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Vol. 26. No. 199. May 1940.

# THE SYNTHESIS OF LUBRICATING OILS BY CONDENSATION REACTIONS.*

## PART II.—THE ENGINE TESTING OF SYNTHETIC LUBRICATING OILS.

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

The engine service characteristics of two synthetic lubricating oils were evaluated by means of an engine test. The oils examined were :—

(1) Synthetic oil $S/_1$ made by the condensation of chlorinated paraffin wax with benzene using an Al catalyst.
(2) Synthetic oil $S/_2$ made by the condensation of chlorinated paraffin wax with benzene using an $AlCl_3$ catalyst.

The service characteristics evaluated were :—

(1) Engine wear.
(2) Oil consumption.
(3) Carbon deposits.
(4) Condition of oil in crank-case.

### Engine Wear.

Engine wear can be evaluated by measuring the change in weight of piston rings, by measuring the increase in diameter of cylinder bores, and by measuring chemically the iron carried away by the lubricant. For the engine tests described in this paper all three methods were employed. The measurement of wear by ascertaining the increase in iron content of the lubricating oil was first suggested by Langdon,[1] and has been employed by Everett and Stewart,[2] and by Boerlage and Gravensteyn.[3] It has been further developed by Merrill, Moore, and Bray,[4] who expressed the increase in iron content of the lubricating oil as a wear index. In this test the wear index, representing the amount of wear in milligrams of iron per 1000 miles of operation, was expressed by the following formula :—

$$W = (C + D)(I_2 - I_1) + R(I_1 + I_2)\frac{567{,}000G}{(B - A)}$$

where $W$ = wear index, in mgms. of iron per 1000 miles.
$A$ = speedometer reading, in miles, when first oil sample taken.
$B$ = speedometer reading, in miles, when second oil sample taken.
$C$ = original volume of oil, quarts.
$D$ = final volume of oil, quarts.
$R$ = volume of make up oil, quarts.
$G$ = density of original oil, lb./gallon.
$I_1$ = per cent. iron in oil sample at $A$.
$I_2$ = per cent. iron in oil sample at $B$.

* Paper received 6th September, 1939.

In deriving this formula it is assumed that :—

(*a*) Oil consumption is a straight-line function of miles of operation.
(*b*) Iron wear is a straight-line function of miles of operation.
(*c*) Oil consumed carries with it a proportional amount of iron.

It is shown in the following section, under the heading "Oil Consumption," that assumption (*a*) is for all practical purposes correct over runs of about 1500 miles.

In Fig. 1 the wear expressed both as wear index and piston-ring wear for

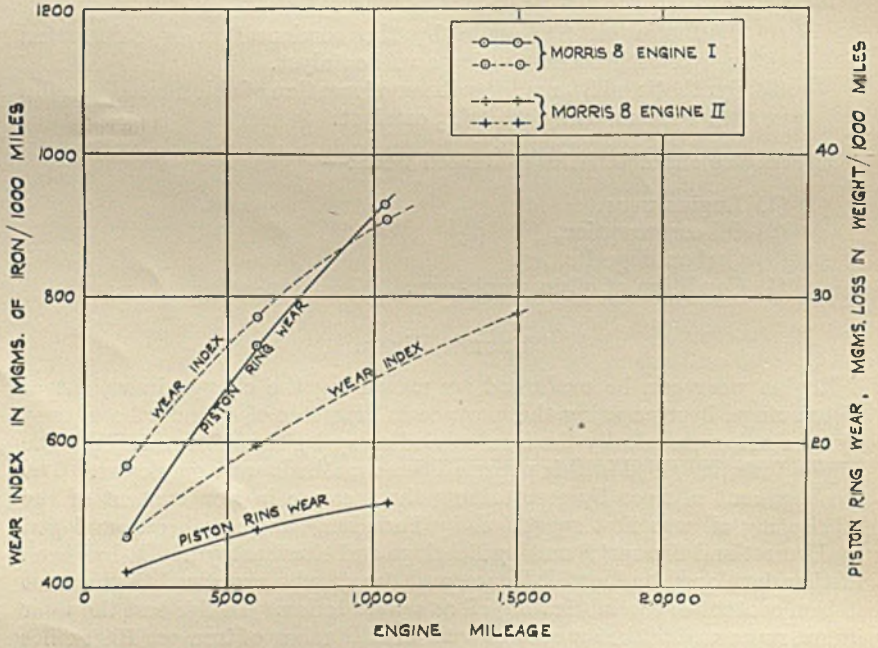


Fig. 1.

two different Morris 8 engines, run at constant speed for test runs of 1500 miles, using the reference oil, is plotted against engine mileage. Bench tests were employed to obtain this and all other data detailed in this paper and the mileage figures quoted here were derived from a speedometer attached to the gear-box of the engine unit. It will be observed that over runs of 1500 miles wear is practically a straight-line function of miles operated. Assumption (*b*) is therefore justifiable for runs up to about 1500 miles.

Wear index gives dependable results for the comparison of the wear properties of several oils if all tests are run under standard engine conditions and the oils evaluated by comparison with a reference oil. The wear data given in this paper have all been referred to a selected reference

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oil, and are really relative wear figures. They have been calculated by the following expression :—

$$\text{Relative Wear} = \frac{Tw}{Rw} \times 100$$

where $Tw$ = wear of test oil.

$Rw$ = wear of reference oil at the same engine mileage as that at which the wear value, $Tw$, of the test oil was obtained.

Since, as has been shown in Fig. 1, wear is a function of the miles the engine has operated, the value $Rw$, whether loss in weight of piston rings, increase in diameter of cylinder bore, or wear index, is easily obtained by interpolation from a plot of reference oil wear against engine mileage. The simplest way of obtaining satisfactory figures for interpolation is to carry out alternate engine tests with reference and test oils as follows : reference oil, test oil, reference oil. A less satisfactory but somewhat more economical procedure is to carry out two test oil runs between reference oil runs as follows : reference oil, test oil 1, test oil 2, reference oil. The latter method was the method adopted for the tests described in this paper. The reference oil employed was a proprietary brand of motor oil.

## Oil Consumption.

Oil consumption as related to direct actual consumption in the engine is dependent on four main factors :—

(1) Engine speed.
(2) Engine design.
(3) Engine changes due to wear.
(4) Oil characteristics—namely, viscosity and volatility, oil consumption decreasing with increasing viscosity and decreasing volatility.

In the engine tests described in this paper factors (1) and (2) above were eliminated as far as possible by using the same engine throughout the tests, run under constant engine conditions. Oil consumption as ascertained from the tests is therefore consumption as affected by factors (3) and (4). Factor (3) engine wear for a given oil was found to be a function of miles operated, and oil consumption for a given oil in a given engine run at constant speed should also be some function of miles operated. In Fig. 2 oil consumption of the reference oil in two different Morris 8 engines operated at constant speed is plotted against mileage. It will be observed that, while the function is not linear, it may be taken to be so without much error over runs of about 1500 miles.

In order to eliminate, therefore, the effect of engine changes due to wear or oil consumption, a relative oil-consumption figure has been employed, in which the actual oil consumption of the test oil at a known engine mileage is compared with the oil consumption of the reference oil at the same engine mileage. This latter value is obtained from a plot of the oil consumption of the reference oil against engine mileage, the reference oil-consumption data being obtained from reference oil tests run at regular intervals throughout a series of experiments.

The relative oil consumption measured is therefore, as near as can be obtained, a function of lubricating oil characteristics.

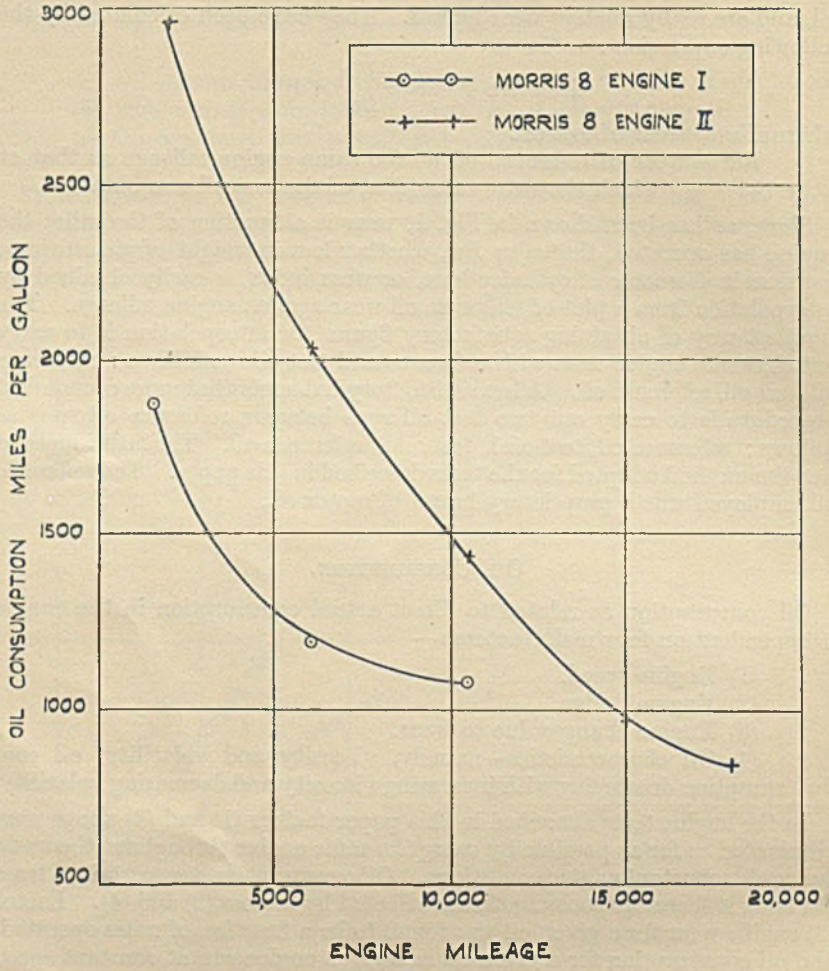


FIG. 2.

## CARBON DEPOSITS.

The more important factors which govern the formation of carbon deposits in petrol engines are :—

(1) Engine design.
(2) Engine running conditions, temperature, speed, load, and miles operated.
(3) Amount of dust in air.
(4) Air–fuel mixture ratio.
(5) Characteristics of fuel.
(6) Oil consumption.
(7) Engine condition.
(8) Characteristics of lubricating oil.

Throughout the tests described here factors (1) to (5) were maintained approximately constant, and hence their effect on the carbon deposits may be considered negligible. Carbon deposits vary with oil consumption, and will be considered here on the basis of carbon deposit per volume of oil consumed.

In Fig. 3 the carbon deposit per volume of oil consumed for two different Morris 8 engines run at constant speed for test runs of 1500 miles using the reference oil is plotted against engine mileage, and is a function of miles

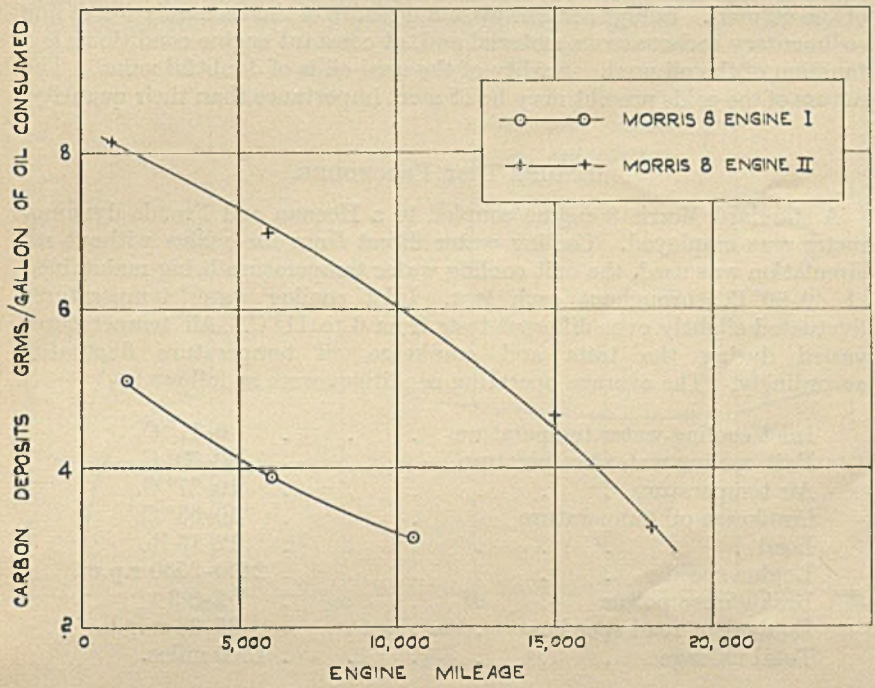


Fig. 3.

operated. As in the case of the wear and oil-consumption figures, carbon deposits have been expressed as relative to the reference oil consumption at the same engine mileage.

Comparison on this basis will therefore indicate to a large extent the differences due to the characteristics of the different lubricating-oil samples tested.

## Condition of Oil in Crankcase.

Changes in characteristics of crankcase oils during service appear to depend considerably on the type of engine, its condition, and manner of operation. Keeping engine conditions constant, as has been done in the present series of tests, demonstrates approximately crankcase changes as a function of new oil characteristics.

The following tests of used crankcase oils give some indication of their service changes :—

(1) Viscosity.
(2) Sludge content.
(3) Acidity.

Viscosity change indicates the accumulation or non-accumulation of soluble polymerized products and residues from cracking and partial burning of the oil and, under constant engine conditions, is a characteristic of the oil used. Sludge content gives a measure of the accumulation of fine sedimentary carbonaceous material and, at constant engine conditions, is a function of the oil used. Acidity of the used oil is of doubtful value. The nature of the acids present may be of more importance than their quantity.

### Engine-Test Procedure.

A standard Morris 8 engine coupled to a Heenan and Froude dynamometer was employed. Cooling water direct from the mains without recirculation was used, the exit cooling water temperature being maintained at 40–50° C. throughout each test. Inlet cooling water temperatures fluctuated slightly over different tests from 6 to 11° C. Air temperatures varied during the tests and crankcase oil temperature fluctuated accordingly. The average operating conditions were as follows :—

| | |
|---|---|
| Inlet cooling-water temperature | 6–11° C. |
| Exit cooling-water temperature | 40–50° C. |
| Air temperature | 10–27° C. |
| Crankcase oil temperature | 40–63° C. |
| Load | 12–15 lb. |
| Engine speed | 2450–2550 r.p.m. |
| Brake horse power | 7·2–8·3 |
| Equivalent road speed | 35–36 m.p.h. |
| Total mileage | 1500 miles. |

Air and cooling-water temperatures were measured by mercury in glass thermometers. Crankcase temperatures were measured by a thermocouple inserted in an internal sheath welded into the crankcase. As far as possible, the oil level in the crankcase was maintained at the maker's recommended level, make-up oil being added gradually as required. Oil consumption was determined from the measured volumes of initial, final, and make-up oils.

In order to disturb the engine as little as possible, only the top ring of each piston was weighed at the end of each test, as the greatest loss in weight occurs in the top ring, and care was taken to replace the same ring on the same piston on reassembling. By not disturbing the other rings, large engine changes were hoped to be avoided to a certain extent. Cylinder bore measurements were taken at the top of each cylinder, two measurements being taken by an internal micrometer, one parallel to the crankshaft and the other at right angles to it. This allowed for any tendency in the cylinders to wear oval. Check bore measurements were also taken at the bottom of the cylinder in a direction at right angles to the crankshaft.

At the end of each test the engine-head was removed, and all carbon deposits on the engine-head and on the top of the piston were detached with a blunt scraper and weighed.

At the finish of each test the oil was drained out of the crankcase while still hot. The crankcase was removed, washed with kerosine, and wiped completely dry. The oil pump was then submerged in a beaker containing 300 c.c. of the reference oil, and the engine motored over with the starter. This oil was sucked up by the pump, passed through the engine oiling system and discharged from the various oil-discharge holes to waste. Any oil retained in the engine was allowed to drain to waste, and the crankcase was not replaced until all oil-drips from the engine had ceased. By means

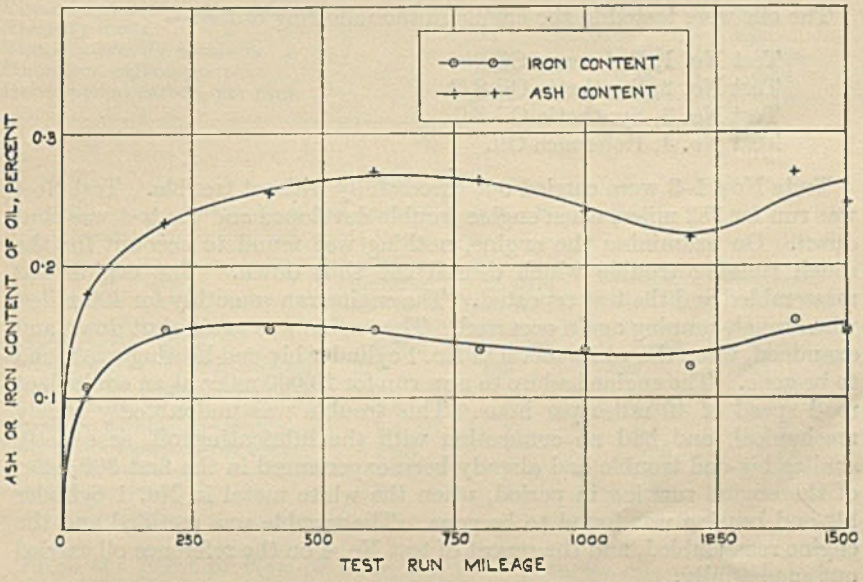


Fig. 4.

of this procedure contamination of the oil samples taken for analysis at the beginning of the test with oil from the previous test was reduced to a minimum. Oil samples for analysis were taken from the pump delivery line by means of a T-piece with sampling cock attached. About 100 c.c. of oil were discharged through the sampling cock and returned to the sump, then approximately 10 gm. of oil were sampled directly into a tared porcelain crucible, samples being taken in duplicate. Samples were taken every 100 miles in the case of the first oil tested—namely, the reference oil. It was, however, found rather difficult to keep up to date with the analysis of such frequent samples and samples were taken every 200 miles for all subsequent tests. In order to determine wear by means of the Wear Index Test, such frequent samples are not strictly essential. It was felt, however, that frequent sampling would be advisable in order to obtain perfectly reliable data as regards ash and iron content. Samples were weighed, ignited, and ash content of the oil was determined. The resultant ash was

then fused with potassium hydrogen sulphate, dissolved in dilute sulphuric acid, and the iron content determined colorimetrically by ammonium thiocyanate. As a further check on the iron content, the iron was also determined volumetrically after reduction in a Jones reductor by titration with $\frac{N}{100}$ potassium permanganate.

Curves, as in Fig. 4, for iron and ash content against mileage during a test run show an initially high increase in ash and iron content, approaching a nearly constant value after the first 250 miles.

## Order of Tests.

The oils were tested in the engine in the following order :—

Test No. 1, Reference Oil.
Test No. 2, Synthetic Oil S/2.
Test No. 3, Synthetic Oil S/1.
Test No. 4, Reference Oil.

Tests Nos. 1–3 were carried out successfully without trouble. Test No 4 was run for 282 miles, when engine trouble developed and the test was shut down. On examining the engine, nothing was found to account for the rough running trouble which caused the shut down. The engine was reassembled and the test repeated. The engine ran smoothly for 490 miles, when rough running again occurred. The engine was again shut down and examined, when the white metal in No. 1 cylinder big-end bearing was found to be gone. The engine had up to now run for 20,000 miles at an equivalent road speed of 40 miles per hour. This trouble was undoubtedly purely mechanical, and had no connection with the lubricating oil, as exactly similar big-end trouble had already been experienced in the first 300 miles of the engine running in period, when the white metal in No. 1 cylinder big-end bearing was found to be gone. The trouble was rectified and the engine reassembled, and the repeat of test No. 4 on the reference oil carried out successfully.

## Results.

The wear, oil consumption, and cylinder deposit data are shown in Table I. The relative values, obtained as explained previously, should be

Table I.

*Actual and Relative Service Characteristics.*

| Property. | Run No. 1. | Run No. 2. | | | Run No. 3. | | | Run No. 4. |
|---|---|---|---|---|---|---|---|---|
| | Reference oil. | Oil S/2. | Interpolated reference oil. | Relative value. | Oil S/1. | Interpolated reference oil. | Relative value. | Reference oil. |
| Wear index, mgm. of iron/1000 miles . . . | 3360 | 2300 | 2960 | 78 | 724 | 2600 | 28 | 1695 |
| Piston ring wear, mgm. of iron | 224·1 | 158·3 | 221·1 | 72 | 89·9 | 218·4 | 41 | 211·3 |
| Oil consumption, c.c./1000 miles . . . . | 2090 | 2300 | 2400 | 96 | 1680 | 2720 | 62 | 3520 |
| Deposits, gm./gall. oil used . | 8·4 | 10·6 | 7·9 | 134 | 9·1 | 7·5 | 254 | 6·3 |

considered against a value of 100 for the reference oil. All relative values for a test oil below 100 indicate that the oil tested is superior to the reference oil. The properties of the oils before and after the 1500-miles engine test are given in Tables II and III.

TABLE II.

*Properties of Original Oils.*

| Oil. | Reference oil. | Synthetic oil, S/1. | Synthetic oil, S/2. |
|---|---|---|---|
| Specific gravity 60° F. . . . . | 0·926 | 0·908 | 0·929 |
| Viscosity at 100° F. (centistokes) . . | 212 | 430 | 273 |
| Viscosity at 200° F. (centistokes) . . | 17·9 | 38·8 | 25·1 |
| Viscosity index . . . . . | 70 | 110 | 100 |
| Viscosity gravity constant . . . | 0·865 | 0·825 | 0·864 |
| Conradson carbon per cent. . . . | 0·98 | 0·38 | 0·12 |
| Ramsbottom carbon, per cent. . . | 0·87 | 0·38 | 0·19 |

TABLE III.

*Properties of Oil after* 1500 *Miles Engine Test.*

| Oil. | Reference oil after Run No. 1. | Reference oil after Run No. 4. | Synthetic oil, S/1. | Synthetic oil, S/2. |
|---|---|---|---|---|
| Specific gravity 60° F. . . | 0·929 | 0·925 | 0·918 | 0·938 |
| Viscosity at 100° F. (centistokes) | 219 | 185 | 492 | 353 |
| Total acidity (mgm. KOH per 1 gm. of oil) . . . | 1·9 | 1·0 | 1·0 | 1·7 |
| Conradson carbon, per cent. . | 3·4 | 2·2 | 1·4 | 1·3 |
| Ramsbottom carbon, per cent. | 2·63 | 1·8 | 1·26 | 0·99 |
| Sludge, per cent. . . . | 1·81 | 0·91 | 0·04 | 1·56 |
| Dilution, per cent. . . . | 2·0 | 3·2 | 3·2 | 3·6 |

From the point of view of wear, the two synthetic oils were definitely superior to the proprietary brand reference oil, the synthetic oil obtained using an aluminium catalyst being also superior to that obtained using an aluminium chloride catalyst. The wear index and piston-ring wear data show fair agreement.

Both synthetic oils were superior to the reference oil on the basis of oil consumption, the oil prepared by the use of an aluminium catalyst being again superior to that prepared by the use of an aluminium chloride catalyst. This is interesting in view of the fact that the oil obtained using an aluminium catalyst S/1 is considerably more viscous than either the reference oil or the second synthetic oil S/2.

In the case of cylinder deposits, both synthetic oils are inferior to the reference oil. Once again, however, despite its higher viscosity synthetic oil, S/1 is superior to S/2.

The acidity, carbon residue increase, and viscosity increase of all the oils after use are very similar. The sludge content of the used oils in the case of the reference oil and the synthetic oil S/2 prepared with the aluminium chloride catalyst is also similar, but the synthetic oil S/1 prepared with the aluminium catalyst is superior in this respect.

## Conclusions.

The synthetic oils made by the condensation of chlorinated paraffin wax with benzene compare favourably with a proprietary brand market oil when subjected to bench tests in a four-cylinder water-cooled Morris 8 engine.

## Acknowledgment.

The authors have to thank Morris Motors for the loan of the Morris 8 engines used in this work.

*References.*

[1] Langdon, *Monthly Bulletin, State College, Washington*, 1932, **15**, No. 2.
[2] Everett and Stewart, *Pennsylvania State College Bulletin*, No. 44.
[3] Boerlage and Gravenstoyn, *Motorship*, 171, August 1932.
[4] Merrill, Moore, and Bray, *Refiner*, 1935, **14** (6), 313.

*Dept. of Oil Engineering and Refining,*
*The University,*
*Birmingham.*

# SIMPLE PETROLEUM TABLES FOR USE WITH DENSITY HYDROMETERS.*

By Verney Stott, M.A., F.Inst.P.

Abstract.

The paper gives two simple tables, (1) showing the change in density of petroleum oils with change in temperature, (2) for conversion of density in g./ml. to weight in air in lb. per Imperial gallon. Used in conjunction with a density hydrometer, the tables enable the weight of a known volume of oil, the volume of a known weight of oil, or the change in volume of a given quantity of oil with change in temperature to be obtained by very simple computations. Examples of the computations are given.

A note is appended on the accuracy of density determinations made by means of British Standard density hydrometers, and also notes explaining the derivation of the tables.

## Tables Required.

The object of this paper is to present two simple tables for use, in conjunction with a density hydrometer, for determining the weight of a known volume of oil or the volume of a known weight of oil.

Provided a density hydrometer with a suitably open scale is used—*e.g.*, a British Standard density hydrometer with sub-divisions equivalent to 0·0005 g./ml., a reading taken on the hydrometer in a liquid at any temperature may be taken as giving, to a sufficient degree of accuracy (see Note 1, p. 240), the density in g./ml. of the liquid at the temperature at which the hydrometer reading is taken.

Having thus obtained the density of the oil at any one temperature, its density at any other desired temperature may be obtained by means of Table I. This table gives values of $\beta \times 10^5$, $\beta$ being defined by the equation

$$\rho_t = \rho_{20} + \beta\,(20 - t) \quad . \quad . \quad . \quad (1)$$

where $\rho_{20}$ is the density of the oil at 20° C. in g./ml.
and $\rho_t$ ,, ,, ,, ,, ,, ,, ,, $t$° C. in g./ml.

The quantity $\beta$ is therefore the change in density of the oil in g./ml. per degree centigrade change in temperature.† It follows from equation (1) that if $\rho_{t_2}$ is the density of an oil at $t_2$ °C. and $\rho_{t_1}$ its density at $t_1$ °C. that

$$\rho_{t_2} = \rho_{t_1} + \beta(t_1 - t_2)$$

a relation which will be made use of later.

The values of $\beta$ given in Table I apply to petroleum oils having the densities $\rho_{20}$ given in the first column of the table. Only small second-order errors are introduced, however, by using for a liquid of known density $\rho_t$ the value of $\beta$ given for a value of $\rho_{20}$ in Table I numerically equal to $\rho_t$. For example, on this basis for $\rho_{40} = 0{\cdot}735$ g./ml. the value of $\beta$ is approximately

* Paper received 14th August, 1939.

† A table similar to Table I, but on a specific gravity basis, has already been published by E. S. L. Beale (*J. Instn. Petrol. Tech.*, 1937, **23**, 213).

0·00083, and this leads to an approximate value of $\rho_{20}$ equal to 0·735 + 20 × 0·00083—*i.e.*, 0·752 g./ml. The actual value of β corresponding to $\rho_{20}$ = 0·752 g./ml. is given in the Table as 0·00080, and this is a more accurate value to take for the liquid of density $\rho_{40}$ = 0·735 g./ml. The use of the approximate value 0·00083 instead of 0·00080 would, however, introduce an error of only 0·0006 g./ml. in the calculated density change over a temperature interval of 20° C. The more accurate value for β may always be obtained from Table I in the way that the value 0·00080 is obtained above. This refinement will, however, only be necessary when large temperature changes have to be allowed for and a high degree of accuracy is required, and when the determined value of $\rho_t$ is less than 0·86 g./ml.

The derivation of Table I is given in Note 2, p. 242.

TABLE I.

*Change in Density (β) in g./ml. per °C. of American Petroleum Oils.*

| $\rho_{20}$. | $\beta \times 10^5$. | $\rho_{20}$. | $\beta \times 10^5$. | $\rho_{20}$. | $\beta \times 10^5$. |
|---|---|---|---|---|---|
| 0·615 | 101 | 0·735 | 83 | 0·855 | 66 |
| 0·620 | 100 | 0·740 | 82 | 0·860 | 66 |
| 0·625 | 99 | 0·745 | 81 | 0·865 | 66 |
| 0·630 | 98 | 0·750 | 80 | 0·870 | 66 |
| 0·635 | 98 | 0·755 | 80 | 0·875 | 66 |
| 0·640 | 97 | 0·760 | 79 | 0·880 | 66 |
| 0·645 | 96 | 0·765 | 78 | 0·885 | 66 |
| 0·650 | 96 | 0·770 | 78 | 0·890 | 66 |
| 0·655 | 95 | 0·775 | 77 | 0·895 | 66 |
| 0·660 | 94 | 0·780 | 76 | 0·900 | 66 |
| 0·665 | 93 | 0·785 | 75 | 0·905 | 66 |
| 0·670 | 92 | 0·790 | 74 | 0·910 | 66 |
| 0·675 | 92 | 0·795 | 74 | 0·915 | 66 |
| 0·680 | 91 | 0·800 | 73 | 0·920 | 66 |
| 0·685 | 90 | 0·805 | 72 | 0·925 | 66 |
| 0·690 | 90 | 0·810 | 72 | 0·930 | 66 |
| 0·695 | 89 | 0·815 | 71 | 0·935 | 66 |
| 0·700 | 88 | 0·820 | 70 | 0·940 | 66 |
| 0·705 | 87 | 0·825 | 69 | 0·945 | 66 |
| 0·710 | 86 | 0·830 | 68 | 0·950 | 66 |
| 0·715 | 86 | 0·835 | 68 | 0·955 | 66 |
| 0·720 | 85 | 0·840 | 67 | 0·960 | 66 |
| 0·725 | 84 | 0·845 | 66 | 0·965 | 66 |
| 0·730 | 84 | 0·850 | 66 | | |

Having determined the density of the oil at any desired temperature *t* °C., Table II * serves to give the apparent weight in air in lb. of the quantity of the oil which occupies 1 gallon at *t* °C. The derivation of Table II is given in Note 3, p. 245.

* Table II was first published in the article "Hydrometers and Hydrometry," by V. Stott, *Report of the World Petroleum Congress*, Vol. II, p. 880, London, 1933, and has subsequently appeared in the British Standard Specification for Density Hydrometers No. 718—1936 and in "Standard Methods for Testing Tar and Its Products," 2nd edition, 1938.

TABLE II.

*Conversion of g./ml. to lb. per Imperial Gallon.*

| Density of oil in g./ml. at $t$ °C. | Correction for calculating the weight in lb. of the quantity of the oil which occupies 1 gallon at $t$ °C. |
|---|---|
| 0·60 | +0·000 2 |
| 0·65 | +0·000 3 |
| 0·70 | +0·000 4 |
| 0·75 | +0·000 6 |
| 0·80 | +0·000 7 |
| 0·85 | +0·000 8 |
| 0·90 | +0·000 9 |
| 0·95 | +0·001 0 |

*Note.*—The correction obtained from the second column is added to the density of the liquid at $t$ °C. and the sum multiplied by 10 to obtain the weight in lb. of the quantity of the oil which occupies 1 gallon at $t$ °C.

The use of Tables I and II in conjunction with readings taken on density hydrometers can best be illustrated by means of examples.

EXAMPLES OF THE USE OF THE TABLES.

(1) *Determination of the Weight of a Known Volume of Oil.*

For this we require the weight of unit volume of the oil at the temperature at which the volume of the bulk of the oil is known. If the density of the oil is determined at this temperature, then Table I is not required, and the computation involves only the use of Table II as follows :—

*Example* (*a*).

Volume of oil at 29° C. . . . . 1056 gal.
Reading of B.S. density hydrometer in the oil at 29° C. . 0·8475 g./ml.

From Table II the weight of the quantity of the oil which occupies 1 gallon at 29° C. is

$$(0{\cdot}8475 + 0{\cdot}0008) \times 10 \text{ lb.}—i.e., 8{\cdot}483 \text{ lb.}$$

Hence the weight of the bulk of the oil is

$$(8{\cdot}483 \times 1056) \text{ lb.}—i.e., 8958 \text{ lb.}$$

Circumstances may require, however, that the density of the oil has to be determined at some temperature other than that at which the volume of the bulk of the oil is known. The use of Table I is then required as well as of Table II, but the computation is still a simple one as follows :—

*Example* (*b*).

Volume of oil at 29° C. . . . . 1056 gal.
Reading of B.S. density hydrometer in the oil at 15° C. . 0·8565 g./ml.

From Table I the value of $\beta \times 10^5$ of the oil is 66, so the density of the oil at 29° C. is $[0{\cdot}8565 - 0{\cdot}00066\ (29-15)]$ g./ml.—*i.e.*, 0·8473 g./ml. From

Table II the weight of the quantity of the oil which occupies 1 gal. at 29° C. is therefore

$$(0{\cdot}8473 + 0{\cdot}0008) \times 10 \text{ lb.}—i.e., 8{\cdot}481 \text{ lb.}$$

Hence the weight of the bulk of the oil is

$$(8{\cdot}481 \times 1056) \text{ lb.}—i.e., 8956 \text{ lb.}$$

In determining the weight of a known volume of oil it is clearly an advantage, when this is practicable, to determine the density of the oil at the temperature at which the volume of the bulk of the oil is known. No knowledge of the change in density of the oil with change in temperature is then necessary and Table I is not required.

(2) *Determination of the Volume of a Known Weight of Oil.*

For this we require the weight of unit volume of the oil at the temperature at which its volume is required. If the density of the liquid is determined at this temperature, then Table I is not required, and the computation involves only the use of Table II as follows :—

*Example* (*c*).

| | |
|---|---|
| Weight of oil . . . . . | 8958 lb. |
| Reading of B.S. density hydrometer in the oil at 20° C. | 0·8535 g./ml. |

If the volume of the oil at 20° C. is required then from Table II the weight of the quantity of the oil which occupies 1 gal. at 20° C. is (0·8535 + 0·0008) × 10 lb.—*i.e.*, 8·543 lb. The volume at 20° C. of the known weight of oil is therefore :—

$$(8958 \div 8{\cdot}543) \text{ gal.}—i.e., 1049 \text{ gal.}$$

If, however, circumstances have been such as to necessitate the hydrometer reading being taken at some temperature other than that at which the volume of the oil is required, then both Table I and Table II are required in the computations as follows :—

*Example* (*d*).

| | |
|---|---|
| Weight of oil . . . . . | 8958 lb. |
| Reading of B.S. density hydrometer in the oil at 20° C. | 0·8535 g./ml. |
| Temperature at which volume of oil is required . . | 60° F. |

From Table I the value of $\beta \times 10^5$ for the oil is 66, and so the density of the oil at 60° F. (15·5̇° C.) is :—

$$[0{\cdot}8535 + 0{\cdot}00066\ (20–15{\cdot}5\dot{)}]\ \text{g./ml.}—i.e., 0{\cdot}8564 \text{ g./ml.}$$

From Table II the weight of the quantity of the oil which occupies 1 gal. at 60° C. is therefore :—

$$(0{\cdot}8564 + 0{\cdot}0008) \times 10 \text{ lb.}—i.e., 8{\cdot}572 \text{ lb.}$$

The volume at 60° F. of the known weight of oil is hence :—

$$(8958 \div 8{\cdot}572) \text{ gal.}—i.e., 1045 \text{ gal.}$$

In determining the volume of a known weight of oil it is clearly an advantage, when this is practicable, to determine the density of the oil at the temperature at which its volume is required. No knowledge of the change in density of the oil with change in temperature is then necessary, and Table I is not required.

(3) *Determination of the Volume at any Desired Temperature of a quantity of Oil having a Known Volume at a Known Temperature.*

Since the volume of any given mass of oil is inversely proportional to its density, Table I serves to determine the change in volume resulting from a change in the temperature of a quantity of oil of known volume at the original temperature, provided that the density of the oil $\rho_t$ at any temperature $t$ °C. is known. The following examples illustrate the computations :—

*Example* (*e*).

| | |
|---|---|
| Volume of oil at 29° C. . . . . | 1056 gal. |
| Reading of B.S. density hydrometer in the oil at 29° C. | 0·8475 g./ml. |
| Temperature at which the volume of the oil is required | 20° C. |

From Table I the density of the oil at 20° C. is :—

$$[0{\cdot}8475 + 0{\cdot}00066\ (29–20)]\ \text{g./ml.}—i.e.,\ 0{\cdot}8534\ \text{g./ml.}$$

The volume of the oil at 20° C. is equal to :—

$$\text{Volume of oil at 29° C.} \times \frac{\text{Density of oil at 29° C.}}{\text{Density of oil at 20° C.}}$$

*i.e.*, to $(1056 \times 0{\cdot}8475 \div 0{\cdot}8534)$ gal. = 1049 gal.

*Example* (*f*).

| | |
|---|---|
| Volume of oil at 29° C. . . . . | 1056 gal. |
| Reading of B.S. density hydrometer in the oil at 20° C. . | 0·8535 g./ml. |
| Temperature at which the volume of the oil is required | 60° F. |

From Table I the value of $\beta \times 10^5$ for the oil is 66, and hence the density of the oil at 29° C. is :—

$$[0{\cdot}8535 + 0{\cdot}00066\ (20–29)]\ \text{g./il.}—i.e.,\ 0{\cdot}8476\ \text{g./ml.}$$

and at 60° F. (15·$\dot{5}$° C.) :—

$$[0{\cdot}8535 + 0{\cdot}00066\ (20–15{\cdot}\dot{5})]\ \text{g./ml.}—i.e.,\ 0{\cdot}8564\ \text{g./ml.}$$

The volume of the oil at 60° F. is equal to :—

$$\text{Volume of oil at 29° C.} \times \frac{\text{Density of oil at 29° C.}}{\text{Density of oil at 60° F.}}$$

*i.e.*, to $(1056 \times 0{\cdot}8476 \div 0{\cdot}8564)$ gal. = 1045 gal.

It will be seen from a comparison of examples (*e*) and (*f*) that the computation is simpler if the hydrometer reading is taken either at the temperature at which the volume of the oil is known or at the temperature at which the volume of the oil is required.

## Notes.

(1) *Accuracy of Density Determination by Means of B.S. Density Hydrometers.*

In the foregoing examples the directly observed reading on a British Standard density hydrometer, adjusted to indicate density in g./ml. at 20° C., has been taken as giving directly the density of the oil in g./ml. at the temperature at which the hydrometer reading was taken. It is desirable to estimate the errors resulting from this.

It will be assumed that a B.S. density hydrometer, having a scale subdivided into intervals of 0·0005 g./ml., is used and that, in order to make the minimum demand on the operator, he is instructed to record the reading as that corresponding to the graduation mark nearest to the level liquid surface, thus relieving the operator of the necessity of estimating fractions of a subdivision. The corrections to be applied to the observed reading to obtain the density of the oil at the temperature at which the hydrometer reading is taken are those for :—

(*a*) the scale error of the hydrometer,
(*b*) the change in volume of the hydrometer between its standard temperature 20° C. and the temperature at which it is read in the oil,
(*c*) the difference between the surface tension of the oil and that for which the B.S. hydrometer is adjusted.

From Table 3, p. 12, of B.S. 718 * the maximum correction under (*a*) would be ± 0·0004 g./ml.

As regards (*b*) we will assume that the hydrometer is read at a temperature differing by 20° C. from the standard temperature of the hydrometer—*i.e.*, either at 0° C. or 40° C.—and that the observed hydrometer reading is 0·845 g./ml. From Table 6, p. 29, of B.S. 718 the correction under (*b*) would be +0·0004 g./ml. at 0° C., and − 0·0004 g./ml. at 40° C. The B.S. density hydrometers covering the density range 0·650 g./ml. to 1·000 g./ml. are adjusted for surface tensions very close to those of petroleum oils so that the correction under (*c*) is negligible.

Collecting all these corrections together, and assuming also that the actual hydrometer reading was midway between two graduation marks on the hydrometer scale, so that the recorded reading is in error by ± 0·00025 g./ml. (*d* say) due to rounding off to the reading to the nearest graduation mark, we have :—

| | | |
|---|---|---|
| Correction | (*a*) | ±0·0004 g./ml. |
| ,, | (*b*) | ±0·0004 g./ml. |
| ,, | (*c*) | 0·0000 g./ml. |
| ,, | (*d*) | ±0·00025 g./ml. |
| Total possible range of corrections | | ±0·00105 g./ml. |

* *I.e.*, "British Standard Specification for Density Hydrometers," No. 718—1936.

In an extreme case therefore where

(*a*) the hydrometer was assumed to have the maximum error permissible under the B.S. specification;

(*b*) a generous allowance of 20° C. was made for the difference between the standard temperature of the hydrometer and the temperature at which the hydrometer was read;

(*c*) the liquid surface was assumed to be midway between two graduation marks, and the reading recorded as one or other of these graduation marks,

the total error is only one unit in the third place of decimals when the directly observed hydrometer reading is taken as giving directly the density of the oil at the temperature of observation. In general, the error would be less than in the extreme case considered.

The error can be substantially reduced, if necessary, by using a hydrometer furnished with a certificate of corrections by The National Physical Laboratory and applying appropriate corrections in accordance with the tables given in B.S. 718. The possible range of the uncertainty in the final result would then be :—

| | |
|---|---|
| (*a*) Maximum error in certified correction . | ± 0·0002 g./ml.* |
| (*b*) Error due to corrections in Table 6 of B.S. 718 rounded off to the nearest 0·0001 g./ml. | ± 0·00005 g./ml. |
| (*c*) Negligible surface tension correction . . | 0·0000 g./ml. |
| (*d*) Assuming one-tenth of a subdivision error in estimating scale reading . . . | ± 0·00005 g./ml. |
| Total possible uncertainty in density | ± 0·0003 g./ml. |

The value ± 0·0003 g./ml. thus derived is again a maximum estimate of the possible error, and in general the actual error would be smaller.

Whether the extra trouble of applying corrections to the hydrometer readings is necessary is a matter for decision by the user on the basis of the accuracy aimed at in his gauging operations. The hydrometer used, however, should be one known at least not to have errors in excess of the B.S. tolerances.

The errors associated directly with the hydrometer have alone been considered, but of course any error in determining the temperature of the oil at the time of taking the hydrometer reading would be reflected as an error in the density of the oil. From Table I the error resulting from 0·1° C. error in temperature would be 0·0001 g./ml. for densities in the neighbourhood of 0·7 g./ml. and 0·00007 g./ml. for densities of 0·8 g./ml. and upwards with intermediate values for intermediate densities.

* The corrections actually determined in the N.P.L. tests of the hydrometers in question are rounded off to the nearest 0·0002 g./ml. on the certificates issued, so that in extreme cases an error of ±0·0001 g./ml. might result from rounding off. Allowing another ±0·0001 g./ml. for possible error in the actually determined correction the total possible error ±0·0002 g./ml. quoted above is arrived at. This is clearly a maximum estimate which would only arise in extreme cases.

(2) *Derivation of Table I.*

Table I has been derived from Tables 7, 8, and 9 of "Density and Thermal Expansion of American Petroleum," by H. W. Bearce and E. L. Peffer, Technologic Paper No. 77 of the National Bureau of Standards, 1916. It is stated in "National Standard Petroleum Oil Tables," Circular No. C. 410, of the National Bureau of Standards, issued 1936, that these tables are largely based on the Technologic Paper No. 77.

