

HYDROCARBON SOLVENTS FROM PETROLEUM AND THEIR INDUSTRIAL APPLICATIONS.*

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THE industrial uses of petroleum products are many and varied, quite apart from their uses as fuels and lubricants. A range of solvents of varying volatilities is an important contribution of the petroleum industry to many manufacturing processes. There is a quite extensive literature on solvents generally, but there does not appear to be any comprehensive discussion on the properties and applications of the petroleum solvents, although numerous papers deal with specific properties and many books describe the uses of these materials in individual processes.

This paper does not attempt to go very deeply into the subject, but merely to give a general description of the commonly available petroleum solvents and the way in which they are used. It is felt that this treatment may be of some interest and use both to the petroleum technologist and to the users of such solvents.

Before the war, a very large variety of petroleum spirits was available for industrial use. Many of these differed only slightly from the main types and were made to suit the individual convenience of users. Nowadays, however, some of the special raw materials are no longer available, and it is in the interests of conservation of supplies to reduce the number of grades made to the main types. The chief solvents now available comprise a range of six Special Boiling-Point Spirits (S.B.P.'s Nos. 1 to 6), Pool Rubber Solvent (R.S.), Pool White Spirit and Pool Distillate. In addition, kerosine and vaporizing oil find some application as solvents. This range of materials has proved in practice adequate for the basic needs of industry and fulfils most of the purposes for which such distillates were employed before the war.

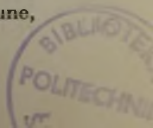
THE MANUFACTURE OF PETROLEUM SOLVENTS.

The light-petroleum solvents are manufactured by distillation from specially selected and refined naphthas. The products are usually subjected to chemical treatment to remove traces of sulphur compounds and improve odour. A brief description of the distillation processes is given below.

The S.B.P.'s and rubber solvent are usually produced in batch-stills, as this is found more convenient on account of the overlapping distillation ranges of the products required. It is possible, however, to produce these spirits from a continuous unit, taking off several sidestreams and combining suitably. White spirit is more often made in a continuous unit, as one definite main product is required from the operation.

Typical batch-stills consist of cylindrical shells about 24 feet in length and 9 feet in diameter, accommodating a charge of approximately 7,000 to 8,000 gallons. The stills are well lagged and provided with closed steam coils

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(at about 140 lb./sq. in.) and open coils (at about 15 lb./sq. in.). Heating by the circulation of hot oil through the coils provides a modern alternative to the method of using closed steam. The open steam is required for the distillation of heavier fractions in order to speed up the process and avoid decomposition. Heat input to the still is automatically controlled. Each still is provided with a fractionating column about 36 feet high and 3 feet diameter. This may either be packed with rings or some other suitable filling or contain, say, twenty trays with bubble-caps, to promote good contact between the ascending vapour and the liquid reflux. The overhead vapour from the column is condensed in a tubular condenser, from which it passes to a reflux drum. From the latter a portion of the condensate is pumped back to the top of the column to

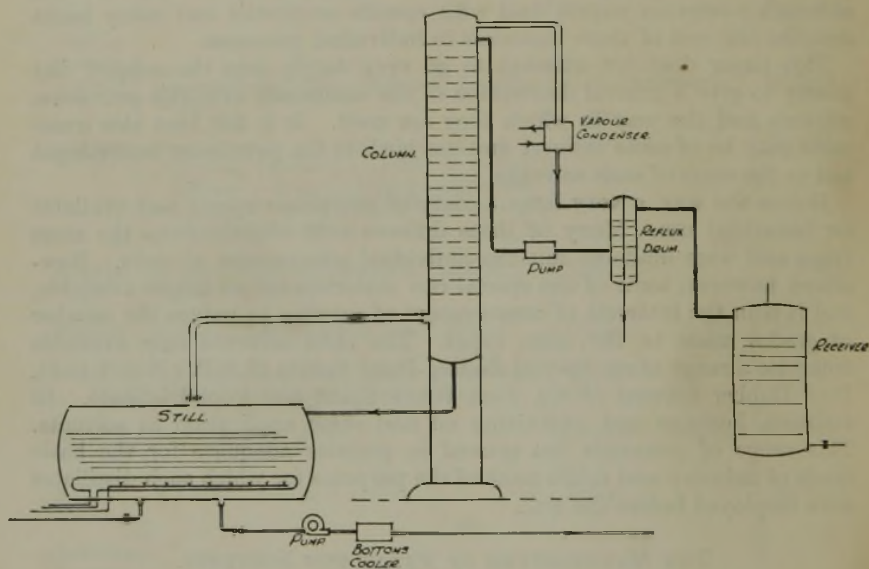


FIG. 1.

BATCH STILL.

provide the necessary reflux for fractionation. The reflux drum, which may be about 6 feet high by 2 feet diameter, also separates the condensed water from the spirit fraction.

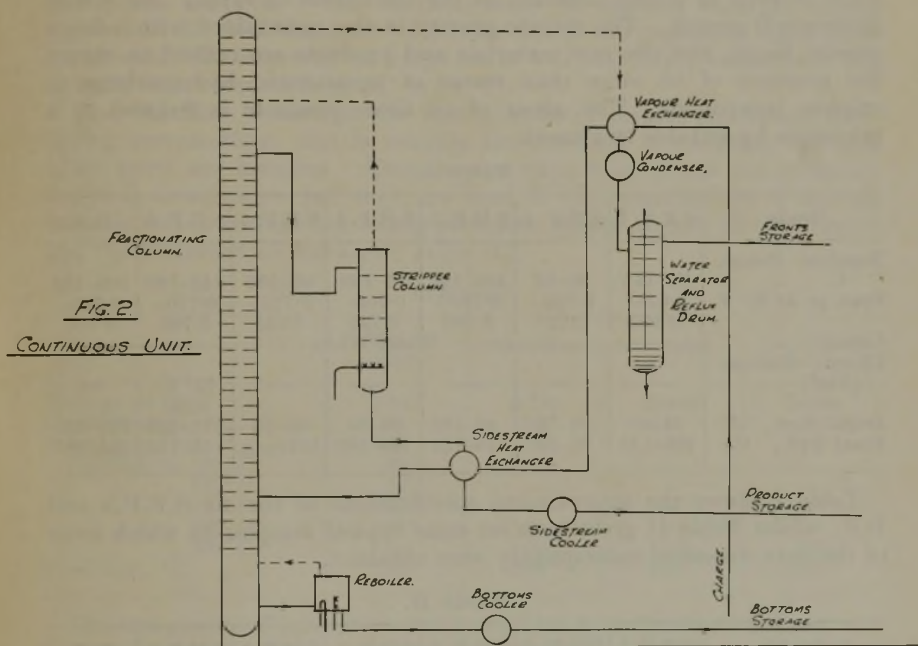
A number of stills, say from three to eight, is grouped in a battery and provided with a series of product receiving tanks, into which suitable fractions from the various stills can be run and accumulated.

Suitably placed thermometers, flowmeters, and control valves enable the rate of distillation, proportion of reflux, and disposal of products to be controlled, mainly from a control panel.

The detailed procedure adopted for a run will depend on the properties of the naphtha being distilled, the characteristics of the plant, and the specifications of the products required. The best operating conditions are worked out by experiment. More or less blending of fractions and re-distillation will be required to enable the final specifications to be met.

A complete run, in a still of type described above, including cooling down and re-charging, will take approximately 50 hours. There is inevitably a distillation loss in processing these light naphthas, and this may amount to some 3 per cent. of the material charged. 1 or 2 per cent. of the charge is also left as heavy bottoms, and this is run off and stored pending re-working to some heavier grade or other means of disposal.

White spirits are very conveniently made in a continuous distillation unit, although batch-stills are often used. In the continuous process a suitable rough cut from the distillation of a crude petroleum is pumped through heat exchangers to the fractionating column. The column may be some 60 to 70 feet high and 3 feet in diameter, containing about thirty plates with bubble-caps. The incoming white spirit enters near the bottom



of the column, but not necessarily at the lowest plate. At the base of the column is a "re-boiler" heated with closed steam at 140 lb./sq. in. and open steam at about 15 lb./sq. in. This steam provides the heat necessary to vaporize the incoming crude white spirit. Steam and light fractions (fronts) are taken off overhead from the column, whilst the main fraction of white spirit is run off as a sidestream from a suitable plate in the column. The heavy fractions of the feed-stock collect in the re-boiler, from which they are continuously run off through a cooler to storage.

The fronts and steam are taken through heat-exchangers to a condenser and thence to a water-separator. From this a portion of the condensate is returned to the top plate of the column to act as reflux. The main white spirit fraction flows to a small "stripper column," where, by the action of live steam, a final control is obtained on the initial boiling point

and flash-point of the product. The main product passes through coolers to storage, where it is held pending final chemical treatment, whilst the overheads from the stripper are returned to the main fractionation column at a point above that at which the main sidestream was taken off.

THE SPECIFICATIONS AND PROPERTIES OF PETROLEUM SOLVENTS.

1. Specifications.

The special boiling-point spirits and rubber solvent are cut to specified distillation ranges, since controlled volatility is their most important property. The percentages distilling at temperatures intermediate to the initial and final boiling points cannot be guaranteed, but the volatility curve is kept as nearly constant as the conditions of supply and manufacture will permit. The specific gravity is also maintained within fairly narrow limits, and the raw materials and products are refined to ensure the presence of no more than traces of unsaturated hydrocarbons or sulphur compounds. The odour of all these products is reduced to a minimum by suitable treatment.

TABLE I.

Grade.	S.B.P. 1.	S.B.P. 2.	S.B.P. 3.	S.B.P. 4.	S.B.P. 5.	S.B.P. 6.	R.S.
Nominal Range, ° C.	35-115	70-95	100-120	40-150	90-105	140-160	100-160
Spec. gr. at 60° F.	0.675- 0.695	0.700- 0.720	0.735- 0.755	0.705- 0.730	0.725- 0.745	0.770- 0.790	0.745- 0.770
Colour	Water White						
Closed flash-pt. (Abel)	—	—	—	—	—	73° F. min.	—
Initial b.pt., ° C.	35-45	68-72	98-105	30-50	88-95	137-143	100-120
Final b.pt., ° C.	100-115	90-95	118-122	140-160	105 max.	155-165	155-165

Table I shows the approximate specifications of the six S.B.P.'s and R.S., whilst Table II gives tests on some typical samples on which some of the data discussed subsequently were obtained.

TABLE II.

Grade.	S.B.P. 1.	S.B.P. 2.	S.B.P. 3.	S.B.P. 4.	S.B.P. 5.	S.B.P. 6.	R.S.
Spec. gr. at 60° F.	0.685	0.711	0.745	0.717	0.729	0.780	0.757
Distillation (° C.):							
Initial b.pt.	43	68	101	48	89	141	113
2% at .	51	69	102½	52	89½	141½	114
10% at .	55	71	103	61½	90½	142	115½
20% at .	58	71½	103½	67½	91	143½	116
40% at .	64	73½	105	81	92	144½	119
50% at .	67	74½	105½	88	93	145½	121
60% at .	70	76	106	95	93½	146½	123
80% at .	80	80	109	112	95	150	129
90% at .	89½	84½	112	126	96½	155½	138½
95% at .	98	89	116	136	99	160	146
Final b.pt., ° C.	105	95	121	149	103	165	157
Recovery .	97%	98%	98½%	97½%	98%	98%	97%
Residue .	1%	1%	1%	1%	1%	1%	1%
Closed flash-pt.	—	—	—	—	—	74° F.	—

It must be mentioned here that all distillation figures quoted are by the standard Institute of Petroleum method. Some users carry out tests with fractionating columns of various types and using flasks of different sizes, oil-bath heating, and similar modifications. The results of such tests are not comparable with the standard figures, on account of the different degrees of fractionation obtained, larger hold-up in the column, etc.; the loss and residue figures obtained may vary widely, according to the method used.

Pool White Spirit conforms to the B.S.I. Specification No. 245 of 1936, as recently modified to meet emergency conditions. The "Freedom from Corrosive Properties" clause now provides that a polished copper strip shall not be discoloured or pitted when heated in the spirit at 100° C. for 3 hours. The B.S.I. Specification calls for 78° F. minimum Abel flash-point, but Pool White Spirit is made to conform with the export regulations for the shipment of paints, etc.; the minimum flash-point requirement for shipment on cargo-boats without undue restrictions has recently been reduced from 93° to 88° F.

Pool Distillate is used in the manufacture of certain paints and slow-drying compositions, and is roughly intermediate in volatility between white spirit and kerosine. Kerosine and vaporizing oil are not primarily designed as solvents, but they are used in the manufacture of stoving enamels and in certain degreasing processes. Typical tests of white spirit and the kerosines are shown in Table III.

TABLE III.

	White spirit.	Distillate.	Kerosine.	Vaporizing oil.
Spec. gr. at 60° F.	0.801	0.795	0.800	0.830
Closed flash-pt., ° F.	94	104	115	95
Initial b.pt., ° C.	149	150	160	145
Distilling to 160° C.	40%	—	—	—
" " 170° C.	72%	—	—	—
" " 180° C.	88%	—	—	—
" " 190° C.	97%	—	—	—
" " 200° C.	—	60%	38%	55%
Final b.pt., ° C.	195	280	285	265

The two grades of solvent known in the U.S.A. as Stoddard Solvent and Petroleum Spirits (Mineral spirits) are roughly equivalent to Pool White Spirit. The specifications are laid down by the A.S.T.M. (Report of Committee D.2, 1940) and are briefly as follows :

TABLE IV.

Grade.	Stoddard solvent.	Petroleum spirits.
Specification No.	D 484-40	D 235-39
Flash-pt. (Tag-closed)	100° F. min.	100° F. min.
Distillation :		
176° C.	50% min.	50% min.
190° C.	90% min.	—
Final b.pt.	210° C. max.	210° C. max.
Corrosion (copper strip)	Only slight discoloration after 3 hrs. at 212° F.	No marked blackening after 30 mins. at boiling point of spirit.

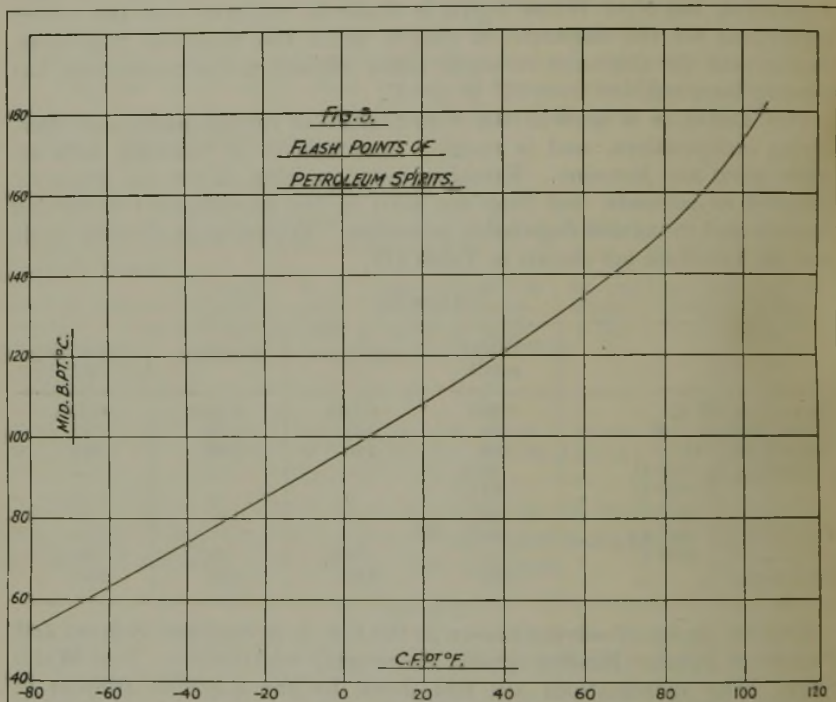
" Stoddard Solvent " is used for dry-cleaning and " Petroleum Spirits " is intended for the paint and varnish industries.

The product known as V.M. & P. (varnish makers' and painters') naphtha generally has a boiling range of approximately 100 to 155° C. and is equivalent to Pool Rubber Solvent.

2. Properties.

(i) Flash-point and Inflammability.

Petroleum vapours, if mixed with air in proportions varying between certain limits, will ignite or explode on the application of a flame or



electric spark. The conditions in which this occurs are dependent on a number of factors, such as temperature, ventilation, the nature of the space in which the air-vapour mixture is formed, the intensity of the spark, and so on. It is necessary to distinguish between the properties of a liquid which determine the ease with which it gives off sufficient vapour to form an explosive mixture with air under certain conditions and the inflammable properties of the vapour so formed.

Considering first the liquid, the usual criterion for its readiness to give off vapour is the " flash-point "—i.e., the temperature at which the liquid will give off sufficient vapour to flash on the application of a flame under arbitrarily selected conditions in a standard apparatus. This figure, the

lower flash-point, is obtained by a procedure involving gradual raising of the temperature, and is dependent to a large extent on the proportion and nature of the lightest constituents present. In the case of narrow-cut fractions there seems to be a fairly close relation between the volatility (measured by the 50 per cent. distillation temperature) and the Abel flash-point. Such a relation is illustrated in Fig. 3, and from this the approximate flash-points of the S.B.P.'s, rubber solvent, and white spirit samples referred to above would be approximately :

TABLE V.

	Flash-point, ° F.	Temperature at which 50% is distilled, ° C.
S.B.P. No. 1	— 54	67
„ „ 2	— 40	74½
„ „ 3	+ 15	105½
„ „ 5	— 7	93
„ „ 6	+ 74	145½
Rubber solvent	+ 40	121
White spirit	+ 93	163

It will be noted that the estimated flash-point of S.B.P. No. 4 is not given above. The 50 per cent. point is only an approximate guide to the ease of formation of vapour in the case of the narrow fractions. S.B.P. No. 4 boils over a wide range, and a better estimate of its flash-point would be obtained from the vapour pressure rather than from the mean volatility. (The 50 per cent. point of S.B.P. No. 4 is 88° C.) Plotting Reid vapour pressures at 100° F. against flash-point, and interpolating for S.B.P. No. 4, leads to a value of approximately — 48° F. for this solvent.

