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FRACTIONAL DISTILLATION ON BINARY MIXTURES. NUMBER OF THEORETICAL PLATES AND TRANSFER UNITS.*

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Summary.

For binary mixtures with constant relative volatility, the number of transfer units can be calculated in a form which readily permits of comparison with the number of theoretical plates required for the same separation. The computation can in both cases be greatly facilitated by using a simple graphical method. Any separation with finite reflux can be exactly converted into an equivalent separation with total reflux by using a modified relative volatility and modified compositions.

It is useful to be able to make a ready comparison of the number of theoretical plates and of transfer units required for a given separation by fractional distillation. For binary mixtures, in which the components follow Raoult's Law and the relative volatility may be assumed constant, a number of analytical methods of calculation are available. For the particular case of total reflux, Chilton and Colburn [1] have derived an equation giving the number of transfer units, while Fenske [2] and Underwood [3] have given equations for the number of theoretical plates. For finite reflux, Colburn [4] has given equations for the number of transfer units, and Smoker [5] for the number of theoretical plates. Dodge and Huffman [6] and Hausen [7] have calculated the number of theoretical plates required, assuming a differential change in composition from plate to plate, and consequently their equations actually give the number of transfer units. For the general case of finite reflux, these various equations do not readily permit of comparison between the number of theoretical plates and the number of transfer units, and involve somewhat laborious computations. By making use of the transformation of co-ordinates used by Smoker [5] in deriving his equation for the number of theoretical plates, somewhat similar and readily comparable equations can be derived for the number of transfer units. By means of a simple graphical construction the work of computation in both cases can be greatly simplified. Also, any case of finite reflux can, by a further transformation, be reduced to an equivalent separation with total reflux.

The method used by Smoker [5] for calculating the number of theoretical plates is illustrated in Fig. 1. Referring to axes OX and OY, the equilibrium curve is represented by the equation

$$y = \frac{\alpha x}{1 + (\alpha - 1)x} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

The operating line is represented by the equation

$$y = mx + b \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

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The origin of co-ordinates is now transferred to O', where the operating line and the equilibrium curve intersect. If the co-ordinates of the point of intersection, referred to the original axes OX and OY, are $(k_1, mk_1 + b)$, k_1 is given by the equation

$$mk_1 + b = \frac{\alpha k_1}{1 + (\alpha - 1)k_1} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

or

$$m(\alpha - 1)k_1^2 + [m + b(\alpha - 1) - \alpha]k_1 + b = 0 \quad . \quad . \quad (4)$$

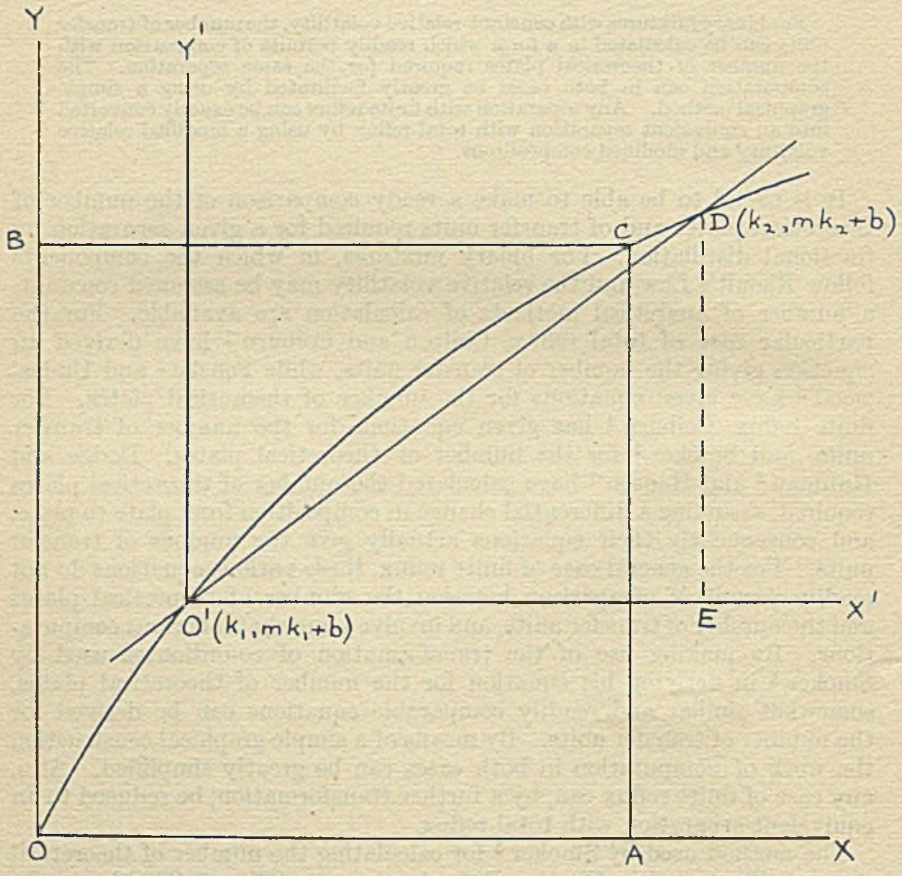

Fig. 1.

Equation (4) has two solutions, representing the two points of intersection of the operating line with the equilibrium curve (continued, if necessary, beyond the normal range of $x = 0$ to $x = 1$). In the following, k_1 is taken as the lower of the two values given by equation (4). For any practical distillation problem, k_1 will lie between 0 and 1 for the operating line of the rectifying section, and will have a negative value for the operating line of the stripping section.

Taking new co-ordinates with the point of intersection O' as origin

$$x' = x - k_1$$
$$y' = y - (mk_1 + b)$$

Substituting in equations (2) and (1), the equation of the operating line becomes

$$y' = mx' \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

and the equation of the equilibrium curve becomes

$$y' + mk_1 + b = \frac{\alpha(x' + k_1)}{1 + (\alpha - 1)(x' + k_1)} \quad . \quad . \quad . \quad (6)$$

Subtracting equation (3) from equation (6) and putting

$$1 + (\alpha - 1)k_1 = c \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

gives

$$y' = \frac{\alpha x'}{c^2 + c(\alpha - 1)x'} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

which is the equation of the equilibrium curve referred to the new origin of co-ordinates, O'.

Using the notation of Colburn,[8] the number of transfer units based on change in vapour concentration is given by

$$N_{OG} = \int_{y_n}^{y_0} \frac{dy}{y^* - y} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

where y^* is the equilibrium value of y corresponding to x and y is the actual value.

Transferring to the new co-ordinates

$$\begin{aligned} y^* - y &= y'^* - (mk_1 + b) - \{y' - (mk_1 + b)\} \\ &= y'^* - y' \end{aligned}$$

From equations (8) and (6),

$$y'^* - y' = \frac{\alpha x'}{c^2 + c(\alpha - 1)x'} - mx' = \frac{x'(\alpha - mc^2) - mc(\alpha - 1)x'^2}{c^2 + c(\alpha - 1)x'}$$

and

$$dy' = m \, . \, dx'$$

Equation (9) then becomes

$$\begin{aligned} N_{OG} &= \int_{x_n'}^{x_0'} \frac{mc\{c + (\alpha - 1)x'\} \, . \, dx'}{x'\{(\alpha - mc^2) - mc(\alpha - 1)x'\}} \\ &= \frac{\alpha}{\alpha - mc^2} \int_{x_n'}^{x_0'} \left\{ \frac{mc^2}{\alpha} \, . \, \frac{dx'}{x'} + \frac{mc(\alpha - 1) \, . \, dx'}{(\alpha - mc^2) - mc(\alpha - 1)x'} \right\} \end{aligned}$$

$$\therefore \quad N_{OG} = \frac{\alpha}{\alpha - mc^2} \left[\frac{mc^2}{\alpha} \, . \, \log_e \frac{x_0'}{x_n'} + \log_e \left\{ \frac{1 - \dfrac{mc(\alpha - 1)}{\alpha - mc^2} \, . \, x_n'}{1 - \dfrac{mc(\alpha - 1)}{\alpha - mc^2} \, . \, x_0'} \right\} \right] \quad . \quad (10)$$

which gives the number of transfer units required to effect a change in composition from x_n' to x_0'.

The equation derived by Smoker [5] for the number of theoretical plates, N_P, required for the same separation is

$$N_P = \frac{1}{\log_e \frac{\alpha}{mc^2}} \left[\log_e \frac{x_0'}{x_n'} + \log_e \left\{ \frac{1 - \frac{mc(\alpha - 1)}{\alpha - mc^2} \cdot x_n'}{1 - \frac{mc(\alpha - 1)}{\alpha - mc^2} \cdot x_0'} \right\} \right] \quad . \quad . \quad (11)$$

For total reflux, the operating line is $y = x$, and intersects the equilibrium curve at the origin O, so that $m = 1$, $k_1 = 0$, $c = 1$, and $x' = x$. Equation (10) then becomes :

$$N_{OG} = \frac{1}{\alpha - 1} \left[\log_e \frac{x_0}{x_n} + \alpha \cdot \log_e \left\{ \frac{1 - x_n}{1 - x_0} \right\} \right] \quad . \quad . \quad . \quad . \quad . \quad (12)$$

i.e., $$N_{OG} = \frac{1}{\alpha - 1} \cdot \log_e \frac{x_0}{x_n} + \log_e \left\{ \frac{1 - x_n}{1 - x_0} \right\} + \frac{1}{\alpha - 1} \cdot \log_e \left\{ \frac{1 - x_n}{1 - x_0} \right\}$$

or $$N_{OG} = \frac{1}{\alpha - 1} \cdot \log_e \left\{ \frac{x_0(1 - x_n)}{x_n(1 - x_0)} \right\} + \log_e \left\{ \frac{1 - x_n}{1 - x_0} \right\} \quad . \quad . \quad . \quad . \quad (13)$$

Equation (12) is the same as the one derived by Dodge and Huffman [6] for total reflux, when calculating the number of theoretical plates on the assumption that there is a differential change in composition from plate to plate. Equation (13), after making the substitution $x = y$, is the same as that given by Chilton and Colburn [1] for the number of transfer units for total reflux.

If now a further transformation of co-ordinates is made by putting

$$x'' = \frac{mc(\alpha - 1)}{\alpha - mc^2} \cdot x' = \frac{mc(\alpha - 1)(x - k_1)}{\alpha - mc^2} \quad . \quad . \quad . \quad (14)$$

then equation (10) becomes :

$$N_{OG} = \frac{\alpha}{\alpha - mc^2} \left[\frac{mc^2}{\alpha} \cdot \log_e \frac{x_0''}{x_n''} + \log_e \left\{ \frac{1 - x_n''}{1 - x_0''} \right\} \right]$$

Now, putting $$\frac{\alpha}{mc^2} = \beta \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (15)$$

$$N_{OG} = \frac{1}{\beta - 1} \left[\log_e \frac{x_0''}{x_n''} + \beta \cdot \log_e \left\{ \frac{1 - x_n''}{1 - x_0''} \right\} \right] \quad . \quad . \quad (16)$$

Equation (16) is of exactly the same form as the total reflux equation (12) with x'' instead of x and β instead of α. In other words, the calculation for finite reflux by equation (16) is identical with the calculation for total reflux if a modified relative volatility and a modified co-ordinate x'' is used, where β and x'' are defined by equations (15) and (14).

The same relation holds good for the calculation of theoretical plates. For total reflux, equation (11) reduces to :

$$N_P = \frac{1}{\log_e \alpha} \cdot \log_e \left\{ \frac{x_0(1 - x_n)}{x_n(1 - x_0)} \right\} \quad . \quad . \quad . \quad . \quad . \quad (17)$$

as given by Fenske [2] and Underwood.[3]

If, in equation (11), substitution is made by means of equations (14) and (15), it becomes :

$$N_P = \frac{1}{\log_e \beta} \cdot \log_e \left\{ \frac{x_0''(1 - x_n'')}{x_n''(1 - x_0'')} \right\} \quad . \quad . \quad . \quad . \quad . \quad (18)$$

Exactly as before, the calculation for finite reflux is identical with a calculation for total reflux when the modified relative volatility β and the modified co-ordinate x'' is used.

The conversion of a finite reflux calculation to a total reflux calculation can also be derived from equations (5) and (8) for the operating line and equilibrium curve respectively. Substituting

$$x' = \frac{(\alpha - mc^2)}{mc(\alpha - 1)} \cdot x'' \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (14)$$

and

$$y' = \frac{(\alpha - mc^2)}{c(\alpha - 1)} \cdot y'' \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (19)$$

equation (5) then becomes :

$$y'' = x'' \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (20)$$

which is the equation of an operating line for total reflux, and equation (8) becomes :

$$y'' = \frac{\dfrac{\alpha}{mc^2} \cdot x''}{1 + \left(\dfrac{\alpha}{mc^2} - 1\right)x''} = \frac{\beta x''}{1 + (\beta - 1)x''} \quad . \quad . \quad . \quad (21)$$

which is the equation of an equilibrium curve with relative volatility β.

There is a simple geometrical interpretation of the transformation from the (x, y) system of co-ordinates to the (x'', y'') system of co-ordinates. In Fig. 1 the operating line (for finite reflux) intersects the equilibrium curve at O' $(k_1, mk_1 + b)$ and D $(k_2, mk_2 + b)$, where k_1 and k_2 are the two roots of equation (4). The area $OACB$ represents the usual range of values $x = 0$ to $x = 1$ and $y = 0$ to $y = 1$. If now the co-ordinates x' and y' (referred to origin O') are each transformed by a multiplying factor so that the lengths of $O'E$ and DE become 1, the slope of the line $O'D$ will become 45°. The equilibrium curve, which is a rectangular hyperbola, will be transformed into another rectangular hyperbola. The area $O'DCO'$ between the operating line and the equilibrium curve will then obviously be of the same type as that between an operating line and equilibrium curve for a case of total reflux. The transformations required to convert the co-ordinates (x', y') to (x'', y'') are given by equations (14) and (19), which can also be demonstrated geometrically. The length $O'E$ is $(k_2 - k_1)$. As k_1 and k_2 are the two roots of equation (4)

$$k_1 + k_2 = \frac{\alpha - b(\alpha - 1) - m}{m(\alpha - 1)}$$

and

$$k_1 k_2 = \frac{b}{m(\alpha - 1)}$$

so that

$$(k_2 - k_1)^2 = \frac{\{\alpha - b(\alpha - 1) - m\}^2}{m^2(\alpha - 1)^2} - \frac{4b}{m(\alpha - 1)} \quad . \quad . \quad (22)$$

From equations (3) and (7)

$$b = \frac{(\alpha - mc)(c - 1)}{c(\alpha - 1)}$$

and, on substituting this value of b, equation (22) gives

$$k_2 - k_1 = \frac{\alpha - mc^2}{mc(\alpha - 1)} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (23)$$

The length $O'E$, which is $(k_2 - k_1)$ in the (x', y') system of co-ordinates, has to become unity in the (x'', y'') system of co-ordinates, giving the relation

$$x'' = \frac{x'}{k_2 - k_1} \quad \text{or} \quad x' = \frac{(\alpha - mc^2)}{mc(\alpha - 1)} . x''$$

which is equation (14).

Similarly, in order that the length DE, which is $m(k_2 - k_1)$ in the (x', y') system of co-ordinates, should become unity in the (x'', y'') system of co-ordinates

$$y'' = \frac{y'}{m(k_2 - k_1)} \quad \text{or} \quad y' = \frac{(\alpha - mc^2)}{c(\alpha - 1)} . y''$$

which is equation (15).

A simple graphical construction can be used to facilitate the numerical computation of transfer units or theoretical plates from equations (16) and (18). The equilibrium curve and the operating line being drawn, the abscissae of the points of intersection give k_1 and k_2. Then

$$x_n'' = \frac{x_n'}{k_2 - k_1} = \frac{x_n - k_1}{k_2 - k_1} \text{ and similarly for } x_0''.$$

$$\beta = \frac{\alpha}{mc^2} \text{ is then readily calculated from } c = 1 + (\alpha - 1)k_1.$$

The further calculation then becomes the same as for a case of total reflux. Having thus determined the factors required for conversion to the total reflux form, the computation of equation (18) can be readily made by using the appropriate nomograms published by Smoker [9] and by Underwood.[3]

Actually it is only necessary to determine k_1 or k_2, as, if one of these is known, the other is readily found from the relation $k_1 k_2 = \frac{b}{m(\alpha - 1)}$. It is convenient to take k_1 as the lower value and k_2 as the higher value, so that $(k_2 - k_1)$ is always positive. For the operating line for the stripping section k_1 will be negative. The value of c in equations (10) and (11) corresponds to k_1. Exactly similar equations can be obtained in which c is replaced by $c' = 1 + (\alpha - 1)k_2$, the origin of the (x', y') co-ordinates

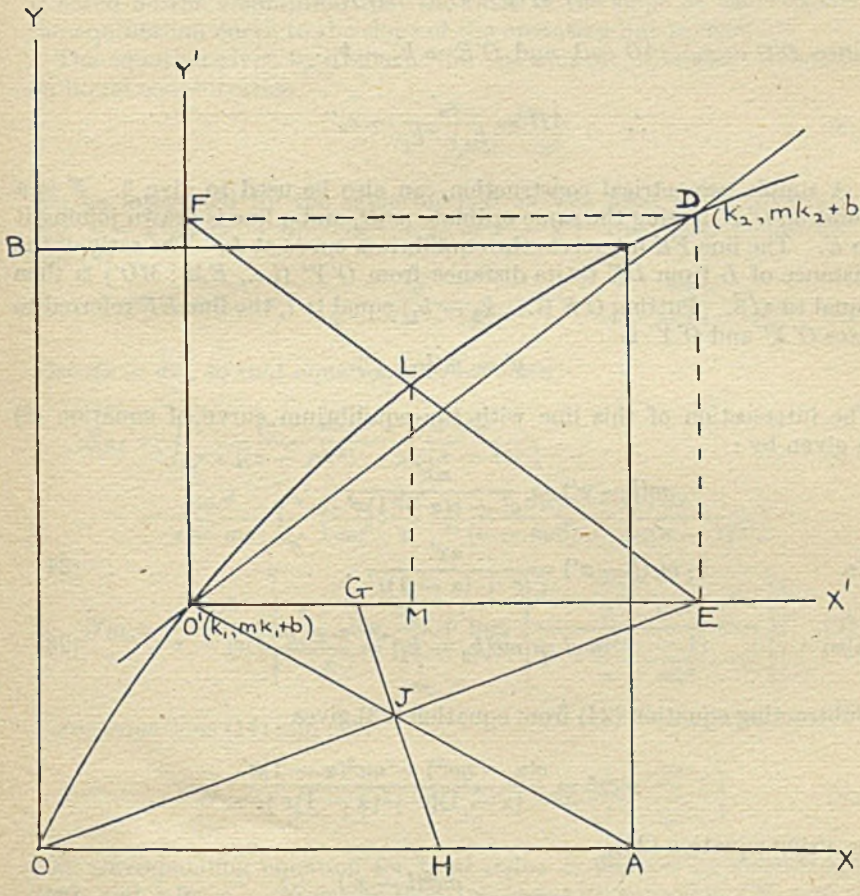

Fig. 2.

then being at the point of intersection D. c and c' are the roots of the equation

$$mc^2 + c\{b(\alpha - 1) - \alpha - m\} + \alpha = 0$$

obtained by substituting for k in equation (4).

Thus $$cc' = \frac{\alpha}{m} \text{ so that } \frac{\alpha}{mc^2} = \frac{mc'^2}{\alpha}$$

and $$\frac{\alpha - mc^2}{mc(\alpha - 1)} = -\frac{\alpha - mc'^2}{mc'(\alpha - 1)}$$

x_n'' can also be obtained purely geometrically as shown in Fig. 2. $O'A$

and OE are drawn to intersect in J. G is any point on $O'E$, and has the abscissa x_n' referred to origin O' or x_n referred to origin O. If a line joining G and J intersects OA at a point H, then $AH = x_n''$.

For
$$\frac{AH}{O'G} = \frac{AJ}{O'J} = \frac{AO}{O'E}$$

Since $O'G = x_n'$, $AO = 1$ and $O'E = k_2 - k_1$,

$$\therefore \qquad AH = \frac{x_n'}{k_2 - k_1} = x_n''$$

A simple geometrical construction can also be used to give β. F is a point on $O'Y'$ having the same ordinate as D, and a line is drawn joining it to E. The line FE intersects the equilibrium curve at L. The ratio of the distance of L from DE to its distance from $O'Y'$ (*i.e.*, $EM : MO'$) is then equal to $\sqrt{\beta}$. Putting $O'E$ (*i.e.*, $k_2 - k_1$) equal to l, the line EF referred to axes $O'X'$ and $O'Y'$ is

$$y' = m(l - x')$$

The intersection of this line with the equilibrium curve of equation (8) is given by:

$$m(l - x') = \frac{\alpha x'}{c^2 + c(\alpha - 1)x'}$$

i.e.
$$mc(l - x') = \frac{\alpha x'}{c + (\alpha - 1)x'} \qquad (24)$$

Also
$$mcl = mc(k_2 - k_1) = \frac{\alpha - mc^2}{\alpha - 1} \qquad (23)$$

Subtracting equation (24) from equation (23) gives

$$mcx' = \frac{c(\alpha - mc^2) - mc^2(\alpha - 1)x'}{(\alpha - 1)\{c + (\alpha - 1)x'\}}$$

or, using equation (23),

$$mcx' = \frac{mc^2(l - x')}{c + (\alpha - 1)x'} \qquad (25)$$

Dividing equation (24) by equation (25),

$$\frac{l - x'}{x'} = \frac{\alpha}{mc^2} \cdot \frac{x'}{l - x'},$$

so that
$$\frac{EM}{MO'} = \frac{l - x'}{x'} = \sqrt{\frac{\alpha}{mc^2}} = \sqrt{\beta}.$$

It may be noted that, if a tangent to the equilibrium curve is drawn at O', the ratio of the slope of this tangent to the slope of the operating line is equal to β. For, differentiating equation (1), the slope of the tangent at O' is equal to $\frac{\alpha}{\{1+(\alpha-1)k_1\}^2}$ or $\frac{\alpha}{c^2}$. This is not a practically convenient method of determining β, on account of the inaccuracy involved in drawing the tangent. The point is, however, of interest, as Colburn [8] has proposed an approximate method for calculating the number of transfer units, which is based on the assumption that the ratio of the slope of the tangent to the equilibrium curve to the slope of the operating line is constant.

The equation given by Colburn [8] for the number of transfer units based on liquid concentration

$$N_{OL} = \int_{x_n}^{x_0} \frac{dx}{x - x^*} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (26)$$

can be integrated by the same method as was used for obtaining N_{OG}. For $x - x^* = (x' + h) - (x'^* + h) = x' - x'^*$ and from equations (5) and (8),

$$x' - x'^* = x' - \frac{c^2y'}{\alpha - c(\alpha - 1)y'} = x' - \frac{mc^2x'}{\alpha - mc(\alpha - 1)x'}$$

Also $dx = dx'$, so that equation (26) becomes:

$$N_{OL} = \int_{x_n'}^{x_0'} \frac{\{\alpha - mc(\alpha - 1)x'\}dx'}{x'\{(\alpha - mc^2) - mc(\alpha - 1)x'\}}$$

$$= \frac{mc^2}{\alpha - mc^2}\int_{x_n'}^{x_0'} \left\{\frac{\alpha}{mc^2}\cdot\frac{dx'}{x'} + \frac{mc(\alpha - 1)\,.\,dx'}{(\alpha - mc^2) - mc(\alpha - 1)x'}\right\}$$

$$\therefore \quad N_{OL} = \frac{mc^2}{\alpha - mc^2}\left[\frac{\alpha}{mc^2}\,.\,\log_e\frac{x_0'}{x_n'} + \log_e\left\{\frac{1 - \frac{mc(\alpha - 1)}{\alpha - mc^2}\,.\,x_n'}{1 - \frac{mc(\alpha - 1)}{\alpha - mc^2}\,.\,x_0'}\right\}\right] \quad (27)$$

Using equations (14) and (15)

$$N_{OL} = \frac{1}{\beta - 1}\left[\beta\,.\,\log_e\frac{x_0''}{x_n''} + \log_e\left\{\frac{1 - x_n''}{1 - x_0''}\right\}\right] \quad . \quad . \quad (28)$$

The corresponding equation for total reflux is derived by substituting α for β and x for x''. Equation (28), together with equations (16) and (18), gives the relation

$$N_{OG} + N_{OL} = N_P\,.\,\frac{\beta + 1}{\beta - 1}\,.\,\log_e \beta \quad . \quad . \quad . \quad . \quad (29)$$

which holds for any separation. For total reflux β is replaced by α.

For two components with low relative volatility, the value of α approaches 1 and the values of c and m are also nearly equal to 1 so that β is also nearly equal to 1. Putting $\beta = 1 + \delta$ where δ is small, then to the first degree of approximation, equations (16), (18) and (29) all reduce to the same form

$$N_{OG} = N_{OL} = N_P = \frac{1}{\delta}\,.\,\log_e\left\{\frac{x_0''(1 - x_n'')}{x_n''(1 - x_0'')}\right\} \quad . \quad . \quad (30)$$

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RECENT DEVELOPMENTS IN WELDING.*

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So great is the pressure of present activities that there is little or no opportunity to study what certain other industries are doing. Nevertheless, it is most helpful to look beyond the bounds of our direct interests, in order to ascertain if the progress that others are making can be adapted to solve the problems with which we are faced individually.

One of the most remarkable developments brought to the forefront by the stimulus of war is that of successful welding. It is to the credit of a comparative handful of far-sighted men that research work in this direction had been intensified to an extent that enabled war-time needs to be met without delay, although many requirements were so novel and exacting that they had not been attempted on a commercial scale before hostilities commenced.

Engineering progress has provided many such achievements, but few things, if any, have been so widespread in their influence on industry as welding. It is the key to the incredibly rapid production of new merchant ships in America. The same methods are applied with equal success to maintenance and repair, not only to hulls and marine engines, but also to plant of all kinds where components require re-conditioning on account of breakage, wear, or corrosion. At the outset it is most desirable to emphasize that no form of welding calls for greater skill or a more varied background of experience than does repair work, since requirements are seldom identical. Even when the method of procedure is agreed between the operator and metallurgical chemist, and the requisite strength assured, it is skill alone by which perfect alignment is preserved. The usual tolerance allowed is 0·001 plus or minus.