Table 7 of the Technologic Paper No. 77 gives densities at various temperatures over the range 0–50° C., generally at each 10° C., of fifty-four refined oils of densities at 20° C. ranging from 0·618 g./ml. to 0·942 g./ml.

Table 8 gives densities of twelve crude oils at 0° C., 25° C., and 50° C., of one at 0° C. and 25° C. and of five at 30° C. and 40° C., the range of densities at 20° C. being 0·811 g./ml. to 0·963 g./ml.

Table 9 gives densities of fifteen fuel oils and lubricating oils at 25° C., 50° C., 75° C., and 90° C., the range of densities at 20° C. being 0·865 g./ml. to 0·957 g./ml.

First of all it was assumed that the densities given could be represented by

$$\rho_t = \rho_{20} + \beta(20 - t)$$

and values of $\rho_{20}$ and $\beta$ were calculated for each of the eighty-seven oils, the method of least squares being used when more than two densities were available for any given oil. From the resulting values of $\beta$ and $\rho_{20}$ values of $\rho_t$ were calculated for each of the oils for each temperature at which the density of the oil was given in the original tables. Values of $\beta$ taken to only two significant figures were used in the calculation of $\rho_t$, as not more than two significant figures would normally be employed. The differences between the calculated values of $\rho_t$ and the values given in the original tables were noted. An analysis of these differences for the refined oils is given in Table A.

TABLE A.

*Differences between Calculated Values of $\rho_t$ and Tabulated Densities for Refined Oils.**

| Maximum difference between calculated and given density for any given oil. | Number of oils having maximum difference given in preceding column. | Maximum difference between calculated and given density for any given oil. | Number of oils having maximum difference given in preceding column. |
|---|---|---|---|
| 0·0000 g./ml. | 2 | 0·0006 g./ml. | 1 |
| 0·0001 ,, | 28 | 0·0007 ,, | 1 |
| 0·0002 ,, | 10 | 0·0008 ,, | 0 |
| 0·0003 ,, | 4 | 0·0009 ,, | 0 |
| 0·0004 ,, | 1 | 0·0010 ,, | 1 |
| 0·0005 ,, | 1 | 0·0011 ,, | 1 |

* The numbers in the second columns of Table A make a total of 50, as against a total of 54 oils for which data are given in Table 7. This is because residuals have not been included for four of the oils for which only two values of the density were given as for these the residuals would necessarily be zero.

From Table A it will be seen that the calculated densities of the refined

oils agreed closely for nearly all the oils * with the given densities, *i.e.*, the relation

$$\rho_t = \rho_{20} + \beta(20 - t)$$

satisfactorily represents the change in density of the oils with change in temperature, over the range 0–50° C. for which densities were available.

An analysis of the residuals for the twelve crude oils for which densities were given at the three temperatures 0° C., 25° C., and 50° C. is given in Table B.

TABLE B.

*Differences between Calculated Values of $\rho_t$ and Tabulated Densities for Twelve Crude Oils.*

| Maximum difference between calculated and given density for any given oil. | Number of oils having maximum difference given in preceding column. |
|---|---|
| 0·0000 g./ml. | 0 |
| 0·0001 ,, | 3 |
| 0·0002 ,, | 3 |
| 0·0003 ,, | 0 |
| 0·0004 ,, | 3 |
| 0·0005 ,, | 2 |
| 0·0005 ,, | 1 |

The residuals are rather larger than for refined oils, but still not excessive.

An analysis of the residuals for the fifteen fuel oils and lubricating oils for which densities were given at 25° C., 50° C., 75° C., and 90° C. is given in Table C.

TABLE C.

*Differences between Calculated Values of $\rho_t$ and Tabulated Densities for Fifteen Fuel Oils and Lubricating Oils.*

| Maximum difference between calculated and given density for any given oil. | Number of oils having maximum difference given in preceding column. |
|---|---|
| 0·0000 g./ml. | 0 |
| 0·0001 ,, | 2 |
| 0·0002 ,, | 5 |
| 0·0003 ,, | 5 |
| 0·0004 ,, | 0 |
| 0·0005 ,, | 0 |
| 0·0006 ,, | 2 |
| 0·0007 ,, | 1 |

Here four-fifths of the maximum differences between the calculated and tabulated densities do not exceed 0·0003 g./ml., although the temperature range covered was 25–95° C.

* Three of the four oils exhibiting differences greater than 0·0005 in Table A were stated in the original paper probably to contain solid particles at the lower temperatures.

Tables A to C having established that, for the large majority of the oils, the calculated values of $\rho_{20}$ and $\beta$ could be used to calculate to a high degree of accuracy the density of the oils at any required temperature, within the temperature range of the given data, by means of the relation :—

$$\rho_t = \rho_{20} + \beta(20 - t)$$

corresponding values of $\beta$ and $\rho_{20}$ were plotted on a graph. From inspection of this graph it was evident that for all values of $\rho_{20}$ from 0·845 g./ml. to 0·965 g./ml. a mean value 66 could be taken as a reasonable value for $\beta \times 10^5$. For densities below 0·845 g./ml. the values of $\beta$ were evenly distributed about an inclined straight line, and the equation of this line was found, by the method of least squares, to be :—

$$\beta = (193{\cdot}02 - 150{\cdot}03\ \rho_{20}) \times 10^{-5}$$

The values of $\beta$ given in the earlier part of Table I were calculated from this relation, and the mean value 66 for $\beta \times 10^5$ for higher values of $\rho_{20}$ was used for Table I.

The value of $\beta$ ($\beta_s$, say) derived from the above equation, or taken as $66 \times 10^{-5}$ according to the value of $\rho_{20}$, was calculated from the density $\rho_{20}$ of each of the eighty-seven oils. The difference $\beta - \beta_s$ was noted for each oil, this difference being that between the value of $\beta$ derived directly from the given densities of the oil and the value of $\beta$ ($\beta_s$) obtained from the general relationship between $\rho_{20}$ and $\beta$ forming the basis of Table I. An analysis of these differences is given in Table D.

TABLE D.

*Differences between Values of $\beta$ Calculated from Density of Oil at 20° C. and Values of $\beta$ Calculated from a Series of Experimentally Determined Densities at Different Temperatures.*

| Magnitude of $(\beta_s - \beta) \times 10^5$, $\beta$-calculated from $\rho_{20}$, $\beta$ calculated from series of densities. | Number of differences of magnitudes given in first column— | | |
|---|---|---|---|
| | Refined oils. | Crude oils, fuel oils and heavy lubricating oils. | Total. |
| Less than −5 | 0 | 0 | 0 |
| −5 | 0 | 0 | 0 |
| −4 | 1 | 1 | 2 |
| −3 | 1 | 3 | 4 |
| −2 | 15 | 7 | 22 |
| −1 | 7 | 2 | 9 |
| 0 | 12 | 5 | 17 |
| +1 | 5 | 4 | 9 |
| +2 | 4 | 4 | 8 |
| +3 | 5 | 2 | 7 |
| +4 | 0 | 2 | 2 |
| +5 | 1 | 2 | 3 |
| Greater than +5 | 3 | 1 | 4 |

For only four out of the eighty-seven oils was the difference $(\beta_s - \beta) \times 10^5$ greater than 5, and three of these were stated in the original paper to be oils which probably contained solid particles at lower temperatures. The difference in the changes in density for 20° C. change in temperature calculated from values of $\beta$ differing by 0·00005 is 0·001 g./ml. Hence close agreement in calculated changes of density would be obtained between changes calculated on the basis of the value of $\beta$ for the individual oil and changes calculated from values of $\beta$ obtained from Table I. This is further illustrated by the fact that for sixty-six out of the eighty-seven oils $(\beta_s - \beta) \times 10^5$ did not exceed 2, corresponding to a difference of only 0·0004 g./ml. in the density change for 20° C. change in temperature according to whether $\beta_s$ or $\beta$ is used in the calculations.

The values of $\beta_s$ given in Table I may therefore safely be used for petroleum oils of the type investigated in the National Bureau of Standards Technologic Paper No. 77.*

(3) *Derivation of Table II.*

Let $\rho_t$ = density—mass per unit volume—of oil in g./ml. at $t$ °C.
„ $W$ = observed weight in air in lb. of a quantity of the oil which occupies 1 gal. at $t$ °C.

The equation for the equilibrium at the time of weighing is :—

$$W \times G\left(1 - \frac{\sigma}{\Delta}\right) = K(\rho_t - \sigma) \quad . \quad . \quad . \quad (1)$$

where $G$ = number of grams in 1 lb.—*i.e.*, 453·592.
$\sigma$ = density of air at time of weighing—assumed to be 0·0012 g./ml.
$\Delta$ = density of weights used, assumed to be 8·3 g./ml.
$K$ = number of millilitres in a gallon—*i.e.*, 4545·96.

From (1) we have :—

$$W = \frac{K}{G} \times \frac{1}{(1 - \sigma/\Delta)} \times (\rho_t - \sigma) \quad . \quad . \quad . \quad (2)$$

The coefficient of $(\rho_t - \sigma)$ in (2) is constant and the equation is in a convenient form for computing values of $W$ for different values of $\rho_t$.

Finally let $c$ be the correction given in Table II.

Then $$W = 10(\rho_t + c)$$

or $$c = \frac{W}{10} - \rho_t \quad . \quad . \quad . \quad . \quad (3)$$

and in the construction of Table II values of $c$ were computed by means of (3) from values of $W$ derived from (2).

*The National Physical Laboratory,*
*Teddington, Middlesex.*

* The values of $\beta$ in Table I agree on the average to within 0·00002 with the "Specific Gravity Correction Factors per ° F." table given by E. S. L. Beale, *J. Instn Petrol Tech.*, 1937, 23, 213, when the latter are converted to the same basis. Close agreement was to be expected, since both tables were derived from the same original data. Beale's values were derived from the N.B.S. Circular No. 154 by a rather less rigid method than that employed in the present paper in obtaining values of $\beta$ directly from Technologic Paper No. 77, on which Circular No. 154 was based.

# PHYSICAL CONSTANTS OF ASPHALTIC BITUMENS.

## PART II.*

By Dr. R. N. J. Saal, K. Meinema, and Dr. P. C. Blokker.

Summary.

This paper gives a survey of the following electrical properties of asphaltic bitumens:

dielectric strength,
angle of dielectric loss,
dielectric constant,
electrical conductivity.

The methods by which these properties have been determined are described in detail.

### Introduction.

A survey is given of some electrical properties of asphaltic bitumens in continuation of a publication from the Laboratory of the N.V. De Bataafsche Petroleum Maatschappij describing various other physical constants of these substances.[1]

The dielectric strength, dielectric loss, and dielectric constant of asphaltic bitumen are of great importance for the different applications of bitumen in the electrical industry, where it is used, for instance, in pothead compounds, sealing compounds for transformers, impregnation material for condensers, insulation material for cables, etc.

### A. Dielectric Strength.

The dielectric strength of a material is the minimum value of the electric-field intensity at which a disruptive discharge occurs in the material under specified conditions.

The dielectric strength is determined with an apparatus in which the material under test is placed between two electrodes. The result of the test is largely governed by the shape of the electrodes and the distance between them.

Usually, an apparatus with two plate or two spherical electrodes is used.

The plate electrodes have a considerable advantage over spherical electrodes, in that any contamination of the bitumen is more easily discovered. In agreement with this, the dielectric strength found with spherical electrodes is invariably higher than that measured with plate electrodes.

In the case of bitumens, the use of plate electrodes has the further advantage that the prevailing conditions more closely simulate actual practice.

For these reasons, part of the measurements were carried out by means of an apparatus with plate electrodes, developed by G. W. Nederbragt.[2] Moreover, measurements were made with spherical electrodes in accordance with the British Standard Specification Test No. 688—1936.[3]

* Paper received 18th January, 1940.

## Plate Electrodes.

Fig. 1 is a sketch of the apparatus with plate electrodes. In this apparatus the dielectric strength is measured between two flat, disk-shaped electrodes, *A* and *B* (diameter 40 mm.), with rounded edges. The electrode *A* is supported by the rectangularly bent rod *C*, which has been cemented into the porcelain tube. All the metal parts of the apparatus are made of nickel steel with a low coefficient of expansion (Invar).

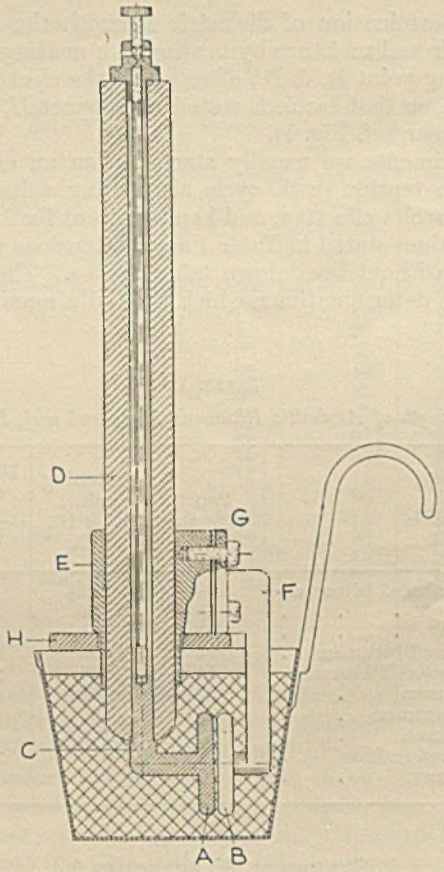


Fig. 1.

APPARATUS FOR DETERMINATION OF DIELECTRIC STRENGTH OF SEALING COMPOUNDS.

To the porcelain tube the block *E* has been soldered, so that one side of the block is in the same vertical plane as electrode *A*. The electrode *B* is connected to block *E* by means of the rod *F*, and the plate *G* being in one vertical plane with electrode *B*. The desired distance between *A* and *B* may be adjusted by inserting a small plate between *E* and *G*.

The principal advantage of the use of Invar is that it can be cemented

into porcelain without fear of the porcelain cracking when it is heated up to 200° C.; an additional advantage is that the position of the electrode *A* with respect to the porcelain tube always remains the same, owing to the low coefficient of expansion of Invar.

In various experiments it was, indeed, found that the distance between the electrodes *A* and *B* changes but very little with the temperature. The 1 mm. distance between the two electrodes may be previously checked by means of a template (thickness of thin end 0·98 mm., thick end 1·02 mm.).

Before the determination of dielectric strength the asphaltic bitumen was freed from air and moisture by heating in a melting pan to 80–100° C. above its softening point R. & B., after which the electrodes were lowered into the bitumen, so that block *E* rested on support *H*, which was placed over the melting pan (cf. Fig. 1).

In these experiments we usually started from an effective tension of 15 kilovolts; the tension (a 50-cycle alternating voltage) was increased stepwise by 5 kilovolts effective, and kept constant for 1 minute after each increase. The values stated in Table I are the tensions which the material could withstand without breakdown taking place. The figures are mean values from three determinations, which showed a maximum difference of 5 kilovolts.

TABLE I.

*Dielectric Strength of Asphaltic Bitumens Measured with Plate Electrode.*

| Bitumen. | Pen./ 25° C. | Softening point, R. & B., ° C. | Dielectric strength in effective Kv./mm. | |
|---|---|---|---|---|
| | | | 20° C. | 50° C. |
| Venezuelan steam reduced bitumen. | 180 | 39½ | 10 | <10 |
| Ditto . . . . . | 43½ | 54 | 30 | 10 |
| Ditto . . . . . | 23 | 61 | 30 | 10 |
| Mexican steam reduced bitumen . | 25 | 63 | 35 | 10 |
| Venezuelan steam reduced bitumen. | 11 | 83 | >60 | 15 |
| Mexican blown bitumen . . | 35 | 88½ | 30 | 20 |
| Venezuelan blown bitumen . . | 39 | 86½ | 25 | 15 |
| Mexican blown bitumen . . | 11 | 129 | 35 | 15 |
| Bitumen from cracked residue . | 1½ | 74 | >60 | 20 |
| Light-coloured bitumen . . | 15 | 55 | 30 | 14 |

## SPHERICAL ELECTRODES.*

The dielectric strength measurements with spherical electrodes were carried out in accordance with the British Standard Specification Test No. 688—1936.[3]

The spherical electrodes, 0·5 inch (approximately 13 mm.) diameter, were arranged horizontally 0·05 inch apart in a porcelain container, into which the bitumen was poured.

* The determinations referred to were carried out at the Central Laboratories of the Shell Marketing Co., Ltd., London, to whom we are indebted for the permission to publish these data.

Before the determination the asphaltic bitumen was freed from air and moisture by heating to 75–90° C. (dependent on the softening point) above the softening point of the bitumen. After cooling down slowly to test temperature the bitumen was maintained thereat for 1 hour before the measurement was made. In the experiments the voltage (a 50-cycle alternating voltage) was raised gradually from zero to the appropriate voltage (10,000 or 20,000 volts) in approximately 10 seconds, and was maintained at this voltage for 1 minute. The voltage was then raised until the breakdown voltage was obtained.

The results found are given in Table II.

TABLE II.

*Dielectric Strength of Asphaltic Bitumen Measured with Spherical Electrodes (according to British Standard Specification Test No. 688—1936).*

| Bitumen. | Pen./ 25° C. | Softening point, R. & B., ° C. | Dielectric strength in effective Kv./mm. 60° C. |
|---|---|---|---|
| Venezuelan steam-reduced bitumen | abt. 450 | abt. 32 | 28 41 |
| | ,, 300 | ,, 35 | 11 12 13 27 |
| | ,, 210 | ,, 38 | 17 33 33 35 36 |
| | ,, 100 | ,, 45 | 40 |
| | ,, 90 | ,, 46[5] | 24 45 |
| | ,, 65 | ,, 50 | 27 38 40 45 45 |
| | ,, 45 | ,, 55 | 35 39 40 43 |
| | ,, 35 | ,, 57[5] | 36 36 38 |
| | ,, 25 | ,, 61[5] | 22 37 38 |
| | ,, 15 | ,, 71 | 27 35 41 |
| | ,, 9 | ,, 85 | 22 |
| | ,, 4 | ,, 115 | (>40 at 90° C.) |
| Venezuelan blown bitumen | ,, 40 | ,, 85 | 35 |
| | ,, 25 | ,, 85 | 30 |
| Bitumen from cracked residue Trinidad Epuré | ,, 1½ | ,, 72 | 36 (15 at 90° C.) |

Each figure is a mean value of three measurements. The different values given for each bitumen grade in increasing order of magnitude refer to samples from different charges and from different refineries.

It will be noticed that different samples of one grade sometimes give widely divergent values. This may be due to variations in the amount of mineral matter present, such as salt, iron scale, etc. The same phenomenon has been observed, although to a smaller extent, with plate electrodes. The explanation may be that with the larger active surface of the plate electrodes there is a greater possiblity of contamination occurring between the electrodes, owing to which there is less variation in results.

Tables I and II show that spherical electrodes usually give far higher figures for dielectric strength than plate electrodes. This may be due to the same fact.

## B. Dielectric Losses.

When an insulating material is exposed to an alternating electric field, so-called dielectric losses usually occur, which manifest themselves as heat evolution. These losses play an important part in insulation technique,

for instance, when a current is sent through a cable; this involves loss of electrical energy, while, moreover, the condition of the cable may be adversely affected by the generated heat.

These losses are partly due to *dielectric hysteresis* and partly to *Ohmic conduction.*

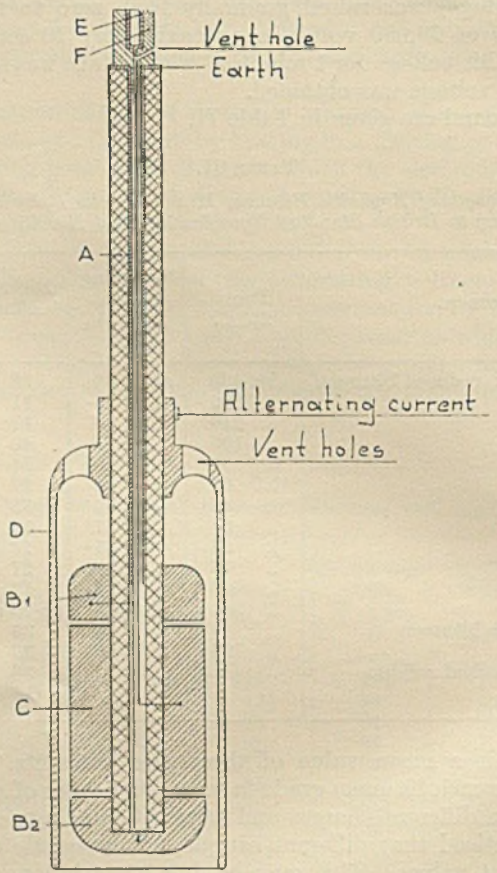


FIG. 2.

APPARATUS FOR DETERMINATION OF DIELECTRIC LOSSES, DIELECTRIC CONSTANTS AND CONDUCTIVITY OF ASPHALTIC BITUMENS.

In the case of a given material and at a definite temperature, both kinds of loss are proportional to the square of the effective voltage. Moreover, the losses caused by dielectric hysteresis increase strongly with the frequency of the alternating current.

As a measure of the losses brought about by *dielectric hysteresis* we used the tangent of the angle of dielectric loss. By the angle of dielectric loss we understand here the phase difference between the dielectric loss current and the dielectric displacement current (*i.e.*, the " wattless " current that would flow if the material were an ideal dielectric).

As a measure of the *loss due to conduction* we used the specific conductance.

The determination of the angle of dielectric loss and the dielectric constant was carried out at a 50-cycle alternating voltage, using a Schering bridge and a cylindrical condenser, which was filled with the bitumen under examination.

A sketch of the cylindrical condenser is given in Fig. 2. The inner cylinder $C$, made of polished Poldi metal, is cemented on to the porcelain tube $A$, and connected to the zero indicator (vibration galvanometer) of the Schering bridge by means of the head-piece $E$ (which is insulated from the earth by the fibre tube $F$). The potential difference between the inner cylinder $C$ and the earth is very slight (about 0·1 volt). The outer cylinder $D$ (also made of polished Poldi metal) is screwed on to a ring which is cemented into the porcelain tube, and which is connected to a supply transformer. Further, there are two guard rings, $B^1$ and $B^2$, which are earthed via the conducting inner wall of the porcelain tube, and which serve to maintain the most homogeneous field possible between the cylinders $C$ and $D$, and to prevent leakage currents from occurring along the porcelain tube.

This apparatus was placed in liquid bitumen; the air could escape through the vent holes. Next, the apparatus was cooled to the desired temperature.

In the experiments the electrical field intensity between the cylinders $C$ and $D$, which were 3 mm. apart, was about 20 kilovolt effective per cm.

These measurements yielded :

1. The angle of loss, the tangent of which indicates the relation between power-consuming current (dielectric loss current + conduction current) and the " wattless " electric displacement current;
2. The capacity of the condenser filled with bitumen (about 100 cm.). Since the capacity of the air-filled condenser is measured as well, the *dielectric constant* is found as the quotient of these two capacities.

The angle of loss thus found is not a direct measure of the losses caused by hysteresis, as the angle measured is also affected by ohmic conduction.

As that part of the angle of loss which is caused by ohmic conduction depends on the frequency in quite a different way from the part due to hysteresis, it is desirable to separate the two parts. The separation takes place so that the losses due to hysteresis are expressed by an angle (angle of dielectric loss), the ohmic losses being expressed by the specific conductance. It was necessary, therefore, to determine also the latter magnitude (this determination is described further on).

The separation was made according to the following equations :

$$\text{loss due to hysteresis} = \frac{2\pi}{9\times10^{11}} fE^2_{\text{eff.}} C \tan \delta_H \quad . \quad . \quad (1)^*$$

$$\text{loss due to conduction} = \frac{E^2_{\text{eff.}}}{R} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

* The factor $9\times10^{11}$ is used because the capacity, unlike the other magnitudes, is not expressed in technical units, but in electrostatic units. The technical unit of capacity (farad) = $9\times10^{11}$ the electrostatic unit (cm.).

where $f$ = frequency.
$E_{\text{eff.}}$ = effective potential in volts.
$C$ = capacity in cm of the bitumen-filled condenser.
$\delta_H$ = angle of loss caused by hysteresis.
$R$ = resistance in ohms.

The ohmic losses may also be expressed by an angle. If dielectric hysteresis is absent, the following equation holds :

$$\tan \delta_0 = \frac{\text{conduction current}}{\text{displacement current}} = \frac{\frac{E_{\text{eff.}}}{R} 9 \times 10^{11}}{E_{\text{eff.}} 2\pi f C} = \frac{9 \times 10^{11}}{R 2\pi f C} \quad . \quad (3) \ .$$

where $\delta_0$ = angle of loss caused by ohmic conduction.
From (2) and (3) it follows that :

$$\text{Loss due to conduction} = \frac{2\pi}{9 \times 10^{11}} f E^2_{\text{eff.}} C \tan \delta_0 \quad . \quad . \quad (4)$$

As the angle of loss is in general small, this equation also holds, approximately, when hysteresis takes place; therefore :

$$\tan \delta_{\text{tot.}} = \text{approx. } \tan \delta_H + \tan \delta_0.$$

In accordance with equations (1) and (4), the total loss is therefore :

$$= \frac{2\pi}{9 \times 10^{11}} f E^2_{\text{eff.}} C \tan \delta_{\text{tot.}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

$\delta_{\text{tot.}}$, the total angle of loss, is the angle found in our measurements. If the resistance is determined at the same time, $\tan \delta_0$ is also known (from (3)), and $\tan \delta_H$ may be calculated as follows :

$$\begin{aligned} \tan \delta_H &= \tan \delta_{\text{tot.}} - \tan \delta_0 \\ &= \tan \delta_{\text{tot.}} - \frac{9 \times 10^{11}}{R 2\pi f C} \end{aligned}$$

As the specific conductance $= \frac{1}{4\pi C_0 R}$ ($C$ = capacity of the air-filled condenser, and $C = C_0 \varepsilon$; $\epsilon$ = dielectric constant), it follows that :

$$\tan \delta_H = \tan \delta_{\text{tot.}} - \frac{18 \times 10^{11} \lambda}{f \varepsilon} \quad . \quad . \quad . \quad . \quad . \quad (6)$$

($\lambda$ = specific conductance.)

For purpose of illustration we append an example of the calculation of the tan $\delta_H$ of a Venezuelan distilled bitumen at 90° C. (No. 3 of Table III).

Measured : $\tan \delta_{\text{tot.}} = 0{\cdot}025$.
$\lambda = 5{\cdot}8\ 10^{-13} \Omega^{-1}\ \text{cm.}^{-1}$
$f = 50$
$\varepsilon = 2{\cdot}88$.

Thus, in accordance with equation (6) :

$$\tan \delta_H = 0{\cdot}025 - 0{\cdot}007 = 0{\cdot}018.$$

TABLE III.

*Angle of Loss, Dielectric Constant and Specific Conductance of Asphaltic Bitumens at Different Temperatures.*

| Asphaltic bitumen. | Temp., ° C. | Steam reduced, Venezuelan bitumen. | | | Steam reduced Mexican bitumen. | | Blown Mexican bitumen. | | | Bitumens from cracked residues. | | Light-coloured bitumen. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | 11. |
| Penetration at 25° C. (SAM 68/38) | — | 175 | 23 | 11 | 25 | 19½ | 38 | 22½ | 11 | 19 | 1½ | 15 |
| Softening point, R. & B. (SAM 67/38), ° C. | — | 39½ | 64 | 86 | 65 | 67½ | 80 | 77 | 120 | 58 | 74 | 55 |
| *Tangent of the total angle of loss × 100 (loss due to hysteresis + loss due to ohmic conduction) | 5 | 2·0 | 1·4 | 0·7 | 1·2 | 1·4 | 1·7 | 1·7 | — | 1·2 | — | 0·2 |
| | 20 | 2·1 | 1·9 | 1·4 | 1·8 | 2·0 | 1·3 | 1·9 | 1·4 | 2·3 | 1·0 | 1·5 |
| | 35 | 2·0 | 2·0 | 1·8 | 1·8 | 2·3 | 1·2 | 1·8 | 1·4 | 2·6 | 1·8 | 3·3 |
| | 50 | 2·9 | 1·9 | 1·7 | 1·7 | 2·3 | 1·5 | 1·7 | 1·3 | 2·2 | 2·1 | 2·5 |
| | 65 | ca. 9·0 | 2·1 | 1·5 | 2·2 | 2·4 | 2·3 | 1·9 | — | 2·9 | — | 1·0 |
| | 80 | — | 3·7 | 1·7 | 4·6 | 4·1 | 5·1 | 2·0 | — | 9·9 | — | 2·4 |
| | 90 | — | 7·8 | 2·5 | — | 7·2 | 8·3 | 4·5 | — | — | — | 5·6 |
| | 100 | — | — | 4·3 | — | — | — | — | — | — | — | — |
| Tangent of the angle of loss due to hysteresis × 100 (only for losses caused by dielectric hysteresis) | 5 | 2·0 | 1·4 | 0·7 | 1·2 | 1·4 | 1·7 | 1·7 | — | 1·2 | — | 0·2 |
| | 20 | 2·1 | 1·9 | 1·4 | 1·8 | 2·0 | 1·3 | 1·9 | 1·4 | 2·3 | 1·0 | 1·5 |
| | 35 | 1·9 | 2·0 | 1·8 | 1·8 | 2·3 | 1·2 | 1·8 | 1·4 | 2·6 | 1·8 | 3·3 |
| | 50 | 2·0 | 1·9 | 1·7 | 1·6 | 2·2 | 1·4 | 1·7 | 1·3 | 2·1 | 2·1 | 2·5 |
| | 65 | ca. 2·6 | 1·8 | 1·5 | 1·8 | 2·1 | 1·9 | 1·8 | — | 1·7 | — | 0·6 |
| | 80 | — | 2·0 | 1·5 | 2·5 | 2·8 | 3·1 | 2·3 | — | 2·3 | — | 0·2 |
| | 90 | — | 3·1 | 1·8 | — | 3·2 | 4·0 | 3·0 | — | — | — | 0·4 |
| | 100 | — | — | 2·3 | — | — | — | — | — | — | — | — |
| Dielectric constant | 5 | 2·66 | 2·63 | 2·62 | 2·66 | 2·72 | 2·73 | 2·74 | — | 2·92 | — | 2·60 |
| | 20 | 2·76 | 2·69 | 2·69 | 2·78 | 2·78 | 2·79 | 2·83 | 2·45 | 2·99 | 3·01 | 2·64 |
| | 35 | 2·81 | 2·76 | 2·76 | 2·86 | 2·89 | 2·82 | 2·90 | 2·49 | 3·16 | 3·09 | 2·75 |
| | 50 | 2·84 | 2·81 | 2·82 | 2·90 | 2·95 | 2·84 | 2·95 | 2·52 | 3·27 | 3·20 | 2·90 |
| | 65 | 2·87 | 2·85 | 2·86 | 2·92 | 3·00 | 2·86 | 2·97 | — | 3·30 | — | 2·91 |
| | 80 | — | 2·88 | 2·87 | 2·94 | 3·03 | 2·90 | 2·99 | — | 3·30 | — | 2·87 |
| | 90 | — | 2·90 | 2·88 | — | 3·06 | — | 3·01 | — | — | — | 2·84 |
| | 100 | — | — | 2·89 | — | — | — | — | — | — | — | — |
| Specific conductance × $10^{-13}\Omega^{-1}$ cm.$^{-1}$ | 35 | 1·1 | <0·1 | <0·1 | <0·1 | <0·1 | 0·12 | <0·1 | <0·1 | <0·1 | <0·1 | <0·1 |
| | 50 | 5 | 0·4 | <0·1 | 0·5 | 0·5 | 0·7 | 0·11 | <0·1 | 0·7 | <0·1 | 0·4 |
| | 65 | 50 | 2·6 | 0·3 | 2·9 | 2·4 | 3·6 | 0·7 | — | 11 | — | 2·9 |
| | 80 | — | 14 | 1·9 | 17 | 11 | 16 | 5·0 | — | 70 | — | 18 |
| | 90 | — | 38 | 5·8 | 50 | 34 | 35 | 13 | — | — | — | 41 |
| | 100 | — | — | 16 | — | — | — | — | — | — | — | — |

* In practice the total angle of loss is usually given; this is a disadvantage, in that the part of this angle governed by the loss due to ohmic conduction depends in quite a different way on the frequency than the part of the angle that is governed by the loss due to hysteresis.

The loss due to hysteresis, expressed in watts, may be calculated from (1); the tension $E$ is given in volts, and the capacity $C$ in cm.

Thus, if a condenser is used with a capacity of 100 cm. (with air as dielectric) and a tension of 20,000 volts is applied at a temperature of 90° C., there is, in the case of the above bitumen, a loss due to hysteresis

$$= \frac{2\pi}{9 \times 10^{11}} \times 50 \times 20{,}000^2 \times 100 \times 2{\cdot}88 \times 0{\cdot}018 \text{ watt}$$
$$= 0{\cdot}72 \text{ watt}$$

and a loss due to conduction (according to equation (2) and (4)) of 0·28 watt.

The total loss is about 1 watt. At temperatures below 70° C. none of the bitumens examined shows a higher loss (cf. Table III). When the plates are 1 cm. apart, the losses would, at a tension of 20,000 volts, even if no heat were transferred to the surroundings, increase the temperature of the bitumen by only 1½° C. per hour.

Thus, the losses are negligible if alternating voltage of low frequency is used.

The measurements further show that in the case of most of the bitumens examined the tan $\delta_H$, and therefore also the loss due to hysteresis as a function of the temperature, passes through a maximum between 20° and 40° C. At higher temperatures the losses due to hysteresis generally increase again. The ohmic losses, which may be ignored at room temperature, increase considerably with rising temperature, however; at temperatures between 70° and 100° C. (dependent on the consistency of the bitumen) the ohmic losses are already larger than the losses due to hysteresis.

At high frequencies of the alternating voltage, however, the loss due to hysteresis invariably becomes considerably larger than the ohmic loss, also at higher temperatures.

### C. Dielectric Constant.

As already said, the dielectric constant is also found when the angle of dielectric loss is measured. As the values given in Table III show, the dielectric constant increases with rising temperature, especially in the temperature range 20–50° C. This increase, which is closely connected with the maximum of the angle of loss, has no practical importance.

At the temperatures in question, the dielectric constants of the various bitumens lie between 2·5 and 3·3.

### D. Electrical Conductivity.

The conductivity was also determined by means of the apparatus sketched in Fig. 2, using direct current. From the capacity of the condenser found when the dielectric constant was measured, the cell constant of the condenser may also be deduced $\left[\text{cell constant} = \frac{1}{4\pi x \text{ capacity (in cm.)}}\right]$.

The cell constant is an apparatus constant which is equal to the product of the determined resistance and the specific conductance.

Therefore the specific conductance can be calculated from the cell constant and the resistance determined.

In the measurements the electric field strength was about 20 kv./cm.

The specific conductance (see Table III) increases considerably with rising temperature, and is generally higher the softer the bitumen; it is approximately proportional to the square of the penetration at a definite temperature.

R. N. J. Saal [4] has derived a relation between the penetration and the viscosity which can be approximated to :

$$\eta = \frac{c}{\text{pen.}^2}$$

($\eta$ = viscosity)
(pen. = penetration)

(strictly speaking, this equation applies only to bitumens which behave like purely viscous liquids); this means that the specific conductance is approximately proportional to the viscosity at a definite temperature; this is also to be expected on the strength of theoretical considerations.

For instance, in the case of bitumens harder than pen./25° C. = 40 the specific conductance at 20° C. $= < 10^{-15}$, at 50° C. $= < 7 \cdot 10^{-14}$. The softest of the bitumens examined (pen. 175) has the lowest value, viz. about $1 \cdot 6 \times 10^{-14}$ at 20° C. and $7 \times 10^{-13}$ at 50° C.

*References.*

[1] R. N. J. Saal, W. Heukelom, P. C. Blokker, "Physical Constants of Asphaltic Bitumen, I," *J. Inst. Petrol.*, 1940, **195**, 29.
[2] G. W. Nederbragt, "World Petr. Congress," Paris 1937, Vol. II, chap. II, p. 653; *Archiv. f. techn. Mess.*, 1937, V, 943.
[3] British Standard Specification for bituminous filling compounds for electrical apparatus, No. 688—1936.
[4] R. N. J. Saal, *J. Instn Petrol. Tech.*, 1933, **19**, 176; "World Petr. Congress," London, 1933, II, p. 515.

# SOME EXPERIMENTS ON SEIZURE BETWEEN LUBRICATED HARD STEEL BALLS.*

By D. Clayton, B.Sc.

Summary.

Experiments have been made to find the effect of change of the test conditions on the behaviour of lubricants in the 4-ball apparatus. In tests with a continuously increasing load, the breakdown loads for mineral and fatty oils were 40 per cent. higher than in tests at a series of constant loads, and rather more for an extreme-pressure lubricant; the wear values corresponded with those found in previous tests for the particular loads. The scatter of the results, however, prevented this method of loading being used to obtain a shorter test than the normal. Tests at half and double the normal speed showed that with increase of speed the breakdown load decreased, the time to seizure decreased, and the wear generally increased. Interrupting the seizure with a mineral oil by removing the load showed that most of the wear occurred in the early part of the seizure period; on restoring the load, even after several minutes, the friction immediately rose to its high value again. This test showed that the continuance of high friction with this type of oil was not merely due to high temperature at the contact persisting from the early part of the failure. Considerable increase of load could be made after recovery before a second seizure resulted. Finally experiments are described showing changes of seizure behaviour due to rigidity of the ball-chuck mounting, and mention is made of a change in the loading system of the apparatus.

## Introduction.

Results of an investigation into the effects of a fairly comprehensive series of lubricants on the seizure characteristics of hard steel balls have previously been published.[1-3] In this work, for which the 4-ball apparatus was used, the standard conditions were maintained throughout. Some experiments have now been made to find the effect of varying the conditions of test—*e.g.*, the speed has been varied, an increasing load test has been tried, the seizure has been interrupted, and the rigidity of the chuck mounting has been varied. This work has been carried out primarily with the ultimate aim of providing information on the phenomenon of seizure, but also for the thorough investigation of a testing apparatus which has a number of good features; in the latter connection Blok [4] has made important claims as to its advantages from the point of view of contact temperature as a criterion of failure in gearing, and as regards correlation with hypoid gear behaviour.

The apparatus and its normal mode of use have been described by Boerlage [5] and in the previous papers. Only the following brief account is therefore given. A ½-in.-diameter hard steel ball is rotated under load in the cavity between three other similar balls clamped together in a cup containing the lubricant. Tests are normally made at each of a series of loads, the speed being 1500 r.p.m. (113 ft./min., 58 cm./sec.). A friction–time chart is autographically recorded, showing the friction behaviour during seizure. The wear is represented by the mean diameter of the circular impressions worn on the three clamped balls. The Hertz line on the wear diagrams shows the elastic deformation. The breakdown load is that

* Paper received 26th October, 1939.

at which seizure first occurs in the course of the one-minute run; it is shown by the line joining the two portions of the wear–load curve.

### Tests with a Continuously Increasing Load.

In a number of extreme-pressure lubricant testing machines the load is increased either continuously or in steps during each test, and it was thought that it would be interesting to see how this method of loading affected the behaviour of lubricants in this apparatus. If consistent results were obtained, much of the information at present provided by tests at each of a series of loads would be available from a single test; thus there would be a breakdown load, which would be influenced to some extent by properties of the lubricant affecting the time to seizure in the usual tests, and the friction–time chart would show the nature of the seizure, giving the maximum coefficient of friction and the time to recovery.

Experiments were made with three oils, one of each of the main kinds available—viz., B.P. paraffin to represent the mineral oils, castor oil to represent the fatty oils, and E.P. oil D to represent the extreme-pressure lubricants of the kind containing sulphurized fatty oil. The weight-carrier on the loading-lever of the apparatus was replaced by a suitable container into which lead shot was run. Owing to a tendency for the loading-lever to bounce on starting at zero load, an initial load of 20 kg. was imposed. The shot stream was cut off as soon as seizure occurred, and the apparatus was stopped after 1 minute total running time.

Starting with a loading rate of 7 kg./sec., the results with B.P. paraffin and E.P. oil D were quite consistent, the breakdown loads being 57½–63 kg. (mean 61), and 165–177 kg. (mean 171), respectively. With castor oil, however, there was a wide scatter, most of the results lying within the range 90–110 kg., but some extending to 140 kg. The experiments were continued to find whether there was any influence due to the rate of loading, rates of 2½ and 5 kg./sec. being used. The mean loads were only a little different, but there was a rather greater scatter.

The diameters of the wear impressions due to seizure varied with the [illegible]lown loads, and corresponded with those obtained in the normal method of test for these loads. This is shown by Fig. 1, in which the mean curves from previous tests have been copied, and are seen to run through the present plotted points as nearly as the mean curves usually represent the results. This agreement would be expected to the extent that once material began to be removed from the lower balls the behaviour would be the same as in the previous tests.

Representative friction–time charts are shown in Fig. 2. The times to recovery and the maximum coefficients of friction were generally similar to those in normal tests.

Taking all the results into account, the mean breakdown loads are 60, 107, and 165 kg. for B.P. paraffin, castor oil, and E.P. oil D, respectively, compared with 43, 75, and 100 kg. by the normal method of test. The increase due to some of the time element of the normal test being expressed as load in this test, leaves the relative values for B.P. paraffin and castor oil practically unchanged, but the new value for E.P. oil D is relatively

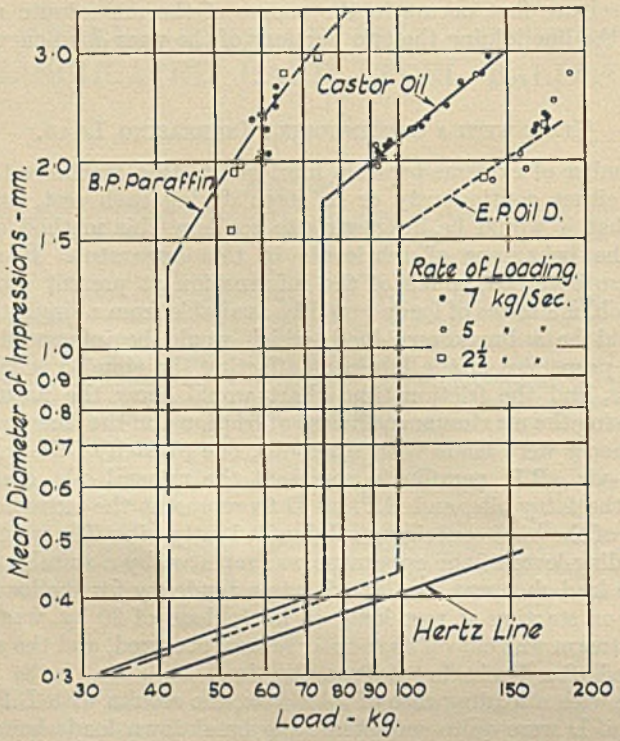


FIG. 1.

WEAR-LOAD DIAGRAM FOR INCREASING LOAD TESTS.

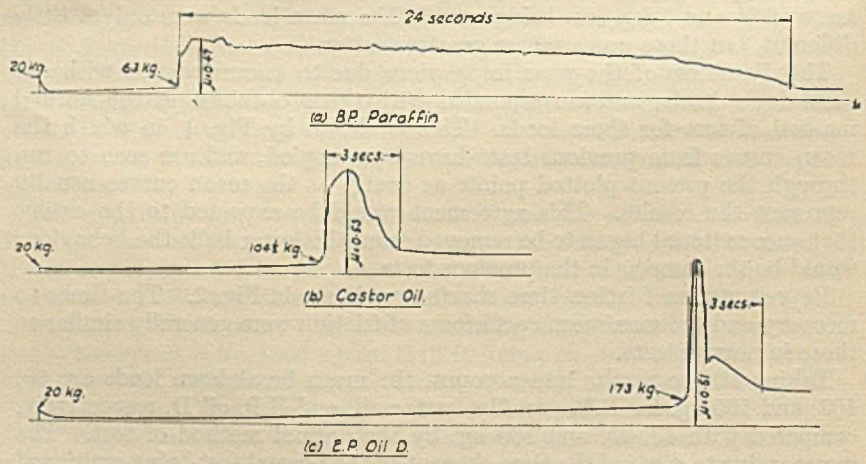


FIG. 2.