It may be of interest to mention here the relationships stated by Ormandy and Craven (*J. Inst. Petrol. Tech.*, 1922, 8, 163) for the flash-points of hydrocarbons. These authors found that the vapour pressures of all hydrocarbons at their flash-points are approximately the same—viz., 12 mm. Hg (0.232 lb./sq. in.) for the lower and 40–50 mm. Hg (0.967 lb./sq. in.) for the higher flash-point. They found also that the lower flash-point in ° abs. is approximately equal to $0.736 \times$ boiling point in ° abs.

S.B.P. No. 6 is the only one of the light solvents which flashes above 73° F., and it is expressly designed to have the maximum volatility consistent with such a flash-point, which confers freedom from the provisions of certain petroleum storage regulations. White spirit flashes above 88° F. (usually above 90° F.), whilst kerosine and Distillate flash above 100° F. and vaporizing oil about 95° F. Flash-point and vapour pressure (*q.v.*) give some indication of the tendency of petroleum products to give off inflammable vapour, but the vapours themselves differ in their limiting concentrations for, and ease of, inflammability.

An explosive or inflammable mixture may be defined as one in which flame can be propagated independently and away from the original source of ignition. It is only between the concentrations represented by the upper and lower limits of inflammability that self-propagation of the

flame will take place after ignition has been effected. Combustion may occur over wider limits with a continuous application of flame.

The explosive limits for petroleum-spirit vapours are usually taken as about 1.2-6 per cent. vol. in air, but the conditions influence the results widely. Thus, the explosive range is usually less in large vessels, and varies also with the direction of the propagation of flame, location of the source of ignition, intensity of igniting spark, etc. The lower-molecular-weight hydrocarbons have a wider explosive range (cf. Wheeler, *J.C.S.*, 1924, 125, 1858).

The following estimated figures give some idea of the explosive ranges for some of the solvent vapours under working conditions:

TABLE VI

Grade.	Vol. % vapour in air.	
	Lower limit.	Upper limit.
S.B.P. No. 1	1.3	7.2
" " 2	1.25	7.0
" " 3	1.1	6.7
" " 4	1.2	6.8
" " 5	1.2	6.8
" " 6	1.0	6.3
Rubber solvent	1.1	6.5
White spirit	1.0	6.2

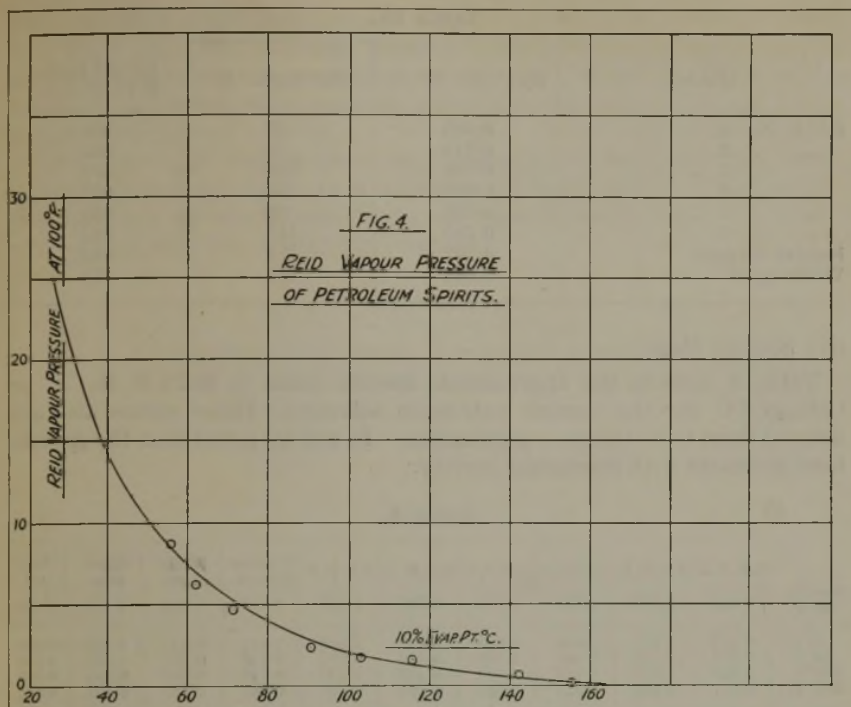
(ii) Vapour Pressure.

The vapour pressure of a solvent influences to a considerable extent its inflammability and also its behaviour on evaporation. The lighter fractions have the greatest effect on vapour pressure, and the property increases quite rapidly with temperature. Table VII illustrates the variation in vapour pressure in lb./sq. in. for some of the products for which typical tests are given in Tables II and III. The Reid vapour-pressure bomb was employed for these determinations.

TABLE VII.

Temp. ° F.	S.B.P. 1.	S.B.P. 2.	S.B.P. 3.	S.B.P. 4.	S.B.P. 5.	S.B.P. 6.	Rubber solvent.	White spirit.
40	2.0	0.8	—	1.4	—	—	—	—
60	3.2	1.3	—	2.2	—	—	—	—
80	4.7	2.8	0.5	3.8	0.8	—	0.3	—
100	8.7	4.6	1.8	6.2	2.3	0.6	1.6	0.15
120	—	—	4.7	—	5.4	1.7	3.7	1.0
140	—	—	—	—	—	3.6	—	3.0

There is a fairly good relationship between the 10 per cent. evaporated distillation point of light-petroleum solvents (*e.g.*, S.B.P.'s and normal gasolines) and their Reid vapour pressures at 100° F., and this is illustrated in Fig. 4.



(iii) Latent Heats of Vaporization.

The latent heats of petroleum products vary considerably with the temperature of evaporation. The value in B.Th.U. per lb. is inversely proportional to the density of the product, so that the latent heat of a gallon of petroleum depends only on the temperature of vaporization.

In Table VIII are recorded the latent heats in B.Th.U./Imp. gallon for a gallon of petroleum product vaporized at various temperatures. Values in B.Th.U./lb. are easily obtained using the known gravities at 60° F. of the particular solvent concerned. These are approximate average figures, and are derived from C. S. Cragoe, "Thermal Properties of Petroleum Products," U.S.B.M. Miscellaneous Publication No. 97, 1929.

TABLE VIII.

Temperature		Latent heat vaporisation, B.Th.U./Imp. gallon, 60° F.
° F.	° C.	
60	15.5	1055
100	38	1022
200	93	930
300	149	840
400	204	750

For the Pool S.B.P.'s and White Spirit at their mid-boiling points the approximate values will be :

TABLE IX.

Grade.	Spec. gr., 60° F.	Mid-b.pt. ° C.	Latent heat, B.Th.U./I.G.
S.B.P. No. 1 . . .	0.685	67	973
" " 2 . . .	0.711	74	962
" " 3 . . .	0.745	105	908
" " 4 . . .	0.717	88	938
" " 5 . . .	0.730	93	930
" " 6 . . .	0.780	145	847
Rubber solvent . . .	0.757	121	885
White spirit . . .	0.801	163	815

(iv) *Specific Heat.*

Table X records the approximate specific heats in B.Th.U./lb./°F. or Cals./gr./°C. for the various petroleum solvents. These values also are derived from C. S. Cragoe's publication. It will be noted that the specific heat decreases with increasing gravity.

TABLE X.

	S.B.P. 1.	S.B.P. 2.	S.B.P. 3.	S.B.P. 4.	S.B.P. 5.	S.B.P. 6.	Rubber solvent.	White spirit.	Kerosine.	Vap. Oil.
Spec. gr., 60° F. }	0.685	0.711	0.745	0.717	0.730	0.780	0.757	0.801	0.810	0.830
0° F.	0.469	0.460	0.450	0.458	0.453	0.440	0.446	0.437	0.429	0.424
60° F.	0.501	0.492	0.481	0.490	0.484	0.470	0.476	0.467	0.461	0.456
100° F.	0.523	0.514	0.502	0.511	0.506	0.490	0.497	0.487	0.481	0.476
200° F.	0.577	0.567	0.553	0.563	0.554	0.540	0.548	0.537	0.531	0.525

(v) *Viscosity.*

The petroleum solvents have low viscosities, which for spirits of similar origin increase with the densities and boiling ranges. Typical figures are shown in Table XI, the results being expressed in centistokes.

TABLE XI.

Grade.	Spec. gr., 60° F.	Boiling range. ° C.	Viscosity in cs.	
			0° C.	20° C.
S.B.P. No. 1 . . .	0.6865	35-115	0.617	0.510
" " 2 . . .	0.7215	70-95	0.776	0.629
" " 3 . . .	0.7470	100-120	0.916	0.717
" " 4 . . .	0.7160	40-150	0.732	0.598
" " 5 . . .	0.7380	90-105	0.853	0.679
" " 6 . . .	0.7735	140-160	1.347	1.017
Rubber solvent . . .	0.7690	100-160	1.132	0.884

White spirits and kerosines are rather more viscous, the former being approximately 1.4 cs. at 20° C., whilst typical figures for kerosine are 2.9 cs. at 0° C. and 1.9 cs. at 20° C.

(vi) *Freezing Point.*

Normal petroleum spirits have very low freezing points, and with low benzene contents figures of down to -120° C. have been found. At

this temperature the spirit becomes pasty. All six S.B.P.'s, rubber solvent, and white spirit can be cooled down to -70°C . with no sign of freezing. Kerosines normally set-up at about -50°C . to -60°C ., while vaporizing oils, which contain more aromatics and less paraffin hydrocarbons, are usually still fluid at -70°C .

The addition of benzole has a very marked effect in raising the freezing point of petroleum spirit, as is indicated in Table XII, which shows the temperatures at which solid begins to separate from blends of a spirit similar to S.P.B. No. 4 with 90s. benzole.

TABLE XII.

% Benzole in blend by vol.	Separation temperature, $^{\circ}\text{C}$.
15	- 50
20	- 45
30	- 35
40	- 30
50	- 25

(vii) Composition.

The S.B.P.'s and white spirit consist essentially of hydrocarbons of the naphthene and paraffin series, with smaller amounts of aromatic hydrocarbons. Prepared, as they are, from straight-run materials and subjected to refining, they contain only traces of unsaturated hydrocarbons. For the same reason, the total sulphur content is negligible and deleterious or corrosive sulphur compounds are absent. Benzene is likely to be present only in quite small quantities, *e.g.*, in S.B.P.'s 1, 2, 4, and, possibly, S.B.P. 5. In no case can the percentage present exceed a few per cent., and this fact is of importance in relation to the "Fume Process" regulations. Toluene, ethylbenzene, and the xylenes are present in the higher-boiling members of the series.

TABLE XIII.

Hydrocarbon Composition of Petroleum Solvents (Per Cent. Weight).

	S.B.P. 1.	S.B.P. 2.	S.B.P. 3.	S.B.P. 4.	S.B.P. 5.	S.B.P. 6.	Rubber solvent.	White spirit.	Kerosine.	Vap. oil.
Aromatics	3.0	4.5	10.5	5.0	4.5	17.5	12.0	19.0	11.0	21.0
Naphthenes	18.0	30.0	40.0	35.0	44.5	38.0	37.5	51.5	17.5	41.5
Unsaturateds	0.5	0.5	0.5	0.5	0.5	1.0	1.0	0.5	2.5	2.5
Paraffins	78.5	65.0	49.0	59.5	50.5	43.5	49.5	29.0	69.0	35.0

The hydrocarbon analyses quoted in Table XIII must be regarded as approximations only. Considerable variation may occur according to the origin of the products.

(viii) Solvent Power.

(a) *Oils and Fats*.—Petroleum spirits are excellent solvents for practically all the animal and vegetable oils and fats, including wool-fat.

An exception is castor oil, which, by reason of its hydroxylated nature, is soluble only to a very limited extent in most petroleum solvents.

(b) *Paraffin Wax*.—Here the solubility depends largely on the temperature, the composition of the solvent, and the nature of the wax. The method of determination of the solubility may also have some bearing on the results.

In Tables XIV and XV an indication of the solubility of wax at 15° C. and 25° C. is given by the results on American 122–5° F. m.pt. wax.

TABLE XIV.
Solubilities American 122–5 Wax.
(Gm. wax/100 mls. solution.)

Temp., ° C.	S.B.P. 1.	S.B.P. 2.	S.B.P. 3.	S.B.P. 4.	S.B.P. 5.	S.B.P. 6.	Rubber solvent.	White spirit.
15	14.1	12.3	9.7	13.5	9.7	9.2	9.6	8.9
25	24.1	23.8	23.0	23.6	22.8	22.3	22.5	20.1

TABLE XV.
Solubilities American 122–5 Wax.
(Gm. wax/100 gm. solution.)

Temp., ° C.	S.B.P. 1.	S.B.P. 2.	S.B.P. 3.	S.B.P. 4.	S.B.P. 5.	S.B.P. 6.	Rubber solvent.	White spirit.
15	20.6	18.1	13.8	19.8	14.2	12.9	13.2	12.0
25	32.5	31.5	30.2	31.1	29.8	28.6	29.0	26.3

The influence of temperature on wax solubility is much greater than the variations between the different solvents in this respect. There is a rough relation between the mean volatility of solvents of similar origin and their solvent power for wax (Fig. 5).

(c) *Rubber*.—When raw rubber is immersed in petroleum spirit, it swells considerably, due to absorption of the solvent. When mechanical action, such as stirring or shaking, is applied, the swollen mass disperses through the unabsorbed solvent forming a colloidal “solution.” If rubber has been masticated (*i.e.*, subjected to mechanical action leading to partial breakdown of the rubber structure) it yields solutions which are of lower viscosity than those of unmasticated rubber in the same concentration and the same solvent.

The presence of aromatics, and to some extent naphthenes, increases the solvent power of spirits for rubber.

Vulcanized rubber also swells to some extent when immersed in petroleum spirit, but mechanical action or heat does not disperse the rubber into colloidal solution.

Chlorinated rubbers are not soluble in petroleum spirits unless a large proportion of aromatic hydrocarbons is present.

Petroleum solvents have to a large extent displaced benzene and other coal-tar hydrocarbons as rubber solvents, on account of the lower toxicity of the former.

Rubber solutions, as used in industry, may contain 6–12 per cent. or more of rubber, in one of the S.B.P.’s or rubber solvent.

(d) *Resins*.—Jordan ("The Technology of Solvents") relates resin solubility with oxygen content. The oxygen-containing types, such as shellac, copal, phenolformaldehyde, and urea-formaldehyde resins, are completely insoluble in hydrocarbons. Those resins which are free from or have low oxygen contents—e.g., rosin esters, coumarone resins, and cyclohexane resins—have a limited solubility in petroleum spirits. Some resins of the phthalic acid (alkyd) type are fairly readily soluble in petroleum. Urea-formaldehyde resins soluble in white spirit have recently been introduced (cf. Worsdall, "O. & C. T. J.," 1940, p. 848).

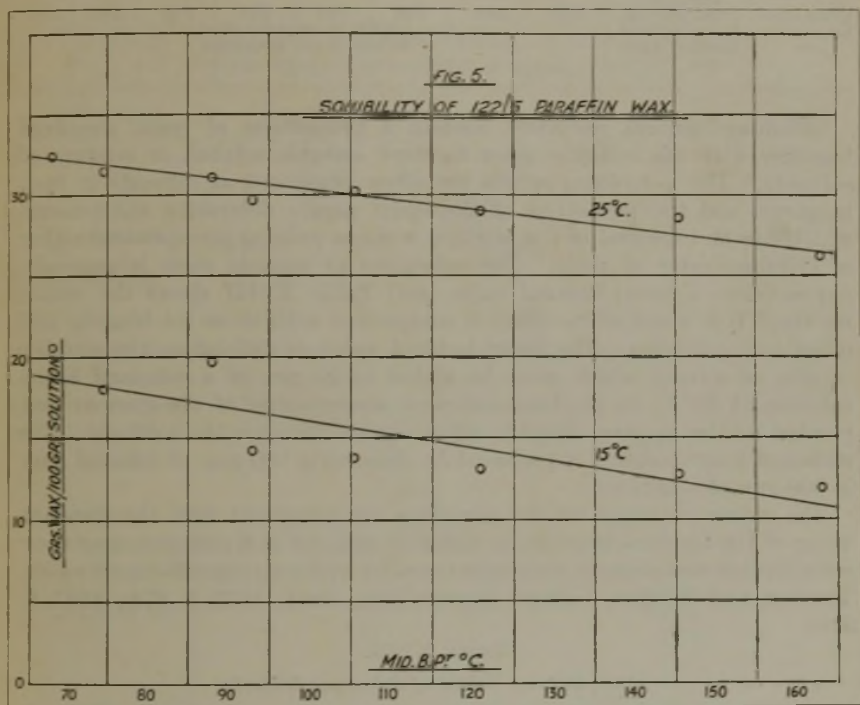


Table XVI is extracted from Jordan, and shows the solubility of a few resins; it refers to mixtures of equal parts of resin and solvent at room temperature.

TABLE XVI.

Elemi *	Dammar †
Rosin ‡	Ester Gum *
Gallipot *	Albertol *
Mastic †	Alkydal *
Kauri Copal †	Polystyrol †

* Soluble.

† Insoluble.

‡ Partially soluble.

The results of some determinations of the solubility of a few gums are

given in Table XVII, and indicate, as does Table XVI, the very wide variations which exist.

TABLE XVII.
Solubilities of Some Resins.
(Gm./100 gm. solution.)

Gum.	Type.	S.B.P. 1.	S.B.P. 2.	S.B.P. 3.	S.B.P. 4.	S.B.P. 5.	S.B.P. 6.	Rubber solvent.	White spirit.
Kauri.	Natural.	Not appreciably soluble							
Bakelite.	Straight phenol-aldehyde.	0.06	0.07	0.10	0.075	0.07	0.13	0.12	0.16
Ester-copal.	Copal-glycerol.	3.16	3.46	3.48	3.20	3.24	3.36	3.65	3.78
Ester-gum.	Rosin-glycerol.	Soluble in any proportion							
—	Modified phenolic.	Soluble in any proportion							

Cellulose lacquers normally contain a proportion of resin, dissolved together with the cellulose ester in some suitable solvent or mixture of solvents. The petroleum spirits are often employed as diluents in such lacquers, and the properties of the spirit partly determine the amount which can be tolerated in the mixture without causing precipitation either of cellulose ester or resin. The tolerance as regards resin is generally expressed as a kauri-butanol value, and Table XVIII shows the values for the S.B.P.'s and white spirit in comparison with those for benzene and other hydrocarbons. The kauri-butanol value is defined as the number of mls. of solvent which must be added to 20 gm. of a standard Kauri solution at 25° C. to produce sufficient precipitation of the gum so that printed matter appears illegible when viewed through the solution. The standard kauri solution is prepared by dissolving 100 gm. of selected gum in 500 gm. of *n*-butanol.

