

# FLOW OF LIQUIDS UNDER CRITICAL CONDITIONS.

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## INTRODUCTION.

MUCH research has been done on the flow of liquids and gases through tubes under different conditions. For Newtonian fluids the laws governing viscous flow through tubes of uniform cross-sections are well founded on both theoretical and experimental grounds. Whilst not so well understood, the turbulent regime for these systems is fairly capable of determination provided certain implicit assumptions in the theory of dimensions are rigidly justified, particularly the principle of geometrical similarity. The intermediate state existing between the two regimes, the critical state, is still a field of contradiction. In the present work this field was particularly studied, and certain significant details are now reported.

## THEORY.

D'Arcy's formula for full flow in enclosed boundaries is

$$H = f \frac{1}{m} \frac{\rho v^2}{2g}$$

where

$$\begin{aligned} H &= \text{head lost over distance } l \\ m &= \text{hydraulic mean depth} \\ v &= \text{mean velocity of flow} \\ \rho &= \text{density of fluid} \\ f &= \text{a pure number} \end{aligned}$$

For a straight tube having circular cross-section  $m = d/4$  and using water at low temperatures the difference in  $\rho$  from unity is negligible.

Substituting for "  $m$  " and rearranging,

$$\frac{f}{2} = \frac{H}{1} \cdot \frac{d}{4} \cdot \frac{g}{v^2}$$

$$v = \frac{Q_t}{A} = \frac{4Q_t}{\pi d^2}$$

where

$$Q_t = \text{volume per sec.}$$

$$\begin{aligned} \frac{f}{2} &= \frac{H}{1} \cdot \frac{d}{4} \cdot \frac{g \pi^2 d^4}{16 Q_t^2} \\ &= \frac{H (\pi^2 g d^5)}{Q_t^2 \cdot 64} \end{aligned}$$

i.e.,

$$\frac{f}{2} \propto \frac{H}{Q_t^2} \text{ for a single pipe.}$$

Also,

T



$$\text{Reynolds Number} = \frac{vd\rho}{\mu} = \frac{vd}{\nu} = \frac{4Qt}{\pi d^2 \nu} = \frac{Q_t}{\nu} \left( \frac{4}{\pi d} \right)$$

where  $\nu$  = kinematic viscosity

i.e.,  $R_e \propto \frac{Q_t}{\nu}$

where  $R_e$  = Reynolds Number.

It is known that  $f/2 = \phi(R_e)$ , i.e., a plot of the friction factor  $f$  against corresponding values of Reynolds numbers gives a smooth curve. In the viscous state a plot of  $\log f/2$  vs.  $\log R_e$  yields a straight line as

$$\frac{f}{2} = \frac{8}{R_e}$$

For other regimes different curves are obtained for different pipes, depending on their degrees of roughness.

Fig. 1 is a reproduction of the figure given by Beale and Docksey<sup>1</sup> in the *Science of Petroleum*, and illustrates the type of curves obtained. It will be seen that the smaller the inner diameter of the pipe the rougher it appears to be—i.e., the higher the value of  $f/2$  ( $k$  on the figure) for the same value of Reynolds number.

It is to be noted that the change-over from the streamline or viscous curve to the turbulent curve is not accepted by all authorities to be the smooth curves shown. The value of  $f/2$  in the critical region is sometimes obtained by extrapolating the turbulent curve backward. In other cases it is advocated that the curves shown should be used. It is the purpose of this work to investigate which of the two proposed methods is to be employed in regions characterized by Reynolds numbers ranging between 1000 and 4000. Only water was used in conjunction with a single pipe, as it is already known that for flow of fluids in pipes what is true of one pipe is true of others.

#### APPARATUS.

The apparatus finally used is shown in Fig. 2. In a previous form only one constant-level device was used at the inlet.

While taking observations of the head during flow in the critical and to a lesser extent in the turbulent regions, it was found that there was a continual oscillation in the level of the exit manometer, increasing with the head of water. It was further observed that the inlet manometer oscillated also roughly in time with the exit oscillation, but the oscillation in the inlet was of much smaller magnitude. As it was uncertain whether the exit oscillation was induced by inlet irregularities or by the turbulence within the tube, it was decided to eliminate any inlet variations of head as completely as possible. Since it was not possible to do this with the single constant-head device, a new one was designed. It was further considered that surface irregularities in the long length of rubber connecting-hose may have induced a varying pressure drop at the end, and consequently in the modified apparatus it was replaced by a large-diameter glass tube of uniform smoothness. The water flowed into the

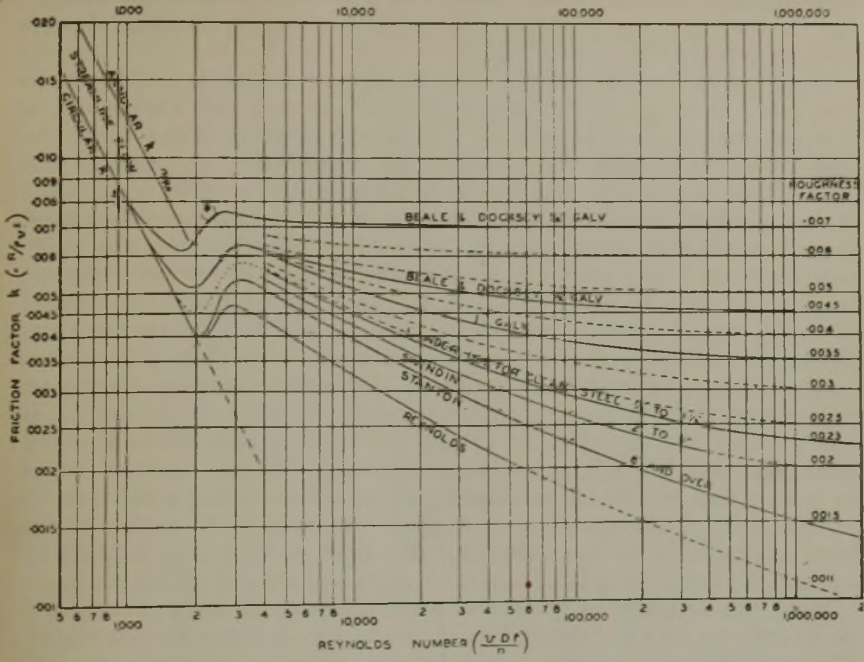


FIG. 1.

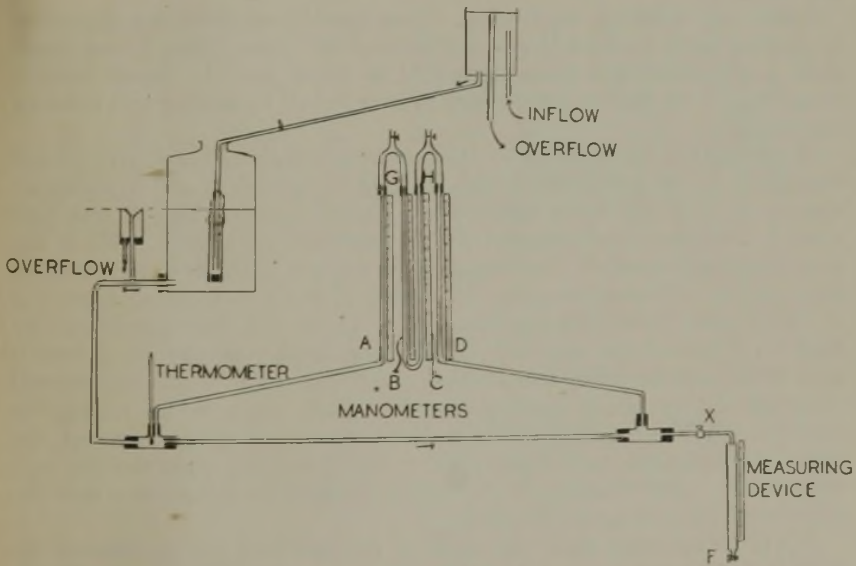


FIG. 2.

large-diameter constant-level device from a smaller constant-level device and, further, lost any tendency for shock by changing direction through  $180^\circ$ , as shown in the sketch.

The level of the water in the large bottle was arranged, initially, to be just below the top of the water manometer, so that the whole range of this manometer could be covered by the one position of the apparatus. The bottle was then raised several feet and re-connected by means of wide glass tubing, and further readings were taken on the mercury manometer. It was observed that while the inlet head remained appreciably constant, there was still slight oscillation in the exit pressure when flow was in the critical region. The head was steady both in the viscous and turbulent regions, but, in spite of all precautions, could not be maintained exactly so in the critical region. Manometric tubes *A* and *D* were used as water manometers. Tubes *B* and *C* contained mercury in their lower halves and water from *A* and *D* in the top. The central mercury manometer was employed for differences in head greater than 90 cm. of water. It was brought into operation on closing the two top taps above *G* and *H* after filling with water to a level above the taps. Initially care was taken to ensure that the board containing the manometers and scales was set exactly vertical in both planes. A small correction to be applied to the scale readings due to the scale zeros not corresponding was obtained by reading the liquid heights in each limb when no flow was taking place.

Since the accuracy in determining the quantity of water flowing had necessarily to be high, the device shown in the sketch was constructed. The small-diameter vertical side tube was calibrated to show 100, 250, and 500 c.c., and was fitted in order to eliminate errors due to eddies and surges, thus enhancing the accuracy. The time taken to fill various volumes was measured by a stop-watch. For the highest heads a 2000-c.c. flask was used.

Before any readings were taken all air was driven from the apparatus by passing water under a large head through the tube. Tap *X* was closed until water overflowed from *A* and *D* to fill *B* and *C*. Small bubbles remaining in the rubber connections were removed by raising and lowering the tubing.

In setting up, the manometer tubes were carefully cleaned, and filtered mercury used, to avoid air bubbles sticking to the tubes, and to eliminate viscous drag of the water meniscus on a dirty patch. Tap *X* was then opened, and the head reduced to the smallest obtainable. When the manometer had steadied, the time taken for a given quantity of water to flow through the tube was taken by closing tap *F* and a stop-watch started as the fluid level passed the zero marking. The watch was stopped as the fluid level passed the required marking. The head readings on *A* and *D* were taken and the water temperature was noted. The head was increased progressively by either opening tap *X* a little more or by raising the reservoir. When the limit of the water manometer had been reached, the head was increased until water filled tubes *G* and *H*, when the top taps were closed. The readings were then continued as before, but now the heads were read on scales *B* and *C*.

It will be apparent from the equation derived that the diameter of the tube is all-important, since its value is raised to the fifth power. Hence,

special care was taken in determining its value. The tube was of copper, cold drawn, with inside diameter assumed uniform over considerable lengths. The methods used were as follows :

METHOD 1.

A section of tube about 17 cm. long was cleaned, dried, and its length measured. It was then filled with mercury with tapping, etc., to remove trapped air.

The mercury was run into a tared beaker, and from its density at room temperature, the diameter was computed.

$$\begin{array}{r} \text{Length} = 16.79 \text{ cm.} \\ \text{Wt. of mercury } 30.14079 \\ \quad 30.02377 \\ \quad 30.09685 \end{array} \left. \vphantom{\begin{array}{r} \text{Length} \\ \text{Wt. of mercury} \end{array}} \right\} \text{Mean } 30.08714$$

$$\begin{array}{l} \text{Density of Hg at } 20^\circ \text{ C.} = 13.5462 \\ \text{Diameter} = 0.410 \text{ cm.} \end{array}$$

METHOD 2.

The section of tube was placed under a Brinell microscope and a number of direct measurements were obtained. It was apparent from the readings that the cross-section was by no means uniform, due probably to the cutting of the soft tube. No completely satisfactory estimate of the diameter could be made.

$$d = 0.405 \text{ cm.}$$

METHOD 3.

A metal plug was turned so as to fit exactly inside the tube. The plug diameter was determined by micrometer.

$$d = 0.410 \text{ cm.}$$

The value of diameter finally selected was 0.410, being that obtained by methods 1 and 3, giving the most consistent and satisfactory results. This value was checked hydrodynamically, as will be shown below, and found to be sufficiently accurate.

LENGTH.

Three operators were asked to make independent determinations of the tube length with a metre rule. All agreed on 190.3 cm., which value was accepted.

RESULTS.

Flow in the viscous regime affords an easy and useful check on the measurements of the various constants of the apparatus, as well as a near-absolute method of determining the accuracy and precision of the technique employed. It is to be noted that there will be pressure losses in the apparatus due to change of sections both at inlet and outlet of the

apparatus. This means that the head registered by the manometer will be too high. For sudden enlargement, the number of velocity heads to be allowed is equal to  $(1 - b)^2$ , and for sudden contraction is  $0.5(1 - b)$ ,

$$\begin{aligned} \text{where } b &= \frac{\text{area of flow pipe}}{\text{area of T piece}} \\ &= \frac{(0.41)^2}{\left(\frac{15}{16} \times 2.54\right)^2} = 0.0296 \end{aligned}$$

Number of velocity heads for enlargement = 0.942

“ “ “ “ “ contraction = 0.485

1.43

$$\begin{aligned} \text{Loss in pressure} &= 1.43 \times \frac{\rho v^2}{2g} \\ &= \frac{1.43}{2 \times 981} \times \frac{(4Q_t)^2}{\pi d^2} \\ &= 0.0418 Q_t^2 \text{ cm. of water.} \end{aligned}$$

This factor is subtracted from the experimental head to give the true pressure head lost in the pipe due to friction.

Thus three runs in the viscous region were made, with a period of several weeks lapsing between each, to test the method and technique. Table I gives the results.

TABLE I.

No.	H, cm. of water.	$Q_t$ , c.c./sec.	$t$ , ° C.	$\nu$ , stokes.	Corrn. to H = $0.0418 Q_t^2$ .	H corrd., cm. of water.	$f/2 \times 10^3$ .	$R_c$ .
<i>Run 1.</i>								
1	3.89	1.111	9.35	0.01333	0.03	3.86	28.8	259
2	7.60	2.065	9.35	0.01333	0.11	7.49	16.2	481
3	13.63	3.400	9.35	0.01333	0.29	13.34	10.63	792
4	16.11	4.170	9.36	0.01333	0.43	15.68	8.31	971
<i>Run 2.</i>								
1	4.86	1.115	4.6	0.015383	0.03	4.83	35.4	226
2	5.53	1.276	4.5	0.015432	0.04	5.49	31.09	258
3	7.44	1.740	4.7	0.015334	0.08	7.36	22.39	352
4	8.90	2.060	4.8	0.015286	0.11	8.79	19.06	419
5	9.41	2.143	4.9	0.015238	0.11	9.30	18.62	437
6	12.39	2.818	5.0	0.015189	0.20	12.19	14.15	576
7	13.90	3.19	5.2	0.015097	0.25	13.65	12.23	627
8	16.94	3.87	5.7	0.014867	0.37	16.57	10.23	809
9	21.16	4.80	5.9	0.014775	0.57	20.59	8.23	1009
<i>Run 3.</i>								
1	3.01	0.933	12.14	0.012322	0.02	2.99	30.06	238
2	4.11	1.144	12.10	0.012336	0.03	4.09	28.18	291
3	5.91	1.613	12.05	0.012352	0.07	5.84	20.18	406
4	7.70	2.045	12.00	0.012369	0.11	7.60	16.60	514
5	9.51	2.57	12.00	0.012369	0.17	9.34	12.82	649
6	14.1	3.56	12.00	0.012369	0.32	13.8	9.44	897

Fig. 3 shows the plot of  $\log (f/2)$  vs.  $\log (R_e)$  for the three runs.

It will be seen that except for a determination on the first run and another at the beginning of the third run, the points lie fairly accurately on the theoretical line  $\frac{f}{2} = \frac{8}{R_e}$ . Thus the constants of the apparatus and

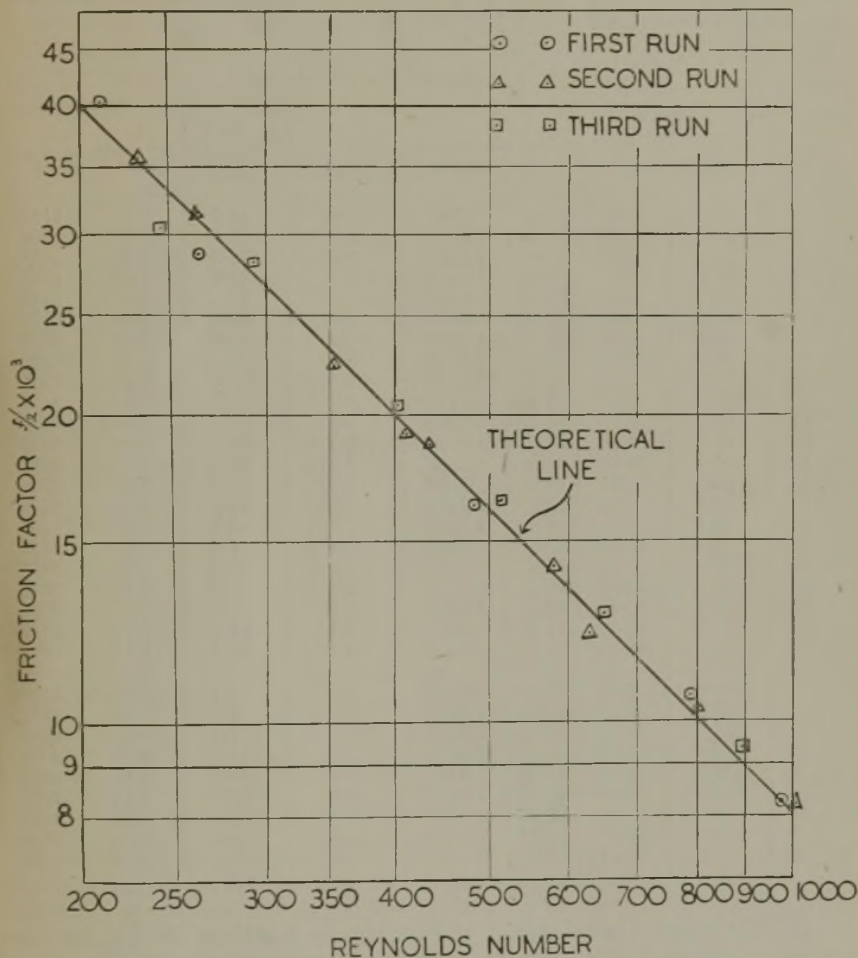


FIG. 3.

the corrections used in the calculations are justified within the degree of accuracy required for engineering data.

The critical regime in the system was investigated by running two series of experiments concentrating on the flow occurring between 2000 and 3000 Reynolds numbers. For continuity, however, both lower and higher values were used, so that a clear connection between the viscous and turbulent states might be evident. Table II gives the results of the runs.

Fig. 4 shows a plot of the friction factor *vs.* the corresponding Reynolds numbers for the critical region. It can be seen from the figure that :

(1) In spite of all the precautions taken to exclude external sources of turbulence, there is an appreciable deviation from the viscous line at all values exceeding 1000 Reynolds numbers. It is shown below that for values of  $R_e$  ranging between 1000 and 2100 this divergence is not accentuated by external sources of turbulence.

TABLE II.

No.	<i>H</i> , cm. of water.	$Q_c$ , c.c./sec.	$t_c$ , ° C.	$\nu$ , centi- stokes.	Corrn. to $H_c =$ $0.0418 Q_c^2$ .	<i>H</i> corrd., cm. of water.	$f/2 \times 10^3$ .	$R_e$ .
1	19.1	4.71	12.05	1.2352	0.6	18.5	7.36	1194
2	23.8	5.59	12.05	1.2352	0.7	23.1	6.79	1406
3	29.3	6.76	12.40	1.2236	1.2	28.2	5.50	1718
4	34.3	7.64	12.45	1.2219	1.4	32.9	5.00	1945
5	38.7	8.23	12.55	1.2186	1.7	37.0	4.81	2113
6	40.8	8.48	12.45	1.2219	1.8	39.0	4.69	2178
7	43.2	8.74	12.40	1.2236	1.9	41.3	4.68	2249
8	46.2	8.90	12.35	1.2252	2.0	44.2	4.92	2280
9	50.3	8.93	13.2	1.1172	2.0	48.3	5.47	2500
10	53.6	9.09	13.2	1.1172	2.1	51.5	5.50	2547
11	56.9	9.25	13.1	1.2004	2.2	54.7	5.65	2430
12	60.0	9.45	13.0	1.2036	2.3	57.7	5.66	2472
13	63.5	9.63	12.9	1.2069	2.4	61.1	5.81	2512
14	66.9	9.81	12.8	1.2103	2.5	64.4	5.81	2559
15	69.7	9.94	12.7	1.2136	2.5	67.2	6.08	2570
16	70.8	10.02	12.4	1.2236	2.6	68.2	6.00	2588
17	74.3	10.22	12.2	1.2302	2.6	71.7	6.05	2618
18	78.0	10.37	12.2	1.2302	2.8	75.2	6.04	2636
19	80.7	10.55	12.1	1.2336	2.8	77.9	6.12	2679
20	84.1	10.65	12.0	1.2369	2.9	81.2	6.37	2704
21	87.7	10.97	11.9	1.2404	3.1	84.6	6.17	2799
22	89.9	11.10	11.9	1.2404	3.1	86.8	6.17	2812
1	29.6	7.28	17.75	1.0626	2.2	27.4	4.96	2148
2	75.5	9.94	18.10	1.0533	4.0	71.5	6.43	2951
3	113.9	12.38	18.15	1.0520	6.2	107.7	6.34	3648
4	149.6	13.74	18.25	1.0494	7.7	141.9	6.78	4093
5	155.1	14.70	18.35	1.0468	8.9	146.2	6.12	4345
6	163.3	15.06	18.70	1.0377	9.3	154.0	6.12	4498
7	176.0	15.72	18.80	1.0351	10.0	166.0	6.07	4699
8	194.0	16.67	19.15	1.0262	11.5	182.5	5.89	5012
9	210.0	17.61	20.30	0.9988	12.6	197.4	5.75	5458

(2) The curve has minimum and maximum positions for  $f/2$ , between which positions a rising portion of the curve is in existence. The spread of the points around this rising portion—*i.e.*, between 2200 and 3000  $R_e$ —is greater than the spread in the viscous region for the same system. Thus the reliability of any single determination is not great in the critical region. Yet, on the whole, the second run connects to the first run fairly well, despite the fact that the apparatus was partly dismantled in between the runs (to change the position of the constant-level device) and allowed to carry water for some days. Thus it may be concluded that, provided special precautions are taken to ensure constancy of inlet level, the viscous and turbulent regions may be connected by a curve showing minimum



and maximum values for  $f/2$ . The shape of such curve, however, is not a symmetrical S-shape.

