bed, so that all the catalyst was being used or regenerated at the same time. The addition of fins to the tubes tended to reduce the maximum catalyst temperature during regeneration, further improvement being effected by the use of a separate cooling medium (molten salts) to remove the heat of regeneration. In modern plants the onstream time has been reduced to 10 min., so that the catalyst is used at its peak of activity before being seriously poisoned. The heat of catalyst regeneration is utilized in preheating the oil-feed and in manufacturing high-pressure steam. Compressed air is also used for the regeneration process. Owing to variations in the properties of the clay catalyst, synthetic catalysts have now been evolved, giving higher octane gasolines and rendering possible the direct production of low acid heat aviation gasoline of high quality. A 50% reduction in catalyst deposit is also obtained with certain charge-stocks. It is now possible to recycle the gas-oil through the unit, giving yields of up to 70% of motor gasoline of similar quality to that given by once-through operation.

Details are given of representative yields from Houdry recycle cracking, attention being directed to the high research and road octane values (see *J. Inst. Petrol.*, January 1942, Abs. No. 71). Houdry gasoline from cracking reduced crude has a high iso-paraffin content at the lower end, and a high aromatic and naphthene content at the higher end, the average composition being 36% paraffins, 22% naphthenes, 25% olefins, and 17% aromatics. The gasoline from catalytic cracking of gas-oil contains little olefins (average composition 46% paraffins, 26% naphthenes, 6% olefins, and 22% aromatics), and is of low acid heat and of octane rating equal to or better than the best straight-run gasolines. Data from catalytic cracking of various stocks indicates that the source has little effect on the quality of the aviation gasoline produced. By changing operating conditions gas-make can be increased, producing sufficient iso-butane for alkylation to bring the Houdry gasoline to 100 octane with 3 c.c. of T.E.L.

In the past 5 years more than a million bbl. of Houdry aviation gasoline have been marketed. It is now considered that the presence of a certain amount of aromatics is necessary for best aviation performance under all flying conditions. With sufficient alkylate production, from 33 to 50% more 100 octane gasoline can be produced without requiring the blending of isopentane.

C. L. G.

181. Patents on Cracking. C. H. Greenewalt. U.S.P. 2,263,557, 25.11.41. Appl. 30.12.37. Production of ethylene and aromatic hydrocarbons by cracking a normally liquid hydrocarbon oil vapour derived from petroleum oil. The vapours are passed through a cracking zone heated to a temperature between 650° and 750° C., the passage being at such a rate that 40-60% of the vapours undergo the cracking reaction. Immediately afterwards the temperature is reduced to below 270° C. by quenching with a cold spray of hydrocarbon distillate. Resulting cracked products are separated into a fraction containing hydrogen and methane, a second fraction containing product olefins, a third fraction containing an aromatic distillate, and a fourth fraction comprising essentially ethane and C₃ and C₄ hydrocarbons freed of the desired product. The fourth fraction is cracked by passing it through a second cracking zone operated at a temperature at least 50° higher than that of the first cracking zone, but not exceeding 800° C. A similar cracking operation to that conducted previously is carried out, and cracked quenched products of the second operation combined with those obtained from the first.

G. C. Conolly. U.S.P. 2,264,434, 2.12.41. Appl. 6.12.38. Method of cracking hydrocarbon oils by contacting with an adsorbent siliceous catalyst containing alumina and a fraction of a per cent. of vanadium oxide in a cracking zone. The amount of vanadium oxide is just sufficient to improve the cracking activity of the catalyst.

H. B. M.

Polymerization and Alkylation

182.* **New Thermal Polymerization Unit Installed By Pure Oil.** C. M. Ridgway and P. A. Maschwitz. *Oil Gas J.*, 30.10.41, 40 (25), 30.—At the Pure Oil Co.'s Smiths Bluff Refinery a variety of crudes are processed in a variety of units to produce a wide range of products, and consequently refinery gas fluctuates in quantity and composition. The method to be used to convert the gas into marketable products had therefore to be flexible, and, after investigation, thermal polymerization was adopted. It was considered that increments in gasoline yield obtainable by increasing the recycle ratio above 5 : 1 or the reaction pressure above 1500 lb. per sq. in. would not be economically sound. Further, since under definite conditions of pressure and recycle ratio the yield and character of the gasoline, especially its octane blending value, depend on the completeness of propane and butane extraction, a recovery process has been adopted, and the absorption method was selected as more suitable than refrigeration. The system gives a high propane recovery under conditions of low fresh feed, and about 50% recovery under full-load conditions. The raw gas is also desulphurized, since the polymerization process is efficient in converting H₂S into sulphur compounds boiling in the gasoline range, which decreases the octane number and the lead response of the gasoline. In addition, desulphurization minimizes corrosion and permits the use of cheaper and, in some cases, more desirable construction materials.

The actual process is in three main steps :—

1. Desulphurization,
2. Feed recovery and conversion,
3. Product treating and recovery,

and the description is illustrated with flow diagrams. H₂S is removed by scrubbing with aqueous diethanolamine solution in Girbotol units. After propane and butane absorption, the gas goes to the polymerization heaters, and then to the flash-towers. The desired vapour pressure is obtained by means of a stabilization tower, the overhead from which goes to a Gray vapour-phase unit, where it is clay-treated for gum removal.

Whilst the mechanical equipment is normal, the solutions of some of the problems are considered of interest and are given in some detail; in particular, the types of pumps, heat-exchangers, and condensers in use are described. Utility consumptions—*e.g.*, steam, water, power, etc.—are outlined in tables. Other tables give operating conditions, compositions of gas streams, and types of yields.

The process has increased average summer production of gasoline by 1000 brl. daily, and has substantially reduced the ethyl fluid consumption required for the entire refinery output of gasoline.

J. C.

183. **Patents on Polymerization and Alkylation.** Universal Oil Products Co. E.P. 541,585, 2.12.41. Appl. 19.5.39. Process for the continuous conversion of butylenes contained in normally gaseous hydrocarbon mixtures into polymer olefins boiling within the gasoline boiling range. A current of a liquified hydrocarbon fraction consisting essentially of butanes and *iso*- and normal butenes is preheated, and thereafter contacted with a solid catalyst consisting of a precalcined mixture of phosphoric acid and a siliceous carrier.

E. W. Thiele. U.S.P. 2,263,056, 18.11.41. Appl. 28.1.38. Improved process of converting heavy hydrocarbon oils into gasoline. Gaseous hydrocarbons, including hydrogen and methane, are treated with a polymerization catalyst at a temperature between 250° and 600° F. In this way unsaturated gases are polymerized into gasoline and some polymers heavier than gasoline. Next the polymer gasoline is separated from the heavier polymers and unpolymerized gases, and the unpolymerized gases subjected to a pressure between 500 and 2000 lb. per sq. in. Thereafter the compressed gases are fractionated, and hydrogen and methane removed. The remaining hydrocarbons are heated to a temperature between 900° and 1300° F. without substantial reduction of pressure in a gas pyrolysis zone. In this way the gases are substantially converted into gaseous olefins and liquid hydrocarbons boiling within the gasoline range. The latter are separated, and the gaseous olefins recycled back to the catalytic gas polymerization stage of the process.

H. H. Meier. U.S.P. 2,264,447, 2.12.41. Appl. 13.4.39. Method of recovering isopentane from a hydrocarbon mixture containing it in combination with normal pentane and amylenes. The mixture is reacted with an added isoparaffin other than isopentane in the presence of an alkylation catalyst, and a fraction consisting essentially of isopentane recovered from the alkylation product. H. B. M.