FRICTION-TIME CHARTS FOR INCREASING LOAD TESTS.

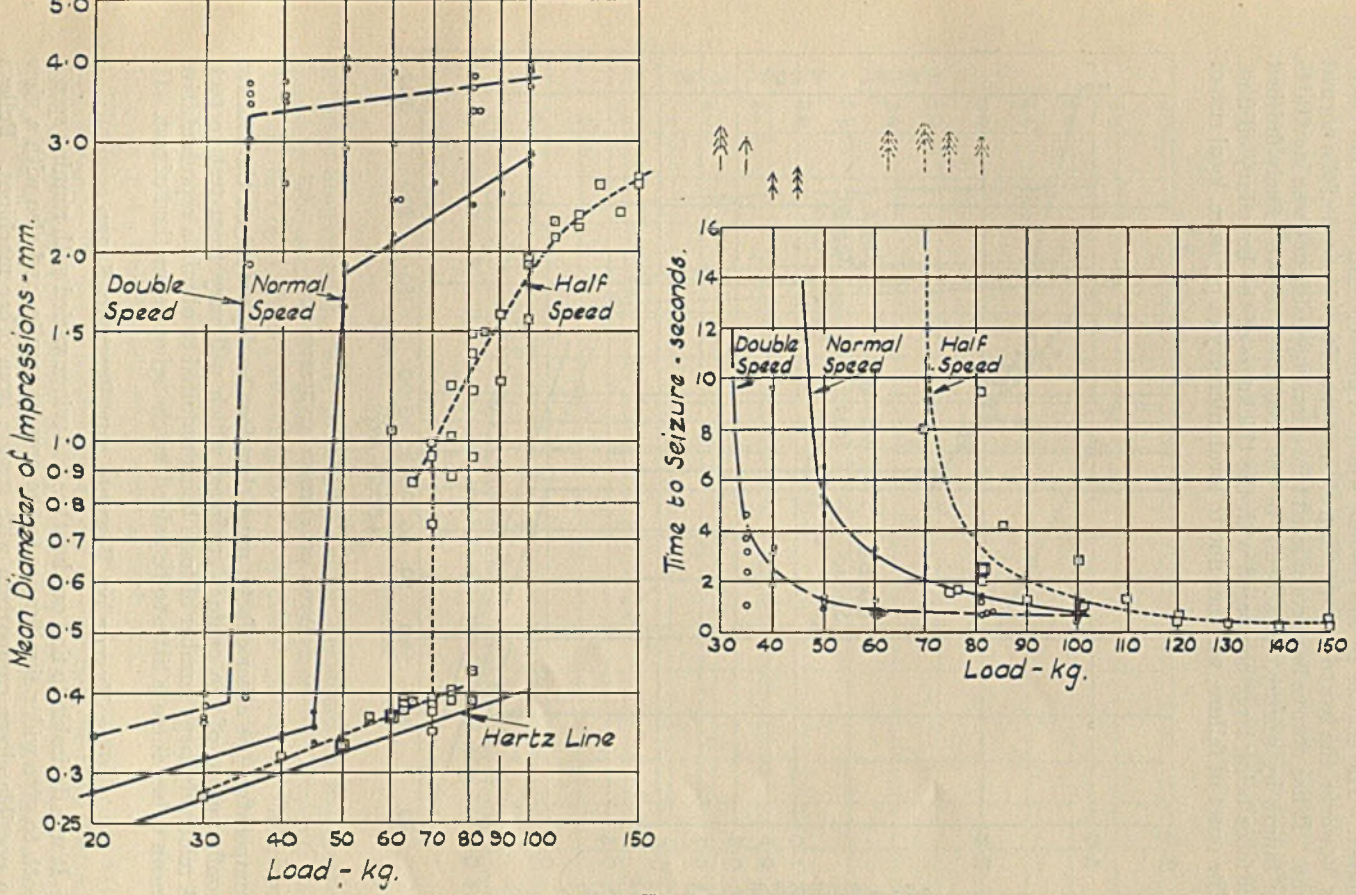


FIG. 3.

MINERAL OIL K1 : TESTS AT 3 SPEEDS.

higher. The scatter of the results, which is greater than in normal tests, is, however, the bar to the adoption of this type of test instead of the normal one. It has always been considered that some inconsistency was inevitable in failure by seizure, on account of the roughness of even finely-finished surfaces being large compared with the thickness of the boundary oil film. The onset of failure, whether due to local intensity of pressure, local rise of

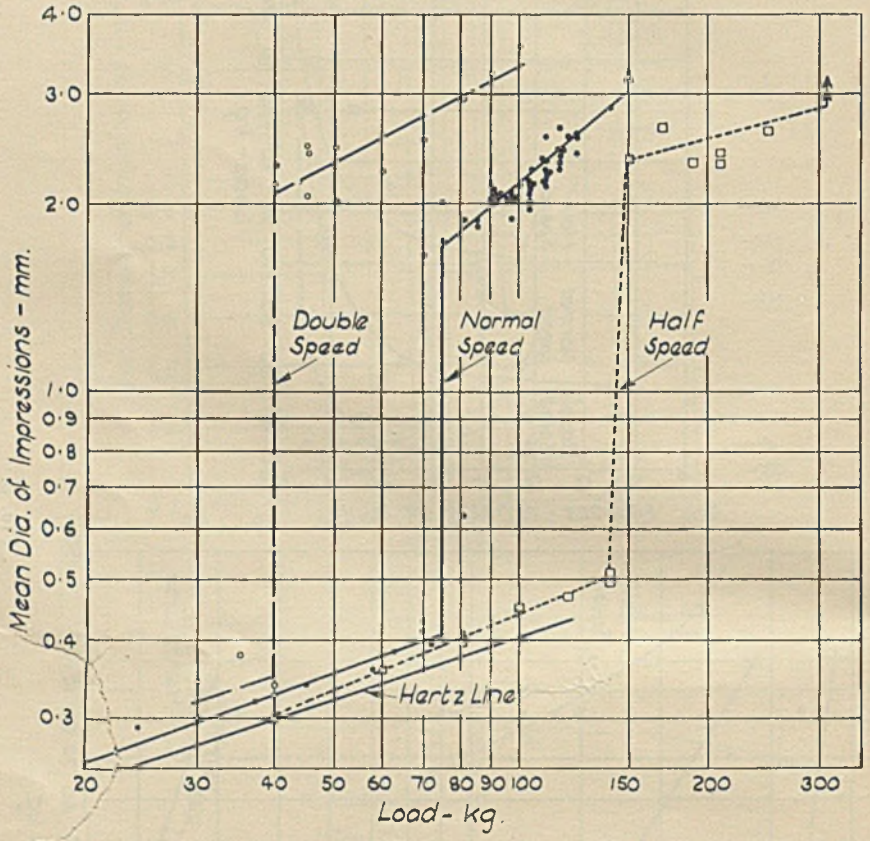


FIG. 4a.

CASTOR OIL : TESTS AT 3 SPEEDS.

temperature, or other effects, must therefore be dependent on the relative configuration of the contact surfaces, which will vary from test to test. A relatively large number of tests being required to obtain a representative mean value, there is little to be gained by changing the method of test.

## THE EFFECT OF VARYING THE RUNNING SPEED.

It was desirable to find out how the behaviour varied with running speed, both to give wider significance to the present results, and also with a view to possible closer comparison with results from other machines. Pulleys

half and twice the normal size on the motor spindle drove the top ball of the apparatus at half and twice the normal speed of 1500 r.p.m. (113 ft./min.). A thin spindle oil, K1, was chosen to represent the mineral oils, and castor oil the fatty oils; the results as regards time to seizure and wear are shown in Fig. 3 and in Figs. 4*a* and 4*b* (the scales of the latter are

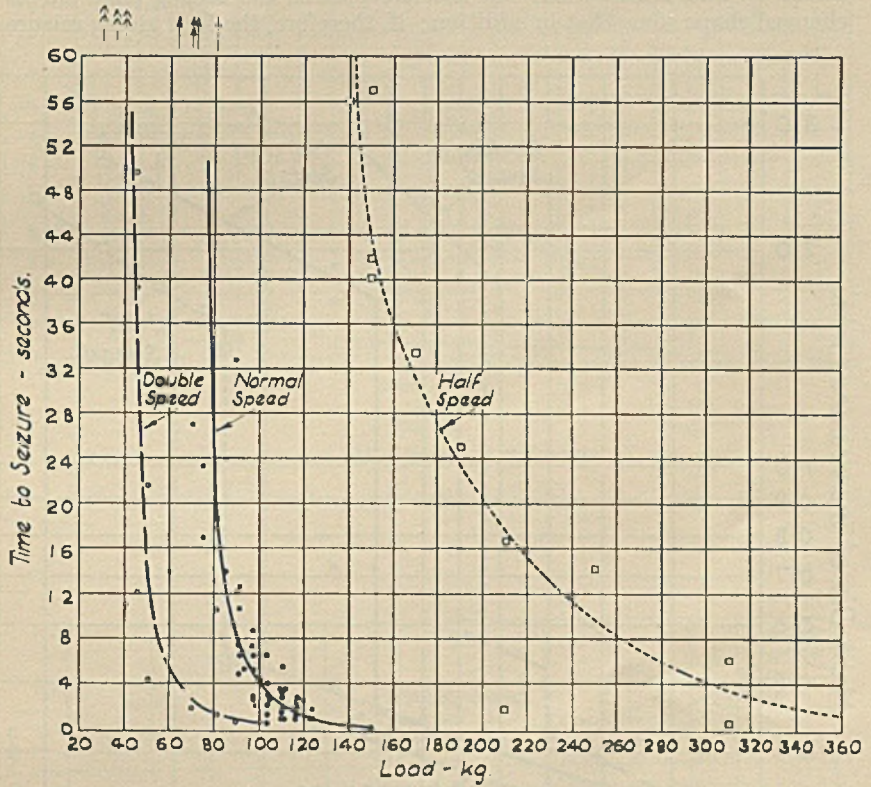


FIG. 4*b*.

CASTOR OIL: TESTS AT 3 SPEEDS.

different from normal). E.P. oil B1, Figs. 5*a* and 5*b*, represented the extreme-pressure lubricants of the kind containing a sulphurized fatty oil, and E.P. oil E, Fig. 6, those containing lead soap and sulphur. In the seizing time–load diagrams the arrows near the top indicate that in these tests there was no seizure within the 60 seconds of the test; where a number is added this shows the number of seconds to seizure, the point falling beyond the limit of the diagram. The vertical arrows in the wear–load diagrams indicate that a welding seizure occurred at that load.

The behaviour of the apparatus at double speed was generally not very satisfactory. There was a tendency to set up vibration, and the friction–time charts were very irregular and variable from test to test; consequently there was rather greater scatter of the wear results, and to some extent of the times to seizure, than at lower speeds.

For the first three lubricants increasing the speed reduced the breakdown load, decreased the time to seizure, and increased the wear. Considering that the speeds were in a geometric progression, it is apparent that the influence of decrease of speed from normal to half on breakdown load and time to seizure was disproportionately large; this was particularly so with castor oil and E.P. oil B1. In the latter cases the seizing time curves changed shape somewhat in addition; if, therefore, the load giving seizure

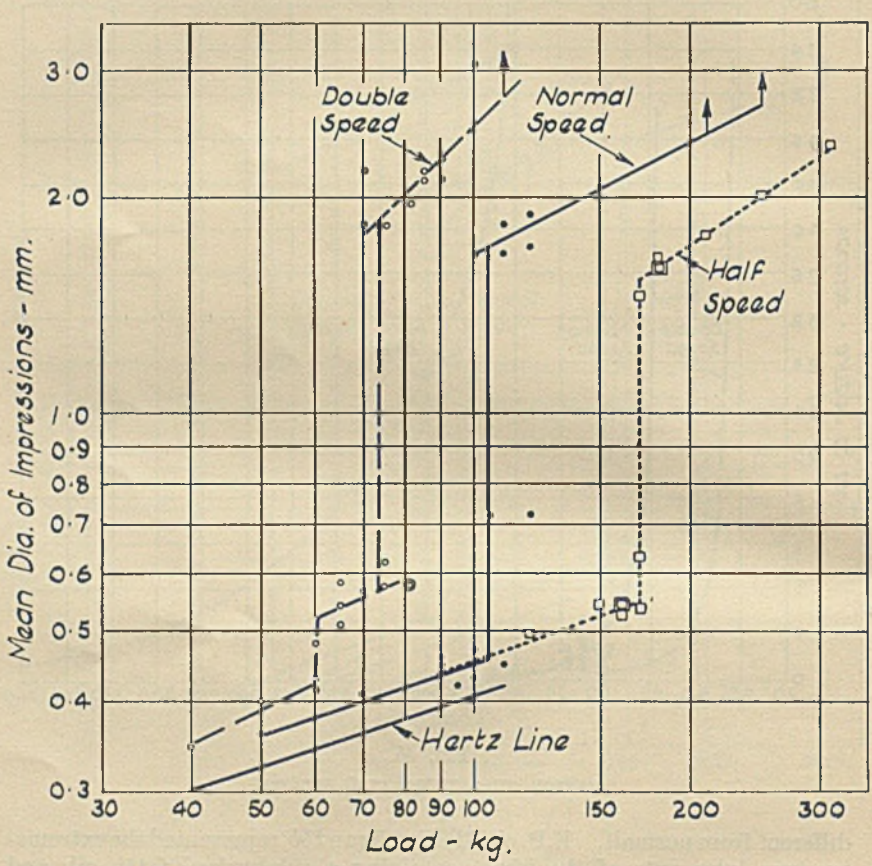


FIG. 5a.

E.P. OIL B1 : TESTS AT 3 SPEEDS.

in 2½ seconds were to be adopted as the breakdown load for gear lubrication, as suggested by Blok [4] and discussed in a previous report,[2] the value at half speed would be particularly high. The influence of decrease of speed on the wear with seizure was most marked with the mineral oil. Similarly the effect on wear without seizure was greatest with this oil, the distance from the Hertz line of the mean line for these conditions being greater with increase of speed. This was partly due to the greater linear travel in the 1 minute of the test at higher speeds, but it was probably influenced also

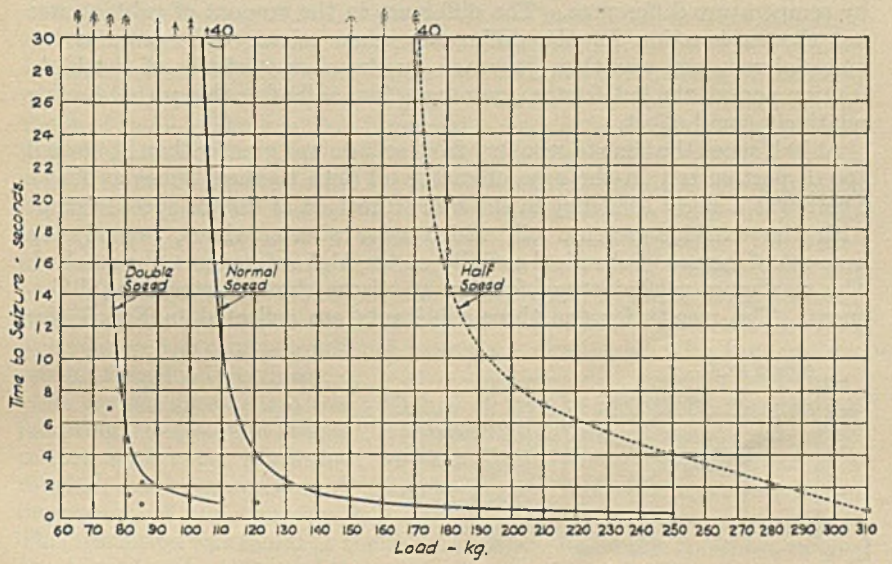


FIG. 5b.

E.P. OIL B1 : TESTS AT 3 SPEEDS.

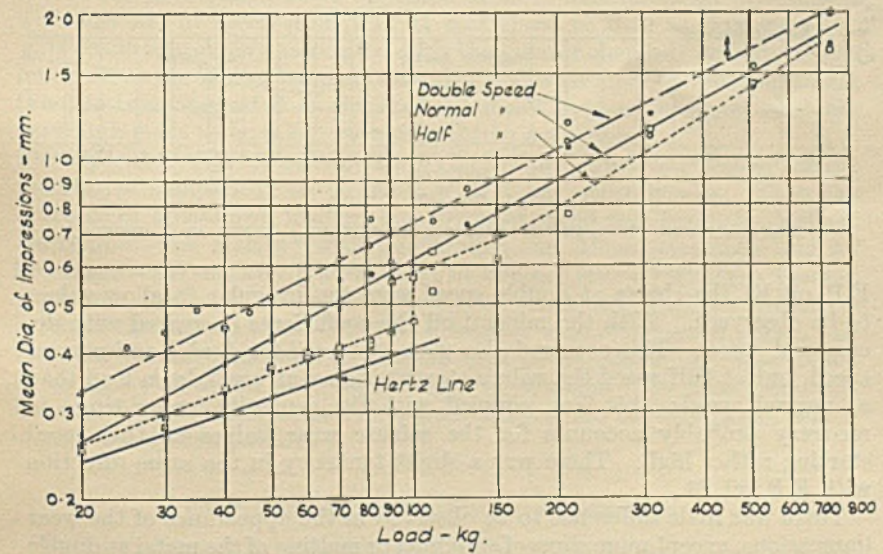


FIG. 6.

E.P. OIL E : TESTS AT 3 SPEEDS.

by temperature differences. The difference in the amount of rubbing was not the explanation for the differences when seizure did occur, as the material removed was then governed by the characteristics of the high-friction period, the low-friction running before and after this period having relatively small effect.

At half speed the time to recovery from seizure was greater than at normal speed, particularly in the case of castor oil (two to three times as long). There was a slight tendency in the same direction at double speed, except with the extreme-pressure oil, which gave shorter times, possibly on account of increased chemical activity at the higher temperatures reached. The maximum coefficients of friction at seizure showed interesting differences. The results for the three lubricants are collected in Fig. 7 (for

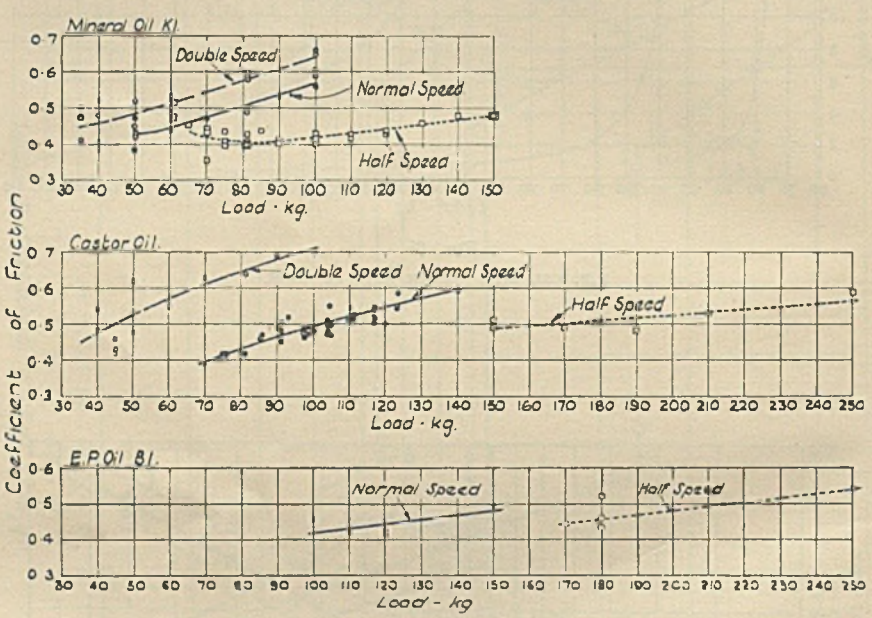


Fig. 7.

MAXIMUM COEFFICIENTS OF FRICTION AT SEIZURE : TESTS AT 3 SPEEDS.

E.P. oil B1 the charts at double speed were too irregular to allow values to be observed). With the mineral oil the coefficients decreased with decrease of speed. This occurred also with castor oil for double and normal speed, but at half speed the values started higher at breakdown load than at normal speed; this fact, coupled with the generally longer times to recovery probably accounts for the seizure wear values at this speed starting rather high. There was a slight tendency in the same direction with E.P. oil B1.

There was little difference to be observed in the appearance of the wear impressions, except more signs of softening or melting of the metal at double speed; the impressions tended to be smoother, and there were " fins " of metal at the trailing edges.

*Lead Soap–Sulphur E.P. Lubricant.*—It had been found in tests at normal speed that E.P. oil E of this type behaved differently from other lubricants.[2] Instead of breakdown at a certain load, with a sudden increase of diameter of wear impression, there was a gradual increase of wear throughout the range of loads. The wear was appreciable even at low loads, but extremely high loads could be taken without the welding seizure occurring which would be the result with other types of lubricants. A slight rise of friction occurred at moderate loads, but it never increased to a high value. The same behaviour was found in tests at half and double speeds. The wear–load diagram for all three speeds is shown in Fig. 6. There were not enough observations of time to rise of friction to enable a satisfactory diagram to be produced; as, however, this rise of friction was not like that at a seizure, the results would not have been comparable with the previous seizing time–load diagrams.

At normal speed there was a change of type of impression through the following succession of stages: (1) a smooth, flat impression, typical of no seizure with other lubricants; (2) a smooth, cupped impression; (3) a rough, scored impression of irregular shape; and (4) a scored, round impression of the type produced by seizure with ordinary lubricants. This transition was found at the other speeds. At double speed the ranges overlapped each other, and there was again no break in the curve; at half speed, however, there was a definite break at 100 kg., at the change between the first two types of impressions. The slight changes of friction were first observed in all cases when smooth wear gave place to scoring wear.

In contrast with the other lubricants, the friction–time charts at double speed were smooth with E.P. oil E. The maximum coefficients of friction were constant at each speed over the range of loads, and, though the differences were small, there appeared to be a definite trend downwards with increase of speed from 0·12 at half speed to 0·10 at double speed. This result is probably associated with the greater chemical activity of the lubricant at the higher temperatures obtained with more severe conditions; this has been suggested as the reason for this type of lubricant enabling very high loads to be taken without welding occurring.

*Comparison with Other Results.*—The results described above enable qualitative comparison to be made with a few other results. Thus the decrease of breakdown load with increase of speed was found by McKee, Harrington, and McKee [6] with the Timken and Almen machines, and by Southcombe, Wells, and Waters,[7] and by van der Minne,[8] with the Timken machine. In the third paper it was also confirmed that the difference between the fatty and mineral oils increased with decrease of speed. In both the second and third papers the wear before breakdown was shown to be high with a lead soap–sulphur type of lubricant; the same result has been found in this investigation, particularly at the highest speed, which is most nearly comparable.

## Examination of the Stages of Seizure.

In order to throw light on the mechanism of seizure and recovery, a few experiments have been made in which the normal procedure in individual tests has been varied.

*Short Running Times.*—A general trend towards higher wear had been noticed when the time to recovery was greater. Although it was apparent that the increase of diameter was not by any means proportional to the time at high friction, it was desired to check this observation more definitely; some tests were therefore made in which the load was taken off the balls soon after the rise of friction at seizure. A thin mineral spindle oil (like that K1 already referred to) was used, the machine running at its normal speed of 1500 r.p.m. In the first tests at 60 kg. the average time to recovery was 20 seconds, and the wear impressions were 1·87 mm. diameter. Taking off the load after 4 seconds of high friction, the wear impressions were 1·53 mm. diameter. This confirmed that the rate of increase of size fell with continuation of the high-friction running. The rate of change of diameter becomes smaller at higher values for the same amount of material removed, but, calculating the volumes involved, the wear was even so only doubled for a five-fold increase of time. A similar result was obtained at 90 kg. The normal time to recovery was 30 seconds, the wear impressions 2·72 mm. diameter; taking the load off after 5 seconds, the wear impressions were 2·25 mm., and the volume worn away was halved.

Comparing these results with those for castor oil, it is apparent that for periods corresponding to the times to recovery of castor oil the wear would be approximately the same, indicating a similar initial rate of wear.

*Interrupted Seizures.*—The time to recovery was in these tests characteristic of the oil. No definite explanation of the mechanism of recovery had been found, but there was apparently a re-establishment of some kind of effective lubrication. The surface of the impressions was too rough to allow a complete fluid film to be formed. Rather was it probable that, first, the increase of size of impression led to wider distribution of the points of contact, so that both by lowering the average load on each and by separation, the maximum temperature reached fell; at the same time the roughness allowed access of the oil, so that by further cooling and the formation of boundary films a balance was re-established between heat generated by friction and heat carried away by conduction and by the oil. The high-friction phase was particularly persistent in the case of the mineral oils, and yet, as had been shown, the major portion of the wear occurred in the first few seconds. This pointed to a delay on the part of the oil in performing the second function described. It seemed that information on this score would be provided by temporarily removing the load to allow flooding of the contacts by the oil, thus cooling and adequately lubricating them.

Tests were made at 60 kg. with the same mineral oil as in the previous tests. It was found that when either momentary (1–2 seconds) or long (5 minutes) intervals were allowed, the friction immediately rose again to its normal value on re-imposing the load, and approximately the same total time of high friction was completed. The time before interruption varied from 2½ to 11 seconds out of total times of 14–23 seconds. In one test there were three breaks, but in each case the friction rose again, to complete 15 seconds total time at high friction before recovery.

It is apparent, therefore, that the continuance of high friction running was not merely a question of high temperature at the contact persisting from the early part of the failure, or of the lack of opportunity for oil to

form a boundary film; the result points to it being governed critically by the surface condition, either roughness or possibly the condition of the metal.

*Load Increased after Recovery.*—Under the same conditions as before, further load was added after recovery in order to discover how stable a state was reached. No change was found for 16 and 32 kg. extra. With 40 kg. extra, further seizure was obtained on two occasions, and no seizure on another. When, however, the load was added especially carefully, no further seizure was obtained on three occasions. With 56 kg. extra there was one non-seizure and one seizure, and with 80 kg. a seizure. The increments in the load were made at about 4 seconds after recovery.

The second seizure was similar to the first one, but the coefficient of friction was higher; it was not quite as high, however, as that corresponding to normal seizure at the higher load. Recovery occurred again in the usual manner, and the final sizes of impressions were nearly the same as would have been obtained in normal seizures at the higher loads. When no further seizure occurred, the wear impressions were still within the range of values for normal seizures at 60 kg., but the average was a little higher.

It is thus apparent that the state after recovery is one of marked stability, considerable additional load being required to cause further seizure.

## Investigation of the Chuck Mounting.

At this stage, owing to failure of the chuck to hold the top ball tightly, a new chuck had to be used. It was found, however, that somewhat different results were obtained. For example, in tests of a mineral oil an unusual number of mild seizures were obtained in the neighbourhood of the breakdown load, and on a number of occasions a vibration started, causing the loading-lever to bounce. The arrangement of the chuck is shown in Fig. 8. It has a plain portion *A* which enters the driving spindle *B* of the apparatus, and is held by a taper pin *C*. It was found that with the new chuck the collar *D* was just out of contact with the end of the spindle, so that the load was coming entirely on the pin. Fitting a washer made the chuck rigid with the spindle when the pin was driven in, and resulted in behaviour which was again rather different. A number of experiments suggested that the differences were due to the elasticity of the system, leading to a series of tests in which the washer thickness was decreased in steps, giving a gradual transition from rigidity of the chuck to maximum freedom with the load coming entirely on the pin.

Fig. 9 shows the succession of time charts obtained with castor oil at 100 kg. (The charts for thicknesses 0·033–0·029 in. were similar to that for 0·035 in., except that additional kicks occurred later in the chart.) The behaviour was consistent with explanation on the following lines. The loading system being somewhat elastic and not heavily damped, there was some tendency for the balls to separate momentarily when the sudden rise of friction occurred at seizure. The hole in the portion *A* of the chuck was large and made contact only at the centre of the length of the pin, thus giving some freedom and elasticity in torsion. With no friction at the washer there was thus opportunity for the twisting movements of the chuck to combine with the freedom of the loading system to give fluctu-

ating contact loads at the balls, and thus a ragged chart. Thicker washers, however, introduced friction at the collar $D$ to resist and damp twisting of the chuck; the breaks in the charts therefore occurred at higher friction loads, and there was less tendency to maintain movements of the loading system. A completely smooth chart was eventually obtained, but still

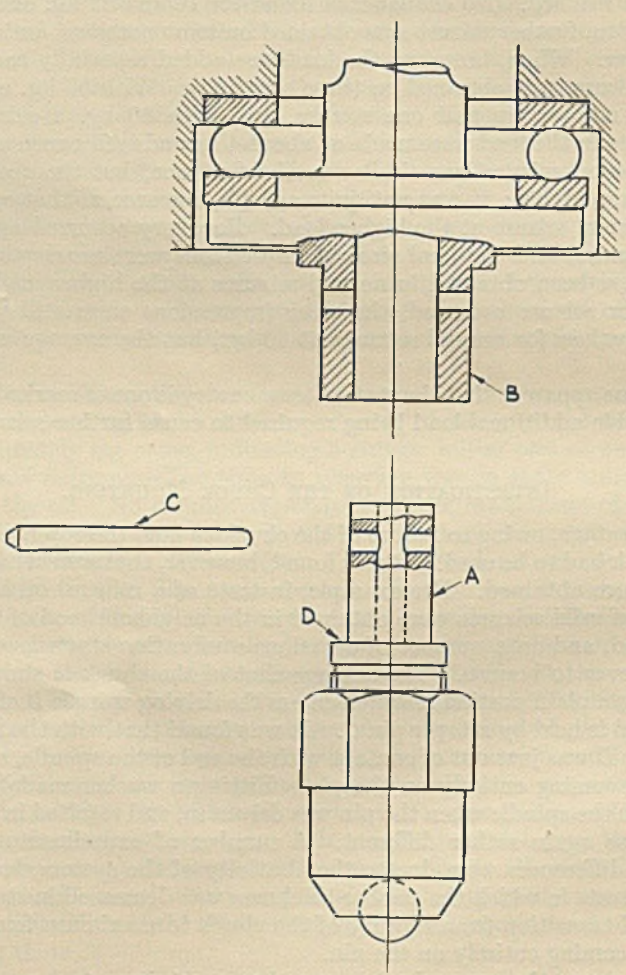


FIG. 8.
BALL CHUCK MOUNTING.

thicker washers made the chuck rigid, and movement could then only occur in the loading system; at this particular load the relief thus obtained was sufficient to prevent the seizure proceeding, the wear impressions being therefore small, 0·7 mm. diameter, compared with 2·1 mm. for normal seizure. At smaller washer thicknesses the wear remained constant, showing that the breaks in the charts did not affect the wear, or that the longer time to recovery compensated for any such effect.

These results were confirmed by modifications to the old chuck and also by experiments with the new chuck in which a new hole was drilled and taper-reamered to fit the pin.

The washer thickness giving behaviour like that with the old chuck was 0·027–0·026 in. This old chuck had been used for all the work previously carried out, and the results so far published are thus all comparable. It seemed desirable, however, to obtain results with the rigid chuck, this being the condition most easily established with certainty. The times to seizure with the mineral spindle oil K1 and castor oil were consistent, and agreed closely with those previously obtained, but the wear curves were

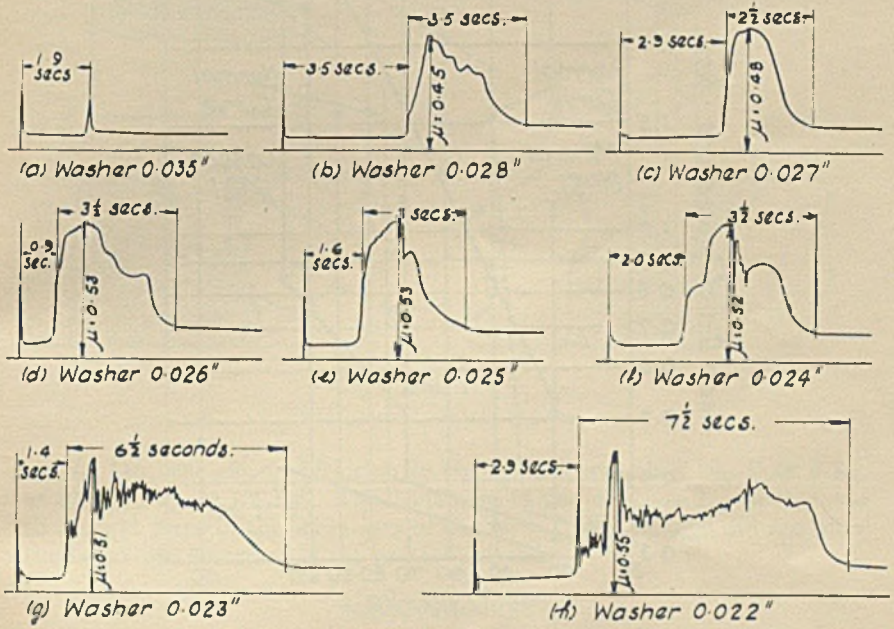


FIG. 9.

EFFECT OF WASHER THICKNESS, CASTOR OIL. 100 KG.

different. Fig. 10 shows that instead of a sudden change at the breakdown load to consistent seizures, mild seizures were first obtained. They began at a slightly lower load, and, in the case of the mineral oil, gradually increased in severity with increase of load. With the fatty oil mild seizures were obtained over a range of loads, and then there was a sudden change to more normal ones. The charts for the high loads were in each case rather more broken than in the usual tests, and for castor oil the maximum coefficient of friction averaged 0·65, an unusually high value. For the mineral oil the coefficient was generally 0·25, but at the highest loads parts of the charts reached the higher values usually found.

Somewhat similar curves to this for castor oil were obtained by van Dijck and Blok [9] and van der Minne [8] for fatty oils in this apparatus. It is probable, therefore, that the chucks which they used were more rigid than those used for the previous tests in this case.

Although the effects of differences of rigidity are not perhaps very serious in this case, in that the times to seizure are unaltered and the relative order of the oils is unaffected, these experiments show that the elasticity of the system has an appreciable effect on the behaviour, and it may be that this factor is one contributing to differences of behaviour in different testing machines. If tests are made under a single set of conditions without a

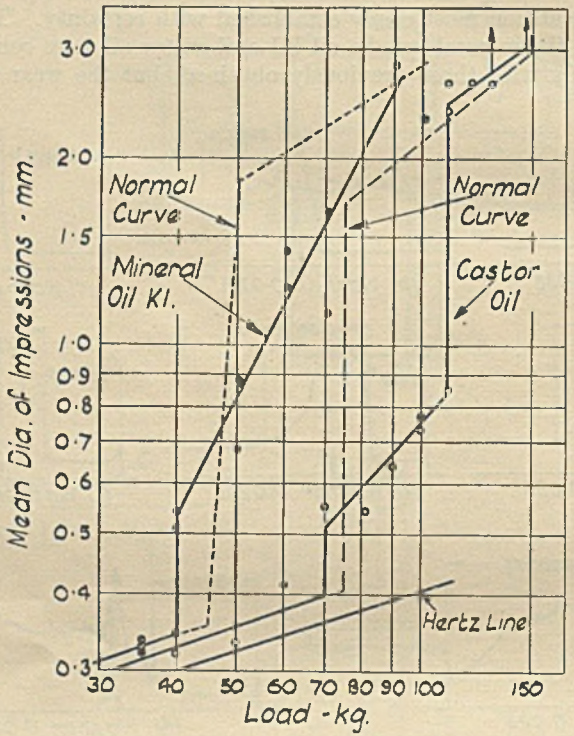


Fig. 10.

TESTS WITH THE CHUCK RIGID.

complete exploration, it is apparent that unusual differences could be found. Baxter, Snow, and Pierce [10] have described how change of the operating conditions of a Timken machine altered the type of seizure obtained, in particular the occurrence of a seizure of the type described above as mild. The behaviour in vehicle back-axles and other practical mechanisms would doubtless be affected similarly.

### Change in Detail of Loading System.

Brief mention may be made here of a change made in the loading system. When preliminary work with this apparatus had shown that an extended programme of tests might usefully be undertaken, the loading system was checked for accuracy. It was then found that there was a relatively large friction force at the top face of the mushroom-shaped piece *A*, Fig. 11*a*,

which transmitted the load from the lever to the column under the ball-cup. As the loading-lever was lowered this face had to slide a little along the under-face of the buffer *B*, and the friction force acting above the level of the fulcrum reduced the operating load by 5 kg. or more at 40 kg. loading. The mushroom was therefore replaced by a conical-ended strut, as shown

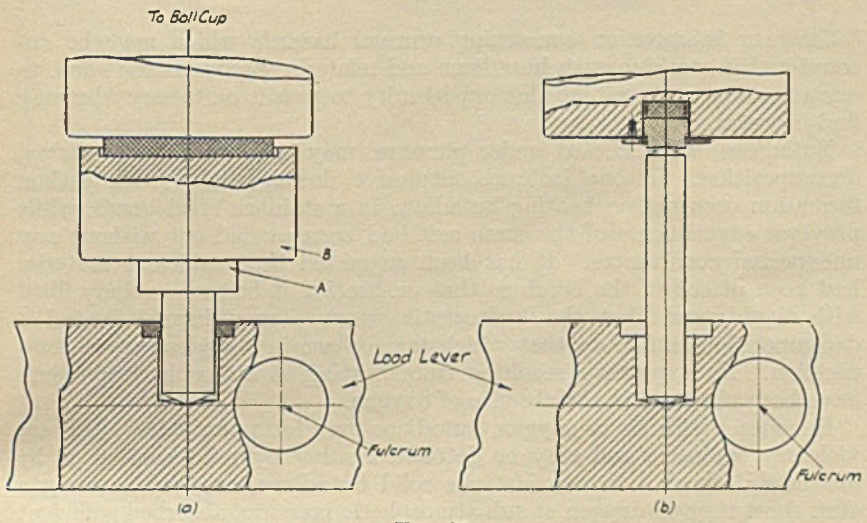


FIG. 11.

DETAILS OF LOADING SYSTEM.

in Fig. 11*b*; the effect of friction in the system was then less than ½ kg. at 40 kg., 1 kg. at 100 kg. The loads were 1½ per cent. small, probably due to a slight error in the short arm of the lever. This change did not alter the behaviour described in the previous section.

ACKNOWLEDGMENT.

This work has been carried out as part of a general programme of research in lubrication in the Engineering Department of the National Physical Laboratory, and the author is indebted to the Director for permission to publish this paper. Acknowledgment is also made of the assistance of Messrs. M. J. Wilkie, B.Sc., and B. W. J. Greig in carrying out the tests.

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# HAZARDS ASSOCIATED WITH BUTADIENE AND ITS PEROXIDES.*

By D. A. Scott.†

Certain information concerning unusual hazards which may be encountered in working with butadiene and related compounds has come to our attention, and we take this opportunity to pass it on to any who may find it useful.

Butadiene, when heated under pressure, may undergo violent thermal decomposition. In one instance, explosive decomposition with carbon formation occurred on heating butadiene in a stainless steel bomb, while previous experiments of the same sort had been carried out without any unexpected occurrences. It has been suggested that sufficient material had been placed in the bomb so that on heating it became entirely filled with liquid, and that the hydrostatic pressure may have initiated a decomposition similar to that which takes place in acetylene upon compression. No explosions resulting from heating at atmospheric pressure have been observed in the absence of oxygen.

In contact with air or oxygen, butadiene may form peroxides which are violently explosive and may be detonated either by mild heating or by mechanical shock. In one instance solid butadiene, exposed for only a very short time to oxygen at sub-atmospheric pressure, absorbed sufficient oxygen so that on warming slightly above the melting point a violent detonation occurred. It is suspected that the behaviour of butadiene in this respect is influenced strongly by the accidental presence of oxidation catalysts or inhibitors. The addition of an inhibitor to butadiene which is to be distilled or allowed to stand, even at very low temperatures, in contact with air or oxygen would help to avoid an accidental explosion.

After emptying a storage tank of crude butadiene some polymer was found in the bottom of the tank. The polymer contained 0·095 equivalents of peroxide oxygen per 100 gm., and could be detonated easily by a hammer blow. The polymer containing the oxygen compounds was insoluble in the butadiene, and the butadiene itself contained only a trace of peroxides. The peroxides were probably formed by reaction between butadiene and air. Subsequent investigation showed that the peroxide could be destroyed safely by treatment with strong caustic soda (48° Be; 47 per cent. NaOH). Thus butadiene might be conveniently freed of peroxides by storage over caustic or by passage through a caustic wash.

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† Shell Development Company, Emeryville, California.

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## Geology and Development.

**697.* Devonian Development Forces Illinois Production Upwards.** H. F. Simons. *Oil Gas J.*, 8.2.40, **38** (39), 16–17.—In the Salem field a 7380-brl. and a 10,000-brl. producer have been completed. These wells are high on the Devonian structure, which apparently follows closely the structure of the overlying Chester and McClosky. Twenty-five Devonian wells have now been drilled at Salem. The average depth of the top of the Devonian lime is 3342 ft., with the pay section 52 ft. lower. The thickness of the pay averages 46 ft. All wells are acid treated. The gas–oil ratio is high, and pressures of 1000 lb./in.$^2$ have been recorded.

The McClosky lime production has declined sharply during the past year, and new completions give only about one-tenth of the output of the early ones, due to loss of pressure. The Devonian wells decline rapidly. Wells are also completed in the Benoist or Aux Vases, or in both. G. D. H.

**698.* Widespread Activity is Planned in Ellinwood District in 1940.** D. Dalrymple. *Oil Gas J.*, 8.2.40, **38** (39), 18, 19, 24.—The Isern pool was opened in 1930 6 ml. southeast of Ellinwood town. Then came Steckel, which combined with Isern to become Silica. This pool extended westwards, and other pools were opened in the Ellinwood district—Ellinwood and Peter. The three pools became one in 1939, on the completion of producing wells in the intermediate areas, and the total productive area was then 21,480 acres. Production is from the Arbuckle lime.

In 1939 two new pools—Marchand and West Marchand—were discovered in the Ellinwood district.

The potentials and allowables for the Ellinwood district are given.

Many dry holes have been drilled in the Ellinwood district, but they are often surrounded by producers. The pay sands are 3200–3350 ft. deep, with the initial well

potentials ranging from 100 to as much as 4000 brl. Drilling conditions are generally favourable. Water disposal is a problem. G. D. H.

**699.* Mississippi Soon to Have Thirty-Seven Wildcat Tests.** G. Weber. *Oil Gas J.*, 15.2.40, **38** (40), 20–21.—At the time of the discovery of Tinsley 3,500,000 acres were leased in Mississippi, but the figure has now been doubled. 2,000,000 acres have been leased in Alabama. Seventy geophysical crews have been at work.

The eighteen Tinsley wells give 5091 brl./day, their potential being 22,500 brl./day. Artificial lift will soon be required in several of the low-pressure wells. Faulting and the lenticular character of the producing zone hamper correlation, so that very little is known of the form of the Tinsley structure. There may be several sand bodies.

A show of oil and gas has been found in a recent well in the old Amory gas-field of North-east Mississippi.

In the vicinity of Tinsley are numerous wildcats. A map shows the location of the current and proposed wildcats throughout Mississippi. G. D. H.