Until quite recently only identical materials could be welded together. Then came certain changes in technique which enabled some degree of variation within the ferrous group. Malleable and cast iron were welded to steel and so on, but the limits were somewhat rigidly defined, and it was thought that greater variations in the respective coefficients of expansion offered an insuperable barrier.

Not long ago a process was perfected which made a clean sweep of most preconceived notions on the subject; it resulted in the achieving of a truly welded union with almost any combination of metals. This important fact is not generally realized, and so far only a few industries, among them the electrical trade in particular, have grasped its importance. Quite apart from repair work, for which the system was primarily evolved, its influence on new production will be potent, to say the least. Aluminium can be welded to steel if needs be, but however striking the dissimilarity between the two metals, tests to destruction, by exerting an increasing pull until something must break, always cause the weaker parent metal to fail first whilst the weld invariably holds fast.

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Corrosion is an influence all too well known to those who handle petroleum. It may be that metal spraying, which is an off-shoot of welding, will be used far more widely to combat this trouble in the future. The spraying of zinc in place of the ordinary method of galvanizing is a most useful possibility, particularly in cases of erection work in which the act of riveting has damaged the original zinc coating locally.

The method by which spraying is done is relatively simple. A " gun " is the most complex item of the apparatus. It is rather larger than the hand-piece of a paint spray, and is provided with an automatic feed for wire (or sometimes powder) of the metal it is desired to spray. As the wire or powder is passed through the oxy-acetylene flame it is instantly melted, the molten particles being ejected by a stream of compressed air.

A matt surface can be coated with the same facility as that common to paint. The surprising point about this process is that by the time the particles of metal reach their mark they are relatively cold. This is shown by the ability to coat thin paper without scorching it. Although adhesion is mechanical and not fusive, as in true welding, adherence is extremely good—so good, in fact, that this method is used to build up certain worn components, but scientific welding engineers prefer to apply new material in the more usual form of feed-rods, contending that in this way the grafted and parent metals have a homogeneous unity that is otherwise impossible.

So far as ferrous materials are concerned, gas welding is mainly confined to cast and malleable iron, whilst the electrical method is reserved for steel, although the demarcation is not inflexible. In this connection certain lines of progress are important and should be remembered, because each has opened up new resources, particularly in regard to maintenance and repair. It seems to have escaped general notice that the thickness of the metal that can be handled offers no deterrent to repair. At one time, not so very long ago, a section of metal 2 inches in thickness was almost a borderline case for welding, but nowadays a massive casting having a section of 10 inches in need of repair would not be regarded by the skilled operator as being at all unusual.

To some extent this is linked up with the fading practice of pre-heating before welding is started. The object of this time-wasting practice was to avoid strains being set up owing to sudden local expansion brought about by the heat necessary to accomplish a weld. New methods for controlling the heat-flow have been devised, so that work can be started at once, even to the extent of dealing with the damaged part whilst it is still in position. Obviously accessibility must be reasonably good and subsequent machining unnecessary. To those unfamiliar with this process it may seem impossible to confine the heat strictly to the point of repair, but it is done so effectively that it is possible to touch close up to the seat of fusion without fear of being burned.

It is hardly surprising, in view of the almost infinite variations in modern welding, that a very great deal of it, as applied to repair work, is undertaken by specialists who are willing to work to the closest limits on a guarantee basis.

Most re-conditioning work is needed for one or more of three reasons—corrosion, wear, and breakage. A great deal of work is done in correcting

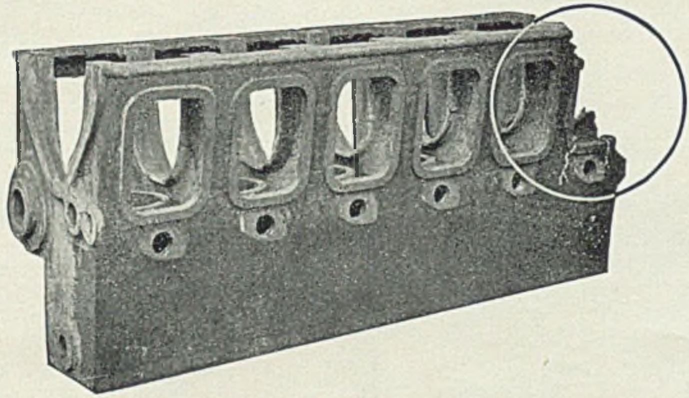

Fig. 1.

COMBINED CYLINDER-BLOCK AND CRANKCASE OF A LARGE DIESEL ENGINE.

Part of the crankcase, at one end, was broken off. The engine belonged to a leading firm of engineers, and they decided immediately to have the damage repaired by welding.

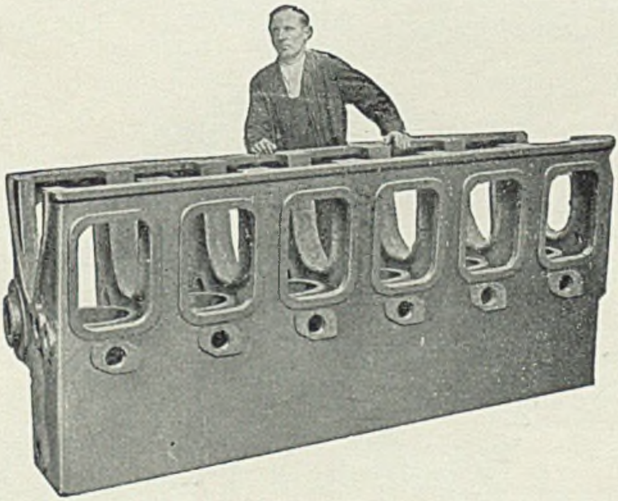

Fig. 2.

CYLINDER-BLOCK AND CRANKCASE SHOWN IN FIG. 1 AFTER IT HAD BEEN RESTORED TO PERFECT CONDITION BY SCIENTIFIC WELDING.

[*To face p.* 158.

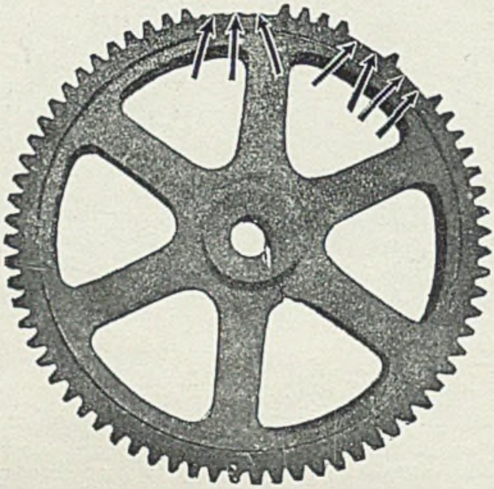

Fig. 3.

A GEAR WHEEL, SIMILAR TO MANY OTHERS USED IN ALL KINDS OF PLANT.
A number of teeth have been broken away.

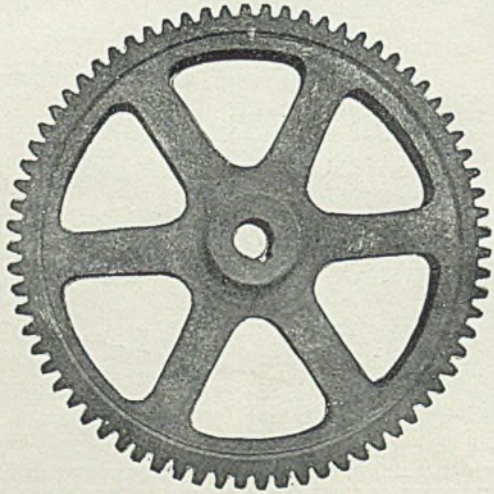

Fig. 4.

THE MISSING TEETH WERE BUILT UP BY SCIENTIFIC WELDING, RE-MACHINED, AND THE WHEEL WAS AS GOOD AS EVER, SAVING THE OWNERS WEEKS OF DELAY AND THE GREATER PART OF THE COST OF A NEW GEAR.

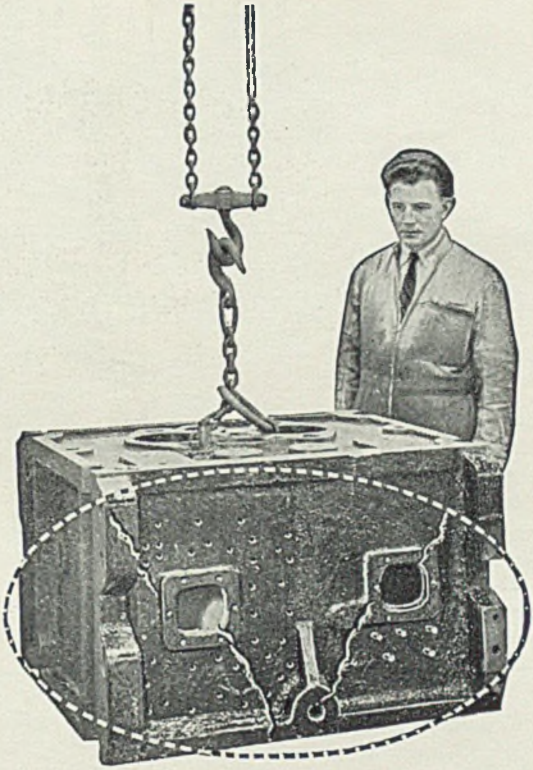

Fig. 5.

ONE OF THE CYLINDER-HEADS OF A LARGE DIESEL ENGINE.

It was cracked on the water-jacket; two other heads were cracked in a similar way. The ship to which they belonged was held up. A temporary repair had already been made by patching—that explains the presence of the numerous holes in the jacket.

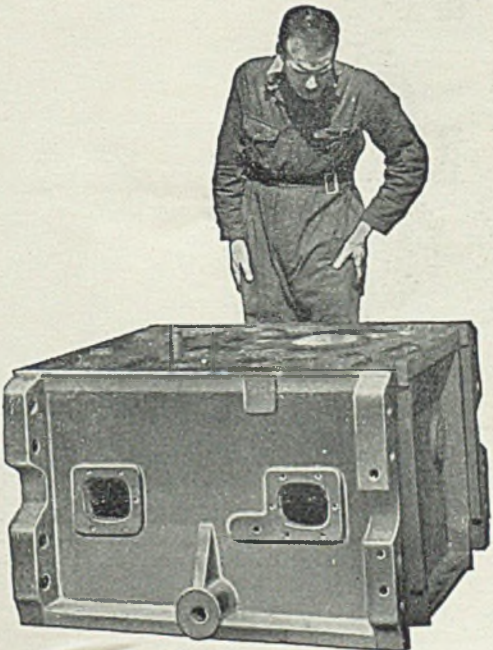

Fig. 6.

THIS IS THE REPAIRED HEAD AFTER ALL THE CRACKS AND HOLES HAD BEEN WELDED.

Unlike a "patch" job, this was a permanent repair, and in a very short time the ship was at sea again. The other heads were repaired in the same way.

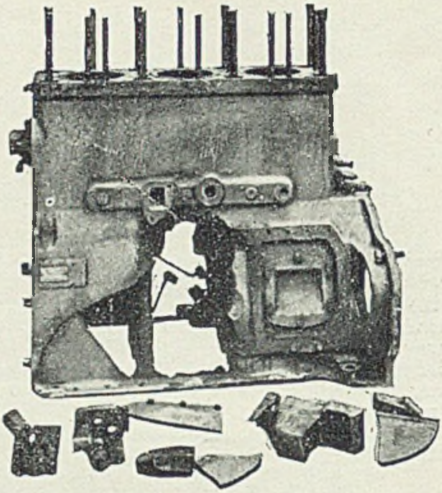

Fig. 7.

THIS ILLUSTRATION SHOWS HOW EXTENSIVE IS THE DAMAGE SUSTAINED BY SOME ENGINE PARTS THAT ARE SENT FOR REPAIR BY SCIENTIFIC WELDING.

It is a three-cylinder block—part of the main engine of a powerful tractor. The whole of the damage to the engine is not shown—the starting engine was also smashed. It will be seen that *both* sides of the crankcase of the main engine are broken out.

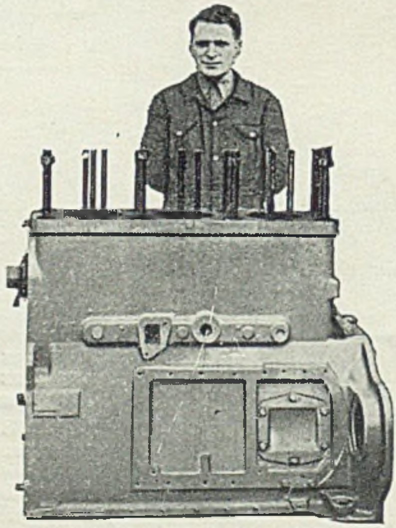

Fig. 8.

HERE IS THE REPAIRED CYLINDER-BLOCK AND CRANKCASE, READY FOR RETURN TO THE OWNERS.

These difficult and extensive repairs were completed within a few days, and apart from the very big saving the owners made on the cost of a new block, they did not lose the use of the tractor during the many weeks they would have had to wait for a replacement.

machining errors and making faulty castings dependable, but such matters are likely to be of lesser interest to readers of this *Journal*.

Few components illustrate the dependability of welding so strikingly as do crankshafts. Fortunately a breakage in this connection is not commonplace, but it does happen from time to time. In these days particularly, prompt replacement is impossible. On the other hand, the reunion of a fractured shaft by scientific welding is no temporary measure, but a permanent and absolutely dependable repair. So much so, in fact, that for years it has been the standard practice of many large transport concerns to have broken shafts welded under guarantee even when replacements were immediately available.

The care taken with work of this kind must be seen to be appreciated fully. Alignment is specially important, but it is the hydrogen " field " process which is largely responsible for the strength secured. Its method of operating is interesting. For a long time the welding of any steel component which had subsequently to receive a high degree of finish was beset with difficulties owing to the almost inevitable pit-marks in the weld metal. These blemishes, whilst not detracting from the strength of the work, could hardly be tolerated on a heavily loaded bearing surface. The reason for them was obvious. Surface marks are due to the affinity of the oxygen in the atmosphere for the molten steel. Far less evident was the cure, although ultimately the complete remedy turned out to be quite simple; for the point of repair was enveloped in hydrogen, and mirror-like surfaces could be obtained at will. At first the supply of hydrogen to cloak the weld was obtained from high-pressure cylinders, but the most favoured method to-day is to use a rod coated with a chemical compound that gives off the required volume of gas directly it is heated in the normal process of repair. This method of welding is so successful that it is freely used to build up worn crank-pins, journals, and other parts. Sometimes oversize diameters are specified, so that after a further long period of duty all that is necessary is precision grinding to restore the shaft to its original limits. This method prevents the need for reducing a worn shaft to below its designed dimensions.

X-ray apparatus of a type specially developed for this work is an important aid towards assuring absolutely reliable results. In the unlikely event of there being a flaw in the weld, this would be revealed and eliminated, however small it might be.

Another point that arises, sometimes in the form of unfounded criticism, is the influence of the weld on heat-treated steel. This is a matter that is always compensated. If the characteristics of the metal are likely to be influenced locally, then restoration is merely a matter of further treatment. A point apt to be overlooked in this connection is the automatic correction that takes place. It is that one layer of electric welding has a valuable normalizing effect on the previous run. This explains why a multi-layer weld has a much finer grain and is far more reliable than heavy single layer weld, which has a coarser crystalline structure. As the final run of welding is not normalized in the manner of the previous runs, an adequate amount of surplus metal is left on the shaft or other component, thus, when finally machined, the weld consists of normalized metal throughout.

So great is the variety of illustrations that can be chosen that it is not easy to select those which will indicate most fully the field of opportunity open to the many branches of the petroleum industry. In the transport of oil from its source to the delivery of derivatives the valuable applications of welding are legion. By this means pipe-lines are made continuous, and whilst damage and loss from leaking joints are avoided, it is no more difficult to remove a length of piping and insert a new one should this step be desirable at any time.

The construction of tanks and pressure containers of all kinds purely by welding methods is well known, and pumping plant is quickly re-conditioned in the same manner. In many examples of corroded parts a welded component has proved superior to a replacement of the original type. The explanation of this is found in the latitude that is possible to the scientific welding engineer in the choice of weld metal. The manufacturer may have found it necessary to compromise in the choice of material, on account of conflicting characteristics, whereas, when the time comes for re-conditioning, the new metal to be welded in position is chosen with a view to combating corrosive influence or abrasion more actively, or to bring about an increase in strength. In this way the new work helps all concerned by supplementing the producers' efforts to reach a more ideal item of equipment. In view of this objective, of which there are countless examples in service, there is no exaggeration in the claim that a welded item is often far better than a new one. At the same time it is much less costly. Rigid comparisons are, of course, impossible, but it is seldom that re-conditioning by welding does not show an overwhelming saving on the price of renewal. Naturally the figure varies, for the welding engineers may be required to carry out several machining operations after the actual welding has been completed. Often the comparison of cost, as it relates to a new part, can be disregarded in the face of a far greater loss of time and output caused by the breakdown of some important item of plant. If it were not for welding, months of delay might ensue, whereas the resources outlined can be put into operation and completed within a remarkably short time. It is surprising how even elaborate repairs which involve the normal processes of welding followed by machining are commonly completed within twenty-four hours.

It is not often realized that there would be enormous maintenance difficulties in regard to foreign-built vessels now sailing with the Allied Fleet were it not for the benefits of welding. With so many ships cut off from the parent yards and factories, aid in refitting and furnishing replacements must come from other sources. Yet these vessels, many of them tankers, are maintained splendidly.

Steam-engine cylinders are welded from time to time. Sometimes fractures are so inaccessible that portions of sound metal are cut away temporarily so that a perfect weld can be made; then the section removed is replaced without leaving a visible trace of what has been done.

Not long ago an important undertaking handling petroleum urgently required a large compressor. Unfortunately, in course of delivery the cast base, weighing 8 tons, was damaged, a large portion being broken away at one corner. To have replaced the casting, involving elaborate machining operations, would have taken several months. Actually the original casting was made ready for installation within five days by skilful and unremitted welding.

This job was not exceptional in the demands it made upon the welding engineers, but the results were most important, as they united a broken link in a chain of urgent production.

Sometimes an oil-storage tank fails without warning and leakage occurs along a riveted seam. Trouble of this kind arose not long ago when a large container developed this type of fault. The tank, which had been in use only a few years, is used to hold the fuel needed for the central heating system of a large block of flats. Owing to surrounding brick-work it was almost impossible to move such a large container, and as the trouble developed in mid-winter, no time could be lost. It was decided to weld the faulty seam, thus making a permanent seal. There was just room to reach the seat of the trouble, but the restricted quarters, together with fumes from the tank, now temporarily drained, made it impossible for welding operators to work for more than ten minutes consecutively. The welding was therefore carried on in relays, but a life-line was attached to each man, who was under constant observation. The repair was completed in a matter of hours, and the tank refilled. It has not given the slightest trouble since it was welded.

Bearing in mind present-day road transport problems, there is little or no excuse for the immobilizing of vehicles, on account of replacement parts being in short supply. In almost every case components which are thoughtlessly thrown on a scrap-heap impose further strain on supplies of raw material. These items can not only be restored to a condition that is equal to a new part, but the job can be done quickly—often within twenty-four hours. Gear wheels from which teeth are broken and lost can be made whole and dependable again, whilst the problem of an ugly smash is straightened out in a manner that is incredible to all those who have no experience of the resources of modern welding. Cylinder-blocks broken into many fragments, by reason of road accident or frost fracture, are pieced together invisibly and with perfect alignment, whilst worn king-pins and other parts are restored to usefulness and dependability again. This is an aspect of welding which can only be touched briefly upon. It should be emphasized, however, that deeply undercut valve-seats can be built up to their original level again with heat-resisting metal that is also capable of withstanding valve hammer far better than cast iron. The increased efficiency resulting from this work is reflected in reduced fuel consumption, amounting to so much as 20 per cent. in many instances. Building up worn splines and keyways is comparatively simple to the expert.

Most industries must undertake a great deal of experimental work, and this is particularly true of those who handle petroleum and its derivatives. From time to time special plant is required for which there is no general demand, with the result that the cost is high. In regard to this matter welding can help a great deal, since it avoids the use of castings, and, in addition, weight is reduced and, still more important, the need for pattern-making is eliminated. It is not suggested that the foundry is likely to be made unnecessary by welding. This is not the case where repetition work is concerned, but when one or even two or three duplicate pieces of machinery are required welding is less costly.

The same methods can be applied even to gear-cutting. This can be done with such accuracy in flame-cutting machines that gears, pinions, or sprockets formed in this way can be put straight into service and without the necessity of any additional finishing. One rather elaborate machine recently put into commission incorporates rather more than fifty gear-wheels and sprockets, each one of which has been flame cut from a steel blank.

In the examples quoted there is considerable material for thought and practical application. There is, however, a pitfall. The craftsman always creates an impression of simplicity in his work and the welding repair worker is no exception to this rule. Ambitious work should therefore never be attempted without the essential backing of experience and the advice of the specialist.

Welding goes a very long way towards solving the difficulties and easing the responsibilities of maintenance engineers. At the same time it can offer alternatives of the greatest value in new construction, and provide a solution to complex metallurgical problems which hinder new developments.

ABSTRACTS.

AUTHOR INDEX.

The numbers refer to the Abstract Number.

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

Geology and Development.

504.* Stratigraphical Analysis and Environmental Reconstruction. T. G. Payne. *Bull. Amer. Ass. Petrol. Geol.*, November 1942, **26** (11), 1697–1770.—In stratigraphy the naming of formations, correlation charts, and faunal lists are not enough, but must be supplemented by palæoecological study of sedimentary types and fossils. A scheme for rapid analysis of data bearing on mode and environment of origin is outlined with special reference to the crinoidal phase of the Grand Tower limestone (Middle Devonian) of Ozora, Ste. Genevieve County, Missouri.

Field description, thin sections, polished sections, binocular study of fragments, chemical tests, sieve and pipette methods, all contribute to petrographical analysis. Genetic classification then distinguishes between autochthonous and allochthonous components. The former may be either syngenetic or epigenetic, according as they are formed contemporaneously with or after the rest of the rock. Account must also be taken of the manner in which each component has been formed. Attributes of the component fragments to be noted are: composition; internal structure; size; percentage of total volume; shape and degree of rounding; surface texture—whether rough, smooth, frosted, etched, striated, pitted; relative position of components; random, parallel, or imbricate orientation of fragments.

Mass properties to be considered are colour, chemical composition in bulk, acid solubility, interstitial cementation, mass texture, packing, porosity, permeability. Plasticity, hygroscopicity, fusibility, and specific gravity are of less stratigraphical importance. Mass textures are either fragmental or crystalline. In the latter case, the effects of chemical precipitation, secondary recrystallization, and secondary crystalline growth must be distinguished. For instance, orthoquartzite, due to growth of secondary quartz, is to be discriminated from metamorphic, recrystallized paraquartzite.

Syngenetic sedimentary structures to be looked for include cross-bedding and other types of stratification, bioherms and biostromes, markings by rain-drops, ice-crystals, wave-ripples, swashes, and animal tracks, tensional mud-cracks, compressional ice-rucking, slumps. Epigenetic structures are solutional, like stylolites; compressional, like folds, faults, cone-in-cone or tensional, like faults and joints.

Palæontological analysis, for which Simpson and Roe's *Quantitative Zoology* (1939) may serve as an introduction, begins by distinguishing life assemblages and death assemblages. In different sediments, prevalent genera and types of gross external morphology (*cf.* Lamont, *Ann. Mag. Nat. Hist.*, Ser. 10, vol. xiv, 1934) should be recorded. The size of the organisms is also useful as an index to factors of salinity, temperature, turbidity, dissolved gases, *e.g.* abundance or poverty of oxygen, in the environment. Dwarf faunas may be due to stunting or to weeding out of large species by selection (*cf.* Shimer, *Amer. Nat.*, vol. xlii, 1908). Presence of broken material, space distribution, and estimates of the numbers of different species in faunules should also be studied, with the *caveat* that short-lived animals, or those with an annual moult, may produce a larger number of preservable hard parts, than their contemporaries.

Payne also analyses the environmental factors in the provision, transport, and deposition of sedimentary materials. He propounds rules such as that " the sea will tend to produce, under given environmental conditions, sediments of similar textural character regardless of differences as to source and type of material being supplied," and that " under given environmental conditions the sea will tend to produce organic assemblages of similar nature regardless of differences as to species and genera available." It is desirable to know the character, slope, and degree of compaction of the substratum, also the direction of movement of the sediment and of the medium. Bottom currents can be estimated from the range of size of particles by means of Hjulstrom's size-velocity curves for erosion and deposition (*Recent Marine Sediments*, A.A.P.G., 1939, p. 13). Conjectures should be attempted concerning depth of water, light intensity, and geographical position. Limiting data can be obtained from the " ecologic valence " of different fossils. Thus, the valence of a species of coral might be: salinity, rather high; mean temperature, 60–85° F.; current velocity under 100 cm./second; dissolved oxygen over 4·0 ml./L; light intensity, above some measurable value.

The chemical changes undergone after deposition, in the zones of weathering, diagenesis, and anamorphism, fall also to be considered, together with the history of the sediment during diastrophic movements. A. L.

505.* Two More Ordovician Well-core Graptolites, Crane County, Texas. C. E. Decker. *Bull. Amer. Ass. Petrol. Geol.*, November 1942, **26** (11), 1771–1775. From McKnight No. 4, Crane County, at 6458 ft. and 6479 ft. respectively *Callograptus tenuissimus* Decker sp. nov. and *Didymograptus* cf. *bartrumi* Benson and Keble are described. The former would probably fall in the sub-zone (a) of the *D. extensus* zone, as Elles indicates that dendroid graptolites are most abundant in that sub-zone which is about the middle of the Skiddaw slates. The nearest counterpart is *C. tenuis* from the Upper Arenig. *D.* cf. *bartrumi* compares with *D. bartrumi* which in the Lower Ordovician of New Zealand is associated with *Tetragraptus fruticosus*. It also approaches *D. nitidus*. A. L.

506.* Stratigraphy of North Dakota. N. Ballard. *Bull. Amer. Ass. Petrol. Geol.*, November 1942, **26** (11), 1776.—In the Carter test and Prairie Oil and Gas Company's Armstrong No. 1 (= Steele of Dr. Kline), beds with red and green sandy shales and a chert conglomerate, ascribed by Kline (*Bull. A.A.P.G.*, March 1942) to the Devonian, are probably partly Jurassic and Triassic. Permian or Pennsylvanian may also be represented. A. L.