The values obtained for the titrations are compared with the standard value of 100 for pure benzene, as different samples of Kauri gum may show considerable variations in their tolerances for hydrocarbons (Balteschwieler, Troeller, and Morgan, *Industr. Engng Chem. Anal.*, 1935, 9, 374; 1937, 9, 540).

TABLE XVIII.
Kauri-Butanol Values of Petroleum Solvents.

Grade.	Kauri-butanol value.	Grade.	Kauri-butanol value.
S.B.P. No. 1 . .	27.5	White spirit . . .	41.5
" " 2 . .	31.9	Benzene . . .	100.0
" " 3 . .	33.3	Toluene . . .	91.9
" " 4 . .	29.4	Xylenes . . .	85.3
" " 5 . .	31.1	cycloHexane . .	54.0
" " 6 . .	35.4	<i>n</i> -Heptane . . .	24.8
Rubber solvent . .	37.4		

(e) *Cellulose Esters.* Cellulose esters are not soluble in petroleum or other hydrocarbons, but a certain amount of petroleum spirit is tolerated by solutions of cellulose in the more expensive alcohols, ketones, and esters. Larger amounts of aromatic hydrocarbons can be tolerated than of paraffins, whilst naphthenes show intermediate results. Nitrocellulose

solutions will tolerate more petroleum spirit than will cellulose acetate solutions in the same concentration in the same solvent.

The tolerance is usually expressed in terms of "dilution ratio"—i.e., the ratio of diluent to solvent necessary to produce permanent turbidity when the diluent is added gradually with shaking to a solution of 10 gm. $\frac{1}{2}$ sec. nitrocellulose in 50 mls. *n*-butyl acetate, the titration being carried out at 20° C. Thus:

$$\text{Dilution Ratio} = \frac{\text{mls. Diluent to produce turbidity}}{50}$$

TABLE XIX.

Dilution Ratios (Nitrocellulose in n-Butyl Acetate).

Grade.	Dilution ratio.	Grade.	Dilution ratio.
S.B.P. No. 1 . .	1.22	White spirit . .	1.24
" " 2 . .	1.20	Benzene . .	2.90
" " 3 . .	1.21	Toluene . .	2.84
" " 4 . .	1.17	Xylene . .	2.76
" " 5 . .	1.18	cycloHexane . .	1.46
" " 6 . .	1.20	n-Heptane . .	1.00
Rubber solvent . .	1.22		

Cellulose acetate solutions have far smaller tolerances for petroleum spirits than have nitrocellulose solutions of the same concentration in the same solvent. Thus, considering solutions of 10 gm. of cellulose ester in 100 ml. of acetone, the following comparison is obtained:

TABLE XX.

Dilution Ratios (in Acetone).

Diluent.	Nitrocellulose.	Cellulose acetate.
S.B.P. No. 1 . . .	9.15	0.92
" " 2 . . .	—	1.10
" " 3 . . .	9.9	1.12
" " 4 . . .	9.0	1.00
" " 5 . . .	—	1.10
" " 6 . . .	—	1.18
Rubber solvent . . .	10.9	1.18
White spirit . . .	11.25	1.3
Benzene . . .	62.5	5.8
n-Heptane . . .	5.0	0.8

The smaller concentration of 10 gm. in 100 ml. solvent is used here on account of the high viscosity of cellulose acetate solutions. It will be noted that the variation in dilution ratio over the range of petroleum solvents is not large.

(ix) *Physiological Action.*

Petroleum distillates have much less physiological action than have many other solvents. One of the most noticeable effects is the removal of fatty matter from the skin by solvent action. This leads to drying and

cracking of the skin and, if not treated, dirt and bacteria enter the pores, and inflammation is set up. This is easily prevented by cleanliness, and by regular treatment, with lanoline or a mixture of one part of lanoline with two parts pure olive oil, of the parts which come in contact with solvents during work. Treatment with antiseptic solutions is also recommended (Home Office Forms 3674, 1863 (1928); 296 and 397 (1932). The sensitivity of the skin to petroleum solvents varies greatly with the individual.

Inhalation of petroleum vapours in small quantities is comparatively harmless, and the worker soon gets accustomed to, and able to tolerate, small concentrations without discomfort. Larger quantities may produce headaches, dizziness, and nausea as the concentration increases, but recovery is rapid when the patient is transferred to the fresh air.

Henderson and Haggard ("Noxious Gases") quote the following figures as an indication of the concentrations of petroleum vapour to produce marked physiological effects :

Least detectable odour	0.03 per cent. vol.
Dangerous for even short exposure	1.1-2.2 per cent. vol.
Rapidly fatal for short exposure	2.4 per cent. vol. and upwards.

As regards toxicity, the paraffin hydrocarbons have very little effect, whilst the naphthenes have perhaps a little more. These two classes of hydrocarbons are those mainly present in the petroleum solvents considered.

The small amount of aromatic hydrocarbons present have a somewhat greater effect, but as the concentration is small, the light petroleum solvents may be considered as innocuous. Considering the pure aromatic hydrocarbons, benzene is usually regarded as being rather more toxic than toluene or the higher aromatics, probably due in part to its higher volatility. Benzene acts as a blood poison, lowering the count of red and white corpuscles and leading to hæmorrhage of the mucous membrane. The "fume process" regulations mention benzene and mixtures containing this hydrocarbon, but toluene and the higher homologues are not included.

THE APPLICATIONS OF PETROLEUM SOLVENTS.

The industrial applications to which petroleum solvents are put may conveniently be divided under three headings: (a) extraction processes in which the petroleum products are used as solvents for oils or fats; (b) deposition processes in which the petroleum products are used as thinners or diluents in solutions which give a film of rubber, cellulose, paint, etc., on drying; and (c) miscellaneous applications, in most of which the petroleum products are used as a source of light or heat.

(a) *Extraction Processes.*

(i) *Oil-seed Extraction.*

The oil from oil-bearing seeds, etc.—e.g., cotton-seed, ground nut, and soya beans—can be removed from the ground product either by pressure or by extraction with a suitable solvent, which is subsequently recovered from the oil by distillation. Occasionally the two processes are com-

bined, the residue from the press, which still contains a proportion of oil, being extracted with solvent. The primary advantage offered by the solvent process is that practically the whole of the oil can be removed, the residual meal containing as little as 0.5 per cent. oil, as against anything between 5 per cent. and 10 per cent. in the case of a pressing plant. There was originally a certain amount of prejudice against the use of extracted oils for edible purposes, but it is now accepted that there is no difference in quality between oils extracted by the two methods. The extracted meals are utilized for feeding purposes or as manures, the extraction process being particularly suitable in the latter case because of the very small proportion of oil in the residual meal, so that extracted meals which cannot be used as cattle foods (castor, for example) make valuable fertilizers. In some cases extracted meals are mixed with a binding agent—e.g., molasses—and compressed into cake nuts or feeding cakes.

The first stage of the extraction process is the breaking up of the oil cells so as to facilitate the action of the solvent, this being effected by some type of grinding machinery varying according to the nature of the seeds or nuts under treatment. Materials such as ground nuts, which require shelling before the grinding process, are first put through a "decorticating" machine. From the grinding house the ground material is passed by elevators and conveyors to bins situated over the extraction vessels, into which it is charged as required.

Solvent from the storage tank is run into the extraction vessel (sometimes warm solvent is used), and the mass is allowed to soak, after which the solution of oil in solvent is run off and the solvent recovered by evaporation and subsequent condensation. Usually a series of extraction vessels is used, arrangements being made so that the fresh seeds or beans are first treated with spirit which has already been used for two or three extractions (and consequently containing a certain amount of oil), whilst fresh spirit is used for the extraction of the seeds which have already been almost completely extracted by previous applications of spirit. By the adoption of this counter-current principle the amount of oil left in the residual meal is reduced to a minimum. The residue in the extractor, after draining to remove solvent, is steamed to remove the last traces of solvent, after which it is passed to the drying machine.

For seed extraction, particularly where the extracted oils are used for edible purposes, the solvent must be free from unsaturated hydrocarbons. A low aromatic content appears generally to be preferred, although solvents of aromatic content anywhere between, say, 5 per cent. and 50 per cent. by weight have been employed successfully in this country. The extraction solvent normally used for seed extraction is S.B.P. No. 2 spirit, although the heavier S.B.P. No. 5 spirit is also used for this purpose.

(ii) *Perfume Extraction.*

In perfume extraction the flower petals are mixed with the solvent in a closed apparatus, at ordinary temperatures, the solvent subsequently being separated by distillation, leaving the perfume wax as a residue. The extracted perfumes are chemically very unstable, particularly at high temperatures, and it is necessary to use a rather volatile solvent such as S.B.P. No. 2 spirit, free from sulphur and unsaturated hydrocarbons.

The extraction of 1 lb. of perfume wax involves the use of large quantities of solvent (100–400 gallons), and it is clear that even a minute percentage of odorous residue in the solvent will be a relatively large one in the perfume wax.

An interesting example of the extraction of essences from flowers is the treatment of pyrethrum flowers with a light-petroleum solvent for the extraction of the pyrethrins, which are used as the toxic principle in many insecticides, fly sprays, etc.

(iii) *Glue Manufacture.*

Bones and other animal refuse are the raw material used for the manufacture of animal glue, bone manures, and bone fertilizers. The bones are extracted in a suitable steam-heated extractor with a solvent, the grade normally used being S.B.P. No. 5 spirit. The solvent removes the oil and grease, the extract being run off and distilled with steam to yield fatty material, which is then distilled to give a white fatty acid used in candle manufacture. The extracted bones are treated in autoclaves at a pressure of $1\frac{1}{2}$ atmospheres in the presence of steam to dissolve out the glue, the extract on concentration yielding animal glue. The residual bones are crushed to a fine powder, and are either sold as bone manure (bone meal) or treated with sulphuric acid for the manufacture of superphosphate.

In the extraction of bones it is essential to use a solvent with an end-point not exceeding, say, 105°C. , since solvents of higher end-point tend to dehydrate the glue substance unduly, giving a product of inferior adhesive quality. On the other hand, the boiling point of the solvent must be sufficiently high to ensure that the bones are gradually dried during the extraction, so that the solvent may have a chance to extract the fats completely.

(iv) *Other Extraction Processes.*

Fish offal and waste food from restaurants are treated in drying plants to remove most of the water content and are then extracted with a solvent (usually S.B.P. No. 2 spirit or S.B.P. No. 5 spirit) to remove oil. The residue is worked up into fish-meals and poultry foods. It may be noted that where these feeding stuffs are sold for consumption by cattle or poultry the seller is required by the Fertilisers and Feeding Stuffs Act, 1926, to state the oil content of such products. The same requirement holds equally in the case of feeding cakes and meals intended for cattle and poultry and made from oil-seeds, *e.g.*, cotton-seed or linseed.

S.B.P. spirits (usually the No. 5 grade) are used for the extraction of grease from dried sewage sludge in certain centres of the textile industry where the extraction of grease is an economic proposition.

(v) *Dry Cleaning.*

In dry cleaning the soiled articles are treated in mechanical washers similar to those used in laundries, petroleum spirit being used instead of water. From the washer the articles are transferred to centrifugal extractors, where the spirit is separated and put back into circulation. The cleaned garments are dried in heated chambers and are finally pressed.

Various types of spirit are used in dry cleaning, many of the smaller concerns using Pool Rubber Solvent or even ordinary motor spirit for the purpose, although the shop-window type of cleaner uses, of course, a non-inflammable chlorinated solvent. The large dry cleaners use white spirit, which, unlike ordinary motor spirit, contains no volatile fractions which lead to excessive working losses and undue fire risks. Since its flash-point exceeds 73° F., white spirit comes outside the restrictions of the Petroleum Consolidation Act of 1928, so that a user does not have to conform with the somewhat irksome requirements of that Act.

The methods adopted for dry cleaning vary considerably, as do the methods by which clean spirit is regenerated from the dirty solvent. In some plants the clothes are placed in a tumbler, which consists of a perforated container (in which are the clothes to be cleaned) inside a fixed container. The perforated container is rotated, whilst clean solvent is fed in at the top of the machine and dirty solvent taken off at the bottom, to be circulated through the reclamation plant. In other plants which operate on a batch system there is no continuous flow of solvent through the tumbler, which means that the last of the dirt has to be removed by the dirtiest solvent and the clothes are removed from a dirty solvent.

Mechanically suspended impurities in the dirty solvent are removed by settling, or preferably a centrifuge, but this treatment does not remove dissolved impurities (mainly mineral oil or fatty oils and greases) or colouring matters. These can only be removed by distillation of the solvent or by treating the dirty solvent with a decolorizing powder.

It may be mentioned that treatment with white spirit (or with any other dry-cleaning liquid) will not remove spots caused by paint or varnish, ink, blood, etc., and it is frequently necessary to "spot" articles which have been dry cleaned, various types of "spot remover" being available according to the nature of the spot to be removed.

(vi) *Leather Processing.*

Rubber solutions or cements are used to stick together the various parts from which the uppers of boots or shoes are built up, immediately prior to stitching. It is essential that the cement should be made up with a volatile solvent, which dries very rapidly, and it is advisable to use a spirit of low aromatic content, because with this type the risk of staining due to penetration of the leather by the cement is minimized. This latter factor is naturally of particular importance in the case of fancy leathers. S.B.P. No. 1 spirit is normally employed in rubber cements.

Channel cements are used for sticking down the leather (which has been cut along a groove on the sole) to allow the sole stitching to be pulled home tightly. Here again a volatile solvent is required in the preparation of the cement.

Apart from their use in the boot and shoe industry, petroleum solvents are employed for degreasing purposes in the preliminary manufacture of the leather itself. Quite large quantities of kerosine are used for the degreasing of skins, particularly in the glove industry, the grade usually employed being Pool Vaporising Oil (a) because the solvent power for grease is higher than that of Pool Burning Oil and (b) because of its better volatility. The skins, after dehairing with milk of lime and sodium

sulphide, are rotated in a wooden tumbler with Pool Vaporizing Oil, sometimes with the addition of a little sulphonated oil, the amount of vaporizing oil used varying from $\frac{1}{2}$ gallon to $1\frac{1}{2}$ gallons per dozen skins, according to the size of skin and its fat content. After the treatment the vaporizing oil is run off and the skins are washed with two or three successive brine solutions to remove the remaining kerosine. Some manufacturers carry out the process at ordinary temperatures, others warm the kerosine up to 90° F., which naturally facilitates the extraction. If the fats and greases are not removed at this stage the finished skins, after dyeing, exhibit white patches or "spue" due to the separation of fatty material on the surface.

It may be appropriate to mention that most of the troubles attributed to the use of kerosine in leather degreasing have been shown to be due to the employment of an insufficient quantity of solvent.

Petroleum solvents are used in the cleaning of furs, their object being to act as wetting agents to facilitate combing of down from the furs before these are given a final sawdust treatment, which removes the residual spirit and gives a "polish" to the fur. Various solvents ranging from motor spirit to white spirit are being used for the purpose.

(b) *Deposition Processes.*

(i) *The Rubber Industry.*

Petroleum solvents are used in many different branches of the rubber industry. Large quantities are consumed by tyre manufacturers and by the proofing industry, and smaller, but appreciable, amounts by makers of adhesive tapes, surgical plasters, golf balls, tennis balls, rubber gloves, etc.

Petroleum solvents for the rubber-proofing and spreading industry should be free from very volatile fractions which enhance the fire risk and lead to excessive evaporation losses, and also free from very heavy or high-boiling fractions which cannot easily be removed from the finished goods. In consequence, Pool Rubber Solvent is usually employed in rubber-proofing and in the manufacture of waterproof garments, etc. Where the proofing machines work very rapidly, or the length of travel of the proofed cloth before being rolled is unduly short, a more volatile spirit may be used—e.g., S.B.P. No. 5 or S.B.P. No. 2 grades.

Petroleum solvents have very largely replaced the coal-tar solvents which were formerly used for rubber-proofing. The advantages of the former are : (a) a more carefully controlled distillation range and evaporation rate ; (b) absence of complex sulphur compounds and unsaturated bodies which might affect the ageing properties of the rubber ; and (c) a lower degree of toxicity, a factor of importance in badly ventilated or congested workshops.

In the manufacture of proofed goods the rubber, intimately mixed with the various pigments, fillers, and accelerators, is masticated, and is incorporated with solvent to give a dough-like mass, which is then coated on to the fabric on steel rollers covered with a moderately hard rubber. The dough is scraped on to the cloth by means of a blade-like gauge while it passes over this roller. The proofed fabric passes over a steam-heated

chest, where the solvent is evaporated. Vulcanization is effected either by cold cure, with a solution of sulphur chloride in carbon disulphide, or by hot cure in stoves heated by steam-pipes. In the second case the mix used for proofing contains the necessary sulphur for vulcanization, but with cold cure vulcanization sulphur is omitted from the mix.

The more modern types of plant are equipped with hoods, through which the mixture of air and solvent vapour is drawn off and passed to a solvent recovery plant, usually of the "activated carbon" type.

The solvents used by the rubber-tyre industry before the war differed very considerably in properties, many buyers having their own purchasing specifications, especially in the case of concerns subsidiary to, or allied with, tyre manufacturers in the States or on the Continent. Most tyre-makers now use S.B.P. No. 4 spirit, although some use Pool Rubber Solvent or a narrow range product such as S.B.P. No. 3 spirit.

In the manufacture of tyres the first stage is the impregnation with rubber of the cord fabric. This may be done either by passing the cord fabric through a solution of rubber in a suitable solvent, or by what is known as frictioning on the calender, a process which eliminates the use of solvent altogether.

The rubber mix used for tyre manufacture is masticated with solvent and milled with the necessary fillers (zinc oxide, etc.), sulphur and organic accelerator (to reduce the time of vulcanization). The mix for impregnation of the cord fabric is white, but for subsequent coats on the fabric and for the tread and bead a black mix is used, the black colour being due to the incorporation of carbon black.