Refining and Refinery Plant

184.* Caustic-Methanol Mercaptan Extraction Process Used. H. W. Field. *Oil Gas J.*, 25.9.41, 40 (20), 40.—It is claimed for this process, developed by the Atlantic Refining Co., that the tetraethyl lead saving caused by elimination of octane rating loss and the increase in lead susceptibility will not only pay for the operating costs, but, in addition, yield a profit. Older methods of sweetening were always a debit to the refiner, since even under the best conditions they improved only the odour of the gasoline. The use of caustic washing units with regeneration was an advance on sweetening alone, substantially improved the lead susceptibility, but only partly removed the mercaptans, necessitating subsequent sweetening. The present process is said to give in a single operation a finished gasoline of sweet odour and negligible mercaptan content. Operating costs are low, since the reagents are cheap, are used only in small quantities, and are almost completely recovered. There is a saving in gasoline, since refining losses are very slight, in ethyl fluid, and hence in lead, chlorine, and bromine, and also in refining chemicals, including those normally used in sweetening. A much higher proportion of sour crudes becomes available, whilst much new plant construction for the purpose of operating new processes to meet mounting octane requirements may be avoided. Other advantages are that the process can handle gasoline of high phenol content, without using special preliminary caustic scrubbers, and that the treated gasoline has an excellent inhibitor response.

The process description is amplified by a simplified flow-diagram and by photographs. The sour gasoline passes into the base of a conventionally operated counter-current extraction column, packed with Raschig rings. Methanol is introduced into the middle of the column and aqueous caustic soda near the top. The treated gasoline disengages at the top of the tower, and the caustic-methanol solution, from the bottom, passes to a stripping column fitted with an internal boiler. From the base of this the regenerated caustic passes back to the extraction column, whilst methanol-water from overhead passes to a separator, where mercaptan is removed. The alcohol is concentrated by fractionation and returned to the extraction column. J. C.

185.* Distillate Production for Direct Utilisation. Anon. *World Petrol.*, 1941, Ann. Refinery Issue, 12 (11), 57.—The economic value of recycling plants for the production of water-white light distillates from gas-wells is discussed, and typical analyses of such distillates are given. Thirty-four recycling plants handling 2,000,000,000 cu. ft. of gas daily are in operation and ten more are planned or under construction. Previous methods of recovery of condensate from gas-wells were restricted to areas where there was a market for the gas or where it could be wasted into the air in relatively small quantities. The present method, which was developed in 1937, consists of delivering the gas at well-head pressure to the plant, separating the condensate at high pressure, compressing the residue gas, and returning it to the well. Apart from surface recovery of condensate, the process reduces the loss of distillate by condensation in the reservoir below the dew-point of those hydrocarbons of which the distillate is composed. On some plants pressure is maintained by cooling exchange with water, gas exchange with cold dry gas, and ammonia refrigeration, at 1200 lb. Circulation of brine in the wet gas-stream prevents hydrate formation and permits temperatures as low as 10° F. The gas thus saved provides a useful reservoir for future requirements. Present condensate production is about 35,000 bbl. per day on Gulf Coast plants and 15,000 bbl. per day in Kern County, California. Typical condensates after stabilization are doctor and corrosion negative, of good colour, odour, and low sulphur content. End-points vary from 385° F. to 606° F., the products distilling 28–74% to 212° F. The residue on distillation is normally kerosine. No chemical treatment of the gasoline is required, and the lead response is high, 1–1.36 c.c. of T.E.L. being required to raise the O.N. from 54.1–58.0 to 72. A further

advantage is the saving in transportation costs, the gasoline being thus available at the field.

C. L. G.

186.* Refiners to Concentrate on 100 Octane. J. C. Morrell and G. Egloff. *World Petrol.*, 1941, Ann. Refinery Issue, 12 (11), 70.—A summary is given with flow-sheets and operating details of the following processes available for the production of 100 octane gasoline or high-octane-rating blending components:—

1. Cold acid polymerization at 65–80° F. of *isobutylene* to *iso-octane*;
2. Hot acid polymerization at 175° F. of mixed *butenes* to *octanes*;
3. *Ipatieff* solid phosphoric acid catalytic polymerization (selective or non-selective) of *olefines*, followed by hydrogenation and a combination dehydrogenation polymerization hydrogenation process in which aviation gasoline is produced from *iso-* and normal *butanes*, by low-pressure catalytic hydrogenation of the polymer;
4. Alkylation in the presence of sulphuric acid in which an *olefin*—*e.g.*, *butene*—is directly added to *isobutane* to form an *isoparaffin*. The volume of *isobutane* available can be increased by isomerization of normal *butane*, using an aluminium chloride catalyst;
5. Hydroforming in which aromatic hydrocarbons are produced in the presence of a catalyst by the hydrogen supplied by recirculating product gas;
6. Catalytic cracking—*e.g.*, of the *Houdry* type using an activated hydro-silicate of aluminium.

Average commercial 100 octane gasoline (army method) consists of 40% of 95 O.N. *iso-octane*, 45% of 74 O.N. aviation straight-run, and 15% of 90 O.N. *isopentane*. whilst 100 octane (motor method) can be blended from 45% *iso-octane*, 40% straight-run, and 15% *isopentane*. The practical advantages of 100 O.N. over 87 O.N. gasoline in airplane performance is shown by comparative data on maximum speed, rate of climb, maximum output, etc.

C. L. G.

187. Patents on Refining and Refinery Plant. J. S. Rowntree. E.P. 541,022, 10.11.41. Appl. 8.5.40. Improvement in apparatus for purifying used oils by treating them with clay and redistilling them at elevated temperatures and under reduced pressure to remove solid particles from the oil, and also diluents such as petrol, etc.

N.V. de Bataafsche Petroleum Maatschappij. E.P. 541,402, 26.11.41. Appl. 22.2.40. Process for refining a hydrocarbon oil which is free from asphalt but contains harmful sulphur in the form of mercaptan and disulphide sulphur. The oil is heated at a temperature between 205° and 370° C. with at least 1 mol. of cuprous oxide, containing less than 10% of cupric oxide, per mol. of mercaptan sulphur in excess of 10%. The process is continued for a sufficient length of time to convert disulphide sulphur and mercaptan sulphur into cuprous sulphide.

L. Dillon and C. E. Swift. U.S.P. 2,261,108, 4.11.41. Appl. 27.4.36. Process for deasphalting oil. The oil is mixed with a diluent to precipitate asphalt, tar, resin, colour bodies, etc., and then subjected to an electric field. Afterwards the precipitated materials are separated from the oil.

F. M. Archibald. U.S.P. 2,261,206, 4.11.41. Appl. 30.12.39. Preparation of mineral-white oils by exhaustively treating petroleum oils of lubricating-oil range with sulphuric acid. The resulting heavy sludge is separated from the oil-layer, which contains finely suspended sludge. Next the oil-layer is blown with air and the sludge material thus formed separated from the oil-layer. The clarified oil is neutralized with an alcoholic alkali solution, the alcoholic layer removed and the oil dried.

C. L. Read. U.S.P. 2,261,287, 4.11.41. Appl. 19.11.38. Improved method of treating relatively heavy petroleum oils having a high carbon content. The oil is countercurrently contacted with a phenol solvent under conditions designed to produce a raffinate phase and a solvent extract phase. The raffinate phase is then removed from the solvent extract phase and the solvent separated therefrom. The

solvent extract phase is cooled to a temperature between 50° and 100° below the temperature in the countercurrent treating tower at the point of withdrawal of the solvent extract phase. About 5–10% of water is added to the cooled solvent extract, and thus 40–60% of the extract oil is precipitated as a cycle oil. The cycle oil is segregated from the extract oil and the solvent removed from the respective phases. The solvent-free cycle oil is then distilled to remove from 40% to 60% of the same as a high-quality, substantially carbon-free product. 40–60% of the cycle oil is removed as a bottoms from the distillation operation and combined with the solvent-free extract oil.

C. F. Holm. U.S.P. 2,261,724, 4.11.41. Appl. 21.4.39. Method of dewaxing hydrocarbon oil to which has been added a diluent which is a preferential solvent for the oil and which has been chilled to precipitate the wax. The mixture is subjected to a multi-stage centrifugal operation, as a result of which substantially all the wax is separated from the oil without recirculating any of the wax and without necessarily recirculating any of the oil.