507.* Development and Use of Engineering Geology. (With a Foreword by Paul Weaver and others). F. A. Nickell. *Bull. Amer. Ass. Petrol. Geol.*, December 1942, **26** (12), 1795–1826.—The hade and direction of fault planes often depend on the nature of the rock formation. Faulted areas usually contain a vast number of individual faults. A structural contour map with unbroken lines, is, therefore, at best an idealization.

Studies of the sites of the Boulder, Grand Coulee, Shasta, Friant, and Marshall Ford dams in North America are used to illustrate such problems. The factors taken into account are :

(1) Local geology, including seismicity.
(2) Character of formations at site.
(3) Thickness of cover or overburden.
(4) Physical stability of rocks.
(5) Possible seepage and detailed features requiring special treatment.
(6) Available construction materials.

Trial holes, seismographic methods—seismic velocity is related to elasticity—migration of tracing fluid between holes, determination of compression and shear strengths, and petrographical and sieve analyses are all of significance.

Boulder Dam, Nevada and Arizona.—The dam of arch-gravity plan is built on the Dam breccia, a Tertiary tuff with monzonitic porphyry fragments, the minimum ultimate strength of which is 9260 lb./sq. in., and maximum 22,400 lb./sq. in. Upper parts of the abutments rest on latite flow-breccia which can carry reduced stresses. The site is jointed and faulted, with a channel 80 ft. deep, due to late Glacial rejuvenation, along the centre of the floor of the gorge. Filling of the reservoir resulted in slight isostatic settlement, and certain faults were revitalized. Microseisms of intensity IV on the Mercalli scale (1931) have been recorded on the faulted margins of depressed blocks some miles from the dam.

Grand Coulee Dam, Washington.—This straight-gravity dam, containing 10 million cu. yds. of concrete, which develops power partly used to pump water into a high-level system of irrigation canals, is on Jurassic coarse-grained granite with intrusions of fine-grained granite and of Tertiary basalt. There are crush-planes. Overburden is of Glacial clays and sand, and of stratified alluvium. There was much slumping when, after the glaciation, the Columbia river excavated the valley-fill, the remaining part of which had to be stabilized by drainage, partial unloading, and dumping of rock along the toe. Faults are widely spaced and probably of Tertiary date. They influence weathering and erosion, and had to be cleaned out below the level of the surrounding floor, filled with concrete, and grouted.

Marshall Ford Dam, Texas.—This straight-gravity structure controls flooding on the Colorado river and serves hydro-electric generation. It rests on nearly horizontally bedded Comanche (Lower Cretaceous) sediments, including sandy limestone, limestones, and shales. Shaly layers slacked on exposure and had to be trimmed immediately before concrete was put in position. Some strata tended to slide under the downstream thrust of the dam. To prevent squeezing of soft material and to obviate seepage, pairs of tunnels were constructed through the doubtful beds in each abutment, and these drifts were then filled with concrete and grouted. Grouting was also used to fill cracks and cavities under the foundations. Artesian flow in the Hensel " sands " at a depth of 200 ft. indicates relative imperviousness of the beds flooring the reservoir.

Shasta Dam, California.—A curved-gravity dam, to be completed in 1944, is intended to control floods on the Sacramento river and regulate the salinity in San Francisco bay, and to serve for power generation. The foundations are on agglomerate, conglomerate, and lava of the Copley formation (pre-Middle Devonian). Intrusions of Dacite porphyry and quartz-diorite are of Jurassic age. Local faults are inactive, but slight earthquakes from Mount Lassen have been calculated for. Weathering is far advanced in the Devonian meta-andesite, and over 3 million cu. yds. of porous material had to be stripped away. Faults and schistose zones with gouge had also to be treated to avoid differential settlement and seepage. Drainage and inspection tunnels have been driven for examination of crush zones and concreting when the reservoir is filled. Strength of the meta-andesite varies from 535 to 35,400 lb./sq. in.

Friant Dam, California.—Where the San Joaquin river leaves the western foothills of the Sierra Nevada, this straight-gravity dam impounds irrigation water. The foundation is mainly quartz-biotite schist with many Jurassic intrusions of pegmatite and dioritic dykes. In general, planes of schistosity dip downstream and strike at a small angle to the axis of the dam. Weathering becomes more intense as one ascends the valley slopes. Faults and seams with unsound rock were investigated by shafts, tunnelled, concreted, and grouted. Strength of the schist varies between 1460 and 20,680 lb./sq. in. Unweathered specimens break along planes according to the orientation of the strain ellipsoid, regardless of the direction of schistosity. A. L.

508.* Calculating the True Thickness of a Folded Bed. G. D. Hobson. *Bull. Amer. Ass. Petrol. Geol.*, December 1942, **26** (12), 1827.—Hobson gives an account of the errors which may arise in calculating true thickness of a bed from vertical thickness multiplied by the cosine of the angle of dip. The calculation becomes less accurate the greater the dip and the greater the ratio of the true thickness of the bed to its radius of curvature. A. L.

509.* Geology and War. P. H. Price and H. P. Woodward. *Bull. Amer. Ass. Petrol. Geol.*, December 1942, **26** (12), 1832.—The strategic applications of geology are numerous. It can be used in the interpretation of terrain for defence and attack, since the geologist understands earth-features better than anyone else, and knows how to forecast them in unfamiliar areas from geological publications, photographs, and maps. Most overseas regions have been examined by geologists now resident in the U.S. The geologist can also point out testing grounds where duplicate conditions exist for anticipated campaigns. He can advise on off-shore, beach, and riverine topography, on soil and likely vegetation, on sites for roads and road-mending materials. He can help in appraising the value or vulnerability of fortifications, camps, batteries, aerodromes, and on the accessibility of water and mineral resources.

Geological advice should be obtained in the conversion of ground to military use for trenches, tank traps, tunnels. Quarrying and the prevention of slumps and debris-slides are also in the geological ambit, and the question of which swamps and quicksands can be reclaimed and which not. Effect of bombardment on different rock types, safety of underground workings as refuges, retention of gas in different rocks and soils, restoration of shelled territory and of oil-wells, are all matters for geological investigation.

Geologists can prospect for brick clays, marl ballast, sand, aggregate for concrete, do map-making and surveying, solve water-supply problems and those of sanitation and interment.

Camouflage and its detection are a new sphere for the geomorphologist who knows so well the natural appearance of a landscape.

Geophysicists can be employed to detect mines, pipes, and metallic underground installations.

The authors recommend that a geological organization should be set up for the application of geological knowledge "in the post-war settlement, and in possible future military and naval undertakings." There should be sustained study of geology in relation to fortification. Handbooks of Military Geology should be prepared. A more intensive search for new sources of raw materials both at home and abroad is necessary now, and will be equally necessary in the future. A. L.

510.* War Trims World Crude Production Ten Percent. Anon. *Oil Wkly*, 1.2.43, **108** (9), 44.—The 1942 world oil production was about 10% below the 2,226,836,000 brl. produced in 1941. This decline reflects in particular the declines in U.S.A., Russia, and Venezuela, as well as those in countries with smaller outputs. The 1942 estimates are rather uncertain owing to the absence of official statistics on many countries. It is possible that both Russia and Venezuela have experienced sharp production declines. Submarine warfare greatly curtailed Venezuelan oil exports early in 1942, but the exports probably rose later in the year.

The Maikop field in Russia was put out of action in 1942, and normal oil movements from Grozny and the Baku district were disrupted by the German invasion. In the

Netherlands Indies and Burma the wells were put out of action before the Japanese invasion, but the Japanese captured some of the British Borneo wells intact.

A table gives the annual crude oil production by countries since 1857. G. D. H.

511.* Crude Reserves Drop as Less Oil is Found than Produced. W. L. Baker. *Oil Wkly*, 1.2.43, **108** (9), 48.—In 1942, for the first time for nearly a decade, the volume of new oil found in U.S.A. failed to equal the production, although the rate of discovery of oil has been declining for the past four years. At the end of 1942 the U.S. reserves were estimated to be 19,325,899,000 brl., a decrease of 263,397,000 brl. during the year. The proven new oil found in 1942 was 1,121,950,000 brl., whereas the production was 1,385,347,000 brl.

The various methods of rating oil-discovery efficiency agree in showing that fewer and fewer barrels of oil are being found, although prospecting efforts are being maintained at high levels. Hence the decline in the discovery of reserves has been due to a failure to find as prolific pools as in previous years. This creates the fear that the nation's larger oil accumulations may have been found, with the consequence that it will be necessary to drill more and more wells if enough oil is to be found to offset producing rates. The amount of oil found in the last three years was little more than half that found in the preceding three years, although more wildcats and more dry holes were drilled, and more new fields were discovered. An average of 1,661,423,000 brl. of new oil was found annually during the past three years, compared with 3,058,239,000 brl. annually during the preceding three years. The average amount of oil found per new field or new horizon was 3,057,830 brl. for the 1940–1942 period, and 7,293,098 brl. for the 1937–1939 period. In 1939 929,659 brl. of oil was found per wildcat, and in 1942 only 354,374 brl. per wildcat.

Most of the 1942 new oil was found in the south-western States, and this amounted to 71% of the total discovered and developed during the year. This region produced 50% of the U.S. oil in 1942, while its discoveries exceeded its production by 113,474,000 brl. Texas now has 57·1% of the U.S. unproduced oil. The Louisiana reserves amount to 1,371,367,000 brl., or 7·1% of the U.S. total. Arkansas has 343,715,000 brl. of reserves. The reserves of Oklahoma, Kansas, and Nebraska fell during 1942, and the same was true of Illinois and California.

Tables give the U.S. reserves discovered for the period 1859–1899, for five-year periods from 1900 onwards, and for separate years from 1935 onwards, with the oil produced in these periods, accumulated reserves, dry holes, and wildcats completed, new fields and pays found, and the average number of barrels of oil found and developed per year, per dry hole, per wildcat, and per new field or per new pay. The reserve trend is analysed by States and areas for the past six years. G. D. H.

512.* Further Slight Decline in Drilling Foreseen for 1943. R. L. Dudley and E. Sterrett. *Oil Wkly*, 1.2.43, **108** (9), 57.—It seems probable that 18,574 wells will be drilled in 1943, inclusive of water-input and secondary recovery wells. There may be 3289 wildcats. These figures show 2250 fewer wells than in 1942, and a wildcat total well below the 4500 desired by P.A.W. An increase in price of crude oil or a relaxation of the restrictions on materials and equipment could, and probably would, mean a large increase in operations. Altogether it is difficult to forecast the year's operations with certainty.

It is reasonably certain that more crude will be needed in 1943 than in 1942. Also the South-western States will probably be called upon to deliver more oil than last year, partly because of a falling off of Illinois' production and the inability of Oklahoma materially to increase its output. Pipe-line construction will facilitate the movement of oil from the South-west. Illinois' production fell 140,000 brl./day during 1942, despite the State's most active wildcatting ever.

P.A.W. is counting on 16,500 wells other than water-input wells, with 4500 wildcats included, but these figures differ markedly from those reached after consulting the operators.

A table shows by States the number of new wells drilled and the number of wells deepened in 1942, with a forecast of the number of new wells in 1943; and the 1942 footage and the 1943 predicted footage.

The companies have indicated that if the material and price situations were improved, the 1943 wells would number almost as many as were drilled in 1941.

Canada, Mexico, and South America will account for the bulk of the drilling outside U.S.A. in 1943. Argentina's crude requirements exceed her production, and political considerations will determine to a large extent the amount of equipment which she will receive in 1943. Venezuela's 1943 activity will depend on the export situation.
G. D. H.

513.* Wildcat Results in 1942 Unsatisfactory. L. J. Logan. *Oil Wkly*, 1.2.43, **108** (9), 67.—Many fewer wildcats than normal were drilled in U.S.A. in 1942, and the discoveries were materially less in number than was hoped for under the drilling programme laid down by the Government. The discoveries were not as numerous as was considered essential for properly maintaining reserves. 3166 wildcats were drilled out of 21,412 wells—a greater proportion of wildcats than usual. The designed programme required 4000 wildcats, finding 624 new oil sources and 116 new gas areas. Actually there were 466 oil discoveries, including 15 distillate finds, and there were 57 gas discoveries. 348 new fields were found, of which 288 gave oil, 47 gas and 13 distillate. Of the new pays 163 gave oil, 2 distillate, and 10 gas.

The average depth of the discoveries was 4222 ft. The new fields had an average depth of 3862 ft., with the oil-fields averaging 3837 ft., the distillate fields 7997 ft., and the gas-fields 2870 ft. The new pays were of an average depth of 4938 ft., with the oil-pays averaging 4974 ft., the distillate pays 6192 ft. and the gas-pays 4110 ft. The average depth reached in the 2643 unproductive wildcats was 3515 ft.

Tables give by States and districts the numbers of new pays and new fields, and the average depths of the discoveries in each of the years 1936–1941, inclusive, the total discoveries in 1942 and their average depth; the numbers of productive and unproductive wildcats in 1942, with the average depths; and the number of oil, gas, and distillate discoveries, with the average depths. G. D. H.

514.* Footage Drilled Declines Less than Volume of Completions. Anon. *Oil Wkly*, 1.2.43, **108** (9), 70.—The average depth (3038 ft.) of all wells drilled in the U.S.A. in 1942 was slightly greater than the 1941 average (2963 ft.). The total 1942 footage was 31·8% less than the 1941 footage, and amounted to 65,056,261 ft. for 21,412 wells.

Illinois, Kansas, Oklahoma, North and West Central Texas, Ohio, Indiana, Kentucky, Montana, and Wyoming are below the national average in their mean drilling depths, and all these States had substantial or sharp declines in drilling activity. The relatively heavy drilling in the Appalachian States, with their comparatively shallow wells, tended to keep down the national average depth. In Pennsylvania, the 1942 wells averaged less than 1700 ft., and New York wells were even shallower, and were 10% more numerous than in 1941.

In 1942 588 old wells were deepened, adding 243,176 ft. of drilling depth. In Texas the average deepening operation was 488 ft., in Oklahoma 263 ft., in Kansas 241 ft., and in California 423 ft. per well.

Over 3,000,000 ft. of 1942 drilling was for water-input, gas-input and salt-water disposal wells. The water-input wells were mainly in Pennsylvania and New York, and aggregated 3,251,122 ft. The gas-input wells were largely in North Texas, Oklahoma, and Illinois.

18,567 new wells were drilled strictly for oil or gas in 1942, with a total footage of 61,362,202 ft. The average drilling depth in wildcat tests was 3516 ft. per well, and was considerably greater than the average in proven fields.

Tables give by States the number, total footage, and average depth of new wells in 1942, with subdivisions according as the wells are in fields, or are wildcat, water-input, gas-input, or salt-water disposal wells; the total new wells in 1942, the total wells in 1941 and the wells drilled deeper in 1942. G. D. H.

515.* One Third Fewer Wells are Completed During 1942. Anon. *Oil Wkly*, 1.2.43, **108** (9), 75.—One third fewer wells were drilled in U.S.A. in 1942 than in 1941, and they totalled 21,412. There were 5638 dry holes, 26% of the total, a somewhat higher percentage than in 1941, when there was comparatively close spacing. 18,567 new wells were drilled for oil or gas, apart from deepenings. Of these, 11,059 found oil or distillate, and 1870 found gas. There were 2995 dry holes in fields and 2643 dry wildcats. Deepening operations were sharply curtailed in 1942, when they numbered 588 against 823 in 1941. The deepening operations were mainly in Illinois, Kansas, Oklahoma, and North and West Texas. 2257 miscellaneous wells were completed in 1942. They were largely water-input wells drilled in Pennsylvania and New York. North Texas had 14 water input wells.

Tables give by States and districts the oil, gas, and distillate completions in 1941 and 1942; the total producing wells in 1941 and 1942; the numbers of dry holes in 1941 and 1942, and the numbers of dry holes in fields and among wildcats in 1942; the numbers of gas-input, water-input, and salt-water disposal wells in 1941 and 1942; and the numbers of wells deepened in 1941 and 1942, with separation according to whether they were dry, or found oil or gas. The total gas, oil, distillate, water-input, gas-input, deepened wells, and dry holes are given for the period 1859–1922, and for each year since 1922. G. D. H.

516.* Usual Growth in Number of Producing Wells Retarded. Anon. *Oil Wkly*, 1.2.43, **108** (9), 78.—In 1942 there were 407,257 producing oil wells in U.S.A., an all-time high, but the net gain of 3675 wells in 1942 was only 42% of the average annual gain for the decade 1931–1941. The failure to maintain the normal expansion in the number of producing wells in 1942 was primarily the result of curtailment in drilling new wells to replace depleted wells, and not so much because of premature abandonment. During 1942 7279 wells were abandoned, compared with 9406 in 1941. In California in 1942, as in 1941, there was a large-scale revival of idle wells.

Transport difficulties caused drastic curtailment of production in the South-western States, and this was largely responsible for the U.S. average production per well being 9·3 brl./day in 1942 against 9·7 brl./day in 1941.

Tables give the number of producing oil wells at the end of each year from 1921 onwards, with the average daily production per well; the numbers of flowing wells and wells on artificial lift at the end of 1941 and 1942 by States and districts, with the average production per well per day in 1941 and 1942. G. D. H.

517.* War Disrupts Upward Rise in United States Crude Output. Anon. *Oil Wkly*, 1.2.43, **108** (9), 80.—1,385,347,000 brl. of oil were produced in U.S.A. in 1942, only 1·3% less than the 1941 output, in spite of the war's interference with transport and supplies. The market value of the crude was 3% above the 1941 figure, giving an average price of $1·17 per barrel.

A table gives the annual production by States since 1859. G. D. H.

518.* Deeper Producing and Drilling Records for Several Districts. Anon. *Oil Wkly*, 1.2.43, **108** (9), 84.—Although the world production- and drilling-depth records have remained unchanged since 1938, both records were established during 1942 in several districts of U.S.A. New producing-depth records were established in West Texas (10,364 ft.), East Texas (10,212 ft.) and South-west Texas (10,168 ft.). On the Texas Gulf Coast the producing-depth record went to 11,815 ft., in North Texas to 7444 ft., in West Central Texas to 4555 ft., and in North Louisiana to 10,546 ft. New Mexico's deepest production is helium at 6950 ft. The first 10,000-ft. test has been drilled in Arkansas, production having been found at 10,477 ft.

A table gives the depth records in the various districts, with the depth, year, formation, and well location. G. D. H.

519.* East Texas Leads U.S. Fields in Both Cumulative and Current Production. Anon. *Oil Wkly*, 1.2.43, **108** (9), 88.—Only about 50 U.S. oil-fields have so far yielded more than 100,000,000 brl. of oil, although many others are approaching this figure. East Texas has given 1,821,593,932 brl. of oil since 1930, more than any entire State except Texas, California, and Oklahoma. The Seminole area has produced more than 1,000,000,000 brl., but this area is formed of numerous closely related pools, some of which have given over 100,000,000 brl. each. Midway-Sunset has produced nearly 1,000,000,000 brl., and Coalinga, Long Beach, Santa Fe Springs, and Oklahoma City about 500,000,000 brl. each.

East Texas also leads in current daily average production, in spite of proration, and was providing 350,000 brl./day at the end of 1942. Next in magnitude as regards current rate of production is Wilmington, with almost 100,000 brl./day. Coalinga, Oklahoma City, Tinsley, and Midway-Sunset are producing over 50,000 brl./day each,

Tables list the fields which lead in current daily average production, giving the discovery year, number of producing wells, and daily average production for the field and per well at the end of 1942; and the fields which have produced over 100,000,000 brl., with the discovery year, cumulative production, and production in 1941 and 1942.
G. D. H.

520.* New Fields and Pays Found in 1942. Anon. *Oil Wkly*, 1.2.43, **108** (9), 97.—348 new fields and 175 new pays were found in 1942. In 1941 there were 346 new fields and 267 new pays.

Tables give the new discoveries by States, with subdivisions according as they are oil-fields, gas-fields, gas-distillate fields, new oil-pays, or new gas-pays, with the name, county, company, well location, and date of completion of discovery well; name, character, and age of producing formation; total depth and completion horizon; initial production, method, and choke; oil gravity. G. D. H.

521.* Producing Oil Wells, Crude Oil Production, and Well Completions in U.S. Fields. Anon. *Oil Wkly*, 1.2.43, **108** (9), 129.—Tables give by States, with the fields arranged alphabetically under counties, the following data: date of discovery; number of oil-wells producing at the end of 1942, with the numbers flowing and on artificial lift; the daily field and average well production at the end of 1942; the 1942 oil production and the cumulative production up to the end of 1942; the number of new wells completed in 1942, with subdivisions according as they are oil-wells, gas-wells, distillate wells, water-input wells, gas-input wells, water-disposal wells, or dry wells; the number of old wells drilled deeper in 1942, subdivided according as they are oil, gas, or dry wells.

Summary tables give the same data for States, and in some cases for State subdivisions. G. D. H.

522.* P.I.W.C. Report on Reserves. Anon. *Oil Wkly*, 8.2.43, **108** (10), 42.—The 1942 oil discoveries in U.S.A. may ultimately account for a maximum possible addition to reserves of 800,000,000 brl., according to W. B. Heroy, P.A.W. Director of Reserves. That would be only 58% of the 1942 production. The proven reserves developed in new fields and horizons amounted to 178,420,960 brl., with proven undeveloped reserves of possibly 241,147,652 brl. 261 new fields were found in 1942, averaging 1,600,000 brl. in reserves per field.

1,385,000,000 brl. of oil were produced in U.S.A. in 1942.

It is forecast that only 16,000 wells will be drilled in 1943, but wildcats may be 20% more numerous than in 1942, when there were 3045 exploratory wells. 5512 or 31% of the 1942 completions were dry, compared with 7025 or 24% dry in 1941. 83·8% of the 1942 wildcats were dry.

A table gives by States the number of new fields found in 1942, with the reserves (proved producing, proved undrilled, total proved, and maximum possible reserves), together with similar reserve data for new horizons. G. D. H.

523.* January Drilling 40% Below Year-Ago Mark. Anon. *Oil Wkly*, 8.2.43, **108** (10), 46.—In the four weeks ended 23rd January, 1943, there were 40% fewer well completions in U.S.A. than in the corresponding period a year ago. The average rate of well completion in the four weeks ended 23rd January, 1943, was 342 per week. California had 4%, Kentucky 64%, and New York 8% more completions than in the corresponding period of 1942, whereas Arkansas had 12% fewer, Ohio 26% fewer, and Indiana 25% fewer than a year ago. 676 of the January completions were oil-wells, 3 distillate wells, 124 gas-wells, and 131 intake and other wells. 34 oil-wells were deepened, and there were 401 dry wells.

Tables give by States and districts details of the well completions in January 1943, with the total wells in January and December 1942 for comparison; also the status of the rigs on 1st February, 1943. G. D. H.

524.* Wildcatting Results Continue Unfavourable During January. Anon. *Oil Wkly*, 22.2.43, **108** (12), 11.—212 wildcats were completed in U.S.A. in January 1943, against 201 in December 1942, but the number was considerably below the figures for January, October, or November 1942. Of the 212 wildcats, 37 found oil or gas, resulting in the opening of 14 new oil-fields, 5 new gas-fields, and 18 new oil horizons. Not only was the number of successful wildcats in January 1943 smaller than is desirable, but the quality of the discoveries was predominantly low. Two-thirds of the discoveries were in States and districts where discoveries frequently represent limited reserves—namely, Illinois, Indiana, Kansas, Michigan, and North and West Central Texas.

During January 1943 Texas led in wildcat activity, having 61 wildcat completions with 16 finding oil and three gas. The percentage success was 31, compared with the national average of 20% of successes. There were four new oil-fields and five extensions. The Stowell field was extended 2 ml., and this Frio sand-field promises to become a major reserve. Illinois had two new fields, three extensions and eight new horizons among 36 wildcat completions. The Friendsville field has 4 producing horizons, the McClosky having been added to the list. Iola has a third producing horizon in the Weiler formation. A 2000-brl. well has been completed in the Blairsville field, and a Christian County test, 30 ml. from the nearest production, has swabbed a little oil with water from the Devonian at 1905–1908 ft.

Three new fields were found in Kansas out of 37 wildcats. The Hunter discovery, with a potential of 3000 brl./day from the Mississippian, seems to be the best. Two Hunton fields and a Wilcox field were opened in Oklahoma, while Michigan had a new oil-field, a new gas-field, and an extension, but none of these appears to be important.

Three Californian wildcats have had good shows, one being 2½ ml. from Coalinga Nose. There was one gas extension.

Tables set out the results of wildcatting in January 1942 and January 1943, by States and districts, and there is a list of the discoveries in January 1943, with the location, dates of spudding and completion, total depth, completion depth, producing formation, method, rate and choke, oil gravity, type of structure, and method of discovery. G. D. H.

525.* New California Wells Have Smaller Producing Ability. E. S. Bunch. *Oil Wkly*, 22.2.43, **108** (12), 33.—The first hundred wells completed in California in 1943 had a combined potential of 10,825 brl./day, whereas the first hundred completed in 1942 netted 53,614 brl./day. The first hundred completions in 1943 accounted for 332,340 ft. of drilling, while the first hundred in 1942 accounted for 571,691 ft. Not a single 1943 completion has had an initial producing capacity of 2000 brl. or more per day, but there were 5 such wells among the first hundred 1942 wells. In 1943 only 2 wells have been in the 1000–2000-brl. class, compared with 18 in 1942.

So far in 1943 only a negligible quantity of new production has been developed, apart from a possible major field in the Coalinga area, a new deep sand strike in the Del Valle region, a surprise extension in the Santa Maria Valley field, and possible production in the Bardsdale area.

The demand for Californian oil has increased during the war, and while production has risen substantially, withdrawals from storage have had to be made. The demand is now over 800,000 brl./day, and may soon exceed 1,000,000 brl./day. Hence there must be intensive drilling in producing fields, and even more intensive exploratory drilling.

Concentration on drilling for heavy crudes is partly responsible for the poorer individual yield of wells this year. Fresh fuel-oil supplies can at present be obtained only by drilling up final locations in old shallow fields, most of which have long been in a decline.

In January 1943 the only discovery was an extension to the Rio Vista natural gas-field, although wildcatting has been up to the average in numbers.

Undrilled locations in proved territory are not great in number. G. D. H.