(3) Comparing Fig. 4 with Fig. 1, it is noted that the position of the present curve corresponds to that of a galvanized tube slightly greater than  $\frac{1}{2}$  in. in diameter. This fact is important, as the diameter of the present tube is only 0.161 in., and on the scheme presented in Fig. 1 the curve should have been above that occupying the highest position. Of course, the fact that the present tube was of drawn copper means that it was a "smooth" tube, and this explains the anomalous position when compared with galvanized tubes—which are assumed to be "rough"

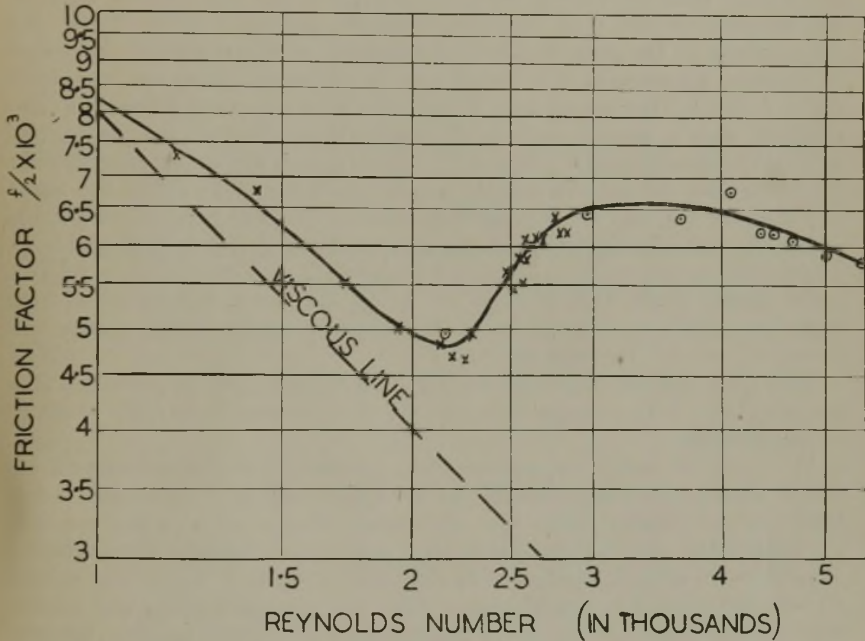


FIG. 4.

compared with copper. Nevertheless, it illustrates the fact that an extremely large error is possible if curves are taken from the literature haphazardly, without extreme care being shown with regard to the nature of the surface of the pipe. It is to be recommended that "spot tests" be made with any particular systems to locate it on the chart shown in Fig. 1. This is an important limitation of the  $f/2$  vs.  $Re$  chart. The number of points required is discussed below. Taking the diameter alone as a criterion of roughness is evidently erroneous—except, of course, in such well-authenticated cases as the Weymouth's Formula for the flow of gases under high pressure and at the very high Reynolds numbers used in commercial transportation of natural gas.

(4) The shape of the curve shown in Fig. 4, coupled with the points discussed immediately above, make it appear that the best method of determining  $f/2$  for the critical regime is to follow experimental procedure,

and not rely on mathematical formulation. The attempts at mathematical derivation of the incidence and significance of the critical region may be studied in Lamb's *Hydrodynamics*, to illustrate the extreme difficulties met in the problem.

It is pertinent here to inquire into the implicit significance and limitations of dimensional analysis on which a correlation such as that existing between  $f/2$  and  $Re$  is based. The first point to remember is that despite the term "analysis" the method is purely an empirical one, based on certain experimental observations. Thus, in deriving the possible nature of the relationship between  $f/2$  and the different variables affecting it, it is assumed that the *only* factors of significance are the velocity of flow, the diameter of the pipe, and the kinematic viscosity of the fluid. By taking these as the only factors and following certain standard procedure in equating dimensions, it is found that, if the assumptions are true, then  $f/2 = \phi(R_e)$ . This means that if no other factor is of significance in the problem, then a smooth repeatable curve will be obtained on plotting  $f/2$  against the dimensionless criterion  $R_e$ . Two points are to be remembered: (1) If, besides the present factors, another is assumed to affect the value of  $f/2$  under any one set of conditions, then a different type of criterion is obtained. (2) If a significant factor is ignored, then, although the analysis denotes that a relationship between  $f/2$  and  $R_e$  should exist—i.e., a smooth curve should result from plotting  $f/2$  vs.  $R_e$ —in fact it will be found that either no curve is obtainable, or the experimentally found points will reveal a "spread" around the curve.

Thus, the relationship between  $f/2$  and  $R_e$  can only be accepted if a smooth curve, with no appreciable spread of the points, is actually obtained by experiment.

The work of many has shown that, provided certain precautions are taken, such a curve is obtainable in the viscous region. This work shows that the precautions taken were sufficient, within the accuracy required in engineering calculations rather than viscometric studies, to produce a smooth curve if such exists—as in the viscous region. Yet in the critical region, the spread is much greater than that characterizing the viscous region. For instance, at  $Re$  of 2550,  $f/2$  yields values ranging between 0.00552 and 0.00608. Thus it can only be concluded that whilst for the viscous region  $f/2$  is wholly governed by  $R_e$ , in the critical region other factors not considered in the criterion  $R_e$  are operating.

An attempt was made to find whether surface tension was such a factor. By applying Buckingham's  $\pi$ -Theorem,<sup>2</sup> Weber's Criterion is obtained,

i.e.,

$$W_e = \frac{\sigma}{dv^2\rho}$$

where

$\sigma$  = surface tension.

$d$ ,  $v$ , and  $\rho$  = diameter, velocity and density as before.

Thus by plotting  $f/2$  vs.  $W_e$  and various combinations of  $R_e$  and  $W_e$ , it was hoped to obtain a curve on which the experimental points will lie smoothly and without the spread, characteristic of the critical curve of  $f/2$  vs.  $R_e$ . None of these attempts, however, resulted in such a curve.

Again, looking at the problem purely from a mathematical viewpoint,

and ignoring the physical significance of the various terms, it is found that a plot of  $f/2$  vs.  $R_e$  is in reality a plot of  $\frac{Hd^5}{Q_t^2 \rho}$  vs.  $\frac{Q_t}{vd}$ . In a single system it reduces to a plot of  $\frac{H}{Q_t^2}$  vs.  $\frac{Q_t}{v}$ . Such a plot is characterized by an

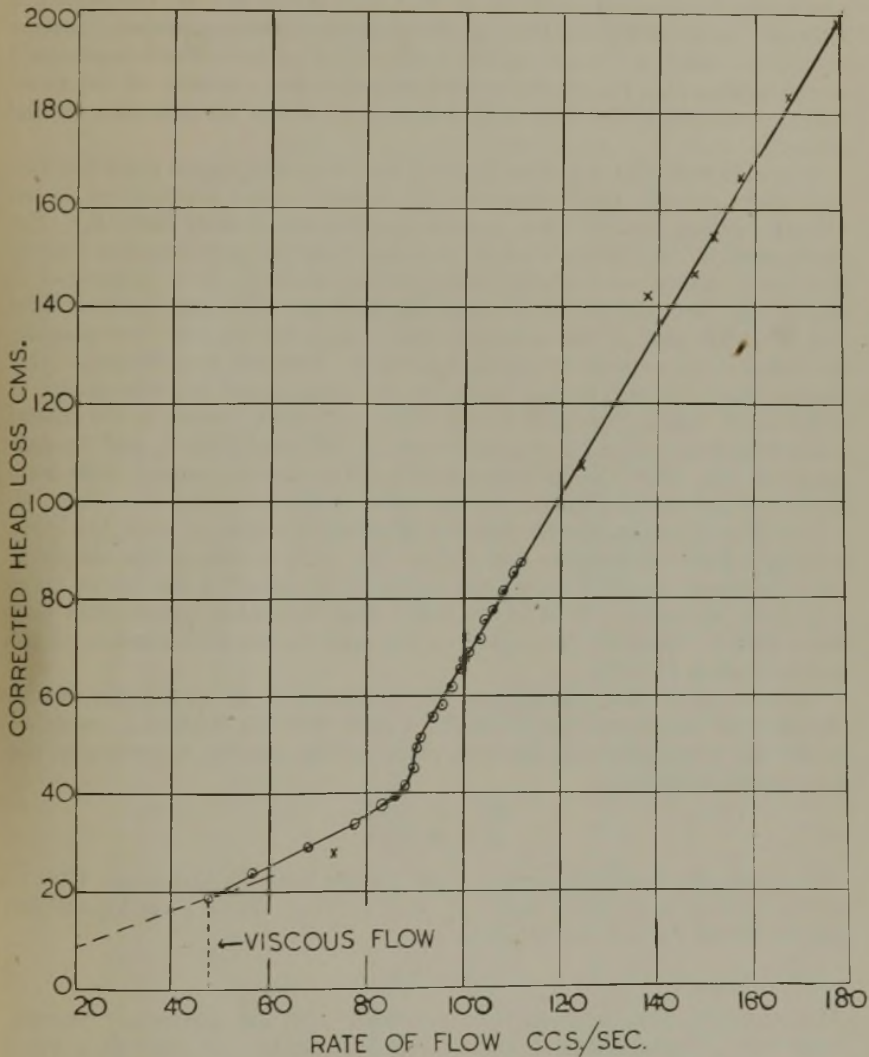


FIG. 5.

exaggerated spread of point for slight inaccuracies in  $Q_t$ .<sup>3</sup> In fact it is an extremely sensitive test of the accuracy of experimental data.

After it was seen that the significance of the Reynolds number in the critical region lies merely in its denoting the fact that such a regime has

been established, and, further, that the Reynolds number is not the sole governing criterion in such a region, it became necessary to find whether a simpler method of plotting the results is obtainable or not. Since plotting  $\frac{H}{Q_t^2}$  vs.  $\frac{Q_t}{v}$  exaggerates the spread of the points, it was thought that simpler plots may be obtained with  $H$  vs.  $Q_t$ . The factor due to viscosity was omitted, as it is known that in the turbulent region viscosity merely determines the type of flow taking place, and is of little direct importance in evaluating  $H$ . Fig. 5 shows that although the viscosity of the water varied between 0.0099 and 0.0124 stokes, it shows no influence on the curve.

It is also seen that a plot of  $H$  vs.  $Q_t$  in the critical region results in two accurately straight lines connected by a small region represented by an almost vertical straight line around the values of 2200–2500  $R_e$ . The lower straight line differs slightly in slope from the line denoting viscous flow, and differs considerably from the upper line. It is important to realize that between Reynolds numbers 1000 and 2200 and between 2500 and 5000 the plot of the corrected head lost in the pipe vs. the quantity delivered is represented by straight lines on Cartesian co-ordinates. This means that the number of points to be determined experimentally in order to determine the characteristic flow curve for a system in the critical regime need not exceed 5–2 points between 1000 and 2000  $R_e$  and 2 points between, say, 3000 and 5000 and a fifth determination around 2000–3000 to locate the vertical section of the curve. To determine the  $f/2$  vs.  $R_e$  curve directly a considerable number of points is required, since the curve possesses both a maximum and a minimum. By means of this simplified plot, however, the five points are sufficient to calculate the whole range of  $f/2$  vs.  $R_e$  curve. It is to be noted that Reynolds criteria still play their part in denoting the regime of flow and the relative position of the points in such a regime.

Another important significance of the plot of  $H$  vs.  $Q_t$  directly is that throughout the range covered by  $R_e$  of 1000–5000 the frictional resistance is directly proportional to the first power of the velocity according to the generalized equation :—

$$H = a + bQ_t$$

or

$$H = p + qv.$$

The constants, however, change their values between the range 1000 to 5000, as is seen by the graph. A plot of  $H$  vs.  $Q_t$  or  $v$  on logarithmic graphs would suggest the equation

$$H = mv^n.$$

This equation has, in fact, been proposed with an apparently varying exponent changing from 1 at a Reynolds number of 1000 to a value greater than 3 at values of  $R_e$  of 2500, and coming down to 1.6 at higher  $R_e$  values, only to rise again to nearly 2.<sup>4</sup> This complicated arrangement is due to the fact that on a logarithmic plot the independent constants ( $a$  or  $p$ ) are included in the arbitrary constant  $m$  and the variable index  $n$ . The complication merely illustrates the disadvantages of indiscriminate use of logarithmic scales in flow problems.

Plotted on Cartesian co-ordinates the critical regime reveals the characteristic of viscous flow in that the head is proportional to the first power of velocity, but departs from viscous flow in that the plot does not pass through the origin, the straight line changes slope at certain points, and in that kinematic viscosity changes up to 25 per cent. appear to be insignificant.

In all model experiments it is important that every circumstance obtain-

TABLE III.

No.	H, cm. of water.	Q <sub>t</sub> , c.c./sec.	t, ° C.	v, centi- stokes.	Corrn. to H, = 0.0418 Q <sub>t</sub> <sup>2</sup> .	H corrd., cm. of water.	f/2 × 10 <sup>3</sup> .	R <sub>c</sub> .
1	21.36	5.251	9.39	1.332	0.68	20.68	6.94	1225
2	31.65	7.143	9.30	1.331	1.26	30.39	5.54	1668
3	42.90	9.091	8.84	1.334	2.05	40.85	4.56	2120
4	49.40	9.770	8.71	1.353	2.37	47.03	4.54	2243
5	59.60	10.50	8.42	1.358	2.74	56.86	4.75	2400
6	71.40	10.93	8.35	1.369	2.96	68.44	5.30	2480
7	84.20	11.65	8.30	1.372	3.37	70.83	4.82	2635
8	101.4	12.75	8.22	1.374	4.03	97.37	5.54	2884
9	118.4	13.91	8.14	1.377	4.80	113.60	5.42	3140
10	141.5	15.27	8.08	1.380	5.79	135.71	5.36	3440
11	161.5	16.34	8.85	1.383	6.61	154.89	5.36	3680
12	175.6	17.06	8.25	1.352	7.21	168.39	3.35	3930
13	193.3	18.10	7.80	1.376	8.13	185.17	5.22	4080
14	218.0	19.69	7.80	1.395	9.60	208.40	4.99	4390
15	260.0	21.50	7.80	1.395	11.48	248.52	4.97	4790
16	286.8	22.68	7.50	1.395	12.75	274.05	4.92	5050
17	337.9	24.60	7.40	1.407	15.00	322.90	4.92	5430
18	369.9	26.02	7.40	1.411	16.80	353.10	4.82	5730
19	396.0	27.13	7.40	1.411	18.23	377.77	4.74	5970
1	22.23	4.95	5.7	1.487	0.61	21.62	8.13	1034
2	25.91	5.62	5.9	1.478	0.79	25.12	7.32	1183
3	26.19	5.65	5.8	1.482	0.80	25.39	7.31	1183
4	30.86	6.51	5.8	1.482	1.10	29.76	6.48	1360
5	30.91	6.52	5.9	1.478	1.12	29.79	6.47	1370
6	35.66	7.78	5.9	1.478	1.50	34.16	5.23	1634
7	35.76	7.46	5.8	1.482	1.38	34.38	5.69	1563
8	41.16	8.31	5.8	1.482	1.72	39.44	5.28	1740
9	45.26	9.00	5.7	1.487	2.01	43.25	4.93	1879
10	45.76	9.16	5.9	1.478	2.09	43.67	4.81	1926
11	48.86	9.48	5.8	1.482	2.23	46.63	4.77	1985
12	51.81	9.90	5.9	1.478	2.44	49.37	4.73	2081
13	55.26	10.16	5.9	1.478	2.56	52.70	4.71	2137
14	58.36	10.57	5.8	1.482	2.78	55.58	4.58	2215
15	58.96	10.59	5.9	1.478	2.79	56.17	4.61	2224
16	64.31	11.05	5.9	1.478	3.03	61.28	4.62	2327
17	65.36	10.96	5.6	1.491	2.98	62.38	4.79	2283
18	72.96	11.40	5.5	1.496	3.23	69.73	4.94	2370
19	78.46	11.68	5.5	1.496	3.39	75.07	5.07	2423
20	85.06	12.41	5.5	1.496	3.84	81.22	4.85	2578
21	107.3	13.51	6.2	1.466	4.55	102.7	5.17	2864
22	120.0	14.12	6.2	1.464	4.94	115.1	5.32	2963
23	143.3	15.62	6.2	1.464	6.06	137.2	5.09	3311
24	169.4	16.93	6.3	1.460	7.12	162.3	5.18	3634
25	199.5	18.59	6.3	1.460	8.60	190.9	5.08	3955
26	212.8	19.3	6.4	1.455	9.25	203.5	5.03	4111
27	454.0	29.0	6.5	1.451	20.85	433.1	4.75	6212
28	478.0	29.4	7.1	1.421	21.5	456.5	4.86	6430

ing in the large-scale apparatus should be copied in the model. In these experiments it was stressed that extreme precautions were taken to ensure that the inlet pressure was maintained constant. In actual practice such precautions are usually impracticable. Thus it is interesting to see the effects of slight oscillation produced at random, and not by any predetermined system, on the curves obtained.

The following results were obtained by using a single constant-level device on the inlet, which maintained the inlet level constant to the limits of reading the manometric scales, throughout the viscous region. The extra velocity required in the critical region produced a slight oscillation in the inlet level as the water entered the constant-level device from the

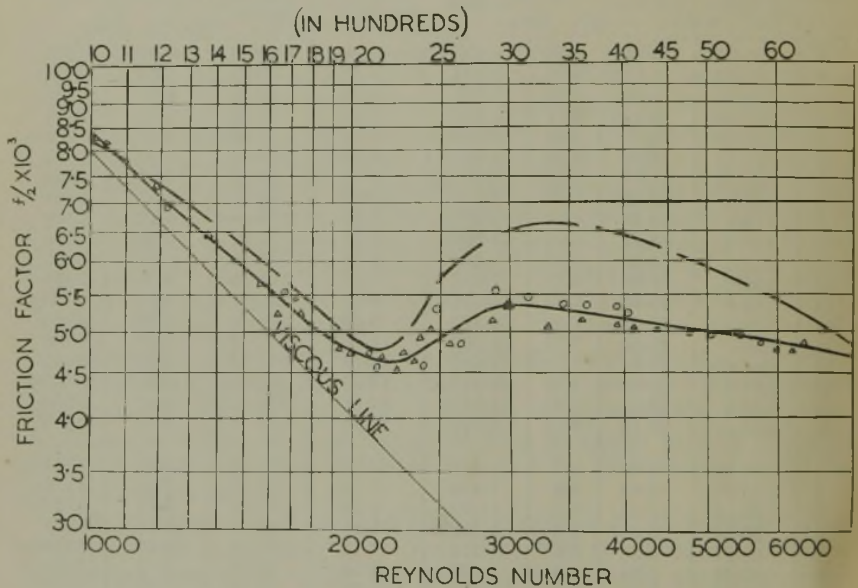


FIG. 6.

tap. This oscillation, coupled with that due to the regime itself, resulted in variation in the inlet pressure comparable with what might obtain in a technical apparatus being fed by a pump having small pulsation. The results obtained in these tests are shown in Table 3.

In Fig. 6 is a plot of  $f/2$  vs.  $R_e$  for this set of experiments. Certain interesting facts become evident on comparing this curve with that obtained in Fig. 4, shown broken on Fig. 6.

Up to a Reynolds number of 2100-2200, the two curves are practically the same. Beyond 2200, however, the two curves become distinctly different. The curve where shocks were not eliminated shows:

- (1) a low value for  $f/2$  for any value of  $R_e$  between 2100 and 6500;
- (2) a greater amount of "spread"—*i.e.*, is less reliable than the curve of Fig. 4. At higher values of  $R_e$  the two curves apparently coincide.

Thus in model experiments care should be exercised that no extra precaution be taken than is practicable in the final apparatus. In other words, discretion should be exercised in choosing a value for  $f/2$  from the literature, not only with regard to roughness, diameter, nature of surface, etc., but also with regard to the actual technique used and precautions taken. In these last sets of results the readings were taken as accurately

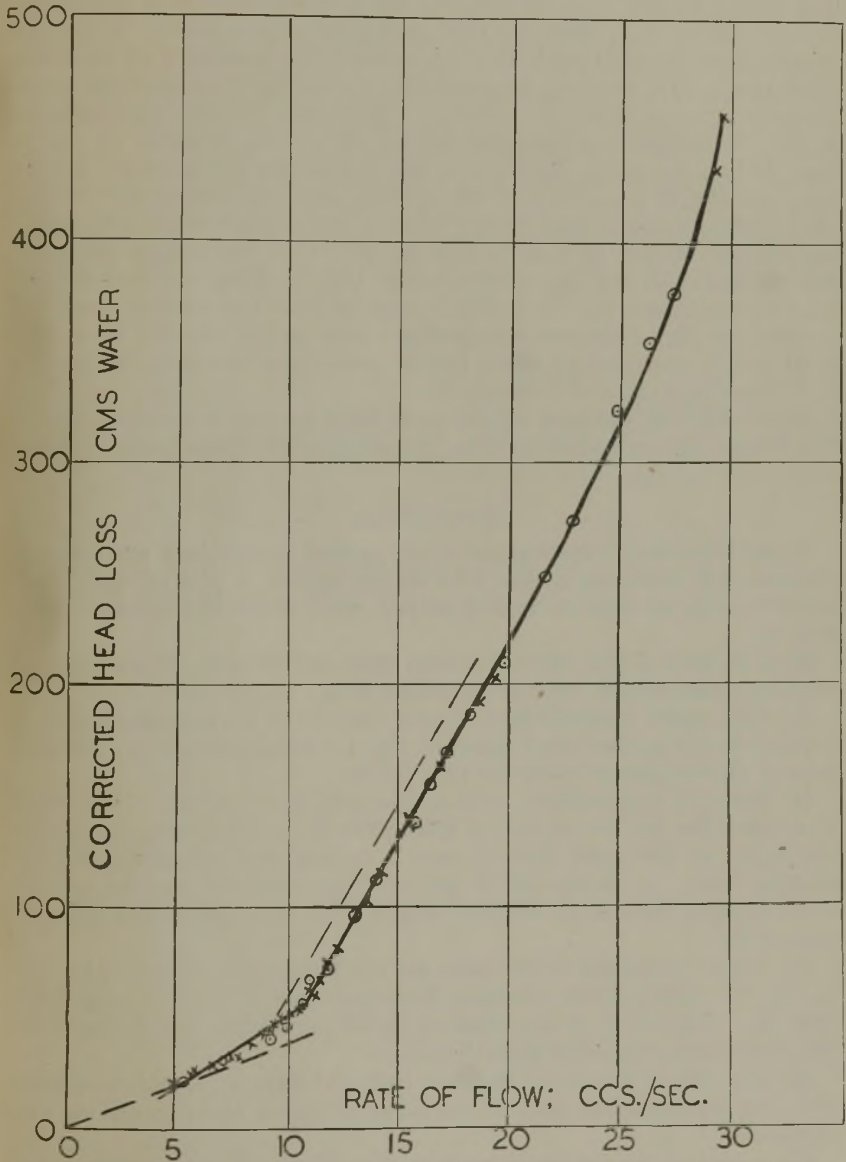


FIG. 7.

as in those previously reported, and all conditions were maintained the same save the random fluctuations in the head. These fluctuations never exceeded 3 mm. water. In each case time was allowed for a steady state to be established.

Finally, Fig. 7 presents results of practical interest and importance. It is a plot of the head lost in frictional resistance against volumetric rate of flow, neglecting a 15 per cent. overall change in kinematic viscosity. It is similar to Fig. 5 in two respects and different from it in two others. For the range of  $R_e$  between 1000 and 2100 approximately it yields a straight line identical with that obtained when pulsation at inlet was eliminated. Also similarly to those tests, a straight line connects points obtained between 3000 and 5000  $R_e$ . These two straight lines obtained in the circumstances mentioned are not, however, identical, as can be seen in Fig. 7, where the dashed line represents the previous results. They are almost parallel, with the present line lying below the previous one. This constitutes the first difference. The second major difference is the absence of the vertical section of the curve connecting the lower straight line with the upper one seen in Fig. 5. Here the two straight lines merely intersect. Thus it is concluded that the vertical section of the curve in Fig. 5 represents an unstable state which can only be realized in laboratory experiments where special precautions are taken to preserve it. In ordinary practice it disappears.

Above 5000  $R_e$  the plot of corrected head loss *vs.* volumetric rate of flow follows the normal curved line characteristic of the turbulent regime.

#### CONCLUSIONS.

(1) In laboratory experiments where special precautions are taken to eliminate all pulsations at the inlet to the system, a plot of  $\log(f/2)$  *vs.*  $\log(R_e)$  yields an asymmetrical S-shaped curve within the region of 1000-5000  $R_e$ .

(2) The limb of this curve, between 1000 and 2200  $R_e$ , is not identical with the extrapolated curve of streamline flow. It lies above it.