**700.* Storms Field is Extended in South-eastern Illinois.** H. F. Simons. *Oil Gas J.*, 15.2.40, **38** (40), 31–32.—Eight new fields have been discovered in White County in eight months. Of these Storm is the most interesting, with nineteen oil wells, four gas wells, and four dry holes. The average initial yield of the oil wells is 288 brl./day and 16,000,000 cu. ft. of gas. The gas wells average 7,000,000 cu. ft./day. The discovery well was a gasser. Oil comes from the Waltersburg sand in the upper part of the Chester series at an average depth of 2247–2268 ft. The oil sand varies in thickness, but averages 20 ft. Gas occurs in the upper part of the Waltersburg, and control is difficult in some wells owing to the common absence of a shale between the gas and oil sections. The field has recently been extended ½ ml. south, making the dimensions 2½ ml. from north to south and over 1 ml. from east to west. The crude oil has a high salt content, which has reduced its value.

The Waltersburg is near the top of the Chester series, and eight other Chester horizons are known to be productive below it. The Lower Mississippian and the Devonian are prospective oil sources. Some of the Chester sands have had good yields elsewhere.

The discovery well showed oil in the Tar Springs and the Waltersburg. Some of the wells have reached the McClosky and given water.

Drilling and casing details are given. The pressure is nearly 1000 lb./in.², and the daily production is now about 2000 brl. G. D. H.

**701.* Illinois Production Tops 400,000 Brl.** H. F. Simons. *Oil Gas J.*, 22.2.40, **38** (41), 37, 54.—The daily production of Illinois now averages over 400,000 brl., for there has been an increase of 9750 brl./day at Louden and 12,000 brl./day at Salem. The rapid rise was due to the race to obtain heavy flush production from the Devonian lime. Pipe-line congestion has affected some areas adversely.

Fifty-one wells had been completed to the Devonian lime of the Salem pool between December and 15th February, with a total initial potential of 233,983 brl. Salem production has risen from 185,000 brl./day in the last week of December to 249,000 brl./day.

Development in the Devonian at Centralia is raising production, but the horizon is thinner than at Salem. The Sandoval Devonian pool is almost drilled out, but the Bartelso Devonian is still being exploited. Numerous wildcats are seeking the Devonian. G. D. H.

**702.* Mexico—Crude Production and Export Data.** Anon. *Oil Gas J.*, 22.2.40, **38** (41), 56–57.—In 1939 Mexico's oil production was 42,479,000 brl. Poza Rica, with 2% of the producing wells, gave 61% of the total oil; the Northern district, with 51% of the wells, gave 13%; the Southern district, with 23% of the wells, gave 11%, and the Isthmus area, with 18% of the wells, gave 15%. Twenty-four wells were completed in 1939, and all except the dry hole at Maguey were in proven territory. The Northern area had three producers and five failures. Five producers and two failures were completed at Poza Rica, and six producers and two failures on the Isthmus. The Maguey well, which went to 8076 ft., had a good show of light oil at 3850 ft.

A deep test is being drilled on the La Presa anticline near Mier, and a well is being drilled for gas production on the adjacent La Lajitas structure.

Exports to Germany were a third of the total exports in 1939.

Tables are given of the exports, export and production taxes, and of the refinery throughputs. G. D. H.

**703.* Alberta Prepared to Greatly Expand Oil Operations.** J. L. Irwin. *Oil Gas J.*, 29.2.40, **38** (42), 26–27.—In 1939 Alberta's oil production was 7,594,441 brl., an increase of 852,372 brl. over 1938. At the end of the year ninety-three wells were producing from the crude-oil zone at Turner Valley against sixty-four at the end of 1938. Proration prevented the production rising more nearly in proportion to the increase in the number of wells. The crude-oil zone at Turner Valley is now known to be 17 ml. long and 1 ml. wide. 90% of the wells are in the southern 5 ml.

In the Vermillion–Lloydminster field oil is obtained from depths of 1400–2000 ft. The Steveville area is attracting attention, for gas wells have already been completed. During 1939 the following areas were under development: Brazeau, Clearwater, Grease Creek, Kootenay Dome, Moose Dome, Sheppard Creek, Waite Valley, Whiskey Creek, Pouce Coupe, Wainwright, Cardston, Del Bonita, Spring Coulee, and Taber.

Tables give data about Alberta's oil production and about the individual fields. G. D. H.

**704.* East Texas Pettit Oil Discovery Result of Long Search.** D. H. Stormont. *Oil Gas J.*, 29.2.40, **38** (42), 31, 32, 39.—Since the discovery of distillate production in the Lower Trinity series at Cayuga, the search for oil in this horizon has been intensive. In February, Campbell No. 1 at Chapel Hill gave 225 brl. of oil/day from 8036–8058 ft. The gas–oil ratio was substantially higher than at Shreveport and Lisbon, Louisiana, which are also Pettit fields, although by no means outstanding. 4 ml. south of No. 1 Campbell, and on the south flank of a deep-seated structure, a well has reached 7958 ft., and is south of a well which found distillate production in the Glen Rose. The Paluxy also has shown distillate production.

The original distillate producer at Chapel Hill was high on the structure. Gas produced here would be valuable in the East Texas field 8 ml. to the east. Geophysical surveys have indicated a possible producing area of 12,000–14,000 acres. Gas accumulation at Chapel Hill is probably due in part at least to a stratigraphic trap.

Late in 1939 gas production was opened in the Pettit oolitic lime zone near Groesbeck on a secondary fault zone east of the Mexia fault plane. This also gives distillate production.

At Opelika oil production is obtained from a stray lime in the anhydrite zones in the Middle Glen Rose, and distillate from the Lower Glen Rose. Three deep tests gave two dry holes and a distillate producer.

A table gives the geological markers from the top of the Comanchean to the Lower Trinity. G. D. H.

**705.* Sizeable Boom in Progress in Centralia's Townsite Field.** H. F. Simons. *Oil Gas J.*, 7.3.40, **38** (43), 18, 19.—More than twelve wells have been completed in the Devonian lime, and many others are under way at Centralia. Up to the present all the new wells have been located in Section 13-1n-1w, Clinton County, but it is evident that the pay zone will cover practically the whole structure, although the production limits will probably not be as great as the Benoist sand pay area, due to sharpening of the structure with depth, and indications that the lime will not be productive as far down dip as the Benoist. The discovery well, an old Benoist well deepened, topped the Devonian at 2863 ft. The pay was encountered from 2903 to 2911 ft., and from 2911 to 2933 ft. However, the latter had a high water content.

The structure is quite regular, although there is considerable variation in porosity and permeability. The average initial production is 500 brl./day, with limits of 250 to 1015 brl. Nearly all the wells make some water (up to 6%). Acid treatment has been applied.

Two attempts have been made to develop McClosky production. Slight shows were found in both, but tests gave considerable water and no free oil.

Drilling details and costs are given. G. D. H.

**706.* West Texas Wildcatters Exploit Holt Horizon.** R. M. Sanford. *Oil Gas J.*, 7.3.40, **38** (43), 23, 24.—Four wells have succeeded in semi-proving 3500 acres in the Holt horizon along the north-west edge of the North Cowden field. This lies at 5200

ft., 1000 ft. below the regular pay level of the Ector County fields. The discovery well gave 217 brl./day. The structure is believed to be a fold closely following the form of the overlying Middle and Upper Permian beds. Most of the Ector County production is from the Double Mountain series of the Middle Permian. The Holt horizon is a lime member of the Clear Fork series (Lower Permian). Some of the small Double Mountain wells of North Cowden are to be deepened to the Holt.

The saturated thickness of the Holt is 30 ft., and its permeability is low. Acid treatment is highly beneficial. A wildcat north of the Sand Hills field and 40 ml. south of North Cowden has given Holt production at 3635 ft.

Six new deep lime tests are proposed in North Ector County. The results of various wildcats in this region are described. G. D. H.

**707.* Dry Holes Limit Music Mountain Pool.** J. P. O'Donnell. *Oil Gas J.*, 7.3.40, **38** (43), 17, 99.—The south-western limits of the Music Mountain pool, just outside the recognized limits of the Bradford field, have now been defined. This pool has fifty-eight flowing wells, twenty-four pumpers, and nine gas wells, producing from a formation discovered in 1937, but developed principally in 1939. The best well is said to have given 600 brl. of oil/hour, and the best gasser 15,000,000 cu. ft./day. The area of the pool seems to be 530 acres, its length 3·7 ml., and its breadth less than 1500 ft. The reserves are estimated at 3,000,000 brl. The maximum production has been 7500 brl. of oil/day. The formation pressure was originally 550–650 lb./in.$^2$. Gas injection is now being applied.

It is not known if the sand body is continuous from north to south, on account of an undrilled central area. The pool is regarded as a stratigraphic trap in a shore-line sand. The sand, known as the Sliverville, is coarse and poorly cemented. Its thickness is very variable. Normally oil is encountered within 10 ft. of the top of the sand, but there may be substantial gas pays above the oil.

The Sliverville lies about 250 ft. above the top of the Bradford Third sand, from which other wells in this area produce.

The oil is heavily paraffinic. G. D. H.

**708.* Shell to Continue Monte Oscuro Exploration.** Anon. *Oil Wkly*, 11.3.40, **97** (1), 56.—A second well is to be drilled on the Monte Oscuro structure to attempt to produce from a 2500-ft. sand, cased off in Monte Oscuro 1, which was abandoned at 9150 ft. Unconfirmed reports say that it made salt water.

Cerro Monte Oscuro is a 17-ml.-long ridge running almost north–south, and lying some 8 ml. east of the Magdalena River and north-east of Nare. It is an asymmetrical anticline which plunges southwards, possibly to a saddle at the Baul River.

G. D. H.

**709.* Saudi Arabia Major Factor in Eastern Hemisphere.** Anon. *Oil Wkly*, 18.3.40, **97** (2), 56–60.—Commercial production has been developed on the Damman dome and also in Kuwait. Only two wells have been failures out of sixty-seven on Bahrein island, which is estimated to have reserves of 150,000,000 brl. The Damman reserve is put at 300,000,000 brl. The Damman production is piped to Ras Tanura, and recent developments have been confined to the 4300-ft. zone.

Seismic and gravity work is being carried out in Saudi Arabia in addition to geological work and structure drilling. The Abu Hadriya well failed to give anything of commercial importance down to 8655 ft. A second test is being made 120 ml. west of Damman, and on the Qatar peninsula a well has logged commercial showings of oil and gas. Favourable results have been obtained on the Burghan structure. G. D. H.

**710.* Argentina's Newest Strike Promises to Rival Famous Comodora Rivadavia.** Anon. *Oil Wkly*, 18.3.40, **97** (2), 70–74.—At Tupungato a well was completed with a production of 500 brl. of oil/hr. from a thick Cretaceous sand. The first well found 1000 brl. of oil/day at 1796 m. The reservoir zones are about 252 m. thick. Little is known about the subsurface characteristics of the Tupungato pool.

32 km. north-east of Tupungato at Lunlunta a 240-brl. well was brought in at 2253 m. An area of 400 acres has been proved at Rio Pescado.

Argentina's 1939 production of 2,959,168 cu. m. of oil was 9% higher than in 1938,

320 wells were completed in 1939 against 304 in 1938, the bulk being at Comodora Rivadavia. Gas injection is being applied in three of the country's four main producing districts. G. D. H.

**711.* Venezuela to Maintain Important Rank.** Anon. *Oil Wkly*, 18.3.40, **97** (2), 84–90.—In 1939 the Venezuelan production rose 9% to 207,952,076 brl., but it will probably fall in 1940, although not due to lack of productive capacity. Completions in 1939 were 415, as compared with 521 in 1938, and 166 were outside the Maracaibo area.

At El Roble the first well was completed at 800 brl./day with eight oil-sands between 8200 and 9600 ft. Other wells have been drilled at El Roble. At Oficina the average initial production per well is 2000 brl., whilst at Jusepin it is 750 brl. from about 4900 ft. Encouraging results have been obtained in wells in the State of Guarico. G. D. H.

**712.* Monte Oscuro will Highlight Colombian Developments.** Anon. *Oil Wkly*, 18.3.40, **97** (2), 93–95.—An attempt is to be made to establish commercial production from a sand cased off at 2500 ft. in Monte Oscuro 1, which was taken to 9150 ft. The structure is an asymmetrical anticline.

Narino 1 was abandoned in the Oligocene at 6516 ft., owing to mechanical troubles, whilst Peralonza 1 was fishing at 9274 ft. Zambito 1 was completed as a water well at 728 m.

Forty wells were completed on the north dome at Petrolea and one producer at Carbonera. One hundred wells were completed at La Cira in 1939, with an average initial production of 528 brl./day. The Infantas field seems to be drilled up.

Colombia gave 23,774,159 brl. of oil in 1939. G. D. H.

**713.* Leasing Indicates Increase in Peruvian Wildcatting.** Anon. *Oil Wkly*, 18.3.40, **97** (2), 96–98.—Wildcatting in the Northern National Reserve and deep testing in the adjacent Zorritos field in 1939 gave poor results. In the Pirin National Reserve adjoining Lake Titicaca one well was abandoned and one gave oil and water.

The Aguas Calientes structure east of the Andes is 15 ml. long and 7½ ml. wide, with dips of 20°. The closure is 3600 ft. and the closed area 50,000 acres. The first producing well gave 750 brl. of oil/day at a depth of 1174 ft., and oil is generally at 1020–1250 ft., probably in the Lower Cretaceous, although some have suggested the Jurassic or the Permian. The field is under water drive. There is as yet no outlet for this oil.

Peru produced 13,496,880 brl. of oil in 1939, 40,000 brl. being from Zorritos, 2,650,000 brl. from Lobitos and 10,806,880 brl. from La Brea-Parinas. In the La Brea-Parinas area a deep well has had an initial output of 1500 brl./day from a sand at 4500 ft.

Most of the drilling was rotary. G. D. H.

**714.* Ecuador may Record New High Production in 1940.** Anon. *Oil Wkly*, 18.3.40, **97** (2), 98.—Ecuador produced 2,260,000 brl. of oil in 1939. The bright spots of 1940 will probably be the continuation of the exploitation of the new crevice production from sands at depths of about 3800 ft., north-east of the Ancon peninsula production. This may be correlatable with the deeper horizons at Santa Elena.

Two unsuccessful wells have been sunk on the San Gabriel concession east of Ancon. G. D. H.

**715.* More Testing Needed to Prove Colombian Reserves.** F. Mendoza and B. Alvarado. *Oil Wkly*, 18.3.40, **97** (2), 103–124.—The history of the early Colombian oil search and development is given briefly. In particular the question of concessions is described. An account is given of the areas held by the various companies, some of their general activities, refining, and transportation.

The bulk of the crude oil produced from Infantas and La Cira is transported by pipeline over 335 ml. to Cartagena. In both these fields the main production is from an Upper Eocene sand, although some oil comes from the Oligocene. The average depth of the main sand is 3200 ft. Infantas is a faulted north–south anticline with the west flank only oil-bearing. La Cira is a gentle north–south arch. The emulsified crude requires dehydration. Gas is stripped and then used for repressuring.

The Cretaceous, which is predominant in the Eastern Cordillera, is productive in the

Barco concession, whilst the petroliferous Tertiary occupies the middle portion of the Magdalena valley. Oil seeps and mud volcanoes are found on the Atlantic coastal plains, but so far drilling in those regions has not been successful. Wells are to be drilled in the Eastern Plains, and there are various other regions with oil possibilities.
G. D. H.

**716.* Late Prospecting Brightens Outlook for Palæozoic Oil in Western Europe.** W. A. J. M. Van Waterschoot van der Gracht. *Oil Wkly*, 18.3.40, **97** (2), 126–129.—The foreland of the late Palæozoic Variscan mountains has been considered as possible oil territory. In some respects it resembles the Appalachian belt. However, the Coal Measure rocks in Europe are to some extent buried by Cretaceous and Tertiary, rendering exploration difficult.

The probable source-rocks are marine beds of the Lower Carboniferous and Devonian. The Silurian also is a possible oil source. A large region in Belgium and England is underlain by the Brabant massif, where only pre-Carboniferous rocks with no promise as oil reservoirs occur below the Cretaceous. At Moll a wildcat was drilled to 6500 ft. and abandoned in basal barren Coal Measures. No oil was found, but there was a little gas. In the Westphalian collieries practically no indications of petroleum have ever been found. Near Winterswijk, however, conditions differ, and oil was found in Coal Measure sandstones in four wells drilled for coal. Several deep tests have been made in this area with promising results. Oil showings have been found 900 ft. below the Cretaceous in Carboniferous beds.
G. D. H.

**717.* Bulgaria will Continue Oil Search in 1940.** Anon. *Oil Wkly*, 18.3.40, **97** (2), 132, 134.—Five areas are of interest with regard to the search for oil in Bulgaria. In the Kostenetz area are valleys filled with Tertiary beds containing coals and bituminous schists. Asphalt veins and bituminous schists are known in the Tertiary of the Kustendil region, but no drilling has been done. North-west Bulgaria is a prolongation of the Rumanian oil basin. There are thick Tertiary deposits, and two bituminous horizons have been noted in Eocene and Pliocene beds. The Provadia district has salt and apparent salt structures. Some shallow drilling has been carried out. The Varna district possesses gas seeps, probably arising from the Oligocene.

The eastern part of the Stara-Planina, or Balkan mountain range, resembles the Carpathians, and has hydrogen sulphide and other gas seeps. It is considered one of the most promising areas in Bulgaria as regards oil.
G. D. H.

**718.* Turkey Continues Testing Despite Disappointments.** Anon. *Oil Wkly*, 18.3.40, **97** (2), 139, 142.—The oil search in Turkey has continued since 1934 without establishing commercial production. A well on the Basbirin structure 70 km. north of Mardin was drilled to 4351 ft. and abandoned in water. One at Hermis in the Midyat region went to 3088 ft. and found many shows of oil, gas, and asphalt. A nearby well had similar showings. A well at Kerbent was abandoned at 3380 ft. in salt water. North of the Tigris a well at Raman Dag is below 2000 ft. Deep drilling has been begun on the Cukorova plains. To the end of 1939 seventeen wildcats had been sunk that had slight oil showings, but all were relatively shallow.
G. D. H.

**719.* Rumanian Outlook Clouded.** Anon. *Oil Wkly*, 18.3.40, **97** (2), 147–150. In 1939 the Rumanian oil production continued the downward trend and fell by 6·8% to 45,640,000 brl. Baicoi-Tintea and Ceptura were the only fields where the production rose during the year. Drilling was 11% less than in the previous year. The difficulty of obtaining sufficiently large blocks of land has restricted exploratory work, as have also political considerations and currency and trade difficulties.

Only seven wildcats were drilled in 1939. Bucsani in 1934 was the last major oil strike, and the Baicoi-Tintea Meotic of 1937 the latest deep sand strike of importance. Eleven of the 1939 completions went to 9870 ft. or more. The deepest production is from 10,560 ft.
G. D. H.

**720.* Alberta has Attained Stabilized Position.** F. K. Beach. *Oil Wkly*, 18.3.40, **97** (2), 170–180.—Only in 1937 did Alberta's production begin to approach its demand for oil. In 1939 the production was 7,594,411 brl., against 6,742,039 brl. in 1938. New refinery facilities have been provided which show that a high-octane gasoline fuel can be made from Alberta crude without blending with imported stocks.

Considerable wildcatting has been carried on, and the major field has been developed in the disturbed foothill belt. Tests have been made in the geosyncline to the east, and although favourable indications have been found, no production has been obtained. In the deepest part the limestone is about 9000 ft. deep. Several fields have been developed in the plains, mostly giving heavy oil from fairly thin sands. Wainwright is the largest field in that area, and wells have also found oil near Lloydminster and Del Bonita. The Turner Valley field is about 16 ml. long, with the main production so far in the south. On the east is the gas cap, whilst the western boundary of the oil is marked by salt water.

Wainwright is 4 ml. long and almost as wide, with oil in thin Lower Cretaceous sands. Isolated wells have been drilled at Taber, Skiff, Dina, Vermillion, and Bragg Creek.

At Medicine Hat gas has been produced since 1890 from the Upper Colorado. Bow Island gave gas, and has been repressured from Turner Valley. Foremost is a small terrace structure, whilst Stoveville gives gas from the Madison limestone contact, and has shown oil. Viking has given gas since 1923 from a sand in the Colorado shale. Kinsella also yields gas. At Brazeau a heavy gas flow was met, and the Madison is expected at 8000 ft. The Clearwater well found several oil zones in the Devonian. At Grease Creek an oil showing has been noted over the Madison, and some production from the Devonian has been obtained at Moose Dome. The findings of various other wildcats are noted. G. D. H.

**721.* British Columbia Government Launches Independent Exploration Program.** Anon. *Oil Wkly*, 18.3.40, **97** (2), 179.—Field work was carried out in the Peace River area as early as 1919, and in 1938 the matter was re-examined with a definite view to testing. The early work showed an area of complex folding with simpler structures immediately to the east. Favourable structures occur at Hudson Hope, Moberly Lake, and where Commotion Creek joins Pine River, but a little to the west are complex structures like Turner Valley, whilst to the east the structures are not sufficiently well defined to warrant early testing. The structure at Commotion Creek and Pine River has been selected for testing. It is 10 ml. long and 4 ml. wide, with the Palæozoic, which is known to be petroliferous, at a depth of about 6600 ft. G. D. H.

**722.* Tests in Alaska Reveal Deep Possibilities.** Anon. *Oil Wkly*, 18.3.40, **97** (2), 185–189.—At Chinitna Bay drilling was recommenced at a depth of 7156 ft. in May 1939, and in the next thousand feet several thin bodies of oil-sand were met. At 8734 ft. a salt water sand was penetrated which could not be shut off for lack of supplies Some oil, gas, and salt water flowed from this well and its closed-in pressure built up to 2000 lb./in.$^2$. Oil and gas had been met at various points from 4600 ft. downwards. This well lies on the top of a dome. The original objective was not reached.

150 ml. to the south at Jutebay a well reached a depth of 6907 ft. without finding commercial oil production.

Oil occurs in the Yakataga–Katalla area, the Chinitna–Chignik region, and near Smith Bay in the extreme north. Commercial production has been obtained. at Katalla only, at which place there are many seepages of paraffin base oil. G. D. H.

**723.* Hispaniola—a New Oil Province.** F. B. Plummer. *Oil Wkly*, 18.3.40, **97** (2), 193–196.—The climate, geography, and history of Hispaniola are described.

The strata of which the island is composed are highly compressed and folded into east–west mountain ranges, of which there are three. The Cordillera Central consists of metamorphic and igneous rocks, the Sierra de Barohuca in the south of igneous and sedimentary rocks, and the Cordillera Septentrional of the north mostly of highly tilted Tertiary beds. The Cretaceous beds are strongly contorted and altered, whilst the Eocene has a thick section of limestone and some shale. The Oligocene has three divisions: at the top a massive, poorly bedded limestone with pebbles and conglomerate; in the middle a massive, coarse, alluvial fan-like conglomerate, and at the base a thin-bedded carbonaceous shale with the appearance of being a good source rock. The Miocene consists of the Upper Yaque marl with sand and conglomerate layers, a middle fossiliferous limestone and the Lower Yaque marl with sand lenses. This last appears to be a source rock, and the oil now produced probably comes from this part of the section. Recent beds rest on the Miocene.

Oil-bearing structures occur in geosynclinal valleys and are generally long, narrow anticlines with steep dips and large closure. There are numerous normal and thrust

faults. Five well-closed anticlines are known—Melano, El Higuerito, Quita Corriza, Canoa, and Monto Cristi. Almost all the drilling has been on El Higuerito. Oil was found in two tests at about 580 ft. in a sand in the Lower Yaque. Most of the wells on El Higuerito had good showings and one gave several barrels of oil.

The prospects of oil in the Miocene and Oligocene seem good, particularly on the northern and southern margins of the island and on the west coast of Haiti.

G. D. H.

**724.* Fifty Rigs Kept Busy as Cuba Attains Peak.** Anon. *Oil Wkly*, 18.3.40, **97** (2), 199–200.—Nineteen operating companies with fifty drilling rigs are at work in the Montembo basin of Cuba. On the most active concession seventy-five wells were put on production in 1939, giving 54–125 gal. of gasoline/day.

Ariguanabo No. 1, drilled after seismic and torsion balance work, found several oil indications in the Oligocene and signs of oil in sandy phases of Upper Cretaceous shales and in tuffaceous conglomerates. A second well put down half a mile away went to 10,034 ft. and found oil shows but no commercial production. A well 1½ ml. south-west of Remedios on a long, narrow structure found oil indications in the Remedios Group limestone at 2306 ft., where there were fine asphalt-filled veins. North-east of Colon a well was abandoned at 6200 ft.

In February the Montembo basin was giving 200 brl./day and the Bacuranao basin 14 brl./day. G. D. H.

**725.* Japanese Entry Alters Mexican Prospects.** Anon. *Oil Wkly*, 18.3.40, **97** (2), 209–216.—As a consequence of the declaration of certain patents as being void, lead tetra-ethyl will now be manufactured in Mexico, and so render possible the improvement of motor spirit.

There have been further labour troubles.

Fourteen out of twenty-four wells were completed as producers in 1939, with an initial aggregate output of 27,064 brl./day. The most prolific wells were in the Poza Rica field. In the Northern district the average depth of the new wells was 1866 ft., but in the Southern district 7769 ft. On the Isthmus of Tehuantepec the average was 2675 ft. Maguey 1 in Tampacan had a gas blow-out at 3850 ft. with 20–25 brl./day of 44 gravity oil, but the well was taken to 8076 ft. in the Jurassic for a dry hole. It was not possible to obtain a permit to test the shallow showing.

Poza Rica's oil production has increased, whereas the Northern, Southern, and Isthmus fields have declined. Up to the beginning of 1940, 6527 wells had been drilled in Mexico, of which 2596 were producers.

Various statistics are tabulated. G. D. H.

**726.* Australian Wildcatting again Starts from Scratch.** Anon. *Oil Wkly*, 25.3.40, **97** (3), 54.—Following surveys in the Kimberley region of north-west Western Australia a trial bore was started at Nerrima, 200 ml. south-east of Broome. At the end of 1939 it was only at 1240 ft., having been hindered by caving in the Noonkanbah series. No oil or gas had been recorded. Similarly a bore at Mount Gambier, South Australia, reached 552 ft. without any oil showing.

The Imray well was completed in the Lakes Entrance district at 1273 ft., and gave 7 gal. of oil/day from a glauconitic horizon at 1253 ft. An air repressuring scheme was under consideration.

At Metung, west of Lakes Entrance, a well reached 1550 ft. and reported dry gas, water, and traces of oil. A second well was drilling at 500 ft. Wells at Lake Boga, Portland, and Nelson, in Victoria, were at depths of 735, 1500, and 1480 ft., respectively, at the end of 1939. The last well had entered granite. At Dutson a well was drilled to 1670 ft. without any sign of oil or gas.

Some thirty-five bores totalling 45,000 ft. have been drilled in the Gippsland area without giving oil or gas. Three wells penetrated the full sequence of Tertiary beds. One south of Bairnsdale entered the Jurassic at 3158 ft.; another east of Sale entered Silurian at 3443 ft., and a third at Paynesville entered the Jurassic at 2966 ft.

The Kulnura boring, which had shown several gas horizons, was taken to 6000 ft. Dry gas at 80 lb./in.$^2$ has been obtained at Balmain Colliery, near Sydney.

Work was resumed in the Arcadia and Hutton Creek bores. The first showed wet gas, and the second, deepened to 4688 ft., was awaiting the testing of gas horizons

below 3700 ft. Traces of oil and gas in quantity were found in a bore at Mount Basset near Roma. G. D. H.

**727.* Effect of Faulting on Accumulation and Drainage of Oil and Gas in the Wilmington Oil-field.** R. Winterburn. *Petrol. Tech.*, Feb. 1940, A.I.M.M.E. Tech. Pub. No. 1154, 1–17.—The beds encountered in the Wilmington field range Miocene to Quaternary, with the Tar, Ranger, Terminal, and Ford producing zones in the Miocene and Pliocene. The developed field is on an anticlinal nose plunging north-west, whilst the four main faults, dividing the field into five structural blocks complicated by minor faulting, run north–south transverse to the axis. One main fault dips west, but the others dip east at 50–60°. The throws are generally 100–250 ft., but some faults die out. Faulting and folding seem to have occurred progressively during Repetto deposition.

The edgewater condition in each fault block is distinctive and unrelated to adjacent blocks. The fault planes seem to form impervious barriers even when pervious beds are against pervious beds, for in many places there are several hundred feet of grey water sands with interbedded shale in contact along a fault with several hundred feet of oil sands and interbedded shale which produce clean oil. In many places the gravity of the oil produced in the various zones shows marked differences on opposite sides of the faults. Gravities conform to structure on each block. Productivity differs on opposite sides of faults. The formation pressures afford evidence that the faults are effective as barriers to the movement of fluids with differential pressures of as much as 400 lb./in.$^2$ across the faults.

Accumulation seems to have occurred in each block independently without fluid movement across the faults. The faults are still effective as barriers. The sealing effect of the fault may be due to a continuous layer of impervious gouge material or to the fact that each bed of sand has been rendered relatively impermeable immediately adjacent to the plane of movement by crushing, shearing, and the development of thin seams of clayey material cutting across the bedding planes.

The effect of the faults on development and production practice is discussed.

G. D. H.

**728.* Forest City Basin Chances Enhanced by Oil Strike.** H. McClellan. *Oil Wkly*, 4.3.40, **96** (13), 17–20.—Oil has been found in the Hunton limestone at a depth of 2279–2285 ft. in the Forest City basin. From the basement upwards the following formations are present: Basal sand (Camb.), Arbuckle limestone, St. Peter sand, Galena–Platteville limestone and dolomite, Maquoketa shale (Ord.), Hunton limestone (Sil.-Dev.), Kinderhook shale, Mississippi lime (Miss.), Cherokee shale, Marmaton group, Missouri series, Virgil series (Penn.), and Big Blue series (Perm.). This basin, lying in North-east Kansas, is a narrow trough east of the Nemaha granite ridge. Its west flank dips steeply, whilst the east flank is gentle. The region suffered post-Hunton uplift, and there was post-Mississippian folding, during which the granite ridge was probably formed, and the Forest City basin appeared.

The history of the area is such that oil may have varied in its site of accumulation as the strength of the basin and the position of its axis changed. The west flank is believed to be so steep as to have lost all oil at the fault line, but the east flank may have comparatively shallow structural or stratigraphic traps. G. D. H.

**729.* U.S.S.R. : Petroleum in the Third Five-Year Plan.** Anon. *Rev. Petrol.*, 16.3.40 (879), 172–173.—It is proposed to produce 48·5 million tonnes of oil in 1942, an increase of 70% over 1939. This will entail drilling 5 million metres in 1942 against 1·9 million metres in 1939. Small wells will be put back on production and gas wastage eliminated. The Ural–Volga region in particular will be developed. This gave 3·6% of the Russian production in 1937 as compared with 0·2% in 1933. It is proposed to raise its output to 7 million tonnes in 1942, and pipe-lines and refineries are to be constructed accordingly. The production of the Emba region will be raised to 2·1 million tonnes in 1942.

In 1938 Russian geologists estimated the reserves to be 8640 million tonnes. Extensive hydrogenation is to be undertaken and synthetic processes started to utilize gas.

It may be noted that the production in the 1933–1937 period was 24% below the project.

The refinery capacity will have to be almost doubled to meet the increased output, and the vulnerability of the Caucasian region, which gives 90% of the production, is undoubtedly the reason for the strenuous efforts to develop the Emba and other areas.
G. D. H.

**730. Subsurface Geology and Oil and Gas Resources of Osage County (Oklahoma). Part III. Townships 24 and 25 North, Ranges 8 and 9 East.** N. W. Bass, L. E. Kennedy, J. N. Conley, and J. H. Hengst. *Bull. U.S. Geol. Surv.*, 900-C, September 1939.—This report deals with the oil- and gas-fields in an area in Osage County lying about 30 miles north-west of Tulsa. Some 1550 wells have been sunk, including dry holes in this area, and oil and gas have been produced from seventeen zones, ranging in depth from 200 to over 2900 ft. The oil-producing formations concerned are the Ordovician, the Mississippian–Pennsylvanian contact, and the Pennsylvanian series. Details are given of the several oil and gas zones and of the subsurface structure embracing them. The area has not been completely explored by drilling, and a few localities within and adjacent to it have yet to be tested, the prospects being good.
H. B. M.

**731.* Oil Deposit of Ekinveren, Turkey.** G. Petounnikoff. *Petrol. Z.*, May 1939, **35** (18), 315.—Ekinveren is a village lying to the south of the town of Sinope, and the geology is essentially Upper Cretaceous deposits overlying highly folded Albian–Aptian beds. The latter are involved in much-faulted anticlinal folds, and petroleum seepages are found in fissures. The oil is "mined" by means of horizontal galleries intersecting the fissures, and is apparently mainly used as a grease. 72% distils over 310° C. and has a gravity of 0·923.
H. B. M.

**732. Oil in Palestine.** Anon. *Bull. Imp. Inst.*, 1940, **38** (1), 96.—According to a report by the Government Geologist to the Imperial Institute, interest in prospecting for oil has been maintained, but so far commercial production has not been achieved. Oil-prospecting licences now in force number thirty-one. The districts concerned include Jebel Usdum, where there are oil seepages and bituminous deposits; Nabi Musa and Yarmuk, where bituminous limestones are developed; Gaza, where several structures have been located but not yet tested.
H. B. M.

**733. Oil in Uganda.** Anon. *Bull. Imp. Inst.*, 1940, **38** (1), 98.—The Director of the Geological Survey of Uganda reports to the Imperial Institute that a second deep boring for oil was put down near the hot springs at Kibero and was drilled to 2245 ft., when it was stopped. A new borehole is being put down to test possibilities about 1 mile to the north of the original site. (See also Abs. 414.)
H. B. M.

**734. Principles and Methods Adopted in the Development of Petroleum Deposits at Devoli.** P. V. Borgucci. *Riv. ital. del Petrolio*, July 1939, **7** (75), 4–5).—The article includes a general description of the stratigraphical characteristics of the petroleum deposits of Devoli (Albania) and a survey of conditions peculiar to the region which have necessitated certain departures from normal rotary drilling technique. The most important of these are complete electrification of the whole field and centralization of power production. Problems of conservation of gas and pressure within the formation are dealt with, and note is taken of experimental methods adopted for the recovery of natural gas.
H. B. M.

**735. San Juan Country. A Geographic and Geologic Reconnaissance of South-eastern Utah.** H. E. Gregory. U.S. Geological Survey. Professional Paper No. 188.—This paper contains an account of a pioneer well drilled near the Goodbridge bridge on the San Juan in 1908 which led to the drilling of more than fifty wells in the Goodbridge field and adjoining regions and to the study of oil possibilities in the whole of south-eastern Utah.

Exploration has for the most part been along the San Juan River, but potential oil-bearing anticlines have been mapped at Fish Creek, Elk Ridge, and Beef Basin; claims have also been staked on northern Sage Plain, Grand Gulch Plateau, and westward to Glen Canyon.

The oil in the San Juan country occurs in the Hermosa and Rico formations, which contain many oil-bearing sands. All the wells in the field have been drilled in these

formations, and at least two of them passed entirely through the Hermosa and possibly older limestone and entered mica-schist of Pre-Cambrian age. In some places the sands are as much as 50 ft. thick. In certain cases it is uniformly porous, as evidenced by the saturation of unbroken rock; in others the oil stains are irregularly distributed along joints and cracks, thus indicating that the sandstone is not uniformly porous. Only a few of the wells drilled in the Goodbridge field have produced large quantities of oil: this fact suggests that the oil in the sands is pockety and discovery by the drill more or less accidental.

Although the original source of petroleum in the San Juan area is unknown, it is evident that its accumulation has been controlled by local structure, climate, and geomorphic features. A series of north–south anticlines and synclines favour accumulation, but nevertheless this is hindered by the aridity of the region and by the canyons. Throughout long periods the strata are drained of water nearly to the bottom of the canyons. The height to which oil may rise depends to a large extent on the amount of oil and water available to fill the pores of the rock. In the case of San Juan Canyon ground water and oil seeps emerge into the bottom of the canyon. H. B. M.

## Geophysics.

**736.* Propagation of Elastic Waves in the Earth.** L. G. Howell, C. H. Kean, and R. R. Thompson. *Geophys.*, 1940, **5** (1), 1–14.—The propagation of waves of single frequencies varying from 100 to 2000 cycles/sec. was studied. The sources of vibration were of two types: an electrodynamic shaker and a magnetostriction tube. The normal electromagnetic pick-ups are not suitable for recording high frequencies, so a special piezo-electric pick-up was designed. The work done showed that in the dry surface layers the attenuation to high frequencies is very great, but this is considerably less marked in the deeper, water-saturated beds. Low frequencies are not seriously attenuated in the surface layers, but in the deeper beds the effect is of the same order as for high frequencies. In the case of horizontal refraction profiles, using high-frequency pulses, the velocities are approximately the same as the velocity of sound in water. The travel–time curves are straight lines through the origin, and the amplitude does not fall off with distance as fast as might be expected from vertical transmission data. S. E. C.

**737.* Velocity Stratification as an Aid to Correlation.** R. F. Beers. *Geophys.*, 1940, **5** (1), 15–21.—Refraction work in the Permian Basin of West Texas showed that the various sediments have characteristic seismic velocities and that it is possible to correlate on the basis of those velocities. Reflection work has since shown that the differences in horizontal velocities are more marked than those in vertical velocities. Because of its wide range—2000–24,000 ft./sec.—the velocity of propagation of seismic waves is one of the most characteristic properties of a sediment. The difficulty lies in accurate measurement of times of travel, since they are so small, but improved methods are being developed. Sufficient evidence has been obtained to show that the correlation of lithologic units can be established over considerable distances by means of their individual velocities, and obscure stratigraphical relationships have been elucidated in this manner. In addition, accurate velocity data make possible the certain identification of reflecting horizons. Further experience will show whether such data will assist in the discovery of stratigraphic traps. S. E. C.

**738.* Experimental Device for Computing Magnetic and Gravitational Anomalies.** J. W. Fisher. *Geophys.*, 1940, **5** (1), 22–30.—The gravitational and magnetic anomalies due to a horizontal slab of material bounded by a given contour can be expressed in terms of the solid angle subtended by the contour at the point where the anomalies are measured. This principle is used in the design of a device which enables one to make direct measurements of the anomalies given by any structure. A coil of wire, carrying an alternating current, is so wound around a model of the structure that the vertical spacing of the coils is kept constant. For the measurement of magnetic anomalies, a small, very compact search coil is held in the position at which the anomaly is to be measured and the mutual induction between the two coils determined. The values obtained for any positions of the search coil will give the relative magnitudes of the

vertical magnetic anomalies at those points. For the determination of the gravitational anomaly, a long, thin solenoid is used instead of the search coil.

S. E. C.

**739.* Direct Method of Interpretation in Resistivity Prospecting.** C. L. Pekeris. *Geophys.*, 1940, **5** (1), 31–42.—In this method the variation in conductivity with depth is determined for the case of horizontal layers. The procedure is outlined and an example worked through to illustrate its application. The theory on which the method is based is given. S. E. C.

**740.* Three-layer Resistivity Curves for the Eltran Electrode Configuration.** S. S. West. *Geophys.*, 1940, **5** (1), 43–46.—A set of standard curves, log. of apparent resistivity plotted against log. of electrode separation, for the case of three layers, and based on the Wenner electrode pattern, has been published. A method is now given whereby the curves for other electrode patterns can be calculated from this published data. Data are given for plotting the curves for the Eltran electrode pattern.

S. E. C.

**741.* Additional Evidence on the Relation of Temperature to Structure in the Salt Creek Oil-field, Natrona County, Wyoming.** C. E. van Orstrand. *Geophys.*, 1940, **5** (1), 47–56.—The structure at Salt Creek is a closed dome with transverse faults. The physical conditions, with the exception of the faults, are uniform, and granite is found at moderate depths below the top of the structure. The field therefore offers an excellent example for determining the relationship between temperature and structure. The first sets of temperature measurements were made in 1922–1923 in twenty-one wells which had remained idle for sufficient time to give thermal equilibrium. These measurements show a very close relationship between temperature and structure. Later measurements, made in nearly one hundred wells when the field was in a state of decline production, confirm this relationship. The disturbing effect of repressuring and producing operations on the thermal gradient is well illustrated in the case of six wells. S. E. C.

**742.* Geothermal Methods of Estimating the Age of the Earth.** C. E. van Orstrand. *Geophys.*, 1940, **5** (1), 57–79.—Tables are given whereby the temperatures in a non-radioactive earth can be calculated and a general idea obtained of the temperatures in the case of a radioactive earth. It is found that a temperature of 76,000° C. at the centre of the earth is consistent with the low-temperature gradients observed in areas that have remained practically undisturbed through long periods of time. Radioactivity alone is insufficient to cause melting at depths of the order of 30 kilometres, but at depths of 500 kilometres it is possible. Between those depths the combined effects of heating and cooling may result in volume changes through recrystallization of substances near their critical temperatures. The age of the earth obtained by geothermal equations is consistent with that obtained by the method of atomic disintegration. S. E. C.

**743.* Results of a Deep Boring at the Tegernsee, Upper Bavaria.** J. Knauer. *Oel u. Kohle*, 1940, **36** (7), 63–66.—Reichsbohrung 429 was drilled to a depth of 2199 m. during 1937–1939, the location being in the Flysch zone on the western side of the lake. The strata below the Flysch cover includes the Cretaceous stages from the Barremian to the Maestrichtian and the Middle and Upper Eocene. These strata are strongly folded and are in part repeated several times. As a result of this repetition, rocks of other ages were not found in the boring. This boring does not solve the problem of the origin of Tegernsee oil. However, it does point to the oil being older than the Barremian, and a Palæozoic origin is consequently not out of the question.

S. E. C.

**744.* Application of the Schmidt Field Balance to the Search for Oil Deposits.** G. Neumann. *Oel u. Kohle*, 1940, **36** (9), 75–78.—The early application of the Schmidt magnetic field balance to the discovery of salt domes was not successful. Later improvements in the instrument have made possible the accurate measurement of anomalies of the order of 10–15 $\gamma$, and the method is now being used in the Gulf Coast, These measurements, however, should be considered not as an independent geophysical

method for the search for structures, but rather as a contribution to the clarification of the sedimentary tectonics.

In regions where there are buried crystalline or early Palæozoic uplifts the magnetic method may be used for regional surveys on which the detailed exploration can be based. In certain cases the method may also be used for detailed work, for although usually it does not give a complete picture of the structure, it does indicate the position of the crystalline core, and hence the probable position of the crest of the structure. The application of the method is similar in the case of areas where the tectonics are determined by later volcanism.

The magnetic method will determine the position of faults in those cases where the fault-plane has been extensively injected with intrusive material, or where the fault cuts the crystalline basement as well as the overlying sediments. S. E. C.

**745.* Importance of Geophysical Exploration and its Application in the Argentine Republic.** Francisco P. de Luca Muro. *Bol. Inform. Petroleras*, Dec. 1939, XVI (184), 35–45.—This article describes in simple language the different methods adopted by geophysicists in studying the character of substrata in the search for petroleum deposits. Remarkable development of these methods and of the instruments used has taken place in the last few years. Present tendency is to apply the gravimetric method as an initial stage, followed by further investigation by the reflection method of seismic prospecting. A useful bibliography of the subject is appended. H. I. L.

## Drilling.

**746.* Use of Fill-Up Line Decreases Blow-outs.** H. F. Simons. *Oil Gas J.*, 7.3.40, **38** (43), 36.—The causes of abnormally high pressures encountered are given in the cases of small gas pockets which may only disturb the drilling fluid without serious mishap, as well as in the case of meeting with extensive and abnormally high-pressure gas reservoirs. Blow-outs occur when the hydrostatic head of the drilling fluid is insufficient to balance the formation pressure. A special study is made of the case where the fluid column is shortened by withdrawal of the drill-pipe from the hole.