The tyre body is built up on a drum from successive layers of rubberized cord fabric, which are bedded down by special tools as the drum revolves. An application of petroleum spirit between the layers assists in the process of consolidation. The beads are bound into the side-walls with fabric, and the breaker strip and tread are then fitted.

The tyre is finally consolidated by vulcanization, this being done by the combined effects of heat and pressure under carefully controlled conditions. The tyre casing is placed in an iron mould, which is embossed internally with the tyre pattern to be transferred to the tread, and an air-bag similar to an inner tube is inserted, the air pressure forcing the tyre into close contact with the mould. The mould is then transferred to an autoclave for the vulcanization process.

In the manufacture of inner tubes the rubber mix is extruded from a machine in the form of a tube, coated with talc powder, and cut into suitable lengths. A hole is cut out for the valve, which is fitted loosely, and the ends are coated with rubber solution and stuck together. The tube is inflated and cured in an iron mould heated by superheated steam, this process fixing in the valve as well as completing the vulcanization.

Dipping processes are involved in the manufacture of toy balloons, surgical gloves, etc. The solution of rubber in a suitable solvent is made up, and a wood or porcelain model or "former," having the shape of the article required, is immersed in the solution, and then removed to allow the solvent to evaporate. By repeating the process several times a sufficient thickness of rubber is built up gradually, after which the article is vulcanized by treatment with a solution of sulphur chloride in a solvent (usually

carbon disulphide), and is finally stripped from the "former." Difficulties are occasionally encountered where the rubber solutions are made up with too volatile a solvent, or where atmospheric temperatures are unduly high, pinholes and blisters being produced, or water being deposited through the chilling resulting from the excessive evaporation rate, with a consequent development of a haze throughout the article.

The solvents used in dipping processes vary in volatility between S.B.P. No. 1 spirit and rubber solvent, according largely to the type of article manufactured.

In the manufacture of tennis balls segments are cut from sheets of suitable thickness, and before closing these together, by means of a solution of rubber in petroleum solvent, a suitable amount of inflating medium is inserted, the ball then being placed in a mould (made in two halves) for vulcanization. The heat of the curing process decomposes the inflating medium—*e.g.*, sodium nitrite and ammonium chloride which produce nitrogen gas—and gives the necessary inflation of the ball.

(ii) *Cellulose Lacquers.*

Nitrocellulose lacquers consist essentially of nitrocellulose dissolved in comparatively expensive organic solvents, together with resins, plasticizers and, in the case of coloured lacquers, pigments. The solvents can be divided into three general classes: the alcohols, esters, and ketones, and since no one solvent combines all the properties which are desirable, a mixture of solvents is employed.

In order to cut down production costs, it is customary to include in the lacquer formula a proportion of diluent, either of petroleum or coal-tar origin. These diluents are not true solvents, and the percentage employed is limited by this fact, since excess of diluent throws the nitrocellulose out of solution. For this reason the diluent must be so selected, both as regards quantity and quality, that it evaporates at the same rate as, or rather more rapidly than, the true solvents in the lacquer. If the diluent is too volatile, pinholes or blisters may be produced when the lacquer film dries, but if it is of too low volatility and evaporates more slowly than the true solvents, there will be an over-concentration of diluent in the film as it dries, and the nitrocellulose will be thrown out of solution, giving rise to what is known as "blushing."

For industrial purposes a rapid rate of drying is often essential, but the rate of drying is limited by the chilling effect due to evaporation. If this limit is passed, water is precipitated from the air, and what is known as "water blush" results.

It is usual to employ petroleum diluents of comparatively narrow distillation range, and, generally speaking, the higher the percentage of aromatics the greater is the proportion which can be included in a lacquer without precipitation of the nitrocellulose—*i.e.*, the greater is the "dilution ratio" of the product. S.B.P. No. 2, S.B.P. No. 3, and S.B.P. No. 6 grades, as well as Pool Rubber Solvent, are all used widely as lacquer diluents. These products correspond approximately in evaporation rate with coal-tar benzole, toluole, xylol, and solvent naphtha, respectively.

The proportion of petroleum diluent in a lacquer can frequently be increased by a modification of the formula used—*e.g.*, by increasing the

amount of butyl alcohol in the lacquer when this is used, by the replacement of butyl acetate by amyl acetate, or of ethyl acetate by cellosolve. It may be economical at times to use a more expensive solvent if it will allow more of the cheaper petroleum diluent to be incorporated without precipitation of the nitrocellulose.

A reference to the use of coal-tar benzole as a lacquer diluent is made in a later section of this paper.

(iii) *Printing Inks.*

The problems of the rotogravure ink industry are, in so far as the choice of a suitable petroleum diluent is concerned, very similar to those of a maker of cellulose lacquers. The essential properties are a satisfactory rate of evaporation and an aromatic content sufficiently high to avoid precipitation of such components of the ink as chlorinated rubber or some of the newer types of resins. Either S.B.P. No. 3 or Pool Rubber Solvent is normally used in printing inks, although some makers include S.B.P. No. 6 spirit in their formula. For really high-speed rotogravure printing (where 40,000 copies an hour may be produced, the paper travels at the rate of 1200 feet per minute, and the ink must dry off completely in a fraction of a second) a more volatile spirit—*e.g.*, S.B.P. No. 2 grade—is used.

Petroleum solvents (usually Pool Rubber Solvent) are also used in the printing-ink industry as "blanket washes" for cleaning ink from the rubber rollers of the printing machines.

(iv) *Paints, Varnishes, etc.*

Paints and varnishes provide the main outlet for Pool White Spirit, and this application of a petroleum product is so well known that any detailed references would probably be superfluous. Originally introduced as a cheap alternative to vegetable turpentine, white spirit was at first marketed under the name "turpentine substitute," but it has now proved itself the equal of turpentine for the great majority of paints used for household or industrial purposes. The main difference between white spirit and turpentine is the greater solvent power of the latter for certain resins and bodied vegetable oils, and this restricts the use of white spirit in some varnishes and enamels.

White spirit is used as a volatile thinner in many bitumen paints and in the compositions employed for printing the pattern on linoleum and oil-cloth.

Kerosine and Pool Distillate are often used in the manufacture of stove enamels and some of the cheaper types of paint.

(v) *Polishes.*

Another extensive outlet for white spirit is in the manufacture of polishes, of which there are three main types :

- (a) Floor, leather, and shoe polishes.
- (b) Emulsified polishes or creams.
- (c) Abrasive polishes—*e.g.*, metal polishes.

Polishes of type (a) consist essentially of a blend of wax (or, more usually, a mixture of waxes) with white spirit, to which is often added a small proportion of turpentine to cater for the prejudices of the "old school." In their preparation the waxes are melted in a steam-jacketed pan and brought to a predetermined "thinning temperature," when the cold solvent is added to the melted wax, with constant stirring. The solvent is added at a rate such that when addition is complete the mixture has reached the so-called "filling temperature" (the optimum temperature for any particular formula), after which the thin paste produced is filled into tins and allowed to cool. The final appearance and consistency of the finished polish depend largely on the correct selection of the "filling temperature."

The emulsified polishes or creams are emulsions of wax in water, made up with an emulsifying agent, and often with the addition also of a proportion of white spirit. These emulsions are usually made in homogenizers or colloid mills, and it is claimed that when white spirit is included in the formula the resultant product is of a smoother consistency and will stand up better to storage conditions.

With the abrasive polishes dirt, stains, and oxidized films are removed by means of an abrasive, assisted by the solvent action of the water and the solvent (usually white spirit) present in the polish. By this means a completely fresh surface is exposed, which polishes on rubbing. Metal polish is a suspension of abrasive in water, the abrasive being thoroughly wetted with white spirit before it is added to the water. Since the abrasive is finely ground and is wetted with a liquid of lower specific gravity than water, this ensures that it will not sink to the bottom and form a paste.

(c) *Miscellaneous Applications.*

(i) *Alcohol Dehydration.*

Alcohol and water cannot be completely separated by distillation, and when, for example, an alcohol/water mixture obtained by the fermentation of molasses is distilled, the "rectified spirit" obtained consists approximately of 95½ per cent. alcohol 4½ per cent. water. This mixture boils at a lower temperature than the boiling points of either pure alcohol or pure water, and until comparatively recently the water content could not be reduced except by the use of chemicals—an expensive process.

Modern methods make use of azeotropic distillation for the production of anhydrous alcohol, and if benzene (C_6H_6) is added to the 95½ per cent. alcohol/water mixture, and the whole distilled, the first product to come over is a three-component mixture in the proportions of 74.1 per cent. benzene, 18.5 per cent. alcohol, 7.4 per cent. water, which boils at 64.85° C. This mixture has a much higher water/alcohol ratio than the original rectified spirit, so that as long as there is any water present (and sufficient benzene), this mixture distils over. In practice an excess of benzene is used, with the result that the residual liquid in the still is an alcohol/benzene blend, and this, when the temperature is increased to 68.2° C., gives a second constant-boiling mixture containing 67.6 per cent. benzene and 32.4 per cent. alcohol, which distils over to leave pure alcohol free from both water and benzene.

The three-component and two-component constant-boiling mixtures are

combined, cooled, and allowed to settle, when they separate into two layers, the upper layer, rich in benzene, being returned to the azeotropic distillation column. The lower layer of alcohol/water, but still containing

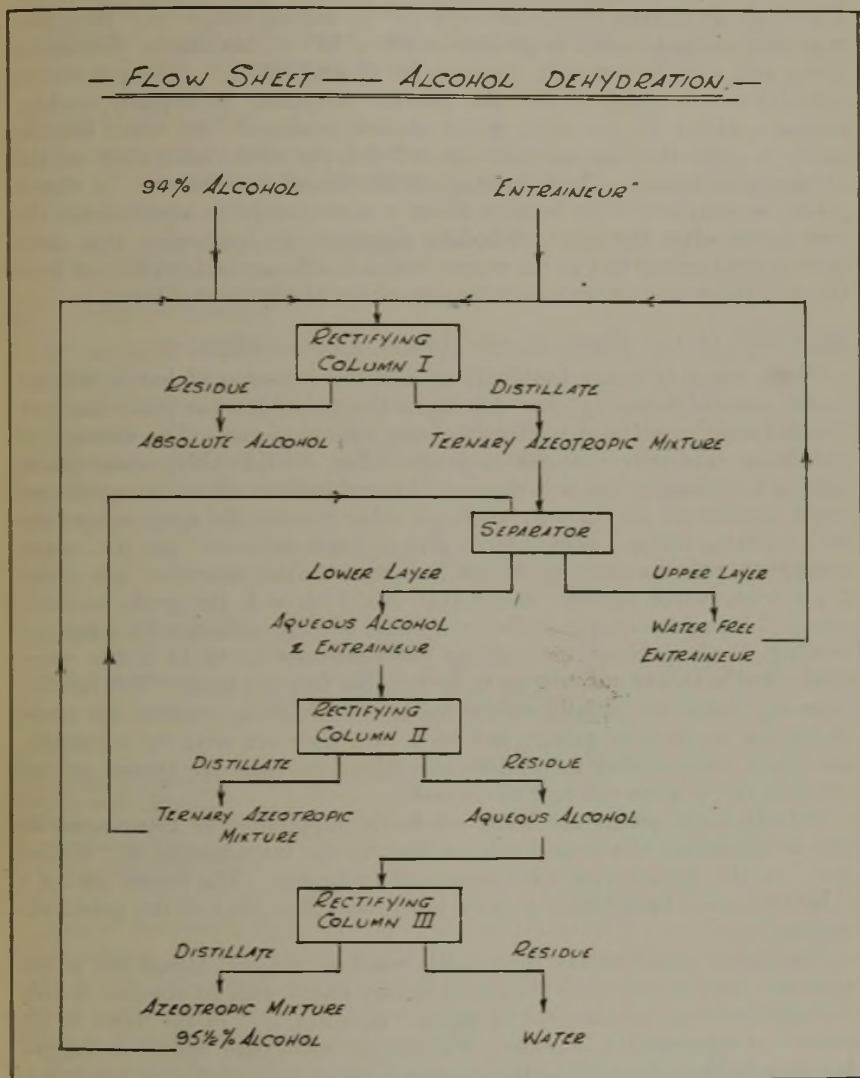


FIG. 6.

FLOW SHEET—ALCOHOL DEHYDRATION.

some benzene, is passed to a small still, where the benzene is removed, and it then goes to the first rectifying still to produce the 95½ per cent. alcohol which is fed to the azeotropic distillation plant. In practice the whole process is a continuous one (Fig. 6).

In the Melle process (Distillerie de Sèvres, Melle, France) a mixture of petroleum spirit and benzene is used as a separation agent (*entraîneur*), in the ratio of 2 volumes benzene to 1 volume petroleum spirit. It is understood that a very narrow petroleum spirit cut was supplied by the Distillerie de Sèvres themselves—94–97° C. boiling range—but that they normally recommended a product with a 10° C. maximum distillation range and with 80 per cent. between 96° C. and 100° C. The quantity of petrol/benzene required for the process (required to replace working losses) is about 0.2 per cent. of the alcohol produced, but where benzene alone is used the loss amounts to 0.3–0.4 per cent. calculated on the alcohol production. The advantage of the mixed "*entraîneur*" is that it gives, as compared with benzene alone, a more complete separation of the two layers when the constant-boiling mixtures are condensed, thus minimizing the amount lost in the water, which is subsequently drawn off from the rectifying column on concentration of the alcohol/water layer.

(ii) *Petrol/Air Gas Plants, Miners' Lamps, Pocket Lighters, etc.*

There are still many hundreds of country houses and hotels without either gas or electricity, and for them the petrol/air-gas plant has provided a convenient and relatively cheap source of gas. The methods of obtaining this petrol/air-gas mixture differ considerably, some plants having a stationary zig-zag, channel-like carburettor where the spirit runs down against an air current, whilst in other models the spirit evaporates on a rotating drum. Some plants give a "rich mixture" gas (*i.e.*, about 5 per cent. petrol vapour in the gas), others a "weak mixture" gas (about 2 per cent. petrol vapour), and S.B.P. No. 1 spirit is the grade normally used. These petrol/air-gas plants are also used in industry for soldering, brazing, cloth singeing, etc., giving gas pressures up to 14 inches water gauge and with gas outputs up to 3500 cubic feet per hour. The smaller-capacity plants are usually driven by means of falling weights, the larger plants by an electric motor, and as a rule they are entirely automatic, the plant commencing to produce gas when the taps are turned on and shutting down when the taps are closed.

Petrol/air-gas plants are being gradually supplanted in many areas by the development of the grid scheme and by the introduction of "bottled gas" of the butane type (Bottogas and Calorgas). The initial cost of a "bottled-gas" installation is very much less than that of the petrol/air-gas plant.

The main requirements of a spirit used in miners' lamps are a low aromatic content, so as to get a non-smoky flame, and an absence of very volatile fractions which tend to cause "building up" of the flame in the heated atmosphere of a mine. The use of petroleum spirits in miners' lamps is falling off owing to the increased popularity of electric lamps and to legislation introduced some few years back, which called for an increase in candle-power, an increase which could not be met by the spirit-type miners' lamps. Lamps of this type are, however, still used extensively for gas detection in mines. S.B.P. No. 4 spirit is the most widely employed grade, but recent experience suggests that less volatile grades are perhaps rather more suitable.

For petrol blowlamps and for incandescent mantle lamps either S.B.P.

No. 1 or S.B.P. No. 4 spirit is chiefly used, although in both cases ordinary motor spirit is often employed.

For petrol lighters a spirit of similar characteristics to that used in miners' lamps is required, S.B.P. No. 4 grade being normally employed. Some customers prefer a narrower-boiling-range product of the S.B.P. No. 2 or S.B.P. No. 3 type, and small quantities of perfume are occasionally added to mask the petroleum odour.

(iii) Laboratory Uses.

Petroleum ethers, of various types, are used for general analytical purposes, as, for example, in the following tests laid down by the Institute of Petroleum :—

Analysis of tar-bitumen mixtures	.	.	.	.	T.B.M. 26 (T.).
Dirt in paraffin scale	.	.	.	.	P.S. 14a.
Free alkali and acid in greases	.	.	.	.	L.G. 5.
Saponifiable matter	.	.	.	.	L.O. 15 (T.).

In addition, 60–80° C. sulphonated petroleum ether is used for the determination of asphaltenes and other analytical purposes (methods A. 12 and F.O. 12), water-estimation spirit in the Dean and Stark water determination, and sludge-testing spirit in the test for the sludging value of transformer oil (T.O. 21). The specifications for these petroleum solvents are summarized below :—

	60–80 Sulphonated petroleum ether.	Water-estimation spirit.	Sludge-testing spirit.
Spec. gravity at 60° F.	Not below 0.680. Not above 0.690.	—	Not above 0.700.
Distillation range.	At least 90% between 60° C. and 80° C.	5% temperature not below 90° C., not above 100° C. 90% temperature not above 205° C.	I.B.P. not below 60° C.—at least 75% at 100° C.— F.B.P. not above 120° C.
Aromatics (by weight).	Not above 0.5%	—	Not above 2%.
Iodine value (Hubl.).	—	—	Not above 0.3%.
Aniline point after treatment with 98–100% sulphuric acid.	—	—	Not above 58° C. (136° F.).

Solvent Recovery.—Reference has already been made to the recovery of used solvent by a distillation process, and it is scarcely necessary to go into details in connection with this form of solvent recovery. Distillation is the normal method of recovering solvent which has been utilized for what in this paper have been classed as extraction processes.

Where petroleum solvents are used in deposition processes, particularly in the rubber-proofing industry, the use of an activated-carbon recovery plant is now the rule, rather than the exception. In such plants the solvent-laden atmosphere is drawn off by means of fans through absorbers containing activated carbon, which takes up a certain quantity of the solvent, depending on (a) the absorbing power of the carbon, (b) the concentration of solvent in the mixed air/solvent vapour, and (c) the temperature of absorption. When the carbon in the absorber is nearly

saturated with solvent, the gases are diverted to a second container, and the solvent from the first absorber is recovered, usually by steaming, followed by condensation from the vapours. It is claimed that with petroleum solvents it is an economical proposition to recover solvent in a concentration as low as 1 part in 2000.