(3) This curve, obtained for a copper tube 0.161 in. in diameter, lies in a region on the general chart shown in Fig. 1 corresponding to a galvanized tube of slightly greater diameter than 0.5 in.

(4) For such experiments a plot of frictional head *vs.* rate of flow yields a straight line for the region of 1000-2200  $R_e$ , another straight line for the region of 2500 and 5000  $R_e$ , and a vertical line connecting the two straight lines. A change of 25 per cent. in viscosity may be ignored. Both straight lines have different slopes from each other and from the viscous line.

(5) Where pulsations in the inlet are not eliminated, a plot of  $\log(f/2)$  *vs.*  $\log(R_e)$  yields an asymmetrical S-shaped curve within the range 1000-5000  $R_e$ . This curve is not identical in all parts with the similar curve obtained where pulsations were eliminated.

(6) The limb of this curve, between 1000 and 2200  $R_e$ , is almost identical with the corresponding part of the curve obtained when pulsations were eliminated.

(7) A plot of the frictional head *vs.* rate of flow for these experiments



(where pulsation in the inlet was present) yields two straight lines intersecting at an approximate value of  $2400 R_e$  and covering the region between 1000 and  $5000 R_e$ . Above  $5000 R_e$  the plot is a curve characteristic of the turbulent region. There is no apparent unstable region connecting the two straight lines. The straight line covering the region 1000– $2400 R_e$  is identical with that obtained in experiments where pulsations were eliminated. The line connecting  $2400$ – $2500 R_e$  to  $5000 R_e$  is parallel to the corresponding line, obtained where pulsations have been eliminated, but is lower in  $H$  values on the chart. Viscosity change of 15 per cent. has been ignored with no apparent effects.

(8) In technical apparatus where pulsations are not eliminated the head lost in the critical region is proportional to the first power of the rate of flow, with the constant of proportionality assuming a value in the region 1000– $2400 R_e$  slightly greater than the value for the viscous regime, and assuming a still greater, but constant value, between  $2400$  and  $5000 R_e$ . Thus the critical regime is similar to the viscous regime in having linear relationships between frictional head and rate of flow, and it is similar to turbulent flow in the small direct influence that viscosity appears to have.

#### References.

- 1 Beale, E. S. L., and Docksey, P., "Science of Petroleum." Oxford University Press, 1938, p. 718.
- 2 Buckingham, E., *Trans. Amer. Soc. Mech. Engrs.*, **37**, 263–96. Cf. Cox, G. N., and Germano, F. J., "Fluid Mechanics" (D. Van Nostrand Co., Inc., 1941, pp. 101–107), for a good summary of the method.
- 3 Sherwood, T. K., and Reed, C. E., "Applied Mathematics in Chemical Engineering." McGraw-Hill Book Co., Inc., 1939, p. 298.
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## GRAPHICAL AND MECHANICAL DETERMINATION OF THE TRUE DIP FROM MAGNETICALLY ORIENTATABLE CORES TAKEN IN CROOKED HOLES.\*

By Dr. G. D. HOBSON.

SEVERAL years ago Lynton<sup>2</sup> described apparatus for the orientation of well-cores according to their magnetic polarity. In vertical holes the satisfactory orientation of cores in this manner makes possible the measurement of the true dip and dip direction of the beds at the point of coring, assuming that the earth's magnetic field at the point of coring is in the same azimuth as at the surface. Cores taken in crooked holes and then orientated magnetically when the core is vertical merely show an apparent dip and dip direction. The inclination of such cores to coincide with the deviation of the hole gives the true dip and dip direction of the beds only when, at the same time, the direction of magnetization of the core is made to agree with the earth's magnetic field.

At the end of his paper Lynton described a mechanical deviation corrector for finding the true dip and dip direction of the beds from magnetically orientatable cores cut in crooked holes. In this device the plane of a board pivoted on the upper end of a vertical rod is set to show the apparent dip and dip direction of the bedding in the core when a horizontal pointer attached to the rod is pointing east-west. The rod, with attached pointer and tilted board, is next inclined at an angle and in a direction corresponding with the deviation of the borehole. If this movement has deflected the pointer out of a vertical east-west plane, the rod is rotated about its longitudinal axis until the pointer lies once more in a vertical east-west plane. The last adjustment is assumed to bring the board into a position in which its plane gives the true dip and dip direction of the beds. In most instances this assumption is incorrect, although the error involved may be small provided that the deviation of the well from the vertical is not large. The error arises from the fact that the final rotation about the rod's longitudinal axis does not restore the magnetic lines of force in the core to their proper direction, except in a few cases. Consequently, the plane representing the dip of the beds is not always correctly set in space.

Johnson<sup>1</sup> noted the seat of the error without stating specifically that the recommended method of using Lynton's mechanical deviation corrector is not flawless. He outlined a series of steps which would give the true dip and dip direction from magnetically orientated cores, but his discussion is not really clear on all points. He also described a stereographic net solution of the problem, and worked out three examples, the basic data for which were not presented in a manner calculated to make easy the understanding of the method employed.

It would appear that the apparent dip and dip direction of the core bedding, coupled with the deviation of the hole, do not, in general, provide

\* Received 4th September, 1942.

sufficient data for determining accurately the true dip and dip direction of the beds. Either the actual direction of the lines of magnetic force in the core or the dip of the earth's magnetic field must also be known. A knowledge of the dip of the earth's magnetic field seems to be most convenient, although it will usually involve the assumption that the dip of the lines of force at the surface, where the dip is most easily measured, is the same as at the point in the earth's crust at which the core was taken. Johnson's stereographic net solution employs the deviation of the hole, the dip of the earth's magnetic field, and the apparent dip and dip direction of the bedding in the magnetically orientated core. If necessary the same data may be used to solve the problem graphically without any special device, although the graphical solution is not so quick as the stereographic net solution.

Consider a core as it lies in the bed from which it is cut in a crooked hole, and focus attention on the true dip and dip direction of the beds, the direction of the earth's magnetic field and the axis of the well—*i.e.*, the axis of the core. The axis of the core can be made vertical by rotating the core about a horizontal line lying in a plane perpendicular to the axis of the well. The angle of rotation is equal to the deviation of the well from the vertical. In most instances the rotation will swing the lines of force within the magnetic core out of the vertical planes containing the earth's lines of force, and it will also change the direction and amount of dip of the beds. Rotation of the core about its axis, now vertical, allows the core's lines of magnetic force to be brought back into the vertical planes containing the earth's lines of force, although the two sets of lines of force will not necessarily dip at the same angle. The apparent dip and dip direction of the bedding in the core may be measured in this position, and the measurements will agree with those obtained on cores, the north and south sides of which have been determined by means of Herrick and Lynton's apparatus.<sup>2</sup>

The graphical solution mentioned above is based on a reversal of the series of movements described in the preceding paragraph, and is as follows:—

Let the dip of the earth's magnetic field be  $\delta$ ; the apparent dip of the beds in the magnetically orientated core  $\alpha$  in a direction  $\theta$ , measured clockwise from magnetic north; and the deviation of the well  $\beta$  from the vertical in a direction  $\phi$ , again measured clockwise from magnetic north.

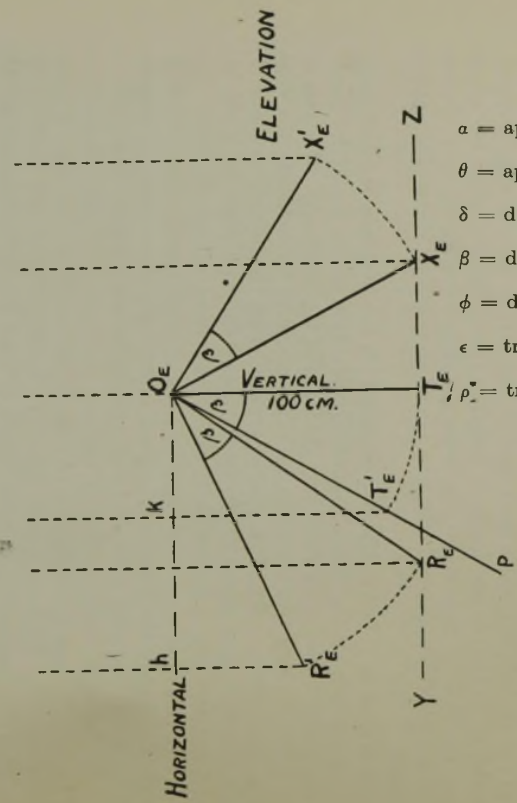
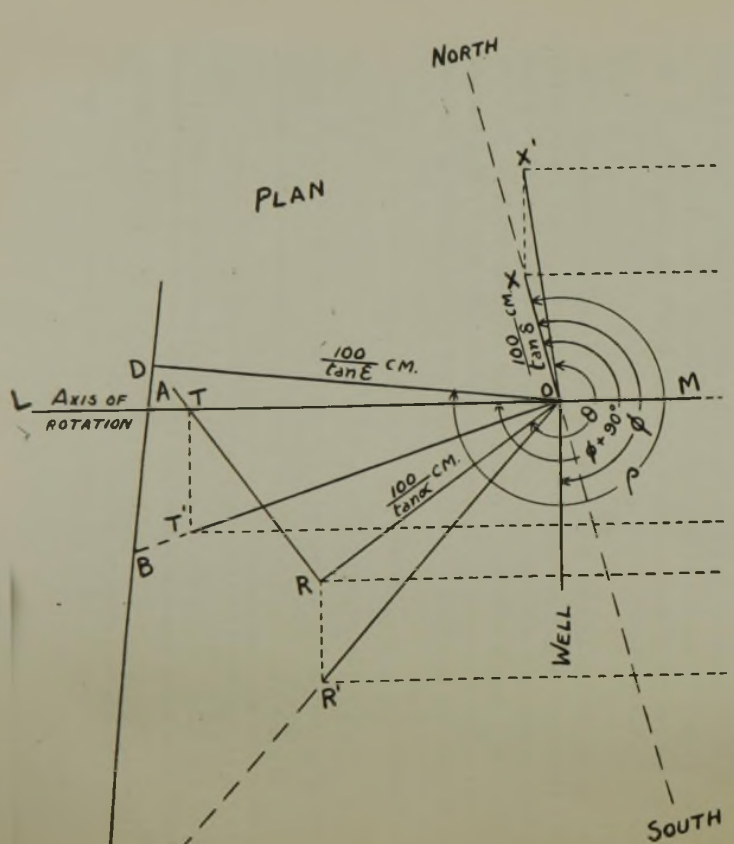
Set out a line representing magnetic north-south (Fig. 1) and mark a point  $O$  near its middle.\* From  $O$  mark off to the north† a distance  $OX$  of length  $\frac{100}{\tan \delta}$  cm.‡ to scale.

The strike of a plane perpendicular to the axis of the deviated hole is

\* This graphical solution involves the use of a plan and elevation. The point on the elevation corresponding with a point on the plan is given the same letter with a suffix  $E$ . The point to which a given point moves as a result of any of the movements described, is given the same letter with a suffix  $'$ .

† In Fig. 1 it is assumed that the magnetic lines of force dip downwards to the north. The method is still applicable even though the dip may not be downwards to the north. The procedure needed to meet this second case will be apparent since the method aims at depicting the actual movements necessary to set the core in its correct position in space.

‡ The choice of 100 cm. as the depth unit is purely arbitrary. Any other unit will serve so long as it is used throughout.



- $\alpha$  = apparent dip of beds.
- $\theta$  = apparent direction of beds.
- $\delta$  = dip of earth's magnetic field.
- $\beta$  = deviation of well from vertical.
- $\phi$  = direction of deviation of well.
- $\epsilon$  = true dip of beds.
- $\rho$  = true direction of beds.

FIG. 1.

THE ANGLES GIVING THE DIP OR DEVIATION DIRECTIONS ARE RECORDED FROM MAGNETIC NORTH AS ZERO.

$\phi + 90^\circ$ , and the plane dips at an angle  $\beta$  in the direction  $\phi + 180^\circ$ . Through  $O$  draw a strike line  $LM$  running in the direction  $\phi + 90^\circ$ . Produce  $LM$ , and on the extension mark a point  $O_E$  which is to be considered as the position on the elevation corresponding with  $O$  on the plan, the elevation being drawn when looking in the direction  $ML$ . Vertically below  $O_E$  on the elevation—i.e., on the extension of  $LM$ —mark a point  $T_E$ , 100 cm. below  $O_E$ , and at right angles to  $O_E T_E$ , draw a straight line  $Y T_E Z$ , which will be the representation of a horizontal line. From  $X$  drop a perpendicular  $XX_E$  on to  $YZ$ , thus locating the position on the elevation corresponding with  $X$  on the plan, for  $OX$  on the plan is the horizontal projection of a line of force which is supposed to run north from  $O$  until it meets a horizontal plane 100 cm. below  $O$ . On the elevation the axis of the well may be represented by a line  $O_E P$  making an angle of  $\beta$  with  $O_E T_E$ . In order to make the well vertical, there must be rotation about the axis  $LM$ , which means rotation about  $O_E$  on the elevation. Applying rotation through an angle  $\beta$  about  $O_E$  will cause  $X_E$  to move to  $X'_E$ , where  $O_E X'_E = O_E X_E$ , and  $\angle X'_E O_E X_E = \beta$ . On the plan, rotation about  $LM$  will cause the plan positions of all points not actually on  $LM$  to be displaced in directions at right angles to  $LM$ . Hence,  $X$  will move to  $X'$ , where  $X'$  is fixed by the intersection of a line at right-angles to  $LM$  through  $X$ , and a line at right-angles to  $YZ$  through  $X'_E$ .

The rotation described in the previous paragraph has swung the earth's magnetic field into the plan direction  $OX'$ . If the vertical core is turned about its axis until its magnetization has the plan direction  $OX'$ , it will be correctly related to the beds from which it was cut, and later rotation through an angle  $\beta$  about the axis  $LM$  will restore it to its original orientation in space.

From  $OX'$  measure an angle  $\theta$  in a clockwise direction and draw  $OR$ , which is  $\frac{100}{\tan \alpha}$  cm. long, to show the apparent dip and dip direction of the core bedding when the core's magnetic lines of force have been made parallel to the magnetization of the beds from which the core was cut. On the elevation  $R_E$  is the point corresponding with  $R$  on the plan. Tilting the core through an angle  $\beta$  about the axis  $LM$ , in order to give it its correct position, causes  $R_E$  to move to  $R'_E$  by rotation through an angle  $\beta$  about  $O_E$ .  $O_E R_E = O_E R'_E$  and  $\angle R'_E O_E R_E = \beta$ . On the plan the position of  $R$  after the rotation is  $R'$ , which is located from  $R$  and  $R'_E$  just as  $X'$  was located from  $X$  and  $X'_E$ . The depth of  $R'$  below  $O$  is  $hR'_E$ , where  $hR'_E$  is measured at right angles to a horizontal line through  $O_E$  on the elevation.

The two points  $O$  and  $R'$  are not sufficient to determine the true dip and dip direction of the beds, and so a third point must be used. Since  $OR$  is drawn as an apparent dip direction, a line  $RA$  at right angles to  $OR$  gives the plan positions of a series of points which are 100 cm. below  $O$  and in the plane of apparent dip of the core bedding when the core is vertical. Any point on the line  $RA$  is suitable provided that it is not too near to  $R$ . Alternatively, a point on a line parallel to  $RA$  through  $O$  may be selected. In this case the point will be at the same level as  $O$ , since it will be on a horizontal line in the plane of apparent dip of the beds. In the present example  $T$ , the point on the plan intersection of  $RA$  and  $LM$ , has been

chosen, and this is represented on the elevation by  $T_E$ , 100 cm. (to scale) below  $O_E$ . On rotation through an angle  $\beta$  about the axis  $LM$  (i.e., about  $O_E$ ),  $T_E$  moves to  $T'_E$ , and the new plan position of  $T$  is  $T'$ , located in the same way as  $X'$  and  $R'$ .  $O'_E T'_E = O_E T_E$  and  $\angle T_E O_E T'_E = \beta$ . The

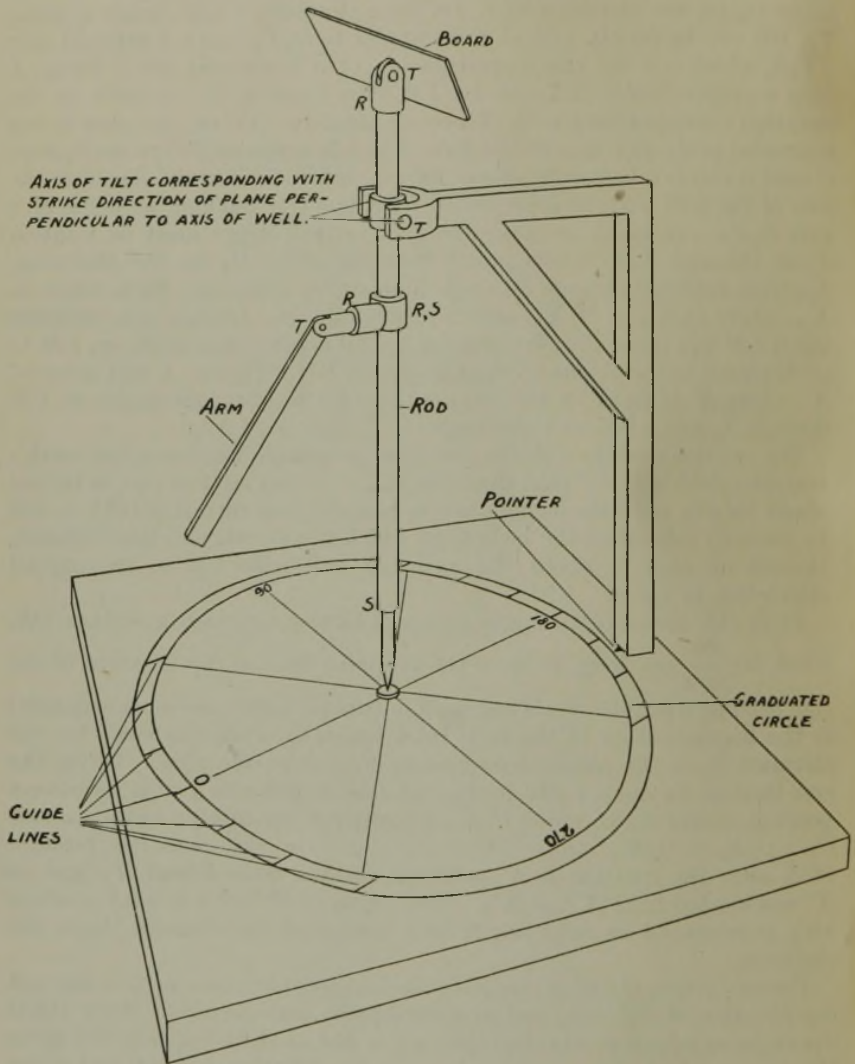


FIG. 2.  
SUGGESTED FORM OF DEVIATION CORRECTOR FOR USE WITH MAGNETICALLY ORIENTATED CORES.

$T$  = axis of tilt;  $R$  = sleeve allowing rotation;  $S$  = sleeve allowing sliding;  $R, S$  = sleeve allowing rotation and sliding.

The concentric circles within the graduated circle have been omitted in this sketch.

depth of  $T'$  below  $O$  is  $kT'_E$ , where  $kT'_E$  is measured at right angles to a horizontal line through  $O_E$ .

From the depths and plan positions of  $R'$ ,  $T'$ , and  $O$ , the true dip and dip direction of the beds may now be determined. By simple proportion a point  $B$  is selected on  $OT'$  or  $OT'$  produced, such that it is 100 cm. below  $O$

( $OB = OT' \cdot \frac{O_E T'_E}{kT'_E}$ ). Similarly, a point  $C$  is selected on  $OR'$  or  $OR'$  produced, such that it also is 100 cm. below  $O$  ( $OC = OR' \cdot \frac{O_E T'_E}{hR'_E}$ ). The

straight line joining  $B$  to  $C$  is the true strike of the beds. A perpendicular  $OD$ , from  $O$  on to  $CB$  or  $CB$  produced, is therefore the true dip direction,

and the length of  $OD$  is  $\frac{100}{\tan \epsilon}$  cm. to scale,  $\epsilon$  being the true angle of dip of the beds. The value of  $\epsilon$  may be found graphically or computed from the length of  $OD$ .

Lynton's deviation corrector can be modified so that it will give the true dip and dip direction of the beds in magnetically orientated cores. Fig. 2 shows the essential features of the modification. A vertical rod is pivoted on a horizontal axis which is considered to be the strike direction of a plane normal to the axis of the well. On the top end of the rod is mounted a board which can be tilted or rotated relative to the rod. The plane of the board is used to define the bedding planes of the formations. There is a slider on the rod below the axis of tilt of the rod. The slider carries a short arm which can be rotated about its own axis and has a pivoted arm on its end. This arm can be set to show the angle of dip of the earth's magnetic field. Centred below the rod when the rod is vertical is a graduated disc which may be rotated about its centre. In addition to being graduated circularly in degrees, the disc has a series of concentric circles of such radii that when the pointed extensible tip of the rod is set on one of them, the tangent of the angle of deviation of the rod from the vertical is given by dividing the radius of the circle by the height of the axis of tilt of the rod above the centre of the circle. The angle of deviation is marked on the circles. The direction of deviation of the well is shown by a pointer on the base board of the apparatus. A series of short guide-lines parallel to the north-south direction on the graduated circle are marked on the edge of the disc.

An additional piece of apparatus is required which takes the form of a protractor screwed flat on to a vertical board. This board, with its plane adjusted to a north-south direction by means of the north-south guide-lines, may be set close to the pivoted arm. The inclination of the arm can then be made equal to the angle of dip of the earth's magnetic field. The board also facilitates the determination of the direction of dip of the arm in the later stages of the process of finding the true dip of the beds.

All the joints on this deviation corrector must be fairly stiff, whether they allow sliding or rotation, and set-screws may be required to maintain them in the positions in which they are set.

Briefly, the method of using the deviation corrector will be as follows:—

(1) Rotate the graduated circle until the angle giving the direction (magnetic) of deviation of the well is opposite the pointer.

(2) Incline the rod to agree with the angle of deviation of the well by setting its point on the appropriate circle.

(3) Set the arm in a vertical north-south plane (magnetic) at the angle of dip of the earth's magnetic field by means of the protractor fixed on the vertical board.

(4) Move the rod into a vertical position and note the direction of the vertical plane in which lies the arm set to show the dip of the earth's magnetic field. Counting this direction as north-south (magnetic), adjust the board at the top of the rod until it agrees with the apparent dip and dip direction of the bedding in the magnetically orientated core. A compass and clinometer may be used for this adjustment.

(5) Incline the rod once more until it shows the same angular deviation from the vertical as the well.

(6) Measure the angle of dip of the board and its dip direction relative to the north point on the graduated circle. The angles obtained are the true dip and dip direction (magnetic) of the beds.

#### References.

- <sup>1</sup> Johnson, C. H., *Bull. Amer. Ass. Petr. Geol.*, 1939, **23** (5), 663.
- <sup>2</sup> Lynton, E. D., *Bull. Amer. Ass. Petr. Geol.*, 1937, **21** (5), 580.



## THE PARLIAMENTARY AND SCIENTIFIC COMMITTEE.

THE Parliamentary and Scientific Committee, of which the Institute of Petroleum is a constituent organization, has been deeply concerned during recent months with the important problem of the more effective use of scientists and technologists in the war effort. After lengthy and thorough discussion of the problem, the Committee decided that the supreme desideratum was the early establishment of a full-time Central Scientific and Technical Board to co-ordinate scientific and technical research and developments in relation to the war effort. As a first step, a distinguished and influential deputation waited on Mr. R. A. Butler, M.P., to urge the acceptance of the proposal by the Government. The next step was the tabling of the following motion on the Order Papers of the House of Commons :—

“ That this House is of the opinion that present circumstances require the early establishment of a whole time Central Scientific and Technical Board to co-ordinate research and developments in relation to the war effort and to ensure that the experience, knowledge and creative genius of British Technicians and Scientists exert a more effective influence over the conduct of a highly mechanised war.”