Blow-outs occurring on withdrawal of pipe have been ascribed to the " piston effect " of such a procedure. It is shown that this is not the case with the majority of blow-outs so occurring, the real reason being the fall in liquid level and, consequently, in hydrostatic head exerted on the formation.

A drawing and description are given for a fill-up line to be connected to the well, below the preventer, in order to fill the well with mud as the drill-pipe is withdrawn. Various methods of rendering this operation simple and foolproof are outlined.

Another danger of blow-out which results from making a trip is the forcing of air into the mud while filling the pipe after the bit has reached bottom. Procedures to be followed to avoid such a danger are given for various cases. A. H. N.

**747.* Maritime and Land Operations Contrasted in Chalkey Field.** N. Williams. *Oil Gas J.*, 7.3.40, **38** (43), 40.—One of two operating companies on coastal Louisiana is developing its properties by the land route, building a good road system, whilst on immediately adjacent properties the other company is operating by water. The latter system is studied in greater detail than the former.

Although maritime development has its advantages in effecting substantial savings in time and cost of well moves, transportation, hauling and other handling problems, this method is generally used as a matter of necessity or expediency, and not of choice. The canal system was dry cut, and the cost has been found to be substantially less than would have been required to build roads and also less than the usual cost of dredging in marshes. Even laying of temporary plank roadways would have involved a greater initial outlay. Drag-lines have been used in excavating the canals. The system and its development are described.

The canal system facilitates the movements of pipe and other equipments as well as of the products from the wells directly upon production.

Details of operations in Chalkey field are given and its development is briefly reviewed. A. H. N.

**748.* New Combination Degasser and Agitator.** L. P. Stockman. *Oil Gas J.*, 21.3.40, **38** (45), 63.—A description is given of an agitator and degasser, the primary function of which appears to be to reduce drilling costs through mud reconditioning by breaking down the viscosity of the drilling fluid, releasing entrained gas or air, and eliminating the necessity of continually replacing weight materials and certain chemicals in the mud.

The combination consists of a vertical steel tower with a combination of baffles and nozzles arranged to secure maximum agitation of the mud under a sustained vacuum. Details of its construction and operation are given, as well as its capacity for treating mud.

An advantage claimed for this degasser combination is that its use definitely reduces drill-pipe corrosion. A. H. N.

**749.* Drilling Activity is Showing Increase.** H. F. Simons. *Oil Gas J.*, 28.3.40, **38** (46), 52.—Statistical data are presented for the number of completions by weeks for 1939 and 1940, drilling tests completed annually from 1919 to 1940, and comparative drilling activity for various States of America. It is concluded that during 1940 activities will show a definite increase. A. H. N.

**750.* Chemicals in Drilling and Producing Operations.** W. W. Robinson. *Oil Gas J.*, 28.3.40, **38** (46), 190.—*Paper presented before American Petroleum Institute.* This long paper considers broadly the steadily growing trend in the application of chemicals to problems affecting the drilling for and production of oil. Chemicals for treatment of muds, the control of heaving shales, treatments for lost circulation, special cements, the use of acids, selective water shut-offs, and the application of surface-tension-reducing agents are reviewed in their relationship to the growing chemical technology which has already been of material assistance to the driller and producer.

The treatment of muds is considered from the viewpoints of weighting and increasing colloidal content, control of viscosity of muds by the addition of reagents, the use of carbonates, silicates, tannate and phosphate salts of sodium, the use of special drilling fluids and fibrous materials, together with a study of the interrelationship of the various properties of muds and the effects of the addition of such reagents on these properties.

The study of the cements includes the study of the chemical entities of the cement itself as well as of the reagents. The methods of increasing the setting time of cement by chemical means are discussed.

Acidization is outlined and a detailed account is given of inhibition and inhibitors. Addition agents, besides inhibitors, include those which speed up the action of acid on dolomitic limestone, those which retard the action on fast limestone, those which reduce the surface tension of the acid and permit the effective withdrawal of the reaction products, and those which permit the acid to "wet through" or penetrate oil-soaked limestone or mud cake.

The paper concludes by reviewing the chemicals used in selective exclusion of water and reduced surface tension washes.

The bibliography contains 86 references. A. H. N.

**751.* Oversize Joints Reduce Drilling Costs in Illinois Basin.** H. F. Simons. *Oil Gas J.*, 28.3.40, **38** (46), 197.—One of the principal items which added to the drilling costs in the Illinois basin development was the excessive wear on tool joints and drill-pipe, the average drill-stem making only about half the footage it would make in other areas. The average life of a standard tool joint set was 20,000–30,000 ft.

By using an oversize joint which increased the outside diameter by $\frac{1}{4}$ in., it was made possible to obtain footages of 33,000–36,000 ft., an increase of 33%. The increase in cost of the oversize joints over standard joints was 5%.

The chief danger arising from the use of oversize joints was in case of a fishing job being necessary. There was only $\frac{1}{16}$-in. clearance to get over the fish when using these oversize tool joints and a standard overshot. A. H. N.

**752.* Causes and Preventions of Stuck Drill-Pipe.** J. E. Warren. *Oil Gas J.*, 4.4.40, **38** (47), 39; also *Oil Wkly*, 1.4.40, **97** (4), 12–15 (Pt. I only).—*Paper presented before American Petroleum Institute.* Various factors which may cause drill-pipe to stick in

the well bore are discussed. These factors include key seating, which occurs when the portion of the drill-pipe which is under tension is brought against the convex side of a crooked well. The pipe tends to drill itself into the walls of the well. Drilling straight holes eliminates this source of danger. Reaming a crooked well cures the fault.

Other factors are improper mud control, cuttings, sand and cavings, and balling-up. Admixtures to increase weight of mud, even if finely pulverized, will settle down and freeze the pipe if the mud is deficient in gel-forming colloids. Filter-cake formation is another important consideration. Cavings, washout, and solution of soluble formation minerals will increase the diameter of the hole where they occur. This results in a drop in the velocity of the mud passing that section of the well, with a consequent tendency for the cuttings and sands to settle and freeze the pipe. Mud conditioning can prevent such dangers. Balling-up refers to the accumulation of sticky mud or formation on the bit or drill assembly. On withdrawal of the drill-stem this accumulation is compacted and may stick the pipe.

The methods of recovering stuck pipe are considered in two classifications. The first includes those methods used to free drill-pipe while keeping the drill-stem intact. Included are the use of oil, circulating clear water, gas slugging, and mechanical methods such as spudding and bumping the pipe. The second includes those methods which are used in case the drill-pipe cannot be freed while it is intact as one unit. This includes "backing off," the use of inside cutters, shooting off pipe, "washing over," use of jars, etc.

Some of the methods require the use of special tools and the service of operators skilled in their use. The application of these methods and a brief description of the procedure used are given. A. H. N.

**753.* High Rotary Speeds in California Drilling.** W. A. Sawdon. *Petrol. Engr*, March 1940, **11** (6), 33.—High rotating speed was so successful in drilling straight, fast holes to depths of 10,000 ft. and more that it practically established a new technique. Rock bits were used almost invariably, and speeds were estimated at 750 r.p.m. The object of these very high speeds was to drill a straight, fast hole with the minimum cost and trouble. The verticality of the surface string was a most important factor. Rock bits with different types of cones were used at different depths and, in general, fine teeth were used at low depths. No bit less than 11 in. in diameter would be used for speeds of 400 r.p.m. and over. Octagonal kellys were used exclusively. The drill-pipe was in tension at all points down till the collar. Detailed accounts are given for bit-speeds programmes.

The practice may be summarized as follows. The drill-pipe is rotated at a high speed until the top of the kelly is near the table. The rotating speed is then slowed down and another foot of hole made with slow rotation. After adding another stand of pipe, the bit is set on bottom and rotation begun slowly to make sure the cones are turning. The table is then speeded up and the procedure repeated.

The reason for slowing down rotation for a short time before breaking connections is to allow the bit to cool. Otherwise the heat generated in the bit by the high-speed rotation would force all water from the mud and bake it in and around the bit to such a degree that the cutter would be frozen on the bit and would not turn.

Critical speeds occur where the pipe vibrates excessively. Methods of remedying this fault are given.

The rate of penetration at the highest rotating speed after setting the surface string averaged 40 ft. in 4 min. It took longer to make the connections than it did to run down the kelly. A. H. N.

**754.* Deepening and Completing a Well in the Lisbon Field, Louisiana. Part II.** P. D. Torrey and F. H. Miller. *Petrol. Engr*, March 1940, **11** (6), 48.—In this exhaustive paper an extremely detailed account is given of the operations and equipment used in deepening a well. The first part dealt with the geology of the district. In this, the second part, the geology section is concluded and drilling is discussed. Conditioning of the hole, equipment used, tests conducted on mud conditioning, and the control and verticality of the well are presented in a complete form.

The paper ends with a description of a sample taker which, it is claimed, provides absolutely representative cuttings between any depth limits desired. It consists essentially of a paddle-wheel, driven by the mud stream itself, which in turn rotates

a cylindrical screen set to take a small portion of the mud stream. The sample of mud and cutting is washed by small jets of water, and the cuttings are collected in a clean and representative manner in a sample holder. A. H. N.

**755.* Layout and Care of Rotary Drilling Equipment.** H. L. Flood. *Petrol. Engr*, March 1940, **11** (6), 189.—Changes are taking place imperceptibly in all departments of oil-field equipments and operations. The use of paint provides an instance in the change of outlook and practice. Formerly the only reason given for using paint was appearance, and hence it was used sparingly. Now it is recognized that painting the equipment pays a dividend, as it prevents excessive rust and corrosion and increases the efficiency of the personnel. A rig which is uniquely painted all white is made the subject of the paper in particular. The use of light colours is advocated on the basis of increasing the pride of the workmen in the equipment, and hence increasing their output.

The draw-works is totally enclosed, and provides a high factor of safety to the crew and a compact space-saving equipment.

Improved methods of controls for the draw-works and the rotary and general equipment are discussed. A. H. N.

**756.* Mud Control Requires Knowledge of Basic Fundamentals.** B. Mills. *Oil Wkly*, 4.3.40, **96** (13), 12–16.—The early development of mud control and usages from water circulation onwards is summarized. The need for the various properties considered essential in modern mud practice is outlined.

Nowadays the terms expressing properties of muds include weight, viscosity, salinity, alkalinity, acidity, thixotropy, settling tendency, and surface tension. Other words used to qualify major properties are: temperature, water separation, filtration properties, slick, thick, fluffy, velvety, texture, natural mud, and synthetic mud. The significance of the major items of this list is the subject-matter of the paper.

The filtration of water from muds under high pressure at great depths, effect of high temperature on viscosity, and the lack of effectiveness of certain treating agents make mud control in deep wells a difficult and exacting task. Under such conditions the filtration rate of water is greatly accelerated and a much thicker wall deposited before the loss of water is stopped than in the case of shallow and less severe conditions. This fact has led to the extensive use of muds rich in colloidal material, having a liberal water content, and composed of mixed particle sizes capable of building a wall rapidly.

Conditioning and practices essential in handling gas are described in detail. A dangerous gas flow is indicated when the viscosity rises sharply, the weight drops, and there is little or no curdling tendency. On the other hand, when the mud shows a strong gelling and curdling tendency, loses weight, and registers an apparent rise in viscosity, a high-pressure salt water has been encountered. Treatments for these cases are outlined.

The complicated problem of regulating weight and preventing loss of circulation, particularly in the so-called "surface" sands, is outlined, together with the usual solutions adopted.

Reduction of viscosity by phosphates is next discussed. The addition of tannic acid to the phosphates helps to make mud more effective when drilling cement. Mud badly cut with cement has been treated effectively with a mixture of bicarbonate of soda and pyrophosphate.

Silicate muds have been effective in drilling caving formations affected by loss of water from ordinary mud.

The significance of *p*H value is briefly explained. A good drilling fluid usually shows a *p*H of about 8·5. In certain bentonitic formations that make mud freely the *p*H may rise to 10; such high alkalinity, however, makes thinning and an increase in the acid content necessary.

The colloidal material in mud begins to flocculate when the *p*H passes 9·5 or 10, although many native muds perform best with a *p*H around 9.

Methods of determining *p*H of muds are outlined. The method of using strips impregnated with dyes sensitive to the *p*H value is given in greater detail than the glass electrode system. A. H. N.

**757.* Drilling Contractor Uses Two Charts to Check Well Progress.** Anon. *Oil Wkly*, 4.3.40, **96** (13), 30.—Use of detailed and composite drilling progress charts enabled one

drilling company to check and analyse methods, performance of equipment, and mud characteristics with remarkable exactness. Two charts were used.

The first chart contains a sectional well log, casing chart, screen, liner and packer assembly, drilling curve, directional survey, equipment record, and an hourly breakdown of operations.

The second chart listed the various mud characteristics, with the well log shown as the horizontal scale. These characteristics were weight, viscosity, % solids, % sands, *p*H value, and " material added."

The charts showed up mistakes, and thus the efficiency of subsequent drilling was increased and better time was recorded. Marked contrasts or extremes were easily spotted on the charts, and reasons for such differences often forced changes in practice and equipment.

The methods of compiling data for, and construction of, the charts are briefly outlined and their use is described. Actual charts are reproduced on a large scale. A. H. N.

**758.* Drilling from Off-Shore Pier Past Experimental Stage.** R. H. Tate. *Oil Wkly*, 11.3.40, **97** (1), 20.—The activities of two years of operations during which nine wells have been drilled to completion from the piling-supported structure located 6000 ft. from the shore-line are studied. The structure on which the work was carried out is supported approximately by 550 basic creosoted pilings averaging 60 ft. in length. The depth of water is only 14 ft., despite the great distance from the shore. The structure has withstood the buffeting of wind and wave and proved a complete success.

The outstanding feature of these operations has been the directional drilling involved. The area has been a veritable testing-ground for this method, and, as a result, a number of revelations pertaining to the practice have been made. The chief one of these is that it is cheaper and generally more satisfactory to tear down one location and move equipment to another than drilling several holes from one central point. The wear and tear on the equipment, particularly the drill-pipe, is tremendous. Fishing jobs are greatly complicated. All routine jobs are similarly made more difficult and expensive in directional than in ordinary drilling.

It was proved that the system is cheaper than if a board walk were constructed from the shore, in spite of the fact that a small flotilla had to be maintained under constant charter.

Safety factors against blow-outs and fires resulting therefrom are outlined. Routine jobs are also described. A. H. N.

**759.* Test in Swiss Alps Projected to 12,000 ft.** Anon. *Oil Wkly*, 18.3.40, **97** (2), 128–129.—A completely electrically equipped wildcat is drilling near Neufchatel, Switzerland. The test, projected to 12,000 ft. if necessary, is on a secondary fold in the Swiss Alps. It started out by taking 12-in. cores, and later was reported taking 6-in. cores consisting chiefly of Jurassic limestone, marble, indurated limestone, and dolomite.

Some oil and gas shows have been reported. A. H. N.

**760.* Drilling Runs Higher in 1940 than in 1939.** L. J. Logan. *Oil Wkly*, 18.3.40, **97** (2), 228–230.—Although drilling was handicapped greatly by the extremely cold weather of late January and early February throughout most of the U.S.A., the industry so far this year has completed approximately 10% more new wells than it did in the corresponding period in 1939.

Statistics are given in monthly periods from 1933 to February 1940 for the average number of wells completed daily in the U.S.A. Detailed tables are given for the first two months of 1940 for the different states and districts, giving total wells and the numbers of oil, gas, and dry wells found, as well as the initial productions, and these are compared with 1939. A. H. N.

**761.* More and Deeper Wells are Being Drilled in 1940.** L. J. Logan. *Oil Wkly*, 1.4.40, **97** (4), 16–18.—Data are given for average drilling depths for every year since 1925, and these show an increase for 1940. Tables and charts are reproduced giving number of wells completed each year and footage drilled for the U.S.A. by years, average daily well completions in U.S.A. by months (1933–1940), and number of rigs

in various fields of the States. All these data reveal an increased activity in drilling and completion this year. A. H. N.

**762.* Construction of Drilling Platforms for Well Sinking through Rocks which are Covered by Shallow Water at Low Tides.** H. Giraldez. *Bol. Inform. Petroleras*, Dec. 1939, XVI (184), 47–56.—This is a well-illustrated article showing the methods adopted for erecting drilling rigs on rocks which are only slightly submerged at low tide. The work consists in building a dyke from the shore to the drilling platform, building up the platform on the rock with concrete blocks and foundation blocks for the rig, and erection of a gantry carrying the various pipe-lines and a gangway, level with the deck from which drilling tackle is operated. H. I. L.

**763. Drilling Patents.** P. H. Nast. U.S.PP. 2,191,491 and 2,181,492, 27.2.40. Appl. 6.6.35 and 23.7.35, respectively. Drill-bits.

J. L. Reilly. U.S.P. 2,191,493, 27.2.40. Appl. 26.2.36. Drill-bit.

C. L. Deckard. U.S.P. 2,191,643, 27.2.40. Appl. 21.6.38. Tubing handling-board for derricks.

A. C. Hamilton. U.S.P. 2,191,652, 27.2.40. Appl. 12.8.38. Method of sealing earth formations comprising injecting potentially hardenable calcined gypsum.

L. A. Rawson. U.S.P. 2,191,681, 27.2.40. Appl. 21.9.38. Derrick construction.

L. L. Brown. U.S.P. 2,191,750, 27.2.40. Appl. 14.2.38. Well-cementing apparatus for inserting cement around casing.

W. T. Wells. U.S.P. 2,191,783, 27.2.40. Appl. 15.7.39. Bridging plug using metallic exothermic reacting material to flow between body and casing and means for igniting this material.

H. D. Sandstone. U.S.P. 2,192,065, 27.2.40. Appl. 20.9.37. Self-loading and unloading bailer of the hydrostatic pressure type.

H. C. Johansen. U.S.P. 2,192,192, 5.3.40. Appl. 7.7.36. Rotary drilling machine with hydraulically operated pistons to raise and lower the table.

L. C. Symons. U.S.P. 2,192,278, 5.3.40. Appl. 22.3.37. Mud screen.

Z. A. Dyer. U.S.P. 2,192,400, 5.3.40. Appl. 12.10.37. Lower plug for cementing wells.

W. N. Mocks. U.S.P. 2,192,478, 5.3.40. Appl. 4.3.39. Pipe clamp.

J. A. Dunn and W. Elliot. U.S.P. 2,192,584, 5.3.40. Appl. 12.11.38. Rotary drilling apparatus where the prime mover may be connected either to the draw-works or the rotary independently or to the rotary through the draw-works.

L. L. Payne. U.S.P. 2,192,693, 5.3.40. Appl. 7.5.38. Wash-pipe adapted to flush fluid at right angles to teeth of cutter on roller-bit.

F. L. Scott. U.S.P. 2,192,697, 5.3.40. Appl. 27.12.38. Cutter mounting for a roller-bit.

S. D. Rowe. U.S.P. 2,193,010, 12.3.40. Appl. 17.9.38. Safety device for catheads.

H. L. Rymal. U.S.P. 2,193,144, 12.3.40. Appl. 25.5.39. Method and apparatus for forming mud seals on completion of well by forming a gel between casing and tubing at a desired point in the well bottom.

E. V. Watts. U.S.P. 2,193,183, 12.3.40. Appl. 4.4.38. Rod catcher.

C. P. Bowie and R. V. Higgins. U.S.P. 2,193,219, 12.3.40. Appl. 4.1.38. Drilling wells through heaving or sloughing formations using a circulating refrigerating fluid to freeze the formation.

E. K. Cole. U.S.P. 2,193,269, 12.3.40. Appl. 24.1.38. Clamp for guy wire cables.

H. S. Davies. U.S.P. 2,193,862, 19.3.40. Appl. 29.5.39. Inclinometer with a siphon-tube arrangement.

A. R. Bone and A. P. Albrecht. U.S.P. 2,193,917, 19.3.40. Appl. 24.10.38. Bit extension.

W. T. Caldwell. U.S.P. 2,194,066, 19.3.40. Appl. 14.11.38. Drilling apparatus of the portable type.

W. P. Kincaid. U.S.P. 2,194,090, 19.3.40. Appl. 12.10.39. Bit breaker.

G. G. Harrington. U.S.P. 2,194,119, 19.3.40. Appl. 19.7.37. Drill-bit with roller cutters.

A. D. Rhodes. U.S.P. 2,194,124, 19.3.40. Appl. 30.8.38. Derrick base.

J. D. Brock, L. R. Leissler and R. A. Warren. U.S.P. 2,194,267, 19.3.40. Appl. 30.10.39. Drilling tool comprising a stem, a bit, a tiltable joint to rotate the bit, and means in the joint to tilt the joint upon relative turning of bit and stem.

C. E. Strom. U.S.P. 2,194,331, 19.3.40. Appl. 24.5.39. Retrievable wire-line bridge-plug.

L. C. Backer. U.S.P. 2,194,631, 26.3.40. Appl. 5.1.39. Straight-hole drill device.

W. F. Feltenberger. U.S.P. 2,194,647, 26.3.40. Appl. 20.2.39. Cable clamp.

L. L. Sanders and G. C. Street. U.S.P. 2,194,675, 26.3.40. Appl. 5.4.37. Drill-bit with cone cutters.

R. R. Bloss. U.S.P. 2,195,200, 26.3.40. Appl. 1.6.37. Brake for drums.

W. J. Opocensky. U.S.P. 2,195,224, 26.3.40. Appl. 3.5.38. Method of surveying wells and apparatus therefor, consisting of means of measuring rotation of a string of rods raised or lowered in stages into well.

D. Cole. U.S.P. 2,195,445, 2.4.40. Appl. 4.10.37. Pipe elevator.

D. M. Smith. U.S.P. 2,195,501, 2.4.40. Appl. 23.2.37. Rotary swivel.

W. A. Curtis. U.S.P. 2,195,530, 2.4.40. Appl. 17.6.39. Thread protector for pipes and casings.

F. D. Snell. U.S.P. 2,195,586, 2.4.40. Appl. 29.2.36. Acid and waterproof cement.

J. W. O'Brien. U.S.P. 2,195,752, 2.4.40. Appl. 18.1.37. Well drilling mud condition and method of maintaining a supply of conditioning agent near the bit and gradually feeding the agent into the mud.

P. H. Jones and A. L. Blount. U.S.P. 2,195,798, 2.4.40. Appl. 20.10.36. Drilling fluid adapted to determination of degree of contamination of core sample by utilizing nicotine in solution.

D. O. Newton. U.S.P. 2,195,898, 2.4.40. Appl. 23.8.38. Apparatus for degassing rotary muds by means of a vacuum tower.

M. Davis, J. E. Lacy, and A. C. Andrews. U.S.P. 2,196,141, 2.4.40. Appl. 25.9.39. Pipe rotating device. A. H. N.

## Production.

**764.* Experimental Plant at Cotton Valley Proves Recycling to be Feasible.** G. Weber. *Oil Gas J.*, 7.3.40, **38** (43), 32–33.—The Cotton Valley field comprises one of the most

outstanding gas-condensate reserves thus far discovered. Extensive field tests have been conducted to find out the possibilities of a recycling project. Two high-pressure separators, a 600-h.p. compressor, and high-pressure lines connecting the unit to two producing wells and one injection well comprise the experimental plant.

Conclusions reached from experiments are: (1) pressures required for injection are of such magnitude as to be economical; (2) design of the production-scale plant should be governed by the type and quantity of a readily marketable product; (3) considering the apparently high super-compressibility of the gas in question, the cost of the compression equipment will be well within the original estimates.

In summarizing, it may be said that this test operation has served its purpose by determining the volume–pressure relationship in a test well. Using data furnished by this test, it has been possible to estimate equipment requirements and to define engineering and economic features which are of vital importance in planning a project for developing a gas-condensate reserve.

The procedure and other results of the test are given. A. H. N.

**765.* Some Unsolved Deep Well Problems under Proration.** G. O. Nevitt. *Oil Gas J.*, 7.3.40, **38** (43), 43.—The conclusions reached from the discussion in the paper are: most deep wells are being drilled and completed by using the most advanced machines and methods, but they are being produced by methods of many years ago.

Many deep wells have produced but a small quantity of the oil actually in place adjacent to the well bore, before going completely to salt water or to excessive gas–oil ratios.

Workovers to control salt-water encroachment or excessively high gas–oil ratios in deep wells have not been entirely successful.

Wells to be drilled between present locations, or the use of more efficient production methods, or both, will have to be used to get all possible recoverable oil from deep formations.

Workable formulas for determining what constitutes the optimum rates of flow of oil and gas from wells, particularly deep wells, have yet to be developed. There is at present more agreement among engineers than among oil executives that such formulæ are the basis for the whole conservation and proration structure. A. H. N.

**766.* Rod-Line Crossings for Producing Properties.** P. Reed. *Oil Gas J.*, 7.3.40, **38** (43), 48.—In devising methods for providing road-crossings for rod-lines at oil-producing properties pumped by central powers, operators have applied much ingenuity in solving the problems presented by conditions in different localities. Photographs and descriptions give some of these methods. Most crossings are made by passing the rod-line under the highway through a casing, and it is frequently necessary to instal a pendulum of some kind to transmit the motion of a rod-line on the surface to a lower level. A. H. N.

**767.* Pressure Maintenance (Cunningham-Lansing Lime Pool, Kansas).** C. C. Rae. *Oil Gas J.*, 14.3.40, **38** (44), 42–43.—*Paper presented before American Petroleum Institute.* Many wells in this pool would now be unprofitable and ready for abandonment without pressure maintenance. The past oil production has been about 2,000,000 brl., of which 1,009,000 brl. were produced prior to pressure maintenance. The normal ultimate oil production can be estimated at 2,800,000 brl. without pressure maintenance. The total volume of gas input has been 84% by volume of the gas produced. An ultimate oil recovery of 5,200,000 brl. is promised under pressure maintenance. This result offers considerable encouragement for other pressure-maintenance projects in the same formations. Results will probably vary with permeability and regularity of the pay zones. It is usually very difficult to consolidate the ownership of oil leases under one operator, which would be necessary to justify the erection of a gasoline or a recycling plant, and begin pressure maintenance early in the life of the pools, when larger volumes of gas are available than would be the case later. A. H. N.

**768.* Improved Pumping Operations in Central Power Units.** G. Weber. *Oil Gas J.*, 14.3.40, **38** (44), 45.—Design and balancing of central-power pumping units require application of many engineering principles, not only during the original installation

work, but also during their operational period, as changing field conditions call for periodic checks to minimize equipment wear and economize on power.

A case in East Texas is studied in particular, as there the problem of keeping central powers in good condition is particularly important. Declining pressures, and in some cases salt-water encroachment, vary individual well loads and necessitate addition of wells which were flowing when the power was first installed.

In this particular case the power was overloaded and out of balance. It was necessary to improve its operation to care for additional wells due to go on the pump, and to reduce power loss and equipment wear. Dynamometers were used in weighing each well at a point on the rod-line immediately adjacent to the power. From the data on the individual cards the amount of force and its direction were computed on the basis of current pumping schedules. From that point proposed pumping schedules which gave better balance were assumed and, by trial and error, the proper counterbalances were determined. Specimen calculations are given in the paper.

As a result, as shown by two representative schedules, the maximum horse-power requirement of the unit was cut from 107 in the old schedule to 43 in the new one. Excessive wear of the gears on the heavy side of the power was halted, and the oil leak in the power due to loosening of the trunnion flange was stopped. A. H. N.

**769.* Treatment and Disposal of Oil-field Brines.** J. J. Rady. *Oil Gas J.*, 14.3.40, **38** (44), 48.—To solve the problem of disposing of oil-field brines the scientific approach is recommended, requiring a study of the fundamental principles involved and careful examination of all previous work done on the subject. Oil-field brines contain more dissolved salts than are found in sea-water. Some brines contain small quantities of relatively rare salts, and attempts are being made to recover these as a part of the brine-treating and disposal process. Salt and gas contents of the brines generally found are briefly discussed.

The effects of brine on fish life are similarly briefly studied. This effect is a function of concentration. The most vital consideration is the effect of brines on public and private water supplies. Chlorides are limited to 250 p.p.m., magnesium to 100 p.p.m., and total solids to 1000 p.p.m.

There are three general methods of disposal of oil-field brines. The first is to impound the brine in evaporation ponds; the second is to divert the brine into a surface stream; the third method involves the return of the oil-field brines to subsurface formations.

Each of these methods has its own advantages and inherent drawbacks. These are discussed under each system. The third system is treated with greater detail, particularly with regard to the essential need of conditioning the brine prior to disposal.

There are two general systems for treating brines to make them fit for subsurface disposal. The closed-type system allows for complete removal of suspended matter, but permits retention of other components in permanent solution of the brine. In the other, the open-type system, all suspended matter, as well as all components that might become suspended, are removed before subsurface injection of the brine. The second system requires five definite steps: (1) separation of oil from the brine; (2) aeration for the removal of carbon dioxide and hydrogen sulphide; (3) stabilization of carbonate components by intimate contact of the brine with calcium carbonate sludge and the like; (4) reduction of dissolved oxygen in the brine; and (5) filtration of suspended matter. A. H. N.

**770.* Gasoline Recovery Devices Tested on Stripper Lease.** P. Reed. *Oil Gas J.*, 14.3.40, **38** (44), 53.—For the purpose of determining the practical value of low-cost methods for recovering small quantities of gasoline in connection with the operation of an oil-producing property which has reached the stripper stage, tests are being conducted using materials of the kind available on any lease. Experiments on refrigeration equipment connected with stripping are also being made.

The paper is a short description of the tests and the equipment. Gasoline recovered by this unit is sold with the crude, thus adding to the production of the property as well as raising the price of the crude. A. H. N.

**771.* Metals in Production—Strainers, Tubing, and Valves.** W. L. Nelson. *Oil Gas J.*, 14.3.40, **38** (44), 56.—The properties required of and the specifications for metals to

be used in strainers, tubing, and valves for oil production are briefly discussed. A table gives the chemical composition (C, Mn, Ni, Cr, Mo, and "others"), yield point, elongation, Brinell hardness, and suggested heat-treatments for metals in stems and seats, valve boltings and bodies, blow-out preventers, casing, and tubing. Seven references are appended. A. H. N.

**772.* Catenary Suspension Increases Rod-Line Efficiency.** H. F. Simons. *Oil Gas J.*, 21.3.40, **38** (45), 42–43.—More extensive use of dynamometers for testing pull-rod-line efficiency has led to the re-examination of the friction losses between the centrally located geared power and the pumping-jack and the remodelling of the pull-rod line to reduce horse-power requirements. It has been known that the catenary suspension of pull-rod lines traversing rough terrain was more efficient than trying to establish straight pull. This was evidenced by an increase in the number of wells which could be pumped by a geared or band-wheel power with pull-rods suspended in this manner over the number of wells which could be pulled when using a straight rod-line. Theoretically the catenary suspension was more efficient; this paper gives quantitative measure of the saving.

Normal loss between geared power and the pump-jack amounts to 3·5–5·0 h.p./1000 ft. of rod-line where the rod-lines are of straight-line construction. By taking advantage of the catenary effect in the construction of the rod-line, using hold-ups and rollers at the appropriate points, and still doll-heads for supports, the power loss can be reduced to 0·85–1·25 h.p./1000 ft. of rod-line traversing gently rolling ground and 2·25–2·50 h.p. over rough terrain. Savings in costs are indicated and the equation for the catenary curve is given for purposes of calculating the necessary sags in feet.
A. H. N.

**773.* Positive Displacement Oil Meters in Production Work.** L. R. Van Arsdale. *Oil Gas J.*, 21.3.40, **38** (45), 44.—*Paper presented before American Institute.* Dissolved gas and entrained gas are the important factors in making installation of the meter through the various stages in the life of the field. Conditions of high temperatures, high pressures, and corrosives are problems which must be handled in the manufacture of the meter. The manufacturer must also produce a meter which will have very little variation in measurement with changes in viscosity or from normal wear. Meters meeting these conditions have been designed and are on the market, giving good operation for long periods of time without necessity of calibration or repair. However, it should be remembered that the positive displacement meter operates under severe conditions at the best. Bearings receive no lubrication except from the liquid passing through the line, and they are subjected to the abrasives contained in the liquid. As is the case with any piece of mechanical equipment, speed of operation is an important factor with regard to rate of wear.

The economies of metering are not only dependent on good design and manufacture, but also on proper operation and maintenance. A. H. N.

**774.* Load and Power Needs of East Texas Wells.** G. Weber. *Oil Gas J.*, 21.3.40, **38** (45), 52.—Tabulated data and a discussion are given for forty-two wells in East Texas. The well data comprise pump-bore, rod-string size and length, strokes/min., stroke length, barrels of fluid lifted/hr., dynamometer loads for maximum and minimum values, calculated maximum load, average horse-power, and peak horse-power. The data show a wide variety of combination of pump and rod size, pump depth, speed, length of stroke, and fluid lifted.

The survey shows that actual loads are substantially less than calculated loads, using the established formula derived from A.P.I. specifications. A. H. N.

**775.* Some Practical Aspects of Water Flooding.** L. C. Converse and R. R. Hawkins. *Oil Gas J.*, 21.3.40, **38** (45), 54.—*Paper presented before American Petroleum Institute.* The paper opens by giving statistics of flooding operations in two States of America. For analytical purposes floods which were started prior to 1938 only are considered, as there is sufficient background to estimate fairly accurately the total amount of oil each will make. Comparisons are made between Oklahoma and Kansas operations.

The reasons for comparative early failure of flooding in these two States are discussed. Lack of experience appears to be the major cause.

Some of the specific causes of failure, which again come back to lack of experience, are: (1) too low saturation; (2) channelling by previous air-repressuring operations; (3) too wide spacing for the viscosity found; (4) too high and improper setting of packers in input wells; and (5) failure to use proper pressures. These five items are discussed in detail.

Graphs are given in an attempt to answer the question of how low a recovery per acre can be successfully flooded. Using set conditions of permeability, viscosity, pressure, and time, the first graph shows spacing *vs.* depth under flowing conditions. A second figure gives the maximum amount of oil which must be recovered under these conditions to break even with oil at $1/brl. The method and characteristics of the graphs are detailed. A. H. N.

**776.* Plugging Off Bottom-Hole Water in Arbuckle Lime Horizon.** J. N. Miles. *Oil Gas J.*, 21.3.40, **38** (45), 57–58.—*Paper presented before American Petroleum Institute.* The conclusions reached of the recent developments in the method of plugging off bottom-hole water in Arbuckle lime are :—

(1) Salt-water encroachment can be controlled in three ways: (*a*) By amount of penetration of producing formation; (*b*) by rate of fluid withdrawal; and (*c*) by remedial work such as water shut-offs.

(2) Acid appears to be essential in shut-off work in Arbuckle lime to open the formation for penetration of cement.

(3) Wells with greater amounts of penetration and hard strata between pay-zones offer greater chances of success.

(4) Indications are that the acid reaction will take place in the water-zone in preference to the oil-zone if given an equal opportunity, and, by the same token, cement will enter the water-zone in preference to the oil-zone.

(5) One of the most attractive features of this type of job is its lower cost.

(6) The amount of success will depend largely on the care of application and the experience of the operator. A. H. N.

**777.* Metals in Production—Oil-Well Pumps.** W. L. Nelson. *Oil Gas J.*, 21.3.40, **38** (45), 62.—The requirements of metals used in pumping equipment are discussed. The parts that are subject to the most severe conditions are the balls and seats of valves, pump barrels, pump plungers, pump liners, and the cages or crowns which contain the valves. The types of steels employed in various parts to minimize wear are given in brief.

A table recommends special materials to be used in oil-pump barrels and plungers, valve cages or crowns, and liners, and gives the per cent. composition (C, Mn, Ni, Cr, Mo, "others"), Brinell hardness, and certain notes on their specialized properties such as "corrosion resistant," "wear resistant," etc. Eleven references are appended. A. H. N.

**778.* Devonian Well Production Decreases Rapidly.** J. McIntyre. *Oil Gas J.*, 4.4.40, **38** (47), 13.—Statistical data are given for the production per well as well as for the whole field in Devonian lime in Illinois. Over-drilling is thought to be the cause of decline in production. A. H. N.

**779.* Full-Scale Pressure Maintenance Under Way in K.M.A. Field.** D. H. Stormont. *Oil Gas J.*, 4.4.40, **38** (47), 34.—The paper describes a co-operative project which started about a year ago, and which has now reached a stage where field-wide operations are under way. When the remaining preliminaries are completed, all available gas will be processed in the field's five natural gasoline and recycling plants, and after being compressed to pressures ranging from 1200 to 1800 lb./sq. in., the residue will be returned to 100 or more input wells in the field.

Detailed charts and discussions illustrate the principles used and the operations necessary. The method of determining the correct quantity of gas to be injected is given, as well as other necessary tests. A. H. N.

**780.* Gravel-Packing Oil-Wells in Gulf Coast Fields.** M. L. Cashion and F. B. Markle. *Oil Gas J.*, 4.4.40, **38** (47), 48.—*Paper presented before American Petroleum Institute.* Gravel-packing has been used for many years in completing water-wells, but it has

been applied to oil-wells only in recent years. As the first oil-wells were gravel-packed successfully in the Gulf Coast area, this paper is a brief history of gravel-packing, with descriptions of methods and equipment developed and used in the Gulf Coast.

Gravel has been extruded successfully through perforated casing to fill the cavities formed by the production of sand. Although gravel-packing has been applied primarily to producing oil- and gas-wells, it has been used also in recycling wells, with excellent results. A. H. N.

**781.* Revised Completion Method.** E. S. Post. *Oil Wkly*, 4.3.40, **96** (13), 22–24.—The first well to be finished under the revised methods, which consist of the use of oil as a circulating medium, drilling-in under pressure and acidizing, flowed at the rate of 895·56 brl. of pipe-line oil per day through 1-in. choke. Several weeks after its completion, the test was maintaining its flow and pressure, suggesting that the output will be sustained, although it was situated between several previously completed wells which failed to do so. The producing formation is the Austin chalk.

The full circulation of oil while drilling caused the chalk cuttings to be removed readily and not dissolved to wall up the face of the hole. It is believed that the low permeability of the chalk-producing horizon is lessened to nil by drilling mud, or by the paste created in dilution of the formation itself.

A sectional elevation is given of the special christmas tree installed, which was fitted with ram-type stuffing-box which acted as a preventer and an oil saver while drilling. Details of operations are also included. A. H. N.

**782.* Derrick on Wheels Services Five Wells.** Anon. *Oil Wkly*, 4.3.40, **96** (13), 26.—A derrick has been equipped with small wheels, enabling it to be pulled along rails and be spotted over any one of five closely spaced pumping wells. Small cable winches or reels, each fitted with a double handle for two-man operation and mounted on pieces of upright anchored casing, easily pull the derrick to any desired position when a well has to be worked on. The rails are embedded in the concrete flooring that is common to the five wells. A. H. N.

**783.* Distribution of Allowables in East Texas Field.** I. I. Gardescu. *Oil Wkly*, 11.3.40, **97** (1), 10–11.—An attempt is made to answer the question: "On what basis should production be distributed among the wells in East Texas if the allocation problem is confined to the legal rights of oil ownership?"

Legal rights of oil ownership are summarized under four headings, and their aspects and influence on production rates of wells and fields are discussed.

Allocation of production under a simple plan is outlined. In this plan present daily allowable of the western marginal wells will be increased to about twenty-three brl. and up. The wells to the east will receive somewhat less than their present allowable, but their ultimate recovery will be greater than the computed volume of recoverable oil in place.

The leases and wells in the fairway will receive a share of the oil that will be as nearly as possible equivalent to their reserve of recoverable oil. A. H. N.

**784.* Principles Underlying Equitable Withdrawals of Oil.** S. F. Shaw. *Oil Wkly*, 11.3.40, **97** (1), 12–18.—The most contentious phase of the subject is that of the quantity of oil which may be produced from a given well. The methods of withdrawals should not be such as to allow one operator to withdraw much greater percentages of his recoverable oil during a given period than an adjacent operator, since this tends to lower the pressure in the area heavily produced to a lower point than in the nearby sector, and thereby causes oil in the adjacent property to flow into the area where production is proceeding at a high rate.

The statement often made that the law of capture is inequitable is discussed. It is shown that this rule or principle of capture still exists, and will continue to exist, regardless of statutes enacted to prevent or to modify its operations. Many cases are cited in detail where it is impossible to prevent the operation of this principle. This is because it is impossible to enact and enforce a law limiting the oil that an operator produces under any and all conditions to only that portion lying under his acreage.

Oil and gas will always tend to flow towards a property where a lower pressure exists than in the place they happen to be.

The quantity of oil in a reservoir, usually considerably greater than that which will be recovered, depends on several factors, the most important of which are :—

(1) thickness of the producing formation ;
(2) porosity of the producing formation ;
(3) percentage of saturation of the formation ;
(4) percentage of the producing formation occupied by oil, gas, and water.

Recoverable contents depend on the four factors mentioned, and

(5) pressure in the reservoir, principally a factor of depth ;
(6) permeability of the formation ;
(7) economics.

The complex inter-dependence of these factors and the way they affect the recoverable quantity of the oil in a reservoir are discussed. Methods of measuring well potentials are critically reviewed and compared for accuracy and equity. Well-spacing problems are analyzed with a view to obtaining optimum recovery values.

Finally, methods employed for establishing daily allowables when operations are curtailed are reviewed and a new method is suggested. This method, briefly, is to calculate the square root of the acreage allotted to each well and multiply this factor by the twenty-four-hour potential of the well, thus arriving at the well factor. The method is illustrated by an example. A. H. N.

**785.* Shock Absorbers for Oil Well Shooting.** J. R. Cozzens. *Oil Wkly*, 11.3.40, **97** (1), 35.—In many cases of shooting wells, the wells fail to respond to the effects of the shots in terms of increased production. After many tests it has been proved that a cause for such failure is the sand-breaking at the bottom of the well, thus allowing fluid to escape through the shales underneath. The damage can be remedied by the use of concrete ; but prevention of its happening is the best course to follow.

To prevent breaking up of the lower formations a shock absorber is placed below the charge. This is of about 3 to 6 ft. of short-fibred asbestos or rockwood insulation material placed in a pocket drilled at the bottom of the well and tamped heavily from bottom to top. The tamping is done by means of a shield placed over the cutting edge of a drill bit.

This comparatively small quantity of shock absorber has been found sufficient to break the rhythmical vibrations at firing time, and to minimize the effects of the downward force of the blast. Stray fibres are removed by suction bailing during the cleaning-out process, and do not interfere in pumping the well. A. H. N.

**786.* 1940 World Production Likely to Exceed '39 Peak.** L. J. Logan. *Oil Wkly*, 18.3.40, **97** (2), 47–49.—Analysis of world crude production is made and certain forecasts are presented for 1940. A chart gives the distribution of world production in 1939 for different continents and countries. A. H. N.

**787.* Production and Drilling Gains Spur Canada.** Anon. *Oil Wkly*, 18.3.40, **97** (2), 164.—A study of production and drilling activities in Canada in recent years is made in this, one of many papers in the international number dealing with similar problems all over the world. A. H. N.

**788.* Taking the Pulse of the Pumping Well.** D. O. Johnson. *Oil Wkly*, 25.3.40, **97** (3), 19 ; also *Oil Gas J.*, 21.3.40, **38** (45), 46.—*Paper presented before the American Petroleum Institute.* Taking the pulse of the pumping well offers a procedure for materially reducing pumping costs on many operations. In planning such efforts, well studies should first be classified as to purpose, that is, as to whether the problem is to eliminate equipment failures, to improve efficiency, or to gather important data useful as a guide in the selection of new equipment. Consideration should then be given to the type of well to be dealt with so that limitation may be better defined. This means knowing whether the well is operating to the capacity of the equipment, or to the capacity of the well, or whether it is prorated.