In the rubber-proofing industry the spreading machines are fitted with carefully designed hoods to collect the solvent vapour and prevent its diffusion into the room. These hoods do not come right down to the steam chests, and they allow a free current of air to be carried up into the hood, where it mixes with the solvent vapour, so as to bring the solvent concentration of the mixture below the lower explosive limit.

Figures quoted by the makers of these solvent-recovery plants show a recovery of 80 per cent. and over of the original spirit used, and it is within the authors' experience that recoveries of this order are obtained in practice by many users. Apart from the financial aspect, the recovery plant has been responsible for an appreciable reduction in the number of fires on the spreading machines and for an improved atmosphere in the spreading rooms.

Legislation—Safety Precautions, etc.—Special boiling-point spirits and rubber solvent are distributed either in bulk (rail car or road wagon) or in packages (barrels or cans), the method employed depending mainly on the quantities delivered and on the distance from the Petroleum Board's nearest bulk stocks. Deliveries in packages naturally involve a rather higher price than deliveries in bulk.

Where delivery is effected by rail car the usual quantity is of the order of 4000 gallons, but the maximum quantity which can be delivered by a road vehicle is 2500 gallons. The regulations covering road transport are laid down in the Petroleum Spirit (Conveyance) Regulations, 1939 (S.R. and O., 1939, No. 1209). Where deliveries are made in packages, these are normally either heavy steel, 50-gallon barrels or the usual type of 2-gallon petrol can.

The regulations dealing with the storage and use of "petroleum spirit"—*i.e.*, any petroleum product with a flash-point (Abel closed test) below 73° F.—are laid down in the Petroleum (Consolidation) Act, 1928. Petroleum spirit must not be kept without a licence unless (1) it is kept in separate glass, earthenware, or metal vessels, securely stoppered and containing not more than 1 pint each, and aggregating not more than 3 gallons, or (2) it is kept and used for motor vehicles, motor boats, etc., in accordance with the Petroleum Spirit (Motor Vehicles, etc.) Regulations, 1929. Storage licences are granted by the appropriate local authority—*i.e.*, the L.C.C. in London (except in the City) and the district council in other areas—and these local authorities may attach to a petroleum-spirit licence such conditions as they may think expedient. (At the present time additional restrictions may be imposed in some areas by the police or the military authorities.)

The Petroleum (Consolidation) Act, 1928, makes it obligatory for vessels containing petroleum spirit (unless the container is the fuel tank of a vehicle, etc.) to be labelled "Petroleum Spirit—Highly Inflammable," such containers to show the name and address of the owner, the sender or the vendor, as the case may be. A further requirement of the same

Act is that all accidents involving loss of life or personal injury by explosion or fire "in or about or in connection with" any premises licensed for petroleum spirit must be reported.

Among the processes certified by the Home Office as dangerous under certain sections of the Factory and Workshops Acts are the following, in which petroleum spirits may be employed :—

- (1) Manufacture, use, and storage of cellulose solutions.
- (2) Certain processes incidental to the manufacture of india-rubber.

The regulations dealing with cellulose solutions are contained in the Cellulose Solutions Regulations, 1934 (S.R. & O., 1934, No. 990), the regulations being amplified in a memorandum issued by the Home Office in 1936 (Form 826, April 1936). The definition of "cellulose solution" in the Regulations is "any solution in inflammable liquid of cellulose acetate, of cellulose nitrate, of celluloid, or of any other substance containing cellulose acetate, cellulose nitrate or any other cellulose compound, with or without the admixture of other substances." The definition of inflammable liquid includes any liquid or mixture of liquids with flash-point below 90° F., so that S.B.P. No. 6 spirit comes within the scope of the Cellulose Solutions Regulations, 1934, although it is outside the scope of the Petroleum (Consolidation) Act, 1928.

Where benzene is used as a component of cellulose solutions, the Regulations insist on certain additional precautions being taken, including the special labelling of receptacles containing cellulose solutions or inflammable liquids in which the benzene content exceeds 15 per cent. by weight. The S.B.P. spirits and rubber solvent all contain very much less than 15 per cent. benzene.

The India rubber Regulations, 1922 (S.R. & O., 1922, No. 329), define a "fume process" as "any process in which any of the following materials :— carbon bi-sulphide (CS_2), chloride of sulphur (S_2Cl_2), benzene (C_6H_6), whether pure or in the form of commercial benzol, carbon tetrachloride (CCl_4), trichlorethylene (C_2HCl_3), or any carbon chlorine compound, or any mixture containing any of such materials is used, or the vapour of any such materials is given off." Ordinarily, no person under 18 years of age must be employed in any fume process (and no person under 16 years of age in any room in which a fume process is carried on), and special regulations apply in connection with medical examination, ventilation, etc.

All petroleum solvents with fractions boiling below, say, 90° C. contain benzene (C_6H_6) to a greater or less extent, and consequently they come, strictly speaking, within the "fume process" regulations. In practice it is usual for the regulations to be waived where the benzene content is not above 5 per cent. by weight. Reference to the table given earlier in this paper will show that the *total* content of aromatic hydrocarbons in the grades likely to contain benzene does not exceed the 5 per cent. limit mentioned.

Other memoranda issued by the Home Office, and of interest to users of petroleum solvents, are the following :—

Memorandum on Dry Cleaning (Form 824, July 1924).
Prevention of Dermatitis (Form 1863, April 1928).

Prevention of Oil Rashes (Form 296, February 1932).

Precautionary Notes for users of volatile organic solvents (Form 297, June 1937).

Memorandum on the cleaning or repairing of oil and acid stills and tanks in factories (Form 814, January 1930).

In conclusion, the authors would express their thanks to the Management Committee of the Petroleum Board for permission to publish this paper, to Mr. G. L. Coles for helpful criticism and suggestions, and to Mr. W. A. Woodrow for determination of some of the data presented.

THE INSTITUTE OF PETROLEUM.

A MEETING of the Institute of Petroleum was held at The Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W. 1, on Tuesday, 10th June, 1941, with the President (Professor A. W. Nash) in the chair.

The PRESIDENT said that the authors of the paper to be read that evening were both well known to the members of the Institute. Mr. Harrap was an authority on special products from petroleum, and contributed a paper on "Dangerous Gases and Products" in 1939, and Dr. Evans was a member of the Institute Council, and was known for his able work on viscosity and other physical properties. Both gentlemen were now engaged on important tasks with the Petroleum Board, and the Institute was extremely grateful to them for finding the time to put together such a useful and appropriate paper in the present circumstances. It was no light task to compile a scientific paper under the strain of war-time conditions, and he would like to express the Institute's thanks to the authors for their work.

The following paper was then read by the authors :

"Hydrocarbon Solvents from Petroleum and their Industrial Applications." By F.N. Harrap, M.Sc., and Dr. E. B. Evans (see page 369).

DISCUSSION.

DR. R. LESSING, in proposing a vote of thanks to the authors, said he did so with sincerity, because this was the type of paper of which the authors could be proud. Although the paper did not put forward any new theories or discoveries, it added to their knowledge, and although the branch of the industry dealing with the production of solvents was quantitatively a minor one compared with the large bulk of products from the other crude oil, he thought it was a most interesting one. The larger branches were in certain respects, if he might say so, of less interest, because the only object of producing perfectly good and useful hydrocarbons was to subject them to complete destruction by one or another method of combustion.

Most of those present probably knew a good deal about solvents, being connected with the production side. Even to them it formed a welcome compilation of facts and figures. But the paper should appeal particularly to the large body of consumers in the chemical and allied industries in which solvents were applied in a variety of processes. He would go so far as to suggest (he did not know whether he was in order) that it might be a useful function of the Institute, in a case such as the present, to make papers available to a wider circle than the Fellows and Members of the Institute itself. Was there any procedure by which it could be published in booklet form for the benefit of those who were users of solvents and were very frequently at a loss to know what to order or to ask for? The question of trying to marry requirements and available supplies was most urgent, particularly at the present time.

Extraction processes were coming more and more into use, employing, of course, not only hydrocarbons, but also what might be termed chemical solvents. It was a useful thing to have the various types which were available, and their properties, made known under war conditions.

One point which had been touched upon was the chemical composition of the solvents, the amount of aromatics, naphthenes, and so on, not only from the point of view of Home Office requirements, but in respect of their behaviour towards the materials to be extracted under various conditions. This was of great importance, and raised the question of the chemical compounds in petroleum which he felt sure would eventually be one of the major problems for the research workers in the oil industry.

He had great pleasure in proposing a vote of thanks to Mr. Harrap and Dr. Evans.

Dr. D. A. HOWES seconded the vote of thanks. The authors had spoken with real authority, and members could take anything they said as being correct. The paper was a very able summary of an extremely complicated subject, and he would like to see it followed up by a series of papers dealing in greater detail with the various aspects of solvents and their applications because, as Dr. Lessing had mentioned, the manufacture and use of solvents constituted a most important subject.

THE PRESIDENT put the vote of thanks to the meeting, and it was carried with acclamation.

Dr. D. A. HOWES said there was one question he would like to ask. The authors had given the properties of a range of petroleum solvents; was he correct in assuming that these were all self-consistent—in other words, that they applied to a series of solvents in present-day use produced from a particular crude oil, or group of crude oils processed in a particular fashion, but that the solvent properties might be considerably modified by a change in the crude source or conditions of manufacture? As the solvents described are mostly paraffin in character, what would be the effect of producing them from a predominantly naphthenic or aromatic crude oil?

Mr. A. J. GOODFELLOW said that the authors had gone into some detail in describing specifications of the S.B.P. grades, but no mention had been made of bromine and iodine values. What was the significance of the specified values which the Pool gave to the grades? There was another point which was outside the scope of the paper, but could a rough outline of the manufacture and uses of petroleum sulphonates be given?

Mr. F. L. BASSETT said that the manufacture of "cut-back" bitumens might be regarded as an example of the use of solvents more or less in the kerosine or gas-oil range, and when working on this subject in Iraq he had not been able to obtain much information on the specification of the distillates to be used for fluxing road bitumen, other than the general descriptions such as "heavy" or "light" kerosine, etc. The set-up of cold mixed bituminous road surfaces depended on several factors apart from the composition of the binder, but from the standpoint of the local manufacturer of cut-back or fluxed bitumen it was desirable to have a fairly definite specification of the solvent oil, as well as of the bitumen.

Dr. EVANS said that the authors would like to express their thanks to the President, Dr. Lessing, and Dr. Howes, for their kind remarks. It had been a pleasure to prepare and present this review of the war-time position of petroleum solvents in this country, and they hoped also that the paper contained information which would be of more permanent interest to those concerned with solvents.

Replying to Dr. Howes, Dr. Evans said that actually the solvent properties described in the paper applied more particularly to those spirits the properties of which were given in Tables II and III. They had indicated in the introductory paragraphs that certain high solvency materials, of a very aromatic nature, which were available before the war, were no longer available, and he thought it could be taken for granted that during the course of the war the material available would continue to be very much of the type of the solvents described in the paper. A check-up from such easily determined features as the gravity would indicate any marked variation. The authors felt that the spirits which had been described were typical of those which were likely to be available for some time to come. Incidentally, they were very similar to one class of solvents available before the war. Certain high-solvency products available before the war were no longer obtainable. Spirits derived from crudes containing higher proportions of naphthenes or, particularly, aromatics would have, in general, higher solvencies, which would render them more suitable for some applications.

In reply to Mr. Goodfellow, Dr. Evans said that the low bromine values which were sometimes quoted were to ensure the almost complete absence of unsaturated hydro-

carbons. If he looked at Table XIII he would notice that the unsaturateds were only in the neighbourhood of $\frac{1}{2}$ per cent., and were getting near to the figure where it was difficult to measure the presence of unsaturateds with any degree of accuracy. Bromine or iodine values in the neighbourhood of 3 or 5 indicated a straight-run product. S.B.P.'s, which had been refined more than ordinary straight-run products, would normally have considerably smaller values than 3 or 5. There was also the possibility of substitution, and that might account for a small value being obtained.

With regard to sulphonates, this was rather outside the scope of the present paper, and he was sorry he could not give offhand any information on that point.

The same remarks applied to the question of fluxes for cutback manufacture, raised by another speaker. The authors' activities had changed considerably since the war, and they were not in a position to discuss the situation as it existed at present.

The PRESIDENT said that he could not contribute anything of value to the discussion because it was outside his sphere of work. They were very grateful to the authors for a paper which introduced a certain amount of the practical side, in which some of the papers of the past had been a little deficient, and enabled those who worked on the theoretical side to appreciate some of the problems and applications of those things with which they were continually experimenting.

One point which arose in his mind was that before the war representatives of petrol companies were saying that their petrol had "something which the others had not got," but petrol had now been reduced to one common brand and the industrial solvents to a mere handful.

The meeting then concluded.

EXPANSION OF CRUDE PETROLEUM, PETROLEUM PRODUCTS AND ALLIED SUBSTANCES

*Report of Institute of Petroleum Sub-Committee J, Sampling and Measurement.**

SUB-COMMITTEE J, Sampling and Measurement, was appointed to deal with questions relating to the measurement of oil in bulk. The expansion of petroleum, petroleum products and allied substances is an important factor to be taken into consideration when dealing with such questions. The sub-committee therefore made arrangements to collect information on this subject, and as a result data were obtained for 179 materials. The object of the report is to present this information in a form which it is hoped will be useful to the petroleum industry.

The expansion data supplied were in a variety of forms, *e.g.*, coefficients of cubical expansion, change in density per degree Centigrade change in temperature, change in reading of a glass specific gravity hydrometer in the liquid with change of temperature, etc. This was a natural and anticipated result of asking members of the sub-committee and others to supply any data available to them. It was considered preferable to adopt this procedure and undertake the work of reducing the data to a common basis, rather than to issue a rigid questionnaire asking for data in a prescribed form which would probably have resulted in much less information being obtained.

In view of the position outlined in the preceding paragraph, it was necessary for the committee to adopt a common basis to which to reduce the information available. It was decided to determine for each material.

(a) Its specific gravity $S_{60^{\circ}\text{F./}60^{\circ}\text{F.}}$ defined by the relation

$$S_{60^{\circ}\text{F./}60^{\circ}\text{F.}} = \frac{\text{Density of material at } 60^{\circ}\text{F.}}{\text{Density of water at } 60^{\circ}\text{F.}} \quad (1)$$

in which density is mass per unit volume.

(b) The value of B for the material, where B is defined by the relation

$$S_{t^{\circ}\text{F./}60^{\circ}\text{F.}} = S_{60^{\circ}\text{F./}60^{\circ}\text{F.}} + B(60 - t) \quad (2)$$

where $S_{t^{\circ}\text{F./}60^{\circ}\text{F.}}$ is the specific gravity of the material at $t^{\circ}\text{F.}$ defined by the relation

$$S_{t^{\circ}\text{F./}60^{\circ}\text{F.}} = \frac{\text{Density of material at } t^{\circ}\text{F.}}{\text{Density of water at } 60^{\circ}\text{F.}} \quad (3)$$

It was found that to the degree of accuracy required in commercial transactions the linear relation (2) is adequate.

In addition to determining $S_{60^{\circ}\text{F./}60^{\circ}\text{F.}}$ and B for each material, it was considered desirable to have some standard of reference with which these values could be compared. Consequently, values of B were deduced

* Mr. Verney Stott was responsible for the collection and presentation of the data, and the Sub-Committee wish to record their thanks to him for the considerable work involved.

from Table 3 of the "National Standard Petroleum Oil Tables" (U.S. Bureau of Standards Circular C 410 : 1936) for the whole range of specific gravity covered by this table. These values are designated by B_s throughout this report, and values of B calculated for individual materials are designated by B_c . Comparison between the value of B_c for a given material and the corresponding value of B_s , i.e., the value of B_s for the same specific gravity $S_{60^\circ \text{F.}/60^\circ \text{F.}}$ as that of the material, not only gives a useful basis of comparison, but also the magnitude of the difference serves to determine over what temperature range, to the degree of accuracy required in any particular operation, the tables in C 410 may safely be used for the material.

Values of B_s derived from Table III of C 410 are given in Table I.* It is

TABLE I.
Values of B_s derived from Circular C 410.

Specific gravity $S_{60^\circ \text{F.}/60^\circ \text{F.}}$	$B_s \times 10^5$.	Specific gravity $S_{60^\circ \text{F.}/60^\circ \text{F.}}$	$B_s \times 10^5$.
0.622-0.631	55	0.743-0.755	45
0.632-0.641	54	0.756-0.766	44
0.642-0.651	53	0.767-0.777	43
0.652-0.663	52	0.778-0.788	42
0.664-0.676	51	0.789-0.801	41
0.677-0.688	50	0.802-0.813	40
0.689-0.702	49	0.814-0.832	39
0.703-0.717	48	0.833-0.865	38
0.718-0.730	47	0.866-0.960	37
0.731-0.742	46	0.961-1.000	36

stated in Circular C 410 that the tables are based largely on an investigation of American petroleum oils published in "Density and Thermal Expansion of American Petroleum Oils" by H. W. Bearce and E. L. Peffer (Technologic Paper No. 77 of the National Bureau of Standards, 1916). This paper gives the density at various temperatures of eighty seven different oils, and from the data given values of $S_{60^\circ \text{F.}/60^\circ \text{F.}}$ and B_c have been calculated for each individual oil. It is of interest to compare these values with corresponding values of B_s obtained from Table I. The comparison serves to indicate how closely values of B_s derived from Table III of C 410 agree with the values of B_c for the individual oils on the properties of which the tables in C 410 were based. This comparison is given in Tables II and III, which, in addition to values of B_c and B_s and the differences $B_c - B_s$, give also the number of density determinations on which each value of B_c is based and the range of temperature covered by these determinations.

In Table II are listed, in order of increasing specific gravity, all the oils for which $B_c - B_s$ is within the range ± 0.00003 . For such oils the use of Table III of C 410 to obtain the specific gravity $S_{60^\circ \text{F.}/60^\circ \text{F.}}$ of an oil would give a result over a range of temperature of 30°F. differing by less than

* The coefficient of cubical expansion of glass is not involved in the definition of B_s given in equation 2 but is involved in Table 3 of C 410; due allowance was made for this when computing values of B_s as defined by equation 2 from Table 3 of C 410.

TABLE II.