526. Petroleum Exploration and Development in Wartime. E. de Golyer. *Oil Gas J.*, 25.2.43, **41** (42), 53.—During the last four years the rate of oil discovery has been less than the rate of oil production in the U.S.A. The need for increased oil production can best be met by the discovery of new pools. During the past four years there has been an excess capacity to produce, and this is still the case, but transport problems will have to be solved before full use can be made of the productive capacity. Even then, however, this will not meet demands.

The numbers of wildcat wells drilled and of geophysical and core-drill crews in operation show the exploratory effort to be at an all-time high, but the results have not been good enough. There is nothing in the past history of the U.S. oil industry to suggest that the annual discovery of about 1,500,000,000 brl. of oil (the present yearly consumption) can be continued indefinitely.

The P.A.W. has recommended the drilling of 4500 wildcats in 1943, compared with 3045 completed in 1942. G. D. H.

527. Drilling Restrictions Bottle Up Large Reserve at Wilmington. L. P. Stockman. *Oil Gas J.*, 25.2.43, **41** (42), 104.—Wilmington has a 50,000,000-brl. reserve in the Tar sand, and this could do much to ease the Californian supply situation, but the refusal to allow exceptions to M-68 as amended renders this reserve unavailable. The present formula penalizes fields with several distinct and separate oil-zones, and while preventing development of the comparatively shallow Tar zone, allows deep drilling elsewhere. There is a P.A.W. objection to drilling two wells on any ten acres, although each well produces from a different sand and a separate zone. P.A.W. recommended that operators should kill wells producing from the Terminal and perforate opposite the Tar and Ranger zones.

Wilmington has five fault-blocks which behave independently. The 200-ft. Tar zone is not as prolific as the Terminal and Ford zones. Its base is 2400–2800 ft. deep, and the oil is highly viscous. Considering the field as a whole, the average acreage per well is about 3½ for all zones. It is believed that the effective drainage area of a Wilmington well is less than 3 acres.

If the desired number of wells were completed, it is estimated that the Tar zone would give about 3,250,000 brl. in its first year, 2,400,000 in the second year, and 10,500,000 brl. in the first five-year period. The 81 proposed wells would require relatively moderate amounts of equipment.

There are about 1600 proved undeveloped acres of Tar zone production at Wilmington, 800 acres being in the Terminal section. In the highest part of the Terminal section there are 7 separate oil-zones—Tar, upper and lower Ranger (Pliocene), upper and lower Terminal, Union Pacific and Ford (Miocene). The Ford zone has not been fully developed. The Tar zone has only 2 wells, both having shown substantial production under natural flow. The Union Pacific zone, a comparatively recent discovery, may be limited to the structurally high positions. The Ford zone has a large crude oil reserve.

Only 7 fields in California show a more attractive steel factor than Wilmington on a barrel/ton basis. G. D. H.

528. Revisions Account for Higher A.P.I. Reserves. Anon. *Oil Gas J.*, 4.3.43, **41** (43), 34.—According to the A.P.I. during 1942, 1,878,976,000 brl. of new oil were found in U.S.A., 493,497,000 brl. more than the 1942 production. Hence the known underground reserves on 31st December, 1942, were estimated to be 20,082,793,000 brl. Most of the new oil was added by upward revision of proved reserves in fields found prior to 1942. The amount provided by this revision was 1,618,925,000 brl.

The reserve estimates do not reflect the availability or the rate at which these reserves can be produced, and the present known oil can be recovered only over a period of many years and at gradually declining rates.

A table gives the estimated proved reserves in the U.S.A. by States for 31st December, 1942, and 31st December, 1941, together with the 1942 production and the new reserves (discoveries, extensions and revisions) added in 1942. G. D. H.

529. Reserve Estimates. Anon. *Oil Gas J.*, 4.3.43, **41** (43), 69.—The bases of the A.P.I., P.A.W., and *Oil and Gas Journal* reserve estimates differ slightly. The total proven reserves as of 1st January, 1943, are given as 20,082,793,000 brl. by the A.P.I., and as 20,675,899,000 brl. by the *Oil and Gas Journal*, a difference of less than 3%. A year before the corresponding figures were 19,589,296,000 brl. and 20,299,543,000 brl., a difference of 3·5%.

Every year estimates of reserves are revised, and this revision is generally upward in the States and invariably upward for the national total. The revision indicates conservatism in the original estimates as well as technical improvements in production methods which increase recoveries where applied. But this revision does not imply much, if any, increase in the oil immediately recoverable. It merely means that the life of the fields has been extended, and the additional oil tends to be that which will be produced later under relatively high cost. If the demand becomes greater than the supply available under present methods, it is necessary to over-produce the fields, and this will necessitate another revision of reserve estimates, which will be downward rather than upward.

According to the *Oil and Gas Journal* estimates revisions added 919,496,000 brl. during 1942, extensions 518,580,000 brl., and new fields and new pays 322,808,000 brl.

As regards individual States the A.P.I. and *Oil and Gas Journal* estimates differ considerably in some cases, possibly because the A.P.I. estimates are made by different committees whose definition of the word " proven " may vary. The A.P.I. estimate of the reserves added by discoveries in 1942 is 260,051,000 brl., and covers new fields only. It is therefore much less than the 322,808,000 brl. given by the *Oil and Gas Journal* estimate which includes new sands in old pools. (A table shows the A.P.I. and *Oil and Gas Journal* estimates of discoveries in 1942 by States.) G. D. H.

530.* Drilling Shifting to Less Prolific Areas. Anon. *Oil Wkly*, 8.3.43, **109** (1), 10.—Scarcity of critical materials and a probable increase in petroleum requirements makes it essential for the oil industry to accomplish more with less and less equipment. It is therefore necessary to concentrate drilling at points where the maximum amount of oil can be obtained by the expenditure of a given amount of steel, but this concentration has not taken place, and, without exception, every one of the prolific producing States completed fewer wells in 1942 than in 1941. On the other hand, drilling in the Eastern area has been maintained at pre-war levels. The percentage of the total U.S. completions in the Eastern non-prolific area was 23·6% in 1941 and 32·6% in 1942, whereas in the South-western group of States the percentage was 39·7% in 1941 and 31·9% in 1942.

Transportation considerations have favoured the drilling in the non-prolific Eastern States rather than in the prolific South-western States. Also the interruption of secondary recovery work in the Eastern States might cause a loss of considerable reserves. But the improvement of transportation facilities will make it more satisfactory to draw oil from the South-western States.

A table gives by States and areas the numbers of wells drilled in 1941 and 1942, together with the numbers likely to be drilled in 1943. G. D. H.

531.* More Oil Found than Produced Says A.P.I. Anon. *Oil Wkly*, 8.3.43, **109** (1), 11.—According to the A.P.I. Committee on Petroleum Reserves, 1,878,976,000 brl. of oil were found in the U.S.A. in 1942, 493,497,000 brl. more than the production. This raised the underground reserve estimate to 20,082,793,000 brl.

Of four separate estimates made on 1942 exploratory efforts, the A.P.I. is the only one to report that more crude was found than produced. However, even this estimate shows the declining discovery rate of the last six years, and does not make clear whether the reserves will be great enough to allow increases in production without the waste which would follow any prolonged production at greater than the optimum rate.

To-day's known oil can be recovered only over a period of years and at gradually declining rates. Most of the new oil the A.P.I. credited to 1942 reserve additions was through upward revision of reserve estimates for fields found prior to 1942, and this amounted to 1,618,925,000 brl. This large upward revision is the result of conservative estimates being made for new fields with the full realization that they may have to be revised in the light of more development.

Most of the new oil found during the year was in Texas, where 1,053,547,000 brl. was located according to the A.P.I., and this was more than twice its 1942 production of 483,371,000 brl.

Tables give the A.P.I. estimates of proved reserves in the U.S.A. by States for the beginning and end of 1942, together with the 1942 production. There is also a comparison of the A.P.I. and P.A.W. estimates of new reserve discoveries in 1942, the former being for new fields and the latter for new fields and new horizons. Summaries are presented for the years 1937–42 inclusive, of the A.P.I. estimates of proved reserves at the end of the year, production during the year, reserve additions due to new fields, additions due to extensions and revisions, with similar data for 1942 and 1941 given by states. G. D. H.

532.* February Drilling Declines to Lowest Point in Years. Anon. *Oil Wkly*, 8.3.43, **109** (1), 34.—In January the completions averaged 346 per week, but in February the average was only 304 per week. In February 1942 the completions averaged 508 per week. 2600 wells were completed in the first two months of 1943, against 4352 in the same period of last year. During 1943 there has been more drilling in Colorado, Kentucky, Montana, and Wyoming than in 1942. Drilling declines greater than the average have taken place in Texas, Louisiana, Mississippi, Indiana, and Michigan.

A table gives by States and districts the classified well completions in February 1943, the cumulative completions for January 1943 and February 1942, and details of the rigs in operation on 1st March, 1943. G. D. H.

533.* Alberta Sets High Production Record in 1942. Anon. *Oil Wkly*, 8.3.43, **109** (1), 35.—The total Alberta oil production in 1942 was 10,143,270 brl., compared with the previous record yield of 9,908,555 brl. in 1941. The average daily yield in 1942 was 27,790 brl. Turner Valley provided 10,003,935 brl. of the total, and this was made up of 9,681,719 brl. of crude and 322,216 brl. of natural gasoline processed from tail gas in the four Turner Valley absorption plants. G. D. H.

534.* Russian Oil Situation Described as "Optimistic." Anon. *Oil Wkly*, 8.3.43, **109** (1), 35.—The winter drive of the Russians has opened the Volga river again for movement of oil by the Russians. According to Zavoico, the Russian oil production, exclusive of Sakhalin, was 238,000,000 brl. in 1941 and 223,000,000 brl. in 1942, but it will probably fall to 195,000,000 brl. in 1943. Sakhalin was credited with 3,285,000 brl. in 1941, and 4,500,000 brl. in 1942, with a similar amount likely in 1943. The Baku area produced 172,645,000 brl. of oil in 1941 and 150,000,000 brl. in 1942. An output of 127,750,000 brl. is estimated for 1943. The Ural-Volga region gave 27,375,000 brl. in 1941 and 42,500,000 brl. in 1942, with 45,625,000 brl. estimated for 1943. G. D. H.

535. Geologic Background of Oil Production in the Illinois Basin. B. F. Hake. *Oil Gas J.*, 11.3.43, **41** (44), 82.—The Eastern Interior (Illinois) Coal Basin of South Illinois and Western Indiana and Kentucky has been submerged and re-elevated repeatedly, the sediments deposited in any one geological episode being relatively thin. Not all parts of the basin behaved identically, and the complex differential movements have influenced the distribution, character, and structural attitude of the strata.

The Ordovician is believed to be the oldest formation in the Illinois basin with potential oil production, and these beds lie 7000–9500 ft. deep in the centre of the basin. The Knox dolomite and the St. Peter have given little oil in Illinois, and the same is true of the Trenton, which has, however, shown better prospects recently. Marine limestones (500 ft.) formed in the Silurian, but they have not given oil occurrences of commercial importance. Further limestones (700 ft.) were formed in the Devonian, which has provided 5% of Illinois' oil and eight important fields, some with very prolific wells. There was elevation towards the end of the Devonian, and in the Lower Mississippian about 1400 ft. of sediments, mainly limestones, were laid down. These have yielded 15% of Illinois' oil, the McClosky with its rapidly declining wells being the most important horizon. In late Mississippian (Chester) times 1200 ft. of sands and muds were deposited, and these variable beds have provided many small fields, the oil possibly having been formed in the Chester shales. The Chester (chiefly Aux Vases, Benoist, Paint Creek, and Cypress) sands have provided 55% of the Illinois oil.

There was uplift and erosion early in the Pennsylvanian, most of the structures in the older beds then approximating to their present form. 2000 ft. of ill-sorted and variable detritus were deposited during Pennsylvanian time, much of it in embayments, lagoons, swamps, deltas, or flood plains. Oil is abundant in the Pennsylvanian of the older fields of Eastern Illinois, and it has probably come from the eroded Chester. The Pennsylvanian wells commonly have little gas and do not flow as a rule. The sands are lenticular, and wells continue to produce for many years at a low rate.

There has been little deformation in the Illinois Basin since the Pennsylvanian, and if younger beds were laid down they have been entirely eroded.

Where sedimentation was slow, oil-fields are generally less prolific than where sedimentation was rapid, for there was greater opportunity for destruction of the organic matter before burial. Illinois seems to have had slow sedimentation except in the Chester, which has given more oil than all the other formations in the basin combined. Extensive, uniform strata permit regional migration and provide large fields as at Salem and Louden, whereas heterogeneity gives mainly small fields (Central and Eastern Illinois) or extensive composite fields. Even on the La Salle anticline, the largest anticline in Illinois, structure is only partly responsible for the shapes and sizes of the oil accumulations. G. D. H.

536.* The Oil-fields of Western Canada. C. M. Hunter. *J. Inst. Petrol.*, March 1943, **29** (23), 75–88.—The paper deals with the geology, development, and certain details of drilling, completion, and production practices of the Canadian oil-fields in general and of Turner Valley in particular. Special difficulties encountered by geologists and drilling engineers in the foothills are mentioned. Athabasca tar sands are also discussed. The paper is followed by a discussion. A. H. N.

537.* Wildcatting and Oil Reserves. F. H. Lahee. *World Petrol.*, March 1943, **14** (3), 30.—A table gives reserve data for the group of eleven States—Arkansas, California, Illinois, Indiana, Kansas, Louisiana, Michigan, Mississippi, New Mexico, Oklahoma, and Texas. The data are given annually for the years 1937–1943 inclusive, as far as possible, and include the proved reserves on 1st January of each year, the net change in proved reserves since the beginning of the previous year, the total new reserves added in the year, the production during the year, the number of years' supply in terms of production during the previous year, the total number of wildcats drilled and the wildcat footage, the proved reserves found per wildcat and per foot of wildcat drilling. The same data are also set out graphically. While the number of wildcats drilled and the amount of wildcat footage have been rising in recent years, the reserves found per wildcat or per foot of wildcat drilling have been falling. G. D. H.

Geophysics.

538.* Micromagnetics : a New Quantitative Geophysical Method. W. P. Jenny. *Oil Wkly*, 8.2.43, **108** (10), 21.—Some sedimentary strata are strongly magnetic, some weakly magnetic, and some non-magnetic. It may safely be assumed that the magnetic material in the sediments will be uniformly distributed within limited regions, and that changes in distribution will be regional rather than local. It is likely that the shallowest structurally disturbed magnetic bed is the source of the observed local anomalies. And structurally undisturbed shallower magnetic beds will add a constant, or, through dip, thickening, etc., a regionally increasing or decreasing effect. Over large areas on the Gulf Coast experience shows that 1 gamma corresponds to 20–30 ft. of local structure in the Heterostegina or Wilcox. It is therefore necessary to survey the area with an accuracy of $\pm$ 1 gamma for each station.

A hypothetical example is discussed in order to explain the new micromagnetic interpretative procedure. By plotting a series of parallel micromagnetic profiles a general course is observed which represents the regional magnetic dip along the profiles. Assuming that the regional magnetic dips of the various profiles lie in a plane, regional magnetic isogams may be drawn, and the positive or negative difference between the station values and the regional intensities gives the local magnetic anomaly at each station. Allowing 20 ft. local anomaly per gamma and connecting the points of equal footage leads to a relative structural contour map. If the general regional dip of the beds in the area is known, combination with the relative structural contour map provides a sub-sea structural contour map. G. D. H.

539. The Use of Electrode Spacing in Well Logging. R. H. Zinszer. *Petrol. Tech.*, March 1943, A.I.M.M.E. Tech. Pub. No. 1590, 1–10.—The quantitative analysis of electric logs must take cognisance of sand thickness, permeability, interstitial water saturation and salinity, mud resistivity, formation temperature, etc.

A series of sands ranging from 1 ft. to 30 ft. in thickness have been studied in California in a well which was cored continuously throughout the section investigated. Circulation of mud was continued for four hours after the last core was taken, in order to ensure a uniform conditioning of the mud. Electrical logging runs were then made with electrode spacings ranging from 5 in. to 89 in. The mud and formation temperatures were measured, and the salinity of the interstitial water was assumed to be the same as that of the water produced. The different electrode spacings provided formation resistivities for different " depths of penetration." On plotting resistivity against " depth of penetration," the resistivity, starting from the resistivity of the mud, increased with " depth of penetration " to a maximum, and then declined for greater penetrations. The increase is due to fresh-water infiltration from the mud. In the case of thin shells the final decrease in resistivity is partly caused by the low resistivity of the adjacent shales. For sands of the same permeability, the maximum occurs at smaller penetrations the thinner the sand. The position of the maximum does not imply smaller penetration of infiltrating fluid in the thin sands, since the shift in resistivity maximum is largely due to the effects of the low resistivity of adjacent shales, which becomes noticeable for thin sands. The limits of infiltration effects can be observed more clearly for thick sands.

There is an approximately linear relationship between log.-resistivity and log.-sand thickness for thicknesses up to about 7 ft., the resistivity being higher the higher the permeability.

A series of theoretical curves were derived for the relationship between resistivity and water saturation at different salinities, and a curve has been constructed to give the relationship between sand thickness and a thickness factor which, when multiplied by the measured resistivity, gives the true sand resistivity. The individual water saturations were obtained by inserting the corrected resistivity on the appropriate salinity curve. Eight sands were examined, and after weighting the saturations for thickness and permeability, the saturation calculated was found to be greater than the critical saturation, suggesting that the sands would produce some water initially.

G. D. H.

540.* Geochemistry's Place in Future Exploration. R. O. Smith. *World Petrol.*, March 1943, **14** (3), 45.—The Russians were the first to employ geochemistry in prospecting for oil. They argued that the gases associated with oil would probably escape to the earth's surface, and perhaps be detectable in the soil, and considered that the ratio of ethane to methane is important.

Non-commercial accumulations of oil can give geochemical indications which are misleading, and these are frequently in limestones near source-beds. A further source of difficulty is the shift of structure with depth or the non-vertical movement of the escaping hydrocarbons. Some hydrocarbons are believed to rise more vertically than others, thus providing a means of estimating the depth of oil deposits. However, exceptions to the normal drift behaviour are not uncommon.

It is possible to determine whether the oil indications come from sand or from limestone beds.

Geochemistry has had notable successes as well as failures. It may be possible later to outline a field precisely, but at present the main requirement is that it should locate oil. Where adequate surveys were made, four out of ten wells located by geochemistry have been successful.

It is possible that three times as much oil is associated with stratigraphic traps as with anticlines, and while the latter are fairly easily found by physical and geological methods, there is no certain and non-laborious method of locating the former. Geochemistry is of value in discovering stratigraphic traps, and in combination with geology and geophysics led to the opening of the Santa Barbara field of Venezuela. It may be expected to be used as an exploratory tool on new prospects, as an outlining agent, and as a means of selecting favourable and unfavourable strata for drilling.

G. D. H.

541.* Accelerated Discovery Through Geophysics. L. I. Freeman. *World Petrol.*, March 1943, **14** (3), 48.—The desire to discover oil directly has led to much research, but has not so far developed any quick and infallible method of locating hidden oil accumulations. New oil-finds in the near future are likely to be made only by the application of every possible method and all knowledge to the areas under examination.

The amount of materials allotted is insufficient to maintain the normal number of geophysical parties in the field, and the operating personnel numbers have fallen below minimum requirements, while labour laws have restricted working time. In view of these difficulties more efficient geophysical exploration requires: (1) The employment of the geophysical unit most suited to a given area, with men in charge who are experienced in that particular area. Competitive exploration should be avoided. (2) The reduction of the time between discovery and testing of a structure, with power to make decisions, to appraise and assemble leases, and to conduct exploratory drilling vested in district offices without reference to headquarters. (3) The pooling of information within each area. This might save many dry holes drilled at great expense. Adoption of the above suggestions might result in accelerated discovery. G. D. H.

542. Amplified Curves Widen Value of Electric Logs. L. R. Dawson. *Oil Wkly*, 1.3.43, **108** (13), 26.—A high percentage of connate water and/or an abundance of volcanic ash in a formation will have a damping effect on the third and fourth curves of electric logs, and under normal sensitivities they will show very little definition of fluid content. This makes it difficult to determine oil–water contacts, and often even the presence of oil and/or gas is not apparent in the normal sensitivity run.

In South-west Texas these conditions are common, and an amplified third curve brings out features which are not distinguishable on the normal run. An example is given, with the normal and amplified third curves, and the amplified third curve clearly shows the fluid content. The amplified sections require only a few minutes' extra time to secure.

In some areas, *e.g.* the Wilcox trend, invasion of the sands by drilling fluid has complicated the interpretation of electrical logs. The third curve is comparatively useless, as it has a high intensity in nearly all the sands. The fourth curve must be used for fluid-content determination, but even its deep penetration is affected over a period of time in drilling ahead. A fifth curve of even greater penetration is used to facilitate interpretation by getting beyond the range of formation invasion, and the fourth and fifth curves together are used as a basis for the interpretation of fluid content. The third curve can often be employed if certain procedure is followed: (1) Electrical logs are run every seven to ten days when drilling in the Wilcox sand; (2) overlap sections are run each time a new run is made, and the changes in the curves are checked; (3) the saline content of the drilling mud is increased just prior to entering the Wilcox to reduce diffusion or ionization effects. G. D. H.

Drilling.

543.* Proper Installation and Care Stretch V-Belt Life. E. Sterrett. *Oil Wkly*, 18.1.43, **108** (7), 10–16.—Detailed instructions and hints on installing and maintaining V-belts on oil-field equipment are given, together with illustrations. The following is a summary of the instructions given: (1) Do not allow oil, grease, or gasoline to come in contact with belts. (2) Avoid exposing belts to sunlight and excessively hot or cold weather. (3) Insure proper-sized pulleys for drive. Too small pulleys shorten belt life. (4) Provide take-up facilities. The initial setting should allow $\frac{1}{3}$ motion towards driven unit, $\frac{2}{3}$ for belt take-up. (5) Avoid heavy overloads. Add one or more belts to initial set-up if loading is increased. (6) Don't leave tools or other objects where they may fall into and damage belts. (7) Avoid abrasion against nearby objects. Slight shaft misalignment may set up destructive side-sway and intermittent contact. (8) Do not force belt on to sheave with tools of any kind. Slack off on take-up and lay belt in grooves. (9) Work belts around grooves until all the slack is on one side of the drive, and then tighten take-up to secure desired tension. (10) Use sufficient number of correct-sized belts to handle maximum load. Check to insure sheaves being over accepted minimum diameters for belt size and type used. (11) Design new drives to call for standard size and length of V-belt with adequate adjustment for stretch. (12) Prevent V-belts from bottoming in grooves. Bottom friction sets up destructive heat, greatly shortening belt life. (13) Do not use belt dressing. If belt slips, clean with rag moistened with high-test gasoline (clear, not ethyl) and tighten drive slightly. (14) See that all sheave grooves are clean, free from burrs or nicks and excessive wear. Replace sheaves and check alignment periodically. (15) On failure of first belt in drive, renew throughout. Save other worn belts for replacements, as second set shows signs of excessive wear. (16) Before starting drive first time, check (*a*) pulley alignment; (*b*) bearings for oil; (*c*) drive clearances. Adjust so that at full load only slight bow or sag appears on slack side. (17) Vertical drives, extremely short-centre installations, and drives for pulsating loads where no flywheel can smooth peaks must be operated more tightly than others. (18) Check for odour of hot rubber. If this persists after first few minutes of operation, drive should be checked throughout for cause and difficulty corrected. (19) Belt should be stored uncoiled; preferably hung over forms of minimum pulley diameter or larger, and in a cool, dark, and dry place. Do not hang spare belts on nails or loop over pipes or single board supports, and do not tie together tightly with cord or wire. (20) Protect against acid fumes, smoke, and dust. A. H. N.

544.* Safeguarding and Extending Cordage Service Life. E. Sterrett. *Oil Wkly*, 25.1.43, **108** (8), 11–15.—Prolongation of rope life begins with its receipt from the warehouse or distributor. If delivered in the sacking-covered coil, the unit should be carried flat, not stood on edge while being trucked to destination. It should rest flat on the truck bed or platform, and should neither lie atop tools, wrenches and pipe, nor below any of these. During transfer it should be kept dry or, if soaked by rain while in transit, the coil should be stripped of its sacking cover and flaked down with end turns not less than outside diameter of initial coil until the fibres have thoroughly dried. Inspection of the inside of the rope frequently demonstrates that the outside may appear dry while the interior still retains considerable water. Twisting the rope between the hands to open a space between adjoining strands permits examination of the interior of the rope. Similarly, thrusting a marlinspike into a rope to open a space permits like examination of a strand. Wet fibres can be recognized by their darker colour, and also by a tendency to cling together, rather than to present an array of fine bristles or fibres sticking out at all angles to the laid material.

Drying of a rope, whether new or well worn, should be carefully done if maximum rope life is to be attained. The rope preferably should be dried in the sun, either laid flat on a smooth, clean surface, or strung back and forth between a pair of horizontal arms on posts so set that the span of rope is not carried over steam pipes, water, or loose dirt or dust. A wet rope, no matter how soon it is again to be needed, should never be wrapped round a fired rig boiler—even if the latter be lagged—the coils thrown across it, or even suspended between two adjoining boilers. The excessive heat to which the outside fibres are exposed will drive off the lubricant which is built into the rope, and will tend to impart a permanent fix or set to the fibres, impairing the ability of the rope to distribute stress equally throughout its cross-section. Storing of rope in an excessively dry place will also result in rapid deterioration. Details are given of the method of storing ropes so that adequate " breathing " is maintained. Hints are also given on correct use of rope. Rope, lubricated at the walk, has built into it ample supply to last its normal working life. It should not be lubricated with any of the mineral or animal oils used around machinery, nor, if accidentally coated with these or crude petroleum, should it be soaked in gasoline to clean. Linseed oil and other quick-drying water-repellants are also detrimental to the life and proper functioning of the outer fibres of a rope, and should not be used.

Rope should never be exposed to acid fumes or hot exhaust gases. Gases such as those emanating from sour crudes can reduce rope life by half through the effect of the fumes on the fibres; alkali dust is equally bad for ropes, in addition to the abrasive action of the particles. To obtain long rope life: run slowly; load gradually; keep dry; splice instead of tie for permanent junction; reverse ends frequently; cut and splice at worn spots. A. H. N.