The motion was supported by 126 members of the House of Commons, but before it could be debated in the House, the Government appointed three full-time scientific advisers and issued the following explanatory statement :—

“ The field of activity of these advisers will be co-extensive with the responsibility of the Minister of Production. They will keep in close touch with the scientific advisers of the Service and Supply Departments, and will be available to assist the departmental organizations of scientific research and technical development. They will not supersede the departmental organizations, which will, for instance, continue to be responsible for the examination of new inventions and technical suggestions in their own fields.

“ They will be responsible to the Minister of Production, but will work under the immediate supervision of the Lord Privy Seal, acting on his behalf.

“ These appointments have been made with a view to completing the existing organization for scientific research and development which has been carefully built up over a number of years and operated with outstanding efficiency.

“ The Government have reviewed the whole position in the light of recent representations, and have decided that the creation of the post of Minister of Production affords the opportunity for this further measure of co-ordination which the Government believe will be to the national advantage.”

By making these appointments, the Government conceded part of the request for a full-time Scientific and Technical Board, but the failure to create such a Board and the consequent attempt to fit the appointments into the existing administrative machine, resulted in an arrangement that was somewhat confusing and baffling and open to criticism such as that exemplified by the following extract from a leading article in *The Times* on the subject.

“The qualifications of the scientists selected are beyond question. What remains to be proved in practice is the use which can be made of their services in the conduct of war under the arrangement now announced.

“On this point the portents are not wholly reassuring. What had been widely urged upon the Government was the association of an authoritative group of scientists not so much with the Ministry of Production—it must be presumed that Mr. Lyttelton has from the first enjoyed the assistance of scientific advisers—as with those responsible for the central direction of the war. It is therefore somewhat baffling to find that, though the three scientists now appointed will work “under the immediate supervision of the Lord Privy Seal”, Sir Stafford Cripps will be acting in this capacity not on behalf of the Prime Minister or of the War Cabinet as a whole, but on behalf of the Minister of Production. This arrangement would, if pressed to its logical conclusion, appear to place a serious limitation on the scope of the functions which they are called on to fulfil.”

The Parliamentary and Scientific Committee, after thorough discussion of the appointments, passed the following resolution which was published in the Press.

“This committee, while welcoming the appointment of three full-time scientific advisers to the staff of the Ministry of Production in so far as it establishes the nucleus of a central scientific and technical board, regrets that their field of activity is apparently to be limited to the sphere of production and does not include the scientific and technical activities of the service Departments or the other Ministries outside the strict field of production. An extension of its functions is needed to ensure that all scientific considerations are co-ordinated and given full weight over the whole field of the national effort. The committee considers, therefore, that in order to cover this wider field, scientific advisers should have direct access to the War Cabinet and that accordingly the Lord Privy Seal should exercise his supervisory functions over the new body directly on behalf of the War Cabinet.”

Dissatisfaction with the appointments was also expressed by the tabling of a number of questions on the Order Papers of the House of Commons, to which the Minister of Production replied in a statement which contained the following sentence.

“Their advice and recommendations will normally be presented to me through the Lord Privy Seal; it will, of course, be for me to

bring their advice and recommendations to the notice of the War Cabinet as may be necessary.”

This sentence would appear to be significant and important as it is the first mention of the provision of a definite link between the scientific advisers and the War Cabinet.

On the basis of the assumption that the appointment of a Central Scientific and Technical Board is not a feasible proposition at the present time, the arrangement that has been made is probably the best alternative and possesses many advantages. The three scientific advisers will work under the supervision of a member of the War Cabinet who took a scientific course at University College, London, was an assistant superintendent at an ordnance factory during the 1914-1918 war, and in his legal practice frequently demonstrated his rapid grasp of scientific facts and principles. Indeed, there could have been no better choice for this supervisory post. Moreover, the scientific advisers will be responsible to the member of the War Cabinet who is in close touch with the greatest number of Ministries, and who will bring scientific advice and recommendations to the notice of all who are responsible for the central direction of the war. It may also be found in practice that the scope of the functions of the scientific advisers is not so circumscribed as would appear from the formal announcement by Government, for as *The Times* states: “The appointments would be meaningless if the new advisers were not intended to survey the whole conduct of the war from the standpoint of science and, free from direct departmental responsibility, tender their general advice on scientific problems and scientific opportunities in whatever field that may arise.” These considerations provide ample ground for the hope that the arrangement will prove to be so fruitful as rapidly to dispel existing misgivings regarding the establishment of a full-time Central Scientific and Technical Board. In any case, the three full-time scientific advisers may confidently be expected to render most valuable service in the war effort, and their appointment is a marked advance on the previous position and is a notable achievement of the Parliamentary and Scientific Committee.

T. DEWHURST.



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## Geology and Development.

**965. Resume of Oil-field Operations in 1939.** R. D. Bush. *California Oil-fields*, 25, July 1939—June 1940.—Total production of oil in the State of California for the year 1939 was 224,253,193 bbl., as compared with a total of 249,398,399 bbl. in 1938. Production for the second half of 1939 was 1,023,627 bbl. more than for the first half.

According to statistics compiled by the American Petroleum Institute, total crude and refined petroleum in storage in Pacific Coast territory at the end of 1939 was 151,935,248 bbl. Decrease in storage during the year was thus 5,749,041 bbl., compared with an increase of 30,864,789 bbl. during 1938. The total amount of crude and refined oil shipped to Atlantic Coast ports was 3,162,000 bbl. more in 1939 than in 1938.

Two new fields, Strand and Paloma, were discovered during the year under review, and in addition new productive areas were developed in a number of fields, including West Montebello, Dominguez, Rosecrans, Wilmington, Torrance in Los Angeles County, and Trico Gas, Greeley, Coles Levee, Mountain View in Kern County.

Appended to the report are tables giving production by districts, and also statistics for each field regarding the average number of producing wells, number of barrels of oil recovered from each well, and amount of water produced. Similar tables are available for gas statistics during the year 1939. H. B. M.

**966. West Montebello Oil-field and Application of the State Gas Law.** H. P. Stolz. *California Oil-fields*, 25, July 1939—June 1940.—West Montebello Oil-field lies to the north of the town of Montebello, and about 12 ml. east of Los Angeles, California. It is approximately  $1\frac{1}{2}$  ml. long and  $1\frac{1}{2}$  ml. wide. This report is the result of a study made by the author, who was consultant to some of the independent oil companies engaged in exploitation of the field.

Since the discovery in 1936 of West Montebello Field in the Second Zone of the "old" field (discovered in 1917) development has been progressive. As wells were deepened, new prolific oil and gas zones were discovered, and moreover, deeper productive sands not yet penetrated can be expected.

By January 1940, 160 wells were producing in the field and the total potential production was estimated at 83,700 bbl. of oil per day. Total gas production at this time was over 97,000,000 cu. ft. per day, or an average gas ratio of over 4000 cu. ft. of gas per barrel of oil.

In January 1941, 189 wells were in production and the average daily yield of oil was 10,067 bbl. Gas production amounted to an average of 57,834 mcf. per day, or an average gas-oil ratio of about 5700 cu. ft. per bbl.

Total cumulative production to 1st October, 1941, amounted to 14,588,552 bbl. of oil and 84,330,566 mcf. of gas. It is estimated that 21,647,500 mcf. of gas had been blown into the air up to that time.

Voluntary curtailment of production not having proved effective, the Attorney General's Office, on behalf of the Director of Natural Resources, brought an action in the Superior Court of Los Angeles County in May 1939. This resulted in the issue of a preliminary injunction in an attempt to restrain overproduction and waste of gas. The order was modified on several later occasions, but on the whole results obtained by the injunction suit were beneficial.

Conservation of gas energy led to a longer flowing life of individual wells, while savings in production costs increased the ultimate revenue. Operators in West Montebello Oil-field gradually learned the benefits to be derived by the conservation of gas energy. H. B. M.

**967.\* Canadian Output Outside Turner Valley Insignificant.** Anon. *Oil Wkly*, 10, 8.42, 106 (10), 46.—Only five fields in Western Canada, all located in Alberta, are producing fairly substantial amounts of crude apart from Turner Valley. Vermilion gave 5415

brl. of oil from ten small wells in May. The one well in the new Tilley field yielded 674 brl. during May, and the Plains 2 well at Taber produced 1032 brl. The five wells at Wainwright yielded 841 brl., and the seven wells at Red Coulee 872 brl. A little oil was obtained from the Terminal well at Del Bonita, and from wells at Dina, while occasionally the Princess field of British Columbia has been on production.

In May Turner Valley gave 866,675 brl. of oil, and the total for all the other fields was 10,057 brl. G. D. H.

**968.\* Two Good Wells at North Turner Valley.** Anon. *Oil Wkly*, 10.8.42, 106 (10), 44.—Major 7 at North Turner Valley gave 2306 brl. of oil in 24 hr., and Foothills 10 1106 brl. in the same time. The former well is 3 ml. south-east of Atlas-British Dominion 2, the most northerly producer at Turner Valley. Foothills 10 is 8 ml. south-east of Atlas. G. D. H.

**969.\* Well Completion Rate Unchanged for Three Months.** Anon. *Oil Wkly*, 10.8.42, 106 (10), 34.—During the past three months the number of well completions has varied only slightly from 56 per day. If this rate continues there will be about 21,000 completions this year.

1585 wells were completed during the four-week period ending 25th July, practically the same as the averages for May and June. 12,707 wells were completed during the first seven months of this year, a decrease of 26% compared with the same period of 1941. Increases occurred in Pennsylvania, West Virginia, New York, and New Mexico, but practically all other districts suffered declines, the worst being a decline of 46%.

Tables give data about the drilling operations in the different states and districts, and details about the types of completions for July 1942, the first seven months of 1942, June 1942, and July 1941. G. D. H.

**970.\* Recent Discoveries Increase Drilling in Jackson County.** F. L. Singleton. *Oil Gas J.*, 20.8.42, 41 (15), 80.—An extensive wildcatting and development programme is under way in Jackson County on the Texas Gulf Coast, with the main activity about 4 ml. south-east and south-west of Ganado. Four new fields have been opened this year. The county now has fifteen producing fields, nine of them opened since 1939. This year's discoveries are Mayo, Harmon, West Mauritz, and Stewart, and they lie on a regional high extending east from Stewart to Mauritz. The oil accumulation is believed to be due to the wedging out of sands against this high. Mayo and Harmon may eventually be joined, although it is not certain that they are producing from the same reservoir.

The Mayo discovery well was brought in at 5408 ft. in the Frio, and gave 115 brl./day initially. Dry gas has been found below the producing sand, and there may be a gas-cap flanking the north edge of the structure. Three sands are productive in the Harmon field at 5375–5380 ft., 5385–5400 ft. and 5321–5329 ft. Production at West Mauritz is from 5447 to 5488 ft.

At Stewart production is from 4985 to 5000 ft., and the discovery well gave 700 brl./day initially. This field apparently has a gas-cap. The Ganado field is less than 2 ml. due east of Stewart, but it is probable that there is an intervening fault. Ganado has an oil sand at 5000–5100 ft., and others which are produced between 5500 and 6400 ft.

Twelve wildcats are planned in this region.

A map is appended.

G. D. H.

**971.\* Typical Oil-Field Structures : Buried Sand Bar ; Burbank Field, Osage County, Oklahoma.** Anon. *Oil Gas J.*, 20.8.42, 41 (15), 54.—A series of sands and shales (Cherokee series) was deposited on the eroded Mississippi lime surface in a basin between the Ozark uplift on the east and the Central Kansas and Nemaha uplifts on the west. The west side of the basin was flat and shallow, and slight movements caused the shoreline to move backward and forward, with a gradual extension westward. In the east there are many producing sands, two of which, the Bartlesville and Burbank, form long, narrow lenses along definite trends. These lenses carry oil. The Teeter-Quincy trend and the Sallyards-Lamont trend have given important amounts of oil.

There is a regional dip of 30–40 ft./ml. with local undulations. Two undulations occur in the Burbank field, where the sand ranges from a feather edge to over 100 ft. in thickness. The sand bodies consist of a number of sand-bars formed on the western shore of the Pennsylvanian sea. The Burbank sand is not uniformly porous. It has a flat base and a convex top generally, and passes abruptly into shales. It is usually most porous where it is thickest. The contained oil is probably of local origin.

There are many fields associated with offshore or nearshore sand deposits.

Some claim that shoestring sands are reflected as minute detectable surface structural features. It is possible that large, shallow sand deposits could be located geophysically. Once the sand-strings are found, the following of certain trends may lead to further discoveries. Exploratory drilling following on the realization that the lenses are likely to be present seems to be the best method of locating them.

G. D. H.

**972.\* Smackover Lime Wedge-Edge Searched for Oil Deposits.** R. Ingram. *Oil Gas J.*, 27.8.42, **41** (16), 76.—The Smackover lime has been shown to underlie most of the Tyler basin, and to carry oil when under suitable structural and textural conditions. The formation does not outcrop, and it produces no oil in Texas. The Tyler-Woodbine basin is bounded on the east by the Sabine uplift, on the west by the Bend Arch, and on the north by the Ouachitas. In the south it widens and dips towards the Gulf of Mexico.

During the early development of the basin, the Woodbine was the main objective, with deep exploration to the Paluxy, Glen Rose, and Rodessa. In 1936 large production was found in the Trinity group at Rodessa, and there were also Trinity discoveries at Talco, and a fault-line structure at the north end of the basin.

The Tyler basin has a neck which runs into south-west Arkansas, and there is also a sudden drop in the Palæozoic basement on an east-west line in Hempstead County. This condition seemed ideal for fault or shoreline oil trapping, and south of the break porous beds below the Trinity were found to pinch out before reaching the surface. This break is some miles north and west of the Mexia-Balcones fault system. In this region the Snow Hill pool in the upper Smackover lime was found in 1936, and the Schuler, Magnolia, Village, and Atlanta discoveries followed.

New conditions were found as exploration moved to the north edge of the neck of the basin where there is a graben. The first wells north of the fault found low permeability, and hopes fell. Evidence of the pinching out of the Smackover was found, and so, in addition to the search for structural traps, there was a search for true stratigraphic and possible shoreline traps.

In December 1941 the Midway Smackover pool was discovered north of the graben and on the north edge of that part of the basin. Midway is a structural trap. The Midway discovery led to extensive leasing along a 200-mi. line from Falls County, Texas, through Hunt County, and east to Arkansas. Some of the wildcats drilled as a consequence have found the Smackover lime, and one showed it to have good porosity and salt water, pointing to the possibility of production in suitable traps higher up.

There are possibilities of oil in the Marine group below the Smackover, and some entertain hopes of conglomerate production if eroded granite surfaces occur beyond the present limits of the Smackover and Eagle Mills.

G. D. H.

**973.\* Summary of Operations, July.** Anon. *Oil Gas J.*, 27.8.42, **41** (16), 99.—During the five-week period allotted to July the number of completions was considerably above that of the four-week period for June, but the weekly averages for the two periods were approximately 315 and 327 respectively. Exploratory work has been going on fairly steadily, and seems likely to increase in the next few months due to intensified wildcatting in Kansas, East, West and Coastal Texas, and North Louisiana. The number of completions in July 1942 was 50% below the figure for July 1941, and the percentage of oil-wells was 53 as compared with 69%.

A table gives details of the completions by States and districts.

G. D. H.

**974.\* Three Starr County Discoveries Highlight Laredo District.** F. L. Singleton. *Oil Gas J.*, 3.9.42, **41** (17), 57.—While there has been a large decrease in field development in the Laredo district during the first seven months of this year, wildcatting



was at the same level as during last year, and eight new fields have been opened, compared with two during the same period of last year. The development decline was due to various restrictions. Ninety-nine wildcats were drilled out of a total of 296 wells.

In Starr County three new Frio-Vicksburg sand-fields were opened, and the potentialities of proved fields along the same trend were enlarged. At North Sun oil was found at a depth of 5386-5389 ft. A second well found another sand at 4907-4914 ft., also in the Frio-Vicksburg. A third well has found a third sand at 4530-4533 ft. Although all the wells are considered to be on the same structure, there are dry wells between the producers.

The Frost field has a producing well yielding oil from 4184-4187 ft. The Garcia field in the extreme south of the county has two producers at a depth of about 3760 ft. The Sun field is now practically defined. It has eighty-two producers with a daily initial production of 1700 brl. The Rincon field now runs north-east-south-west for 5 ml.

In Hidalgo County two important gas-distillate reserves were added to the list of fields. These are Pentas and Donna near the Rio Grande river. Multiple sands have been logged in them, and there is the possibility of finding oil production down-dip, as has happened on other similar structures.

South-west of the old Bruni field the McLean field added a new deeper sand for the Jackson shoreline tend, and it is believed to be of upper Yegua age.

The Washburn field has six Wilcox producers, and has now been defined in the west and south-west. In the Green Branch area, McMullen County, a gas-well has been completed in the Wilcox at a depth of 5720 ft.

The 1942 discoveries in the Laredo district are tabulated, and a map shows the sites of the fields. G. D. H.

**975.\* Typical Oil-Field Structures; Monocline; Cabin Creek Field, Kanawha County, West Virginia.** Anon. *Oil Gas J.*, 3.9.42, 41 (17), 32-B.—During early Mississippian time the whole of the Appalachian basin, which lies between the Appalachians and the Cincinnati geanticline, was not far from sea level, and lenticular sands were laid down in the eastern part, with irregular sands in Ohio. The basal sand is generally named the Berea, but all sands so named are not necessarily contemporaneous. A series of folds were formed parallel to the mountain trend.

Cabin Creek is on the flank of the Warfield anticline in a lenticular sand of Berea age. The sand contains no water, so that the oil occurs down the structure, with gas at the top of the lens. Elsewhere other sands act as oil reservoirs, and, excepting the Lower Devonian Oriskany sand, they tend to be older in Northern Pennsylvania than in South-west Pennsylvania and West Virginia, where they are of Mississippian and Pennsylvanian age. All are more or less lenticular and typical off-shore deposits. A map, contour map, and cross-sections are included. G. D. H.

**976.\* Work Outside Turner Valley Aids Canadian Oil Outlook.** J. L. Irwin. *Oil Gas J.*, 3.9.42, 41 (17), 25.—The Alberta oil production rose by 363,066 brl. in the first half of 1942 to give a total of 5,144,462 brl., 5,090,929 brl. being from Turner Valley. There has been a marked increase in the production from fields outside Turner Valley. Turner Valley has 190 producers, thirteen with allowables of over 400 brl./day, and the other fields have twenty-five producers. Vermilion is by far the best producer of the nine Alberta fields other than Turner Valley, and it gives 14-22° A.P.I. oil from the Lower Cretaceous at depths of 1600-1900 ft. Many of the Vermilion wells have to be pumped.

Ram River No. 2 has had a good oil-showing in the Devonian lime at a depth of 4300 ft., with indications of a 75-ft. porous zone. This well is 12 ml. south-east of No. 1, which met a major fault and was abandoned. No. 2 first had oil-showings at 4250 ft. In five days after closing in the casing pressure built up to 125 lb./in.<sup>2</sup>, and finally it reached 165 lb./in.<sup>2</sup>.

The monthly production is tabulated for Alberta as a whole, and the total production of each of the fields other than Turner Valley is listed for the first half of 1942. A map showing the well locations of Turner Valley is included. G. D. H.

## Drilling.

977.\* **Steel Mud-Tanks Prove Practical in Many Areas.** G. B. Nicholson. *Oil Wkly*, 3.8.42, 1106 (9), 33-36.—Details of such systems are described and illustrated photographically. In addition to fulfilling requirements where conditions of terrain obviate digging earthen pits for mud systems, steel tanks offer numerous advantages which, in the opinion of companies which advocate their use, may be summed up as follows: (1) Cost of tanks is not excessive, while construction considers mobility and durability to permit use over a long period. Digging and filling pits are eliminated, and setting-up and dismantling require little time. (2) Pump and equipment repairs and replacements are materially reduced by use of properly designed steel tanks, due largely to partial removal of abrasives from mud by means of baffles, and by maintaining positive hydrostatic head on suction to assist pump action. (3) Small, compact but adequate systems forestall use of excessive mud, an economy amplified by flexible use of only portions of tanks which are needed for particular drilling conditions. Contamination is lessened, while loss due to seepage or breaks in dikes is averted by quick detection and repair. A further economy is realized by many oil companies which save mud in the systems and move it to the next location. (4) Mud engineers have facilities for accurately testing and treating muds, enabling them to conduct exact chemical treatments, and to maintain precise weight and viscosity. Positive tests may be made to determine exact characteristics of in-going mud, as well as variations in mud level in tanks, to determine proper input rate. A. H. N.

978. **Patents on Drilling.** J. C. Arnold. U.S.P. 2,288,876, 7.7.42. Appl. 21.1.41. Magnetic logging of well-bores characterized by rotating an inductor coil simultaneously about two axes at right angles to each other.

M. C. Bowsky. U.S.P. 2,288,884, 7.7.42. Appl. 11.12.39. Electrical logging in oil-filled wells.

J. Neufeld and E. H. Cooley. U.S.P. 2,288,973, 19.7.42. Appl. 15.12.39. Well-survey method and apparatus using electrical fields.

C. A. Shope. U.S.P. 2,289,217, 7.7.42. Appl. 16.4.41. Tubing rack for derricks affording free removal of tubing.

R. W. Stuart. U.S.P. 2,289,687, 14.7.42. Appl. 14.2.41. Method and apparatus for logging wells during drilling by measuring the electrical conductivity and hydrogen-ion concentration of the drilling fluid.

L. B. Hellman. U.S.P. 2,289,707, 14.7.42. Appl. 31.1.41. Drilling bit.

H. Dixon. U.S.P. 2,289,829, 14.7.42. Appl. 14.3.42. Fishing-tool shoe with V-shaped cutouts.

J. Neufeld. U.S.P. 2,289,926, 14.7.42. Appl. 18.3.40. Well-survey method and apparatus measuring radioactive radiations naturally emitted from formations traversed by a well-bore.

B. M. Scivally. U.S.P. 2,290,000, 14.7.42. Appl. 16.5.42. Pipe-cutter adapted to cut by rotation inside a pipe stuck in a well.

M. Schlumberger. U.S.P. 2,290,075, 14.7.42. Appl. 3.4.39. Thermal process and device for surveying the beds traversed by drill-holes by measuring the rate of heat transmission in these beds.

J. T. Hayward. U.S.P. 2,290,179, 21.7.42. Appl. 4.3.39. Method of detecting washouts in rotary well-drill strings by studying the stroke-cycle rate of the slush-pump.

C. W. Perkins. U.S.P. 2,290,247, 21.7.42. Appl. 20.6.41. Pipe-racker for operation on the platform of an oil-derrick.

W. J. Crites. U.S.P. 2,290,408, 21.7.42. Appl. 21.2.41. Exploration of boreholes by measuring and indicating the difference between the volume of fluid pumped into and out of the well.

J. Cuthill. U.S.P. 2,290,409, 21.7.42. Appl. 7.4.39. Means for withdrawing casing from wells or boreholes.

F. Squires. U.S.P. 2,290,502, 21.7.42. Appl. 29.12.38. Apparatus for forming subterranean cavities by a mechanical device.

C. W. Kinnear. U.S.P. 2,290,595, 21.7.42. Appl. 1.11.39. Rotary drill-bit with vertical cutting teeth.

W. Brauer. U.S.P. 2,290,735, 21.7.42. Appl. 20.3.39. Automatic cathead.

E. Gruenweld, H. R. Durbin and W. H. Tilley. U.S.P. 2,290,956, 28.7.42. Appl. 15.6.40. Retarding setting rate of Portland cement by incorporating 0.2 to 0.4% casein.