American Oils from N.B.S. Technologic Paper No. 77 having Values of $B_c - B_s$ within the Range ± 0.00003 .

Ref. No.	Ref. to source of data.	Number of density values given in original data.	Temperature range covered by original data, ° F.	Material.	Specific gravity $S_{60^\circ \text{F./}60^\circ \text{F.}}$	Value of $B_c \times 10^5$	Corresponding value of $B_s \times 10^5$ derived from Table 3 of C 410.	Difference $(B_c - B_s) \times 10^5$
1	a	2	32-77	Refined oil, pentane.	0.623	57	55	+2
2	a	2	32-77	Refined oil, pentane.	0.626	54	55	-1
3	a	2	32-77	Refined oil, pentane.	0.642	54	53	+1
4	a	2	32-77	Refined oil, pentane.	0.642	53	53	0
5	a	7	32-122	Naphtha.	0.687	49	50	-1
6	a	7	32-122	Gasoline.	0.707	49	48	+1
7	a	7	32-122	Naphtha.	0.711	47	48	-1
8	a	7	32-122	Gasoline, Texas.	0.738	47	46	+1
9	a	7	32-122	Gasoline, Pennsylvania.	0.740	46	46	0
10	a	7	32-122	Gasoline (treated), California.	0.741	48	46	+2
11	a	7	32-122	Gasoline (treated), California.	0.752	46	45	+1
12	a	7	32-122	Naphtha, Indiana.	0.754	46	45	+1
13	a	7	32-122	Engine distillate, California.	0.776	44	43	+1
14	a	7	32-122	Gasoline, Oklahoma.	0.784	42	42	0
15	a	7	32-122	Kerosine, Pennsylvania.	0.788	41	42	-1
16	a	7	32-122	Kerosine, Pennsylvania.	0.789	41	41	0
17	a	7	32-122	Kerosine, Pennsylvania.	0.789	41	41	0
18	a	7	32-122	Lighthouse oil, Louisiana.	0.791	41	41	0
19	a	7	32-122	Kerosine, Pennsylvania.	0.794	40	41	-1
20	a	7	32-122	Kerosine, Pennsylvania.	0.795	40	41	-1
21	a	7	32-122	Kerosine, Ohio.	0.799	41	41	0
22	a	7	32-122	Kerosine, Indiana refined.	0.802	41	40	+1
23	a	7	32-122	Kerosine, Oklahoma.	0.803	41	40	+1

24	a	7	32-122	Kerosine, Mid-Continent.	0-807	41	40	+1
25	a	7	32-122	Kerosine, California.	0-814	41	39	+2
26	a	3	32-122	Crude oil, Pennsylvania.	0-815	40	39	+1
27	a	7	32-122	Kerosine, California.	0-819	41	39	+2
28	a	3	32-122	Crude oil, Louisiana.	0-820	41	39	+2
29	a	3	32-122	Burning oil (High F.T.).	0-829	37	39	-2
30	a	7	32-122	Refined oil, Louisiana Mineral Seal.	0-829	37	39	-2
31	a	3	32-122	Crude oil, Texas.	0-832	39	39	0
32	a	3	32-122	Crude oil, Pennsylvania.	0-833	39	38	+1
33	a	3	32-122	Crude oil, Louisiana.	0-843	36	38	-2
34	a	7	32-122	Refined oil, Pennsylvania.	0-848	37	38	-1
35	a	7	32-122	Refined oil, Indiana.	0-852	38	38	0
36	a	3	32-122	Crude oil, Ohio.	0-854	40	38	+2
37	a	3	32-122	Refined oil, neutral.	0-855	37	38	-1
38	a	3	32-122	Refined oil, neutral.	0-862	36	38	-2
39	a	2	32-77	Crude oil, Mid-Continent.	0-863	37	38	-1
40	a	7	32-122	Refined oil, California. Stove oil (treated).	0-866	39	37	+2
41	a	6	50-122	Refined oil, Pennsylvania.	0-868	36	37	-1
42	a	4	77-203	Autocylinder	0-869	35	37	-2
43	a	3	32-122	Crude oil, Oklahoma.	0-871	39	37	+2
44	a	7	32-122	Dynamo oil, Pennsylvania.	0-871	36	37	-1
45	a	7	32-122	Refined oil, Pennsylvania.	0-871	36	37	-1
46	a	4	77-203	Fuel oil.	0-871	38	37	+1
47	a	4	77-203	Autocylinder.	0-872	35	37	-2
48	a	3	32-122	Refined oil, Louisiana.	0-874	37	37	0
49	a	3	32-122	Refined oil, Louisiana, neutral.	0-874	36	37	-1
50	a	7	32-122	Refined oil, Pennsylvania.	0-875	34	37	-3
51	a	4	77-203	Fuel oil.	0-879	37	37	0
52	a	3	32-122	Marine engine oil.	0-884	37	37	0
53	a	4	77-203	Gas engine oil.	0-887	34	37	-3
54	a	3	32-122	Gas engine oil.	0-888	36	37	-1
55	a	3	32-122	Refined oil, Louisiana.	0-891	37	37	0
56	a	3	32-122	Crude oil, California.	0-898	39	37	+2
57	a	7	32-122	Refined oil, Indiana.	0-902	36	37	-1
58	a	3	32-122	Paraffin oil.	0-902	37	37	0

TABLE II—continued.

Ref. No.	Ref. to source of data.	Number of density values given in original data.	Temperature range covered by original data, ° F.	Material.	Specific gravity $S_{60^{\circ} \text{ F.}/60^{\circ} \text{ F.}}$	Value of $B_c \times 10^5$	Corresponding value of $B_s \times 10^5$ derived from Table 3 of C 410.	Difference $(B_c - B_s) \times 10^5$
59	a	7	32-122	Engine oil.	0.903	37	37	0
60	a	3	32-122	Cylinder oil.	0.905	38	37	+1
61	a	3	32-122	Crude oil, California.	0.907	37	37	0
62	a	4	77-203	Locomotive oil.	0.907	36	37	-1
63	a	4	77-203	Non-condensing cylinder oil.	0.907	36	37	-1
64	a	3	32-122	Crude oil, Louisiana.	0.910	38	37	+1
65	a	3	32-122	Paraffin oil.	0.911	37	37	0
66	a	3	32-122	Crude oil, Texas.	0.914	37	37	0
67	a	3	32-122	Cylinder oil.	0.917	40	37	+3
68	a	4	77-203	Locomotive oil.	0.921	36	37	-1
69	a	4	77-203	Marine-engine oil.	0.924	36	37	-1
70	a	3	32-122	Crude oil, California.	0.926	39	37	+2
71	a	4	77-203	Gas-engine oil.	0.927	36	37	-1
72	a	4	77-203	Gas-engine oil.	0.927	36	37	-1
73	a	2	86-104	Crude oil, Texas.	0.929	39	37	+2
74	a	7	32-122	Refined oil, Texas.	0.929	37	37	0
75	a	2	86-104	Crude oil, Texas.	0.930	37	37	0
76	a	4	77-203	Stationary-engine oil.	0.935	35	37	-2
77	a	3	32-122	Gas-engine oil.	0.938	36	37	-1
78	a	2	86-104	Crude oil, Texas.	0.940	37	37	0
79	a	3	32-122	Refined oil, Texas.	0.941	36	37	-1
80	a	4	77-203	Marine-engine oil.	0.946	36	37	-1
81	a	3	32-122	Refined oil, Texas.	0.946	36	37	-1
82	a	2	86-104	Crude oil, Texas.	0.950	38	37	+1
83	a	4	77-203	Fuel oil.	0.960	37	37	0
84	a	4	77-203	Fuel oil.	0.961	36	36	0
85	a	2	86-104	Crude oil, California.	0.967	37	36	+1

TABLE III.

American Oils from N.B.S. Technologic Paper No. 77 having Values of $B_o - B_n$ outside the Range ± 0.00003 .

Ref. No.	Ref. to source of data.	Number of density values given in original data.	Temperature range covered by original data, ° F.	Material.	Specific gravity $S_{60^\circ \text{ F./}60^\circ \text{ F.}}$	Value of $B_c \times 10^5$	Corresponding value of $B_s \times 10^5$ derived from Table 3 of C 410.	Difference $(B_c - B_s) \times 10^5$
86	<i>a</i>	3	32-122	Cylinder oil.	0.900	42	37	+5
87	<i>a</i>	3	32-122	Refined oil, Indiana.	0.931	41	37	+4

TABLE IV.

Materials for which Data were supplied to the Committee having Values of $B_o - B_s$ within the Range ± 0.00003 .

Ref. No.	Ref. to source of data.	Number of density values given in original data.	Temperature range covered by original data, ° F.	Material.	Specific gravity $S_{60^\circ \text{ F./}60^\circ \text{ F.}}$	Value of $B_c \times 10^5$	Corresponding value of $B_s \times 10^5$ derived from Table 3 of C 410.	Difference $(B_c - B_s) \times 10^5$
88	<i>h</i>	—	55-65	Spirit.	0.660	49	52	-3
89	<i>b</i>	—	—	American petroleum.	0.662	52	52	0
90	<i>b</i>	—	—	Gasoline, Persian.	0.662	52	52	0
91	<i>i</i>	—	32-86	Gasoline, Iraq S.R.	0.667	53	51	+2
92	<i>c</i>	—	62-92	Benzine, light, Rumanian.	0.682	52	50	+2
93	<i>i</i>	—	32-86	Gasoline, isoOctane.	0.702	46	48	-2
94	<i>d</i>	—	68-86	Gasoline, light crude.	0.703	49	48	+1

TABLE IV—continued.

Ref. No.	Ref. to source of data.	Number of density values given in original data.	Temperature range covered by original data, ° F.	Material.	Specific gravity $S_{60^{\circ} \text{ F.}/60^{\circ} \text{ F.}}$	Value of $B_c \times 10^5$	Corresponding value of $B_s \times 10^5$ derived from Table 3 of C 410.	Difference $(B_c - B_s) \times 10^5$
95	<i>b</i>	—	—	Aviation spirit.	0.707	48	48	0
96	<i>c</i>	—	63-92	Spirit. Distillation range 0-109° C.	0.708	51	48	+3
97	<i>c</i>	—	61-92	Spirit. Distillation range 0-124° C.	0.715	48	48	0
98	<i>g</i>	3	56-85	Benzine, Iranian B.	0.724	45	47	-2
99	<i>g</i>	7	52-76	Benzine, Iranian B.	0.725	44	47	-3
100	<i>d</i>	—	68-86	Export gasoline.	0.725	48	47	+1
101	<i>b</i>	—	—	Benzine.	0.726	47	47	0
102	<i>g</i>	8	53-80	Benzine, light, Rumanian.	0.726	49	47	+2
103	<i>h</i>	—	55-65	Spirit.	0.744	47	45	+2
104	<i>h</i>	—	55-65	Spirit.	0.751	47	45	+2
105	<i>c</i>	—	60-92	Spirit. Distillation range 124-148° C.	0.751	48	45	+3
106	<i>g</i>	2	54-82	Blend : 20% Aviation Benzol and 80% Iranian Benzine B.	0.753	47	45	+2
107	<i>c</i>	—	62-92	Raw benzine.	0.754	47	45	+2
108	<i>h</i>	—	55-65	Spirit.	0.754	47	45	+2
109	<i>g</i>	4	52-75	Blend : Ethyl Alcohol and Iranian Benzine B.	0.757	46	44	+2
110	<i>c</i>	—	60-92	Spirit. Distillation range 148-164° C.	0.760	45	44	+1
111	<i>c</i>	—	57-63	Benzine, heavy.	0.772	43	43	0
112	<i>d</i>	—	—	Spirit. Distillation range 164-178° C.	0.773	44	43	+1
113	<i>b</i>	—	—	White spirit.	0.779	43	42	+1
114	<i>b</i>	—	—	Kerosine (SO ₂ refined).	0.782	39	42	-3
115	<i>d</i>	—	68-86	Export gasoline.	0.784	42	42	0
116	<i>c</i>	—	—	Spirit. Distillation range 178-200° C.	0.788	44	41	+3
117	<i>b</i>	—	—	Kerosine.	0.790	42	41	+1

118	c	—	—	Distillation range 160-178° C.	0-795	42	41	+1
119	i	—	32-86	Gasoline, British Borneo.	0-799	44	41	+3
120	c	—	60-92	Distillation range 200-220° C.	0-802	43	40	+3
121	e	—	32-86	Kerosine, Iranian.	0-802	41	40	-1
122	b	—	—	L.T. B.O.	0-804	40	40	0
123	c	—	68-92	Kerosine, Rumanian. Camponi Bacau.	0-804	42	40	+2
124	c	—	61-92	Kerosine, Rumanian. Glodeni.	0-804	38	40	-2
125	c	—	—	Raw product. Tateani-Antal. P. Goreatura.	0-805	38	40	-2
126	c	—	—	Kerosine, Rumanian. Policiori.	0-806	42	40	+2
127	c	—	68-92	Kerosine, Rumanian. St. Romana.	0-808	43	40	+3
128	c	—	—	Spirit. Distillation range 178-195° C.	0-810	42	40	+2
129	c	—	61-92	Kerosine, Rumanian. Policiori.	0-811	38	40	-2
130	c	—	—	Raw product. Marita-Ochisor. P. No. 4.	0-811	42	40	-2
131	c	—	61-92	Kerosine, Rumanian. Campina.	0-812	39	40	-1
132	c	—	62-63	Kerosine.	0-812	41	40	+1
133	i	—	32-86	Kerosine, Venezuelan.	0-813	42	40	+2
134	c	—	58-92	Spirit. Distillation range 220-238° C.	0-814	39	39	0
135	c	—	—	Raw product. Camponi Bacau S. No. 1.	0-814	42	39	+3
136	i	—	32-86	Kerosine, Borneo (Edeloanu-treated).	0-815	41	39	+2
137	i	—	32-86	Kerosine, Trinidad (Edeloanu-treated).	0-816	41	39	+2
138	c	—	58-92	Spirit. Distillation range 238-252° C.	0-823	38	39	-1
139	c	—	68-92	Kerosine, Rumanian. Bustenari.	0-826	42	39	+3
140	c	—	64-92	Spirit. Distillation range 195-215° C.	0-826	42	39	+3
141	c	—	61-92	Kerosine, Rumanian. Moreni.	0-827	40	39	+1
142	c	—	—	Crude product. Baicoi S. No. 1.	0-831	40	39	+1
143	c	—	—	Crude product. Policiori P. No. 4.	0-834	39	38	+1
144	c	—	—	Crude product. Bustenari Faget S. No. 1.	0-834	41	38	+3
145	c	—	58-92	Spirit. Distillation range 252-270° C.	0-834	38	38	0
146	c	—	—	Crude product. Berca S. No. 3.	0-837	39	38	+1
147	c	—	—	Crude product. Campina S. No. 58.	0-838	38	38	0
148	b	—	—	Crude product, Persian.	0-840	40	38	+2
149	c	—	—	Crude product. Campina S. No. 1.	0-842	39	38	+1
150	i	—	60-113	Gas oil, Rumanian waxy.	0-843	38	38	0
151	c	—	—	Crude product. Glodeni P. No. 1.	0-843	38	38	0
152	c	—	58-92	Spirit. Distillation range 270-290° C.	0-843	37	38	-1

TABLE IV—continued.

Ref. No.	Ref. to source of data.	Number of density values given in original data.	Temperature range covered by original data, ° F.	Material.	Specific gravity $S_{60^{\circ} F / 60^{\circ} F.}$	Value of $B_o \times 10^5$	Corresponding value of $B_o \times 10^5$ derived from Table 3 of C 410.	Difference $(B_o - B_s) \times 10^5$
153	e	3	68-176	Transformer oil, No. 1.	0.845	37	38	-1
154	c	—	58-92	Spirit. Distillation range 290-311° C.	0.850	36	38	-2
155	e	3	68-176	Transformer oil, No. 2.	0.852	36	38	-2
156	c	—	—	Crude oil. Bustenari S. No. 44.	0.854	39	38	+1
157	e	—	50-158	Shale oil.	0.857	37	38	-1
158	c	—	—	Crude oil. Colibasi P. No. 36.	0.861	39	38	+1
159	c	—	59-64	Gas oil.	0.861	38	38	0
160	c	—	63-91	Distillation range 311-329° C.	0.862	39	38	+1
161	g	4	55-123	Transformer oil.	0.863	36	38	-2
162	d	—	68-86	Gas oil.	0.863	39	38	+1
163	b	—	—	Gas oil.	0.865	38	38	0
164	c	—	63-91	Distillation range 329-344° C.	0.865	39	37	+2
165	e	—	50-158	Refined machine oil.	0.867	35	37	-2
166	c	—	—	Crude oil. Lucacesti. P. Schinoasa.	0.872	38	37	+1
167	e	3	68-176	Transformer oil, No. 1.	0.876	36	37	-1
168	c	—	64-91	Distillation range 344-363° C.	0.876	39	37	+2
169	c	—	100-118	Distillate at 363° C.	0.881	37	37	0
170	c	—	—	Crude oil. Gura Ochetei S. No. 9.	0.888	39	37	+2
171	c	—	—	Crude oil. Sarata-Monteoru P. No. 3.	0.892	39	37	+2
172	e	—	50-158	Fuel oil.	0.893	37	37	0
173	i	—	32-86	Gas oil. Rumanian asphaltic.	0.893	39	37	+2
174	b	—	—	Fuel oil.	0.895	37	37	0
175	c	—	—	Crude oil. Moinesti. P. Sigmunda.	0.895	38	37	+1
176	c	—	61-90	Distillate at 340° C.	0.896	37	37	0
177	e	—	50-158	Refined spindle oil.	0.900	35	37	-2

178	c	—	61-92	Distillation range 340-343° C.	0.900	37	37	0
179	c	—	63-92	Distillation range 286-304° C.	0.902	39	37	+2
180	c	—	64-91	Distillation range 340-343° C.	0.904	37	37	0
181	i	3	113-167	Venezuelan waxy distillate.	0.905	34	37	-3
182	c	—	63-92	Distillation range 304-321° C.	0.908	37	37	0
183	c	—	—	Crude oil. Tintea S. No. 7.	0.910	37	37	0
184	c	—	63-92	Distillation range 321-339° C.	0.910	37	37	0
185	c	—	64-92	Distillation range 339-340° C.	0.910	38	37	+1
186	e	—	50-158	Engine oil (refined).	0.910	34	37	-3
187	i	—	32-86	Borneo solar oil.	0.913	39	37	+2
188	e	—	50-158	Olive oil.	0.917	37	37	0
189	b	—	—	Lubricating oil.	0.918	35	37	-2
190	c	—	111-129	Lubricating oil, vacuum extra.	0.923	34	37	-3
191	c	—	129-167	Lubricating oil, vacuum extra.	0.923	36	37	-1
192	c	—	212-254	Lubricating oil, vacuum extra.	0.923	36	37	-1
193	g	4	58-123	Venezuelan cylinder oil (edeleanised).	0.923	34	37	-3
194	d	—	68-86	Crude oil, Potrero.	0.925	39	37	+2
195	c	—	90-97	Vacuum extra heavy.	0.930	35	37	-2
196	d	—	68-86	Light fuel oil.	0.934	38	37	+1
197	e	—	50-158	Fuel oil.	0.935	36	37	-1
198	c	—	57-92	Vacuum ideal.	0.935	36	37	-1
199	c	—	77-86	Lubricating oil.	0.942	36	37	-1
200	i	3	32-86	California (Lab. No. 42,884).	0.942	39	37	+2
201	i	2	58-124	Straight-run, Miri.	0.944	37	37	0
202	g	4	58-124	Fuel oil, Borneo.	0.944	37	37	0
203	g	—	59-124	Furnace oil, Iranian.	0.945	38	37	+1
204	c	—	71-95	Residue.	0.950	36	37	-1
205	c	—	95-135	Residue.	0.950	36	37	-1
206	c	—	100-196	Residue.	0.950	36	37	-1
207	d	—	68-86	Heavy fuel oil.	0.951	39	37	+2
208	e	—	50-158	Fuel oil.	0.954	36	37	-1
209	g	—	59-124	Fuel oil, Mexican.	0.965	36	36	0
210	d	—	68-86	Evaporated crude oil.	0.968	39	36	+3
211	g	4	55-121	Fuel oil (asphaltic), Venezuelan.	0.972	35	36	-1
212	i	3	32-86	Venezuelan (Lab. No. 42,885).	0.980	36	36	0
213	i	4	50-131	Cut-back asphaltic bitumen.	0.983	34	36	-2

TABLE V.