M. S. Agruss and G. W. Ayers. U.S.P. 2,261,866, 4.11.41. Appl. 2.10.39. Method of treating sulphur-bearing hydrocarbon oil containing paraffinic and non-paraffinic constituents. The oil is contacted with a reagent selected from the group consisting of morpholine and its derivatives. Thereafter the mixture is subjected to conditions which produce liquid phases. These phases are then separated to produce fractions of the oil which are relatively more, or relatively less, paraffinic and have a reduced sulphur content. Finally the reagent is separated from the fractions.

J. W. Orelup. U.S.P. 2,262,466, 11.11.41. Appl. 31.5.38. Stabilization of a petroleum distillate tending to be unstable in the presence of light by the addition of a compound selected from the group consisting of binaphthalene oxide, *isobinaphthalene oxide*, and binaphthalene dioxide.

W. A. Proell. U.S.P. 2,263,102, 18.11.41. Appl. 15.12.39. Method of decolorizing a petroleum oil which involves wetting a decolorizing clay with 40–110% by weight of sulphuric acid of 60–95% strength and percolating the mineral oil through a bed of the acid-wetted clay.

W. A. Schulze. U.S.P. 2,264,220, 25.11.41. Appl. 9.11.38. Method of sweetening mercaptan-containing light petroleum oil by dissolving air in the oil. Thereafter the oil is contacted with a solid sweetening reagent consisting of an absorbent material impregnated with a solution of a copper salt and a chloride. The sweetened oil is then passed to a zone of lower pressure to remove a substantial amount of the oxygen-denuded air, and a controlled portion of the sweetened gasoline recycled to the mercaptan-containing oil prior to the point of air introduction.

N. E. Lemmon and D. W. Bransky. U.S.P. 2,264,904, 2.12.41. Appl. 17.4.39. Improved process of preparing white mineral oil in which a mineral oil distillate is treated with a number of portions of fuming sulphuric acid and the sludge formed is removed prior to the addition of each subsequent portion of acid. The improvement lies in removal of substantially all of the black sludge acids from the acid-treated oil.

H. B. M.

Chemistry and Physics of Petroleum

188. Separation of Hydrocarbons by Azeotropic Distillation. B. J. Mair, A. R. Glasgow, Jr., and F. D. Rossini. *Bur. Stand. J. Res., Wash.*, 1941, 27 (1), 39–63.—In the work on the chemical constitution of petroleum, the separation of pure hydrocarbon compounds is accomplished by the appropriate interlocking of the fractionating processes of distillation, crystallization, extraction, and adsorption. However, it may frequently happen that distillation alone in its several variations may suffice to bring about a substantially complete separation of given hydrocarbons or of groups of isomeric hydrocarbons.

The principles involved in azeotropic distillation are discussed and the three systems illustrated: (a) no azeotropic mixture formed, (b) formation of a maximum boiling mixture, (c) formation of a minimum boiling mixture.

With some exceptions nearly all polar organic molecules of suitable volatility form with hydrocarbons minimum boiling azeotropic mixtures. Such organic molecules include those containing OH, COOH, CN, NH₂, and NO₂ groups.

In terms of the difference in b.pt. between the lower-boiling pure component and the minimum-boiling azeotropic mixture the lowering is greatest for the paraffins, and diminishes in the order naphthenes, mono-olefines, diolefines, and aromatics. Data are given for the azeotropic mixtures of members of these various types of hydrocarbon with ethyl alcohol, and it is shown that when the b.pt. of the hydrocarbon is considerably below that of the polar substance the composition of the azeotropic mixture will be high in the given hydrocarbon. As the b.pt. of the hydrocarbon increases the composition of the azeotropic mixture becomes leaner in hydrocarbon. Data are also given for azeotropic mixtures of benzene with primary, secondary, and tertiary alcohols.

In a general discussion on separation by azeotropic distillation it is recommended that the azeotrope-forming substance should:—

1. Have a b.pt. not more than 30–40° C. away from the boiling range of hydrocarbons to be separated;
2. Be completely soluble in water;
3. Be completely soluble in the hydrocarbon at the distillation temperature;
4. Be readily obtainable in pure state;
5. Be non-reactive with the hydrocarbons or the still material.

It is also necessary that the mixture of hydrocarbons to be separated should have previously been fractionated into a series of substantially constant-boiling fractions. Results are presented of azeotropic distillations, each performed as a single batch distillation in a column with a separating efficiency of 90–100 theoretical plates. These include separation of:—

- (a) Aromatics from naphthenes and paraffins;
- (b) Naphthenes from paraffins;
- (c) Various kinds of aromatics from one another;
- (d) Various kinds of naphthenes from one another.

The benefit of distillation at reduced pressure prior to azeotropic distillation is also considered. In general, the different types of hydrocarbons show significantly different changes in b.pt. with pressure, and a primary separation by this means is suggested. A general scheme for separating hydrocarbons by distillation alone is presented.

Finally, a list is given of hydrocarbons which, it is known, can be separated by distillation alone in its several variations of normal and reduced pressures and distillation with an azeotrope-forming substance.

D. L. S.

189. Heats of Isomerization of the Five Hexanes. E. J. R. Prosen and F. D. Rossini. *Bur. Stand. J. Res., Wash.*, 1941, 27 (3), 289.—Calorimetric measurements have been made which yield values for the differences in the heats of combustion of the five hexanes in the liquid state at 25° C.

These values, which are also the heats of isomerization in the liquid state at 25° C., have been combined with calculated values for the differences in the heats of vaporization to give values for the heats of isomerization in the gaseous state at 25° C. With a knowledge of the heat content of the various isomers in the gaseous state as a function of the temperature, it has been possible to obtain values for the heats of isomerization in the gaseous state at several temperatures from 0° to 1000° K.

In carrying out the determinations, the values of the ratio of the heat of combustion of each isomer of hexane to that of normal hexane have been determined as accurately as possible. The apparatus and method used are described fully, and the procedures for the purification of the five hexanes outlined.

The following values for the heats of isomerization were obtained for the liquid state at 25° C. and calculated to the gaseous state at 298° and 0° K. The figures for the gaseous state at 600° and 1000° K. were calculated, utilizing data calculated by Pitzer for each of the isomers at these temperatures.

	Heat of isomerization for $nC_6H_{14} = iC_6H_{14}$.				
	Liquid.	Gas.			
	25° C.	0° K.	298° K.	600° K.	1000° K.
	kg.-cal./mole. 0	kg.-cal./mole. 0	kg.-cal./mole. 0	kg.-cal./mole. 0	kg.-cal./mole. 0
<i>n</i> -Hexane					
2-Methyl-pentane	-1.30 ± 0.21	-1.04 ± 0.25	-1.68 ± 0.23	-1.40 ± 0.25	-1.18 ± 0.28
3-Methyl-pentane	-0.76 ± 0.19	-0.42 ± 0.23	-1.09 ± 0.21	-0.78 ± 0.23	-0.36 ± 0.26
2:3-Dimethyl-butane	-1.96 ± 0.20	-1.89 ± 0.24	-2.58 ± 0.22	-2.05 ± 0.24	-1.63 ± 0.27
2:2-Dimethyl-butane	-3.49 ± 0.18	-3.60 ± 0.23	-4.44 ± 0.21	-4.16 ± 0.23	-3.44 ± 0.26

D. L. S.

190. Isolation of 1:2:3:4-Tetramethylbenzene, 5:6:7:8-Tetrahydronaphthalene, 1-Methyl-5:6:7:8-Tetrahydronaphthalene, and 2-Methyl-5:6:7:8-Tetrahydronaphthalene from Petroleum. B. J. Mair and A. J. Streiff. *Bur. Stand. J. Res., Wash.*, 1941, **27** (4), 343.—This paper constitutes the second report of the work on hydrocarbons in the kerosine fraction of the petroleum which is being investigated by the Bureau.