J. E. Ortloff. U.S.P. 2,291,055, 28.7.42. Appl. 2.4.42. Working platform for derrick masts.

W. N. Oswald. U.S.P. 2,291,100, 28.7.42. Appl. 5.7.40. Deflecting tool, including a knuckle joint.

M. E. Norris. U.S.P. 2,291,251, 28.7.42. Appl. 8.4.41. Drill-pipe protector remover and applicator.

J. W. Buchanan and C. C. Milligan. U.S.P. 2,291,371, 28.7.42. Appl. 3.8.40. Method and apparatus for cementing liners in wells.

R. T. Cloud. U.S.P. 2,291,692, 4.8.42. Appl. 2.6.38. Magnetic logging of geological formations traversed by a bore-hole.

W. J. Crites. U.S.P. 2,291,698, 4.8.42. Appl. 11.7.38. Temperature responsive means adapted for use under external pressure for imparting linear movements in response to temperature changes.

A. L. Lay and C. C. Farque. U.S.P. 2,291,732, 4.8.42. Appl. 26.4.40. Drilling rig comprising a portable rig, derrick, engine, hydraulic transmission and gear-operated drill revolving means.

G. E. Behnke. U.S.P. 2,292,036, 4.8.42. Appl. 28.6.40. Bearing for drill-bits using cone-cutters.

E. W. Isley. U.S.P. 2,292,126, 4.8.42. Appl. 8.4.39. Well-drilling apparatus, including a drill unit of the advancing motor type and means for using sludge-water around the motor-housing.

A. D. Garrison. U.S.P. 2,292,267, 4.8.42. Appl. 7.7.37. Preparation of drilling muds of special viscosity characteristics attained by use of additives.

A. L. Gibbons and H. H. Harrison. U.S.P. 2,292,268, 4.8.42. Appl. 6.3.39. Well-straightening device.

T. J. Crawford. U.S.P. 2,292,363, 11.8.42. Appl. 18.8.41. Method of treating oil-well casing thermally to certain temperatures depending on their diameter to thickness ratios.

A. R. Maier. U.S.P. 2,292,457, 11.8.42. Appl. 14.8.41. Travelling block.

C. T. O'Connor. U.S.P. 2,292,711, 11.8.42. Appl. 22.1.41. Wire-line socket and tool-latch.

P. H. Jones. U.S.P. 2,292,838, 11.8.42. Appl. 6.12.38. Method and apparatus for imparting directional magnetic properties to core-samples.

- C. L. Charles. U.S.P. 2,292,867, 11.8.42. Appl. 15.1.40. Drilling apparatus of the portable percussive type.
- A. S. Rairden. U.S.P. 2,292,971, 11.8.42. Appl. 12.6.40. Well-cable tool-drilling line and method of making same.
- C. D. Johnson. U.S.P. 2,293,259, 18.8.42. Appl. 25.3.41. Device for preventing clogging of drilling bits.
- A. H. Brunberg. U.S.P. 2,293,380, 18.8.42. Appl. 14.3.41. Safety platform for oil-well derricks.
- L. E. Mathews. U.S.P. 2,293,396, 18.8.42. Appl. 5.10.40. Derrick drill of the portable type.
- W. C. Francis. U.S.P. 2,293,603, 18.8.42. Appl. 3.3.41. Roller bit with the cutters on ball and roller bearings.
- R. S. Kail. U.S.P. 2,293,904, 25.8.42. Appl. 22.9.39. Method of batch cementing of a porous formation in a well.
- H. J. Woolslayer, E. A. Campbell, and C. Jenkins. U.S.P. 2,293,958, 25.8.42. Appl. 11.8.41. Narrow bottom tiltable mast for oil-well derrick structure.
- R. Neuhaus. U.S.P. 2,293,997, 25.8.42. Appl. 1.8.39. Method of making tool-joints.
- E. S. Long. U.S.P. 2,294,506, 1.9.42. Appl. 5.7.40. Drill-pipe protector and tool therefor.
- H. V. Steadman and E. E. Davis. U.S.P. 2,294,521, 1.9.42. Appl. 24.6.41. Removable plug for drilling strings to be used in coring operations.
- L. E. Garfield. U.S.P. 2,294,544, 1.9.42. Appl. 15.8.40. Cutter teeth for well-drills, the outward and inward sides of which are more abrasive resistant than the rest.
- C. E. Reed. U.S.P. 2,294,629, 1.9.42. Appl. 26.2.40. Earth-boring tool.
- T. B. Wayne. U.S.P. 2,294,877, 1.9.42. Appl. 5.9.41. Treatment of drilling fluid with a small percentage of a water-soluble polyphosphoric acid compound.
- M. Williams. U.S.P. 2,294,067, 8.9.42. Appl. 16.10.37. Drilling mud composition of an aqueous slurry of clay containing saccharic acid.
- S. W. Mims. U.S.P. 2,295,418, 8.9.42. Appl. 30.11.39. Apparatus for well cementing.  
A. H. N.

### Production.

979.\* **Predetermining Results of Secondary Recovery Methods.** W. L. Horner. *Oil Wkly*, 3.8.42, 106 (9), 22.—It is emphasized that secondary recovery methods which prove successful in one field may fail in another and *vice versa*. Water-flooding is discussed in some detail. It is maintained that, provided certain tests are performed and data are collected and studied, predictable results can be made. The problems in water-flooding vary with every property and every well. The correct solution of the problems depends on depth of sand, sand thickness, and porosity and permeability of the sand. Correct consideration of those factors determines the well-spacing best suited to the property, the amount of water the intake wells should receive before oil-wells are drilled, pressure to be used, and property equipment—whether pumping or flowing. The present system of calculating the quantitative oil universally recoverable by water-flooding was developed at Bradford in 1933. Prior to that time recovery was approximately foretold by using cores to determine the amount of oil in place, then multiplying that amount of oil by a fixed fraction which

was an experience factor. Whereas oil recoverable by gas expansion and by gas injection may be expressed as a part of the pore volume, water-drive yields are also modified by two factors which can be measured—connate water and residual oil content. The term residual oil content refers to oil left in place after water-drive. Since these factors can be determined directly, and recoverable oil content can be calculated with greater accuracy by using them, there is no necessity for the use of empirical means. Successful predictions now require more accurate measurements of porosity than obtainable through the conventional methods. Measurements of connate water content, shrinkage, reservoir pressures, and residual oil content are also required.

It has been observed that in many cases the practice of injecting gas has increased the rate of recovery from oil reservoirs. During recent years production curves from a large number of fields have been published in which it is typically shown that production decline was arrested by this means of secondary recovery. However, in many such cases unbiased investigation of underground conditions shows that natural water-drive has often been an unrecognized factor and was responsible for much of the additional recovery which has been credited to gas injection. During recent years laboratory investigations have disclosed the mechanisms which control the decline of rate of oil movement and the relative increase in flow of gas which results from depletion of the reservoir. By applying these principles to facts measurable through analysis of cores and reservoir fluids, past performances have been reliably reconstructed, and it is believed that proper use of this technique is an acceptable basis for the prediction of future behaviour of pressures and gas-oil ratio in any given field during production by natural means, water drive or with gas injection. It is observed that under either method of secondary recovery the amount of gas produced/brl. of oil does not exceed the amount dissolved until a substantial portion of the recoverable oil has been produced.

A. H. N.

**980. Development, Operation and Valuation of Oil and Gas Properties.** Part 11. P. J. Jones. *Oil Gas J.*, 6.8.42, **41** (13), 39-40.—This part of the paper is a continuation of Part 10 in particular. Producing efficiencies are discussed, together with formulæ for their calculation. Production under partial water-drive is analyzed briefly.

A. H. N.

**981. New-Type Multiple Completion Technique Developed in Illinois.** H. F. Simons. *Oil Gas J.*, 6.8.42, **41** (13), 31-32.—Normally, the multizone-completion method used has been one of the following: (1) The use of a removable section in the casing string, opposite the upper pay-zone or zones. These removable sections were cut out after the lower zone had been completed and tested. Generally this removable section was either aluminium-alloy pipe which could be cut out, eaten out with acid, or shot out with explosives. (2) The use of black merchant pipe opposite the upper horizons. Here again this section was removed with an expanding tool (either a wall scraper or a mill), after the lower zone was completed. (3) Some operators used the regular casing string, later removing the portion opposite the upper pay-zone with an expanding tool, an expanding mill, or a whipstock.

The new method does not use a removable section and does not require a mill to cut out the pipe opposite the upper pay-zones. Actually it is a succession of liners, or a succession of casing sections, run in the well with the portion of the hole opposite the upper pay-zones being left uncased. The procedure, when completing in three zones, is to run either a slotted or blank section of pipe opposite the lower zone and up to the base of the next higher pay. This liner is run on the tubing and is cemented in place. The second liner is run on the tubing and cemented in the hole above the second lowest pay-zone and extends to the base of the third and highest pay-formation; this liner is, of course, run in on the tubing. The remainder of the casing string is then run to the desired depth and cemented in the regular manner. Each of the zones can be shot, cleaned out, and produced.

Repair work and certain details of multiple completion jobs are given.

A. H. N.

**982. Automatic Discharge from Salt-Water Pits in the East Texas Field.** Anon. *Oil Gas J.*, 13.8.42, **41** (14), 42.—The automatic discharge is accomplished by a pick-

up pump at a salt-water pit with an automatic starter and shut off. A float is hung on a chain inside a vertical concrete pipe. The chain passes over a small wheel, and a lead weight is attached to its other end, hanging outside the pipe. The small wheel is on the switch-box of the pump-motor, and immediately beneath it is a lever which is forked at both ends. Stops are placed on the chain at the desired points, and these engage the lever, thereby providing a means of tripping the switch to start and stop the motor. The vertical concrete pipe is open at the bottom so that its water level will be the same as that of the pit. When the water reaches a certain level the motor is turned on and it runs until the water has been drawn down to a predetermined level. Discharge from the pick-up pump goes to a water-disposal well located outside the limits of the field. Other details are given. A. H. N.

**983. Strong Acid Gives Encouraging Results in West Texas Wells.** H. F. Simons. *Oil Gas J.*, 13.8.42, 41 (14), 37-38.—The primary reasons for increasing the strength of the acid used are: (1) a reduction in costs, (2) a greater increase in production of the well, and (3) less clean-out time after acidization. Actually there is a considerable number of phenomena concerned with the use of stronger acids not easily explained. One of the reasons for not using the heavier acids originally was the fear of plugging the formation, due to the sludge produced through the reaction of the acid with the limestone. The 15% acid is also slightly less viscous and has a lesser tendency to emulsification. Testing of a sample of the formation with a stronger acid will determine, in many instances, whether an adverse effect would be produced. The use of acid stronger than 25% is impracticable because of the difficulty of inhibiting the stronger acids.

From a table it is seen that the swabbing time after using 20% averaged 13.9 hr., while swabbing time following the use of 15% acid averaged 21.1 hr. The amount of fluid swabbed was less when 20% acid was used. The number of hours flowed, after acidizing the well, was 16.8 in the case of 20% acid and 36.1% in the case of the 15% acid; volume flowed was 297.3 brl. for the 20% acid and 233 brl. for the 15% acid. The comparison is even more outstanding when it is seen that the brl./hr. is 17.6 with the stronger acid and 6.4 with the standard 15% solution.

When using 15% acid, it was noted that slugs of spent acid would be produced, after which clean oil would be brought to the surface for a while and then another slug produced. The swabbing or flowing of the well would have to be continued for some time before it was certain that all the spent acid had been removed from the hole. It has been noticed that when using the 20% or 25% acid, all the spent acid is recovered, after which the well begins making clean oil. For this reason alone, the time spent in cleaning out after acidizing is considerably reduced. Theories for explaining this phenomenon are given briefly. A. H. N.

**984.\* Low-Cost Heater Solves Freezing on High-Pressure Wells.** G. M. Wilson. *Oil Wkly*, 17.8.42, 106 (11), 26.—Reduction of flow-pressure from 3300 lb. down to a 550-lb.-gathering-system pressure was causing the flow manifold to freeze up, due to expansion of gas-distillate production. Collection of ice made it difficult to operate manifold valves, and often caused a stoppage of flow into the gathering system. Freezing would occur at elbows where danger of bursting was more acute.

Solution to the problem lay in installation of some sort of hot-water or steam-jacket that would hold the flow-line temperatures above freezing. Such a system, however, had to be simple and sufficiently automatic in operation to permit its being left unattended for perhaps several days at a time, since the wells are widely spaced and are some distance from field headquarters. It was finally decided to use a small gas-fired water heater, set up at some distance from the well, which would circulate water through an insulated jacket welded to the flow manifold, then return to the heater to be reheated.

The heater is of the type commonly used in apartment houses and industrial plants. It is known as the "booster type," which in this particular size has a storage capacity of only 18-20 gal. It is not intended to store heated water; instead it is designed to heat up quickly and send it out into the circulating system. It will give up approximately 115,500 b.t.u./hr., and can heat 160 gal. of water/hr. A moderate temperature is maintained, and it can be adjusted to any point which

suits the flow conditions of any particular well. The unit has a 150-lb. working pressure capacity. The heater and the mode of its use are described with illustrations.

A. H. N.

**985.\* Plugging Air Channels with Floating Sand.** F. R. Cossens. *Oil Wkly*, 17.8.42, 106 (11), 33.—The sand-plugging procedure is generally carried out by releasing the air pressure on a badly channelled intake well, and pulling any packers which may have been seated in the sand. Fresh, crude oil, into which has been vigorously stirred floating sand (proportions being 1 measured gal. of floating sand in normal pasty form, to each 50 gal. of oil), is introduced into the well until the chamber at the bottom is filled. Connections are replaced at the casing head, and air from the compressor unit is forced into the well until sufficient pressure has accumulated to force the oil and sand residue back into the sand body. Length of time and amount of pressure required for the task depend on conditions existing in the sand area. One to three days of continuous forcing, at a built-up air pressure of 100–300 lb., are the average ratio for most districts. After fluid and plugging residue has been thoroughly forced into the sand, the air pressure is released at the casing-head, and the chamber is re-filled with clean oil. Pumping equipment is next installed with necessary connections so that the well can be circulated freely for 24–36 hr., then pumped dry. Oil circulated by the pump washes the face of the chamber free of floating sand which has accumulated upon it during the forcing process, but greater quantities have normally been pushed back into the larger sand-channels where the material remains untouched by the reservoir washing.

A. H. N.

**986.\* Special Bottom-Hole Pressure Truck has Advantages.** J. C. Albright. *Oil Wkly*, 17.8.42, 106 (11), 30.—The unit is used to test over forty producing wells frequently to determine reservoir conditions. The complete unit consists of a light truck on to which has been placed a special body fitted with trays, bins and drawers for tools and spare parts, plus all necessary equipment for testing and determining bottom-hole pressures. Included in the equipment is a self-contained mast, thus eliminating the need for individual masts or tripods at each well, and thereby releasing material that can be used elsewhere. Also included is the equipment necessary for testing and checking the indicating pressure gauges.

The mast is carried on a heavy steel supporting member bolted securely to the back of the chassis frame sills and resting on the rear bumper for additional support. The supporting member is massive enough for the truck to be driven over rugged terrain with the mast raised without danger of side-sway or tipping.

The hoist and the method of working it are described in detail and illustrated.

A. H. N.

**987.\* Truck-Mounted Steam Cleaning Unit Performs Many Jobs.** E. Sterrett. *Oil Wkly*, 17.8.42, 106 (11), 17.—A unit having a steam-generating coil similar to those used on Diesel-powered trains for heating passenger compartments is described. Tank-cleaning may be done with steam alone, steam from the generating unit being carried to the job in a standard steam hose or through combination of flexible piping and hose, and directed against the surfaces to be cleaned. This method relies largely on the dual blasting and heating effects of the steam to remove the loosened dirt, and is not as satisfactory as the one usually followed, in which steam from the generating coils is mixed with water, so as to make the resultant steam as wet as possible. This reduction of steam temperature guards against blistering of tank-paint, and also provides sufficient condensation flow, as the relatively cold tank metal is contacted to form a flushing film which aids greatly in removing the waste and dirt without spattering it over adjoining structures.

If further refinement of the cleaning is desired, the steam added to the steam-flow may carry cleaning compound of any desired strength, the cleaner being added in the drum or other mixing vat and picked up in solution from that point by the suction hose from that end of the unit pump transferring the mixture into the flow-line to the washing nozzles. A few details are included.

Tubing pulled from a well being serviced is frequently found to be so clogged with paraffin, especially through certain zones of the well depth, as to require thorough

cleaning before returning to the well. Where such tubing is to be steamed out, the operation is speeded up and removal made more complete if the tubing be stacked with the end away from the well a foot or so lower than the other, and with the random lengths taken care of at the lower end. Close ranking of the tubing at the high end reduces the labour of switching the steam nozzle and enables a check on finished work to be kept without markers or other aids. The steam generator is set up as for tank-cleaning, except that the dilution stream pumped into the steam is pure water only, to give as great a volume of flushing fluid as possible after the heat in the steam has liquefied the paraffin. The nozzle used is different from that used for tank-cleaning. Details are given.

Cleaning surface lines is also extensively described. The unit is described in detail at the end of the paper. Safeguards are built into the unit which automatically cut off the fire and stop the operating motor if the water pressure becomes too low, if the fuel flow is stopped, or if the temperatures passed a predetermined maximum. Since the blower fan is started at the same time that the magneto is set in operation, accumulation of gases within the generator housing to the point where an explosion might occur is prevented and the space ventilated adequately. Pressure-actuated devices cut off the fuel unless the boiler is filled and either water or steam pressure maintained at the desired setting, it being necessary to fill the tubes with water by a hand pump before starting the operating engine; otherwise the unit would cut off and remain inactive, thus preventing the tubes from being burnt out by being fired when dry.

A. H. N.

**988.\* Weak Acid Gives Good Results in North Central Texas Wells.** Part 2. H. F. Simons. *Oil Gas J.*, 27.8.42, 41 (16), 37-38.—Part 1 of this paper discussed the use of 20% acid in New Mexico and West Texas, where the normally used inhibited 15% hydrochloric acid was ineffective. This part deals with using a weaker acid than the usual 15% where this acid failed. A 10% acid is studied, as it produced better results in one particular field than the 15% acid. The exact explanation for the better success of the weaker acid is not forthcoming, and its value can best be judged on the results. There are several factors which might contribute to the success of the 10% acid. The weaker acid solution is less viscous and produces a less viscous spent acid. It is therefore less likely to emulsify. The weaker acid has a very good non-emulsifying characteristic and, as might be expected, has lower surface tension. However, non-emulsifying agents and surface-tension-reduction agents have been added to the weaker acid to increase these qualities. Another factor which may be important is the small amount of soluble material in the formation. The inhibition of the acid against steel corrosion is no problem.

Comparative study of the two strengths is made. Wells in the area are all on the pump, and are acidized with the tubing in the well. One method is to pull the rods and leave the standing valve in place and load the tubing with oil. The acid is then put in the casing and followed with oil from the stock-tanks. The acid is left on the formation for about an hour, after which it is pumped out through the tubing. Another method is to fill the hole with oil and pull the standing valve. The acid is then put down through the tubing and allowed to stand on the formation approximately as before. In the meantime the rods are run in the well, preparatory to pumping out the acid and load oil.

Formulæ are given for diluting the strong acid. As the amount of soluble material in the formation is reduced (the average calcium carbonate in the KMA "sand" is 15.35%), less acid is required to remove the material and open the pores in a given volume of the formation. In a case where the well is shot and the contact area quite great, penetration of the 10% acid is sufficient to open drainage channels that are rather extensive. It is shown that a little over 7 cu. ft. of pure limestone is dissolved by 1000 gal. of the 10% acid, which means that when the formation contains only 15.35% calcium carbonate, 45.5 cu. ft. of the formation will react with the acid. The problem thus becomes one of forcing the weak acid into the formation to fecontact the greatest volume of soluble material. The average treatment of 3000 gal. of 10% acid results in the removal of calcium carbonate from 136.5 cu. ft. of formation. The lack of complete success of the stronger acid may, in part, be due to a Jamin effect caused by its higher surface tension.

A. H. N.



989. **Patents on Production.** A. Boynton. U.S.P. 2,288,605, 7.7.42. Appl. 8.12.39. Differential flow-device with valve-controlling means, for the gas-lifting of liquids from wells through a tubing.

J. P. Bradner. U.S.P. 2,288,780, 7.7.42. Appl. 21.2.40. Packer of the conical type which is used in formation testing by seating it against a shoulder in the well-bore.

A. J. Zschokke. U.S.P. 2,288,931, 7.7.42. Appl. 1.8.41. Gun perforator with laterally directed gun-bores spaced at different angles and interconnected.

A. J. Zschokke. U.S.P. 2,288,932, 7.7.42. Appl. 4.8.41. Gun perforator with multiple bores and a central cartridge bore.

A. L. Parker. U.S.P. 2,289,382, 14.7.42. Appl. 7.11.40. Tube coupling.

L. Yost. U.S.P. 2,289,401, 14.7.42. Appl. 24.3.41. Submersible pumping unit for deep wells.

L. M. Trawick. U.S.P. 2,289,603, 14.7.42. Appl. 3.9.40. Well-flowing apparatus containing a choke made of tubing and collars.

J. F. Cailloux. U.S.P. 2,289,696, 14.7.42. Appl. 28.10.40. Tubing head comprising a soft deformable support.

L. C. Chamberlain and O. E. Barstow. U.S.P. 2,289,755, 14.7.42. Appl. 28.8.40. Apparatus for treating wells by simultaneously injecting fluid into at least two zones traversed by the bore.

J. N. Gilman and G. S. Giveen. U.S.P. 2,289,772, 14.7.42. Appl. 9.3.40. Convertible pumping system adaptable for operation as a high- or low-pressure system and using centrifugal pump.

J. W. Johnson. U.S.P. 2,290,127, 4.7.42. Appl. 31.1.40. Sand and gas excluder means for wells.

C. E. Burt. U.S.P. 2,290,141, 14.7.42. Appl. 14.1.39. Perforation cleaning method and apparatus using a packer above the screen and injecting fluid above the packer to create suction through the perforations.

C. E. Burt. U.S.P. 2,290,142, 14.7.42. Appl. 23.12.39. Retrievable well-packer with a body adapted for attachment to a tubular string for passage through a well-casing.

C. M. Blair, Jr. U.S.P. 2,290,154, 21.7.42. Appl. 27.6.40. Process for breaking petroleum emulsions of the water-in-oil type using a demulsifier from a general class of compounds.

A. Parmeson. U.S.P. 2,290,351, 21.7.42. Appl. 23.2.38. Swab for wells comprising a mandrel and divided sealing means on the mandrel.

M. De Groote and B. Keiser. U.S.P. 2,290,411, 21.7.42. Appl. 27.6.40. Process for breaking petroleum emulsions of the water-in-oil type by means of a demulsifier from a general class of diamines.

M. De Groote. U.S.P. 2,290,413, 21.7.42. Appl. 11.10.40. Composition of matter and process for preventing water-in-oil type emulsions resulting from acidization of calcareous oil-bearing strata.

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R. W. Skinner and P. B. Skinner. U.S.P. 2,290,774, 21.7.42. Appl. 9.9.40. Oil-well swab.

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K. T. Penick. U.S.P. 2,291,499, 28.7.42. Appl. 26.5.39. Balancing device for pumping units using a counterbalance fluid in a cylinder.

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C. W. Stancliffe. U.S.P. 2,291,771, 4.8.42. Appl. 13.5.39. Apparatus for the determination of the moisture content of sands and other materials comprising scale beam.