When interpreting the dynamometer card in such work it should be borne in mind

that the load recorded is really the dead-weight load plus or minus the relative acceleration of the hanger and polished rod, and that acceleration forces can come from the stored energy in rod-strings as well as from the hanger. This principle explains many peculiar cards and allows a further exploitation of the information dynamometer cards contain, to effect improved pumping results. Mature experience in this type of work indicates that there is a large field for its further expansion, and that what we know to-day is only a forerunner of to-morrow's possibilities, and that the original method of lifting oil, although it has undergone much improvement, can still further be improved to meet pumping conditions and the need for lower pumping costs.

The paper is generously illustrated by figures of dynamometer cards and their interpretations. A. H. N.

**789.* Gun Perforations and Acidization in Open Formation of the Limestone Pays in the Peruvian Basin.** J. A. Jones. *Oil Wkly*, 1.4.40, **97** (4), 19–21.—*Paper presented before American Petroleum Institute.* It is stated that in most wells in the area under discussion there is a very thick producing zone with great variation in saturation, porosity, permeability, and density between the top and bottom of each zone, and that any type of completion in such wells that involves the section as a whole may not give the best results.

Selective gun perforations of the saturated zones, according to the formation variations as indicated by cores or drilling rate curves—concentration of shots in the more dense sections—greatly increase the surface exposed to acid action. The channels and crevices created by the bullets affect the permeability factor by connecting the separated pore spaces and giving increased outlets to the bore.

Acid treatment following gun perforations has given excellent results in increasing the potentials and rates of recovery in a high percentage of the wells to which this technique has been applied. The author explains the method and includes tables and comparisons of results obtained on sixteen typical wells. A. H. N.

**790.* Locating and Counterbalancing Central Pumping Powers.** S. J. Pirson. *Oil Wkly*, 1.4.40, **97** (4), 28.—Attention is focused in this long paper on the application of dynamometer cards to the study of central pumping power problems, and particularly to the application to the reduction of pumping costs by permitting a reduction to a minimum of the necessary prime-mover powers. The method used is to solve the following problem, graphically and in a complete manner: "Being given the lease lay-out, represented by a figure, and having five wells, A, B, C, D, E, individually pumped and for which the individual dynamometer cards are given by other figures, it is desired to replace the individual pumping units by a central power whose location and counterbalance for minimum power consumption is to be determined."

To obtain the satisfactory location, a method of successive approximations is used and the location is found in two steps. This point being found in the first half of the paper, the loads of the wells are balanced against each other and the off-balance power is determined, and finally a counter-balance load is located to bring all the loads into balance. A. H. N.

**791.* Factors that Determine Profitable Secondary Recovery.** R. T. Zook. *Petrol. Engr*, March 1940, **11** (6), 23–26.—The paper is an informal and detailed discussion on the procedure and various observations involved in appraising the factors that determine profitable secondary recovery. It deals more particularly with water-flooding operations.

Typical values for costs encountered in water-flooding, in terms of cents/brl. of water pumped in and of oil recovered, etc., are given. An average cost in Pennsylvania in operating 1800 wells at an average depth of 1600 ft. has been, over a period of ten years, 37 cents/brl., exclusive of taxes and overhead charges. The balance of cost of operation against profits is given for various cases.

Coring, its cost per foot, types of bits used, and the information to be gained therefrom are detailed. Porosity, permeability, oil and water saturation are discussed and their significance in water-flooding is illustrated by reference to typical examples in accepted practice. The variation in permeability of the sand is of particular importance, and extensive coring is advocated in order to be in a position of obtaining optimum values from flooding or other secondary recovery operations. Typical cases

of sands with streaks of high and low permeabilities are discussed. Where the soft streak is between two hard streaks, the use of compressed air to create "Jamin" action has been found definitely helpful.

The theoretical bottom-hole pressure possible to use for water is 1 lb./ft. of depth. In practice, twice this amount is permissible. Greater pressures appear to lift the crust of the earth, creating a crevice in which the water passes instead of going through the sand. On release of pressure the strata subsides to the original level.

A discussion of the requirements of pressure equipment and well spacings then follows. Development costs and the great importance of coring and organizing research work form the concluding part. A. H. N.

**792.* Zinc Guides Reduce Electrolytic Pitting in Sucker Rods.** H. L. Flood. *Petrol. Engr*, March 1940, 11 (6), 31–32.—Tests of zinc rod guides are being made in West Texas with the view of eliminating sucker rod breakages, or at least reducing their frequency. Moulded on the rods at intervals as guides, the zinc serves to "feed" the current rather than permit the discharge of current from and the resultant pitting to occur in the steel itself.

In the tests it was observed that (1) the zinc should be pure, and (2) the behaviour and condition of the zinc guides should be studied closely by pulling the rods frequently. Two precautions were found necessary: (1) The rod surface must be clean to insure a satisfactory contact between the zinc and steel, and (2) the rod and mould must be preheated.

The results show that the process is worth while continuing, but only as a last resort in wells giving the maximum amount of trouble. It is also concluded that frequent inspection is essential, even in the apparent absence of troubles.

A graph of rod-break frequency in one well is given for rods with and without zinc guides. The average number of days the rods were operated was about four times as great for the former case as for rods without zinc guides for all break numbers from 1 to 11. A. H. N.

**793.* Fundamental Phase Behaviour of Hydrocarbons.** J. E. Sherborne. *Petrol. Tech.*, Feb. 1940, A.I.M.M.E. Tech. Pub. No. 1152, 1–15.—The phase rule is discussed for a one-component system and extension is made to a pressure–temperature–specific volume diagram. In general only liquid, liquid–vapour, and vapour phases need be investigated in considering hydrocarbon reservoir systems. For a two-component system the phase rule shows that it is possible for four phases to co-exist, but no case has yet been found of more than two liquid phases co-existing. The discussion here is limited to systems with only one liquid phase, although the production of oil from deeper zones of higher pressure and temperature may disclose the co-existence of two or more liquid phases. In a reservoir hydrocarbon systems are considered to consist of varying mixtures of the component natural gas and the component crude oil. The pressure–temperature–composition diagram is examined for a two-component system with only one liquid phase, and the significance of dew- and bubble-points are indicated. The conditions obtaining in production are discussed in the light of these equilibrium diagrams. G. D. H.

**794.* Disposal of Salt Water in the East Texas Field.** A. S. Rhea and E. B. Miller. *Petrol. Tech.*, Feb. 1940, A.I.M.M.E., Tech. Pub. No. 1151, 1–10.—Some 200,000 brl. of salt water/day are produced in the East Texas field, and it is expected that the amount will eventually rise to 700,000. In the early days some water was disposed of by surface methods, but they were not satisfactory. By returning water to the Woodbine sand pressure is maintained, and in the absence of plugging material and if average permeability is encountered, it is unnecessary to use extraneous pressure for water injection.

As a protection to surrounding production water is injected at a point below the oil–water contact and below a shale break or other impervious barrier to prevent upward migration. In the first disposal plant the closed system was used, but proved impracticable. Tests showed that chemical treatment of the water was necessary, and the open system was adopted. The iron content must be reduced to a negligible figure and bacteria must be eliminated. The aerated water is corrosive, and hence all iron and steel must be protected. Care must be taken in completing injection wells.

The disposal of salt water by injection seems economically possible, but the data are insufficient to determine the cost/brl. yet. G. D. H.

**795.* Gas Injection at Loudon, Illinois.** R. J. Sullivan. *Petrol. Tech.*, Feb. 1940, A.I.M.M.E. Tech. Pub. No. 1173, 1–15.—The Loudon pool on the western rim of the Illinois Basin's deeper part is 15 ml. long and 3½ ml. wide. Three horizons—Weiler sandstone at 1390 ft., Paint Creek sand at 1460 ft., and Benoist or Bethel at 1500 ft.—in the Chester (Mississippi) series are productive. There are wide variations in the permeability, porosity, and thickness of the sands. The pool is generally anticlinal.

The history of the development and production of the pool is given. 25% of the wells still flow. Gas injection has been adopted on some properties to supplement natural energy, so as to drive underground oil while it is in its most fluid state, to avoid at the same time the drilling of unnecessary and even harmful wells, and to conserve and process a meagre gas supply before it has been dissipated. Pressure decline is expected to be rapid. Well spacing ranges from 5 or 6/acre to 1 to 20 acres where gas injection can be applied.

Gasoline is removed from the gas and the latter is then compressed to 750 lb./in.$^2$. Data are given of the volumes injected, pressures, etc., and there are gas potential maps. The best results are obtained in regions of high sand permeability. The results to date are encouraging, and no channelling has been encountered. G. D. H.

**796.* Recent Changes in California Voluntary Oil-curtailment Methods.** J. Jensen. *Petrol. Tech.*, Feb. 1940, A.I.M.M.E. Tech. Pub. No. 1153, 1–13.—The formula now applied in California establishes the allotment for all wells by giving consideration to three items only: (1) A graduated minimum allotment based on the depth of the well; (2) a remaining allotment derived by applying a power factor to the potential of the well remaining above its minimum allotment; (3) a top allotment for the larger wells which varies according to the demand for oil or the outlet for oil that is produced. The first item recognizes the increase in drilling and pumping costs for deep wells. This item is fixed, but the others are varied from time to time according to conditions. The total lease allotment is the sum of the individual well allotments, and may be produced as the operator pleases so long as he does not produce in a way offensive to his neighbours.

Oil curtailment would be relatively simple if it were not necessary for the old wells to give up allotment to permit the new wells to produce. The new formula has ameliorated this problem to some extent. It applies the burden uniformly and there are no favourites. G. D. H.

**797.* Government Oil-field at Tupungato, Mendoza.** Anon. *Bol. Inform. Petroleras*, Dec. 1939, XVI (184), 3–4).—The last of the four wells, T.19, T.20, T.21, and T.22, which only came into production in October 1939 with an output of 939 m.$^3$, produced in November the large quantity of 10,690 m.$^3$ at a depth of 2048 m. Total output for 1939 up to November came to 106,494 m.$^3$, with the result that owing to lack both of sufficient transport and storage space, the output has to be restricted. H. I. L.

**798. Application of Well-Test Data to the Study of a Specific Gas-Production Problem.** M. A. Schellhardt, U. J. Dewees, and W. H. Barlow. U.S. Bureau of Mines: *Report of Investigations No.* 3493, March 1940.—The Lone Star Gasoline Company's A. Jones No. 1 gas well in the Sumrall Survey, Buffalo Field, Texas, was completed in 1934, and subsequently showed an abnormal decline in shut-in pressure during a period when a negligible volume of gas was being withdrawn from the reservoir. The only other well in the southern part of the field (A. Beggs No. 1) which was believed to produce from the same reservoir showed no such unaccounted-for decline during the period of reduced pressure in the Jones well. It was, therefore, considered probable that subsurface leakage from the casing or, alternatively, migration of gas from the reservoir to shallower porous strata through channels outside the casing were responsible for the decline in Jones No. 1 well. A study of conditions in this well was conducted under a co-operative agreement between the Bureau of Mines and the American Gas Association. The first part of the investigation included recordings of subsurface temperatures when wellhead connections were closed, and confirmed that gas was

migrating into a shallower stratum at about 2200 ft. below derrick-floor datum. Surface and subsurface pressures, temperatures, and fluid recoveries under different operating conditions in the Jones well were subsequently compared with those of the Beggs well. The report embodies the data obtained from these investigations, and illustrates in particular the value of subsurface temperature data in the study of subsurface leakage from gas wells. H. B. M.

**799. Production Patents.** A. L. Parker. U.S.P. 2,191,582, 27.2.40. Appl. 8.6.37. Tube coupling.

A. S. Gould, W. M. Emery, and R. E. Hyde. U.S.P. 2,191,692, 27.2.40. Appl. 16.3.39. Pipe-line working tool for cutting and threading pipe.

R. W. Lohman. U.S.P. 2,191,765, 27.2.40. Appl. 2.7.38. Temperature indicator for wells using a helical resistance coil which changes its resistance with change in temperature.

G. F. Turechek. U.S.P. 2,191,781, 27.2.40. Appl. 26.4.39. Pressure compensator for gun perforators.

K. Koller. U.S.P. 2,192,011, 27.2.40. Appl. 30.6.37. Apparatus for preventing condensation in gas mains using a burner which draws gas from the line, burns it, and returns hot products of combustion into mains.

W. C. Nalley. U.S.P. 2,192,236, 5.3.40. Appl. 27.12.38. Well flowing device and method of packing off space between an upper gas sand and a lower oil sand and then using the gas to produce the oil.

C. W. Thornhill. U.S.P. 2,192,336, 5.3.40. Appl. 19.7.37. Screen packer.

P. C. Norman and K. C. Norman. U.S.P. 2,192,480, 5.3.40. Appl. 13.1.38. Apparatus for raising liquids from wells by an air lift pump and a non-return valve.

L. Bryan. U.S.P. 2,192,484, 5.3.40. Appl. 24.10.38. Pipe coupler.

G. E. Szekely. U.S.P. 2,192,565, 5.3.40. Appl. 6.4.38. Threaded follower pipe joint or fitting.

F. I. Alexander. U.S.P. 2,192,591, 5.3.40. Appl. 13.9.38. Casing perforating gun.

L. M. C. Seamark. U.S.P. 2,192,805, 5.3.40. Appl. 18.3.36. Casing-head equipment for bore-holes or wells.

H. R. Toney. U.S.P. 2,192,945, 12.3.40. Appl. 15.8.38. Oil well bottom release valve.

H. D. Collins. U.S.P. 2,193,020, 12.3.40. Appl. 14.2.38. Fluid pump construction.

K. T. Penick. U.S.P. 2,193,110, 12.3.40. Appl. 7.9.38. Blow-out preventer.

G. W. Walker. U.S.P. 2,193,150, 12.3.40. Appl. 19.8.37. Double acting pump for wells.

E. L. Wheless. U.S.P. 2,193,309, 12.3.40. Appl. 29.8.35. Method and apparatus for flowing high-pressure gas wells in which gas is suddenly expanded to freeze its water content and then melting and draining the water so formed.

P. Lazarides. U.S.P. 2,193,426, 12.3.40. Appl. 12.7.38. Pipe clamp.

J. C. Fortune and W. R. Walne. U.S.P. 2,193,587, 12.3.40. Appl. 2.1.37. Stuffing-box and tool joint combination.

E. J. Basye. U.S.P. 2,193,668, 12.3.40. Appl. 23.5.39. Apparatus for operating a well cable one end of which is connected to a work load in the well and the other to a counter-balancing weight. A reciprocating motion is imparted to the cable.

W. M. Stratford. U.S.P. 2,193,775, 12.3.40. Appl. 18.6.38. Method of treating a well on completion with a gravel pack by mixing metal carbonate with the gravel and subsequently dissolving the carbonate.

F. L. Dieterich. U.S.PP. 2,193,807 and 2,193,808, 19.3.40. Appl. 4.1.38 and 27.7.38. Cementing practice for earth wells wherein portland cement and calcium carbonate are used, the latter to be partially destroyed by acid subsequently and form a porous material.

F. H. Hohemann. U.S.P. 2,193,922, 19.3.40. Appl. 15.11.37. Valve and flexible gate.

V. H. Gilliland and J. J. Graham. U.S.P. 2,194,017, 19.3.40. Appl. 24.10.36. Apparatus for producing oil, comprising a pump with a gas anchor in which oil and gas are intimately mixed.

B. H. Scott. U.S.P. 2,194,154, 19.3.40. Appl. 22.7.35. Deep well pump.

N. Johnston and R. V. Quinn. U.S.P. 2,194,229, 19.3.40. Appl. 15.10.38. Apparatus for examining a well casing magnetically.

W. E. King and J. S. Abercrombie. U.S.P. 2,194,254, 19.3.40. Appl. 14.1.29. Pressure equalizer for blow-out preventers.

H. Allen. U.S.P. 2,194,255, 19.3.40. Appl. 4.2.36. Blow-out preventer.

H. Allen. U.S.P. 2,194,256, 19.3.40. Appl. 7.5.37. Multiple seal blow-out preventer.

H. Allen. U.S.P. 2,194,257, 19.3.40. Appl. 2.7.37. Ram with tapered wear plates.

H. Allen. U.S.P. 2,194,258, 19.3.40. Appl. 27.12.37. Ram with laminated plates for blow-out preventers.

H. Allen. U.S.P. 2,194,259, 19.3.40. Appl. 27.12.37. High-pressure multiple plate packing for rams, valves, and blow-out preventers.

H. Allen. U.S.P. 2,194,260, 19.3.40. Appl. 7.6.38. Single-screw blow-out preventer.

H. Allen. U.S.P. 2,194,261, 19.3.40. Appl. 7.5.37. Gate valve, seat, and packing.

H. Allen and M. T. Works. U.S.P. 2,194,262 and 2,194,263, 19.3.40. Appl. 2.7.37. Split housing manifold valve.

J. S. Abercrombie and H. Allen. U.S.P. 2,194,264, 19.3.40. Appl. 27.12.37. Manifold valve.

J. S. Abercrombie. U.S.P. 2,194,265, 19.3.40. Appl. 10.6.38. Braden head and tubing hanger.

H. Allen. U.S.P. 2,194,266, 19.3.40. Appl. 2.7.37. Non-corrosive insert seat for gate valves.

F. M. Mason. U.S.P. 2,194,561, 26.3.40. Appl. 6.12.37. Submersible structure adapted to work in wells.

W. E. Schoenock. U.S.P. 2,194,616, 26.3.40. Appl. 17.11.37. Means for operating oil wells consisting of special connections of piping.

C. J. Coberly. U.S.P. 2,194,740, 26.3.40. Appl. 22.4.37. Deep well pumping device consisting of a pump and tubings to transmit actuating fluid to, and pumped fluid from pump.

A. K. Wise. U.S.P. 2,196,134, 2.4.40. Appl. 31.1.39. Paraffin cutting and scraping tool consisting of a body and radially disposed fins and a scraper which assumes a horizontal position on the upstroke and a vertical one on the downstroke.

A. H. N.

## Transport and Storage.

**800.* Expansion Roof Effects Economy in Storage of Gasoline.** C. L. Marner. *Oil Gas J.*, 22.2.40, **38** (41), 22.—Tests have been carried out during a thirty-day trial in a special gasometer unit connected to several gasoline tanks in order to obtain data on storage losses during breathing. Hourly records were obtained of atmospheric liquid and vapour temperatures, gasoline and vapour inventory in cubic feet, and the amount of expansion and contraction of vapours above the liquid level of gasoline in the tanks. The principal factors governing the rate of evaporation of the liquid are: Surface temperature, which causes increase or decrease of the pressure of the air–vapour mixture above the liquid fuel—hence the rate at which transition from liquid to vapour takes place; area of evaporation surface and renewal of air over the evaporating surface. It was found that the surface temperature of the gasoline in the tanks was approximately the same as the outside shade temperature, but that there is a time lag when the atmospheric temperature changes. Data are tabulated showing the gasoline content of air vapour mixtures at various surface temperatures, and pressures based on gasoline of 9 lb. Reid V.P. at 100° F., and a diagram reproduced showing the effect of surface temperature of liquid on the expansion of the vapour. C. L. G.

## Crude Petroleum.

**801. Survey of Crude Oils of the Producing Fields of Arkansas.** O. C. Blade and G. C. Branner. U.S. Bureau of Mines: *Report of Investigations No.* 3486, Jan. 1940.—The oil-fields of Arkansas are situated in the southern part of the State and have proved an important factor in development of the northern coastal plain region of the Mid-Continent area. Up to the end of 1938 the region had produced a total of 480,167,560 brl. of crude oil, peak annual production being attained in 1925. Producing fields can be divided into two groups—those developed prior to 1936 wherein the oil is derived almost entirely from Upper Cretaceous formations, and those developed subsequently, largely owing to successful results of geophysical exploration. The later discoveries have been made by deeper drilling, and production is from the Lower Cretaceous and older rocks. The characteristics of the several crude oils examined to a large extent reflect the different geological conditions of oil occurrence.

This report describes the principal oil-fields of the State with reference to forty-five samples of typical crude oils obtained therein. The most prominent property is a high sulphur content; out of the forty-five samples analyzed, thirty-five have 0·7% sulphur or more, the average for all being 1·51%. Other chemical and physical properties change as the sulphur content varies. In classification the largest number of samples is in the intermediate base group, the second largest being naphthene intermediate oils; paraffin and naphthene base types *per se* are, however, also produced.

H. B. M.

## Gas.

**802.* Hydrogen Sulphide Detector.** F. B. Behrens. *Oil Gas J.*, 28.3.40, **38** (46), 86.—A description is given of a hydrogen sulphide detector and alarm based on the operation of a photo-electric cell, a strip of moist lead acetate paper being placed between the light source and the cell. Samples of gas are taken from fifteen different stations at a rate of 20 cu. ft. per min. and passed through the indicator box, the formation of appreciable quantities of lead sulphide shutting off light from the cell and operating the alarm. A micro-ammeter enables an accurate determination of the $H_2S$ content well below the danger point. The instrument has been in operation for well over a year without requiring attention, except for renewals of paper tape and chemical.

C. L. G.

## Cracking.

**803. Catalytic Cracking of Hydrocarbons.** G. Egloff, J. C. Morrell, C. L. Thomas, and H. S. Bloch. *J. Amer. Chem. Soc.*, 1939, **61**, 3571–3580.—The effect at atmospheric temperature of an activated silicon–alumina mass on the reactions of some aliphatic

hydrocarbons was studied under conditions which allowed comparisons between (1) the catalyzed and the uncatalyzed reactions, (2) the cracking of paraffins and olefins of the same chain length, and (3) homologues in both the paraffin and the olefin series. *n*-Butenes were passed over the catalyst at temperatures between 385° and 600° C., and considerable polymerization to materials of high b.pt. and decomposition to lighter gases accompanied isomerization to *i*-butene. At flow rates of 200–230 volumes of gas per volume of catalyst per hour, the isomerization did not change with temperature between 450° and 600° C.; the production of *i*-butene was 24·1% ± 1·5% of the $C_4$ fraction of the product. *n*-Pentenes yielded 50% of *i*-pentenes when passed over the catalyst at 400° C., and behaved generally in a manner similar to their lower homologues, the *n*-butenes. The effect of the catalyst on *n*-octenes was, first, an isomerization to *i*-octenes, these being principally methylheptenes dimethylhexenes and trimethylpentenes (probably by the migration both of alkyl groups and of the double bond), followed by cracking to gaseous products, consisting, in the main, of *n*- and *i*-butenes and some propene and pentenes. Between 375° and 450° C. conversion amounted to over 80%. The effect of the catalyst on cetene at temperatures between 300° and 450° C. appeared to be: (1) isomerization to more volatile branched-chain hexadecenes, either with or without migration of the double bond; (2) scission of the chain to an almost equal extent at each bond, except those near the extremities of the chain; (3) isomerization of any normally liquid olefinic products to *i*-olefines; and (4) with longer times of contact or at higher temperatures, secondary decomposition of the longer chained primary products. The catalytic cracking of *n*-octane resulted in a lower yield of methane, ethane, and ethylene, and also a higher yield of hydrocarbons with five to seven carbon atoms and of hydrogen, than obtained by pyrolytic cracking; also, it was seven to eight times more rapid. The temperature necessary was higher than that required for the catalytic cracking of the *n*-octenes. The products of the catalytic cracking of cetane, mainly $C_3$–$C_5$ hydrocarbons, were quite different from those of thermal cracking. Those products in the gasoline boiling range were a mixture of branched- and straight-chained hydrocarbons, whereas with cetene they were chiefly branched-chain. Although cetane and cetene react in the same way to pyrolytic cracking, cetane does not undergo catalytic cracking so easily as cetene.

R. D. S.

**804.* Cracking Coil Control.** C. Barnes. *Petroleum*, Feb. 1940, 1, 121.—In thermal cracking the degree of conversion taking place is a function of time, temperature, and character of charging stock. Conventional regulation of a cracking coil from temperature, pressure, and rate of change, while effectively controlling the process within definite limits, does not, in effect, control the actual degree of conversion taking place, which tends to fluctuate with different operations. Unless rate of conversion is constant, there will be a lack of uniformity in the product. To control a cracking unit to maintain a selected degree of conversion involves determination of the time the flowing fluid is in the conversion section of the coil; this has been done as a result of research by R. L. Rude on density of flowing liquids, in collaboration with the British American Oil Co., Ltd., Toronto, Canada, and the Bailey Meter Co., Cleveland, Ohio, and has resulted in the commercial production of an improved control system for cracking coils. The system is based on supplementing the usual control elements by developing a differential head across one or more orifices made at particular points on the path of the fluid. Such "flow responsive" apparatus provides data which can be interpreted as fluid density. The time of detention of the fluid in the conversion part of a coil is given by $Vd_m/W$, where $V$ is volume of the coil, $d_m$ average density of the fluid taken at inlet and outlet of the conversion section, and $W$ is the weight rate of flow of fluid through a given orifice. The relationship between weight rate $W$, orifice coefficient $C$, differential head $h$ developed across the orifice, and the density of the fluid $d$ at the orifice, is given by $W = C\sqrt{hd}$. Particulars, diagrams, and illustrations of the necessary instruments, their construction and layout, are given. H. B. M.

**805. Cracking Patents.** M. T. Carpenter. U.S.P. 2,189,196, 6.2.40. Appl. 23.11.36. Production of furnace oil from cracking-still distillates, by subjecting the distillates to polymerization at a temperature of 400–600° F. by the action of a catalyst consisting essentially of a calcined mixture of phosphoric acid and kieselguhr. The distillate is then redistilled to produce a fraction suitable for domestic furnace oil and characterized by freedom from formation of gums and non-volatile residues.

T

H. Tropsch. U.S.P. 2,194,335, 19.3.40. Appl. 21.6.35. Reforming straight-chain paraffins boiling within the gasoline range by subjecting them in vapour phase and under sub-atmospheric pressure to the action of activated magnesite at a temperature of 1200–1500° F. for a period not longer than four one-hundredths of a second.

N.V. Nieuwe Octrooi Maatschappij. E.P. 518,024, 15.2.40. Appl. 12.8.38. Process for cracking heavy hydrocarbons by introducing them in the vapour phase at a temperature exceeding 480° C., together with a heat-carrier gas into a cracking zone. The gasoline is separated by condensation from the mixture obtained, the remaining gaseous constituents with a boiling point below the range of gasoline compressed and contacted with an absorption liquid. Subsequently a rich vaporous fraction is separated off from the compressed gaseous constituents by absorption, followed by vaporization, and polymerized. H. B. M.

## Hydrogenation.

**806. Nickel as a Catalyst for the Hydrogenation of Aromatic Halogen Compounds.** C. F. Winans. *J. Amer. chem. Soc.*, 1939, **61**, 3564–3565.—The author has been enabled to hydrogenate aromatic halogen compounds containing a readily reducible group by the use of Raney nickel at temperatures below 150°C., and has found that these halogen compounds behave exactly like their unhalogenated analogues in regard to time, temperature, and effectiveness of hydrogenation. R. D. S.

## Polymerization.

**807. Preparation and Structure of High Molecular Weight Polybutenes.** R. M. Thomas, W. J. Sparks, Per K. Frolich, M. Otto, and M. Mueller-Cunradi. *J. Amer. chem. Soc.*, 1940, **62**, 276–280.—The polymerization of *iso*butene is rapid and exothermic and temperature control is important. The general effect of lowering the reaction temperature is to increase the rate of reaction and to produce a polymer of higher molecular weight than obtained by polymerization at elevated temperatures. The best catalysts are titanium tetrachloride, boron fluoride, and aluminium chloride. The lower olefins such as ethylene and propylene are apparently inert to the reaction, but certain compounds, for example, the normal butenes, act as poisons, and a product of lower molecular weight results. This is also the case with the higher olefins and, remarkably enough, the presence of small quantities of di*iso*butene or tri*iso*butene greatly decreases the yield and molecular weight of the poly*iso*butene; this seems to indicate that neither the dimer nor the trimer represent stages in the formation of high polymers. The dimers and trimers themselves do not give high polymers at low temperatures, but at room temperature polymerize slowly to oily products. Other poisons are sulphur compounds and hydrogen halides—the latter cause production of low molecular weight poly*iso*butenes, perhaps by bringing about intermediate formation of di*iso*butene. The hydro-halogen acids exert a beneficial effect upon polymerization of olefins at high temperatures, using boron fluoride as the catalyst. Temperature control being important, diluents are employed to moderate the violence of the reaction and to ensure uniformity of production. The molecular weight of the polymer increases exponentially with concentration of the diluent until 80% diluent is reached, when the molecular weight drops suddenly and precipitously. Catalyst efficiency is highest at greatest dilution, since there is then minimum occlusion of the unreacted catalyst in the diluent. In one of the experiments, at least 0·03% of catalyst was required for the reaction to commence. Generally speaking, the yields of these reactions are 90% or better, but the yield has no influence upon the average molecular weight of the poly*iso*butenes. A brief discussion on the structure of these materials is given in this paper, and the authors conclude that the polymers are linear, probably in a "head to tail" formation, although "head to head" and random structures are possible, as well as mixtures of all three types. It is assumed that all of these structures include one residual terminal double bond. R. D. S.

**808. Patents on Polymerization.** Rohm and Haas A.-G. E.P. 517,195, 23.1.40. Appl. 22.7.38. Method of polymerizing symmetrical dichloroethylene, employing as catalyst one or more peroxides, *e.g.*, benzoyl peroxide, hydrogen peroxide, or tetrahydro-naphthalene peroxide.

Rohm and Haas A.-G. E.P. 517,213, 23.1.40. Appl. 30.8.38. Production of technically valuable chlorinated hydrocarbons, including the step of polymerizing trichlorethylene, using one or more inorganic or organic peroxides as catalysts. High molecular products are not obtained to any appreciable extent, the products being essentially dimeric and trimeric fluid products and little higher polymeric products.

I.G. Farbenindustrie A.-G. E.P. 517,799, 8.2.40. Appl. 6.12.38. Catalytic polymerization of low molecular olefines or mixtures containing same to liquid hydrocarbons in the presence of phosphoric acids or phosphoric acid anhydride. An admixture of free metals which are less electro-positive than hydrogen is used with the acids in finely-divided form.

I.G. Farbenindustrie A.-G. E.P. 518,054, 15.2.40. Appl. 17.10.38. Process for the polymerization of olefines having tertiary carbon atoms, with sulphuric or phosphoric acids of medium or high concentration. The olefines, if desired in admixture with other unsaturated or saturated hydrocarbons, are allowed to trickle with the acid through high reaction chambers charged with filler bodies or other materials having a dispersing action. Thereafter the layers of the reaction product formed by sedimentation are separated from each other.

Sinclair Refining Co. E.P. 518,163, 20.2.40. Appl. 17.5.38. Improved process for the production of polymerized olefins from hydrocarbon gas mixtures containing olefins. A gaseous mixture containing a substantial amount of normally gaseous higher olefins is passed at a temperature not substantially in excess of 550° F. in contact with a polymerization catalyst such as solid phosphoric acid deposited on silica.

I.G. Farbenindustrie A.-G. E.P. 518,558, 29.2.40. Appl. 5.9.38. Process for the catalytic depolymerization of polymers of low boiling mono-olefines by working in the presence of appreciable amounts of steam.

R. F. Ruthruff. E.P. 518,749, 6.3.40. Appl. 1.9.38. Polymerization of olefinic hydrocarbons by contacting at an elevated temperature with a solid catalyst composed of a mixture of pyrophosphate and an inactive substance.

J. W. C. Crawford. E.P. 518,970, 13.3.40. Appl. 5.9.38. Manufacture of polymerization products from alpha-chloroacrylic acid and its esters. H. B. M.

## Synthetic Products.

**809. Patents on Synthetic Products.** Studien- und Verwertungsgesellschaft mit Beschrankter Haftung. E.P. 517,002, 17.1.40. Appl. 27.7.38. Production of paraffin wax from gases containing carbon monoxide and hydrogen, using catalysts of cobalt or a mixed catalyst containing cobalt at a temperature below 200° C. and under a pressure of at least two atmospheres.

E. I. Du Pont de Nemours & Co. E.P. 517,143, 22.1.40. Appl. 19.7.38. Production of mono- and dimethyl formamides by reacting methanol with carbon monoxide and ammonia at a temperature between 150 and 300° C. and at a pressure of 300 to 1000 atmospheres.

Armour & Co. E.P. 517,247, 24.1.40. Appl. 31.8.38. Preparation of di-esters of unsaturated glycols by reacting a fatty acid chloride having 12–18 carbon atoms with an inert solvent.

Carbide and Carbon Chemicals Corporation. E.P. 517,332, 26.1.40. Appl. 23.7.38. Process for activating silver surface catalysts, particularly for use in effecting the direct chemical combination of olefines with molecular oxygen to form olefine oxides. The silver is treated with ozone and water vapour to form silver peroxide and the ozonized silver thereafter so treated as to alter chemically the silver oxide and form an active surface catalyst.

Carbide and Carbon Chemicals Corporation. E.P. 517,333, 26.1.40. Appl. 23.7.38. Improvements in the process of making olefine oxides by direct catalytic oxidation of olefines by means of molecular oxygen.

D. J. Branscombe and Imperial Chemical Industries. E.P. 517,382, 29.1.40. Appl. 25.7.39. Manufacture of new iodinated esters by causing a saturated or unsaturated aliphatic alcohol containing at least three carbon atoms to interact with a mono- or polyiodo-aromatic homocyclic or heterocyclic carboxylic acid, or with the acid halide of such an acid, or alternatively by causing a halogen ester of the said alcohol to interact with a neutral salt of the said acid.

E. I. Du Pont de Nemours. E.P. 517,582, 2.2.40. Appl. 29.7.38. Preparation of new dihydropolycyclic aromatic hydrocarbon-sulphur reaction products and a lubricating compound containing these products as lubricant assistants.

I.G. Farbenindustrie A.-G. E.P. 517,673, 6.2.40. Appl. 3.8.38. Manufacture of 1-amino-2-chloro(or bromo)-4(or 6)-nitrobenzene-6(or 4)-sulphonic acid, wherein a 4(or 6)-nitrobenzene-6(or 4)-sulphonic acid, containing a halogen atom in 1-position and in 2-position a chlorine or bromine atom, is treated with ammonia.

I.G. Farbenindustrie A.-G. (E.P. 517,674, 6.2.40. Appl. 3.8.38. Manufacture of 2-chloro(or bromo)-4(or 6)-nitro-1-aminobenzene-6(or 4)-sulphonic acid, wherein 4(or 6)-nitro-1-aminobenzene-6(or 4)-sulphonic acid or a salt thereof is treated in water or an aqueous salt solution or an inert organic solvent at ordinary or reduced temperature with elementary chlorine or bromine.

I.G. Farbenindustrie A.-G. E.P. 517,685, 6.2.40. Appl. 3.8.38. Manufacture of *α*-halogenvinyl methyl ketones by causing hypochlorous acid or hypobromous acid to react on vinyl methyl ketone and splitting off water from the condensation products thus obtained by steam distillation.

I.G. Farbenindustrie A.-G. E.P. 517,692, 6.2.40. Appl. 4.8.38. Manufacture of β-indole acetic acids by reacting an indole which is unsubstituted in the β-position to the nitrogen atom with formaldehyde and hydrocyanic acid or a salt thereof and then saponifying the β-indole acetic acid nitrile to the corresponding carboxylic acid.

The Distillers Co., Ltd. E.P. 517,740, 7.2.40. Appl. 3.8.38. Manufacture of formaldehyde from carbon monoxide and hydrogen or a gas mixture containing them, by the joint action of heat and a catalyst. The catalyst is prepared from nickel as pure as possible with which has been incorporated up to 5% of one or more activators, *e.g.*, zinc, lead, manganese, magnesium, iron, silicon.

N.V. de Bataafsche Petroleum Maatschappij. E.P. 517,758, 7.2.40. Appl. 4.8.38. In the manufacture of *iso*butane from normal butane the normal butane or normal butane-containing mixtures not containing substantial proportions of olefines are passed continuously in the gaseous phase at temperatures below 200° C., over a solid catalyst. The catalyst consists of aluminium chloride mixed with or brought on to a carrier substance with such a short contact time that substantially no decomposition and formation of higher boiling products takes place.

James Anthony and Co. E.P. 517,793, 8.2.40. Appl. 6.8.38. Improvement in the manufacture of organic acids by fermentation of carbohydrates by a mycelium-producing mould. The nutrient solution for the fermentation is treated before it is inoculated with the ferment with an agent which destroys vitamins or other growth stimulants.

G. L. Stahly and W. W. Carlson. E.P. 517,820, 9.2.40. Appl. 4.8.38. Production of a benzyl ether of dextran by reacting dextran with a mixture of benzyl halide, an

alkali hydroxide, and water, and continuing the reaction until a dextran ether derivative soluble in acetone is obtained.

Boots Pure Drug Co., Ltd. E.P. 518,149, 19.2.40. Appl. 21.9.38. Preparation of mono-chlorinated derivatives of ethylene in which the other three hydrogen atoms of the ethylene are substituted by the same or different aromatic groups. The corresponding triaryl ethylene dissolved in a suitable solvent is treated with chlorine.

N.V. de Bataafsche Petroleum Maatschappij. E.P. 518,325, 23.2.40. Appl. 7.9.38. Production of unsaturated halogen-containing derivatives of propene, preferably allyl chloride, by dehydrohalogenation of a polyhalogen propane capable of splitting off hydrogen halide (*e.g.*, propylene chloride). The vapours of the polyhalogen propane are subjected to a temperature above 450° C. for a length of time sufficient to dehydrohalogenate about 40% of the polyhalogen propane.

G. W. Johnson. E.P. 518,372, 26.2.40. Appl. 22.8.38. Improvements in the synthesis of hydrocarbons with more than one carbon atom in the molecule and contingently minor amounts of liquid or solid oxygen-containing derivatives thereof by conversion of carbon monoxide with hydrogen. Gases already subjected to the reaction are returned to the reaction space, the volume per unit of time of the gases returned being at least twenty times that of the fresh gas introduced.

Universal Oil Products Co. E.P. 518,392, 26.2.40. Appl. 15.9.38. Hydrogenation of octanes by subjecting their vapours in admixture with a molal excess of hydrogen of less than 60% to contact with a catalyst comprising reduced nickel at a temperature between 170 and 215° C. under a pressure of from atmospheric to 14·1 kg. per cm. The time of contact corresponds to liquid space velocities of approximately four per hour.

W. G. Groves. E.P. 518,450, 27.2.40. Appl. 29.9.38. Manufacture of alkyl substituted phenols of the benzene series by subjecting the sodium salt of the aromatic sulphonic acid corresponding with the desired phenol to fusion with sodium hydroxide in the presence of the sodium salt of another aromatic sulphonic acid or the sodium salt of a phenol.

G. W. Johnson. E.P. 518,605, 1.3.40. Appl. 15.7.38. Production of liquid hydrocarbons by the catalytic conversion of carbon monoxide with hydrogen. Cyclic hydrocarbons are added which are vaporized to a substantial extent under the reaction conditions.

Studien- und Verwertungsgesellschaft. E.P. 518,614, 4.3.40. Appl. 30.7.38. Hydrocarbons which are solid, liquid, or readily liquefiable can be produced from gases containing carbon monoxide and hydrogen in equal amounts or more carbon monoxide than hydrogen, under pressures between two and ten atmospheres and at temperatures below 320° C. in the presence of iron catalysts, if the catalysts are pretreated with gases containing carbon monoxide under normal pressure or some pressure which is lower than that used in the subsequent production of hydrocarbons.

I.G. Farbenindustrie A.-G. E.P. 518,656, 4.3.40. Appl. 1.9.38. Manufacture of *N*-substituted aminosulphonic acids and aminocarboxylic acids by causing a primary aminosulphonic acid or aminocarboxylic acid salt to react with an aliphatic or *cyclo*-aliphatic aldehyde or ketone and, with or without isolating the reaction product, reducing same catalytically with hydrogen.

Carbide and Carbon Chemicals Corporation. E.P. 518,685, 5.3.40. Appl. 2.9.38. Production of an alkenylbenzene at a high rate of reaction and with minimum formation of by-products and resinous materials by the dehydrohalogenation of a halogenated alkylbenzene. An α-halogenated alkylbenzene is passed into a molten catalyst consisting of an amine having at least two organic radicals attached to the nitrogen atom, each containing more than four carbon atoms. The alkenylbenzene is removed from the catalyst in the vapour phase as it is formed.

W. W. Groves. E.P. 518,697, 5.3.40. Appl. 3.9.38. Manufacture of dichlorobutenes by causing gaseous chlorine to act on gaseous butadiene in the presence of a diluent which is inert to chlorine and butadiene.

Standard Oil Development Company. E.P. 518,775, 7.4.40. Appl. 1.9.38. Preparation of alkyl phenol sulphides by heating alkylphenol together with sulphur and an inorganic compound of an alkali metal, in the presence of a non-aqueous inert solvent. Heating is continued until evolution of hydrogen sulphide ceases, and thereafter the free alkylphenolsulphide is obtained by treatment with acid.

Carbide and Chemicals Corporation. E.P. 518,823, 8.3.40. Appl. 7.8.37. Manufacture of olefine oxides by the direct chemical combination of olefines with molecular oxygen in the presence of active surface catalysts. Complete oxidation of the olefines is repressed by incorporating inhibitors with the reactants.

W. J. Tennant. E.P. 518,915, 12.3.40. Appl. 10.6.38. Preparation of $\Delta_1$-alkenyl malonic or cyanoacetic esters by the reaction of an alkylidene (other than the ethylidene) malonic or cyanoacetic ester with an alkylating agent consisting of an alkyl or aralkyl salt in the presence of an isomerization agent.

E. I. Du Pont de Nemours & Co. E.P. 518,985, 13.3.40. Appl. 12.9.38. Manufacture of benzidine by the reaction of nitrobenzene with hydrogen in the presence of a nickel catalyst and an aqueous alkaline solution. Thereafter the aniline is separated from the other reaction products and the latter converted into benzidine.

Les Usines de Melle. E.P. 518,998, 13.3.40. Appl. 4.10.38. Production of aliphatic ethers from aliphatic alcohols by subjecting the latter to an acid dehydrating process of such a nature that a relatively large proportion of the olefine is produced. The olefine is recovered, converted into alcohol, and returned to the reaction vessel.

F. J. Cahn. E.P. 519,072, 15.3.40. Appl. 13.9.38. Preparation of alkylolamine salts of lower molecular weight sulphocarboxylic esters of higher molecular weight alcohols.

B. R. Harris. E.P. 519,230, 20.3.40. Appl. 4.10.38. Conversion of a salt of a lower molecular weight sulphocarboxylic acid ester of a higher molecular weight alcohol into a different salt of said ester. An aqueous solution of the original salt is passed into contact with a base-exchange material containing replaceable cations of the second salt whereby an exchange of cations takes place and the second mentioned salt of the sulphocarboxylic acid ester is formed.

L. Auer. U.S.P. 2,189,772, 13.2.40. Appl. 23.10.26. Improved heat-bodied oil products are obtained by mixing about 5% of dry sodium oxalate with a fatty oil and heating the mixture until the salt is dispersed (300–350° C.).

A. L. Davis. U.S.P. 2,191,455, 27.2.40. Appl. 29.9.38. Process for the extraction of a fat or oil from an oleaginous material of non-mineral origin which contains colouring matter soluble in the said fat or oil. The material is subjected to the action of a liquid solvent mixture consisting of a liquid saturated hydrocarbon having 3 to 4 carbon atoms and a small proportion of an ether selected from the group consisting of dimethyl ether, methyl ethyl ether, and diethyl ether. Thereafter the extract is separated from the residue and finally the solvent from the residue.