545.* Drilling Curb Hits Rotary Rigs Harder Than Cable Tools. Anon. *Oil Wkly*, 1.2.43, **108** (9), 86.—Primarily reflection on the fact that restrictions on drilling more severely affected development in fields of the South-west, Middle West, and California than work in the Appalachian region, there was a sub-normal proportion of rotary rigs in operation in the United States on 1st January, 1943 (53% of the total), and a greater than normal ratio of cable-tool operations (47%). A table gives data on types of rigs doing different jobs by states for the United States on 1st January, 1943.

A. H. N.

546. Application of Direct Motor Drive With Use of Electric Motor. N. Williams. *Oil Gas J.*, 4.2.43, **41** (39), 31.—Rotating entails considerably lighter power loads than hoisting, so when the rotary table is driven by the hoisting engine or motor there is an excess of power for that purpose. In an independent drive for the rotary a smaller engine or motor can be used, making possible substantial economies in power and fuel costs. At the same time, with the hoisting engine or motor operated only for that purpose, wear and tear on this equipment and on the line or jack-shafts, through which the rotary table would be driven, are reduced, saving in maintenance and replacement costs.

Electric motors approach the steam engine in smoothness of performance and control. However, in direct drives their ability to absorb shock loads, such as are incurred in rotary-table operation when increasing and decreasing speeds, has been dependent on the provision of a suitable flexible coupling or connection in the drive-shaft between the prime mover and the load. In the absence of adaptable couplings for that purpose, operation of motors also has usually called for installation of reduction-gear units or other means of indirect drive.

Problems which have stood in the way of employment of electric motors in direct rotary drives apparently have been overcome, however, in an installation that has been made on a large diesel-electric rig operated by a large major company on the Louisiana Gulf Coast. The installation, the first of its kind, has now been in operation several months and has proved unusually effective, meeting all requisites for wide flexibility and simplicity in speed control and smooth performance. The unit is so small and compact that it occupies less space on the derrick floor than a steam-powered prime mover, and is so placed that it presents practically no obstruction. The rig is a drilling barge assembly used in maritime operations in the marsh and water areas along the coast. Diesel engines driving the generators supplying the electricity are capable of delivering 1000 h.p. The power plant is housed on a separate submersible-type barge with cable extensions to the main drilling barge. The draw-works, three mud-pumps, wire-line coring unit, and various auxiliary units, are all driven by independent motors as prime movers. All equipment is of the large and heavy-duty type and suitable for Gulf Coast deep drilling. Details are given of the coupling used, the type of installation adopted, and of the electric circuit employed.

A. H. N.

547.* Proper Care Can Double Service Life of Rubber Hose. E. Sterrett. *Oil Wkly*, 8.2.43, **108** (10), 11–14.—Of all the oil-industry equipment involving rubber in its construction, rubber hose is least likely to be rendered unserviceable solely through the loads placed on it by the service for which it is designed. Experts estimate that not one hose in ten actually wears out through carrying fluids, including gases and steam. External heat, light, acids and gases, abuse, and unnecessary abrasion shorten the life of most units, and the greatest factor in hose deterioration is abuse. The amount of rubber in a rubber-lined cotton fire hose is relatively slight, while the percentage of the same material in a rotary hose may be high, but in either instance failure of the sealing material—the rubber—renders the hose unfit for further service. The paper deals with various abuses of hose and gives hints on its proper maintenance.

The following is a summary of how to prolong hose life: Handle with care. Avoid kinking when uncoiling. Let hose untwist when pulling from coil. Avoid stretching hose—when filled to working pressure it tends to shorten and fastening both ends rigidly when fully extended imposes severe strains on fabric. Do not walk on hose, nor roll heavy objects over even a wire-reinforced hose. If once deformed, do not attempt to hammer a flattened hose back to round again. If pressure does not help reshape the deformed section, cut out damaged length and splice with rigid coupling Avoid sharp bends and kinks. Hose is designed to carry equal stresses all around its circumference. In a kink the outside is overloaded, the crimp carries no pressure. Hose is built with a factor of safety of four. Operating under a lower factor decreases hose life, due to excessive fatigue. Do not expect a hose to span wide gaps and carry load. A plank spanning the gap will support the hose and prevent overstressing. Be sure the hose is used in the service for which it was built. Suction hose is not built to withstand interior pressure, nor pressure hose to resist collapse, nor should steam be carried in water hose. Hose not in use should be carefully drained, then coiled and stored flat in a cool, dark place away from sunlight, oils, acid, and fumes. A. H. N.

548. Value of Directional Drilling to Straighten Hole Shown by Wood County Discovery. H. F. Simons. *Oil Gas J.*, 11.2.43, **41** (40), 41–42.—The paper describes the use of directional drilling to straighten a well in a particular instance. The drilling of the well demonstrated the application of the technique. In this case, directional drilling was tried after attempts to shoulder-up failed, and an excellent comparison of the techniques was afforded. It also showed that in areas commonly known for ease of drilling and where all the necessary precautions are taken, a hole may deviate from the vertical. Also, while the formations are such as to make the hole drift from the vertical, it does not necessarily follow that the straightening of the hole is easily accomplished.

It is believed that the condition of the mud affected the deviation of the hole to a great extent. Considerable difficulty was experienced in getting an adequate water supply for the drilling of the well, and sufficient water was not available to control the viscosity of the mud properly while drilling the interval from 2600 to 3700 ft. The mud became practically jelly-like with a viscosity of 100 seconds A.P.I. for 500 c.c. out. Cuttings were not removed properly from the bit, the thick mud reduced the rate of penetration, and the drillers probably increased the weight beyond what they would have used had the mud been normal. Using a mud weighing 9·5 lb./gall. with a viscosity of around 23 secs. A.P.I. for 500 c.c. and slightly less weight, this section could probably be drilled without the hole deviating appreciably. The hole deviated to a slightly greater value than 4°. The time required to bring the hole back by directional drilling was 11 tours and during this time 273 ft. of new hole was made. This can be contrasted with the 26 tours spent in attempting to straighten the hole by shouldering up and by the use of the cement plug. During this time only 187 ft. of hole was made, and in the shale being drilled this should have taken about $1\frac{1}{4}$ tours. The net time comparison in tours could be $23\frac{3}{4}$ for the shouldering-up method which produced no results to eight tours for the whipstocking method which did produce the desired results. The method also compares favourably with the shouldering-up method on a cost basis. A. H. N.

549. Response of Gulf Coast Drilling Mud to Chemicals, Temperature and Heat Treatment. G. Fancher and R. L. Whiting. *Petrol. Tech.*, March 1943, A.I.M.M.E. Tech. Pub. No. 1589, 1–15.—The experimental work was carried out on a typical drilling mud from the Hastings field of Texas. The mud contained only 8% (dry weight) of material of colloidal dimensions, which is largely illite. The treatment of the mud was carefully standardized, and viscosities were measured in a Stormer viscometer, and gel strength in a Stormer viscometer modified by the addition of a chainomatic weight device. Successive quantities of tenth-molar and molar solutions of various phosphates were added to samples of the mud, and the viscosities, and in some cases the *p*H and filtration rate, were measured. The effects of dilution were examined. Dilution lowered the viscosity and gel strength while increasing the filtration rate, and the polyphosphates as a group caused greater viscosity reduction than the orthophosphates. The number of mols. of polyphosphate required for a maximum reduction in the viscosity of the mud caused solely by surface adsorption of the chemical was independent of the particular polyphosphate used. The viscosity-reduction curve obtained on dilution is seemingly a function of the type and chemical nature of the aqueous solution added, the viscosity at the time of chemical treatment, the original stability of the suspension, and the mineral composition of the mud.

Sodium acid pyrophosphate and sodium tripolyphosphate were more efficient than other complex polyphosphates for chemical treatment, and mud treated with either of these two compounds showed maximum reduction in viscosity and minimum filtration rates at low concentrations, while the treated muds were virtually unaffected by heat treatment.

Heating causes permanent changes in the rheological properties of a mud, the changes depending on the time of heating up to a certain maximum time. The viscosity of a mud at an elevated temperature depends on the relative value of the viscosity–

temperature variation of water, and the effect of temperature on the dispersed clay in the mud.

Generally, the minimum filtration rates for chemically treated muds were obtained at points of maximum reduction in viscosity. G. D. H.

Production.

550. Volumetric and Viscosity Steadies of Gas and Oil from the Santa Maria Valley Field. R. H. Olds, B. H. Sage and W. N. Lacey. *Petrol. Tech.*, March 1943, A.I.M.M.E. Tech. Pub. No. 1588, 1–11.—The specific volumes of the trap liquid and of four mixtures of this with the co-existing trap gas from a surface separator in the Santa Maria Valley field, were determined at 100°, 190°, and 250° F., and at pressures up to 4000 lb./in.^{2}. The viscosity of three mixtures of the trap samples was measured at 100°, 190°, and 250° F. for pressures up to 5000 lb./in.^{2}. The gas–oil ratio of the four mixtures ranged from 111 to 813 cu. ft./brl.

Studies of the volumetric behaviour of the trap liquid showed the specific volume of the bubble-point liquid to increase at a diminishing rate with increase in bubble-point pressure. For the sample with a gas–oil ratio of 111 cu. ft./brl. the curvature of the bubble-point locus is opposite to that for the trap sample. The bubble-point pressure increases almost linearly with the gas–oil ratio for a given temperature, the rate of increase being higher the higher the temperature. There is an almost linear relationship between formation volume and gas–oil ratio throughout the heterogeneous region covered by this experimental work.

For the trap liquid, the viscosity is a minimum at the bubble point, and log.-viscosity increases roughly linearly with the pressure, and is lower the higher the gas-oil ratio.

Tables give the composition and properties of the trap samples, the composition of the experimentally studied mixtures, and the volumetric behaviour of these mixtures; the properties of the bubble-point liquid, and the viscosity of the experimentally-studied mixtures and of the bubble-point liquid. Much data are presented in graphical form. G. D. H.

551.* Proper Counterbalancing—An Equipment Conservation Measure. E. N. Kemler. *Oil Wkly*, 11.1.43, **108** (6), 9–12.—The paper deals with the elements of counterbalancing wells and treats the problem in a very simple manner. When new equipment is installed a smaller size of unit can frequently be used if the engineer or manufacturer can be assured that the well will be kept properly counterbalanced and, in the interests of conservation, operators of equipment should see that this is done. There are several possible means of checking whether or not a well is properly counterbalanced. D. O. Barrett has outlined one simple procedure which can be used by any field man. ("Proceedings, 21st Annual Meeting, A.P.I."—1940, *Bulletin*, 226, p. 200.) This method uses the clutch, which is a torque or power transmitting device, to check the torque or power being transmitted. The procedure in this method is as follows: 1. Set the throttle on the engine at a fixed position. 2. Release the clutch slowly to the point where it will pull the peak load. A further release will result in the clutch slipping equally on the up and down stroke if the well is properly counterbalanced. If it is considerably out of balance, it will slow up and slip on one side and speed up and hold on the other. A little experience with wells in and out of balance will develop a technique in checking of wells. Usually the speed variation in the case of wells out of balance is noticeable and can be used to check the well. When the throttle is not set at a fixed position the time lag of the governor may cause speed fluctuations that might be incorrectly interpreted, so that it is important that the throttle be set before the counterbalance is checked.

Other methods will be discussed in future instalments on this problem.
A. H. N.

552.* Good Judgment Required to Fight Production Corrosion Problems. F. Briggs. *Oil Wkly*, 11.1.43, **108** (6), 13–16.—The problems encountered in corrosion are discussed together with the tests to be made and countermeasures to be taken to minimize corrosion troubles in production. The selection of proper equipment involves the two items of tubing and rod string. With tubing, the selection is between manufacturing processes rather than chemical or alloy content. However, tubing fabrication such as wrought iron can be specified. Sucker rods, while more involved in alloy content, have been more or less standardized as to type. The field application of zinc to the rods is a process of moulding. The mould should fit around the rod, be approximately 5 ins. in length and contain enough volume to hold between 2 and 5 lb. of zinc. The rod should be prepared for the zinc by cleaning the surface of all scale and then slightly roughing so that a good bond between the rod and the zinc may be obtained. Only pure zinc should be used. Zinc inserts for specially prepared cages are commercially manufactured and may be obtained where the producer does not desire to mould his own zinc protectors.

The inspection of rods and tubing is a technical service rendered by a few specialized companies. Pitted rods can be found and discarded by the field personnel, but a new and intricate device is required to locate the small fatigue cracks prevalent in rods subjected to high loads and corrosive fluids. Inspection of the tubing walls is also an involved process but one that is available in most localities. (A very comprehensive description of these two inspection processes was published in *The Oil Weekly*, March 17, 1941.) Insulated flanges for lines are manufactured commercially. These flanges are installed between the suspected source of the electric currents and the part to be protected, whether it be well or storage tank.

The chemical processes for combating corrosion are of two types : those that tend to change the fluid characteristics from " acidic " to " basic," and those that form a protective sludge coating on the tubing walls and the surface of the rods. The first method is used mainly in closed systems of small dimensions, such as the cooling system of an engine. The sludge coating chemical is sold commercially and usually involves injecting the chemical in the casing at regular intervals. In each case, instructions for the use of these chemicals are provided by the manufacturer.

A. H. N.

553.* Application of Gravel Packing to Unconsolidated Sands. R. Winterburn. *Oil Wkly*, 11.1.43, **108** (6), 17–23.—Both prepacked gravel liners and gravelling by circulation are discussed.

Perforated liners which are prepacked with gravel in the annulus between the liner and a perforated outer sheath before being run into the well have come into general use among small operators at Wilmington. The most important factors affecting the performance of this type of gravel screen are : (1) Selection of proper gravel size. (2) Provision of ample area of perforations in outer sheath. (3) Uniform tight packing of the gravel in order to prevent movement of gravel and possible uncovering of perforations before the liner is landed. (4) Thorough removal of mud and filter cake from the well before placing on production.

Selection of proper gravel size has been the subject of much experimentation, and is covered in a general discussion of the selection of gravel size elsewhere in the article. Perforated outer sheaths used in prepacked liners are generally made of plates punched with $\frac{3}{32}$-inch round holes on $\frac{5}{32}$-inch centres, 60-mesh horizontal slots, or woven steel wire screen. These types have 25% to more than 30% of their surface consisting of perforations and have performed satisfactorily. Outer sheaths resembling conventional slotted liners in per cent. of area perforated have not yielded as high initial rates in comparable wells.

Gravel packing by circulation is then discussed, followed by the principles of flow and sand-carrying capacities of flowing fluids. Experience in Wilmington wells has demonstrated that sand entry is practically eliminated in all cases where the ratio of maximum gravel diameter to the 10-percentile sand-grain diameter is 12 or less. The finest sand encountered in most Wilmington wells has a grain diameter at the 10-percentile point of about 0·015 inch. Gravel sizes used most commonly in prepacked liners are 0·003 to 0·131-inch and 0·131 to 0·187-inch. One manufacturer has standardized on 0·070 to 0·110-inch gravel and one operator has installed a number of liners packed with 0·078 to 0·093-inch gravel. Recently a number of liners have been packed with 0·187 to 0·270-inch gravel. This size is designed to permit the entry of small amounts of sand into the well, with the purpose of minimizing the plugging action which apparently takes place at the outer periphery of the gravel. This practice is discussed.

In gravel-packed wells the most common gravel diameter used is 0·131 to 0·187-inch; some wells have been packed with 0·093 to 0·131-inch gravel, and several of the early jobs used $\frac{1}{4}$- to $\frac{3}{8}$- or $\frac{1}{2}$-inch gravel. Those wells packed with this coarse gravel (more than $\frac{3}{16}$-inch) have produced sand to some degree but have experienced much less difficulty than the average well with conventional liner.

A. H. N.

554.* Performance of Unconsolidated Sand Wells Using Gravel Packing. R. Winterburn. *Oil Wkly*, 18.1.43, **108** (7), 20.—Graphical data are presented on the performance of gravel-packed wells. In the case of the circulated gravel packs it is noted that the curves show an initial rate of decline which is less than or equal to that of conventional wells. In the later stages the circulated packs show nearly constant or accelerated decline, while in the conventional wells the tendency is for the rate of decline to diminish. Wells with prepacked liners exhibit more rapid initial rate of decline of productive index, decreasing in later stages. Throughout the history available up to now, the rate of decline has remained more rapid than in comparable wells with conventional liners.

In general, it has been observed that wells gravel packed with mud as a circulating fluid have considerable lower initial productive indices than comparable wells with conventional liners. A few wells which were gravel packed with oil as a circulating fluid have apparently exhibited better initial productivity, although data are not available to permit direct comparisons with conventional completions made at the same time.

Experience at Wilmington has demonstrated that: (1) Reduction of production expense, ability to produce at higher rates for several years, and elimination of the risk of sand abrasion and collapse of liners can be attacked through the use of circulated gravel packs and prepacked liners in areas and zones presenting acute sand problems. (2) Where all sand is screened by the gravel pack, plugging at the gravel face may reduce the productivity of the well to uneconomic rates before the producing sands are depleted. (3) There is a possibility of increasing the economic life of wells without necessity of remedial work by use of gravel large enough to permit production of small amounts of sand continuously. However, this practice entails increased operating costs and greater risk of eventual damage to liners.

Possibility of using smaller water strings and still providing ample clearance for washing over and recovery of liners with the same inside diameter in the case of the circulated gravel packs should be considered. This is illustrated by the fact that a 4-inch liner may be washed over through a 7-inch water string, while the same liner prepacked to $5\frac{1}{2}$-inch outside diameter would require an $8\frac{5}{8}$-inch water string to permit washing over.

In deciding whether to select gravel designed to screen all sand or to permit small quantities of sand to be produced with the oil, no general rule can be stated. All experience bearing on the particular case under consideration should be reviewed. Those wells in which initial production rates of from 100 to several hundred brls./day are anticipated, and which experience has shown may be expected to have relatively long productive life before declining to uneconomic rates, are in a position to benefit to the greatest extent from the minimum production costs and absence of risk of damage to the liner to be gained by complete exclusion of sand. On the other hand, low-pressure-heavy-oil zones yielding wells of small initial production afford the best opportunity for advantages to be gained from use of coarse gravel to permit some sand entry into the well.

A. H. N.

555.* Degasification of Coal Seams Would Give East Gas Fuel. Anon. *Oil Wkly*, 18.1.43, **108** (7), 33.—The paper presents a brief explanation of methods which can be used to degas coal seams using vertical as well as Ranney's horizontal boreholes. Technical and economical factors are studied in brief.

A. H. N.

556. Efficiency of Bradford Water Floods Can be Greatly Increased. H. M. Ryder. *Oil Gas J.*, 21.1.43, **41** (37), 29.—The principal unnecessary losses of oil have been caused because of: (1) Not utilizing all of the pay-sand. (2) Flooding the sand too slowly to wash out all the available oil. (3) Shooting very open and worthless sand so heavily that it takes most of the water supplied, leaving an entirely inadequate amount for the pay-sand. (4) Not providing proper back pressure for floods—*i.e.*, one-sided flooding. (6) Packing off pay-sand. (7) Ignoring old water, known or unknown, already in the sand. (8) Unnecessarily trapping oil between floods and the edges of sand layers. The first four items are discussed separately and in some detail; the last four are grouped and discussed together. It is concluded that if Bradford producers are to realize the extra $100,000,000, which they can do, they must flood all the sand at their wells, they must flood it at as nearly the most efficient speed as possible, provide sufficient intake wells, and drill their producing wells into oil instead of into water. This is being done on some properties.

Objections to these conclusions are: (1) Experience is considered to indicate that high pressure causes " by-passing " not found at low pressures. (2) All the available oil is expected to be produced at some time, no matter what plan of development and operation is followed. (3) If a property has not produced satisfactorily, the sand is considered to be the only cause. The method has nothing to do with it. (4) A neighbouring property or the producer's own property has shown a profit with slow flooding, therefore slow flooding is satisfactory. (5) Production over many years is desired as income insurance. Full-speed flooding is considered to water out the sand too rapidly. (6) Full-speed flooding produces most of the oil during the first year. This is considered to result in an unbalanced income and in unnecessarily excessive taxes. These arguments are discussed. A. H. N.

557. Dual Completions in Kansas. N. Williams. *Oil Gas J.*, 21.1.43, **41** (37), 53–54.—Producing horizons concerned in the dual completions in Rice and Barton Counties are the Kansas City–Lansing series as the upper zone and the Arbuckle lime as the lower zone. The former, which is found around 2870 ft., contains from one to three pay-zones with a thickness of from 5 to 15 ft. each. The Arbuckle lime, which is found at slightly under 3200 ft., probably has a thickness of several hundred feet, but generally is not penetrated more than 15–20 ft. Minimum penetration to get production is desired, sometimes not more than a foot or two, because of the danger of water encroachment. For dual completions involving these two formations the practice has been to drill the well first to the top of the Arbuckle dolomite, usually with rotary tools. Then, with the oil-string landed at that point and cemented with enough cement to fill up behind the casing to above the top of the Kansas City-Lansing series, the well is completed in the Arbuckle in the usual manner, and the productivity in that formation established. Then a packing element is installed in the bottom joint of the oil-string, this being run in and set with the string of tubing that is to be used in producing the well. The packer used so far has a flapper valve on the bottom which closes the opening when the tubing, which is run through the opening, is pulled. To test the effectiveness of the packer element in sealing off the Arbuckle, the hole above the packer is bailed dry. With the effectiveness of the seal assured, completion of the well in the Kansas City–Lansing producing zone is undertaken. Completion practice by perforating the casing and acidization is described.

Success of the operation depends largely on the use of an adequate amount of cement in cementing the casing to extend above the top of the upper producing horizon, and on the effectiveness of the seal between the two formations. Should water conditions develop in either formation that cannot be corrected by cementing and that make further production of oil from that zone impossible, the formation can be squeezed and the remaining formation produced alone. All packing elements are made of drillable materials, so that if a failure should occur, packer can be removed and another installation made. A. H. N.

558.* Pressure Maintenance Success is Highly Lenticular Field. J. A. Korafeld. *Oil Wkly*, 25.1.43, **108** (8), 21–22.—The stratigraphy and production history of the Batesville field are given. Success of pressure maintenance at Batesville has been correlated with simultaneous application of efficient production methods in the operation of Bird, Hanley and Sheedy properties. These have insured a greatly-lengthened flowing life, so that currently 75% of the total number of wells on the company's two blocks are still flowing. At one time the entire field produced as much as 1600 brls. of oil/day, largely from flowing wells. These methods include: (1) Use of bottom hole chokes to control the gas-oil ratio; (2) constant use of small tubing strings; (3) low production rates; (4) elimination of open-flow potential tests for long periods.

The slim tubing strings consist of both ¾-inch and 1-inch. This has remained a constant practice since the field's discovery. The policy of small withdrawals/well and constant production operation as contrasted with large intermittent withdrawals is believed to have created less possible disturbance of the reservoir. Company officials estimate that pressure maintenance will result in doubling of the ultimate per-acre yield within the limits of the two blocks being pressured. A. H. N.

559.* Preventing Oil Traps in Pressured Sands. F. R. Cozzens. *Oil Wkly*, 25.1.43, **108** (8), 28.—One fundamental objective in sand pressuring is to have forces from opposing input wells to meet, as early as possible, in an area of producing wells. An input well with leaky packers, or with packers set too high or too low in the sand, delivers an irregular and feeble pressure, often sufficient to force oil only a short distance from the input zone. Normal pressures from the other inputs, travelling faster and with more strength, reach the producing wells first, and, finding no counter resistance, they move on to trap quantities of oil between the producers and the weak input well. In air or gas pressuring, such traps can generally be released by greatly increasing pressure for a time on the faulty input (after repairs are made), while pressures on nearby inputs are reduced in proportion. In the case of water-flooding, however, this treatment is not practical, because the counter pressure is generally a back flood and the oil cannot be forced through a water-soaked sand.

A well which responds too slowly in comparison with others in the pattern suggests a too tight or restricted sand zone, or some mechanical barrier. Wells which have been in steady production and suddenly begin to fluctuate, and dwindle with no apparent cause, usually indicate weakness in sand pressure, at or very near the producing zones. Wells, building up sudden and abnormal heads of salt water with a receding oil output, often reveal that too high a pressure is being inducted into the low, or water-logged sections of sand. Conflicting, or counter pressures, which meet outside a producing zone may often be detected by an abnormal kickback or a sudden building up of pressure in the input well. These and similar observations are easily noted by keeping daily well records on production and input. Once this practice has become established, prompt adjustments can be made to prevent formation of oil-traps, and the result in more than 80% of the cases is a substantial saving in oil plus a far more effective oil recovery. A. H. N.

560. East Texas' Future Directly Related to Return of Water to Woodbine Sand. Part I. H. F. Simons. *Oil Gas J.*, 28.1.43, **41** (38), 175–178.—Recent production history of the field is reviewed. Graphical representations of production and pressure data are given. Bottom-hole-pressure maps of the East Texas field naturally show the results of producing rates in various sections. Where the well density is high, the pressure is down and all the wells are pumping. In areas where the withdrawal has been more restrained the pressure is up and the wells flow. A water map of the field also reflects the production rate and the rate of encroachment. The water is approaching from three sides—west, south, and north—the east and highest side of the field being practically free from water. By maintaining the bottom-hole pressure above 1000 lb., or even increasing it slightly by controlling the withdrawal, the oil will be flushed out of the sand evenly, the water level will rise gradually, wells will continue to flow until they begin to make water, and the pumping period will be comparatively short. There will be only about 3% oil remaining in the formation after such flushing by natural water drive. The recovery of oil will be increased by some 600,000,000 brls. of oil.

The alternative is to permit the pressure decline to continue, hasten the need for pumping equipment, increase the expense of getting the production, hasten the abandonment of many wells, and decrease the ultimate recovery. Testimony at the recent hearings of the Railroad Commission on the East Texas field showed that the bulk of the wells are abandoned soon after they begin making 300 brls. of water daily. After a well gets to making 100 brl. of water it takes about 10 months for it to get to the point where it can no longer produce its allowable and fall into the marginal class where it can produce less than 20 brl./day. After another 18 months the well is abandoned, at which time it is making from 300–400 brl. of water/day and 504 brl. of oil.