The aromatic fraction of the kerosine which distilled 114–144° C. at 56 mm. Hg was distilled at 56.8 mm. Hg, producing a series of constant-boiling fractions. Then by azeotropic distillation and fractional crystallization 1:2:3:4-tetramethylbenzene and 5:6:7:8-tetrahydronaphthalene were isolated from fractions distilling 118–120.5° C. at 56.8 mm. Hg, 2-methyl-5:6:7:8-tetrahydronaphthalene from fraction 137–140° C. at 56.8 mm. Hg, and 1-methyl-5:6:7:8-tetrahydronaphthalene from fractions distilling 141–144° C. at 56.8 mm. Hg.

Further azeotropic distillation and recrystallization were utilized to separate and purify these hydrocarbons.

The purification of the 1:2:3:4-tetramethylbenzene was followed by determinations of the refractive index and freezing point. As, however, little reliable data had been published for the other three hydrocarbons, synthetic samples of these were obtained and purified.

The amounts of impurity in the "best" lots of each of the four hydrocarbons from petroleum and in the three synthetic samples were estimated as follows, in mole fraction:—

Hydrocarbon.	From petroleum.	Synthetic materials.
1:2:3:4-Tetramethylbenzene	0.0006 ± 0.0001	—
5:6:7:8-Tetrahydronaphthalene	0.015 ± 0.002	0.0057 ± 0.0008
1-Methyl-5:6:7:8-tetrahydronaphthalene	0.0029 ± 0.0004	0.0034 ± 0.0005
2-Methyl-5:6:7:8-tetrahydronaphthalene	0.0046 ± 0.0007	0.031 ± 0.004

Values of certain physical properties all extrapolated to zero impurity were determined as follows:—

	1:2:3:4-Tetra-methylbenzene.	5:6:7:8-Tetra-hydro-naphthalene.	1-Methyl-5:6:7:8-tetra-hydro-naphthalene.	2-Methyl-5:6:7:8-tetra-hydro-naphthalene.
B.pt. at 760 mm. ° C.	205.04 ± 0.03	207.57 ± 0.10	234.35 ± 0.05	229.03 ± 0.05
Freezing pt. in air at 1 atmos. ° C.	-6.25 ± 0.01	-35.80 ± 0.02	-22.90 ± 0.03	-39.75 ± 0.03
Density at 25° C. g./ml.	0.9015 ± 0.0001	0.9662 ± 0.0002	0.9682 ± 0.0002	0.9500 ± 0.0002
Refractive Index at 25° C.:				
n_C	1.51362 ± 0.00007	1.53466 ± 0.00015	1.53738 ± 0.00010	1.52920 ± 0.00010
n_D	1.51811 ± 0.00007	1.53919 ± 0.00015	1.54190 ± 0.00010	1.53365 ± 0.00010
n_F	1.52923 ± 0.00007	1.55065 ± 0.00015	1.55325 ± 0.00010	1.54498 ± 0.00010
Specific dispersion at 25° C. $(n_F - n_C)$	0.01732 ± 0.00005	0.01655 ± 0.00010	0.01639 ± 0.00005	0.01662 ± 0.00005
d				

D. L. S.

191. Patents on Chemistry and Physics of Petroleum. M. de Groote and B. H. Keiser. U.S.P. 2,262,357, 11.11.41. Appl. 27.6.40. Process for resolving petroleum emulsions of the water-in-oil type by subjecting them to the action of a demulsifier consisting of a product of the kind derivable by an acylation reaction between: first, a high-molecular-weight monocarboxy-acid; and, second, a cyclic polyamine having at least one of the following radicles: arylamine, hydroaromatic amine, dipiperidyl, piperidylpyridine, piperazine, piperidine, pyridine, cyclic imido ether, cyclic amidine, and cyclic triethylene triamine radicles. The acylated derivative is characterized by the presence of at least one basic amino-nitrogen atom and by freedom from quaternary ammonium radicles.

M. de Groote and B. H. Keiser. U.S.P. 2,262,358, 11.11.41. Appl. 27.6.40. Process for breaking petroleum emulsions of the water-in-oil type by subjecting them to the action of a demulsifier consisting of an acylation derivative of a polyamine. The acylation product is characterized by the presence of (a) at least one high-molecular-weight carboxy-acid radicle, and (b) at least one polybasic carboxy-acid radicle. Additionally it is characterized by the fact that there is at least one polybasic carboxy-acid radicle acting as a linking radicle between the amine residue and a high-molecular-weight carboxy-acid residue.

M. de Groote and B. H. Keiser. U.S.P. 2,262,736, 11.11.41. Appl. 27.6.40. Process for breaking petroleum emulsions of the water-in-oil type which involves subjecting them to the action of a demulsifier consisting of a polyglycol ether produced by reacting an alkylene oxide with an acylation product derived by reaction between a ricinolic acid body and an acylation-reactive amine.

M. de Groote. U.S.P. 2,262,743, 11.11.41. Appl. 12.5.41. Process for breaking petroleum emulsions of the water-in-oil type by subjecting them to the action of a demulsifier consisting of oxyalkylated imidazolines substituted in 2-position by a radicle containing 11-22 carbon atoms and selected from the group consisting of alicyclic hydrocarbon radicles, aliphatic hydrocarbon radicles, and aliphatic hydrocarbon radicles substituted by hydroxyl radicles. H. B. M.

Analysis and Testing

192. Correlation of the Chemical and Electrical Changes Observed during the Oxidation of Mineral Insulating Oil. F. M. Clark. *Proc. 43rd A.M., A.S.T.M.*, 1940, **40**, 1213-1234.—Of the many chemical and electrical tests which have been suggested as a means of examining the deterioration of an oil, no one test has been found sufficient for evaluating the important properties of a good mineral transformer oil—namely, retention of high dielectric strength and resistance to sludge formation, the latter property having proved particularly difficult to evaluate.

An analysis is made of the value in estimating oil deterioration of tests for the following properties: hydrophil, restivity, colour, acidity, potential sludge formation, power factor, and dielectric strength. The limitations of the colour and acidity tests in the determination of oil quality are shown by graphs in which the colour and acidity are plotted against the potential sludge formation value, and these show that, at a certain point, neither the colour nor the acidity changes appreciably, despite a continued increase in the potential sludge formation value. The latter, as determined by a long-time high-pressure oxidation procedure, is itself of value, and bears a linear relation to the power factor, which, however, is affected by the presence of contaminating materials and by uncontrolled factors in commercial transformer operations. The dielectric strength appears to be unaffected by dielectric changes in the oil, as shown by changes in the power factor, and to be unrelated to the colour, acidity, or potential sludge formation value.

The changes in power factor, acidity, and ester value of highly refined mineral oil produced by oxidation in open and sealed glass containers are discussed. J. F. T

Motor Fuels

193.* Research to Meet Motorists' Demand for 100 Octane Fuel. Anon. *World Petrol.*, 1941, Ann. Refinery Issue, **12** (11), 66.—The Bureau of Mines 1941 winter report (RI. 3576) on the trend of gasoline quality is summarized and discussed, and the methods used by refiners to meet the increasing demand for higher octane number are outlined. Increases in the octane ratings of the different winter grades from the

period 1935-36 to the period 1940-41 were as follows: Regular grade 69.6-74.4, premium grade 76.7-80.2, and third grade 57.5-65.6. In general, gasolines contain more high-boiling components, and vapour pressure of premium and third grade has increased. Summer grades tend to be rather higher in octane rating than the winter grades. The great increase in octane rating can no longer be satisfied by leading, and refiners have been compelled to instal equipment for catalytic cracking, polymerizing, isomerization, alkylation, hydro-forming, poly-forming, etc. It appears possible that in a few years the higher-priced automobiles will be designed for 90 or even 100 O.N. gasolines. To obtain 90 O.N. gasolines will require processes such as Houdry catalytic cracking or hydro-forming followed by leading, but above this figure new cracking processes will be required unless *iso*-octane, neo-hexane, or the new triptane can be cheaply produced. Current production of 100 O.N. gasoline in the U.S. is estimated at 40,000 brl. per day, rising to 54,000 brl., and military requirements as 20,000,000 brl. per annum. Fifty new plants are contemplated, the only serious factor in reaching the required production being the time required to instal the equipment. C. L. G.