O. M. Reiff. U.S.P. 2,191,498, 27.2.40. Appl. 27.11.35. Manufacture of mineral oil composed of liquid oils and waxy hydrocarbons in which is incorporated a small proportion of wax-substituted phenol prepared from chlor-wax, unsubstituted phenol, and anhydrous aluminium chloride. The mixture is heated to approximately 350° F. and thereafter water is added to remove the aluminium chloride.

S. Musher. U.S.P. 2,192,866, 5.3.40. Appl. 20.8.38. Production of a novel mineral oil composition containing a small amount of the mineral oil soluble constituents derived from a dehydrated, low moisture containing salted, macerated olive paste. The oil is substantially free of the fibres of the olive paste.

L. A. Hamilton. U.S.P. 2,193,331, 12.3.40. Appl. 2.2.39. Preparation of a mineral oil composition in which is incorporated a small proportion of the product obtained by reacting sulphur chloride with a solvent tar derived from the solvent extraction of petroleum. The reaction product is first treated to remove corrosive sulphur, and is present in sufficient amount to inhibit the deleterious effect of oxidation on the oil.

A. A. Levine. U.S.P. 2,193,823, 19.3.40. Appl. 9.4.37. Preparation of pentachlorostyrene by passing chlorine gas into liquid ethylpentachlorobenzene maintained at a temperature between 60 and 200° C. in the presence of light but in the absence of a halogenated catalyst. H. B. M.

## Refining and Refinery Plant.

**810.* Large Houdry Catalytic Gasoline-Treating Unit.** H. S. Norman. *Oil Gas J.*, 28.3.40, **38** (46), 106.—Reference is made to various types of Houdry catalytic plants in operation, and a description is given of a Houdry catalytic gasoline-treating plant at Marcus Hook, Pa., of 18,000 brl. daily capacity. Cracked and reformed gasoline from the catalytic cracking plants is heated by heat exchange to 250° F. at 200 lb. pressure, and in a furnace to 660° F., and passed to one of the two catalytic treating cases at 645° F. After heat exchange it passes to the fractionating tower at 540° F., where 2% of polymer bottoms are removed. The catalyst cases are operated in three-hour cycles, regeneration of one tower being effected by blowing air heated to 700° F. through it after purging with steam to remove oil vapour. The resulting oxidation of mercaptans, sulphur, and carbon deposits raises the temperature to 1000° F., the catalyst being finally cooled to the operating temperature by a molten salt-circulating system. Treating of the gasoline results in a reduction of the gum (copper dish) from 35 to 6 mgm., and gives a good colour, doctor sweet and satisfactory copper strip test product without any loss in octane number. Gasoline with copper dish gum tests of 200 mgm. have been reduced to 5–7 mgm. by this process. C. L. G.

**811.* Caustic Washing of Gasoline and Caustic Regeneration.** L. M. Henderson, G. W. Ayres, and L. M. Ridgway. *Oil Gas J.*, 28.3.40, **38** (46), 114.—In an investigation into the reason for the incompleteness of the regeneration of caustic soda used for the preliminary washing of cracked and straight-run gasolines from various Texas crudes, it was found that a number of organic acids were present in the gasolines. These are not appreciably hydrolyzed in the boiling aqueous solution, and consequently cannot be removed by steam regeneration, although they do not interfere with the reaction of the lower boiling aliphatic mercaptans. The acids from the soda washing of a cracked Texas gasoline largely consisted of *o*-thiocreosol, with smaller amounts of *p*-thiocreosol. thiophenol, *o*-cresol, phenol, and naphthenic acids. Water soluble acids, *e.g.*, formic, acetic, *iso*butyric, *iso*valeric, etc., were also identified in the caustic-soda extract. In some cases the water-soluble organic acids amounted to 70% of the total acidity, so that a preliminary water wash of the gasoline is indicated. C. L. G.

**812.* Refining Characteristics of Mississippi Crude Oils.** G. Egloff and G. B. Zimmerman. *Oil Gas J.*, 28.3.40, **38** (46), 145.—A laboratory distillation has been carried out on two samples of crude oils from the Tinsley field, Yazoo County, Mississippi. The crude oils had the following average properties: S.G. 0·848; Sulphur 0·77%; Cold test 15° F.; Visc. S.U./100° F. 69. Estimated yields on refining were: 250° E.P .gasoline (61 O.N.) 12·0%, or 400° E.P. gasoline (41 O.N.) 29·2%; kerosine 9·5%; light gas oil 21·4%; heavy gas oil 19·8%; and residue 19·9%. The low octane rating of the gasoline indicates the necessity for cracking and reforming cracking of the topped crude. After removing the 400° E.P. gasoline, reforming the naphtha and polymerization of the cracked gases gives 66·2% of 68/70 O.N. gasoline. When making 9·5% kerosine, cracking the remaining crude, reforming and polymerizing, a yield of 57·5% of 67/69 O.N. gasoline is obtained. Omitting the naphtha reforming a yield of 40·5% of cracked and polymer gasoline of 68/70 O.N. is obtained, while when kerosine is manufactured the yield of cracked and polymer gasoline is reduced to 31·8%. The

straight-run gasoline is sweet, but the cracked material requires sweetening and inhibiting. A yield of over 25% of asphalt may be obtained by blowing. Lubricating-oil production would involve dewaxing and probably solvent extraction in addition to decolorizing treatment. C. L. G.

**813.* Factors Affecting the Refiner's Choice of Crudes.** G. A. Beiswenger. *Petrol. Tech.*, Feb. 1940, A.I.M.M.E. Tech. Pub. No. 1155, 1–11.—With relatively few exceptions, available processing methods and addition agents make it theoretically possible to produce any type of refined product from any crude source, although it may not be economically sound to do so. There is a practical limit to the production of high-quality products from inferior feed stocks. By physical and chemical tests and a small-scale distillation, it is possible to make a selection from crudes according to available processing equipment and the products required.

The desirable features and the means whereby they may be obtained are discussed for gasolines, kerosines, tractor fuels, gas oils, lubricating oils, and asphalts, and the characteristics of crudes suitable for giving various products are indicated and also set out in tabular form. G. D. H.

**814.* Engineer and Chemist in the Refining of Petroleum.** A. J. Zanetta. *Bol. Inform. Petroleras*, Dec. 1939, XVI (184), 5–18.—This is a well-illustrated paper in which Dr. Zanetta deals with the various processes applied to the crude petroleum in order to obtain many different products of importance. He points out the essential part played by the chemist in collaboration with the engineer in perfecting these refining processes. H. I. L.

**815.* Dehydration and Desalting of Petroleum in Mendoza.** Fermo Monti. *Bol. Inform. Petroleras*, Dec. 1939, XVI (184), 27–29.—The presence of large quantities of sodium chloride in the crude oil has the effect of choking the tubes of the heat interchangers, of depositing carbon in the still tubes, of corrosion due to the acid reactions taking place, and finally of depositing ash in the burners of oil-burning plant and thus increasing the consumption. Analyses of the oils at Cacheuta and Tupungato are given (Tables 1 and 2), and particulars are given of the results of dehydration and desalting by the electrical method. Tables 3 and 4 give particulars of the trials carried out, which resulted in an efficiency of 85·54%. The best results were obtained either without the addition of extra water or with the addition of 10% of soft water. H. I. L.

**816.* Desalting of Petroleum at Plaza Huincul.** R. Carrozzi, L. Hudson, and V. Garcia Cano. *Bol. Inform. Petroleras*, Dec. 1939, XVI (184), 30–34.—This article bears on the same subject as the foregoing abstract. A table is given showing the percentage of salt contained in the different oils extracted in the Argentine. Results of trials by centrifuging and by heating under pressure for the separation of salts in oils obtained at Plaza Huincul are shown in Tables 2 and 3, while treatment by electricity is detailed in Table 4. At the La Plata refinery sulforricinate of ammonia is used for desalting, in the proportion of 1 to 8000 parts by volume of petroleum (see Table 4). Neither the operation of centrifuging nor that of heating under pressure is as efficacious or as efficient as the electric treatment. H. I. L.

**817. Refining Patents.** R. B. Day. U.S.P. 2,189,058, 6.2.40. Appl. 14.4.37. Refining hydrocarbon oils by contacting the oil in the absence of hydrochloric acid with a dry, preformed solid reaction product of a zinc silicate and hydrochloric acid, the said product being substantially devoid of free hydrochloric acid.

F. W. Breth. U.S.P. 2,189,128, 6.2.40. Appl. 17.7.36. Refining of mineral oil by treating with oleum in the presence of a member of the group consisting of urea and salts of urea under sulphonating conditions, and recovering from the treated oil the mahogany sulphonic bodies formed during sulphonation.

J. V. Starr and G. A. Beiswenger. U.S.P. 2,189,844, 13.2.40. Appl. 18.10.33. Treatment of mineral oil containing asphalt by extracting with a mixture comprising a selective solvent of the phenol type and a halogenated hydrocarbon having a specific gravity higher than 1.

T. C. Whitner, Jr. U.S.P. 2,189,850, 13.2.40. Appl. 6.3.37. Removal of mercaptans from a sour petroleum distillate by converting the mercaptans to copper mercaptides which remain dissolved in the distillate. Subsequently the copper mercaptides are removed from the distillate with an alkyl amine.

W. J. Edmonds. U.S.P. 2,189,885, 13.2.40. Appl. 18.9.31. Separation of wax from oil by diluting the oil with a liquefied normally gaseous hydrocarbon solvent and cooling the mixture to successively lower wax separation temperatures in a plurality of separate chambers. The precipitated wax is separated from the oil solvent mixture in the last chamber and the solvent removed from the dewaxed oil.

C. Ellis. U.S.P. 2,190,471, 13.2.40. Appl. 26.8.38. Sulphuric acid-treated cracked petroleum distillate is treated with a hydrocarbon-soluble heavy metal salt of a phenolic body and insoluble metallic compounds allowed to form. Thereafter the insoluble compounds are separated and the ability of the distillate to develop acidic compounds on distillation thus suppressed.

J. B. Staten. U.S.P. 2,191,357, 20.2.40. Appl. 15.12.37. Petroleum emulsions of the water-in-oil type can be broken by treating with cactus juice.

J. B. Rogerson. U.S.P. 2,194,269, 19.3.40. Appl. 21.3.38. Treatment of salt-impregnated crude oil by heating under super-atmospheric pressure adapted to prevent excessive deposition of salt in the heating equipment. Thereafter the pressure is reduced to a degree adapted to effect vaporization of water and low boiling point constituents, and finally the unvaporized constituents are filtered to remove the crystallized salt.

C. M. Loane. U.S.P. 2,194,312, 19.3.40. Appl. 13.6.38. Deterioration of refined mineral oils is prevented by dissolving in the oil less than 0·04% of a product formed by condensing with a Friedel–Crafts catalyst, chlorinated paraffin wax with a compound selected from the group consisting of naphthols and polyhydroxyl benzenes.

D. L. Pennington and W. L. Benedict. U.S.P. 2,194,321, 19.3.40. Appl. 31.12.37. Refining of hydrocarbon distillates by subjecting them to the sweetening action of a copper compound and afterwards treating the distillate with a salt of orthophosphoric acid to remove objectionable reaction products.

C. Wirth. U.S.P. 2,195,833, 2.4.40. Appl. 30.9.37. Method of removing salt water or brine from hydrocarbon oil by heating in a flowing stream to a temperature between 325 and 375° F. at super-atmospheric pressure. A stream of water is separately heated to the same temperature under sufficient pressure to prevent vaporization, and the two streams thereafter commingled. The mixture while still in a heated state is introduced into a settling chamber wherein the conditions are such that the resultant salt water and de-salted oil are caused to stratify.

G. W. Johnston. E.P. 517,618, 5.2.40. Appl. 27.7.38. Removal of phenols from oils and waste aqueous liquors by extracting the oils while heating under pressure with the aid of a waste aqueous liquor containing phenols. Subsequently the extract is separated at atmospheric or increased pressure by cooling into phenols and water containing phenols. The latter is treated with extraction or adsorption agents for the removal of the phenols.

E. A. Ocon. E.P. 518,263, 22.2.40. Appl. 12.7.38. Preheated bituminous oil is injected into a flash zone and a substantial portion thus vaporized. Subsequently hot vapours are passed into the flash zone to increase the amount of vapours and a portion of the resulting residues is subjected to distillation under cracking conditions. The vapour products of distillation are filtered through an absorbent contact mass capable of eliminating deleterious coke-forming substances, and are afterwards used as the hot vapours in the flash zone.

G. W. Johnson. E.P. 518,745, 6.3.40. Appl. 31.8.38. Separation of hydrogen chloride from mixtures containing olefines or diolefines having at least four carbon atoms. The mixture is brought into contact with a liquid substance which is stable to hydrogen chloride and has a boiling point above that of hydrogen chloride and below that of olefines or diolefines in the gaseous mixture. H. B. M.

## Safety Precautions.

**818. Procedure for Applying for Tests made on all Explosives and Blasting Devices by the Explosives Division of the Bureau of Mines.** Anon. U.S. Bureau of Mines: *Schedule IC*, 1939.—This schedule gives full information regarding practical tests of explosives by the appropriate Division of the Bureau. The scope of the tests covers explosives for use in coal-mines to determine their permissibility; for metal mines, tunnels, quarries, and other engineering operations (which presumably includes oil-well drilling) to determine their characteristics; blasting devices for use in coal-mines or relevant to any one of the individual tests listed in the schedule. The information includes instructions for submitting for test explosives and equipment for blasting devices; conditions under which tests are made; methods of testing involving chemical analysis (as laid down in U.S. Bureau of Mines *Bulletins* 51, 96, 219, *Technical Papers* 78, 160, 162, 282, and *Report of Investigations* 3337), also physical tests which are individually described and include physical examination, unit deflective charge, gallery tests, determination of gaseous products of explosion, rate of detonation, pendulum friction test, explosion by influence test, and large impact test. Provisions are stated for the permissibility of explosives and blasting devices and tolerances allowing for reasonable limits of variation in results of analyses and tests are enumerated. H. B. M.

## Chemistry and Physics of Petroleum.

**819. Hydrogen Bonds Involving the C–H Link. VIII. The Solubilities of Completely Halogenated Methanes in Organic Solvents.** M. J. Copley, G. F. Zellhoefer, and C. S. Marvel. *J. Amer. chem. Soc.*, 1939, **61**, 3550–3552.—This paper gives solubility data on $CCl_3F$ and $CCl_2F_2$ in a wide range of organic solvents at 32·2° C. and at various pressures. The solubilities are almost always lower than would be predicted from Raoult's law, indicating that compound formation between solvent and solute does not occur. This work gives support to an earlier postulation of the authors that C–H ⟵ O and C–H ⟵ N bonds are formed by the hydrogen of the halogenated methane and the oxygen and nitrogen atoms of the solvent molecules. R. D. S.

**820. Action of Elementary Fluorine in Organic Compounds. VI. The Vapour-Phase Reaction between Ethane and Fluorine in Progressively Varying Proportions.** J. D. Calfee, N. Fukuhara, and L. A. Bigelow. *J. Amer. chem. Soc.*, 1939, **61**, 3552–3554.—An account is given of the vapour-phase fluorination of ethane over a copper gauze catalyst in which the gases reacted in progressively varying proportions. The more important products have been identified, and the approximate proportions in which they have been formed have been determined. In each case a smooth reaction took place. R. D. S.

**821. The Action of Aluminium Chloride on Aromatic Hydrocarbons. II. The 1 : 3-Dimethyl-4-Propylbenzenes.** D. Nightingale and B. Carton, Jr. *J. Amer. chem. Soc.*, 1940, **62**, 280–283.—Whereas 1 : 3-dimethyl-4-*iso*propylbenzene yields 1 : 3-dimethyl-5-*iso*propylbenzene as the principal trialkylbenzene when warmed with aluminium chloride for three hours at 55° C., the 1 : 3 : 4-normal compound hardly changes and, in fact, requires to be kept at 100° C. for four hours before there is any considerable change to the 1 : 3 : 5-*iso*hydrocarbon. The 1 : 3 : 4-normal hydrocarbon was synthesized from *m*-xylene and *cyclo*propane using aluminium chloride as the catalyst, and it was also prepared by the reduction of 4-propionyl-*m*-xylene. The 1 : 3 : 5-*iso*-compound was synthesized from *m*-xylene and three different alkylating agents, namely, *iso*propyl chloride, normal propyl chloride, and normal propyl formate, again using aluminium chloride as catalyst. These syntheses give support to the contention of Smith and Perry (*J. Amer. chem. Soc.*, 1939, **61**, 1411–1412; *J. Inst. Pet.*, 1939, **25**, Abstr. No. 1362) that, during the alkylation of *m*-xylene in the presence of aluminium chloride, a 1 : 3 : 4-hydrocarbon is the initial product, which is subsequently rearranged to yield a 1 : 3 : 5-hydrocarbon. R. D. S.

**822. Remarks on the Structure of Fluorene.** E. Bergmann and T. Berlin. *J. Amer. chem. Soc.*, 1940, **62**, 316–317.—When 2-acetoxyfluorene undergoes the Fries rearrangement the product is 1-acetyl-2-hydroxyfluorene and, similarly, 2-acetoxyfluorenone gives 1-acetyl-2-hydroxyfluorenone. The rearrangement of 2-allyloxyfluorenone, however, gives two isomers, the 1- and the 3-allyl-2-hydroxyfluorenone, forming a well-crystallized molecular compound. Thus, as has been previously stated, no fixed "fine structure" exists in fluorene, but the dibenzo*cyclo*pentadiene framework seems to hold. R. D. S.

**823. Action of Fluorine upon some Simple Aliphatic Chlorinated Hydrocarbons.** W. T. Miller. *J. Amer. chem. Soc.*, 1940, **62**, 341–344.—The reactions of the lower aliphatic chlorinated hydrocarbons with pure fluorine were generally smooth and easily controlled, and they occurred principally in the gas phase and at the liquid surface under essentially "non-ionic" conditions. Some of the differences between the reactions of fluorine and the reactions of the other halogens with these aliphatic compounds may be due to the radical type mechanisms functioning, in which the fluorine molecule is split symmetrically, and the author considers that this type of mechanism is of the greatest importance in this connection. The types of reactions observed were: substitution of hydrogen attached to saturated carbon; substitution of hydrogen attached to double-bonded carbon; addition to ethylenic bonds; dimerization of saturated molecules by removal of two hydrogen atoms; dimerization of ethylene derivatives accompanied by the addition of two fluorine atoms; secondary reactions due to the presence of chlorine fluoride. R. D. S.

**824. Chlorination of 1-Hexyne in Reactive Solvents. II.** R. O. Norris and G. F. Hennion. *J. Amer. chem. Soc.*, 1940, **62**, 449–450.—The study of the chlorination of 1-hexyne in various oxygen-containing solvents has been continued with special reference to the effect of high proton concentrations on the reaction. 1-Hexyne was chlorinated as an emulsion in concentrated hydrochloric acid, 30% sulphuric acid, and 30% phosphoric acid, and as a solution in methanol saturated with hydrochloric acid. Both *cis*- and *trans*-1 : 2-dichloro-1-hexene were obtained, but oxygen-containing compounds were not isolated. A trichloride having b.pt. 90–93° C. at 10 mm. is now reported as 1 : 1 : 2-trichloro-1-hexene rather than as 1 : 2 : 1-trichlorohexane as previously formulated; indeed the authors were unable to prepare the latter from 1-hexyne. Chlorination of 2-chloro-1-hexene produced *cis*-1 : 2-dichloro-1-hexene and 1 : 1 : 2 : 2-tetrachlorohexane. The authors suggest a mechanism for the reactions occurring in the investigation. R. D. S.

**825. Hydrogen Fluoride as a Condensing Agent. IX. Reactions of Di- and Tri*iso*-butylene with Phenol.** J. H. Simons and S. Archer. *J. Amer. chem. Soc.*, 1940, **62**, 451.—With large quantities of hydrogen fluoride di- and tri-*iso*butylene both suffer cleavage to give p-*tert.*-butylphenol; however, with smaller quantities of hydrogen fluoride, di*iso*butylene gives an uncleaved product, p-*tert.*-octylphenyl, although tri*iso*butylene did not give any compound that corresponded to the expected dodecylphenol—perhaps even milder conditions are required. R. D. S.

**826. Inhibition of Ethylene Polymerization by Nitric Oxide.** H. D. Burnham and R. N. Pease. *J. Amer. chem. Soc.*, 1940, **62**, 453.—The polymerization of ethylene is subject to acceleration by substances believed to give rise to radicals, and the authors now find that the reaction is inhibited by nitric oxide, the effect of which falls off as the reaction advances, as in the case of the inhibition of the hydrogenation of ethylene, mentioned in the following communication (Abs. 827). The polymerization of ethylene is therefore evidently of the radical chain type. R. D. S.

**827. Inhibition of the Hydrogenation of Ethylene by Nitric Oxide.** H. D. Burnham and R. N. Pease. *J. Amer. chem. Soc.*, 1940, **62**, 453.—Since the dissociation of ethane to yield ethylene and hydrogen is inhibited by nitric oxide one might expect the reverse reaction to be similarly affected. The authors find this to be the case. The effect of the inhibition tends to fade out as the reaction proceeds. R. D. S.

**828. Photochemical Reactions of Oxalyl Chloride and Phosgene with *cyclo*Hexane.** M. S. Kharasch and H. C. Brown. *J. Amer. chem. Soc.*, 1940, **62**, 454.—In the photolysis of both phosgene and oxalyl chloride in *cyclo*hexane in the liquid phase, the authors have isolated the acid chloride of *cyclo*hexane carboxylic acid quantitatively, and they believe the reaction takes place through a free radical or atom mechanism in which the formation of the –COCl free radical plays a leading rôle. R. D. S.

**829.* Polycyclic Aromatic Hydrocarbons. Part XXI.** G. M. Badger, J. W. Cook, and F. Goulden. *J. chem. Soc.*, Jan. 1940, 16–18.—The syntheses of the 6 : 9 : 10-trimethyl and the 5 : 6 : 9 : 10-tetramethyl derivatives of 1 : 2-benzanthracene is described.

These two compounds, together with 1 : 2 : 9 : 10-tetramethylanthracene, were tested for carcinogenic and growth-inhibitory activity, the results being published elsewhere. E. H. W.

**830.* Thermal Polymerization of Styrene and its Inhibition.** S. G. Foord. *J. chem. Soc.*, Jan. 1940, 48–56.—The author has investigated the effect of a considerable number of organic compounds on the rate of polymerization of pure styrene. Two main groups were classified, " inhibitors " and " retarders."

A detailed examination of benzoquinone and related substances was made. From the results on these strong inhibitors, support is claimed for a theory of the kinetics of stabilization by inhibitors. E. H. W.

**831.* Examination of the Mechanism by Which " Cool " Flames Give Rise to " Normal " Flames. Part III. The Physical Characteristics of the Two-Stage Process Ignition of Ether–Oxygen Mixtures.** M. Maccormac and D. T. A. Townend. *J. chem. Soc.*, Feb. 1940, 143–150.—It has been shown previously by these authors (*vide J. chem. Soc.*, 1939, 337, 341) that with ether–air mixtures the two-stage process of ignition could be observed in cold media at high enough pressures.

In this paper are given the results of an investigation using ether–oxygen mixtures under these conditions. From experiments carried out at constant pressure, and the fact that the " blue " gives a greater volume of products than the " cool " flame, the " blue " flame is now recognized as having characteristics differing from both the " cool " and normal flames. E. H. W.

**832.* Examination of the Mechanism by which " Cool " Flames give Rise to " Normal " Flames. Part IV. The Chemical Character of the " Blue " Flame Initiated in the " Cool " Flame Products of Ether–Oxygen Mixtures.** M. Maccormac and D. T. A. Townend. *J. chem. Soc.*, Feb. 1940, 151–156.—A new method for examining the gaseous products of flames is described. The products of " cool " and " blue " flames were analyzed, and differences between the two flames are shown. Much larger amounts of aldehydes and peroxides were produced by the " cool " flame, these compounds being decomposed in the " blue " flame. Acetaldehyde is said to play an important part in both " cool " and " blue " flames, and further examination of ether is being deferred until a similar detailed study of acetaldehyde itself has been made. E. H. W.

**833.* Studies in Water-in-Oil Emulsions. Part III. The Effect of the Relative Phase Volumes on the Type of Emulsions Stabilized by Magnesium Oleate.** R. C. Pink. *J. chem. Soc.*, Feb. 1940, 211–212.—Discrepancies in the results published in the literature prompted this author to make a detailed investigation of the effect of the ratio of the phase volumes on the type of emulsion produced. It was found that the method of preparation affected the type of emulsion to a certain extent. On standing there was a decrease of stability, and some of the emulsions with a higher concentration of soap underwent a reversal of type. E. H. W.

**834.* Polycyclic Aromatic Hydrocarbons. Part XXII.** C. L. Hewett. *J. chem. Soc.*, March 1940, 293–303.—Derivatives of phenanthrene with substituents in at least three of the 1-, 2-, 3-, or 4-positions are carcinogenic. 1 : 2-Dimethylchrysene should therefore be active. A synthesis of this compound is described, and in the biological tests now progressing activity has already been shown. Further, in these phenanthrene

derivatives, benzene rings may be interchanged with methyl groups without loss of activity. Hence a synthesis of 1 : 2 : 3 : 4-tetramethylphenanthrene was attempted. This, however, was unsuccessful, 1 : 2 : 3 : 4-tetramethylanthracene being produced instead. In order to study the effect on the carcinogenic activity of the size of the 2-substituent in 3 : 4-benzphenanthrene, 2-*iso*propyl-3 : 4-benzphenanthrene was synthesized, a new method being devised. This compound has not yet been assessed for activity. E. H. W.

**835.* Polycyclic Aromatic Hydrocarbons. Part XXIII.** J. W. Cook and (Mrs.) A. M. Robinson. *J. chem. Soc.*, March 1940, 303–304.—Carcinogenic properties are shown by 5-methyl, 5-ethyl, 5-*n*-propyl, and 5-*n*-*iso*propyl derivatives of 1 : 2-benzanthracene. To determine whether increase in the length of the carbon chain would cause any change in activity, 5-*n*-butyl, 5-*n*-amyl, 5-*n*-hexyl, and 5-*n*-heptyl derivatives were prepared. These new homologues of 1 : 2-benzanthracene are undergoing biological tests, and preliminary results suggest that there is a steady decline in carcinogenic activity with increase in length of the side chain. E. H. W.

**836.* Solvent Effects with Optically Active Saturated Hydrocarbons.** A. W. Pryde and H. G. Rule. *J. chem. Soc.*, March 1940, 345–347.—These authors have extended the work done on *d*-pinane by Rule and Chambers (*vide J. chem. Soc.*, 1937, 145) by making similar measurements on *l*-dimenthyl, *l*-dibornyl, and *d*- and *l*-*iso*camphane in a variety of non-polar solvents.

In no case was a simple relation between the optical activity and the refractive index found, but the relation previously observed with *d*-pinane is shown to be fortuitous. E. H. W.

**837. Physical Properties of Purified 2 : 2 : 3-Trimethyl-Pentane.** D. B. Brooks, F. L. Howard, and H. C. Crafton, Jr. *Bur. Stand. J. Research* (*Wash.*), 1939, **23** (6), 637–641.—In connection with an investigation of paraffin hydrocarbons as aviation fuel constituents, a sample of 2 : 2 : 3-trimethylpentane was prepared synthetically and after fractionation was obtained in a state of great purity.

Methylethyl-*tert.*-butylcarbinol was refluxed with about 0·5% iodine and the mixture of resulting olefins was recovered by distillation, dried with $CaCl_2$, refluxed with Na, and fractionated in a 100-by-2 cm. column. The portion, b.pt. 107–114° C., was hydrogenated, washed with $H_2SO_4$, water, $NaHCO_3$, and then three times with water. It was then dried, distilled from Na, and fractionated.

The resulting product was of such purity that a good freezing point was obtained. The freezing point and melting point were determined in an apparatus in which the rate of cooling or heating could be accurately controlled. Other properties measured included the boiling point and its variation with pressure, refractive index and density and their variations with temperature. D. L. S.

**838. Physical Properties of Some Purified Aliphatic Hydrocarbons.** D. B. Brooks, F. L. Howard, and H. C. Crafton, Jr. *Bur. Stand. J. Res.* (*Wash.*), 1940, **24** (1), 33–45.—The hydrocarbons discussed in this paper were prepared in connection with an investigation of the suitability of various paraffins as constituents of aviation fuel. Eight were synthesized, one was isolated by fractionation from a commercial synthetic crude, and two were obtained from commercial sources. All were further purified by distillation in fractionating columns of high efficiency.

3 : 3-Dimethylbutene-1, 2 : 3-dimethylbutene-1, and 2 : 3-dimethylbutene-2 were synthesized, commencing with acetone and magnesium amalgam to form pinacol hydrate, converting this into pinacolone and then by refluxing with Na to pinacolyl alcohol. Dehydration of the alcohol yielded a mixture of olefines from which the desired hydrocarbons were separated by distillation.

2 : 2-Dimethylbutane was prepared from 3 : 3-dimethylbutene-1, and 2 : 3-dimethylbutane from 2 : 3 : dimethylbutene-2 by hydrogenation under pressure.

2 : 3 : 3-Trimethylbutene-1 was synthesized from acetone and *tert.* butyl magnesium chloride, yielding 2 : 3 : 3-trimethylbutanol-2, which on dehydrating formed the desired olefine. This was also hydrogenated to give 2 : 2 : 3-trimethylbutane.

3-Ethylpentane was synthesized from triethylcarbinol formed by the action of ethyl propionate on ethyl magnesium bromide. Triethylcarbinol, on distilling slowly

in the presence of 0·5% iodine, yielded the olefine which on hydrogenation gave the desired paraffin. 2 : 3 : 4-Trimethylpentane was prepared by fractionation of a mixture of isomeric octanes, whilst *n*-heptane and 2 : 2 : 4-trimethylpentane were carefully fractionated from purest batches of the certified hydrocarbons.

These products were examined and the following physical properties determined: freezing point, boiling point and its variation with pressure, refractive index and density and their variations with temperature. D. L. S.

**839. Chemistry and Physics Patents.** F. M. Clark. U.S.P. 2,191,338, 20.2.40. Appl. 7.7.38.—Stabilized mineral oil is produced by incorporating with the oil about one-tenth to 3% of wood resin.

U. B. Bray and C. E. Swift. U.S.P. 2,191,091, 20.2.40. Appl. 4.8.31. Treatment of oil by dilution with a liquefied normally gaseous hydrocarbon diluent and maintaining the diluted oil under sufficient pressure to keep the hydrocarbon diluent in a liquid state. Thereafter the oil plus diluent are clay-treated and separated from each other.

J. P. Loumiet. E.P. 517,550, 1.2.40. Appl. 29.7.38. Protracted and intimate contact is obtained between two non-miscible fluids of different densities by causing them to travel jointly and at great velocity along a curved tubular path. The centrifugal force developed by the curvature of the path and the velocity of the fluids separates them laterally to the path, the denser one being outward and the lighter one inward with respect to the centre of curvature. The relative positions of the two liquids are subsequently inverted and the process repeated at frequent intervals.

T. A. Clayton. E.P. 518,158, 19.2.40. Appl. 12.1.39. Preservation of oils, rubber, and other oxidizable substances by the incorporation of a diarylamine compound having at least one of the hydrogens of at least one of the aryl rings substituted by an alkenyl-oxy group.

Ruhrchemie A.-G. E.P. 518,334, 23.2.40. Appl. 8.9.38. Production of cobalt and magnesium catalysts for use in the catalytic conversion of carbon monoxide and hydrogen. When using solutions of the nitrates or chlorides of cobalt and magnesium it has been found effective to employ a magnesium solution, the magnesium content of which is greater than that corresponding to the stoichiometric proportion of magnesium to cobalt in the catalyst to be produced.

Socony-Vacuum Oil Company, Inc. E.P. 519,371, 26.3.40. Appl. 20.8.38. Apparatus for alternately effecting catalytic conversion of hydrocarbons and regeneration of the catalyst. The apparatus comprises a number of heat-transfer surfaces in spaced relation within a container or converter in which a reaction material is brought into contact with a catalyst mass. H. B. M.

## Analysis and Testing.

**840. Quantitative Analysis of Gaseous Hydrocarbons by Adsorption and Desorption.** E. Ferber and H. Luther. *Angew. Chem.*, 1940, **53**, 31–35.—The separation of gaseous paraffinic hydrocarbons by fractional distillation is clumsy and slow. The authors have devised a method of adsorption and desorption with active charcoal and other adsorbents, selected according to the materials treated. In this way they have separated the hydrocarbons into binary mixtures, after which further analysis was easy. E. W. S.

**841. New Physical Chemical Method for the Determination of Constituents in Mixtures, and its Application to Mineral Oils, Synthetic Oils, and Tar Fractions.** G. Ibing. *Angew. Chem.*, 1940, **53**, 60–65.—The method, based on theoretical reasoning, produces highly practical results. According to Raoult's law it is possible to find the concentration of solutions by very accurate measurements of the freezing point. The conditions for this are that the molecular weight of the dissolved constituent must be accurately known, and that there must be a true atomic solution. It is

shown that with the new method it is comparatively easy to make analyses hitherto regarded as being very difficult, *e.g.*, determination of the benzol content in technical spirits, condensed aromatic hydrocarbons in fuels, etc. E. W. S.

## Motor Fuels.

**842. Co-operative Fuel Research Motor Gasoline-Survey, Summer 1939.** E. C. Lane. U.S. Bureau of Mines: *Report of Investigations* 3492, Feb. 1940.—This report concerns the properties of commercial motor fuels, and has been compiled through the co-operation of the Co-operative Fuel Research (C.F.R.) Committee and the U.S. Bureau of Mines. It deals with 1679 different samples of motor fuel, representing the products of over 100 oil companies in the United States. The data are grouped together under three main headings—premium, regular, and third-grade gasoline—and include results of determinations of specific gravity, sulphur content, Reid vapour pressure, A.S.T.M. octane number, and distillation characteristics, the latter being corrected to sea-level. Comments are offered on the copper-strip corrosion test, which was apparently only positive in a single sample of third-grade fuel; on the octane number, wherein it appears that 90% of the regular is higher and wider by one octane number for 1939 summer than for the corresponding period in 1938, being virtually unchanged in the case of the premium grade, but up to 4·5 higher in 1939 for the third-grade gasoline. In the matter of volatility, the ranges of vapour pressures, in which 90% of the samples of each grade fall, show practically no change in level and spread for 1939 compared with corresponding samples examined in 1938 summer. Temperature ranges in distillation for regular and premium grades are essentially unchanged in 1939, though the middle range of temperatures for third-grade fuel is appreciably lower than was found in the 1938 survey. H. B. M.

**843.* Distillation Curves of Blends.** W. L. Nelson. *Oil Gas J.*, 29.2.40, **38** (42), 64.—It is shown that the boiling range of intermediate distillation products can be computed from true boiling-point curves of the crude oils, but the A.S.T.M. distillation curves are very misleading for this purpose. Examples are given of the T.B.P. curves of a gasoline and a fraction from it, showing that the two curves lie along the same line, with the exception of a few per cent. at the initial and final parts of the curve of the fraction, where the fractionation is necessarily inadequate. Similar curves are reproduced for gasoline from a crude oil and of a blend of three gasoline components. C. L. G.

**844.* National Motor Spirit.** Report by Government Commission, Argentine. Anon. *Bol. Inform. Petroleras*, Dec. 1939, XVI (184), 19–23.—The Commission came to the conclusion that the fuel to be recommended would be a mixture of 20–30% of absolute alcohol and 80–70% of petrol, which would be suitable for I.C. engines. The alternative use of etherized alcohol is not recommended, as in that case the proportions of the mixture are limited to 30% and 70%, respectively. The alcohol would be denatured by the addition of 3% of *iso*propanol. Full particulars of tests are given. H. I. L.

**845. Patents on Motor Fuels.** T. W. Bartram. U.S.P. 2,193,666, 12.3.40. Appl. 14.9.37.—Cracked hydrocarbon motor fuel of the type which tends to deteriorate on storage, as evidenced by colour and gum formation, is treated with a small proportion of a sulphurized diaryl arylene diamine. The latter is obtained by reacting a sulphur halide and a diaryl arylene diamine in the presence of a substantially inert solvent at a low temperature.

D. B. Macdonald. E.P. 518,958, 12.3.40. Appl. 2.9.38. The properties of fuels for internal combustion engines are improved by the addition of compounds soluble in the fuel concerned and having a porphyrine nucleus.

D. B. Macdonald. E.P. 519,408, 26.3.40. Appl. 17.8.38. Method of improving the properties and/or combustion of liquid fuels consisting wholly or partly of hydrocarbons by the addition of bone oil with or without additional substances, such as sterols, anhydrous lanoline, and phosphatides. H. B. M.

## Lubricants and Lubrication.

**846.* Superfinish.** D. A. Wallace. *J. Soc. Aut. Engrs*, 1940, **46** (2), 69–92.—Superfinishing is a new method of finishing metal surfaces. The tool used is a bonded abrasive in which the relatively coarse grits are firmly embedded; hence, only the cutting points of the grits are available to remove material from the surface to be treated. The work is rotated and the abrasive block pressed against it with an oscillating motion, the object being to ensure that no particle of abrasive follows the same path twice. The method is characterized by low abrasive speed, low pressure, and low surface temperature. It is claimed that, whereas all accepted production methods of surface-finishing leave a micro-layer of amorphous and fragmented material, superfinishing forms a crystalline surface of great smoothness. The necessity of "running-in" rubbing surfaces is thus avoided, and the optimum clearances can be established during manufacture. Other advantages are the ability to carry greater loads without breakdown of the oil film, and reduced wear.

In some tests on the S.A.E. oil-testing machine, a ground surface having a smoothness of 13·5 micro-in. (profilometer reading) caused failure with a particular lubricant at 111 lb. By superfinishing to 2 micro-in. the same oil only failed at 217 lb. By a modification of the same machine it was demonstrated that initial wear was much reduced by superfinishing. The process has been successfully applied to many automobile components during the past two years; among other advantages it is stated that crankcase sludge is reduced, since the primary cause of sludge formation has been metallic particles worn off lubricated surfaces. K. A.

**847. Patents on Lubricants.** W. L. Evers. U.S.P. 2,188,943, 6.2.40. Appl. 28.12.35. Production of an extreme pressure lubricating composition consisting of a hydrocarbon lubricant and a small portion of triaryltrithiophosphite.

H. Goethel, H. Tramm, and P. Schaller. U.S.P. 2,190,918, 20.2.40. Appl. 5.7.35. The characteristics of lubricating oil are improved by the addition of a substantial proportion of a polymerization product of propylene. The said product is obtained by treating propylene-containing material under super-atmospheric pressure and at a temperature of approximately — 30° C. in the presence of a polymerization catalyzer, long enough to permit the greater part of the reaction to take place, after which the temperature is raised to room temperature under increased pressure to complete the reaction.

S. E. Jolly. U.S.P. 2,190,715, 20.2.40. Appl. 16.1.37. Production of an extreme pressure lubricant consisting of a lubricating oil containing a minor percentage of alkyl benzene dichlorphosphine in which the alkyl group contains from three to four carbon atoms.

C. L. Ocon. U.S.P. 2,191,972. 27.2.40. Appl. 1.11.37. Recovery of high-quality lubricating oils from inferior oil stocks by subjecting the latter to a de-asphaltizing process, dewaxing the oil which has been de-asphaltized, and selectively separating these from a relatively more paraffinic fraction. The relatively less paraffinic constituents are extracted and subjected to differential separation by means of normally liquid aliphatic hydrocarbons boiling above 400° F., mixed with a solvent medium for alkyl compounds.

W. B. McCluer. U.S.P. 2,191,767, 27.2.40. Appl. 15.12.34. Process for extracting a lubricating oil of Pennsylvania grade by mixing with the oil a solvent which is selective as to molecular type and which is furthermore completely miscible with the oil. Subsequently, the mixture is contacted with a second solvent which is selective as to the same molecular type as the first solvent, but which is relatively immiscible with the oil although completely miscible with the first solvent. The first solvent is scrubbed from the oil by the second solvent.

L. B. Turner. U.S.P. 2,192,700, 5.3.40. Appl. 20.5.38. Production of an improved lubricating oil comprising a hydrocarbon oil and an organic sulphur compound prepared by reacting a halogenated compound having an aliphatic chain with a sulphide so as to replace the halogen with sulphur.

O. P. Puryear. U.S.P. 2,193,771, 12.3.40. Appl. 6.10.37. Production of a lubricating oil composed of petroleum lubricating oil and the product resulting from heating together sperm oil, lanolin, and sulphur to temperatures of about 320–330° F. to form a sulphurized-oil lanolin base.

F. R. Mosel and D. R. Nijk. U.S.P. 2,194,478, 26.3.40. Appl. 2.8.37. Manufacture of a non-halogenated compounded lubricant comprising a mineral lubricating oil and from 1–10% of an organic compound having at least 2 *iso*cyclic 6-carbon rings in close proximity to each other and at least 2 hydroxyl radicals separated from the rings by not more than 1 carbon atom.

A. C. G. Egerton. U.S.P. 2,195,167, 26.3.40. Appl. 30.6.38. Prevention of formation of gum-like products in lubricating oils subjected to the action of an atmosphere containing oxides of nitrogen in an internal combustion engine. A gum inhibitor comprising a urea derivative containing at least two alkyl groups is introduced into the oil.

R. Priester. U.S.P. 2,195,225, 26.3.40. Appl. 25.10.38. Manufacture of a drying oil from castor oil by heating it at a temperature between 150 and 250° C. in the presence of a small amount of a sulpho compound of a lower aliphatic hydrocarbon.

B. H. Shoemaker. U.S.P. 2,195,659, 2.4.40. Appl. 6.2.37. Preparation of a sludge-resistant mineral oil comprising a highly refined mineral oil, normally susceptible to the formation of excessive sludge and the development of high acidity, and a small amount of extract obtained from the solvent extraction of uncracked mineral oils.

E. C. Carmichael, R. J. de Gray, and J. H. Prall. U.S.P. 2,196,101, 2.4.40. Appl. 23.9.38. Improved mineral lubricant oil compositions embodying a major portion of a viscous mineral lubricating oil fraction and a minor proportion of a nitrated fatty oil.

H. G. Berger, R. C. Moran, and F. M. Seger. E.P. 519,288, 20.3.40. Appl. 13.10.38. Manufacture of a composition suitable for addition to mineral lubricating oil to enable it to withstand extreme pressures. A part only of the chlorine in chlorinated aliphatic hydrocarbon material is chemically substituted with a thiocarbonate group. H. B. M.

## Asphalt and Bitumen.

**848.* Temperature Susceptibility of Asphaltic Bitumen.** D. C. Broome, *Petrolcum*, Feb. 1940, 1 (4), 126.—Reference is made to the number of methods in existence for measuring the temperature susceptibility of asphaltic bitumens, and their relative values are discussed. The American methods, based on penetrations at different temperatures, using different times and weights, are considered unsound owing to the varying stresses, since many bitumens are of plastic nature. The Pfeiffer and van Doormal penetration index is based on an assumption that the penetration at the ring and ball melting point is 800, which is frequently not the case. The effect of stress is shown by a series of ductility figures carried out on different rates of pull. The Continental method of determining the plastic range by the temperature difference between the breaking point (*e.g.*, Fraass) and the softening point is of practical value. Abraham's method, based on the penetration at 32° F. and 115° F. and the softening point, as well as Kelly's float test index, suffer also from the difficulty of reconciling figures obtained at varying stresses. Considerably sounder theoretically are the number of methods based on rate of change of viscosity with absolute temperature, it being emphasized that the viscosity determinations should be carried out at the same rate of shear. The susceptibility of bitumens is reduced by the presence of a high asphaltene content, or by mineral matter, and increased by the presence of oily constituents. With oxidized bitumens, the temperature susceptibility is low over the medium range, but they frequently tend to be brittle at low temperatures and exceptionally fluid at high temperatures. C. L. G.