A study is made of water production and its effects on the economics of the field. Plug-back operations to reduce water productions are briefly described. The operator producing salt water has a choice of attempting to gain a shut-off, of making arrangements for the reinjection of the water at the same time applying for an oil bonus for the water returned to the formation, of shutting in the water producer and asking for the 1 brl. of oil for each 50 brls. of water shut in, or of curtailing the water production to 10 times the allowable/day getting the oil that is produced with that amount of water. The 1 brl. of oil for each 50 brls. of water returned defrays the expense of injecting the water. If the bonus oil can be produced from the operator's own properties, he can transfer the allowable to these. Or he can purchase this oil from another producer for around $0·93/brl. If an operator has two wells on a lease, both making water, he can convert one to an injection well and take his bonus oil from the other well or another well which does not make any water. The only limit to this arrangement is the amount of water which can be handled economically and the proration restrictions on per-well production.

One fact forcing many operators to favour salt-water-production restriction and/or reinjection is the scarcity of pumping equipment. Without some means of maintaining the reservoir pressure at its present level, 1600 wells will be converted from flowing wells to pumpers during 1943. Obtaining that much pumping equipment is a serious problem. If pumping is restricted or postponed by reinjection of water then existing pumping plants can be transferred to meet the demand. A. H. N.

561. Completion Practices in North-west Wilmington Area, California. W. R. Cabeen and A. L. Hunter. *Oil Gas J.*, 28.1.43, **41** (38), 179.—Drilling and cementing practices are given first, followed by the completion programme. After testing the water shut-off and drilling the cement the hole is under-reamed. The next step is to run prepacked gravel liner to bottom, blanking off the shaly portions of the section. The electric log, run on the interval below the F_1 point (shoe point), is used to determine the intervals to be produced and those to be blanked in the combination liner. There are three sections that are usually blanked : (1) That shaly interval approximately 50 ft. in thickness occurring between the two main sandy phases of the Ranger zone; (2) the interval between Ranger (Pliocene) and Terminal (Miocene) varying in thickness from 165–190 ft., according to the particular location, its structural position, etc., and (3) the J shale, which is approximately 90 ft. thick. Cementing the blank liner sections in North-west Wilmington has proved to be the wisest procedure. The advantages of cementing the blank intervals are : (1) to assist in the prevention of liner collapse due to production of sand from below these blanked shale intervals, and the resultant removal of their support in the hole which, together with disintegration of the overlying shale by absorption of water, causes these shale intervals to move in against the liner and collapse it, which usually necessitates the expense of a redrill job. The source of water in the Ranger-Upper Terminal section in North-west Wilmington is found in this grey sand streaks in the predominately shale intervals (2) and (3) mentioned above. Source of the water in these intervals has been found by core data and water-witch determinations, and varies stratigraphically from one fault-block to another, depending on factors governing the accumulation of fluid in each fault-block. Therefore it follows that the technology to be applied will vary according to the fault-block and the position of the well under consideration in that fault-block. A surprising number of liners in wells in North-west Wilmington have collapsed in the last few months. In all these wells the blank sections had not been given support by cementing.

(2) By cementing these blank sections the above-mentioned wet streaks occurring in these shaly intervals are cemented off, giving the well a much lower cut. This also stops the disintegration of the shale by the water behind the blank which aids in and leads to collapsing the liner. (3) If at any time it is necessary to plug the well back, it is only necessary to put a bridge-plug in the cemented blank to make an effective shut-off. In North-west Wilmington this is especially important as the J sand, in the lower portion of the hole, is in certain areas the most likely member to go wet first necessitating the plugging of the bottom of the hole.

Cementing of the blank sections is described in detail, followed by a short discussion on gravel packing in this area of California. The paper is to be concluded in another instalment. A. H. N.

562. Some Kansas Flooding Practices. P. Reed. *Oil Gas J.*, 4.2.43, **41** (39), 36–37.—In the past year there have been a number of instances of operators introducing water-flooding into shoestring sands where they have been repressuring with gas or air for a number of years. In these programmes water-flooding has been applied on part of the shoestring, while at the same time the operator continues to repressure the remainder with gas or air. One operator who is doing this on a shoestring which has been repressured with gas since 1935 says that results indicate that the lifting cost with water-flooding is about half of that for producing with gas repressuring. Lifting cost for this shallow shoestring property, including depreciation of equipment as well as the regular lease expenses, but not including depletion or office overhead, has been running between 40 and 60 cents/brl. during repressuring with gas.

The water-flooded section is near the centre of the shoestring. The pattern adopted is the elongated or rectangular five-spot, 250 × 500 ft. Input wells are not located as near the edge of the shoestring as producing wells. Some of the input wells had formerly been used for injection of gas. Before converting them to water-flooding they were shot and tubing was cemented in the usual manner; results have been satisfactory. The general custom in this part of the Kansas water-flooding territory is for operators to pump rather than flow-producing wells from the beginning. One operator who turned from pumping to flowing on a fairly large scale later returned to pumping in order to produce at a faster rate. However, in some cases stopcocking is done with success in the last stages of flooding after the peak has past and production has dropped to a marginal status.

Multiple completions are described in some detail. Sources and treatment of water are briefly discussed. A. H. N.

563. East Texas Salt-Water-Disposal Project May Set Pattern for Future. H. F. Simons. *Oil Gas J.*, 4.2.43, **41** (39), 38–41.—The organization of the co-operative project is described together with certain of the economics involved. Injection of the salt water amounts to practically a secondary recovery project, as the returned water will maintain the natural-water drive which is forcing the oil upward and out. The rate of water influx is approximately 625,000 brl./day under present pressure conditions, as shown in a preceding article (*Oil Gas J.*, 28th January, 1942, p. 175), and if all the water is returned, the oil withdrawal may be at that rate or 550 brl./day. Maintaining the natural water drive will be much more effective than depleting the field of its reservoir pressure and producing less ultimate recovery under less efficient operation. Another eventuality to be considered is the exhaustion of the incoming water, something which has happened in other water-drive fields. While it is not expected in East Texas, it is a possibility which might cause the loss of a huge quantity of oil. The plan is eventually to inject all salt water produced in the field into the Woodbine sand, but putting the plan into operation is naturally slowed by the war effort, which prevents or delays the obtaining of equipment. Consequently, the plan will be effected through units, all being part of the system and each going into operation as soon as completed. Different plans are discussed.

The system selected consists of aeration, chlorination, more aeration and settling, filtering, and finally gravity injection into the Woodbine sand. A typical system for handling 25,000 brl./day will consist of two gathering pits of 12,000-brl. capacity each with the incoming water being aerated and chlorinated. Generally, the water will flow by gravity from the lease-tanks to the gathering pits, and will be transferred from them to the injection plants by pump pressure. The injection-plant facilities include chlorinators, a 25,000-brl. pit, eight pressure filters, and one or more injection wells. Chlorination of the salt water will be by electrolysis. About 7 volts and 400 amp. are used to effect the liberation of the chlorine. The capacity of the cells to generate chlorine is dependent on the size and number of plates. The plates are made of graphite and are $1\frac{1}{4} \times 6 \times 30$ in., and four of them will give sufficient capacity for 5000/6000 brl. of salt water daily. The current necessary for the chlorination will be provided by direct-current generators driven by internal-combustion engines or by motor-generator sets. Internal-combustion engines used for this purpose are 15-h.p. output.

The chlorinators are located just ahead of the large aeration pits, sometimes in conjunction with, but separated from, a skimming pit which removes any oil from the salt water. The final filtering will be in pressure filters operating at low differential. These filters consist of assorted sands and gravels specially selected. Facilities for backwashing the filters consist of pumps and the necessary connections to change direction of flow. Details of wells, meters, cement-lined casings, etc., are given.
A. H. N.

564.* Economics of Water Flooding. H. S. Milam. *Oil Wkly*, 8.2.43, **108** (10), 15–16.—In North-eastern Oklahoma and South-eastern Kansas at the beginning of last year there were 72 water-flood projects in operation. During the year 1941 additional acreage placed under water-flood amount to 1597 acres, making the total acreage under water-flood 8454 acres. The total pipe-line runs of all oil production in North-eastern Oklahoma and South-eastern Kansas for 1941 amounted to 9,636,289 brl., of which 3,976,390 brl. of 40%, was produced from the properties under water-flood. From North-eastern Oklahoma during 1941 the pipe-line runs amounted to 6,261,664 brl., with 2,970,350 brl. or 48·2% coming from the water-flood projects. This is an increase of 327,543 brl. over the production during 1940.

From South-eastern Kansas during 1941 the pipe-line runs amounted to 3,374,625 brl., of which 1,006,040 brl. were produced by water-flood methods. This amounts to 29·8% of the pipe-line runs for the same period. At the beginning of this year the total number of water-injection wells on water-flood projects was 3370, and the number of new producers drilled will be only slightly less than that figure. The accumulative total of oil produced by water-flood methods up to the first of this year amounts to 15,525,098 brl. This production has been obtained with an oil–water ratio of 1 to 11·4 (meaning that one barrel of oil was produced for each 11·4 brl. of water injected).

The most outstanding water-flood project, and the best known, is the Forest Producing Corporation No. 1. The original 160-acre pattern having produced up to the first of this year, a total of 1,048,009 brl. of oil, or an average recovery of 6550 brl./acre. This project was started in the autumn of 1935, and is still producing about 20 brl./day. The production during the first few years was pumped from a central power, but is now being flowed. This project is located in Section 18–26n.–17e. Sections which are not responding are also reviewed.

There are a few projects that have already made a recovery of in excess of 3000 brl./acre, and a few more that have reached the 2000-brl. stage, but these are of course the elder projects. The majority are approaching the 2000-brl. stage. Costs are briefly discussed, and in general terms only. Methods of reducing costs (*e.g.*, by wider spacing) are outlined.
A. H. N.

565.* Calculation of Actual and Effective Counterbalance. E. N. Kemler. *Oil Wkly*, 8.2.43, **108** (10), 17–20.—Counterbalancing may in theory be applied to accomplish any one of many functions. It may be applied to equalize the peak torque on the equipment, to make the average torque or horse-power on the up and down strokes equal, to make the peak bearing loads a minimum, etc. It is generally applied to reduce equipment loads or size, and as such will probably reduce the peak or average torque. Practically any normal well, when properly counterbalanced for peak torque, will have nearly equal up- and down-stroke speeds and power requirements and minimum average torque. Any attempt to calculate the proper counterbalance will require the use of a dynamometer card unless some empirical formula or rule is employed. The determination of the proper amount of counterbalance from a dynamometer card may be quite difficult. The method to be used will depend on the purpose of counterbalancing. Three practical purposes are keeping of peak effective load a minimum, keeping peak torque a minimum, and balancing up- and down-stroke average torque or what is equivalent, the up- and down-stroke horse-power. The difficulties involved will depend on the shape of the dynamometer card and on the degree of accuracy desired. The square type of card is frequently identified with slow-speed pumping. In this case a counterbalance equal to the average of up- and down-stroke loads will result in equal set or effective up-stroke and down-stroke loads, equal peak torques, and will make the average torque on the up stroke equal the average torque on the down stroke and will also make the up-stroke power equal the down-stroke power.

The paper gives an illustration of calculating counterbalance for a particular example. A. H. N.

566.* Computing Lifting Efficiency of Oil Wells Produced by Intermittent Flow.—S. F. Shaw. *Oil Wkly*, 8.2.43, **108** (10), 28.—Behind all calculations is the desire to estimate the quantity of gas under a given flowing pressure that is required to lift a barrel of oil under conditions of maximum lifting efficiency, or of maximum capacity of the educator. Methods of comparison for determining the quantity of gas required for continuous flow can be worked out fairly satisfactorily, but methods for determining the quantity of gas required to lift a barrel of liquid by intermittent flow are not as satisfactory, and the writer has therefore employed another basis for computing the number of cu. ft. of compressed gas required to lift liquids when employing the slug-flow type of discharge, which method might be termed the "volumetric method," because of the displacement type of flow that takes place.

Lifting efficiency when displacing oil might be compared, as a measure, with that of the volumetric efficiency of a compressor when compressing gas. The gas in the cylinder is all displaced at the end of a stroke, and is discharged, except that which remains in the clearance spaces between the piston and the head in the cylinder, or in the spaces around the valves that are not flush with the cylinder walls. In intermittent flow, gas is injected into the eductor between the slug at a higher pressure than that required just to balance the slug of liquid; it may be injected into the eductor for a slight period after the slug begins to spill over at the top of the well, even though this be at increased expenditure of power; also a portion of the bottom of the liquid slug may tend to drop back into the gas column. These factors tend to reduce the volumetric efficiency of the displacement operations, but a large number of tests seem to indicate that the quantity of gas required for this type of flow can be determined by the volumetric method within about 10% of that actually needed. If the quantity used is in excess of 10% of that computed as necessary, it would be well to examine the setup for inefficiencies in the manner in which the method is employed.

The theory of the method is briefly explained; tables are presented for the use in the calculations, and finally an example is solved and the solution discussed in some detail. A. H. N.

567.* Constant Intake Hook-up Improves Gas-Lift Operation. Anon. *Oil Wkly*, 22.2.43, **108** (12), 21–22.—The operator of a large gas-lift station in a western oil-field encountered fluctuating intake pressure immediately after the plant was put on the line. The shift workers were constantly changing and adjusting position of the valves on the intakes to smooth out operation cycles, frequently being obliged to pinch the intake to the point where the volume handled was insufficient to operate the gas-lift equipment at the individual wells. The problem was put up to the chief engineer with a limit on the amount of money to be spent. He proposed one solution after another, most of which called for an elaborate hook-up requiring several expensive instruments, valves, and regulators. A solution was finally reached which required only three controllers: the main pressure controlling valve and two pilots. The intake line was cut near the plant scrubber to install a flanged master-gate valve. A 4-in. by-pass was placed around this connection, into which the main pressure controller was flanged, all of this being installed below ground-level in a gate box large enough to protect the equipment and furnish sufficient space for adjustment, replacement, and maintenance. Two pilot valves, on a half-inch line from the scrubber, control the operation of the main pressure controller, which is set to operate about half-way between wide open and closed. One of these pilots is permanently adjusted to control the pressure to a maximum of around 25 lb., and is not touched again except to pack the stem at long intervals and to test for control range. The second valve is variable, which the operators may adjust to maintain any desired pressure below the maximum of 25 lb., depending on plant conditions at time of adjustment. The plant has worked smoothly since the installation of the controllers. A. H. N.

568.* Comparison of Beam and Rotary Counterbalances. E. N. Kemler. *Oil Wkly*, 22.2.43, **108** (12), 28.—Force diagrams for upstroke and downstroke movements of pumping beam is studied for both beam and rotary balance. The important factor to be noted in connection with forces in the beam counterbalance is that the pitman bearing must be able to carry a load in either direction. If beam balance is used, the pitman and pitman bearings must be designed to work with beam balances. Provision must be made for adjustment of these bearings to prevent lost motion and bearing trouble. In most cases some beam balance can be used with the simple type pitman in use on many wells without changing the bearings. The amount which can be safely used can be determined from analysis or from experience.

The case of rotary balance is then noted. In this case the pitman is always in tension. The bearings will always be loaded in the same direction, and can be of a simpler design. The pitman and crank bearings must be designed to carry the full sucker-rod load in the case of rotary counterbalance. The balance is between the crank and well in the case of the beam balance, and, therefore, may reduce the load for which the pitman bearings must be designed. They must be designed to carry the full counterbalance in case the sucker rods fail near the top in the case of beam counterbalance. Because provision must be made to take care of conditions where sucker rods fail, there will be little difference between the size of bearing required. The bearings when only beam balance is used must be adapted to take loads in either direction. Care must be taken in the operation to see that such bearings are properly adjusted and that provisions for adjustment are furnished. When the ratio of stroke to beam length is short the counterbalance weight will act downward, and will produce only vertical components. This load may vary in magnitude only. Except for the horizontal component of the pitman pull, the load on the sampson post will be vertical. In the case of a unit with crank bearing and sampson post on the same foundation the pitman component produces only internal forces and the foundation carries only the vertical counterbalance and sucker-rod loads.

Calculations are made for rotary balance forces both for downward weight effect and radial centrifugal effects. Rotary and beam counterbalancing are studied by typical examples. A. H. N.

Transport and Storage.

569.* Experimental Data with Dusts to Determine Effects on Pipeline Transmission and Orifice Coefficients. G. M. Kirkpatrick. *Pipe-line News*, August 1942, **14** (8), 12.—Before the outbreak of war the Blaw-Knox Co., Pittsburg, P.A., in the course of investigating the operating characteristics and efficiency of a gas-cleaner of their own design, attempted to simulate conditions existing in gas transmission lines by means of glass pipe. This enabled visual data to be collected. This article summarizes the work accomplished before the war and indicates favourable lines of research for the future.

Figures are given to illustrate the way in which dust is laid down when the gas has been caused to swirl or flow in a spiral path by reason of a 90° elbow. Others illustrate the formations when flow straighteners were employed to enforce straight-line flow. Observations made during runs of this type disclosed some unexpected conditions. Where straight-line flow existed there was no observable evidence of sediment in a clear, open line. Sediment did not occur at elbows and orifice plates or in the presence of spiral flow. It seemed that the rate of progress of the moving sand-dunes bore some relationship to the velocity of gas.

To obtain some idea of what may take place in a sag or underbend in a gas line, the glass pipe was set up with one joint sloping down to a 45° elbow and the other joint sloping up and away from the elbow. Less than one quart of oil was introduced in the upstream end of the line, and dust was then blown in. Dust was deposited and held by the oil in the downward-sloping line. Of greatest interest, however, was the heavy deposition of oily dust in the upstream half only of the elbow. The oil collected and remained in the downstream half of the elbow. Similarly observations were made with the glass pipe and elbow placed to resemble an overbend.

Summarily as a result of these and similar experiments useful data were also obtained on the manner in which dust is laid down in a gas line; the circumstances and way in which dust moves in the line; action of dust and liquid on an orifice plate; and effect of dust and liquid on orifice meter measurement. H. B. M.

570.* Somastic Coating Effects Substantial Steel Savings. Anon. *World Petrol.*, November 1942, **13** (12), 52.—In the past it has often been the practice to use steel pipe in weights ranging from 25 to 50% or more in excess of the minimum required by line-operating pressures, when laying pipe-lines in corrosive soils, in order to anticipate corrosion losses. An alternative is to use pipe of the thickness required by operating pressures and apply protective measures, such as coating. In such cases it is essential that the coating should be able to withstand handling, etc., and give the desired degree of protection throughout the useful life of the line. In normal times the cost of such protective measures must be balanced against the cost of the additional steel required of the alternative method. In war-time, however, economy of steel usage assumes a greater importance.

One method of pipe protection which has proved successful in Bureau of Standards tests, and in practice, is to coat the pipe with asphalt mastic, known commercially as Somastic pipe coating. It consists of asphalt, graded mineral aggregate, and long-fibre asbestos, mixed by weight and batched at carefully controlled temperatures. The reinforcement of the mixture by the use of limestone dust and sand, as well as the thickness of the applied coating, develops sufficient strength to withstand the handling imposed by normal pipeline construction methods. A firm bond of coating to pipe is secured by the application of a special primer coat. The mastic may be applied at central or railhead plants adjacent to the line, or, by the use of travelling equipment, on the line itself. By the use of lighter piping a saving in steel usage of 33% is estimated, and the protective material can be applied at a cost lower than the value of the steel replaced.

Application of this coating method to the relaying of old lines is described. Much pipe which would otherwise have to be discarded can be re-used after reconditioning and coating. R. A. E.

Gas.

571.* Poe Sees Need for More Natural Gas Lines to Meet Increased Demand. Anon. *Pipe-line News*, December 1942, **14** (11), 15.—At a recent A.P.I. meeting, E. Holley Poe, Natural Gas and Natural Gasoline Director of P.O.C., is reported to have stated that the natural gas demand in 1942 would exceed that of 1941 by 25% and in some areas by as much as 40%. He estimated that probable consumption in the United States in 1942 would approach 3 trillion cubic ft., or the approximate equivalent in heat energy of 124 million tons of coal, 879 billion kilowatt hours of electricity, or 540 million barrels of fuel oil.

Problems confronting the natural-gas industry are likened to those arising in the production, refining, distribution, and utilization of oil and its many by-products. It has to be remembered, however, that the natural-gas industry is concerned with a well-to-burner operation, and large reserves must be kept available in readiness for a sudden peak demand.

Problems resulting from the impact of war are summarized thus: increased demands by both war industries and private industries; lack of materials to expand facilities; shortage of man-power; increased expenses; heavy tax burden; expected requirements of natural gas, natural gasoline, and related hydrocarbons by all phases of the war effort; need for relief during the war period from express or implied covenants in leases by reason of limited supplies of critical materials which prevent the orderly drilling of wells on such leases. H. B. M.

Hydrogenation.

572. Patents On Hydrogenation. A. Pott. U.S.P. 2,308,247, 12.1.43. Appl. 3.12.38.—In a process of hydrogenating distillation extraction products from coal, the coal is extracted with a solvent, the extract is filtered and then hydrogenated. The process is improved by drawing off the substantially unhydrogenated sludge arising in the hydrogenation stage and adding this to the crude coal-extract solution prior to filtration. H. B. M.

Polymerization and Alkylation.

573. Patents On Polymerization amd Alkylation. A. Wassermann. E.P. 551,512, 25.2.43. Appl. 23.9.41.—Catalysts are prepared by heating a mixture of copper sulphide, copper sulphate, phosphoric acid, and water to a temperature higher than 90° C. The catalyst is used in the production of olefines of relatively high boiling point from olefines of lower boiling point. H. B. M.

Synthetic Products.

574. New Process Increases Output of Butyl Rubber Without Greatly Altering Plants. Anon. *Pipe-line News*, August 1942, **14** (8), 12.—W. S. Farish, president of Standard Oil Co. of New Jersey, reports that the five butyl plants being built for the U.S. Government were originally designed to take care of 60,000 tons per year. Improvements in the manufacturing process have, however, enabled the Company to modify the design of the plants only slightly and yet raise their capacity very substantially.

A new programme approved by the War Production Board raises the preparation capacity of *iso*butylene from 60,000 to 90,000 tons a year. It is believed that the additional *iso*butylene required to take advantage of the full potential butyl capacity can be obtained by the Government.

Mention is also made of Flexon, which, though not actually as good as butyl rubber, makes better tyres than reclaimed rubber. *iso*Butylene is used in its manufacture. Developments of these two substitutes are indicative of the intense research and development work now being undertaken to further the synthetic rubber campaign. H. B. M.

Refining and Refinery Plant.

575. X-Ray Analysis and Chemical Scale Removal. S. C. Morian. *Refiner*, January 1943, **22** (1), 12–15.—Recently properly selected chemical solvents were applied to remove scale from an ammonia absorption refrigeration plant used by a large Gulf Coast Refinery. The equipment that was descaled consisted of two condenser units and three absorber units. Each condenser unit contained 324 2-in. × 16 ft. 11-gauge tubes, a total of 1360 sq. ft. of surface; each absorber unit contained 691 ⅞-in. × 16 ft. 14-gauge tubes, a total of 4358½ sq. ft. The grand total square feet of surface to be cleaned was 15,774. The materials used in the removal of scale from this equipment consisted of 2750 gallons of specially prepared solvents, capable of disintegrating and dispersing the scale, and special pumping and heating equipment. The heating units were used to raise the temperature of the solvents, thereby increasing the solution rate. The latter was important, since it was impossible to shut down the units for longer than 24 hours. The solvent pump discharge was tied into the absorber first in line. Cold solvent was then pumped into the system to establish circulation and to remove air pockets. A few pounds back pressure was held on the discharge to keep the units full. This was necessary to avoid a siphoning effect. As soon as the units were full and a circulation rate of two brl./minute was established, the heating unit on the solvent pump discharge line was cut into the system gradually in order to avoid unnecessary stresses due to sudden temperature rises, and the actual treatment began. A check on the effect of the solvent on the equipment was maintained at all times by observing the effect on special metal test strips which were placed at strategic points in the solvent input and discharge lines. No extra labour was necessary to complete the successful chemical removal of the scale deposits, and fire hazards and other ordinary attendant dangers were reduced to a minimum, since it was unnecessary to use mechanical types of cleaning equipment. All the scale was removed, leaving no nuclei for new scale formation. Data are given

The selection of the solvent can only be made if the composition of the scale, the solute, is known. X-Ray analysis appears to be one of the most rapid and economic methods. The method is described and illustrated, references to more detailed papers by Hull and others on this method of X-ray analysis being given. A. H. N.

576. Effect of High Pressure Extrusion on the Adsorption Capacity of Floridin. R. C. Amero and R. G. Capell. *Refiner*, January 1943, **22** (1), 22–26.—The effect of extrusion of clay on its efficiency as a percolator is studied mineralogically. Of much importance is the fact that the orientation of the clay mineral flakes in the rods is different from those in the crude fuller's earth. In the rods there is a marginal zone in which there is some parallel orientation of the clay mineral flakes. With high magnification this zone can be seen to be composed of small masses of clay minerals. Each mass is composed of clay mineral flakes in uniform orientation similar to the crude earth. The orientation of each mass is slightly different from that of its neighbour, so that the effect between crossed-nicols is that of a patchwork of extremely minute masses, each with a different orientation. There is therefore an important difference in the texture of the crude and extruded earth. This cannot be well demonstrated by photomicrographs, because it is evident only when the stage of the microscope is rotated. It can, however, be demonstrated to an audience by an apparatus for projecting on a screen the microscopic image as it is obtained from a thin section. Extrusion does not accomplish any mineralogical change. The X-ray diffraction patterns for the extruded and unextruded earth are identical. Extrusion undoubtedly results in an increase in the amount of active adsorbent surface exposed. Floridin fuller's earth, the most widely used oil decolorizing medium in the United States, has been enhanced in value about 30% in 20 years, largely through the addition of an extrusion step in processing. Extrusion brings about profound changes in the microscopic and possibly the submicroscopic character of the clay, which will, when thoroughly understood, throw a new light on the properties of clays. A. H. N.

577. An Application of Arc-Welding in the Maintenance of Heat-Transfer Equipment. W. H. Parlette. *Refiner*, January 1943, **22** (1), 27–28.—The short paper describes, with illustrations, the method adopted in maintaining the efficiency of a heat exchanger through arc-welding of baffles which have been corroded and restoration of the tube bundle. A. H. N.

578. Fractionating Tower Fabricated From Tank Steel. E. Sterrett. *Refiner*, January 1943, **22** (1), 30–32.—A fractionating tower, to be used in extracting toluene from the stream on a recycling plant, was manufactured from a battery of idle 55,000-brl. storage tanks. The paper describes certain procedures. A. H. N.