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W. F. McMahon. U.S.P. 2,291,911, 4.8.42. Appl. 7.3.39. Apparatus for raising oil and gas from oil-wells.

C. Malinowski. U.S.P. 2,291,972, 4.8.42. Appl. 14.5.40. Pumping mechanism having reciprocating elements.

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A. Arutunoff. U.S.P. 2,292,345, 11.8.42. Appl. 23.8.40. Oil-production control device.

E. O. Bennett. U.S.P. 2,292,349, 11.8.42. Appl. 8.5.40. Well-pumping assembly for wells having a line of pumping rods adapted to activate a pump within the well.

A. L. Smith. U.S.P. 2,292,670, 11.8.42. Appl. 17.11.41. Well perforating gun with a special bore for the bullet.

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E. L. Barker. U.S.P. 2,293,012, 11.8.42. Appl. 9.4.41. Well-casing head construction with vertical side outlets.

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H. A. Montgomery. U.S.P. 2,293,442, 18.8.42. Appl. 7.5.40. Well-cleaning apparatus.

G. S. Bays. U.S.P. 2,293,488, 18.8.42. Appl. 6.4.38. Apparatus for determining permeability of an oil-well core using a liquid under constant pressure for the flowing fluid.

T. G. Myers. U.S.P. 2,293,616, 18.8.42. Appl. 28.2.38. Submersible structure adapted to be submerged in well liquids, for electrical instruments in a casing.

A. Boynton. U.S.P. 2,293,706, 25.8.42. Appl. 18.5.39. Liquid ejector in the form of an intermittent pneumatic pump.

E. W. Patterson. U.S.P. 2,293,915, 25.8.42. Appl. 25.9.39. Counterbalanced pumping unit for a well.

E. W. Patterson. U.S.P. 2,293,916, 25.8.42. Appl. 3.8.40. Air-balanced pumping unit and pressure regulation thereof.

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J. J. Grebe. U.S.P. 2,294,294, 25.8.42. Appl. 27.9.37. Treatment of wells by forcing a resin-forcing substance between the casing and the well.

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M. De Groote and B. Keiser. U.S.P. 2,295,163, 8.9.42. Appl. 21.3.41. Process for breaking petroleum emulsions of the water-in-oil type using a water-soluble esterification product.

M. De Groote and B. Keiser. U.S.P. 2,295,164, 8.9.42. Appl. 21.3.41. Process for breaking petroleum emulsions of the water-in-oil type, using an esterification product.

M. De Groote and B. Keiser. U.S.P. 2,295,165, 8.9.42. Appl. 21.3.41. Process for breaking petroleum emulsions of the water-in-oil type, using a water-soluble esterification product.

M. De Groote and B. Keiser. U.S.P. 2,295,166, 8.9.42. Appl. 21.3.41. Process for breaking petroleum emulsions of the water-in-oil type by using a water-soluble esterification product.

M. De Groote and B. Keiser. U.S.P. 2,295,167, 8.9.42. Appl. 21.3.41. Process for breaking petroleum emulsions of the water-in-oil type using a water-soluble esterification product.

M. De Groote and B. Keiser. U.S.P. 2,295,168, 8.9.42. Appl. 21.3.41. Process for breaking petroleum emulsions of the water-in-oil type using a water-soluble esterification product.

M. De Groote and B. Keiser. U.S.P. 2,295,169, 8.9.42. Appl. 21.3.41. Process for breaking petroleum emulsions of the water-in-oil type using a water-soluble esterification product.

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A. H. N.

## Transport and Storage.

990.\* **Recent Developments in Cathodic Protection of Bare Pipe-Lines.** G. R. Olson. *Petrol. Engr*, May 1942, 13 (8), 35.—Little information is available regarding relative costs of protection of pipe-line afforded by cathodic protection alone, or combined with varying degrees of coating, over long periods of operation. A description is given of a method of cathodic protection applied to short sections of old bare lines which had become so seriously corroded that reconditioning or replacement would otherwise have been necessary within a few years.

An electric power-line carrying single high-voltage and low-voltage conductors was built parallel to the pipe-line. At suitable intervals transformers were installed to step down the supply voltage from 2300 to 110 volts, and each pole was fitted with a small rectifier unit of special design to permit easy adjustment of output ratings to suit field requirements under service conditions. An anode of scrap pipe was installed near the base of the pole, and the pipe-line used as common return for both circuits. Pipe to soil potential measurements are used as a guide in adjusting unit outputs, but subsequent changes are frequently necessary as a result of experience or change in conditions. Two installations covering respectively 20.9 and 4.8 m. sections of bare pipe were placed in service early in 1941, and tables and graphs give details of the section of line protected, cathodic protection requirements, overall efficiency of the installations, and measurements of soil resistivity and pipe to copper sulphate plug potentials along the line. Subsequently other sections of pipe, some bare and others poorly coated, have been protected by similar installations, and details are given. Current densities required for protection of sections of bare pipe vary from below 1 to over 6 expressed in milliamps per sq. ft. of pipe surface exposed, and requirement does not appear to correlate with other available data. The average current density of the two initial lines varies from 2.2 to 2.9 milliamps per sq. ft. of pipe surface exposed. Records show the greatly reduced frequency of corrosion leaks resulting from the protection applied. Ten poles per mile run of pipe was used for the initial scheme, but pole spacing will depend on whether the pipe is bare or coated and relative costs of equipment required. Improvements in ground anodes are desirable, and experiments are in hand with this object in view. Estimates are given of savings in future steel requirements as a result of the installation concerned.

R. A. E.

## Gas.

991.\* **Natural Gas—An Important Factor in California's Economy.** W. A. Sawdon. *Petrol. Engr*, July 1942, 13 (11), 80.—California has a greater number of natural gas consumers than any other State in the U.S.A., is second in natural gas sales and is the only large producing State that neither imports nor exports natural gas. The State is almost dependant on natural gas for heating, and industry relies largely on it for fuel. Until recently there was more than enough gas from oil-wells to meet demand, and little dry gas was taken from gas-fields even during peak loads. Tables and graphs show the total production of casing-head and dry gases and their utilization for the period 1923-41. The percentage of unconserved gas has been greatly reduced in recent years, and in 1941 amounted to only 3.6. Control of gas-oil ratios in the production of oil-wells and the possible effect on gas production of a change in product demand are factors which necessitate increased attention being paid to gas supplies from natural gas-wells. In 1941 such gas represented about 9% of total production. The number of producing wells is 110, mainly situated in the Rio Vista field and serving the San Francisco Bay area. This has rendered possible the release of a large gas-line from the south to transport oil to refineries. Additional gas-wells are being drilled.

R. A. E.

992.\* **Natural Gas—Possibilities of Exploitation in Great Britain.** L. Ivanovsky. *Petroleum*, August 1942, 5 (8), 133.—The production of synthetic fuel from natural gas sources presents obvious advantages at a time when coal is in short supply. In an appendix, the process for converting natural gas into water gas and hydrogen

with the aid of steam and suitable catalysts, referred to in Technical Paper 622 of the Bureau of Mines, is described. This process could be modified to provide a suitable "synthesis gas" which could be used as raw material for Fischer-Tropsch or Robinson-Bindley processes. This would simplify the processes and possibly offer economic advantages. Little information is available in regard to the potential supplies of natural gas in the U.K., but according to a report of 1938 a group of Scottish gas-wells could supply over 10 million cu. ft. of gas per day, although sealed at that time. They appear to provide the most important source of natural gas in this country. In addition, supplies of methane could be obtained from coal-mines, coal and coke-oven gases, and sewage works. Extracts from the *Bulletin of the Imperial Institute* dealing with the natural gas situation in Great Britain are given in the Appendix.

R. A. E.

### Polymerization and Alkylation.

993. Patents in Polymerization and Alkylation. Anglo-Iranian Oil Co. E.P. 546,037, 24.6.42. Appl. 23.12.40.—Process for the polymerization of olefines, especially normally gaseous olefines, for the production of motor spirit or a blending material for same. During the operation a solid phosphoric acid catalyst composed of *ortho*-phosphoric acid, copper *ortho*-phosphate, and calcium *ortho*-phosphate is used. The ratio of *ortho*-phosphoric acid to copper *ortho*-phosphate and calcium *ortho*-phosphate in the catalyst is greater than 4 : 1 : 1, but not substantially greater than 8 : 1 : 1.

Standard Oil Development Co. E.P. 546,334, 8.7.42. Appl. 10.7.40.—Method of converting *isoparaffinic* hydrocarbons into hydrocarbons of higher molecular weight by reaction with normally gaseous olefines. The reaction is effected in the presence of a catalyst consisting of a product formed by the reaction of a saturated normally liquid hydrocarbon and aluminium chloride or aluminium bromide.

Texaco Development Corp. E.P. 547,214, 19.8.42. Appl. 7.5.40.—Process for the production of high anti-knock hydrocarbons suitable for motor fuel by alkylating a low-boiling *isoparaffin* with C<sub>3</sub> and C<sub>4</sub> olefins.

W. E. Bradley and K. J. Korpi. U.S.P. 2,286,183, 16.6.42. Appl. 2.5.38.—Production of motor fuels by reacting *isoparaffinic* hydrocarbons of less than seven carbon atoms per molecule with olefinic hydrocarbons having more than two carbon atoms per molecule, in the presence of an alkylating catalyst and diamyl ether.

W. E. Bradley and K. J. Korpi. U.S.P. 2,286,184, 16.6.42. Appl. 14.5.38.—Process of forming alkylated paraffinic hydrocarbons by reacting *isoparaffinic* hydrocarbons of less than seven carbon atoms per molecule with olefinic hydrocarbons having more than two carbon atoms per molecule in the presence of strong sulphuric acid and a low-molecular-weight carboxylic acid.

F. D. Parker. U.S.P. 2,286,504, 16.6.42. Appl. 30.1.39.—Production of branched-chain saturated hydrocarbons boiling within the gasoline range. *isoparaffinic* hydrocarbons are reacted with normally gaseous olefinic hydrocarbons in the presence of an alkylating catalyst. The process is characterized by contacting the gaseous olefins with a hydrocarbon liquid absorbing medium prior to contact with the *isoparaffin* and alkylating catalyst. In this way is produced a liquid mixture containing absorbed olefins, which is in turn mixed with liquefied *isoparaffins* and catalyst.

H. Heinemann. U.S.P. 2,286,543, 16.6.42. Appl. 10.7.41.—Alkylation of *isoparaffins* with olefins which involves reacting an *isoparaffin* with an olefin at a temperature between 300° and 500° F. under a pressure of 300–450 lb. per sq. in. in the presence of a catalytic composition containing a metal halide selected from the group consisting of zinc halides, aluminium halides, ferric halides, and stannic halides, in admixture with an oxygen containing compound of antimony.

H. B. M.

### Synthetic Products.

994.\* Synthesis of Known Hydrocarbons in Petroleum. W. L. Faith. *Petrol. Engr.*, May 1942, 13 (8), 96.—In view of the increasing importance attached to the preparation of individual hydrocarbons from petroleum, the most satisfactory methods of synthesizing various hydrocarbons known to be present in petroleum are reviewed.

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The most common methods of synthesizing paraffinic hydrocarbons are: (1) Wurtz reaction, (2) Clemmensen reaction, (3) Grignard reaction, (4) electrolytic reduction of ketones and esters, (5) catalytic hydrogenation of olefines which may be prepared by dehydration of alcohols. The proper method to choose for a particular hydrocarbon depends on several factors, including availability of raw materials, but purification of products at each step and efficient fractionation in the final step are of utmost importance. Twenty-eight paraffinic hydrocarbons have already been isolated by Rossini of the Bureau of Standards from fractions of Mid-Continent crude.

Methane, ethane, and propane can be prepared in large quantities by fractionation of natural and cracking still gases. Twenty-two of the other paraffins can be prepared by method (5), which is generally preferred and is more adaptable to large-scale manufacture. Details are given of the starting alcohol and intermediate olefin in each preparation, with references to literature giving requisite details of process. 3-Methyloctane has been made by Grignard synthesis and *n*-decane and *n*-dodecane by Wurtz synthesis. Present commercial production of paraffinic hydrocarbons and future possibilities are discussed.

Twelve different naphthenic hydrocarbons have been isolated by Rossini from petroleum fractions. The most suitable method of preparation of the majority of these is catalytic hydrogenation of the corresponding aromatic hydrocarbon. This may be carried out at room temperature and slightly elevated pressures using a platinum oxide plus platinum-black catalyst, or at higher temperatures and pressures using a nickel catalyst. A list is given of eight naphthenic hydrocarbons prepared by catalytic hydrogenation, showing raw material, catalyst used, and literature reference. The remaining four naphthenes have been prepared from the corresponding alcohol by similar methods as are applied in the case of paraffinic hydrocarbons. The lower naphthene hydrocarbons are already being produced commercially, and the catalytic hydrogenation method is readily adaptable to large-scale manufacture given pure raw materials. Future possibilities are discussed.

Twenty-one aromatic hydrocarbons have been isolated by Rossini from petroleum. These may be prepared by a wider variety of reactions than either paraffin or naphthene hydrocarbons, but the choice of the particular combination to use in a given case is a matter of experience. As examples, methods often applied are: (1) Friedel and Crafts reaction, alkyl halide condensed with a benzene compound in the presence of  $AlCl_3$ , (2) reaction of benzene with alcohols, esters, ethers, olefines, and naphthenes in the presence of a condensing agent such as  $BF_3$ ,  $H_2F_2$ , and  $H_2SO_4$ . Suitable methods of preparing various benzene and naphthalene hydrocarbons are listed with appropriate references. The manufacture of benzene hydrocarbons by cyclization of *n*-paraffin hydrocarbons is also mentioned.

R. A. E.

**995.\* Synthetic Rubbers to Meet Requirements of Natural Rubber in Industry.** C. C. Pryor. *Petrol. Engr.*, May 1942, **13** (8), 127.—The article traces the history of rubber synthesis and describes the reactions involved in the manufacture of Buna S, Buna N, Neoprene, Butyl rubber, Ameripol, Chemigums, Thiokols and Vistanex. The properties and applications of these synthetic materials are also described, and production figures for the U.S. during the three years 1939/1941 are given.

R. A. E.

**996. Synthetic Drying Oils.** Anon. *Chem. Tr. J.*, 21.8.42, 111, 179.—E.P. 545,765 of 1941 granted to E. I. du Pont de Nemours & Co. describes the production of synthetic drying oils by the polymerization of butadiene and its homologues. Previous methods of polymerizing unsaturated hydrocarbons have given low yields of products, inferior in drying characteristics to natural drying oils. In the present invention butadiene or its homologues are subjected to high temperatures and pressures in the presence of (a) 3-6% of a promoter consisting of an aldehyde, preferably *n*-butyraldehyde, or a ketone, (b) a catalyst consisting of a copper salt of an organic or other weak acid, e.g., cupric acetate, and (c) 10% to 30% of a hydrocarbon solvent, e.g., benzene. Smaller quantities of promoter give low yield of drying oil and higher quantities produce rubbery materials. An example is given of a mixture of 80 parts of butadiene, 17 parts benzene, 3 parts *n*-butyraldehyde, 12 parts of catalyst mixture (iron powder, copper metal, iron oxide and copper acetate) heated in a bomb

for 5 hours at 160° C., cooled, filtered and the volatile matter removed by evaporation. A yield is given of 24.8 parts of a pale yellow, very viscous, oily polymer of iodine number of approximately 400, readily soluble in organic hydrocarbons, which forms hard, tough, adherent coatings of excellent durability and chemical resistance, drying being accelerated by the usual catalysts. C. L. G.

### Refining and Refinery Plant.

**997.\* Butane as a Source of Motor Fuel Volatility.** J. W. Vaiden and J. O'Reilly. *Petrol. Engr.*, May 1942, **13** (8), 116.—Of recent years refiners have sought means of utilizing butane to the best advantage, so that its use as refinery fuel gas could be avoided. The methods utilized included direct sales, with and without propane admixture, as fuel for industrial and household purposes, direct use as motor fuel in trucks fitted with special fuel systems, use as raw material for polymerization units and, most important, increased incorporation in motor fuel as a result of reduction of propane content achieved by better fractionation. Consequently refiners have become increasingly dependent on butane as a source of volatility and anti-knock quality for motor gasolines. The enormous demand for butane as raw material for preparation of 100 octane aviation gasoline and of synthetic rubber thus creates a difficult problem for refiners in connexion with motor-fuel quality. The position is further aggravated by restriction of tetraethyl lead supplies and probably reduction in quality and quantity of natural gasoline available due to *isobutane* and *isopentane* extraction, and expected curtailment of carbon-black manufacture. It is probable that the butane output of many of the smaller refineries and natural gasoline plants will be available for the present, owing to the fact that installation of small alkylation and isomerization units is not yet economically feasible, but conversion of butane heating systems to use propane only, and of trucks using butane to run on motor fuel is likely to be restricted by steel requirements.

It is suggested that part of the butane deficiency can be made good by incorporation of propane, and the modification of specifications may become necessary to permit the use of propane instead of butane to give a finished motor fuel of approximately the same vapour pressure as at present allowed. In addition, the changed conditions will necessitate more efficient operation of present plants, and possibly installation of new equipment to ensure maximum extraction of butanes and propane, although such measures may not have been economically justified in the past.

A change in the demand-supply balance will probably further assist the position. Increased reforming of straight-run gasolines to produce butenes will probably be necessary, and this will automatically reduce the quantity of motor fuel available and increase the yield of cracked gases. Demand for motor fuel is also expected to decline. Careful planning is recommended, especially in plants expecting to supply butanes for war purposes, otherwise a period during which no satisfactory motor fuel can be prepared may arise.

R. A. E.

**998.\* Substitute Metals and Alloys for Refinery Uses.** B. B. Morton. *Petrol. Engr.*, May 1942, **13** (8), 130.—In view of the present shortage of metals such as chromium, nickel, copper, etc., the possibilities of substitute materials for various refinery uses are discussed. For sub-zero temperatures down to -75° F. carbon steels properly treated with aluminium and controlled as to grain size offer the best present substitute for nickel-containing steels.

Where metal temperatures of 1200–2000° F. are involved, and particularly where replacement is difficult and expensive, no change from the usual 25% chromium 12% nickel type of alloy steels is to be recommended in view of the markedly superior resistance to corrosion and the superior strength at high temperature of this alloy. Possible substitutions in the high-temperature range are listed.

In the low-temperature range, defined as the region in which liquid water exists, the demand is mainly for non-ferrous alloys, the type being dependent on the nature of the corrosive material encountered in the particular service. In order to conserve copper, substitution of these alloys by cast-iron equipment for condensers, coolers, pumps, etc., is being considered and put into practice. A list of possible substitutions in the low-temperature range for various services is given.

R. A. E.

999.\* What can be done about Sulphur in the Refinery. A. W. Trusty. *Petrol. Engr*, May 1942, 13 (8), 72.—The average cost of corrosion to the refiner is 1 c. per gallon of refined gasoline. In addition, the cost of treatment of distillates of high sulphur contents to meet specifications has been enormous, and the effects of sulphur compounds in reducing lead susceptibility and gum inhibitor susceptibility are well known.

The sulphur compounds of most interest to the refiner are hydrogen sulphide and mercaptans. The hydrogen sulphide contents of sour gases from some American fields are quoted. Caustic soda is usually employed for removing hydrogen sulphide from liquid petroleum fractions, but cannot be used economically for treatment of gases containing considerable amounts of hydrogen sulphide. For such gases the Shell process involving treatment with a solution of tripotassium phosphate, or the Girbotol process involving absorption in an aliphatic amine solution, may be applied, in both cases the treating medium being regenerated and the  $H_2S$  removed either burned or used for acid manufacture. The processes are briefly described.

Doctor treatment almost invariably results in lowering of octane number and lead susceptibility of the gasoline, but these effects may be reduced by pretreatment with caustic soda solution. Control of the doctor treatment is of great importance, and best results are obtained when (a) the temperature of the gasoline is held above 85° F., (b) addition of sulphur is made in solution in sweet rather than sour gasoline, (c) addition of sulphur follows doctor contact rather than preceding it, (d) adequate contact time of doctor solution and sour gasoline is allowed. For economies in consumption of chemicals and tetraethyl lead, especially in war-time, elimination of doctor test from specification is advisable. Substitution by a maximum mercaptan content, including a provision for removal of light mercaptans by specifying that none can be removed by a 5% soda solution, is suggested. Methods designed to remove mercaptans from sour gasolines include the caustic-methanol and the solutizer processes, which are briefly described. Reductions in sulphur contents and improvements in octane ratings and lead susceptibilities of gasolines treated by the caustic-methanol process are illustrated. To eliminate the adverse effects on lead susceptibility of polysulphides formed during doctor treatment and of other sulphur compounds present in gasolines, methods for desulphurization have been investigated. A Perco catalytic desulphurization unit installed in a natural gasoline plant in West Virginia reduces the total sulphur content of the gasoline from 0.26% to 0.004%, increases the initial octane rating by  $3\frac{1}{2}$  numbers, and greatly improves lead susceptibility. The process involves heating the product in a pipe-still, passing the vapours through a bauxite catalyst under a pressure of 40 lb. to convert sulphur compounds to hydrogen sulphide. After condensing and cooling the gasoline, the sulphide is removed by caustic wash. Catalyst yield is 4000–5000 brl. of gasoline per ton. Methods for determining the percentages of free sulphur and of the various types of sulphur compounds present in a petroleum distillate are given, and the distribution in distillates from Oregon Basin, Wyoming, crude oil shown. R. A. E.

1000. Patents on Refining and Refinery Plant. U. B. Bray. U.S.P. 2,281,667, 5.5.42. Appl. 22.7.33. Method of refining petroleum oil containing paraffin waxes. The oil is mixed with liquefied hydrocarbon gases having a vapour pressure greater than atmospheric at ordinary atmospheric temperature. The mixture is then cooled to a temperature sufficient to congeal the wax content and passed through a settling tank to separate high-melting wax from the oil mixture. The remaining portion of wax content is separated by filtration.

F. B. Downing and C. J. Pederson. U.S.P. 2,282,513, 12.5.42. Appl. 26.7.39. Production of a viscous petroleum oil normally subject to deterioration in colour, but which has incorporated in it a small amount of an organic compound of the type of Schiff's base, obtained by condensing 1 mol. of an aliphatic polyamine containing at least two primary amino-groups directly attached to different carbon atoms of the same open chain with at least 2 mols. of an aldehyde, so that 1, and only 1, mol. of aldehyde reacts for each primary amino-group of the polyamine.

H. G. M. Fischer and W. James. U.S.P. 2,282,514, 12.5.42. Appl. 26.7.39. Production of colour stabilized light petroleum oils from hydrocarbon oils by subjecting the oil to contact with air while in the presence of 3–5 gm. of iron oxide consisting of



$\text{Fe}_2\text{O}_3$ , per 1000 c.c. of oil at a temperature between 200° and 350° F. The iron oxide is removed from the oil without withdrawing substantial amounts of colour bodies by distillation.

D. R. Stevens and J. E. Nickels. U.S.P. 2,282,594, 12.5.42. Appl. 2.3.39. Method of producing a doctor-sweetened gasoline having improved resistance to oxidation changes and improved response to anti-oxidant and anti-knock compounds. The gasoline containing mercaptans is treated with a solution of sodium plumbite in an amount sufficient to convert the reactive mercaptans to lead mercaptides, and with sulphur in an amount just sufficient to convert these mercaptides to alkyl disulphides. Afterwards the lead sulphide-gasoline suspension thus formed is treated with a solution of sodium tetraborate having a concentration sufficient to increase the settling rate of the suspension without rendering the gasoline sour.