**849. Patents on Asphalt and Bitumen.** Ebano Asphalt-Werke A.-G. E.P. 518,655, 4.3.40. Appl. 1.9.38. Preparation of bituminous materials having high resistivity

against heat and cold and a low viscosity by blowing asphalt-free viscous mineral oil distillates of crude asphalt-base oils with air at temperatures between 160 and 200° C. for 30–200 hr. The products are suitable for use as binders, saturants, and adhesive compounds.

Standard Oil Development Co. E.P. 519,119, 18.3.40. Appl. 15.9.37. The adhesivity of bituminous compounds can be increased by heating with a metal oxide so that the acidic compounds present are converted to metal soaps.

H. Marc. U.S.P. 2,188,204, 23.1.40. Appl. 24.1.36. Bituminous composition composed of 35–75% asphalt having a softening point between 150 and 300° F., a petroleum solvent, up to 15% dipentene and 1–10% resin derived from cumene and indene.

J. A. Montgomerie and P. K. Archibald. U.S.P. 2,190,604, 13.2.40. Appl. 16.5.38. Preparation of a slow-breaking bituminous emulsion from difficultly emulsifiable pyrogenous residue of organic substances when the residue is not emulsible in dilute aqueous alkali alone.

H. Dohse and F. Spoun. U.S.P. 2,191,295, 20.2.40. Appl. 27.10.36. Bituminous and solid substances used in road materials are brought together in the presence of an adhesive selected from the group consisting of cation-active organic derivatives of ammonia.

L. Kirschbraum. U.S.P. 2,194,428, 19.3.40. Appl. 30.12.36. Construction material composed of flexible fibrous felt saturated with a binder. The felt base carries a coating of asphalt in which is incorporated an oil-diffusing substance to retard hardening of the coating on exposure.

K. C. Laughlin and H. E. Cier. U.S.P. 2,195,536, 2.4.40. Appl. 31.12.35. Manufacture of a light coloured asphalt from an asphaltic oil by adding liquid propane to the residuum of an asphaltic crude oil. The temperature is raised to 80–150° F. and the precipitate thereby formed separated off. The remaining solution is treated with sulphuric acid and the acid thereafter removed. On raising the temperature again to 20–130° F. a second precipitate of a light-coloured asphalt is obtained.

A. B. C. Dahlberg. U.S.P. 2,192,284, 5.3.40. Appl. 24.3.36. Mineral road aggregate of an acid character is bituminized by applying to the aggregate when wet a layer of slaked lime. The lime is allowed to react on the aggregate for at least 15 minutes and then oleic acid is applied to the coated aggregate to form water-insoluble soaps. The bituminous binder when applied forms a close cohesion to the soaps and thus to the mineral aggregate. H. B. M.

## Special Products.

**850. Patent on Special Products.** Consortium fur Electrochemische Industrie, G.m.b.H. E.P. 418,220, 19.3.40. Appl. 4.10.38. In the production of carbon tetrachloride, perchlorethylene vapour is led to a reaction space heated to 700–800° C., and through which chlorine flows simultaneously. After partial conversion, it is fed to the middle part of a fractionating column, from the upper part of which the carbon tetrachloride formed distils off while the perchlorethylene condenses in the lower part.

B. Buxbaum. E.P. 518,664, 5.3.40. Appl. 24.5.38. Mineral oil is improved by the admixture therewith of a paste comprising colloidal sulphur and an oily, fatty or aqueous vehicle. The particle size of the sulphur is less than 5 μ.

Societa Italiana Pirelli. E.P. 519,603, 1.4.40. Appl. 4.1.39. Improvement in the manufacture of electric cables of the constant-volume type having an oil-impregnated insulation. The oil or compound used to impregnate the insulation is not ordinarily gasogenic, but is rendered so by the addition of a gasogenic substance liquid at normal temperatures, and having a vapour pressure higher than that of the most volatile component of the oil or compound. H. B. M.

## Detonation and Engines.

**851.* High-Output Aircraft Engines.** E. W. Hives and F. Ll. Smith. *J. Soc. Aut. Engrs*, 1940, **46** (3), 106–117.—The authors contend that indirect or liquid-cooled engines are better adapted to the future trend of aircraft design than the direct or air-cooled type. The liquid-cooling system is now straightforward and absolutely reliable. The introduction of 100-octane fuel afforded temporary relief from detonation problems, but these are once more looming up again. A substantial gain in limiting B.M.E.P. is obtainable by injecting water into the manifold, but this is not considered a very practical way of increasing specific power output. Data are quoted showing the effect on specific output of improving blower efficiency and of using a two-stage blower with intercooler.

A new theory is advanced in explanation of the hot corrosion of exhaust valves by leaded fuels. The stellite coating of exhaust valves has not proved entirely satisfactory, and an 80/20 nickel–chromium alloy has proved more resistant to lead attack under severe conditions.

Lead–bronze bearing materials are troublesome in production, and the trend towards more powerful units is rendering improved bearings imperative. The Rolls-Royce Laboratories have developed aluminium–tin alloys having superior mechanical properties and less tendency to seize under conditions of restricted lubrication.

Other items discussed in the paper include interchangeable power plants, sleeve valves, liquid cooling systems, and ejector exhausts. K. A.

**852.* Running Petrol Engines on Coal Gas.** Anon. *Engineer*, 16.2.40, **149** (4388), 168–169.—The conversion of a petrol engine to run on town's gas can readily be made by the use of the gas carburettor described, which was designed primarily for running-in engines after assembly, but is equally suitable for traction purposes with engines developing up to 18 B.H.P. For engines of greater horse-power larger carburettors are available.

In this design suction of the engine automatically induces admission of air and gas through the medium of a spring-controlled piston, an adjustment being provided so that the carburettor can be set to give mixtures of different air–gas ratio and to allow for district variations in gas quality.

The maximum power output of a converted engine is stated to be about 12% lower than that obtained on petrol, while the gas consumption is between 25–30 cu. ft. per B.H.P. per hr.

Although the volume of gas which can conveniently be carried by a vehicle in a low-pressure gas bag limits its range to between 10–20 miles, it is pointed out that for town work, such as goods delivery, this mileage should be adequate, assuming sufficient filling stations to meet normal requirements could be readily made available. It has here been assumed that the high-pressure cylinder storage system with its greater capacity would not be extensively developed in the present emergency owing to the capital outlay on the necessary compression plant and other specialized equipment.

The cost of running on town's gas is anticipated to be lower than on petrol, and marked economy is obtained on slow running; furthermore greater ease of starting is secured. E. F. C.

**853.* The Kadenacy Engine.** Anon. *Engineering*, 23.2.40, **149** (3867), 195–197.—The object of the Kadenacy system is the improvement in the efficiency of two-stroke-cycle oil engines. The basic principle involved is utilization of the depression in the cylinder caused by rapidly opening the exhaust ports during the expansion stroke to secure an enhanced air charge. To obtain maximum efficiency it has been found that the exhaust system should bear a definite relation to the valve timing, and it is recommended that the exhaust system be matched up to the engine with a convenient arrangement of exhaust pipe and silencer.

The simplicity of the Kadenacy system is shown by the fact that it can be employed in the majority of existing engine designs without the necessity for basic alterations by modifications to the valve timing and port areas. Still further improved performances have been experienced by Messrs. Armstrong Whitworth Securities Co., Ltd., in engines specially designed to operate on the system, and two such examples are described and

illustrated in detail. The single-cylinder model designed for general industrial purposes is of 437 c.c. capacity and develops 5 B.H.P. at 1000 r.p.m., corresponding to a B.M.E.P. of 73·9 lb./sq. in. The six-cylinder engine is of 7·07 litres capacity, the rated output being 118 B.H.P. at 1200 r.p.m., giving a B.M.E.P. of 90 lb./sq. in. This engine, however, unlike the single-cylinder model, is fitted with a Roots-type blower, supplying in normal operation air at 2 lb./sq. in.

In both engines the combustion chamber consists mainly of a spherical recess in the piston top with partly conical sides, the main portion of the upper surface of the combustion chamber being formed by the head of the mechanically operated overhead exhaust valve. Tangentially arranged inlet ports cause a pronounced rotational swirl of the incoming air, which, combined with the movement set up on compression by the specially shaped piston top and underside of the cylinder head, promotes good fuel distribution and combustion. The injector is carried in the cylinder head, and is placed so that the spray enters the combustion space tangentially and with a slight downward angle towards the centre. E. F. C.

**854. Prospects of C.I. Engines.** L. Keuleyan. *Aircr. Engng*, 1940, **12** (132), 43.—Although both the four- and the two-stroke cycle C.I. engine will have their application in aviation, it is the author's opinion that since the highest specific power is required from a given weight, only the two-stroke cycle engine can compete favourably with a modern petrol aircraft engine.

The results of several series of tests carried out in the U.S.A. are presented as evidence of the possibilities of the C.I. aero-engine. In a single-cylinder four-stroke cycle engine smooth operation without combustion shock was obtained under boosted conditions, and fuel consumptions of 0·39 lb./h.p./hr. were recorded with I.M.E.P.'s of 240 lb./sq. in. and at 2000 r.p.m. Other experimenters claim that the four-stroke cycle C.I. engine, with the present technique of combustion control, can attain lower specific fuel consumption than the lowest obtainable from the petrol engine using 100 octane fuel to maximum economy advantage. The altitude performance of the oil engine will also be fully equal to that of the petrol engine.

As regards the two-stroke cycle oil engine, performances obtained with the uniflow single-cylinder $4\frac{5}{8} \times 7$ in. engine with piston-controlled inlet ports and poppet exhaust valves were highly satisfactory and have equalled German performances.

The writer concludes by illustrating the very high grade of development achieved in the two-stroke cycle field by the Junkers C.I. engines. The main contributory factors have been increase in engine speed and scavenging efficiency and the use of an exhaust-gas turbine which is claimed to increase the power output by more than 25% without raising fuel consumption. E. F. C.

**855. Examination of the Knocking Sound in Otto Engines with Electro-Acoustic Equipment.** A. W. Schmidt and K. Generlich. *Z. ver. dtsch. Ing.*, 1940, **84**, 48.—The authors have developed electro-acoustic instruments and have made tests with them since 1934, reaching a final stage in 1939.

By means of the instrument described it is possible to plot diagrams from which may be seen not only the commencement of knocking, but also the intensity of the knock. It is hoped to introduce a more exact knocking index than the octane number of to-day. With the equipment described it is also possible to determine the knocking rate in ordinary engine cylinders even simultaneously on all six cylinders of an engine during actual operation. E. W. S.

**856. Tests of the Power Output of an Internal Combustion Turbine.** A. Stodola. *Z. ver. dtsch. Ing.*, 1940, **80**, 17–19.—The author was able to make tests with the first turbine running in actual operation by internal combustion of liquid fuels, and to measure the thermal efficiency. The turbine is installed in a bomb-proof power station in Switzerland, and is apparently using gas oil or diesel oil as fuel. The thermal efficiency is about 18%. It is considered possible even to-day to bring about a material increase in the efficiency. The engine is used for emergency power, and is especially adapted for this purpose because of the small space required. The turbine requires no boiler and no cooling water, and there is practically no consumption of lubricating oil.
E. W. S.

## Coal and Shale.

**857. Correlation of Analysis of Coal with the Products of Carbonization in Externally-heated Retorts.** V. F. Parry. U.S. Bureau of Mines: *Report of Investigations No.* 3482, Dec. 1939.—Certain coals with similar chemical composition, as revealed by analysis, act differently in a given retort, and the products of carbonization may accordingly differ. It is for this reason that the commercial carbonization of coal to produce coke and by-products has developed largely as an art based on experience, and not as a science. The object of the present investigation was to correlate the results of experimental carbonization with the properties of the coals tested. The following conclusions were reached after correlating the results of carbonization tests of 125 coals with their analyses. The amount of tar that will form in the retort is directly proportional to the square of the oxygen-free volatile matter contained in the coal, and inversely proportional to the absolute temperature of carbonization. The amount of water which will form during destructive distillation at low temperatures is directly proportional to the oxygen content of the coal raised to the 1·3 power. The amount of gas in B.T.U. per pound of coal is directly proportional to the volatile heating value, and inversely proportional to the square of the volatile matter in the coal. The amount of coke resulting from carbonization is the sum of the fixed carbon plus ash, plus a factor "R." Factor "R" is defined as the percentage of the original coal that remains in the coke as a product of decomposition from volatile matter in the coal. H. B. M.

**858. Patent on Coal.** H. Koppers. U.S.P. 2,194,359, 19.3.40. Appl. 7.4.37. Process for improving the yield of valuable hydrocarbons in the low-temperature gaseous products evolved in retort ovens during low-temperature carbonization of a coking charge at a temperature below 750° C. by externally applied coking heat to produce gas and coke. H. B. M.

## Economics and Statistics.

**859. Crude Petroleum and Petroleum Products, November 1939.** Anon. U.S. Bureau of Mines: *Monthly Petroleum Statement No.* 192.—In November 1939 production of crude oil in the United States reached the highest level in history, the daily average being 3,729,600 brl., as compared with the previous record of 3,723,000 brl. in August 1937. Daily averages in November 1939 were higher than those for the previous month in most States, though production in California and Illinois showed a slight decline. Averages for Michigan (68,200 brl. daily) and Louisiana (200,000 brl. daily) established new production records. During November 1939 crude oil stocks also increased by nearly 3,000,000 brl., this being the first gain since last April and reflecting chiefly declines in runs to stills and in exports. Gasoline yields during the month under review reached a new peak of 45·8%. Residual fuel oil was the same as in October, but light fuel oil showed a decline in yield from 13·5% in October to 13·1% in November. The Bureau of Labor Statistics records that the price index for petroleum products was 53·9 in November 1939, as compared with 54·0 in the previous month and 51·5 in November 1938. H. B. M.

**860. Natural Gas Consumption Decreased in 1938.** Anon. U.S. Bureau of Mines: *Mineral Market Report No. M.M.S.* 772, Dec. 1939.—In 1938 the marketed production of natural gas decreased for the first time since 1933, the decrease being approximately 5% from the peak of 2,407,620,000,000 cu. ft. reached in 1937. All the major classes of consumption, with the exception of field use, also showed a decrease, the largest being in miscellaneous industrial use. Large amounts of low-priced gas used in the field and in carbon-black manufacture, particularly in Texas and Oklahoma, were responsible for a decline in value of natural gas at the wells from an average of 5·1 cents in 1937 to 4·9 cents in 1938. Similarly, the average value at points of consumption declined from 21·9 cents in 1937 to 21·8 cents in 1938. 29% of total consumption in 1938 was used for field purposes, 16% for domestic purposes, 5% for commercial purposes, 14% for carbon-black manufacture, 7% as fuel in electric public-utility power plants, 5% in petroleum refineries, 2% as fuel in cement plants, and 22% for all other

industrial purposes. 53,770 gas wells were in use at the end of 1938, compared with 55,050 at the beginning of the year. 2236 wells were drilled during the year, which indicates that 3516 wells were abandoned or shut down during the year, as compared with 2284 in 1937. H. B. M.

**861.* World Legislation on Petroleum.** Anon. *Bol. Inform. Petroleras*, Dec. 1939, XVI (184), 66–75.—This is a continuation of a reference index to laws affecting the exploitation of petroleum in different countries and to literature published in that connection. The first of these records was published in No. 174 of this journal. This number includes, among others, Russia, Uruguay, and Venezuela. H. I. L.

**862.* Economic Dynamics of the Domestic Demand for Motor Fuel.** N. D. FitzGerald. *Petrol. Tech.*, Feb. 1940, A.I.M.M.E. Tech. Pub. No. 1174, 1–7.—Domestic motor-fuel demands rose from 226,000,000 brl. in 1925 to 522,000,000 brl. in 1938. Numerous influences are at work determining the expansion and fluctuation of demand for motor fuel. The primary components are the number of motor vehicles registered ($R$ millions), the price of motor fuel to the consumer ($P$ cents/gal., average in fifty large cities), the miles of hard-surfaced rods ($H$ thousands), and the national income ($N$ billion dollars). $T$ is the number of years since 1924. The annual demand for motor fuel in millions of barrels is then given by

$$D = 17{\cdot}865R - 7{\cdot}199P + 0{\cdot}023HT + 0{\cdot}409N.$$

This equation conforms well with the actual data. Equations representing the separate effects of each component on the demand have also been derived.

There are secondary components affecting the demand, and of the primary components price alone is the demand-generating element over which the industry has some control. G. D. H.

**863. Canadian Mineral Industry in 1938.** Canada Dept. of Mines and Resources: *Mines and Geology Branch Bureau of Mines No.* 804, 1939.—Nearly 97% of the total Canadian output of petroleum is now obtained from the Turner Valley field in Alberta, in which there were sixty-eight producing wells at the end of 1938 and seventeen in process of being drilled. The main producing area lies in the southern part of the field, and has a proved length of nearly five miles and a width of two miles. The northern part of the field is about nine miles away, and as yet few wells have been drilled, though the area is attracting considerable attention. It is not known yet whether the intervening nine miles between the southern and northern parts of the field will prove to be productive, but should this be the case the Turner Valley field would have a proved length of some seventeen miles.

Small quantities of oil are also produced from the Red Coulee field, Wainwright, Ribstone, Taber, and Moose Mountain areas in Alberta. In south-west Ontario commercial quantities are produced at Petrolia, Oil Springs, Bothwell, Dawn, Warwick, West Dover, and Moser; in New Brunswick it is produced at a place about nine miles south-west of Moncton; and in the North-west Territories about fifty miles west of Great Bear Lake.

Production in the Turner Valley field throughout 1938 was prorated so that output should not exceed demand. In September this demand reached a peak of 862,413 brl. from the field, the daily production being placed at 28,300 brl. a day during the period 12th to 24th September.

In the southern part of the field, where the oil obtained is a light crude ranging from 40 to 50° A.P.I. gravity, thirty-eight wells were brought into production in 1938. In the northern area the completion of Home-Millarville No. 2 was important, as the favourable structure is known to extend for several miles to the north of the well.

During the year under review Canada exported $877,553 worth of petroleum and products and 4,987,879 Imp. gal. ($458,997 worth) of gasoline and naphtha.

Retail sales of gasoline in Canada amounted to 762,591,000 gal. in 1938. Turner Valley crude oil is used in practically all the refineries in Alberta, Saskatchewan, and Manitoba, and imports to these provinces were only slightly in excess of 500,000 brl. H. B. M.

# BOOK REVIEWS.

**Evaluation of Petroleum Products.** Sponsored by Sectional Committee Z-11 on Petroleum Products and Lubricants; published by the American Society for Testing Materials. 1940. Pp. 52. Price 75 cents.

This publication contains six articles dealing with lubricating oils, petroleum lubricating greases, gasoline, diesel fuels, fuel oils, and aviation fuels and lubricating oils, and represents a valuable supplement to the A.S.T.M. publication on "The Significance of Tests."

The six papers review the present status of the testing of products and lubricants, mainly with reference to A.S.T.M. methods of test, and discuss what additional test methods are desirable in the future. Each paper presents a complete summary of the present position on the subject, referring to a number of sub-committees of the A.S.T.M. the work of which is still in progress, and gives a carefully selected list of references to the literature. The paper on gasoline by T. A. Boyd is perhaps outstanding and summarizes the connection between volatility of the fuel and performance in a car in a very simple and complete manner; knock characteristics, tetraethyl lead, gum content, sulphur, and specifications are similarly considered. S. D. Heron's article on aviation fuels and lubricating oils is particularly apposite at the present time, and includes a paragraph summing up the difference in point of view on knock testing in America and elsewhere, and suggests the desirable characteristics for a knock-testing method suitable for international acceptance.

The definition given in the article on lubricating oils—"The primary object of lubrication is to provide between bearing surfaces a film of a type that will permit the conversion and the use of power without large friction losses and without serious harm to the lubricated surface"—appears to be unduly cautious, as similarly the later statement that "Except under very mild operating conditions, the life of reciprocating parts is comparatively limited."

"Evaluation of Petroleum Products" is particularly valuable in that it provides a short, concise summary of the testing methods in relation to petroleum products (with the exception of asphaltic bitumens), and emphasis should be placed on the sub-title ("A Résumé of *Present* Information"). The views expressed on some of the test methods will undoubtedly require revision in the course of a year or so, in view of the concentrated research work being continually carried out on some of the problems to which reference is made.

The great value of this booklet is that an impartial estimate has been set forth by competent authorities on the basis of information at present available of the relation between behaviour in use—the real criterion—and laboratory test methods of petroleum products.

F. H. Garner.

**Collected Researches on Cylinder Wear.** By C. G. Williams, with a foreword by the Rt. Hon. Lord Austin. Pp. 119. I.A.E. Automobile Research Committee, Brentford, Middlesex. Price 10*s*.

Although the Research Department of the Institution of Automobile Engineers has investigated numerous problems confronting the automobile industry during recent years, probably no aspect of its work has attracted such widespread interest as that devoted to cylinder wear. Ten years ago the automobile trade was seriously worried by the generally high rate of cylinder wear which curtailed the service life of engines. Much individual research was undertaken by manufacturers, but it was Mr. C. G. Williams and his staff who tackled the problem in a fundamental manner. From time to time the fruits of their researches were made available to Affiliated Manufacturers and Operators, and portions of their work have subsequently been reported in the I.A.E. Journal and other publications.

Now, for the first time, the whole series of Reports has been published in collected form, and this little volume should prove a handy work of reference. The Reports are given in order of publication, commencing with a "Discussion of Published Information on Cylinder Wear" (October 1931, 39 references), and a summary of "Experiences of Manufacturers and Operators." The First Interim Report, issued in March 1933, opens with a description of the single-cylinder engines and measuring apparatus used. Various operating conditions, popularly supposed to accelerate

wear, were studied, but by far the most important factor proved to be low cylinder-wall temperature. It was shown that the greatly accelerated rate of wear of cylinders and piston rings, which occurs when the cylinder-wall temperature is less than about 60° C., is associated with the condensation of water from the products of combustion. The "Corrosion Hypothesis" is further investigated in the Second Interim Report, wherein it is established that the guilty party is carbon dioxide—"an inevitable product of the normal combustion of every hydrocarbon," to quote the Foreword.

It was appreciated that, although *rate* of wear is abnormally high under low temperature operating conditions, abrasive wear cannot be ignored as a factor affecting total wear. Subsequent Reports deal primarily with the evaluation of many of the numerous factors affecting wear, such as mixture strength, load, clearances, ring design, and materials. There are some interesting tests on dirty oils, from which it would appear that the nature of the ash content is more important than the quantity. The influence of viscosity has also been studied in some detail; the beneficial effect of the lighter oils in rapidly establishing a lubricating film was readily shown by motoring tests on a cold engine.

That the information made available by the I.A.E. Research Department has alleviated the cylinder-wear problem is evident from a summary of "Recent Experiences of Manufacturers and Operators" (June 1937). The improvement was chiefly apparent in engines subject to frequent conditions of cold operation and which were, until recently, the worst offenders. However, the general level of wear still leaves room for further improvement, and it is satisfactory to learn that it is intended to pursue a continued methodical examination of the whole problem. K. Arter.

**Examen des Lubrifiants.** By Emile Robbe. Pp. 128. Published by L'Usine, 15 Rue Bleue, Paris, 1937. Price 30 *frs.*

In these days, when the word co-ordination is on so many lips, a book such as this attracts an interest out of the common. There are eight chapters and two appendices. Appropriately, in the first chapter, a short introductory one, are some timely hints on correct sampling.

The second chapter concerns physico-chemical tests. The list is comprehensive enough, but the treatment with one or two notable exceptions is brief. As well as the usual tests, including viscosity, volatility, saponification value, Conradson carbon value, and resistance to heating, there are methods for estimating rubber and graphite. Viscosity determination is certainly brought up to date, but the space given to the only kinematic viscosimeter mentioned, the Baume Vigneron, is at the expense of the dismissal in a few lines of the commercial instruments. The method described for determining resistance to heating is the simple one of inserting a dish containing the oil in an oven for a given time, after which the loss of weight by volatilization is determined, and the heated oil examined for insoluble in chloroform and tendency to carbonization. This method is practically obsolete in this country.

Chapter Three is a short one devoted to the examination of used oils. Apart from the determination of diluent by steam distillation, the only other aspect treated is the composition of ash, methods being given for estimating silica, iron and aluminium, copper, zinc, calcium, and magnesium.

One page comprises Chapter Four on insulating oils, and this is solely concerned with the determination of dielectric strength.

Fatty oils are treated in Chapter Five. As well as the usual tests for iodine value and unsaponifiables, a few spot tests for the more common varieties are described.

Soluble cutting oils and pastes form the subject of Chapter Six. Outlines are given for their inspection for appearance, ease of emulsification, frothing tendency, action on metals, ash, resin, water, alcohol, and ammonia contents.

In Chapter Seven greases are dealt with, some methods, notably Ubbelohde drop point and Kiessling's method for consistency, being described in detail, a detail which seems superfluous in the case of density. One method, namely that for water content, uses xylene in the Dean and Stark apparatus. In addition to the determination of oil and soap contents, methods are given for the detection of sugar, amidon, and dextrin, as well as rosin and rosin oil.

The last chapter will probably interest most of all oil chemists and engineers alike, containing as it does some indications on the question of the practical testing of

lubricants. The aspects touched upon are friction testing, temperature rise in ball bearings, gear, and motor oils. In suggesting the use of an electric motor to drive the power unit and so save fuel, the important influence of the latter has apparently been overlooked.

The two appendices concern the recovery of solvents and the fitting out of a laboratory, respectively.

As an introduction to a more serious and detailed study of the subject, or for engineers concerned with controlling the purchase of oil to a specification, the book gives a broad outline unobscured by a mass of detail. J. L. TAYLOR.

# BOOKS RECEIVED

**Institution of Mechanical Engineers, Transactions, Vol. 142, July–December, 1939.** 11″ × 8⅝″. Pp. 503.

This volume contains several long Papers dealing with the engineering aspects of transport, which were to have been presented at the New York Meeting of the Institution, cancelled owing to the outbreak of war. "Motor Transport," by E. C. Ottaway, and "Problems of the Highway User in U.S.A.," by F. C. Horner, both contain much valuable economic data. Air transport is reviewed by A. Gouge ("Transatlantic Air Transport") and E. T. Allen ("Trend of Air Transportation"). The volume also contains the Thomas Hawksley Lecture by Sir Leonard Pearce on "Forty Years' Development in Power Station Plant."

**Junior Institution of Engineers, Transactions, Vol. 49, 1938–39.** 8¼″ × 5¼″. Pp. 572.

Papers on "Applications of Bitumen," by A. P. Morris, and "Surface Heat Exchangers," by R. Sutcliffe, are included among many Papers of general engineering interest. The Presidential Address of Sir Charles Bressey deals with "Roads and Traffic."

**The Heavy Industry of Manchoukuo,** pubd. by Japan Economic Federation, Tokyo. 7⅞″ × 5″. Pp. 83 and map.

A short reference is included to the oil shale industry. The total deposits of oil shale in Manchoukuo are estimated at 7,600 million metric tons, most of which is deposited at Fushun, the rest being distributed in the Chientao, Sanshing and Jehol districts.

There is a directory of the principal mining companies in Manchoukuo.

**A.S.T.M. Index to Standards, January, 1940.** 9″ × 6″. Pp. 152.

Subject and numerical indexes of all standards and tentative standards included in the 1939 edition of A.S.T.M. Standards.

**New South Wales, Geological Survey; Coal Resources of the Maitland–Cessnock–Greta Coal Districts.** L. J. Jones. 9½″ × 5¾″. Pp. 225. 3 maps in pocket. Pubd. Sydney. 9*s*.

This Report of the N.S.W. Department of Mines is mainly concerned with the geology and mining development of the area. It contains also a summary of the report of the Director of Fuel Research, England, on the suitability for low temperature carbonisation and hydrogenation of samples from the Greta district.

# INSTITUTE NOTES.

MAY 1940.

## NEW MEMBERS.

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

Elections are subject to confirmation in accordance with the By-laws, Section IV, Pars. 9 and 10.

*As Fellows.*

| | |
|---|---|
| MOND, Albert Levy | London. |
| EISNER, John Hans | Ellesmere Port. |

*As Members.*

| | |
|---|---|
| GASCOIGNE, George Norman | London. |
| SCHARGES, Walter Herbert | Cape Town. |
| TEMPLE, George Edward Maskell | Iran. |
| TOKAYER, Oscar | London. |

*Transfer to Member.*

| | |
|---|---|
| HIGGS, Percival George | Egypt. |

*As Associate Members.*

| | |
|---|---|
| ALLCARD, Harry Ganly | Manchester. |
| BRADFORD, Job Ronald Tremellen | London. |
| CARTER, Edward Howard | Willerby. |
| FORSTER, Denis Williams | Warrington. |
| GREIG, Alan Lancelot | London. |
| HILTON, John Sydney | Leeds. |
| KENYON, Harold Frederick | Cambridge. |
| MARSHALL, Edward Thomas | H.M. Navy (R.N.R.). |
| PARTRIDGE, William Arthur | London. |
| ROGER, Arthur | Warrington. |

*As transfer to Associate Member.*

| | |
|---|---|
| LISLE, Brian Orchard | New York. |

*As Students.*

| | |
|---|---|
| AUSTIN, John Martin | Birmingham. |
| BUXTON, Geoffrey | Birmingham. |
| CHEETHAM, Harry Alan | Birmingham. |
| CLARKE, Geoffrey Jardine | London. |
| CUDE, Arthur Leslie | Birmingham. |
| CHIVERS, Harold Victor | Birmingham. |
| GRUNBERG, Leander | Birmingham. |
| HAWKES, John Cecil | Birmingham. |
| METCALFE, John Leslie | Birmingham. |
| NEILSON, Ian McIntosh | Birmingham. |
| SHACKELL, Douglas Ashton | Birmingham. |
| SIMPSON, Alan Murray | Birmingham. |
| TONGE, Peter | Birmingham. |
| WISEMAN, Kenneth William | Birmingham. |
| WOOD, George Frederick | Birmingham. |

The following have been transferred to Fellowship under the temporary regulations in force for 1939 :—

MALHERBE, Gideon John. MACLEAN, Thomas Traill.
TITCHMARSH, George Henry.

## CANDIDATES FOR ADMISSION.

The following have applied for admission to the Institute or transfer to another grade of membership, and in accordance with the By-laws the proposals will not be considered until the lapse of at least one month subsequent to the issue of this *Journal*, during which 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 any candidate.

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

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

AGOSTINI, Pierre Leon, Engineer, c/o Trinidad Leaseholds, Ltd., Forest Reserve, Trinidad, B.W.I. (*J. L. Harris ; F. S. Tindall.*)

BROWN, Norman Fraser, Fields Chief Engineer, Indo-Burma Petroleum Co., Ltd., Rangoon, Burma. (*C. F. C. Moore ; A. E. Day.*)

COOPER, Arundel David, Chemist, c/o The Anglo-Egyptian Oil Co., The Refinery, Suez, Egypt. (*J. Kewley ; W. P. Hodgson.*) (*Trans. to Fellow.*)

PACHACHI, Nadim, Student, Ministry of Economics, Baghdad, Iraq. (*S. E. Coomber ; G. D. Hobson.*) (*Trans. to Associate Member.*)

PEASE, Sherman Levi, Engineer (*U.B.O.T.*), 626, 16th Avenue Southeast, Minneapolis, Minnesota, U.S.A. (*G. S. Taitt ; R. F. Connock.*)

PRUTTON, Carl F., Ph.D., Professor of Chemical Engineering, Case School of Applied Science, Cleveland, Ohio, U.S.A. (*W. Miller ; J. F. T. Bowles.*)

SUTER, Hans H., Geologist, c/o Trinidad Leaseholds, Ltd., Pointe-a-Pierre, Trinidad, B.W.I. (*B. G. Banks ; H. C. H. Thomas.*)

TULLY, James, Engineer, Aln House, Thropton, Northumberland. (*C. Dalley ; H. W. Barnes.*)

ARTHUR W. EASTLAKE,
*Honorary Secretary.*

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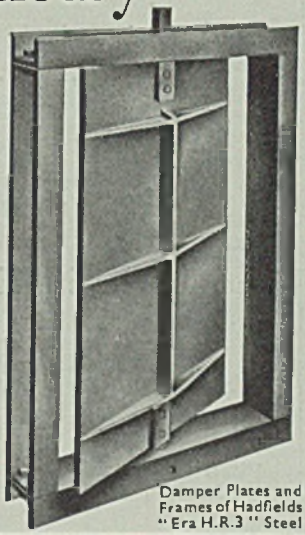

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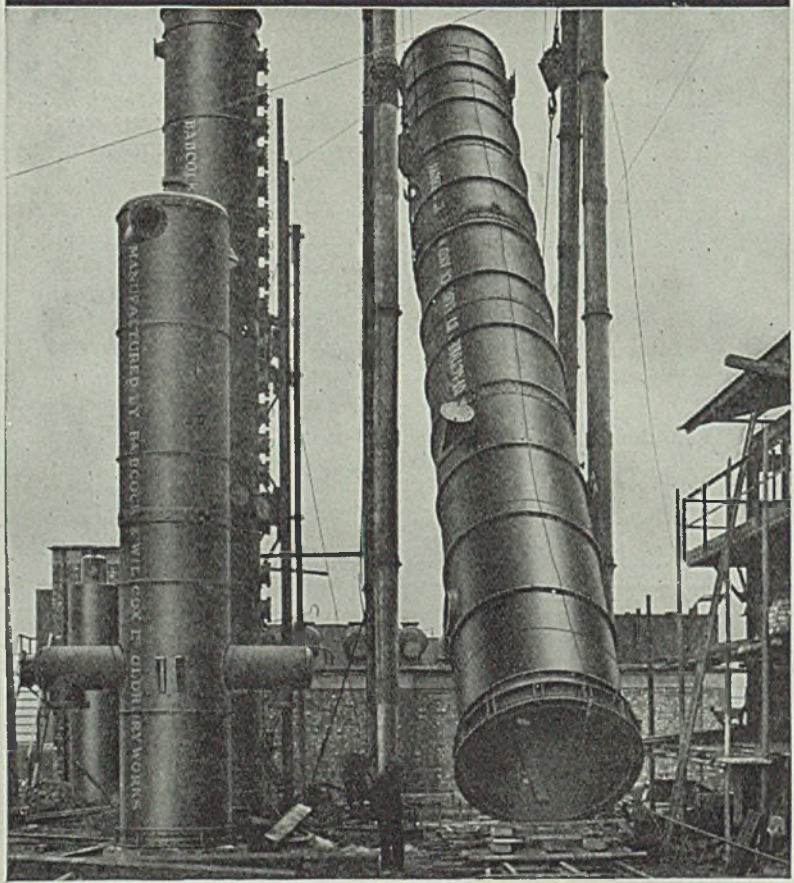

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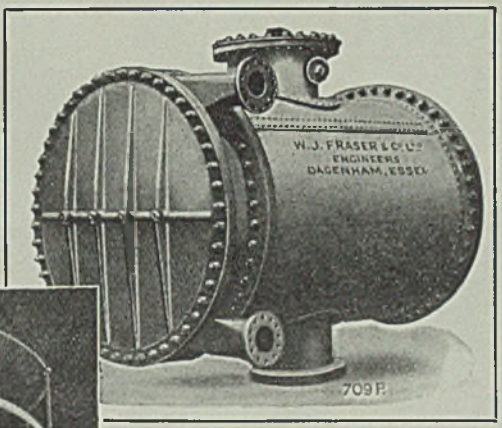


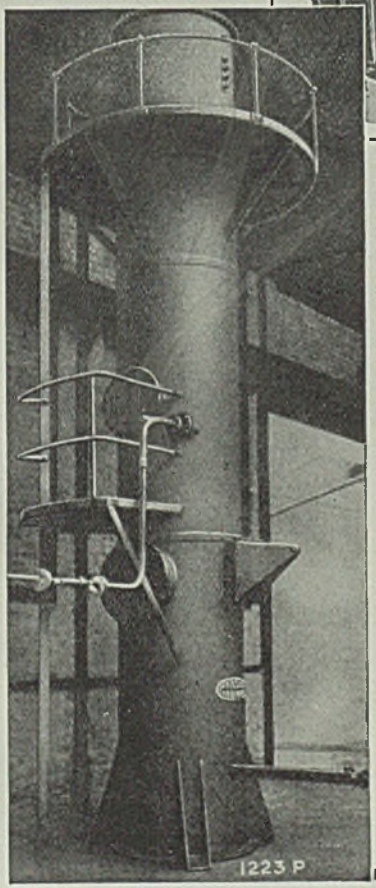


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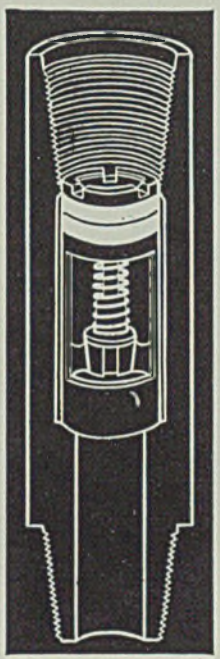

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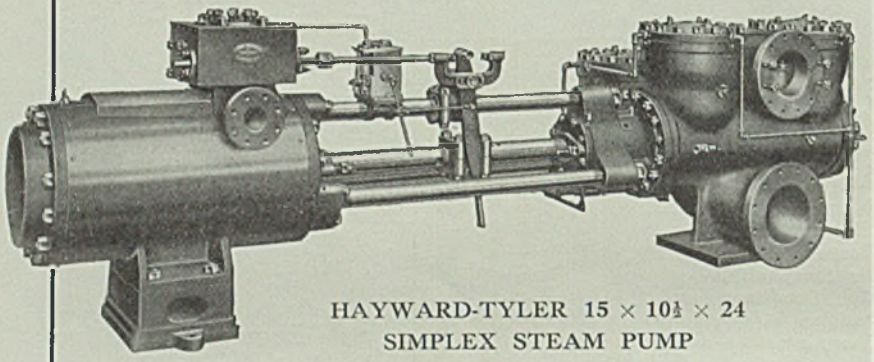

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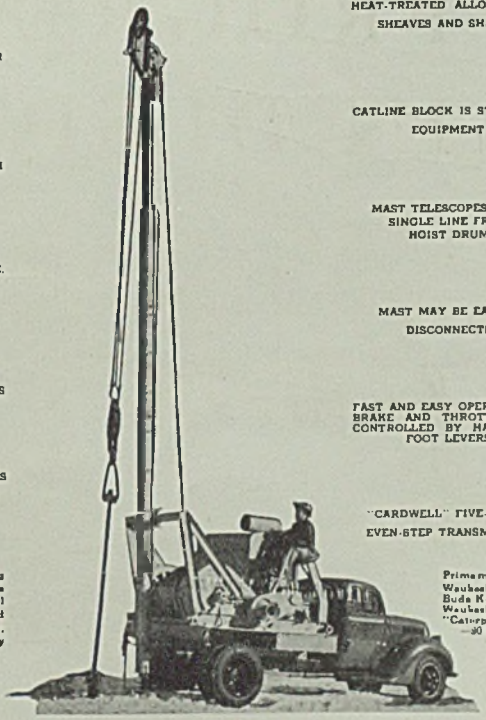


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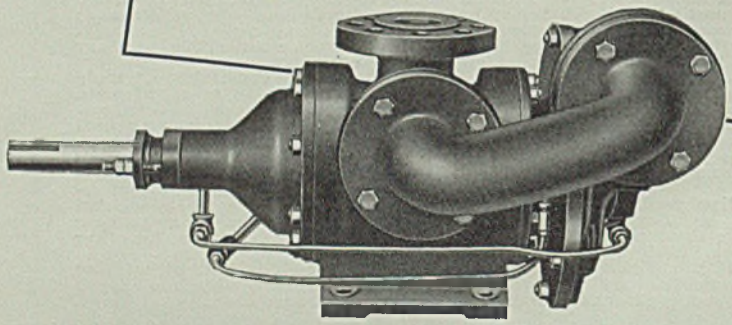

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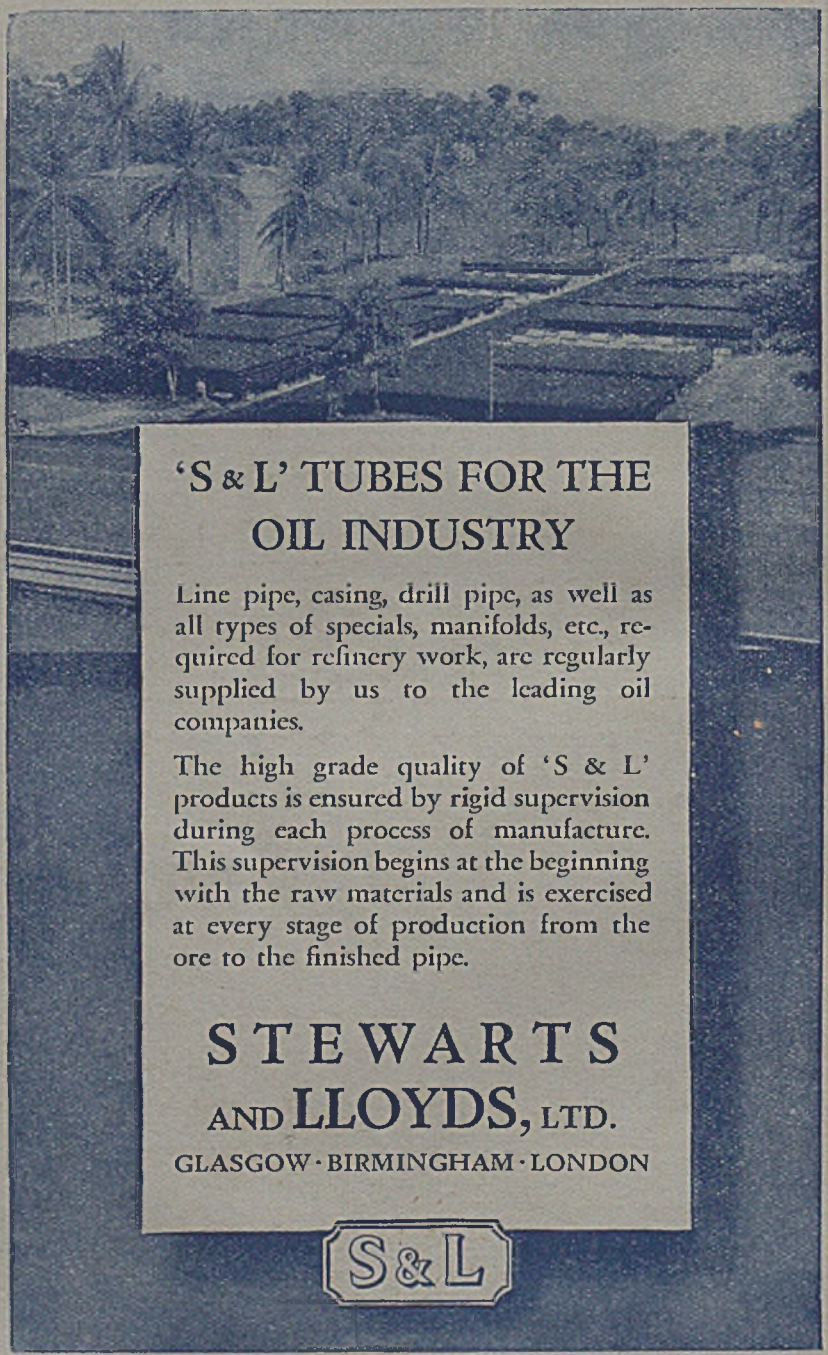
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