579. Patents On Refining and Refinery Plant. C. Weizmann. E.P. 551,215. 12.2.43. Appl. 6.8.41.—In plant or apparatus used for the thermal treatment of materials in the vapour phase which are liable to give carbon deposits, copper is used as a lining. The copper is in the form of pure copper or oxidisable alloys of copper, and is used either as the inner surface of the tube or vessel or as a coating thereon. Plant embodying this lining may be used in the cracking of oils and tars, aromatization of aliphatic oils, destructive hydrogenation of carbonaceous substances, polymerization of unsaturated hydrocarbons, etc. H. B. M.

Fire Prevention.

580. Methods of Combating Fires In Oil Storage Tanks. J. D. McCamey. *Oil Gas J.*, 3.12.42, **41** (30), 33.—The article is taken from a manual devised to assist field employees in the protection of crude-oil storage tanks. Steel-roof tanks equipped in an approved manner practically eliminate the possibility of fires from normal causes, but the importance of regular inspection and maintenance of safety devices is stressed, and parts requiring special attention in cone-roof tanks and tank openings and on floating roof tanks are mentioned. All tank-roof equipment, where possible, should be of vapour-tight design, and gauge or thief openings should be provided with non-ferrous seats. The capacity of the fire wall around crude storage should be 125% of the storage capacity unless deflecting couples are provided. The area should be kept free of vegetation, and should drain to a point where a pipe of adequate capacity should be installed. The drain-pipe should be below actual ground level and equipped with a low-pressure valve placed outside the fire wall and protected from freezing. Drain-valves to be closed except when actually draining water. Adequate equipment, mechanized and manual, to construct auxiliary dykes, fire walls, pipe lines, etc., in emergency, should be readily available.

The use of steam as extinguishing agent should be limited to cases where other agents are not available, and then applied safely where vapours only are burning at a leak of limited extent. Foam produced by chemical reaction between sodium bicarbonate, a foam-producing ingredient and aluminium sulphate is considered the most effective in combating tank fires. Difficulties of maintenance of proper solution preclude the 2 solution system. For a dry-powder installation recommendations are : A minimum of 4 lb. of powder per sq. ft. of oil surface of the largest tank to be protected, a rate of foam application of $\frac{1}{4}$ g.p.m. per sq. ft. of surface protected. Since 1 gal. of water with 1 lb. of powder creates 8 gal. of foam, requirements for a tank of 80,000 brl. capacity and 117 ft. diameter would be 22 tons of foam powder and a water delivery rate of 1012 g.p.m. at a pressure of 100 lb. per sq. in. The number of fixed foam installations on tank farms is limited, probably due to cost and difficulties of obtaining adequate water supply.

Precautions to be observed in arranging transfers to other tankage from a burning tank are given. Crudes which contain even small quantities of sediment and water are subject to the boil-over phenomenon, but they will normally burn for a period of 6 to 8 hours before it occurs. Digging a ditch at the inside toe of the fire wall during the waiting period will assist in retarding the resulting flow. Normally the downwind side constitutes the greatest hazard and consideration should be given to this in erection of auxiliary fire walls, etc., outside the regular one.

As a precaution against ignition by lightning, resistance tests should be made if there is any doubt, and if the resistance exceeds 25 ohms special grounding connections to the tank installed. Means of dealing with grass fires are suggested and the importance of good housekeeping stressed.

There should be a clearly established procedure for handling reports, equipment, and manpower in the event of a fire. The 3 major types of fire recognized are : (1) a vapour fire in which no appreciable amount of any other product is involved, (2) a vapour and petroleum fire, (3) an oil-surface fire of major importance, with vapours controllable by extinguishing the oil fire. Vapour fires are subdivided into cases where the vapour mixture between the roof and liquid stores is (*a*) too rich to explode, (*b*) explosive.

Characteristics of these two types of vapour fire are described. Possible causes of outbreak and precautions to be observed in dealing with each individual type of fire are given and the method of extinguishing considered most applicable to each is described in detail. R. A. E.

Physics and Chemistry of Hydrocarbons.

581. Sulphur Compounds from Panuco Gasoline. W. Friedmann and C. Canesco. *Refiner*, January 1943, **22** (1), 1–5.—The sulphur compounds present in the gasoline cut, range of 75–140° C., have been isolated and identified by the following procedure : An acid sludge which had been formed in refining Panuco gasoline with concentrated sulphuric acid (E.P. 175° C.) was drawn, settled, separated from the gasoline, and diluted with ice and water. The light tar which separated was neutralized with lye, and steam distilled until no more oil came over. A considerable amount of resinous matter not yet investigated remained in the still, 60 litres steam distilled, golden-yellow oil, D_{20}–0·917, were recovered ; its terpene-like odour was not unpleasant in spite of the high sulphur content of 21·7%. 4·5 litres of sludge oil were roughly fractionated into twelve cuts. Each cut was redistilled several times, taking 2° cuts, and these cuts were then combined into groups depending on their gravity or sulphur content ; they were submitted to further fractionation until fractions of a certain boiling constancy were obtained.

In no case were pure sulphur compounds obtained by fractionating overhead products. Later investigation will determine whether azeotropic mixtures are formed or not. Even the cuts which, according to the boiling points, could be considered as almost pure were not suitable material for the preparation of derivatives which had to identify the sulphur compounds. On the other hand, the preparation of the mercuric chloride additive products and their recrystallization until the melting points remained constant proved a practical way. Repeated recrystallizations were inevitable when the alkylated thiophanes appeared as isomers, which, as a rule, were roughly separated in three or four recrystallizations of the additive products. The purified additive salts were decomposed by sulphide of sodium, the liberated thiophanes driven off with steam, the aqueous distillate extracted, and the dry extract rectified. Only the thiophanes are mentioned because no sulphur compound so far separated from a main cut or from an intermediate one, could be identified as open-chain sulphide.

The identification of the thiophanes is described in detail. The sulphur compounds found in small fractions, range of few degrees except for the first with a range of 82–110° C., are discussed. The full conclusions to be drawn from the work are postponed for a second publication. A. H. N.

582. Thermal Cracking Chemistry. P. H. Faust. *Refiner*, January 1943, **22** (1), 6–8.—An elementary explanation of the chemistry of cracking is given, with a description of simple hydrocarbons and their structural formulæ. It is stated that only the olefines do not occur in detectable amounts in the crude itself. A. H. N.

583.* The Formation and Structure of Some Organic Molecular Compounds. J. Weiss. *J. Chem. Soc.*, April 1942, 245–252.—In his study of organic molecular compounds the author confines himself to the two typical classes in which the colour of the molecular compound is deeper than that of either of the two components. These include on the one hand compounds of benzoquinones, or substances derived from them, with aromatic hydrocarbons, amines, or phenols. The second class includes molecular compounds of nitro-compounds with unsaturated hydrocarbons and their derivatives. It is claimed that a modification and extension of a theory advanced by Hammick and Sixsmith, and Gibson and Leoffler to the whole group of molecular compounds explains their formation and structure in every detail. These workers suggested a polarization mechanism similar to an oxidation-reduction reaction for the formation of molecular compounds between aromatic amines and nitro-compounds.

The author believes that formation of the deeply molecular compounds is due to a complex molecule, essentially ionic in character, which is formed from the two components by an electron transfer from the unsaturated hydrocarbon or its derivative (donor A) to the quinone or polynitro-compound (acceptor B) according to the net reaction

$$A + B \rightleftharpoons [A] + [B]^{-}.$$

The following points are discussed in support of this theory :

(*a*) Structure and rate of formation of the molecular compounds; (*b*) the heats of the formation; (*c*) the equilibrium in solution (and the influence of hydrostatic pressure on it); (*d*) colour of the molecular compounds; (*e*) crystal structure and intermolecular distances; (*f*) the dipole moment in solution; (*g*) the electrical conductivity in solution; (*h*) relationship to the semiquinones and other free radicals and radical ions. H. B. M.

584. Emergency Use of Oil-Coal Suspensions as Colloidal Fuel. W. L. Faith and H. W. Zabel. *Refiner*, January 1943, **22** (1), 9–11.—The technical and economic problems of mixing coal and oil are being studied by the authors, but only preliminary results have been obtained so far. These results indicate that a high-speed propeller mixer is satisfactory for preparing fuels in which the final viscosity is not over 80 seconds Saybolt Furol. This figure is only approximate, but mixing experiments to date indicate that above this value thorough mixing does not take place. It is obvious that as the viscosity of the mix increases, more power is necessary, and that as the coal concentration is increased, a point is reached where the suspension loses most of its liquid characteristics. The final viscosity during mixing can of course be lowered by raising the temperature of the oil, and this procedure is recommended. An equation has been developed by means of which the viscosity of the suspension can be calculated directly from the viscosity of the oil itself at the same temperature, and the volume concentration of coal in the suspension. This equation is (for 200-mesh coal) :

$$\frac{\mu_f}{S_f} = \frac{38{\cdot}4}{38{\cdot}4 - C_v} \cdot \frac{\mu_0}{S_0}$$

where μ_f = kinematic viscosity of the suspension.

$\frac{\mu_0}{S_0}$ = kinematic viscosity of the oil.

C_v = volume percent coal is mix.

For 325-mesh coal the constant 38·4 should be replaced by 37·5.

Kinematic viscosities can be converted to Saybolt Furol seconds and vice versa by means of the usual viscosity conversion charts. It is recommended that in no case should an attempt be made to prepare fuels containing more than 50% coal by weight. 40% by weight appears to be a more satisfactory upper limit.

The problem of storing and handling is mainly that of the settling of the coal. This is discussed in full.

In calculating the friction head in pumping colloidal fuel through pipes, the following equations may be used : For viscous flow (low flowrates and coal concentration below 38% by volume)

$$\frac{H}{L} = \frac{V\mu_0}{D^2\rho_0} \cdot \frac{K_0}{K_0 - C_v}$$

where D = diameter of pipe in feet; H = difference in static head between two points in a pipe, feet of flowing substance; L = length of pipe, feet; V = mean velocity of flow in pipe, feet/sec.; μ_0 = coefficient of viscosity of oil, pounds/ft. sec.; ρ_0 = density of oil, lbs./cu, ft.; C_v = percentage coal by volume in suspension; K_0 = 38·4 for 200-mesh coal. For turbulent flow the usual plots of Fanning friction factors *vs.* Reynolds number may be used, assuming the viscosity and gravity of the oil-coal suspension are the same as those of the oil medium itself. This assumption introduces only a very slight error. For plastic or "plug" flow (coal concentrations above 38% by volume)

$$\frac{H}{L} = 32\left[\frac{\tau_y}{g\rho D} + \frac{\eta_v}{g\rho D^2}\right]$$

where τ_y = yield value of plastic fuel, lb./sq. ft.; η_v = coefficient of rigidity of fuel, lb./ft. sec.; g = acceleration due to gravity = 32·2 ft./sec.^{2}. In practically all cases of industrial importance, only viscous flow will be encountered, and calculations should be based on that assumption.

The economic factors involved are discussed together with typical colloidal fuel preparation plant. A. H. N.

585.* A Method for the Accurate Analysis of Gaseous Mixtures. C. H. Bamford and R. R. Baldwin. *J. Chem. Soc.*, January 1942, 26–39.—The authors state that various inherent sources of error render standard methods of gas analysis unsuitable for adaptation to precision measurements on mixtures containing a number of constituents. In their experience, analyses reproducible to 0·1–0·2% for the main constituents of the mixture can be obtained with a standard Bone and Wheeler apparatus, but the absolute accuracy is usually less than this, and the presence or absence of constituents in concentrations of 0·1–0·2% is always in doubt. It is claimed that the method described in this paper gives results accurate to 0·03% for individual constituents. The method of analysis involves successive quantitative conversion of the components of the gas into carbon dioxide and/or water, which are measured separately. Measurement is effected by determining the pressure exerted in one of two standard volumes of known ratio. This enables either large or small amounts of gas to be measured with accuracy.

The method described has been tested with various mixtures of known composition and its accuracy thus checked. H. B. M.

Analysis and Testing.

586.* Viscosity Measurement and Viscosity Index. J. C. Cragg and E. A. Evans. *Journ. Inst. Petrol.*, April 1943, **29** (232), 99–123.—The paper and its long discussion analyse the effects of errors in viscometry of the accuracy with which the viscosity index may be returned. The possible accuracy of viscometry as laid down by the recommendations of the Institute of Petroleum are also discussed. A. H. N.

Motor Fuels.

587. Substitutes for Petrol in France. E. Kalmanovsky. *Petroleum*, December 1942, **5** (12), 203.—The total quantity of gasoline and substitutes available in France in

1941 was equivalent to about 700,000 tons of gasoline, and about half of this was represented by diesel oil and gasoline released by the Germans. These releases cannot be counted on in future, and, although an increase in synthetic motor-fuel production is planned, no increase in power alcohol output can be expected. It is therefore by the use of solid fuels for gas producers that a solution must be sought. Increases in charcoal and wood for gas producers are planned to provide the equivalent of 420,000 tons of gasoline in 1943, but this quantity is insufficient for the requirements of the 100,000 heavy lorries fitted with gas producers. The possibility of using peat with a water content of 30–40% and ash content of 25% for this purpose by the Gazes system has been proved by trials, and plans to increase production of such peat to 200,000 tons in 1942 were made. Conversion of diesel engines to operate on producer gas either by (*a*) conversion to spark ignition or (*b*) starting on fuel and subsequently operating with gas is also being investigated. The possibilities of steam traction are being studied. R. A. E.

588. News from Japan. Anon. *Chem. Tr. J.*, 5.2.43, **112**, 130.—According to the Japanese, the output of natural rubber in the Netherlands East Indies and Malaya is not being curtailed. The surplus is being processed into gasoline by dry distillation of Hevea rubber and subsequent alkylation and hydrogenation of the low-boiling hydrocarbons produced. A factory has been built at Kuala Lampur, and the first unit capable of producing 100 tons a month of high-octane gasoline is said to be in operation. It is also proposed to use oil-refinery equipment in Japan for the purpose.

Oil-wells at Tarakan are said to be in commission again, and Wohokama (Java) refinery to have resumed operations on crude from Kroeka field, the output of which is expected to be reduced to 200,000 tons a year. R. A. E.

589. Patents on Motor Fuels. Standard Oil Development Co. E.P. 551,237, 12.2.43. Appl. 29.12.41.—In a process for the isomerization of paraffin hydrocarbons the reaction is conducted in the presence of a Friedel–Crafts type catalyst and a quantity of an alkyl halide which is equal to about 50–150% by weight of the hydrocarbon present. The alkyl halide acts as a mutual solvent for the catalyst and the normal hydrocarbon which is to be converted.

Anglo-Iranian Oil Co. E.P. 551,644, 4.3.43. Appl. 20.3.40. *iso*Paraffins are produced from normal paraffins by contacting the latter with a catalyst prepared by heating together aluminium halide and hydrated aluminium chloride to a temperature at which reaction takes place between them. The hydrated aluminium chloride is not present in sufficient quantity completely to hydrolize the aluminium halide.

International Catalytic Oil Processes Corp. E.P. 551,663, 4.3.43. Appl. 28.8.41. Gasoline of relatively high octane number and of increased stability is produced by catalytically cracking a gas oil in the presence of a used catalyst. Gasoline is recovered from the ensuing reaction, and this is afterwards subjected to catalytic reforming in the presence of fresh or regenerated catalyst.

E. T. Layng. U.S.P. 2,307,689, 5.1.43. Appl. 29.2.40. Olefinic hydrocarbons are converted into hydrocarbons of higher-boiling points by contacting them at a high temperature with a catalytic material consisting of a mass of porous granules of supporting material impregnated with material prepared in the following way. A complex of ammonia and a metal pyrophosphate capable of reduction to a polymerization catalyst are heated to a temperature of about 750° F. in a non-reducing atmosphere for a sufficiently long period of time to effect regeneration of the metal pyrophosphate. H. B. M.

Lubricants and Lubrication.

590.* An Investigation into Reclamation Practice. 1. Passenger Transport Undertakings. Anon. *Petroleum*, July 1942, **5** (7), 112.—This article discusses the information obtained by a questionnaire to more than 200 passenger transport companies and corporations.

Five types of reclaiming plants appear to be used and these can be grouped as follows:

(a) Mechanical filtration without the use of adsorbents, chemicals, etc.
(b) Filtration with adsorbents.
(c) Alkaline washing and settling treatment.
(d) Combined chemical and physical treatment.
(e) Centrifuges.

Mechanical filtration does not of course remove fuel dilution or acid content from a used oil, but it has proved sufficient in a number of cases. The questionnaire shows that 72% of the operating firms use one particular make of mechanical filter.

Filtration with adsorbents, if carried out efficiently, will produce an oil free from all suspended matter and acid bodies. A high degree of decolorization is also obtained. 15% passenger transport undertakings are using a plant operated on this principle.

Washing with alkaline solutions and subsequent settling do not appear to offer any advantage over adsorbent filtration, and only 5% of the transport companies used this method. The more complicated process of giving the oil an acid wash followed by clay was favoured by only 4% of the operating firms.

Centrifuging has not become a very popular reclaiming method, and only 3% of the companies were stated to be using this process.

This investigation also dealt with the extent to which used oil is reclaimed, and it is considered that about two-thirds of the waste oil which could actually be recovered is in fact reclaimed or used in the most appropriate way. The reclaimed oil is used instead of fresh oil in 21·5% cases, for topping up in 58% cases, and for filling crank-cases (topping up being carried out with fresh oil) 14%, the remaining miscellaneous uses accounting for the balance of 6·5% cases. D. L. S.

591. Low Temperature Characteristics of Greases. T. A. Maxwell. *Refiner*, January 1943, **22** (1), 16–18. *Paper Presented before National Lubricating Grease Institute (America).*—A specific phase of service requiring a special lubricant has been the exposed bearings of military aircraft. These may alternately be roasted under tropical suns and chilled to perhaps 100° below zero on nocturnal flights at high levels. The study covered in this paper was undertaken as background for fabrication of lubricants suitable for such service, to establish the rôle of dfferent soap bases and different oil viscosities in determining the behaviour of greases in ball-bearing service at low temperatures. To evaluate the performance of the test lubricants at low temperatures, the torque test outlined in Army–Navy Specification AN–G–3 of 30th May, 1942, was used. An eight-ball 204 open bearing was packed with 5 gm. of grease, closed with slip-fit shields, and run in 100 turns each way. The bearing was then chilled on a straight-line curve to test temperature in 2 hrs. and soaked for 1 hr., rotating two turns every 15 min. At the end of the soaking period the time necessary for a complete revolution with 2000 gm. cm. applied torque was determined. The apparatus is described and illustrated diagramatically. Another apparatus used was a modified form of the British Air Ministry's Specification DTD 201, "Controls Lubricating Oil." The results are discussed.

In summary it may be stated that the low-temperature bearing torque characteristics of greases fabricated from different metal bases and low-viscosity-index oils appeared to be dependent chiefly on the viscosity of the oil used. Barium greases seemed to stiffen somewhat above the average of the other greases tested. Since the use of very light oils is dictated by low-temperature requirements, part of the problem lies with the refiner to produce stocks of the best possible volatility characteristics for the grease compounder to try his art on. Much work remains to be done in determining the effect of viscosity index, of phenomenal pour points, of blending agents, and of extreme pressure and/or oiliness additives which may be added to light oils.

A. H. N.

592. Patents on Lubricants and Lubrication. T. G. Rolhner and L. H. Sudholz. U.S.P. 2,308,427, 12.1.43. Appl. 16.10.40.—Vinifera palm oil is added to a mineral lubricating oil to impart to it enhanced extreme pressure lubrication characteristics. Alternatively sulphurized Vinifera palm oil which has been reacted with phosphorus may be used for this purpose.

H. B. M.

Asphalt and Bitumen.

593. Patents on Asphalt and Bitumen. J. T. Hines. E.P. 551,765, 9.3.43. Appl. 28.10.41.—In the manufacture of asphaltic paving mixtures two different sizes of aggregate, one coarse and the other fine, are first independently coated with a binding agent. The coarse aggregate is coated with only so much binder as will form a thin film or coating on each fragment, but not sufficiently to permit the mass being pressed to a rigid condition. The fine aggregate is coated with the least amount of binder required to render the mass easily compressible without being rigidly cemented together. The two coated aggregates are then mixed together in the proportions to fill in, with the fine material, the voids in the coarse.

R. L. Ortynsky. U.S.P. 2,308,245, 12.1.43. Appl. 28.6.41. A Mexican-type paving asphalt is produced by oxidizing an asphalt having the following composition : Asphaltenes 1·5–5%, petroleum resins 55–65%, aromatic oil the balance. The resins and the oil have specific dispersions above 200 and flash points above 500° F. The oxidixed asphalt has an asphaltene content of 50–60% and a softening point of at least 360° F. The oxidized asphalt is fluxed with 1·1–1·6 parts of petroleum extract per part of oxidized asphalt. The resultant fluxed asphalt is blended with a hydrocarbon distillate having a Saybolt viscosity between 400 and 1100 at 100° F. and a viscosity index above zero. The blended asphalt has a penetration of 25–200 at 77° F.

H. B. M.

Special Products.

594. Naphthenic Acids and Soaps. Anon. *Seifensieder-Zeitung.*, 8.7.42, **69** (14), 211.—A brief review is given of information from various sources (without references) on the manufacture, properties and applications of naphthenic acids and soaps. The acids are derived from the acid sludge from the refining of distillates by extraction with *ca.* 5% NaOH solution, and hydrocarbons are removed from the resulting emulsion by vacuum distillation or by dispersing the emulsion in water and mixing with hydrocarbon soluble and water-soluble solvents (*e.g.*, toluene and acetone) causing separation into two layers. The acids are recovered from the aqueous layer by precipitation with SO_2 and H_2SO_4, but require distillation to give a sufficiently pure product. Refining is effected with acid and clay, or by vacuum or superheated steam distillation or extraction with aniline. Neutralization of naphthenic acids with alkali yields soft viscous soaps easily soluble in water and of good foaming power. They are not hardened by salts and alkali, and can take up large quantities of salts, not being susceptible to electrolytes. By combination with fatty acid, soaps, electrolytes, perfumes, etc., a variety of useful soaps can be prepared. The neutral potassium naphthenate is stated to have strong bactericidal and germicidal properties. Use in the textile industry is restricted by the strong odour, necessitating the use of the more highly refined grades and of perfumes. The soaps are also used in textile emulsions—*e.g.*, sizes prepared from neutral fat, naphthenic acids, and aqueous soda or borax solutions, these being easily removed by washing. Cotton yarn is softened by the use of 0·6–1·5% of naphthenic acid sulphonate, also used as a textile finisher. Pests are controlled by the use of ammonium naphthenate in combination with hydrocarbons, bases, and aromatic nitro-compounds. Mixtures of equal parts of potassium naphthenate and sodium fluoride are used for the preservation of timber, while copper naphthenate is used to impregnate timber to control pests. Salts of heavy metals and of aluminium are relatively insoluble in water but subtle in hydrocarbons, and are prepared by treating the acid with a solution of the metal salt, washing with hot water, and dehydrating. Metallic naphthenates are used in the manufacture of lacquers, in printing, and in painting. A solution of naphthenic acid in turpentine is used as a rust-preventive. Calcium naphthenate is stated to improve the elasticity of acetate films and to be used in drilling and batching oils. Medical uses of the metallic naphthenates include a mixture of lithium naphthenate and olive oil for curing throat and skin diseases. Triethanolamine naphthenate is used to clarify liquid soaps. Esters of naphthenic acids are used in the perfumery industry. Tests normally carried out on naphthenic acids include water content, acid value, iodine value, and unsaponifiable content.

C. L. G.

595. Dangerous Anti-freezing Solutions. Anon. *Technical News Bulletin*, U.S. National Bureau of Standards, March 1943, No. 311, 17.—Attention is directed to the serious dangers of corrosion likely to result from the use of anti-freezing solutions containing calcium chloride and other salts in automobile cooling systems. Their use in all Government-owned motor vehicles has been prohibited, and the manufacture of anti-freezes compounded with inorganic salts or petroleum distillates has now been forbidden. Irreparable damage can be done by corrosion of water-pumps and cylinder heads, particularly if of aluminium alloy, and of radiators, particularly if of copper. No inhibitors have been found of any value under practical conditions. Determinations of specific gravity, evaporation tests or a simple chemical test (with silver nitrate) will indicate the presence of brine solutions. C. L. G.

596.* Wartime Chemicals from Natural Gas. Part 2. G. Egloff. *Petrol. Times*, 20.3.43, **47** (1191), 136–137. (See also *J. Inst. Petrol.*, April 1943, **29** (232), 124–134.—The whole paper is published here in one part.) Toluene production and synthesis of explosives from natural gas are discussed. Nitroparaffin from natural gas may well develop into one of the newer and valuable sources of high explosive. Methane gas when nitrated produces tetranitromethane. This compound is the most destructive explosive known to man, and is extremely difficult to handle. About 20 years ago, in a university laboratory in Switzerland, work was in progress with tetranitromethane, which is usually a reaction product of toluene nitration in small concentrations. Ten grams of this substance killed 10 individuals, wounded 20, and nearly wrecked the building. No commercial process has been worked out to make this product available for use by the armed forces

Anaesthetic and agricultural uses for products from natural gas are then discussed, and the paper ends with a discussion of plastics and substitute fats for food.

A. H. N.

597. Patent on Special Products. Standard Oil Development Co. E.P. 551,852, 12.3.43. Appl. 27.12.40.—In hydrocarbons such as lubricating oils, or natural or synthetic rubber, there is employed as oxidation inhibitor, a polyvalent metal salt of a dehydroxy dialkyl diaryl sulphide or polysulphide or polymers of such compounds, or their selenide or telluride analogues. At least one of the valencies of the metal in the salt is connected to an alkyoxy group. H. B. M.

Coal and Shale.

598.* The Primary Gaseous Products of Carbonization. L. Bolton, J. E. Cullingworth, B. P. Ghosh, and J. W. Cobb. *J. Chem. Soc.*, April 1942, 255.—This paper reports the results of investigations of the products of carbonization of a variety of substances differing in constitution and oxygen content—namely, cellulose, bakelite, glycerine, petroleum coke, anthracite, and New Hucknall and Sharlston Wallsend coals. In each case the substance was heated in stages of 100° in a vacuum up to 1100° or more. Gas formed at each stage of fractional distillation was collected, measured, and analyzed.