Materials for which Data were supplied to the Committee having Values of $B_c - B_s$ outside the Range ± 0.00003 but within the Range ± 0.00005 .

Ref. No.	Ref. to source of data.	Number of density values given in original data.	Temperature range covered by original data, ° F.	Material.	Specific gravity $S_{60^\circ \text{ F.}/60^\circ \text{ F.}}$	Value of $B_c \times 10^5$	Corresponding value of $B_s \times 10^5$ derived from Table 3 of C 410.	Difference $(B_c - B_s) \times 10^5$
214	<i>i</i>	—	32-86	Gasoline, Iraq acid-treated, cracked.	0.709	52	48	+4
215	<i>i</i>	—	32-86	Gasoline, Iraq acid-treated, cracked.	0.711	52	48	+4
216	<i>i</i>	—	32-86	Gasoline, Trinidad.	0.727	51	47	+4
217	<i>i</i>	—	32-86	Gasoline, Rumanian.	0.731	50	46	+4
218	<i>c</i>	—	—	Spirit. Distillation range 109-124° C.	0.744	49	45	+4
219	<i>h</i>	—	55-65	Spirit.	0.750	49	45	+4
220	<i>c</i>	—	63-92	Spirit. Distillation range 124-148° C.	0.767	48	43	+5
221	<i>c</i>	—	63-92	Spirit. Distillation range 142-160° C.	0.782	46	42	+4
222	<i>i</i>	—	32-86	Gasoline, Iraq acid-treated. Reformed, redistilled.	0.791	46	41	+5
223	<i>i</i>	—	32-86	Gasoline, Iraq acid-treated. Reformed, as received.	0.792	46	41	+5
224	<i>c</i>	—	68-92	Kerosine, Rumanian. "Vega."	0.819	44	39	+5
225	<i>i</i>	—	32-86	Kerosine, Trinidad.	0.823	43	39	+4
226	<i>c</i>	—	68-92	Kerosine, Rumanian. Gura Ochitei.	0.830	43	39	+4
227	<i>i</i>	—	32-86	Kerosine, British Borneo.	0.838	42	38	+4
228	<i>i</i>	—	32-86	Kerosine, Borneo untreated.	0.845	42	38	+4
229	<i>c</i>	—	63-92	Spirit. Distillation range 215-237° C.	0.848	42	38	+4
230	<i>i</i>	—	32-86	Residue from re-distillation of a mixture of cracked and reformed Iraq benzines.	0.862	42	38	+4
231	<i>i</i>	—	32-86	Kerosine, Borneo (Edeleanu extract).	0.863	43	38	+5
232	<i>c</i>	—	63-92	Distillation range 237-262° C.	0.868	41	37	+4
233	<i>c</i>	—	—	Crude oil. Moreni S. No. 14.	0.869	41	37	+4
234	<i>c</i>	—	63-92	Distillation range 262-286° C.	0.887	42	37	+5
235	<i>g</i>	6	58-123	Fuel oil (paraffinous), Iranian.	0.921	42	37	+5
236	<i>i</i>	3	59-123	Straight-run, Southern.	0.921	42	37	+5
237	<i>i</i>	3	113-167	Sumatra.	0.925	33	37	-4
238	<i>i</i>	—	32-86	Residue from reforming Iraq benzine.	0.931	41	37	+4

TABLE VI.

Materials for which Data were supplied to the Committee having Values of $B_o - B_s$ outside the Range ± 0.00005 .

Ref. No.	Ref. to source of data.	Number of density values given in original data.	Temperature range covered by original data, ° F.	Material.	Specific gravity $S_{60^\circ \text{ F.}/60^\circ \text{ F.}}$	Value of $B_o \times 10^5$	Corresponding value of $B_s \times 10^5$ derived from Table 3 of C 410.	Difference $(B_o - B_s) \times 10^5$
239	<i>c</i>	—	62-92	Benzine, heavy Rumanian.	0.714	42	48	- 6
240	<i>i</i>	—	32-86	Gasoline, Borneo straight-run.	0.789	49	41	+ 8
241	<i>g</i>	8	52-88	Benzine, Borneo.	0.789	48	41	+ 7
242	<i>g</i>	5	52-86	Blend, ethyl alcohol and Borneo benzine.	0.790	48	41	+ 7
243	<i>g</i>	4	32-86	Ethyl alcohol (100% EtOH).	0.794	47	41	+ 6
244	<i>g</i>	4	32-86	Ethyl alcohol-water mixture (95% EtOH by mass).	0.809	48	40	+ 8
245	<i>c</i>	—	124-160	Kerosine, Rumanian. "Vega."	0.819	45	39	+ 6
246	<i>c</i>	—	154-203	Kerosine, Rumanian. "Vega."	0.819	46	39	+ 7
247	<i>k</i>	3	32-104	<i>m</i> -Xylene.	0.869	47	37	+ 10
248	<i>k</i>	3	32-104	Toluene.	0.871	52	37	+ 15
249	<i>g</i>	7	51-87	Aviation benzol.	0.876	54	37	+ 17
250	<i>k</i>	—	32-86	Benzole.	0.881	57	37	+ 20
251	<i>g</i>	5	49-86	Pure crystallisable benzene.	0.883	60	37	+ 23
252	<i>k</i>	3	32-104	Benzene.	0.884	59	37	+ 22
253	<i>i</i>	3	77-131	Sumatra (Lab. No. 42,886).	0.983	45	36	+ 9

TABLE VII.
Values of B_c for Asphaltic and Bituminous Materials.

Ref. No.	Ref. to source of data.	Number of density values given in original data.	Temperature range covered by original data, ° F.	Material.	Specific gravity $S_{60^\circ \text{ F.}/60^\circ \text{ F.}}$	Value of $B_c \times 10^6$
254	<i>h</i>	—	70-320	Bitumen.	1.013	37
255	<i>f</i>	18	59-378	Asphalt.	1.016	31
256	<i>j</i>	—	60-275	Bitumen, Venezuelan. Pen. 180/200.	1.020	34
257	<i>i</i>	—	50-104	Asphaltic bitumen, Venezuelan. Pen. 80/100.	1.022	33
258	<i>f</i>	18	59-353	Asphalt.	1.024	32
259	<i>i</i>	3	50-104	Asphaltic bitumen, Egyptian. Pen. 80/100.	1.026	43
260	<i>f</i>	18	59-367	Asphalt.	1.028	32
261	<i>j</i>	—	60-275	Bitumen, Venezuelan. Pen. 41/50.	1.034	36
262	<i>f</i>	18	59-372	Asphalt.	1.042	33
263	<i>f</i>	18	59-367	Asphalt.	1.044	32
264	<i>g</i>	4	57-120	Edelenau extract.	1.045	37
265	<i>f</i>	18	59-378	Asphalt.	1.059	33
266	<i>j</i>	—	60-275	Bitumen, Panuco. Pen. 10/15.	1.078	34

TABLE VIII.
Frequencies of Values of $B_c - B_s$.

Value of ($B_c - B_s$) $\times 10^6$.	American petroleum oils of N.B.S. Technologic Paper No. 77.			Materials listed in Tables IV-VI.		
	Number of materials having value of $B_c - B_s$, given in column A.	Percentage of materials having value of $B_c - B_s$, given in column A.	Percentage of materials having value of $B_c - B_s$, within the range ± 0.00003 .	Number of materials having value of $B_c - B_s$, given in column A.	Percentage of materials having value of $B_c - B_s$, given in column A.	Percentage of materials having value of $B_c - B_s$, within the range ± 0.00003 .
A.	B.	C.	D.	E.	F.	G.
+9	0	0	98	1	1	78
+8	0	0		2	1	
+7	0	0		3	2	
+6	0	0		2	1	
+5	1	1		8	5	
+4	1	1		16	10	
+3	2	2		11	7	
+2	10	12		27	17	
+1	15	17		23	14	
0	24	28		29	18	
-1	25	29	98	16	10	78
-2	7	8		13	8	
-3	2	2		7	4	
-4	0	0		1	1	
-5	0	0		0	0	
-6	0	0		1	1	
-7	0	0		0	0	
-8	0	0		0	0	
-9	0	0		0	0	
Total	87	—	—	160	—	—

0.0010 from that given by the use of the value of B_c applicable to the particular oil. In Table III are similarly listed the oils of Technologic Paper No. 77 for which the value of $B_c - B_s$ is outside the range ± 0.00003 . Of the eighty seven oils for which data are given in Technologic Paper No. 77, eighty five fall into Table II, and only two into Table III, and these two are recorded in the original paper as being oils probably containing solid particles at low temperatures.

There is therefore very close agreement between the values of B_c for the individual oils and the corresponding values of B_s obtained from Table I.

A similar comparison is made in Tables IV to VII between values of B_c for individual materials for which data were supplied to the committee and the corresponding values of B_s from Table I.

In Table IV are listed materials for which the values of $B_c - B_s$ fall within the same range as in Table II, viz., ± 0.00003 , and 126 out of the 179 materials for which data were supplied to the committee come within this table.

The materials, twenty five in number, for which $B_c - B_s$ is outside the range ± 0.00003 but within the range ± 0.00005 are listed in Table V. For these materials the use of B_s instead of B_c for reducing specific gravities $S_{t^\circ \text{F.}/60^\circ \text{F.}}$ to $S_{60^\circ \text{F.}/60^\circ \text{F.}}$ would result in errors exceeding 0.0010 but not exceeding 0.0015 when $t^\circ \text{F.}$ differs from 60°F. by 30°F.

Tables IV and V together account for 151 out of the 179 materials for which data were supplied. The remaining twenty eight materials are accounted for in Tables VI and VII. Table VI includes fifteen materials for which $B_c - B_s$ is outside the range ± 0.00005 . This table includes data for materials such as ethyl alcohol and toluene, which, though of interest to petroleum technologists, are materials which would not be expected to fall into line with ordinary petroleum oils.

Table VII includes thirteen asphaltic and bituminous materials having specific gravities $S_{60^\circ \text{F.}/60^\circ \text{F.}}$ greater than 1.000. No values of B_s are available for specific gravities $S_{60^\circ \text{F.}/60^\circ \text{F.}}$ greater than 1.000, but it is interesting to note that eleven out of the thirteen materials listed in Table VII have values of B_c within the range ± 0.00004 of the value 0.00036 for B_s valid for $S_{60^\circ \text{F.}/60^\circ \text{F.}} = 1.000$.

A rapid survey of the comparisons of B_c and B_s given in Tables II to VI inclusive may be obtained from Table VIII. In the first half of this table the number of the American petroleum oils of Technologic Paper No. 77 which have values of $B_c - B_s$ given in column *A* of the table are given in column *B*, and the corresponding percentages of the total number of oils are given in column *C*. The second half of the table summarizes similarly the frequency of each value of $B_c - B_s$ for the materials listed in Tables IV to VI, but six liquids of Table VI having values of $B_c - B_s$ greater than 0.00009 have been omitted because they are special liquids, e.g., pure crystallizable benzene.

The percentage of the American petroleum oils of Technologic Paper No. 77 which have values of $B_c - B_s$ within the range ± 0.00003 is very high, being 98 per cent., and this was to be anticipated, as these are the oils from which the values of B_s were derived. It is perhaps also of physical significance in that it may imply relative uniformity in the types of American petroleum from which the data for C 410 were obtained. Nevertheless,

whilst the percentage of materials from Tables IV to VI having values of B_c-B_s within the range ± 0.00003 is not so high as for the oils of Technologic Paper No. 77, it is still quite high—namely 78 per cent.—and shows that values of B_s derived from Table III of C 410 are applicable to a large number of the materials for which data were supplied to the committee.

CONCLUSIONS.

It cannot be claimed that the data collected are completely representative of all modern petroleum oils and petroleum products. Nevertheless, the data given in Table IV indicate that the "National Standard Petroleum Oil Tables" (U.S. Bureau of Standards Circular C 410 : 1936) are applicable to the degree of accuracy required in commercial transactions, to a large number of materials in addition to the American oils on which the construction of the tables of C 410 was based. It is hoped that Tables IV to VI will be useful when a decision has to be made, with regard to any particular product, whether the tables of C 410 may safely be used for the material, or whether it is necessary to use expansion data determined for the material itself.

The data collected may be taken as corroborating the wide applicability of the tables of C 410, and also as indicating their limitations. It is considered that an attempt to provide tables on the lines of those in C 140, which would be more widely applicable than those tables, would not be justifiable, as the work involved would be very great, and the resulting tables would not be capable of sufficiently more general use to justify the work. The best practical policy is to use the tables of C 410 wherever this is justifiable, and to use appropriate expansion data for such materials as differ from those on which C 410 is based so much as not to warrant the use of C 410.

Sources of Data.

- a. "Density and Thermal Expansion of American Petroleum Oils" by H. W. Bearce and E. L. Pepper, National Bureau of Standards Technologic Paper No. 77, 1916.
- b. Dr. F. B. Thole.
- c. Steaua Romana S.A.
- d. Mr. McConnell Sanders.
- e. The National Physical Laboratory.
- f. Asphalt Laboratory, Monheim.
- g. Mr. H. Hyams.
- h. Mr. W. J. Jeffs.
- i. Shell Refining and Marketing Co., Ltd., Central Laboratories.
- j. Dr. F. H. Garner.
- k. International Critical Tables.

OBITUARY.

WILLIAM MACNAB.

WILLIAM MACNAB died at Cookham Dene on 2nd September, in his 84th year. Educated at Greenock Academy and the Edinburgh Institution, he later studied chemistry and allied sciences at Glasgow University and Anderson's College. In his early career he specialized in sugar chemistry, holding first a post as analyst in a sugar refinery at Magdeburg and later one as chief chemist to the Clyde Wharf Sugar Refinery in London. Then for a few years during his connection with the Water Softening Company he was concerned with chemical and engineering problems, and installed plants in Canada and the United States. About 1897 he entered into a consulting partnership with C. Napier Hake, which practice he carried on alone after the latter had left this country for Australia. This work led to his association with mining, metallurgy, and the explosives industry, with which his name is chiefly connected. Before 1914 he was one of the recognized leading authorities on explosives, and during the last war was a member of Lord Moulton's Committee on Explosives, and Technical Adviser to the Ministry of Munitions. He was selected by the Government to compile "Technical Records of Explosives Supply, 1915-1919," being intimately connected with the design and erection of many of the large explosive works built at that time.

William Macnab was prominently connected with many scientific societies, and his association with this Institute goes back to 1913. In the first *Journal of the Institution of Petroleum Technologists*, as it was then, he is described as a "member who agreed to become such prior to the Foundation," and was thus connected with the earliest aims of Sir Boverton Redwood in its foundation. He continued his association with the Institute up to 1940, and was elected a Fellow in 1938.

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Geology and Development.

1014.* Micropalæontology, Past and Present. C. Croneis. *Bull. Amer. Assoc. Petrol. Geol.*, July 1941, 25, 1208-1255.—The author traces the rise of interest in microscopic fossils from the period when Leeuwenhoek's development of the forerunner of the microscope made possible their detailed study, through the several centuries of sporadic investigation, mainly by individual scientists, in interest of pure research, to the time when micropalæontology as a utilitarian science was commenced some twenty-five years ago. He also traces the development of the science and the progressive multiplication of the micropalæontologic groups studied.

The origin and growth of the science as a subject in university curricula are reviewed and suggestions made for future expansion and for improved training in this special field. Brief consideration is also given to the academic background prospective palæontologists should acquire in order to best serve the science as well as the organization which purchases their services.

The future of the science is also analysed, and suggestions are given for enlarging the scope and significance of the field, and thus enhancing its commercial significance. Illustrations of unusual micropalæontologic objects to be expected in crude oils are given, together with a bibliography of the various publications available. R. J. W.