194. Patents on Motor Fuel. N.V. de Bataafsche Petroleum Maatschappij. E.P. 540,824, 31.10.41. Appl. 8.12.39. Production of higher-boiling hydrocarbons from olefines by continuously feeding a monomeric olefine having at least six carbon atoms in the molecule to a dispersed circulating mixture of an *isoparaffin* or hydrocarbon mixture containing an *isoparaffin* and 85-110% of sulphuric acid. Dispersion is maintained at a temperature between 50° and -20° C. and feeding of the olefine is so regulated that the molar ratio of *isoparaffin* to olefine at the instant of olefine introduction is at least 2 to 1.

Standard Oil Development Co. E.P. 541,067, 12.11.41. Appl. 6.2.40. Improved process for catalytically reforming naphthas by conducting the operation in the presence of 0.1-2% by weight of sulphur calculated on the weight of naphtha treated. The naphthas to which the process may be applied are hydrocarbon oils boiling substantially in the motor-fuel range. These may be derived from any source—*e.g.*, products of distillation, hydrogenation, cracking of coals, tars, mineral oils, shales, peats, lignites, etc., or products of synthetic processes such as the Fischer synthesis.

Anglo-Iranian Oil Co. E.P. 541,106, 13.11.41. Appl. 8.3.40. Production of *isoparaffins* such as *isobutane* or *isopentane*, or mixtures containing such *isoparaffins*. The normal paraffin or a mixture of hydrocarbons containing the normal paraffins in admixture with a hydrogen halide is contacted with a solid catalyst consisting of alumina alone or alumina and an inert substance or substances.

G. H. Freyermuth and A. E. Robertson. U.S.P. 2,263,239, 18.11.41. Appl. 24.8.39. Preparation of a motor fuel consisting substantially of a cracked gasoline which has been almost wholly freed of unsaturated aliphatic hydrocarbons having more than one double bond per molecule, and which has been reduced to a sulphur content of less than 0.1%. The motor fuel contains, in addition, 5-20% of butadiene, 0.5-20 mg. of tricresol per 100 c.c. fuel, and 0.5-6 c.c. of lead tetraethyl per gallon of fuel.

W. E. Forney. U.S.P. 2,263,266, 18.11.41. Appl. 19.2.36. Method of manufacturing a high anti-knock motor fuel by passing a hydrocarbon mixture containing substantial proportions of unsaturated olefine hydrocarbons through a zone in intimate contact with phosphoric acid. A temperature of approximately 375° F. is maintained in the zone, and also a superatmospheric pressure. In this way portions of the hydrocarbons are converted into constituents condensable under conditions obtaining in the zone. Thereafter a liquid oily product is withdrawn from the zone and washed to remove any acidic constituents. The resultant washed oil is blended with a low-octane motor fuel to increase substantially its octane rating.

B. H. Shoemaker and J. R. Wilson. U.S.P. 2,264,894, 2.12.41. Appl. 27.9.39. Preparation of a motor fuel consisting of cracked hydrocarbon distillates of the character of gasoline which normally tend to deteriorate and develop gum, and a small amount of the condensation product formed by reacting a compound selected from the class consisting of aldehydes and ketones free of hydroxy-substituents with an organic primary diamine. The condensation product is added in sufficient quantity to retard deterioration of the cracked hydrocarbon distillates.

C. E. Adams. U.S.P. 2,265,051, 2.12.41. Appl. 27.9.39. Production of a motor fuel consisting of cracked hydrocarbon distillates of the character of gasoline which normally tend to deteriorate, and a small proportion of the condensation product obtained by reacting a compound selected from the group consisting of aldehydes and ketones free of hydroxy-substituents with an organic polyamine having at least three amino-nitrogen atoms, of which at least two are primary. H. B. M.

Gas, Diesel, and Fuel Oils

195. Patents on Gas, Diesel, and Fuel Oils. G. H. Cloud. U.S.P. 2,261,227, 4.11.41. Appl. 21.4.39. Preparation of a fuel for compression-ignition engines of the diesel type. The fuel consists of a hydrocarbon diesel fuel blended with a phosphite ester of a compound selected from the group consisting of hydroxyl alcohols and thio-alcohols. The ester contains three organic groups, each of which has an alkyl group. The hydrocarbon components of the fuel boil below 700° F., and the ester is added in sufficient amount substantially to enhance the ignition quality of the fuel.

R. Rosen. U.S.P. 2,261,290, 4.11.41. Appl. 22.12.38. Preparation of a fuel for compression-ignition engines of the diesel type. The fuel consists of a hydrocarbon diesel fuel blended with a thiophosphate ester containing in the molecule three to four sulphur atoms and three organic groups, each of which has an alkyl group. The hydrocarbon component of the fuel boils below 700° F., and the ester is added in sufficient amount substantially to enhance ignition properties of the fuel.

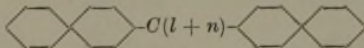
G. H. Cloud. U.S.P. 2,263,234, 18.11.41. Appl. 1.3.40. Manufacture of a high-speed diesel fuel consisting of hydrocarbon diesel fuel blended with a small proportion of alkyl trisulphide to improve ignition qualities of the fuel. H. B. M.

Lubricants and Lubrication

196. Recovery of Used Lubricating Oil. F. Frank. *Chem. Age*, 20.12.41, 45 (1173), 316.—In commenting on a recent paper by J. E. Walker appearing in *The Chemical Age*, the author gives reference to other works on the same subject. The great importance with which the subject is viewed in Germany is stressed, and certain great concerns the policy of which is to regenerate lubricating and transformer oils are named. It is urged that similar work would be beneficial to war-time as well as peace-time Britain. A. H. N.

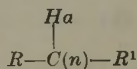
197. Patents on Lubricants and Lubrication. P. S. Allam. E.P. 541,384, 25.11.41. Appl. 29.5.40. The specification relates to oil filters of the kind comprising a mass of porous material through which oil, and more particularly oils used in the lubrication of internal-combustion engines, may be passed to remove suspended particles. It is also claimed that the filter neutralizes undesirable acidity of the oil. The filtering medium has mixed with it a salt or ester of an amino-acid having at least one amino-substituted hydroxyalkyl group.

W. A. Whittier. U.S.P. 2,261,862, 4.11.41. Appl. 18.12.37. Manufacture of a lubricant consisting of a mineral lubricating oil and a compound of the type



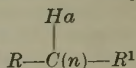
in which the hydrogen in the benzene rings is halogen substituted or unsubstituted, C is an aliphatic radicle having any number (*n*) of carbon atoms in excess of one, and a halogen is united to aliphatic carbon.

W. A. Whittier. U.S.P. 2,261,864, 4.11.41. Appl. 18.12.37. Preparation of an extreme-pressure lubricant consisting of a mineral lubricating oil and a halogenated compound of the type



R and R¹ are benzene nuclei in which one or more hydrogen atoms are substituted by aliphyl radicles, C is a straight aliphatic chain having *n* carbon atoms, where *n* is three or more. Ha represents a halogen united to aliphatic carbon atoms linked between the benzene nuclei.

W. A. Whittier. U.S.P. 2,261,865, 4.11.41. Appl. 2.12.38. Preparation of a lubricant consisting of a mineral lubricating oil and a halogenated compound of the type



R and *R*¹ are benzene nuclei, *C* is a straight aliphatic hydrocarbon chain having any number (*n*) in excess of four carbon atoms, and *Ha* represents a halogen united to one or more carbon atoms linked between the benzene nuclei.