M. A. Dietrich. U.S.P. 2,282,710, 12.5.42. Appl. 14.6.39. Method of inhibiting deterioration of petroleum hydrocarbons in the presence of metals normally active to catalyse deterioration. Incorporated in the petroleum hydrocarbons is a small amount of an organic compound having an amino-nitrogen atom and a divalent sulphur atom each singly bonded to adjacent aliphatic carbon atoms in open-chain configuration.

V. L. Chechot. U.S.P., 2,286,344, 16.6.42. Appl. 9.12.39. Process of acid-refining viscous hydrocarbon oil with the production of acid sludge characterized by its ready pumpability. The oil is contacted with sulphuric acid in the presence of an added amount of finely-divided elemental sulphur. The resultant acid-sludge is settled and the sludge separated from the oil.

V. L. Chechot. U.S.P. 2,286,345, 16.6.42. Appl. 16.2.40. Production of mineral white oil by fuming sulphuric acid treatment. The acid is applied in a plurality of multiple dump treatments, each of which treatments comprises a plurality of successive steps of acid addition and agitation. The acid sludge is removed from the treated oil only on the completion of each of the multiple-dump treatments.

J. R. Miller. U.S.P. 2,286,369, 16.6.42. Appl. 2.1.31. Method of purifying used lubricating oil by mixing with it a solid impurity-adsorbing material, mechanically agitating the mixture heated to a temperature to cause volatile impurities to be liberated, while contacting the surface of the oil-body with air. Afterwards vapours of volatile impurities are withdrawn from the oil and the oil is treated to separate solid material from it.

A. Y. Mottlam. U.S.P. 2,287,118, 23.6.42. Appl. 29.4.38. Process for the removal of organic sulphur compounds of the mercaptan type from a mineral oil boiling in the range 100–700° F. The oil is treated with an aqueous solution of an aliphatic amino alcohol at atmospheric pressure and at a temperature between 60° and 85° F.

A. J. Mueller. U.S.P. 2,287,119, 23.6.42. Appl. 2.2.39. Method of removing soluble impurities from a hydrocarbon product which involves bringing it into contact with a solid adsorbent. The adsorbent is wetted with a substantially pure low-molecular-weight aliphatic alcohol.

Le R. G. Story. U.S.P. 2,288,754, 7.7.42. Appl. 23.6.34. Method of inhibiting gum formation in cracked hydrocarbon distillates by the addition of 0.01–0.1% of  $\alpha$ -naphthol.

W. H. Sowers. U.S.P. 2,288,853, 7.7.42. Appl. 15.5.39. Process of concentrating the aromatic content of hydrocarbon distillate which is completely miscible with liquid sulphur dioxide. The distillate is extracted at temperatures below the freezing point of water with a solvent comprising sulphur dioxide, alcohol, and water. Afterwards the solvent is removed from the distillate.

G. Egloff. U.S.P. 2,291,885, 4.8.42. Appl. 21.8.40. Conversion of hydrocarbon oil by subjecting it to desulphurizing conditions in the presence of a desulphurizing catalyst and hydrogen. In this way are formed hydrogen sulphide from sulphur compounds and a substantially sulphur-free oil.

D. L. Campbell. U.S.P. 2,293,241, 18.8.42. Appl. 22.6.40. Process for the segregation of hydrocarbon constituents containing three and less hydrocarbon atoms in the molecule from hydrocarbon constituents containing four and more carbon atoms in the molecule, and also for the segregation of a gas stream comprising hydrogen from feed-gas mixtures containing the same.

L. L. Lovell. U.S.P. 2,293,395, 18.8.42. Appl. 18.8.41. Improved process of sweetening sour hydrocarbon oil containing mercaptans by treatment with a copper catalyst. In this way mercaptans are converted to disulphides.

W. B. Chenault. U.S.P. 2,293,591, 18.8.42. Appl. 18.8.39. Method of treating acid raffinates from solvent extraction processes using a solvent blend containing sulphuric acid. The acid raffinate is almost completely neutralized by means of an absorbent earth, and the solvent is then stripped from the neutralized raffinate. Subsequently the oil content of the raffinate is decolorized by contact with fresh adsorbent earth.

E. A. Ocon. U.S.P. 2,294,126, 25.8.42. Appl. 12.9.38. Process for distilling and fractionating a crude petroleum oil in heat exchange with heat-treated hydrocarbon products undergoing fractionation.

C. G. Gerhold and B. J. Flock. U.S.P. 2,294,547, 1.9.42. Appl. 10.10.38. Process for the recovery of a normally gaseous fraction rich in polymerizable olefins from the mixture of vapours and gases produced in the conversion of hydrocarbons.

H. B. M.

## Metering.

**1001.\* Technique of Precision Control in Refining Processes.** R. B. Wery. *Petrol. Engr*, May 1942, **13** (8), 86.—The demand for increased output, the shortage of skilled labour, and the need for producing materials of greater purity are factors which have led to increased necessity for more precise automatic control. Improvements in design of plants resulting in reduced stored heat capacities and increased thermal potentials emphasize this need, but accentuate the difficulties of control. The effects of process conditions, such as mass or capacity of system, thermal potential used in heating and cooling, conductivity of materials used in heat-transfer equipment and other factors, on the time lag or interval between change in conditions and the corresponding effect on the recorder or controller are discussed. Proper adjustment of controllers is accomplished by synchronizing the rate of heat input with the rate of heat absorption, so that a rate of automatic reset as well as a throttling range adjustment is an essential part of an efficient controller.

Special consideration is given to control of fractionating columns designed to separate relatively pure products from a variety of feed-stocks. Whilst the degree of perfection attained in the control of the tower temperature is the criterion for determining the effectiveness of the entire control system, minimizing the rates of change of other controllable variables greatly simplifies the problem of control. The actual position of the sensitive element of the temperature controller for most efficient control for the separation desired must be determined experimentally, but fitting of several thermocouple wells in the region selected is desirable, so that shifting of the couple can be accomplished whilst the unit is in operation. Introduction of a mixing vessel in the line to iron out major variations in feed composition may be necessary in some cases. Variations in main-line steam pressure may be controlled by interlocking the tower-temperature controller with a rate of flow controller on the steam line to reboiler.

Control of tower pressure can be obtained in several ways. Where cooling water flow is throttled, it is desirable to interlock a rate of flow controller in the water line with the pressure controller to eliminate the effect of changes in water rate due to changes in pressure differential across the control valve. The importance of rate of feed control is stressed. The Brown system of control of fractionating columns for production of cuts of narrow boiling range is illustrated.

R. A. E.

## Chemistry and Physics of Hydrocarbons.

**1002.\* Cetane Numbers and Physical Properties of Normal Alkyl Benzenes and Other Hydrocarbons.** Part III. Evaluation of *n*-Alkyl Benzenes and Certain Related Hydrocarbons as Diesel Fuels. T. Y. Ju, C. E. Wood, and F. H. Garner. *J. Inst. Petrol.*, August 1942, **28** (224), 159-171.—The cetane numbers of *n*-dodecyl benzene and *n*-tetradodecyl benzene were found to be 68 and 72, respectively. The blending curves for these two *n*-alkylated benzenes with low-standard-reference fuel are straight lines.

The blending cetane numbers of three diphenyl homologues were obtained by interpolation or extrapolation from blends with high-standard diesel reference fuel: the blending curves are not linear. The cetane number of *m*-diisopropyl benzene is too low to be run straight in the engine. The blending cetane number of the unblended hydrocarbon as obtained by extrapolation is — 12.

A summary is given of blending cetane numbers obtained in the present work and of those previously published in the literature, and, while the data are incomplete, they indicate that the hydrocarbons with a compact or highly branched structure tend to have low cetane numbers. There is thus a general similarity existing between octane number and cetane number, in that the type of structure which gives a high octane number also gives a low cetane number.

A. H. N.

**1003. Patent on Chemistry and Physics of Hydrocarbons.** Shell Development Co. E.P. 546,148, 30.6.42. Appl. 31.1.41. Process for transferring components from their solution in one phase to another phase which is substantially immiscible with the first phase. As an example of the process, the extraction of mercaptans from hydrocarbon oils with aqueous solutions of caustic alkali is given. In the first place, the solution is fractionated to produce at least two fractions containing portions of extractable components, the fractions having different degrees of ease of transference towards the solvent. The solvent is then flowed through an extraction zone and withdrawn from it. At different points in the direction of flow of the solvent are introduced the fractions in order of decreasing ease of transference of their solutes to be extracted. These are then flowed through at least part of the zone in counter-current to the solvent. Finally the fractions are combined in the zone and withdrawn.

H. B. M.

## Motor Fuels.

**1004. Patents on Motor Fuel.** Standard Oil Development Co. E.P. 546,406, 13.7.42. Appl. 19.4.40. Production of normally liquid saturated hydrocarbons suitable for use as a motor fuel by the alkylation of saturated hydrocarbons containing at least one tertiary carbon atom per molecule, with mono-olefines. The process involves the use of a catalyst consisting of water saturated with boron trifluoride. The mixture to be treated contains an excess of ethylene over the equimolar quantities of olefin and saturated hydrocarbons.

Texaco Development Corp. E.P. 546,640, 23.7.42. Appl. 10.10.40. Preparation of a motor fuel consisting essentially of a blend of substantial portions of aromatic hydrocarbons within the gasoline boiling range and a saturated paraffinic hydrocarbon fraction of comparatively broad gasoline boiling range. The fuel consists essentially of isoparaffinic hydrocarbons and a minor proportion of saturated  $C_3$  and  $C_6$  paraffinic hydrocarbons, and is substantially free from normal paraffin hydrocarbons of higher molecular weight than normal pentane. The blending octane number by the C.F.R.M. method of a 50% blend of benzene with the saturated paraffinic components of the fuel is at least 93.8.

R. P. Frazer. E.P. 547,029, 11.8.42. Appl. 16.10.40. Method of preparing a pumpable and highly stable combustible mixture of liquid and pulverized coal. The coal is reduced to a state of fineness such that 100% will pass through a screen of 300 mesh, and it is then compounded with a viscous mineral oil and a substantial proportion of a liquid of coal-tar distillate origin, e.g., one containing cresol and/or indene and/or pyridine.

Standard Oil Development Co. E.P. 547,077, 12.8.42. Appl. 27.3.41. Production of a motor fuel consisting of a hydrocarbon fuel base adapted for spark ignition engines, blended with at least 2% of an *N*-alkylated aromatic amine containing an oxygenated aliphatic substituent group in the aromatic nucleus.

W. J. Backoff, N. D. Williams, J. F. O'Loughlin, and H. L. Moir. U.S.P. 2,284,080, 26.5.42. Appl. 6.10.38. Preparation of a composition for use as a gum solvent and consisting of 50–90% of refined mineral oil boiling above the boiling range of kerosene and 50–10% of a mixture of esters of phthalic and benzoic acids boiling above 350° F.

L. C. Kemp. U.S.P. 2,286,814, 16.9.42. Appl. 28.10.39. Process for the manufacture of high-anti-knock motor-fuel hydrocarbons. The process includes catalytically converting a mixture of carbon monoxide and hydrogen to a synthetic hydrocarbon mixture composed mainly of hydrocarbons having from 1 to 10 carbon atoms per molecule, the C<sub>3</sub>–C<sub>4</sub> fraction of which consists essentially of aliphatic hydrocarbons composed largely of olefins and relatively free from *isobutylene*. From this synthetic mixture is separated a fraction rich in normal butane and another fraction rich in normal butylenes. The butane-rich fraction is subjected to isomerization to form *isobutane*, which latter is separately reacted with the butylene-rich fraction by contact with an alkylation catalyst to produce normally liquid saturated hydrocarbons having a high anti-knock value and boiling within the motor-fuel range.

T. H. Rogers and V. Vorhees. U.S.P. 2,287,359, 23.6.42. Appl. 20.8.30. Method of preserving a cracked hydrocarbon distillate which tends to deteriorate and develop gum on storage. Incorporated in the distillate is a trace of naphthol, less than 1%, but sufficient substantially to retard such deterioration.

A. B. Hersberger. U.S.P. 2,287,736, 23.6.42. Appl. 16.5.39. Separation of an oil which contains paraffinic and naphthenic hydrocarbons into fractions respectively more paraffinic and more naphthenic than the original oil by extracting with a solvent consisting of morpholine and a lower aliphatic alcohol.

E. L. D'Ouille. U.S.P. 2,288,875, 7.7.42. Appl. 30.12.39. Process of converting hydrocarbon oils which comprises contacting the oils with a catalyst prepared by the gelation of blast-furnace slag with an acid wherein the slag is partly dissolved, washing, drying, and igniting the resultant gel.

A. J. Van Peski. U.S.P. 2,289,605, 14.7.42. Appl. 9.5.39. Production of a motor fuel comprising a gasoline-type motor fuel and a small amount of a knock suppressor consisting of a compound combining a metal having an atomic number from 26 to 29 inclusive, with an organic component, having a basic structure which contains an atom combination selected from the group consisting of N = C – N – C = O and N = C – N – C – N, or their tautomers, the structure containing at least two double bonds.

R. F. Marschner. U.S.P. 2,289,716, 14.7.42. Appl. 19.10.39. Method of lowering the acid heat of catalytically cracked gasoline without unduly impairing its octane number and tetraethyl lead response. The gasoline is fractionated into a light fraction having an end-point of 150–250° F. and a heavy fraction. The light fraction is hydrogenated to effect at least 20% saturation, but not more than 90% saturation of the olefins contained therein. Finally the partly hydrogenated light fraction is blended with the unhydrogenated heavy fraction.

C. L. Thomas. U.S.P. 2,292,677, 11.8.42. Appl. 17.5.39. Process involving contact of a hydrocarbon distillate with a cracking catalyst under catalytic cracking conditions and separating the gas and gasoline. The gasoline is separated into a low- and a high-boiling fraction, and the gaseous products are separated into a plurality of fractions. One of these comprises essentially hydrogen and uncondensable hydrocarbon gases, and another a fraction consisting essentially of C<sub>3</sub> and C<sub>4</sub> hydrocarbons. C<sub>3</sub> and C<sub>4</sub> olefins are catalytically polymerized, and those polymers boiling within

the gasoline boiling range are combined with the low-boiling gasoline fraction from the cracking operation. The mixture is contacted with a hydrogenation catalyst and the hydrogenation product recovered. Afterwards it is blended with the high-boiling gasoline fraction from the cracking operation.

J. M. Mavity. U.S.P. 2,292,708, 11.8.42. Appl. 31.10.40. Process for catalytically converting hydrocarbon oil into high anti-knock gasoline. Disposed in the oil is an alkyl silicate and a metal alkoxide capable of reacting with the alkyl silicate to form a conversion catalyst *in situ*. The hydrocarbon oil mixture is subjected to catalytic conversion to produce a substantial yield of gasoline.

P. J. Harrington. U.S.P. 2,293,205, 18.8.42. Appl. 16.9.39. Production of motor fuel from a petroleum oil boiling below 420° F. The fuel has a high octane number and a high susceptibility for knock-suppressing agents. The oil has a sulphur content of less than 0.1%, and is of a character which could normally be desulphurized by bauxite treatment. 0.1-0.5% of free sulphur is added to the oil, which is then passed over a bauxite catalyst. Temperature and pressure are so controlled that substantially no cracking of the oil occurs.

H. B. M.

### Gas, Diesel, and Fuel Oils.

1005. Patent on Gas, Diesel and Fuel Oils. S. H. Hulse and J. O. Collins. U.S.P. 2,288,401, 30.6.42. Appl. 28.3.40. Method for improving sour Diesel-fuel petroleum distillates which involves adding thereto distillate oil containing at least 10 mg. of mercaptan sulphur per 100 ml. of oil, lead sulphide, an alkali, and reactive sulphur. The reactive sulphur is added in a proportion to form, by reaction with the mercaptans, stabilized organic compounds containing from 20 to about 200 mg. of active sulphur per 100 ml. of the oil.

H. B. M.

### Lubricants and Lubrication.

1006.\* Changing Concepts of Petroleum Lubricants. J. W. Poole. *Petrol. Engr*, May 1942, 13 (8), 140-145.—It is now becoming more widely recognized that only engine performance can be depended on as a criterion of lubricants. In the past, research was, generally speaking, more concerned with finding more exact or efficient ways of meeting traditional specifications. These specifications are still used in the majority of cases, and tests are made for, and oils judged by gravity, flash point, fire test, viscosity, viscosity index, pour point, colour, neutralization number, Conradson carbon, unsulphonated residue, corrosion, sulphur content, oxidation tests, and emulsion tests.

Each test method is reviewed, and its significance and limitations commented on, with appropriate literature references. Many are useful for plant-control purposes, but from the service point of view the significance often attached to them is not justified by the evidence now available, and deductions made from the results of such tests are sometimes misleading. Even when considered collectively, conventional specifications based on these laboratory determinations are inadequate, since they provide no certain assurance that oils complying with them will give the best, or even satisfactory service performance.

R. A. E.

1007. Oil Dermatitis. Anon. *Chem. Tr. J.*, 26.6.42, 110, 662.—The May issue of the *Industrial Accident Prevention Bulletin* of the Royal Society for the Prevention of Accidents discusses the value of adding antiseptics to cutting oils to reduce dermatitis. The usefulness of antiseptics is considered debatable, although oils can contain appreciable quantities of bacteria. Dermatitis is primarily caused by dirty oil blocking the pores of the skin, though minute particles of metal and the presence of any free alkali aggravate conditions. Bulletin No. 2 of the D.S.I.R. entitled "Memorandum on Cutting Lubricants and Cooling Liquids and on Skin Diseases Produced by Cutting Lubricants," states that the addition of antiseptics—*e.g.*, 1-2% carbolic acid, to lubricants and of 0.5% of water-soluble disinfectants to cutting emulsions—has not given altogether satisfactory results and cannot be relied upon to prevent

skin rashes. The American Mutual Insurance Co. at one time advocated 2% of paraformaldehyde or 5 oz. of phenol to every 5 gal. of oil. Commercial disinfectants are sold for use with cutting oils, or are added to the oils during manufacture but the addition of antiseptics is less common nowadays in the U.S.A. C. L. G.

**1008. Patents on Lubricants and Lubrication.** J. E. Schott. U.S.P. 2,281,623, 5.5.42. Appl. 30.7.41. Preparation of a substantially liquid and non-stringy lubricating oil for internal-combustion engines operating at high sustained speeds and under severe conditions of temperature and pressure such as may be encountered in Diesel-engine lubrication. The composition consists of a mineral lubricating oil compounded and heated with small amounts of an aluminium soap of a saturated fatty acid and a compound selected from the class consisting of glycol mono-ethers and di-glycol mono-ethers in such proportions that the viscosity of the oil is not materially increased.

U. B. Bray. U.S.P. 2,281,824, 5.5.42. Appl. 22.9.42. Manufacture of a lubricating oil containing a relatively small proportion of an alkaline-earth metal soap of a saponifiable organic acid to overcome the deposition of resinous and varnish-like materials in severe service internal-combustion engines. The composition also contains a small quantity of an oil-soluble alkaline-earth metal compound of a thiophenolic derivative to overcome corrosive conditions developed in the oil. The added constituents do not materially increase the viscosity of the original lubricating oil.

E. Lieber. U.S.P. 2,281,942, 5.5.42. Appl. 20.5.38. Preparation of an addition agent for lubricating oils. A phenolic ester of a fatty acid having a chain of at least 10 carbon atoms is heated with a Friedel-Crafts catalyst at a temperature of at least 250° F. for a sufficient length of time to effect molecular rearrangement of the ester. Heating of the resultant reaction mixture is continued until the ester is substantially polymerized into higher-molecular-weight compounds. Afterwards an oil-soluble organic product of high boiling point is separated from these higher-molecular-weight compounds.

E. R. Barnard. U.S.P. 2,282,599, 12.5.42. Appl. 17.11.37. Prevention of "feathering" of piston rings in high-speed Diesel engines while such rings are coated with a film of synthetic hydrocarbon lubricating oil produced by the catalytic polymerization of liquid *isobutylene* at a temperature between 0 and 100° F. 0.001-0.2% of a substance selected from the class consisting of the oil-soluble compounds of oxygen, sulphur, phosphorus, and chlorine is dissolved in the lubricating oil.

B. T. Brooks. U.S.P. 2,284,258, 26.5.42. Appl. 18.3.37. Preparation of a lubricant consisting of a mineral lubricating oil and a small amount of an oleone.

Texaco Development Corp. E.P. 547,286, 21.8.42. Appl. 15.2.40. Preparation of a lubricating oil for the bearing surfaces of an internal-combustion engine. The lubricant consists of a mineral oil having incorporated in it 0.01-2.0% by weight of a corrosion-inhibiting compound consisting of a tri-alicyclic ester of phosphorous acid in which the alicyclic radicals are selected from the group consisting of *cyclohexyl* and alkyl-, aryl-, and aralkyl-substituted *cyclohexyl* radicals.

G. E. Merkle. U.S.P. 2,285,452, 9.6.42. Appl. 26.2.40. Manufacture of a lubricant of the class consisting of oil and grease bases and containing dispersed therein 3½-15% by weight of unsaponified basic lead carbonate.

G. E. Merkle. U.S.P. 2,285,453, 9.6.42. Appl. 9.4.40. Preparation of a lubricant containing, as a wear-reducing agent, finely divided titanium dioxide up to 10½% by weight.

G. E. Merkle. U.S.P. 2,285,739, 9.6.42. Appl. 9.5.40. Preparation of a lubricant which contains finely divided zinc sulphide dispersed therein and is characterized by its freedom from ingredients which would cause progressive abrasion action on the wearing surfaces to which it is applied.

E. Lieber. U.S.P. 2,287,110, 23.6.42. Appl. 29.12.38. Manufacture of a lubricant consisting of a waxy hydrocarbon oil and a condensation product of a ketone having carbo-cyclic and open-chain aliphatic radicals of at least 6 carbon atoms with a short-chain dihalo aliphatic hydrocarbon of 1 to 5 carbon atoms.

M. Pier and F. Christmann. U.S.P. 2,287,901, 30.6.42. Appl. 17.4.33. Preparation of a lubricant consisting of a viscous hydrocarbon containing a waxy distillation residue of a product prepared by the condensation of an acid chloride of a carboxylic acid having a molecular weight of more than 200.

B. H. Lincoln. U.S.P. 2,288,288, 30.6.42. Appl. 26.8.38. Preparation of a lubricant consisting of a major proportion of an oil of lubricating viscosity and a minor proportion of dithylarsenic phenyl stearate.

B. H. Lincoln, G. D. Byrkit, and W. L. Steiner. U.S.P. 2,288,289, 30.6.42. Appl. 17.4.40. Preparation of a lubricant consisting of a major portion of an oil of lubricating viscosity and a small amount of a stannic salt of an organic acid bearing at least one aromatic ring.

W. M. Malisoff. U.S.P. 2,289,509, 14.7.42. Appl. 1.11.33. Production of a lubricant consisting of a viscous hydrocarbon oil and a halogenated ester of a phosphorus acid.

A. Beerbower and A. J. Morway. U.S.P. 2,289,748, 14.7.42. Appl. 18.2.39. Preparation of an improved grease composition consisting of 5-50% of soda soap in mineral lubricating oil, a slight excess of acid and, as an inhibitor of oxidation, a small amount of guaiacol.

J. G. McNab. U.S.P. 2,289,795, 14.7.42. Appl. 1.9.39. Preparation of a lubricating composition consisting of a mineral lubricating oil and small amounts of polyvalent metal salts selected from each of the groups consisting of aluminium and alkaline-earth metal salts. The total amounts of these salts is 0.1-3.5% by weight of the oil, and the amount of each type of metal salt is at least one-tenth of the total metal salt present.