In a discussion of results obtained and tabulated in this paper attention is directed to the general similarity in the nature and temperature sequence of the primary gaseous products of decomposition from substances of such widely differing composition and complexity. Decomposition invariably occurred in two phases: up to 600° the gaseous products were accompanied by liquids which by their removal were obviously responsible for the progress towards a common type of solid residue; in the second phase from 700° upwards there were no liquid products, but always a dominating emission of hydrogen, also widely differing quantities of carbon monoxide. X-Ray examination of cellulose and glycerine residues revealed an early breakdown of the original structure, followed by a repatterning of the carbon atoms in a hexagonal graphitic network visible at 400–500° and more distinct from 800° upwards.

Correlation of all results obtained confirms Burgess and Wheeler's conclusion in regard to coal that there is a critical temperature of decomposition in carbonization, marked by greatly increased evolution of hydrogen at 700–800°. It would appear, however, that this is not a special property of coal or of any of its petrographic constituents. It is a normal feature of molecular condensation in solid residues formed at lower temperatures during carbonization. H. B. M.

599. Fuel for Producer Gas. J. Devon. *Petroleum*, December 1942, **5** (12), 201.—Limits necessary in respect of size, ash content, and moisture content of anthracite used as producer-gas fuel for vehicles in the U.K. are given, and the reasons for such limitations described. Activation of the fuel by deposition of sodium carbonate on to its surface by immersion in a solution of the carbonate is claimed to increase ease of starting and acceleration, increase gas production, and to produce a softer clinker, less liable to stop gas production. Critical air-blast values—*i.e.*, the amount of air in cu. ft. per min. necessary to maintain combustion—are given for wood charcoal, some coals and manufactured coal fuels. Volume/weight relationships for anthracite, charcoals, and coke are shown. General characteristics of coke fuels vary somewhat from those of natural fuel, but they permit of operation in the same plants, although giving a smaller mileage for the same producer hopper size. R. A. E.

Economics and Statistics.

600. Asphalt and Related Bitumens. A. H. Redfield. U.S. Bur. Mines. Chapter (preprint) from *Minerals Yearbook*, 1941, Washington 1942.—It is reported in this summary that in 1941 the demand for asphaltic substances in the United States showed a marked increase over the previous year. Sales of rock asphalt increased by 43% in quantity and by 19% in total value. Producers' sales of gilsonite in Utah amounted to 36,407 tons valued at $851,623 in 1941 as compared with 31,930 tons valued at $770,711 in 1940.

23% more asphalt was produced at petroleum refineries in the United States in 1941, the greatest advance being made in the north-eastern quarter and the Mid-Continent area.

Stocks of petroleum asphalt at refineries were decreased by 10,000 tons during the period 31st December, 1940, to 31st December, 1941, although in Oklahoma, Kansas and Missouri, in the Rocky Mountain district, and in Texas, stocks at refineries increased.

Sales of petroleum asphalt by refineries to domestic consumers in the United States increased in quantity by 26% in 1941 as compared with 1940. Of the total quantity thus sold in 1941, 64% was used in the form of paving asphalt, paving flux, cut-back asphalts, and asphalt emulsions, for highway and street construction and for surfacing aerodrome runways. 25% of sales to domestic consumers was used for roofing purposes, and although shipments of prepared roofing increased by 29%, domestic sales of roofing asphalt and flux combined increased from 1,218,695 tons in 1940 to 1,671,696 tons in 1941.

In 1941, 8,831,000 brl. road oil were sold by refineries to domestic consumers, representing an increase of 5% over the figure for 1940. H. B. M.

601. Carbon Black. G. R. Hopkins and H. Bakus. U.S. Bur. Mines. Chapter (preprint) from *Minerals Yearbook*, 1941, Washington, 1942.—It is reported that during the year 1941 there was an increase in both production and sales of carbon black in the United States and that new records were established. Although exports continued to decline as a result of the war, domestic sales showed a sharp advance. Also by the time the rubber shortage began to affect the market other defence industries were demanding more carbon black, with the result that producers stocks decreased by 30% during the year.

480,212,000 lb. of carbon black were produced in Texas during 1941, representing 81% of the total output in the United States during the year. Louisiana produced 78,050,000 lb., as compared with 55,610,000 lb. in 1940. Kansas and Oklahoma together produced 35,803,000 lb. in 1941 compared with 33,287,000 in the previous year.

Carbon black is still most commonly produced by the channel process, but in this report it is noted that other processes, in particular Lewis, roller, "special" and thermatomic, are gaining in importance.

Statistics obtained from producers indicate that domestic sales in 1941 were apportioned as follows: 439,502,000 lb. to rubber companies; 28,198,000 lb. to ink companies; 5,840,000 lb. to paint companies and 58,469,000 lb. to miscellaneous purposes (including 3 months' exports).

The average value of carbon black at the plants rose from 2·90 cents per lb. in 1940 to 3·26 cents in 1941.

H. B. M.

602. Natural Gas. F. S. Lott and G. R. Hopkins. U.S. Bur. Mines. Chapter (preprint) from *Minerals Yearbook*, 1941. Washington, 1942.—Policy in the natural gas industry in the United States during 1941 was governed by the following factors: gas supply for expanding markets, particularly in the Appalachian region; transport facilities to consuming centres; availability of materials and equipment; measures necessary to protect installations from possible damage by sabotage or enemy attack. At the outbreak of war on 7th December, 1941, it was fully realized that natural gas must aid war production without hindrance, despite increasing difficulties.

Statistics given in this report show that marketed production of natural gas amounted to the new high level of 2770 billion cubic ft., or 4% more than in 1940. The gain in demand was mostly from industrial consumers, notably miscellaneous industrials (18%) and portland-cement plants (29%).

Prior to 1941 the average value of natural gas at the producing wells showed a persistent decline. In this year, however, it increased to 4·7 cents per thousand cubic ft. Reported completions (2·911) of gas wells in 1941 were 22% greater than the 1940 total. During the period under review there were rapid developments in the use of natural gas and its liquefied gases as constituents in the production of essential chemicals. It is forecast that many well-known substances which have long been made from other source materials—*e.g.*, ammonia, ammonium nitrate, acetylene, and alcohols—will be produced in quantity by processing the lighter hydrocarbons associated with petroleum.

In addition, many new compounds have been produced including explosives prepared by the nitration of methane and synthesis of nitro-hydroxy compounds.

H. B. M.

603. Natural Gasoline and Liquefied Petroleum Gases. F. S. Lott and A. T. Coumbe. U.S. Bur Mines. Chapter (preprint) from *Minerals Yearbook*, 1941, Washington, 1942.—1941 was the second successive year in which production of natural gasoline in the United States showed a sharp increase, and it is asserted that this was in fact the most profitable to the industry of any recent years. The gain in production over 1940 exceeded 15%, and daily outputs during 1941 increased consistently from 6·7 million gallons in the first quarter to over 8·2 million gallons in the last quarter.

Owing to war conditions the demand for natural gasoline increased by over 20%, and production was inadequate to meet this new demand. Thus 60 million gallons had to be withdrawn from storage in 1941. In 1940, 54 million gallons were added to stocks.

The proportion of natural gasoline used at refineries in motor fuel during 1941 increased to 7·1%, after remaining at the comparatively low level of 6·6% in 1939 and 1940.

Cycling operations in Texas increased at a slower rate in 1941 than in 1940. The number of cycling and repressuring plants reporting to the Railroad Commission of Texas increased from 32 to 45. In Louisiana the largest cycling plant in the world began operating in July 1941, in the Cotton Valley Field, Webster Parish, and in December a second large plant was started at South Kennings, Jefferson Davis Parish.

Natural gasoline production by compression plants continued to increase rapidly because of the cycling operations in Texas. Production by the absorption process expanded moderately in all the important producing States except California and Oklahoma, where failing gas supplies restricted the throughput in certain important fields.

Increased demand for suitable components for blending into 100-octane aviation gasoline stimulated development of "super-fractionation" technique, thus facilitating isolation of such lighter-end hydrocarbons as *iso*butance and *iso*pentane in relatively pure form.

48% more liquefied petroleum gases were sold in 1941 than in 1940, and it is believed that the volume of deliveries to consumers in 1941 would have been even greater had equipment for handling and utilizing such gases been more freely available and had diversions for consumption as raw material in the manufacture of high-octane gasoline and other products been less exacting. The phenomenal increase in demand for this fuel is best realized when it is noted that in 5 years annual sales have quadrupled; moreover, in 1941 the total for each of the several gases under review, except pentane, is higher than the combined total for all liquefied gases reported as recently as 1936.

H. B. M.

PUBLICATIONS RECEIVED.

Géologie et Richesses Minerales de la region d'Erzincan (Turkie). By Dr. V. Stchepinsky. Institut d'Etudes et de Recherches Minières de Turquie.

Etude Paleontologique de quelques gisements du Lias d'Anatolie. By Dr. Galib Otkun. Institut d'Etudes et de Recherches Minières de Turquie.

Contribution a l'étude de la faune cretacee de la Turquie. By Dr. V. Stchepinsky. Institut d'Etudes et de Recherches Minières de Turkie.

Le dispositif géologique du secteur petrolifère du Bassin de Boyabat. By Maurice M. Blumenthal. Institut d'Etudes et de Recherches Minières de Turquie.

The Petroleum Industry : a selected list of recent references. The Library of Congress, Division of Bibliography, Washington.

British Standard Handbook No. 2.—Workshop Practice. Pp. 464. British Standards Institution, 28, Victoria Street, London, S.W.1. Price 7*s*. 6*d*. net.

In this volume are gathered together the essential technical data from the many British Standards applicable to engineering workshops, so that every engineer concerned with design or manufacture may have by him the latest British Standard practice. There has been some rearrangement in a few of the specifications, but the essential text and tables have not been modified.

INSTITUTE NOTES.

June, 1943.

PROFESSOR VLADIMIR N. IPATIEFF.

The Chicago Chapter of the American Institute of Chemists held a banquet on 20th November, 1942, in honour of Professor Vladimir N. Ipatieff on the occasion of his seventy-fifth birthday. Papers were read by Dr. Gustav Egloff on "Ipatieff's Influence on Industry," by Mr. Frank C. Whitmore, of the Pennsylvania State College, on "Ipatieff, his Influence on World Chemistry," and by Professor Ward V. Evans, of North-western University, on "Vladimir N. Ipatieff."

In the course of his paper Dr. Egloff said that Professor Ipatieff was not only celebrating his seventy-fifth birthday, but also fifty years in the chemical profession, during which time he had been responsible for discoveries and developments which had profoundly affected world chemistry and industry. He had organized the chemical industry in Russia during the Great War, and later was given a similar assignment by the Soviet Government, eventually becoming the head of a Committee that was appointed by the Academy of Sciences to re-establish and expand its contacts with foreign scientific bodies. Twelve years ago he had come to the United States and joined the Universal Oil Products Company, and since then he had accomplished his greatest work.

Among the many discoveries made by the Professor were the establishment of the fundamental structure of isoprene, the basic hydrocarbon of rubber; the production of butadiene from ethyl alcohol by catalytic treatment, upon which process the synthetic rubber industry of the U.S.S.R. was built; the preparation of ethylene from ethyl alcohol by catalytic dehydration; and the production of ketones and aldehydes from alcohols, using brass as a catalyst.

In the early stages of his career, Professor Ipatieff, who was then an artilleryman, studied the rates of combustion of various nitroglycerine explosives at pressures up to 4500 atmospheres, and it was this type of research which opened the way to the discovery of the field of commercial high-pressure chemical reactions such as the hydrogenation and destructive hydrogenation of organic compounds.

Another achievement of the first magnitude was the discovery of a solid phosphoric acid catalyst which polymerized olefins in cracked gases to motor fuel of high octane rating. Prior to this discovery, the by-product gases from cracking operations to produce motor fuel were burned under boilers or stills, or vented into the air.

One of the Professor's crowning achievements was the alkylation of paraffins with olefins, a reaction which had hitherto been thought impossible, but which was now the groundwork for the production of 100 octane aviation spirit.

Professor Ipatieff's impact on other industries had shown itself in the development of a new chemical industry, new metallurgy, new instrumentation, and a host of other materials which supply new chemicals and equipment necessary to carry out processes which he had given as a heritage to the present generation and to generations yet to come.

STUDENTS' SECTION, BIRMINGHAM UNIVERSITY.

A Meeting of the Section was held on 21st January, 1943, in the Oil Department, and a very interesting talk was given by Mr. C. A. P. Southwell. The subject was "Production from a Sandstone Reservoir," and the talk dealt largely with the problem of secondary recovery.

A joint meeting of the Section and the Birmingham Section of the Institute of Chemists was held at the University, Edmund Street, Birmingham, on Monday, 8th March, 1943. Dr. A. E. Dunstan introduced a film, "A.I.O.C. Operations in Persia," and gave a short talk, illustrated by slides, dealing with the development of Petroleum Products, and their future.

An extensive section dealing with the geology, production, transport, refining, and by-products of oil, was organized by the members of the Section, for the Mining and Fuel Production Exhibition given by the Birmingham University Mining Society, at the beginning of March. The Exhibition was held in connection with the Fuel Economy Drive, and had the full co-operation of the city authorities and the Ministry of Fuel and Power. Students were in attendance throughout the week to explain the exhibits, which included many models, diagrams, full-sized equipment, photographs, and synthetics. Synthetic rubber was made on the spot. Over 24,000 passed through the two large marquees, which also contained exhibits dealing with Metal Mining, Coal Mining, and Coal Utilization.

HONOURS.

Major G. M. Barrett, R.A., Fellow of the Institute, has been awarded the M.B.E. for "devotion to duty and service of exceptional merit."

PAPERS FOR MEETINGS.

The Publication Committee is now preparing the programme for meetings to be held from September next onwards, and will welcome the submission of papers for presentation. They should be forwarded to the Chairman, Publication Committee, Institute of Petroleum, c/o Imperial College of Science and Technology, Prince Consort Road, London, S.W.7.

CANDIDATES FOR ADMISSION.

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

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

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

Blowers, Frank Frederick, Laboratory Assistant, Anglo-American Oil Co., Ltd. (*S. J. W. Pleeth; M. E. W. Miller.*)

Goodwin, Alfred Frank, Works Manager, Silvertown Lubricants, Ltd. (*L. O. Maskell; E. A. Evans.*)

Jacobs, Thomas Henry, Laboratory Assistant, Petroleum Board. (*S. J. W. Pleeth; M. E. W. Miller.*)

Low, Peter, Installation Manager, Petroleum Board. (*Dr. E. B. Evans; C. Chilvers.*)

Matthews, Charles, Technical Representative, Matthew Wells & Co. (*V. H. Stott; A. E. Dunstan.*)

Meulen, Hubert Ter, Technologist (B.P.M.). (*I. G. Nixon; G. Baars.*)

Moon, Sidney E. A., Deputy Chief Chemist, Silvertown Lubricants, Ltd. (*L. O. Maskell; J. L. Taylor.*)

Piotrowski, Waclaw de Junosza, Adviser on Fuel, Polish Ministry. (*Dr. R. C. Fisher; D. H. Carter.*)

Rose, Geoffrey Thomas, Chemical Assistant, Petroleum Board. (*S. J. W. Pleeth; M. E. W. Miller.*)

*

STEPHENS, Francis Edward, Chemical Assistant, Shell-Mex & B.P. Ltd. (*S. J. W. Pleeth ; M. E. W. Miller.*)

APPLICATIONS FOR TRANSFER FROM MEMBER TO FELLOW.

CHAPMAN. Stanley Herbert, Technical Assistant. (*A. E. Chambers ; C. Dalley.*)

FORSTER, Leslie, C.B.E., Engineer. (*T. L. Bonstow ; J. G. Biermann.*)

PLEETH, Samuel J. W., Chemist. (*Dr. E. B. Evans ; J. Cantor.*)

ARTHUR W. EASTLAKE,
ASHLEY CARTER,
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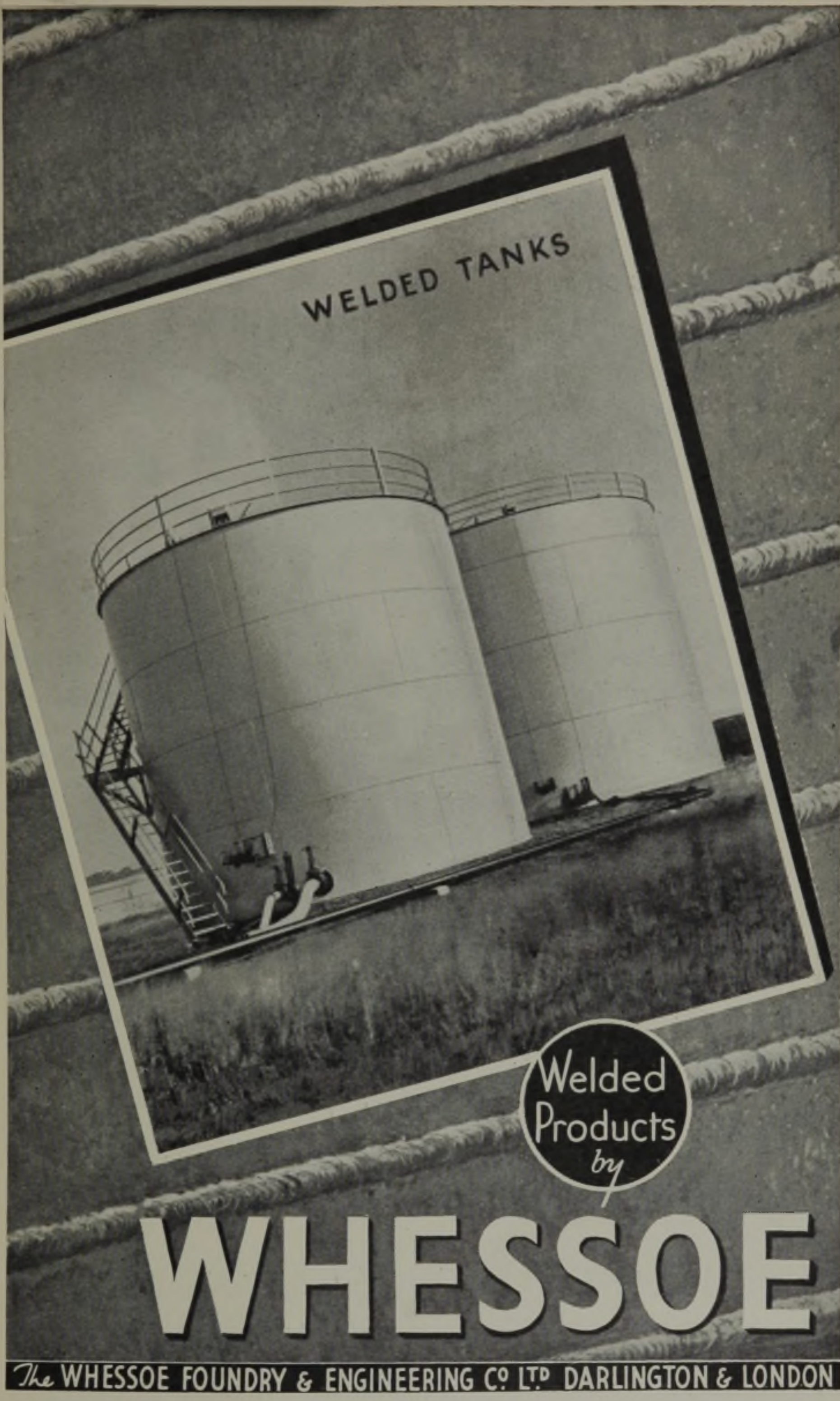
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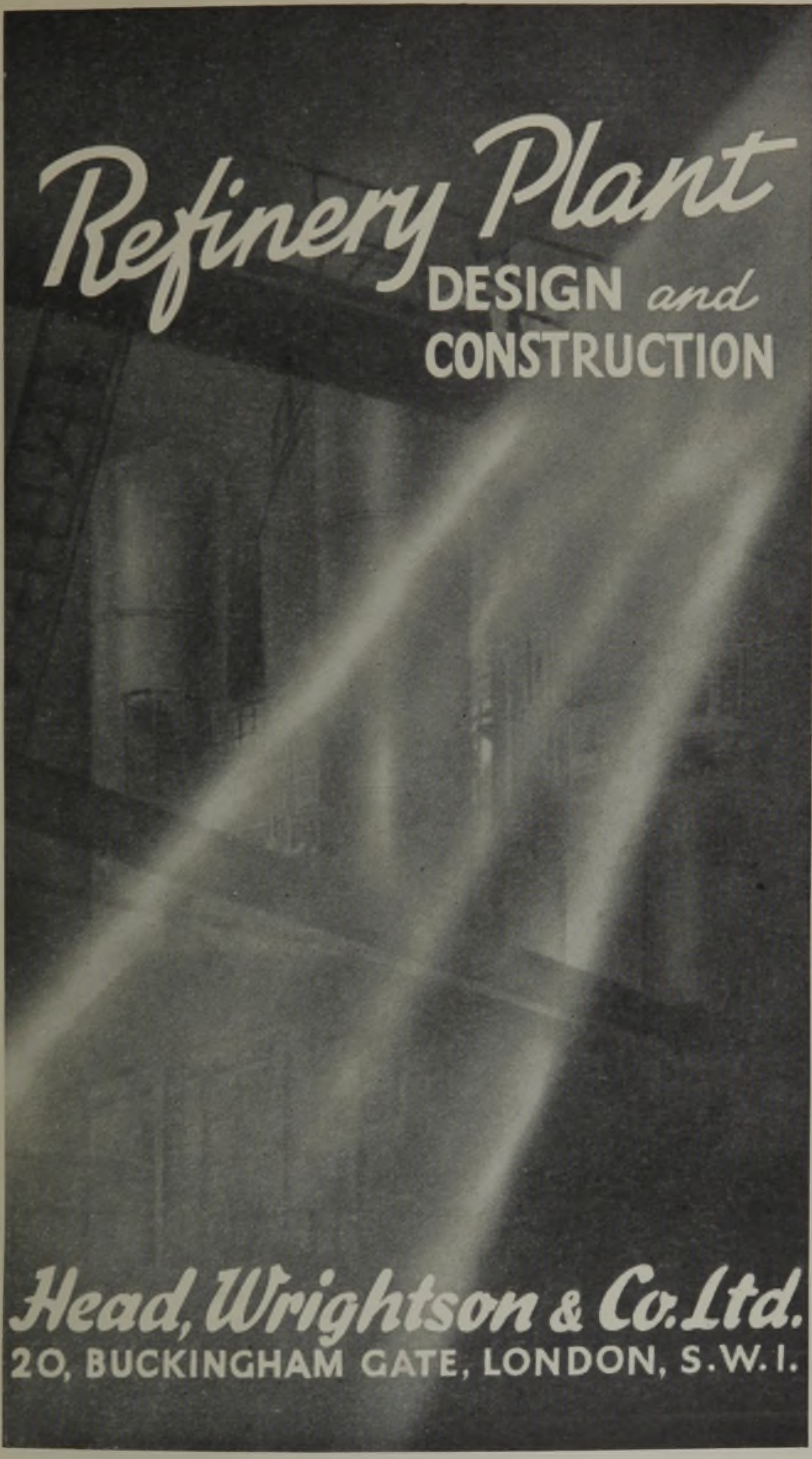

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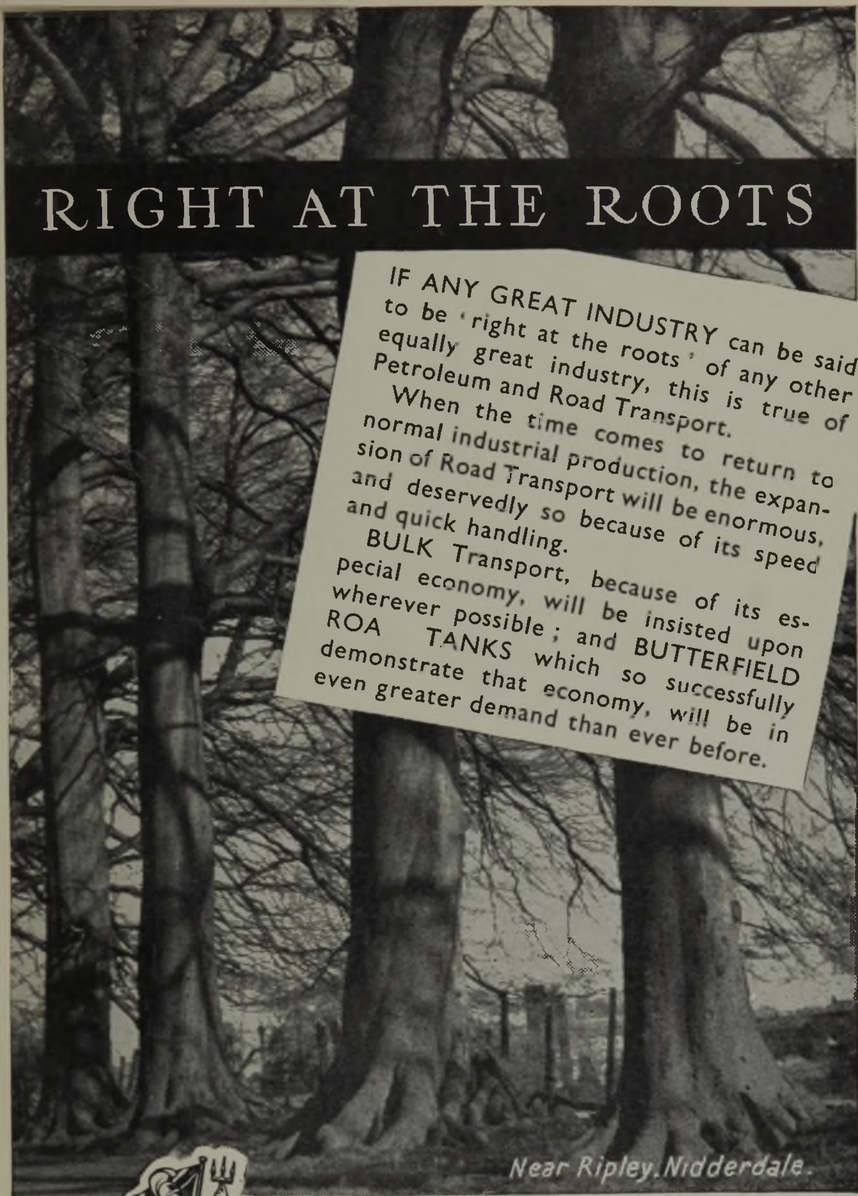
RIGHT AT THE ROOTS
IF ANY GREAT INDUSTRY can be said to be 'right at the roots' of any other equally great industry, this is true of Petroleum and Road Transport.
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