B. H. Lincoln and G. D. Byrkit. U.S.P. 2,262,019, 11.11.41. Appl. 26.5.39. Preparation of a lubricant consisting of a major proportion of a mineral lubricating oil and a minor proportion of a compound containing two oxygen atoms in a heterocyclic ring.

B. H. Lincoln and A. Henriksen. U.S.P. 2,262,773, 18.11.41. Appl. 19.3.37. Preparation of a lubricant consisting of a major proportion of a lubricating oil and a minor proportion of a halogenated aromatic substituted fatty acid.

E. Lieber. U.S.P. 2,262,809, 18.11.41. Appl. 12.10.38. Preparation of a lubricant consisting of a waxy lubricating oil, a condensation product of halogenated "tall" oil, and a cyclic compound.

A. J. Morway and J. C. Zimmer. U.S.P. 2,262,813, 18.11.41. Appl. 13.8.38. Production of lubricant addition agents by heating an unsaturated terpenic compound with a phosphorus halide at a temperature between 250° and 375° F.

M. F. Finike and J. H. Bartlett. U.S.P. 2,263,265, 18.11.41. Appl. 24.2.38. Preparation of an improved lubricating oil of high spreading and penetrating ability. The composition consists of a mineral lubricating oil in which has been dissolved 1-5% of an ester of normal carbonic acid.

J. I. Wasson and W. M. Smith. U.S.P. 2,263,664, 25.11.41. Appl. 25.1.40. Preparation of a lubricating composition consisting of an oil and a small amount of a substance selected from the class of tertiary alkyl aromatic mono-ethers which are characterized by having at least two alkyl groups attached directly to the aromatic nucleus, one of which is a tertiary alkyl group, and the other an alkyl group containing at least two carbon atoms in the molecule.

B. H. Lincoln and G. D. Byrkit. U.S.P. 2,264,319, 2.12.41. Appl. 12.10.39. Preparation of a lubricant consisting of a major proportion of oil of lubricating viscosity and a small proportion of halogenated foots oil.

B. H. Shoemaker, J. W. Gaynor, and L. W. Mixon. U.S.P. 2,264,893, 2.12.41. Appl. 29.6.38. Method of inhibiting oxidation of a highly refined, viscous hydrocarbon oil by adding thereto, in combination, a high sulphur-containing fraction from a crude oil, and an organic compound selected from the class consisting of polyhydric phenols, alkyl polyhydric phenols, hydroxy-condensed poly-ring compounds and alkyl-hydroxy condensed poly-ring compounds.

W. H. Bahlke. U.S.P. 2,264,896, 2.12.41. Appl. 20.6.38. Manufacture of an oxidation resistant viscous hydrocarbon oil consisting of a highly refined viscous hydrocarbon oil normally susceptible to oxidation and small amounts of sulfurized sperm oil, and an organic compound having anti-oxidant properties selected from the class consisting of polyhydric phenols, alkyl polyhydric phenols, naphthols, and alkyl naphthols.

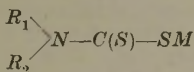
J. M. Musselman. U.S.P. 2,264,999, 2.12.41. Appl. 15.7.39. Preparation of a lubricant consisting of a mineral lubricating oil and a small amount of a salt of ring-containing amine compound selected from the group consisting of dicyclohexylamine, diphenylamine, and hexamethylene tetramine; also a carboxylic acid from the group consisting of fatty acids of at least ten carbon atoms and naphthenic acid.

B. H. Lincoln and W. L. Steiner. U.S.P. 2,265,774, 9.12.41. Appl. 24.2.40. Preparation of a lubricant containing in combination a major proportion of a hydrocarbon oil, $\frac{1}{2}$ -10% by weight of a chlorinated carbon compound and from 0.001 to 2% by weight of a sterol.

J. C. Zimmer and A. J. Morway. U.S.P. 2,265,791, 9.12.41. Appl. 6.4.39. Preparation of an improved lubricating grease for use on ball and roller bearings at high temperatures, and consisting of a major proportion of mineral lubricating oil, sodium soap of a raw rapeseed oil, and an excess of free alkali over that necessary to saponify the rapeseed oil.

R. Rosen. U.S.P. 2,265,819, 9.12.41. Appl. 2.12.39. Preparation of a composition of matter consisting of a hydrocarbon oil boiling above the kerosine boiling range and a small amount of an oil-soluble organo-diphosphine compound. The latter is incorporated in sufficient amount to reduce the formation of varnish-like deposits on hot metal surfaces of internal-combustion engines lubricated by the composition.

G. L. Matheson. U.S.P. 2,265,851, 9.12.41. Appl. 8.5.40. Preparation of a lubricant consisting of a mineral lubricating oil and a dithiocarbamate compound of the formula



R_1 and R_2 are organic groupings of which $R_1 + R_2$ contains at least eight carbon atoms in alkyl groups, and M is a metal selected from the class consisting of alkaline earth metals and metals of the iron sub-group of the periodic system. H. B. M.

Asphalt and Bitumen

198. Asphalt and Related Bitumens. A. H. Redfield. *Minerals Yearbook Review of 1940*. U.S. Bur. Mines, 1941.—As in previous reports, this one takes care of production of native asphalt and bitumens, manufactured or petroleum asphalt, and road oil in the United States, also foreign trade in these commodities during the year 1940. It shows that the total domestic and foreign demand for petroleum asphalt (including Trinidad Lake asphalt and grahamite) was 9% in excess of that of 1939, and exports from the United States were also 30% greater. 458,665 tons of rock asphalt, 31,930 tons of gilsonite, and 70 tons of wurtzilite were produced in 1940. In that year petroleum refineries in the United States produced 8% more asphalt than in 1939. Some of these increases were due to foreign demands, though State highway construction was undoubtedly responsible for greater market activity, and roofing manufacture alone accounted for 24% of the total sales of asphalt during the year under review. In the matter of road oil, refinery returns indicate a slight increase on 1939, the amount being 8.5 million brl., of which only a comparatively small quantity, 56,000 brl., was shipped abroad. H. B. M.

Special Products

199. Helium. R. A. Cattell and C. W. Seibel. *Minerals Yearbook Review of 1940*. U.S. Bur. Mines, 1941.—The total output of helium in 1940 was approximately 156 million cu. ft., or more than 90% of the world's total production. The bulk of this output was obtained from helium-bearing natural gas produced from the U.S. Government's Cliffside gas-field and treated in the Bureau of Mines helium plant near Amarillo, Texas. As the Government owns gas rights over 50,000 acres at Cliffside (which covers the entire geological structure optimum for gas production), the field is operated according to approved engineering practice, and only when supplies of helium at Amarillo are actually required: this is conservation at its best. Hitherto practically all helium produced in the United States was appropriated by the War and Navy Departments, little, if any, being available for industrial and other domestic requirements. The chief plant up to 1929 was at Fort Worth, Texas, but this closed down owing to the natural gas supply feeding it being exhausted. With the advent of Amarillo, helium has become available for non-Government activities, and these include production of helium-oxygen mixtures to mitigate caisson disease, from which divers and caisson workers suffer; the use of helium as a diluent in anaesthetics to prevent fires and explosions; as a diluent for cyclopropane; as an aid to meteorologists in forecasting weather; as a general aid in scientific research. In the services helium is used for inflating lighter-than-air craft, for observational and meteorological balloons, and for barrage balloons as protection against air attack. The price of helium per 1000 cu. ft. in the year under review ranged from \$8.4 for Government purposes to \$13.1 for industrial, medical, and general scientific use. H. B. M.