R. E. Burk. U.S.P. 2,290,032, 14.7.42. Appl. 21.4.39. Manufacture of a lubricating composition consisting of a lubricating oil having colloidally dispersed therein an iron compound from the group consisting of oxides and sulphides. The iron compound is present in relatively small but sufficient amount to improve the extreme pressure properties of the oil.

E. W. Cook. U.S.P. 2,290,316, 21.7.42. Appl. 21.1.41. Preparation of a lubricant consisting of a major proportion of a mineral lubricating oil and a minor proportion of a sulphurized aldehyde amine.

S. P. Waugh. U.S.P. 2,291,066, 28.7.42. Appl. 10.1.41. Manufacture of a lubricant suitable for use in metal working operations and consisting of a stable aqueous emulsion containing mineral oil, a saponified component derived from the fatty acid mixture obtainable from palin oil, and a phosphorus-containing substance effective to increase the load-carrying capacity of the composition.

O. L. Maag. U.S.P. 2,291,166, 28.7.42. Appl. 7.1.39. Preparation of a lubricating composition containing a major proportion of a lubricating oil and up to 10% of a fluorinated member of the paraffin series heavier than methane.

A. J. Morway. U.S.P. 2,291,404, 28.7.42. Appl. 24.12.36. Preparation of a lubricating composition consisting of a lubricating oil and a sulphurized *isobutylene* polymer having a molecular weight above 1000.

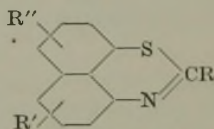
F. M. Watkins. U.S.P. 2,292,308, 4.8.42. Appl. 11.10.40. Preparation of a lubricant consisting of a petroleum lubricating oil and a metal salt of an alkyl mono-ester of an alkenyl-substituted succinic acid. The metal is selected from the group consisting of calcium, aluminium, barium, cadmium, chromium, magnesium, nickel, tin, and zinc.

B. H. Lincoln and G. D. Byrkit. U.S.P. 2,292,456, 11.8.42. Appl. 18.7.40. Preparation of a lubricant consisting of a hydrocarbon oil and a minor proportion of trimethylene-1-, 2-disulphide.

R. A. Swenson. U.S.P. 2,292,672, 11.8.42. Appl. 29.6.40. Preparation of a semi-fluid lubricant consisting of petroleum oil, 25-55% of blown asphalt and 2-20% of high lead soap comprising the reaction product of litharge and a fatty oil of fish origin.

C. E. Earle. U.S.P. 2,293,052, 18.8.42. Appl. 4.11.40. A lubricant consisting of a mineral oil, a lithium soap, and a calcium soap. The proportion of the soaps is at least sufficient to thicken the oil substantially, but is not in excess of 40% of the total. Lithium constitutes a sufficient proportion of the added soaps to increase the viscosity of the oil.

J. H. Bartlett. U.S.P. 2,293,237, 18.8.42. Appl. 29.12.39. Preparation of a lubricant consisting of a mineral lubricating oil and a small quantity of a compound of the formula :



in which R, R' and R'' are selected from the class consisting of hydrogen and halogen atoms and amino, mercapto, hydroxyl, and organic groups.

P. R. Van Ess. U.S.P. 2,293,419, 18.8.42. Appl. 27.5.41. Process for dissolving in a mineral oil a difficultly soluble open salt combining a polyvalent metal with an aromatic hydroxy monocarboxylic acid, in which the carboxylic radicle is directly attached to the aromatic nucleus. In this way is produced an anti-ringsticking lubricating oil.

J. F. Nelson. U.S.P. 2,293,445, 18.8.42. Appl. 19.11.38. A lubricant consisting of a highly refined mineral oil and tritertiary butyl *ortho* hydroxy phenyl phosphite.

S. P. Waugh. U.S.P. 2,294,526, 1.9.42. Appl. 22.5.41. A lubricant consisting of a hydrocarbon oil in which has been dissolved a neutral metal soap of a character not normally soluble in the oil. Solution is achieved by adding a sufficient amount of a sulphocarboxylic acid.

V. L. Ricketts. U.S.P. 2,294,804, 1.9.42. Appl. 1.6.36. Production of a lubricant for metallic bearing surfaces consisting of a mineral lubricating oil and a small amount of an aliphatic ester of phosphorous acid in which each aliphatic group has from 1 to 5 carbon atoms.

W. J. D. Van Dijk. U.S.P. 2,294,817, 1.9.42. Appl. 3.4.34. Preparation of a lubricant for metallic bearing surfaces consisting of a lubricating oil to which has been added a small amount of a reaction product of a fatty oil and an oxide of phosphorus.  
H. B. M.

## Asphalt and Bitumen.

**1009. Patents on Asphalt and Bitumen.** Standard Oil Development Co. E.P. 547,242, 19.4.42. Appl. 31.3.41. Production of an aqueous emulsion of bitumen of the oil-in-water type containing a compound of a metal selected from the following: aluminium, tin, boron, chromium, zinc, molybdenum, and vanadium.

Standard Oil Development Co. E.P. 546,523, 17.7.42. Appl. 27.7.40. Process for obtaining light-coloured plastic materials from the asphaltic residues from the distillation of petroleum oils. The residue is treated with a solvent which dissolves the light-coloured bitumen alone or together with other components of the residue.



The solution thus obtained is treated to remove black asphaltens if present and the remaining solution treated with a decolorizing agent. Finally the decolorizing agent is removed and the solution is treated to separate the light plastic components.

J. Miller. U.S.P. 2,281,854, 5.5.42. Appl. 2.8.40. Apparatus for manufacturing cylindrical containers of paper material suitable for packaging asphalt.

R. E. Burk. U.S.P. 2,282,703, 12.5.42. Appl. 28.10.36. Method of manufacturing asphalt which involves oxidizing petroleum residuum by heating and agitating in exposure to oxygen and thickening to desired melting point and penetration. After oxidation there is incorporated in the mixture a small amount of a naphthenate of a metal of the group consisting of cobalt, manganese, lead, vanadium, and zinc.

C. H. Whitacre. U.S.P. 2,286,244, 16.6.42. Appl. 9.12.40. Incorporation with asphaltic material of small amounts of wood, liquid rosin acids, and a sulphate of a metal from the alum-forming metals, aluminium, and iron.

A. B. Hersberger. U.S.P. 2,286,414, 16.6.42. Appl. 5.8.39. Production of an asphalt of reduced staining tendency from flux asphalt. A small quantity of a substantially water-insoluble soap is added to the flux to cause gelation of the exudable oil content. Afterwards the mixture is airblown at a high temperature.

R. E. Burk and C. H. Whitacre. U.S.P. 2,287,511, 23.6.42. Appl. 23.11.36. Manufacture of asphalt by heating to 350-400° F. and thickening a petroleum residuum, in the absence of injected air, to asphalt consistency with a small amount of an aluminium chloride catalyst.

D. R. Wiggam. U.S.P. 2,289,229, 7.7.42. Appl. 6.4.38. Preparation of a composition comprising in homogeneous admixture a bituminous material selected from the group consisting of coal tar, pine tar, gilsonite, and stearin pitch; and ethyl cellulose. The composition consists of non-volatile substances, and has a higher softening point and greater toughness than the bituminous material. H. B. M.

### Special Products.

**1010. Calcium Naphthenate.** Anon. *Chem. Tr. J.*, 19.6.42, 110, 634. The uses of calcium naphthenate in the paint and varnish industries is discussed by A. Minch in the April 1942 issue of *Canadian Chemistry and Process Industries*. These include (a) as bodying agent for the slower bodying oils in varnish cooking, (b) as drier in cases where pigment darkening which would result from the use of a lead salt, must be minimized, (c) as part or complete substitute for lead driers for use with vehicles which have a poor tolerance for lead driers, e.g., oils containing saturated fatty acids which precipitate lead driers, and (d) as drier in conjunction with lead and cobalt for use with natural resin varnishes. C. L. G.

**1011. Petroleum Resins in Paper Makers Sizes.** Anon. *Chem. Tr. J.*, 26.6.42, 110, 17. In the 1941 *Proceedings* of the Paper Makers Association, papers given at a conference on "Sizing Problems in War-Time" in November 1941, are included. It was reported that satisfactory complete replacement of rosin could be effected by sulphurized oils (factis), particularly emulsions of lightly sulphurized rape oil, sodium stearate, and sodium naphthenate, and partial replacement by the softer grades of coumarone resins and by petroleum resins. Owing to the dark colour of petroleum resins, they were considered only for the production of wrapping papers made from stock containing kraft paper and general waste. Difficulties in emulsifying the petroleum resin alone were overcome by replacing only part of the rosin by petroleum resin and using the sodium rosinate as the dispersing and stabilizing agent. Papers produced with petroleum resin sizes are satisfactory as regards strength and other properties. C. L. G.

**1012.\* Deterioration of Over-Refined Insulating Oils.** E. W. Steinitz. *Petroleum*, August 1942, **5** (8), 138.—In a large industrial works, in which oils meeting A30 specification had been used with satisfaction for years, switches commenced to give off a gas of acrid smell, and corrosion of metallic parts was observed six weeks after filling up with a fresh batch of oil meeting the same specification. The used oil in the switches was tested and results were: acid No. 3.4 mgm. KOH per gm., saponification No. 9.3 mgm. KOH per gm., water content 1.4%, breakdown voltage 6500. The cause of the trouble was eventually traced to interaction between the oil and an insulating "fibre" used in the switch. Similar material had been used in this and other switches for many years without difficulty. This "fibre" was found to be a couched cardboard containing resins and ground wood as well as cellulose. It was porous and hygroscopic, water content normally 15%. Fibre of this type should be dried and deaerated before immersion in oil. The present tendency of the electrical industry to use pure cellulose paper for submersion in oil is in line with the latest research work. The new oil was found to be of the over-refined type prepared from a different base and by a refining process different from that applied to previous supplies of A30 oil used. Discussions on the need for revising B.S.S. 148 have already taken place. Tentative conclusions reached from the results of the present investigation are: (1) Inclusion of acid-number determination after oxidation is desirable. (2) A second catalyst, preferably a fibrous material, ought perhaps to be included in a revised sludge test. (3) Consideration should be given to the base of the oil in selecting a refining method for insulating oils. (4) At a later stage some references to preferred bases and refining methods and the most desirable composition of the finished product might be included in the specification. R. A. E.

**1013.\* "Quick Rubber" Campaign under Way to Meet Civilian Transport Needs.** Anon. *World Petrol.*, August 1942, **13** (9), 22.—Through improvements in the process of manufacture it has been found possible to increase the capacity of planned butyl rubber plants from 60,000 to 132,000 tons per annum without using additional materials of construction. The annual production of synthetic rubber under Government auspices is thus raised to about 900,000 tons to be achieved in 1944, with 300,000 tons scheduled for 1943. In addition to these specially designed plants, arrangements are being made to utilize existing facilities and available materials for the production of further quantities of butadiene, and for the conversion of this product into synthetic rubber of the Buna type for civilian requirements. The methods to be employed include: (a) thermal cracking at high temperature, (b) cracking with air injection, (c) cracking with superheated steam injection, (d) cracking with flue-gas injection. In addition, arrangements are in hand for the manufacture of Flexon, produced from *isobutylene* by addition of a catalyst at low temperatures, and of Thiokol. Both these products can be used for manufacturing tyres capable of giving limited mileage under not too strenuous driving conditions. Plans are also afoot for producing additional butyl rubber in makeshift plants. Extensive investigations are being carried out on alternative rubber substitutes and on methods of improving known processes of production of synthetic rubber and of manufacture of tyres from them. R. A. E.

**1014.\* Petroleum Resins—The Acrylic Resins.** C. C. Pryor. *Petrol. Engr.*, May 1942, **13** (8), 80.—The acrylic and methacrylic resins are products resulting from polymerization of the monomeric derivatives of acrylic acid, of which the esters, which form thermoplastic resins of unusual character, are of most importance commercially at present. These esters can be obtained from petroleum sources—*e.g.*, methyl methacrylate from propylene via acetone, acetone cyanhydrin and reaction with sulphuric acid and methyl alcohol. Polymerization of the esters may be accomplished under the influence of heat, light, oxygen, and/or peroxide type catalysts. Methacrylate esters can be cast-polymerized direct in predesigned moulds or can be first polymerized in finely divided form and subsequently moulded in any manner suitable for a thermoplastic resin. The resins possess outstanding clarity and light-carrying ability, but have limited compatibility with other synthetic polymers and natural resins. Apart from *iso*- and *n*-butyl methacrylate polymers, the five methacrylate polymers produced commercially are incompatible with each other, and co-polymerization of the monomers is necessary to obtain desired variations.

Properties of the five resins are given, those of the polymethyl methacrylate making this the most important commercially. This resin can also be readily moulded and handled. The extensive applications of the resins in the automotive, textile and aircraft industries, and to household articles are reviewed. R. A. E.

**1015. Patents on Special Products.** Universal Oil Products Co. E.P. 546,709, 28.7.42. Appl. 3.4.40. Manufacture of butadiene by subjecting normal butane to contact with a catalyst consisting of 80-99% of alumina and 1-20% of chromium oxide at a temperature between 550° and 650° C., under a pressure between 0.5 and 2.5 atmospheres, and for a time of contact between 0.05 and 1 sec. Afterwards the butenes thus obtained are subjected to a further contact with a separate portion of the same catalyst at a temperature between 500° and 700° C., under subatmospheric pressure, and for a time of contact not exceeding 1 sec. In this way a substantial yield of butadiene is obtained.

Standard Oil Development Co. E.P. 547,048, 11.8.42. Appl. 12.2.41. Continuous operation for the conversion of hydrocarbons to desired products while in the vapour phase. The vapours contain suspended therein a quantity of catalyst which may be in the form of a powder, granules, grains, lumps, shaped bodies, etc.

S. H. McAllister. U.S.P. 2,285,601, 9.6.42. Appl. 29.2.40. Production of glutaric acid by continuously introducing *cyclopentane* into a nitric-acid-containing solution maintained at a temperature of about 110° C. The nitric acid in the solution is kept at about 14-20% by continuously adding nitric acid. The crude reaction mixture is removed and the glutaric acid recovered.

J. Delattre. U.S.P. 2,285,785, 9.6.42. Appl. 13.7.40. Method of producing more valuable products from a gaseous hydrocarbon mixture. The mixture is separated into three fractions, an *isobutane* fraction, a normal butane fraction, and a fraction comprising *iso*- and normal butenes. The normal butane fraction is subjected to dehydrogenation to form butene and hydrogen, and butene and unconverted normal butane are separated from the hydrogen. The butene and unconverted normal butane are combined with the *iso*- and normal butenes, and the mixture is then subjected to polymerization under conditions designed to polymerize substantially all the *isobutene* and only a portion of the normal butenes to *isooctenes*, leaving the quantity of normal butene unconverted approximately equal to the volume of *isobutane* in the mixture. Finally *isooctenes* are separated from the normal butane and unconverted butenes, and the last two products are combined with the *isobutane* fraction and subjected to alkylation to form a substantially saturated gasoline from the butene and *isobutane*.

G. Alleman. U.S.P. 2,288,769, 7.7.42. Appl. 5.9.36. Method of oxidizing aliphatic hydrocarbons by passing oxygen-containing gas into the hydrocarbons while heating to 120-200° C., and substantially lowering the temperature during the latter part of the oxidation.

S. L. Bass and E. F. Graves. U.S.P. 2,291,442, 28.7.42. Appl. 22.11.38. Preparation of an internal-combustion-engine fuel consisting of a liquid hydrocarbon fuel having a viscosity below 50 sec. Saybolt Universal at 100° F. to which has been added 0.1-5.0% by weight of an aromatic ester of phosphoric acid containing at least one aromatic radicle having a molecular weight of 100 or more. H. B. M.

### Detonation and Engines.

**1016. Patents on Detonation and Engines.** Standard Oil Development Co. E.P. 546,780, 30.7.42. Appl. 12.8.40. Method of fueling an internal-combustion engine using a solid injection fuel system, by feeding a liquid fuel to the engine from a main fuel supply tank and increasing the cetane number of at least a portion of the fuel, after it leaves the supply tank, by contacting it with a separate supply of a solid and at least partially soluble ignition promoter.

E. M. Marks. U.S.P. 2,285,294, 2.6.42. Appl. 11.6.40. Process for reforming naphtha to improve its anti-knock quality. The naphtha is contacted under reforming conditions of temperature and pressure, with a catalyst consisting of aluminium oxide and an alkali metal borate. H. B. M.

## BOOKS RECEIVED.

**Transactions of the Institute of Marine Engineers, 1941-42.**

**Proceedings of the 21st Annual Convention of the Natural Gasoline Association of America.** 14th-15th May, 1942.

**History of Coke Making and of the Coke-Oven Managers Association.**

**Photomicroscopy of Salt in Petroleum.** By L. F. Christianson and J. W. Horne. U.S. Bureau of Mines.

**Creep Properties of Steels Utilized in High-Pressure and High-Temperature Superheater and Steam Pipe Practice." Part I. Carbon Steels.** By H. J. Tapsell. British Electrical and Allied Industries Research Association.

**British Standards Institution.** No. 987C 1 1942. "Camouflage Colours." 1s. 6d.



# INSTITUTE NOTES.

NOVEMBER 1942.

## 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.

BOWES, Emmerson, Laboratory Assistant, Lobitos Oilfields, Ltd. (*V. Biske; J. Wood-Mallock.*)

BUTCHER, Kenneth Leopold, Chemical Engineer, Shell Refining & Marketing Co. (*John A. Oriel; G. W. Dorrell.*)

HUMPHREY, Kenneth Ernest, Chemical Engineer, Foster Wheeler, Ltd. (*Dr. R. C. Fisher; E. A. Satchell.*)

KING, Stanley, Research and Refinery Plant Control Chemist, London and Thames Haven Oil Wharves, Ltd. (*E. Hunting; W. J. Wright.*)

MC EWEN, George Charles, Chemist, A.I.D. Test House. (*E. R. Styles; F. W. Bristow.*)

NEUBALD, Walter Noel Selby, Labour Officer, Petroleum Board. (*E. W. Unmack; E. J. Dunstan.*)

SIMP KIN, Francis Ronald, General Manager, Eastern Counties Lubricants, Ltd. (*Frank Dakin; Walter Kay.*)

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## MEMBERS SERVING WITH HIS MAJESTY'S FORCES.

The Council invites members serving with any branch of H.M. Forces to send a note of their rank and unit to the Secretary.

The following addition to lists already published has been received :—

HURST, N., Acting Pilot Officer, R.A.F.

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## ADDRESSES OF MEMBERS.

Since the outbreak of war the postal addresses of many members have changed. A considerable number of such changes has been notified to the Secretary, and every effort has been made to give effect to these in the despatch of the *Journal*. Members whose *Journals* are still being forwarded to the wrong address are asked to advise the Secretary of their correct address.

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CONTRIBUTIONS TO THE *JOURNAL*.

There is at present a great shortage of contributions to the *Journal*. Members are invited to submit papers on any subject relating to Petroleum Technology, for consideration by the Publications Committee. Such contributions should be typed on one side of the paper only, and the number of diagrams and tables kept down to the minimum.

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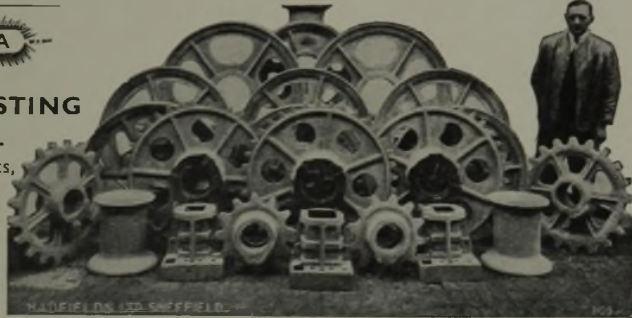
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
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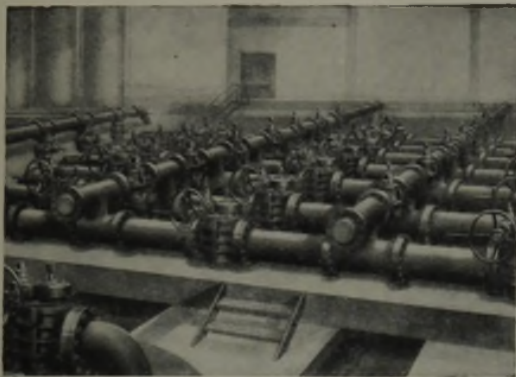
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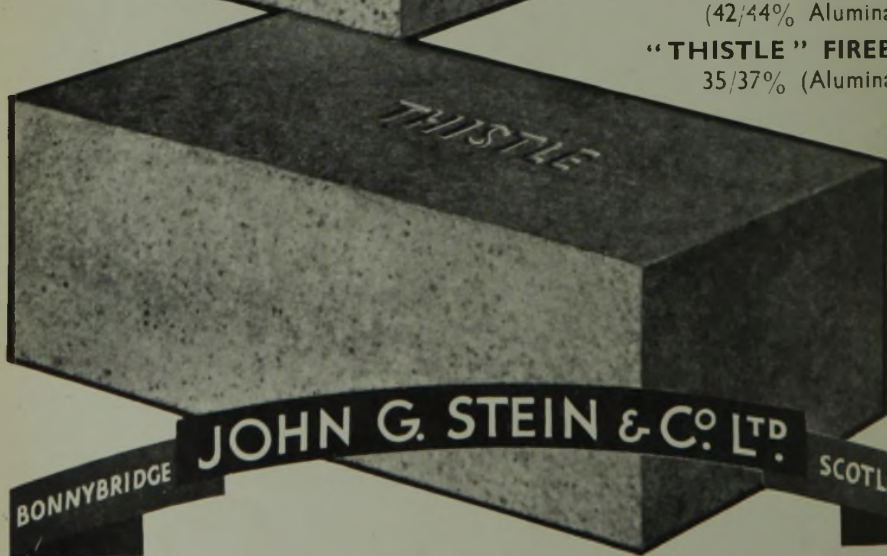
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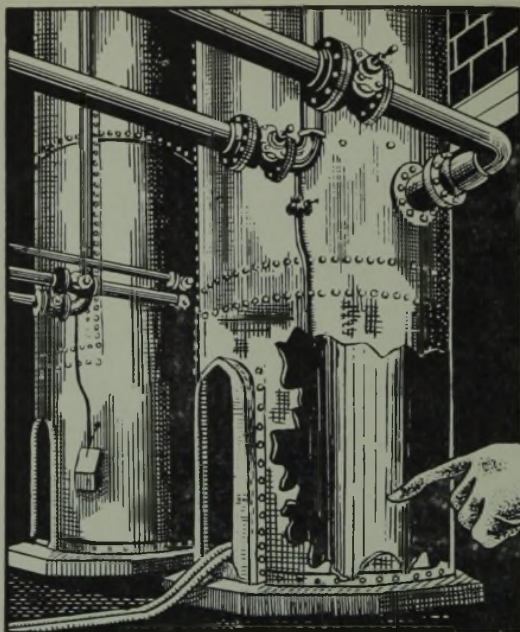


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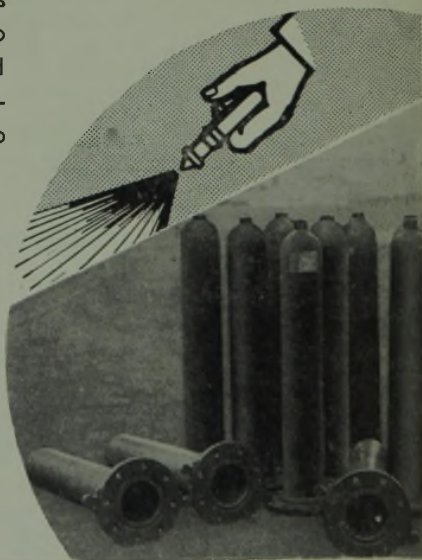
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