200.* 62 Million Gallons of Toluene Yearly for National Defence. O. W. Willcox. *World. Petrol.*, 1941, Ann. Refinery Issue, 12 (11), 57.—The 1939 production of toluene in the United States from coal distillation amounted to about 20,000,000 gal., being

used for manufacture of solvents, dyestuffs, etc. It is calculated that in addition 50 to 60 million gal. of toluene per annum will be required for national defence. While toluene occurs in straight-run and cracked gasolines, the yield is generally very small in the former case and separation difficult in the latter, owing to the presence of azeotropic mixtures, although the use of selective solvents facilitates recovery. A plant has been constructed at a Houston refinery to produce 2 million gal. of toluene a year by fractional distillation, and this plant is being duplicated. A similar plant of 4 million gal. a year capacity is also being erected at an Illinois refinery. The recently perfected Kellogg hydro-forming process enables a yield of 80% of aromatics (of which 15 to 20% is toluene) to be obtained from heavy naphtha plus hydrogen-rich recycle gas. A hydro-forming unit capable of producing 5 million gal. of toluene a year is in operation at a Texas City refinery, and further plants at Ponca City and a Baytown refinery will produce 2,500,000 gal. and over 10,000,000 gal. toluene, possibly rising to 27,000,000 gal. Other hydro-forming units in operation but not scheduled for toluene could also be used. C. L. G.

201. Patents on Special Products. J. E. Edgar and H. A. Woods. U.S.P. 2,262,926, 18.11.41. Appl. 24.9.40. Preparation of a flushing-oil composition especially suitable for removing sludge and lacquerous deposits from internal-combustion engines. The composition consists of not more than 5% by weight of water, 2-10% by weight of diacetone alcohol, 5-25% by weight of a sodium salt of mahogany sulphonic acid having a p_H not exceeding 7, and the remainder a blend of mineral lubricating oil and a highly aromatic, liquid sulphur dioxide soluble petroleum extract boiling in the kerosine range. The composition has a viscosity of approximately 100 S.S.U. at 100° F. and a flash-point in excess of 150° F. as determined by the A.S.T.M. closed-cup method.

C. F. Reed. U.S.P. 2,263,312, 18.11.41. Appl. 30.6.38. Reaction of a highly paraffinic hydrocarbon fraction, essentially free from aromatic and unsaturated constituents, with a gaseous mixture of sulphur dioxide and chlorine. The invention also relates to the production of organic compounds containing sulphur, chlorine, and oxygen by bringing paraffinic hydrocarbons in the liquid state into contact with sulphur dioxide and chlorine while irradiating with short-waved light.

J. W. Orelup. U.S.P. 2,265,189, 9.12.41. Appl. 17.2.40. Preparation of a composition of matter consisting of a combination of diphenyl with a dyestuff and designed for use as a colouring agent for petroleum products.

E. W. Carlson. U.S.P. 2,265,799, 9.12.41. Appl. 16.4.40. Preparation of an oil emulsion consisting of a mineral oil, water, an emulsifying agent, and a foam suppressing salt selected from the class of salts produced by reacting an alkali metal hydroxide with an amphoteric oxide. H. B. M.

Detonation and Engines

202. Radioactive Spark Plug. Anon. *Chem. Tr. J.*, 21.11.41, 109 (2844), 256.—U.S.P. 2,254,169 granted to J. H. Dillon features a plating or alloy of a radioactive metal such as polonium on one or both electrodes, or the electrodes may be made from a nickel and polonium alloy. It is claimed that a spark will readily be generated by such a plug even when the battery is low. Tested at -15°, 30% fewer revolutions were required to start the motor as compared with other plugs.

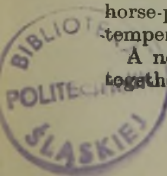
It is claimed that the longer the radioactive plug is used the more efficient it becomes. D. L. S.

203.* Correcting Engine-Test Data by Means of a Nomograph. R. O. Kinsey and E. E. Batzell. *Oil Gas J.*, 30.10.41, 40 (25), 40.—The A.P.I. standard rating test form for internal-combustion engines requires that horse-power values observed on test be corrected to conditions of 60° F. and sea-level altitude by use of the formula

$$H_s = H_o \times \frac{29.92}{p} \times \sqrt{\frac{t + 460}{520}}$$

where H_s = brake horse-power under standard conditions, H_o = observed brake horse-power, p = observed barometric pressure in inches of mercury, and t = observed temperature in degrees F.

A nomograph is presented, by means of which this calculation may be avoided, together with a detailed explanation of the method used in its construction. J. C.



INSTITUTE NOTES.

FEBRUARY, 1942.

FORTHCOMING MEETINGS

Friday, 1st May. Annual General Meeting at 12 noon.

Institute Luncheon at 1.15 p.m. at the Connaught Rooms, London, W.C. 2.

The Council is making arrangements for a series of monthly meetings of the Institute to be held in London during May to September.

NOMINATION AS PRESIDENT.

Mr. CHRISTOPHER DALLEY, M.I.E.E., Vice-President, has been nominated by the Council as President of the Institute for the year 1942-43.

HONOURS.

H.M. The King has conferred the award of the Knight Grand Cross of the Order of the Bath upon Sir FRANK E. SMITH (Fellow) for his distinguished services to aircraft production and supply.

NEW MEMBERS.

The following elections have been made by the Council in accordance with the By-Laws, Sect. IV, para. 7.

Elections are subject to confirmation in accordance with the By-Laws, Sect. IV, paras. 9 and 10.

As Students.

ASHFORTH, George Kenneth.

FOSTER, Douglas Vernon.

BOESE, Alan Charles.

GARRETT, Philip Arthur.

CLAYTON, Peter Brierley.

HICKS, Alexander Edward.

DOD, Geoffrey Francis.

LINDNER, James Neville Donovan.

DRYER, Stanley Raymond Collins.

WALL, Thomas Gulliver.

WINWARD, Anthony.

All the above are students at the Department of Oil Engineering and Refining, The University of Birmingham.

CANDIDATES FOR ADMISSION.

The following have applied for admission to the Institute or transfer to another grade of membership.

The names of the candidate's proposer and seconder are given in parentheses.

- BURROUGHS, Leland Clare, B.Sc., Technologist, Shell Oil Co., New York
(*R. I. Lewis ; Dr. R. Stern.*)
- HALL, Reginald Harold, B.Sc., Chemist, Petroleum Board. (*C. E. Burnett ; J. E. Haslam.*)
- HOBBS, John Francis, B.Sc., Engineer, Anglo-Iranian Oil Co. (*D. Comins ; C. A. P. Southwell.*)
- JOHNSON, Joseph James, Draughtsman, Petroleum Board. (*J. A. Oriel ; C. G. Williams.*)
- JONES, Edward Lewis, Lt. R.C.E., B.Eng., Chemical Engineer, Calgary, Canada.
- OLDFIELD, Arthur Edward, Police Officer, Birmingham, (*T. G. Hunter ; J. F. F. McQueen.*)
- PATERSON, Leonard Andrew, Director, Morris & Co., Shrewsbury. (*C. E. Burnett.*)
- PROCTOR, Wilfred Ernest, Lubricating Oil Supervisor, Petroleum Board
(*R. G. Stickland ; A. Moon.*)
- SCOTT, Roland, A.M.Inst.Chem.E., Chemical Engineer, Midland Tar Distillers Ltd., Oldbury. (*T. G. Hunter ; A. W. Nash.*)
- SMITH, William Henry, Lubricating Oil Representative, United Oil Co., Stoke-on-Trent.
- STRAWSON, John William, Engineering Draughtsman, Petroleum Board.
(*J. A. Oriel ; C. G. Williams.*)
- TIPLER, Francis, M.Inst.Mech.E., Engineer, Petroleum Board. (*C. Chilvers ; E. B. Evans.*)
- WESTON, Reginald Alfred, Chemist, Cargo Superintendents (London), Ltd.
(*H. Moore.*)
- WHYTE, Thomas Robert Norman, Superintendent, Petroleum Board.
- WILSON, John Wilfred, B.Sc., Ph.D., Research Chemist, I.C.I., Ltd. (*R. F. Goldstein ; C. E. Wood.*)
- WITARD, Stuart Lancaster, Mechanical Engineer, Le Grand, Sutcliff & Gell, Ltd. (*J. Cuthill, N. Matheson.*)

Applications for Transfer.

- FISCHER, Raoul Konrad (Member). (*G. H. Coxon ; C. W. Wood.*)
- LAND, Edwin Jacob (Associate Member). (*B. S. Brailey ; R. A. Eldridge.*)
- MATHESON, Niels (Member). (*C. Dalley ; R. R. Tweed.*)

ARTHUR W. EASTLAKE,
Honorary Secretary.

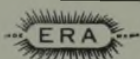
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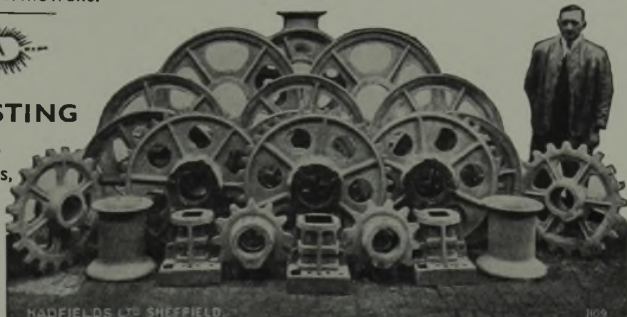
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


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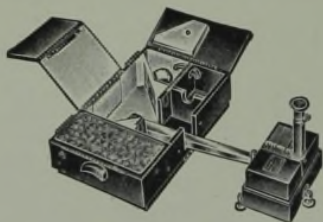
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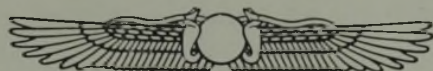
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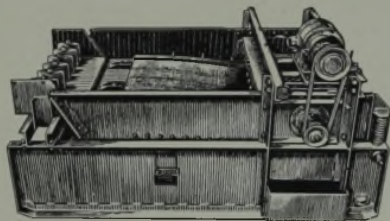
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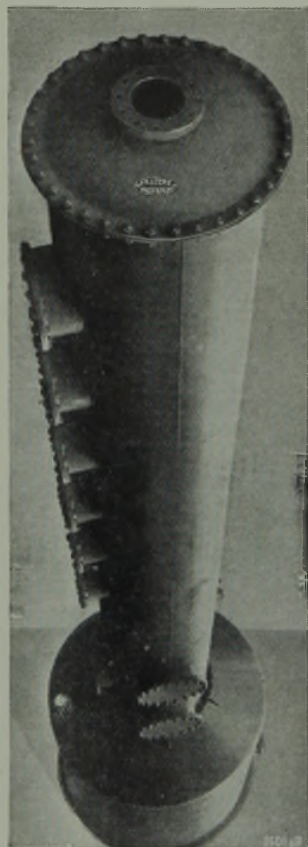
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We are glad to send this report on our "Cardwell" Model S twin-engine draw works.

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

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

In checking the round trip time, the following results were obtained: at 7,006 feet, we had 45 stands of 4-1/2" and 55 stands of 2-1/2" drill pipe in the hole. We pulled a stand every 2 minutes and 20 seconds in low gear; 2 minutes in second gear; 1 minute and 20 seconds in third; 1 minute and 15 seconds in fourth. Coming out at 7,006 feet we pulled 25 stands in second gear; 21 in third; 22 in fourth and 22 in fifth. We cannot give you the exact time as we had to stop at intervals to change tongs, etc., but as near as we could figure, it took 2 hours and 20 minutes to pull out from bottom, 7,006 feet.

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

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Yours very truly,
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E. A. Bender

EAB:BB

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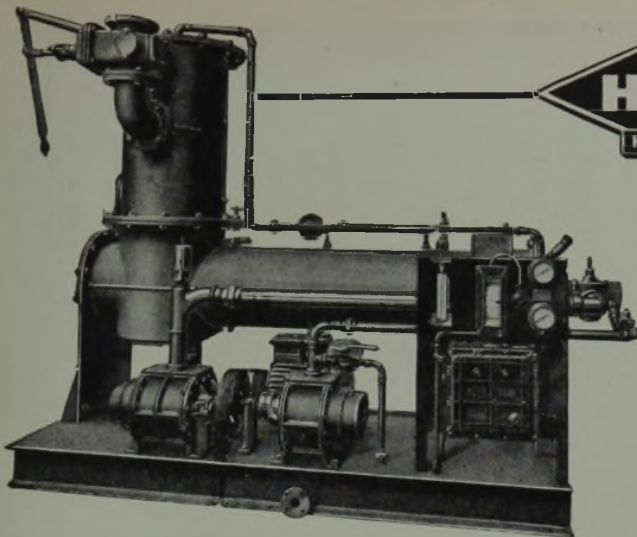
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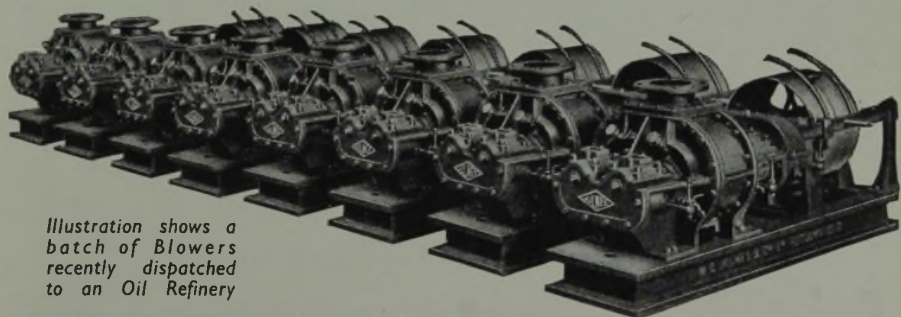


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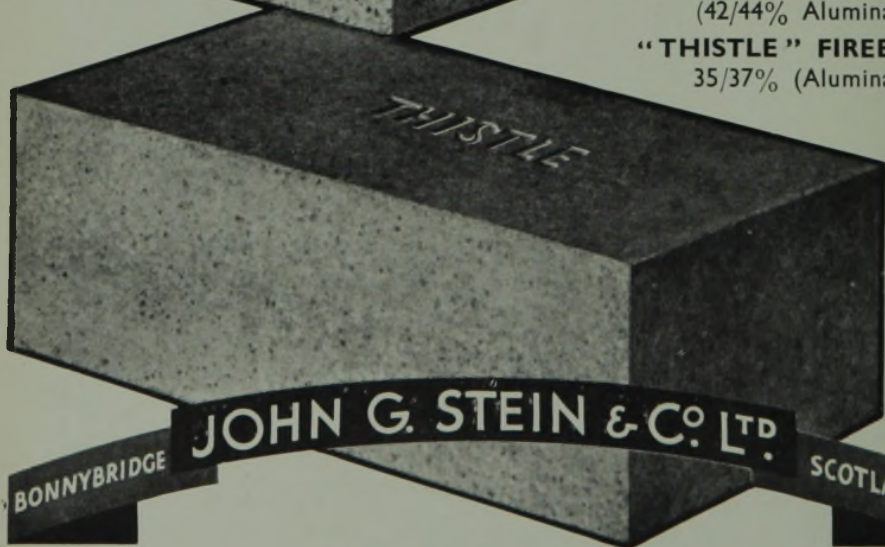
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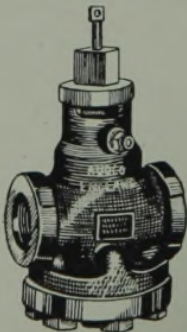
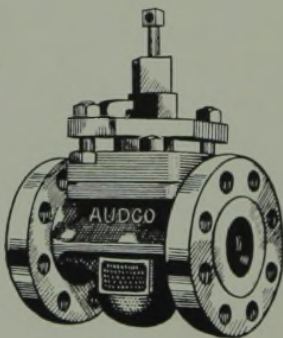
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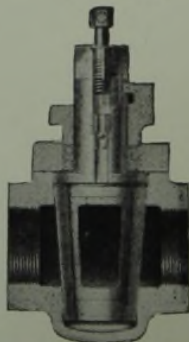




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