1015.* Estimation by Volumetric Methods of Recoverable Oil and Gas from Sands. J. F. Dodge, H. C. Pyle, and E. G. Trostel. *Bull. Amer. Assoc. Petrol. Geol.*, July 1941, 25, 1302-1326.—Practical accuracy in volumetric estimates of oil and gas reserve is dependent both on the accuracy and completeness of the data available and on the skill and resourcefulness of the engineer or geologist in analysing and visualizing the reservoir conditions and fitting together the fragmentary data into a

compatible whole, recognizing similarities with and differences from other fields within his experience, as well as the practical limitations of the factors involved, their relative importance and relative weight. With the practical disappearance of unrestricted production in American oil-fields the utility of the once universally employed decline-curve methods for estimating reserves has, in a large measure, been destroyed. The author discusses the involving factors and the need for their modification. Recovery factors for oils are distinguished from those for gases for co-occurring and produced oil and gas mixtures.

R. J. W.

1016.* Thrust Faulting and Coarse Clastics in Temblor Range, California. F. S. Hudson and G. H. White. *Bull. Amer. Assoc. Petrol. Geol.*, July 1941, **25**, 1327-1342.—The Temblor Range, the most south-easterly of the individual ranges forming the Coast Range, extends from Polonio Pass (west of Lost Hills oil-field) south-easterly to the vicinity of Maricopa, where it merges with the foothills of the western end of the east-west trending San Emigdio Range. The San Andreas Rift zone may be said to mark the south-western edge of the Temblor Range, and on its opposite side is the San Joaquin Valley, into which the range sends south-east trending spurs, such as Elk Hills and Buena Vista Hills. The range consists of two parts, arranged "en échelon," the northern one lying north-east of, and extending south-east of, the northern end of the southern part. The natural boundary between the two parts appears to be marked by an oblique-trending fault extending along the south-western side of Little Santa Maria Valley—4 miles west of McKittrick—and thence N. 60° W. across the crest of the range. The paper deals with the southern part of the range, which is essentially anticlinal and, save for certain pre-Cretaceous crystalline rocks, the oldest rocks exposed in it being Oligocene and a discussion of certain of the formations of the south Temblor Range, is formulated rather than a stratigraphic or palaeontologic study. An index map is given indicating the geologic area discussed, together with sectional diagrams with references to various publications dealing with the area under discussion.

R. J. W.

1017.* Seismic Velocity Variations in San Joaquin Valley, California. W. S. Olson. *Bull. Amer. Assoc. Petrol. Geol.*, July 1941, **25**, 1343-1362.—Velocities, in some form, enter into all seismic calculations, and when the precise distribution of velocities is known, it is possible to solve with a similar degree of accuracy the problems of finding the exact locations and slopes of any reflecting horizons.

The author defines the various types of velocities, velocity being definitely a function of depth, although the precise manner in which depth and associated factors influence the elastic constants of rocks is not known, but in none of the wells has a negative coefficient of increase with depth been found when all observations are included. The velocity decreases with depth only for limited distances, and is a function of geographical location. Velocity data have been obtained in approximately eighty wells in the San Joaquin Valley, and the analysis of these has revealed the existence of rapid lateral changes in velocity, the causes of which are discussed, also their effect on seismic-reflection mapping. Some methods for correcting reflection-survey data are considered.

R. J. W.

1018.* Geology of Eola Oil-field, Avoyelles Parish, Louisiana. F. W. Bates. *Bull. Amer. Assoc. Petrol. Geol.*, July 1941, **25**, 1363-1395.—Eola, located in the Louisiana Gulf Coast area, in the south central part of the State, was discovered in January 1939, the location of the structure being attributed solely to geophysics. Principal production is secured from sands at top of Sabine Wilcox of the lower Eocene at a depth of about 8500 ft.; commercial oil-sands have been logged on some wells in the Cockfield and Sparta. Some ninety oil-wells have been completed from the Wilcox and three from the Cockfield; twelve dry holes have been drilled on and adjacent to the field. Eola was the first field in the area to produce oil in commercial quantities from the Sabine Wilcox.

Structurally the field appears to be a large nose extending south-east from the Cheneyville salt dome, securing its north-western closure from a very complex system of normal faults. A total relief of about 400 ft. on top of the Wilcox has been established

by the drill with a maximum elevation of 300 ft. of the producing sand above its water-level. Up to December 1940 the field has produced more than $4\frac{1}{2}$ million barrels of oil, 43° A.P.I.; whilst probable ultimate recovery is more than 60 million barrels thus indicating the field to be one of the major petroleum reserves in the area.

R. J. W.

1019.* Complex Structure of Cement Field Poses many Problems. R. Ingram. *Oil Gas J.*, 10.7.41, 40 (9), 23.—Development at Cement began in 1917, since when there have been several cycles of activity. More than 20 million barrels of oil have been recovered, and a total of twice that amount is expected. There are two domes on a north-west-south-east anticline outlined in Permian beds.

In locating wells at Cement considerable preliminary work is necessary because of the steep dips, probable faulting, lenticular sands, and truncation of the Pennsylvanian at the top of the structure. Thus, the Rowe sand production was only in a semi-circular strip. In all there are about twenty pay sands, but a well often produces from sands not found in its neighbours. This behaviour is explained by some as due to a main fault parallel to the axis of the structure with minor faulting, and by others as due to a plane of steep crumpling rather than a fault.

G. D. H.

1020.* Well Logs and Field Data of Active Oil Areas—West Texas. Anon. *Oil Gas J.*, 10.7.41, 40 (9), 50.—The first development was in 1923, when two pays were opened at Big Lake, the upper one in the Permian Big lime at 2400 ft. A decline in production in 1928 led to a deep test which found a show in the Ordovician at 8520 ft. The latter gave more than 2000 bbl. of oil and 20,000,000 cu. ft. of gas/day. Two other wells were small, but a fourth gave 7000 bbl. of oil and 60,000,000 cu. ft. of gas.

By the end of 1927 a number of major fields had been opened in the Permian lime—Hendrick, Church-Fields and McElroy, McCamey, Yates and Chalk-Settles—and in 1928 these gave 120,651,900 bbl. of oil. Up to 1934 a number of Ordovician failures had been recorded in several pools, and in 1935 a well went to 12,786 ft. without any good shows in the Ordovician. However, twelve producers have been brought in the Ordovician at Sand Hills, where the formation is considerably higher than was expected. In 1940 three additional deep pools were found, two producing from the Ellenburger and one from a Silurian lime.

The pre-Permian geology is not yet fully outlined, but the highs appear to coincide generally with the line of folding running south-east from Hendricks. Between this and the rise at Big Lake to the east is a deep basin filled with Permian lime and anhydrite, which carries the Ordovician out of economical prospecting depths. In the west the Devonian and Silurian flank the high on its western side, and this production may extend westward.

A generalized stratigraphical column and a series of well logs are included.

G. D. H.

1021.* Stratigraphic Traps Renew Interest in Western Kansas. Anon. *Oil Gas J.*, 17.7.41, 40 (10), 18.—Oil has been found in a Viola lime stratigraphic trap on the south-eastern flank of the Central Kansas uplift. The well is 5 ml. north of Sylvia, and encountered the Viola at a depth of 3773 ft. The structural position of the Viola lime is similar to that in the Zenith pool 6 ml. to the south-west, where there is a truncated south-plunging terrace. The Zenith field has yielded 4,609,090 bbl. of 40° oil since its discovery in September 1937. Its present daily average is 7916 bbl. 258 wells are producing, about 130 of them from the Viola at an average depth of 3800 ft. About 3480 acres have been developed.

Four miles west of the Zenith structure seven wells have been completed at Stafford giving Viola oil, and one produces from the Arbuckle.

A table summarizes the developmental data for the Viola lime in Western Kansas, and a typical well log is given for the Lower Palaeozoic of the Zenith field. A palaeogeographical map of the south-eastern flank of the Central Kansas uplift shows the edge-line of the Viola lime and the various Viola fields.

G. D. H.

1022.* Discoveries of New Reserves almost Balance Withdrawals. W. V. Howard. *Oil Gas J.*, 31.7.41, 40 (12), 38.—Discoveries and extensions during the first six months

of 1941 have estimates of 568,900,500 brl., 92,620,000 brl. less than the production for the same period. Last year the estimate for the first half was 275,688,000 brl., and for the whole year 1,371,463,000 brl., and a similar relationship is possible this year.

The discoveries and major extensions in the first six months of 1941 are listed with the proved acreage, formation and its thickness, and estimated reserves.

G. D. H.

1023.* World Production Declines as Market Losses Continue. J. P. O'Donnell. *Oil Gas J.*, 31.7.41, 40 (12), 40.—Preliminary estimates of world production for the first half of 1941 show a decline compared with the first half of 1940. The estimate is 1,052,429,000 brl., 3.5% below last year. The U.S.A. production fell by 21,000,000 to 661,521,000 brl. The U.S.S.R.'s production rose by 2% to 110,896,000 brl., whilst Venezuelan output was 102,000,000 brl., a decrease of 3%. In Venezuela three new fields were opened—Las Ollas, Santa Rosa, and Santa Barbara. The Iraq production probably declined by 70%. Egypt and Canada had marked gains.

The estimated production for the first half of 1941 is tabulated by fields, and compared with data for the same period in 1940.

G. D. H.

1024.* Drilling in the United States Slightly Below Last Year. W. V. Howard. *Oil Gas J.*, 31.7.41, 40 (12), 58.—9724 oil-wells, 1251 gas-wells, and 3278 dry holes were drilled during the first half of 1941. The average initial production of the wells was less than for the same period of 1940. In Michigan and Illinois average initials are about 70% down. The eastern fields show little significant change, and of the 2183 oil-wells reported, one-half are input wells for water-flooding in the Bradford district. There was a large increase in the number of 3000-ft. wells completed for less than 100,000 cu. ft./day. In Ohio especially, the search for oil has become subsidiary to drilling for gas.

Apart from the Falls City district of the Forest City basin, there is little activity in that region. Much more attention is being paid to Western than to Eastern Nebraska. One of the main activities in Kansas has been the linking of old pools. On the flanks of the Central Kansas uplift stratigraphic traps are assuming greater importance, and the discovery of oil in a Pennsylvanian sand opens up a large, virtually untested area for prospecting.

In Oklahoma a number of Wilcox pools were found, some to the west of the Seminole district, some in the north central part of the State, and some in the south-western district. Woodbine prospecting has been revived in East Central Texas following the discovery of Hawkins. Ordovician production in West Texas is expected by some to have possibilities equal to the Permian. North Central Texas is becoming an area of deeper drilling. Ellenburger production has been found at K.M.A., Worsham, Electra, and in Cooke County. There has been a 10% decline in activity in coastal Louisiana and a 30% decline in South-west Texas.

The completions, their status, and average production are tabulated by States or districts for the first halves of 1941 and 1940.

G. D. H.

1025.* Production in Mid-Continent Rises; Texas, East Decline. W. V. Howard. *Oil Gas J.*, 31.7.41, 40 (12), 60.—The U.S.A. oil production was 661,521,324 brl. during the first half of 1941, 23,194,190 brl. less than in the same period of 1940. Illinois, Texas, Oklahoma, and Michigan had a total decline of 40,167,957 brl. Production in the north-eastern States as a whole decreased by 22,995,579 brl. Increases of 20% took place in Kansas and Wyoming. Tinsley was responsible for a 220% rise in Mississippi, and Falls City development raised Nebraska's output by 940%.

Texas' decline of 4.5% was not uniformly distributed. California's production was practically unaltered, whilst the Rocky Mountain production rose by 9%. In descending order of output, the first five States are Texas, California, Oklahoma, Illinois, and Louisiana. The seventy-five largest fields are tabulated in order, and the annual production by States is given for the period 1935–40.

Brief notes are given on some of the leading fields.

G. D. H.

1026.* Illinois—Benton Field Discovery Climaxes Successful Half-year. Anon. *Oil Gas J.*, 31.7.41, 40 (12), 71.—During the first six months of 1941 more fields were discovered than in any like period since the State's revival as a leading oil-producing State. Despite declines in the outputs of the leading fields, the new discoveries have maintained, and even increased, the total production. The daily production during the half-year has averaged 326,932 brl., nearly 110,000 brl./day less than a year ago.

The main activity has been in White County, most of the discoveries being along the Wabash River. The Rising Sun field has given excellent recoveries from the Tar Springs and Aux Vases sands, but the Benton pool of Franklin County is outstanding, and is now the State's largest producer. It gives 30,000 brl./day from the Tar Springs sand. The long-awaited Devonian test at Loudon came in at 2500 brl./day, but almost immediately began making large volumes of water, and all subsequent wells have had water troubles.

The Illinois discoveries are listed for the first half of 1941; the half-yearly productions are tabulated by fields for the period 1939–41, and the production by months for 1941; and the completions and their status are summarized by fields for the first six months of 1941.

G. D. H.

1027.* South-west Texas—Oil on Flanks of Distillate Pools Outstanding Discovery. F. L. Singleton. *Oil Gas J.*, 31.7.41, 40 (12), 73.—Although no spectacular developments took place in South-west Texas during the first half of 1941, new sand discoveries and important extensions increased the district's potentialities. Drilling operations showed a sharp decline and totalled 862 wells with 302 abandonments. On the Lower Gulf Coast prolific production was opened in down-dip sands flanking the Agua Dulce and Stratton fields. Oil was also found in deeper sands in the Lower Oligocene. At Stratton the oil is down-dip in the distillate sands. Stratton and Agua Dulce are on a single elongated anticlinal structure. An important new sand appears to have been opened at Midway, and a lower Frio sand has been brought in at Luby. Favourable showings have been logged in 10,000-ft. tests at St. Charles, McCampbell, and East Flour Bluff. Few important developments took place in the Laredo district. There was a fair amount of wildcatting on the Wilcox trend, extending along the old Jackson shore-line trend. Bee Creek and Tenney Creek were further developed in the Balcones fault-line district.

The half-yearly production is tabulated by fields for the period 1939–41, the discoveries, completions, and their status are listed for the first half of 1941, and the monthly outputs are given for the same period.

G. D. H.

1028.* California—Reserves Maintained Largely by Discovery of Deeper Sands. L. P. Stockman. *Oil Gas J.*, 31.7.41, 40 (12), 81.—California's crude oil reserve was not maintained during the first six months of 1941. New discoveries have added but little to the reserves, but deeper drilling and extensions in proved fields have maintained reserves fairly well. Kettleman Hills is expected to produce 26,600 brl./acre from 16,000 acres, and it is hoped that a well, now at 12,490 ft., has proved oil below the present productive zone, the McAdams of the Upper Eocene.

Three new oil-fields and one gas-field have been discovered during the first six months of 1941. The Raisin City field is the first commercial accumulation found north of Coalinga, and it is believed to be substantial. The Oak Canyon field of the Newhall-Castaic region first showed a small heavy-oil accumulation, but a deeper discovery gave 720 brl. of oil/day with 900,000 cu. ft. of gas from a well in the Modelo at 6960 ft. It is on the northern end of the Halsey anticline. The value of the heavy oil discovery at Union Avenue, Kern County, is not yet determined. Two wells have been completed in the Vernalis gas-field of San Joaquin County. A summary is given of wells completed and of the discoveries in the first half of 1941; the monthly production is given by fields for the same period, and the half-yearly output is tabulated for the period 1939–41.

G. D. H.

1029.* Louisiana Gulf Coast—Field Development Reaches Peak; Old Domes Yield Deep Pays. H. L. Singleton. *Oil Gas J.*, 31.7.41, 40 (12), 86.—Ten new fields were found in the first six months of 1941, and several million barrels of new reserves were

added by exploration around old salt domes. The new fields range 7700–10,800 ft. in depth, and multiple sands have been logged in some. Important deep-sand production has been opened on the following known salt domes: West Cote Blanche, Belle Isle, Gueydon, Venice, Potash, Welsh, Anse La Butte, and Pine Prairie. The new developments are described. New sand discoveries have also been made in the following structures which are believed to be deep-seated salt domes: South Crowley, White Lake, Kenilworth, West Lake Verret, and West Bay.

Several new fields were found in the Delta district, and include Delacroix Island and Octave Pass. Several sands have been logged in the Miocene. The Port Allen field yields oil from 9610 ft., with several shallow sands above, and the Unknown Pass field in Lake Catherine came in with 325 bbl./day from a well at 9887 ft.

The new discoveries in the first half of 1941 are listed; there is a summary by fields of the status of wells drilled in the same period and the monthly production of the fields. The half-yearly production by fields is tabulated for the period 1939–41.

G. D. H.

1030.* Texas Gulf Coast—Maurbro Discovery Keeps Jackson County in Limelight. N. Williams. *Oil Gas J.*, 31.7.41, 40 (12), 92.—During the first half of 1941 eleven new fields were discovered. Drilling operations were increasing at the end of the period, after being below the previous half-year's level. Maurbro seems to be the most important discovery. Nine wells have been completed in the Frio at about 5220 ft. New sands have been found and extensions made at Lolita. There was much drilling at West Ranch, and a new sand has been opened at Ganado at 6468 ft. Two new sands have been brought in at West Ganado.

Sheridan was one of the two Wilcox fields, and before it was discovered it was thought that Wilcox production was limited to the uppermost 500 or 600 ft. Now deeper exploration has been undertaken in proved Wilcox areas. Important Cockfield production seems to have been proved at Garwood at a depth of 6104 ft.

As regards marine development, success has been achieved in the Sabine Pass field with a well in the Miocene at 4980 ft. Two Frio sand discoveries were made at Chenango and Oyster Bayou, but the former seems rather disappointing.

The half-yearly production by fields is tabulated for the period 1939–41. The new discoveries are listed for first half of 1941. The status of wells drilled and the monthly production by fields are listed for the same period.

G. D. H.

1031.* Oklahoma—All Districts Add to Reserves in Half-Year of Great Activity. R. Ingram. *Oil Gas J.*, 31.7.41, 40 (12), 96.—Although only in the first stages of development Guthrie and Tecumseh Lake were producing more than 2000 bbl./day at the beginning of June. Simpson production was found in the old Velma pool and at Velma, opening up a large area for prospecting in South-west Oklahoma. This area gave much new oil, with a boom at West Hewitt, deepening and new drilling at Empire, and steady drilling at Tussy, Hobart, Cement, and West Frederick.

The most important single development as regards new production was the Cumberland pool. New pools are being sought in Central Oklahoma on trends and cross-trends from the Nemaha Ridge, and one success was Guthrie with 200 acres of Wilcox production. Misener–Hunton production has been obtained by plugging back from the Wilcox at Coyle and Ramsey.

Nine new pools were opened in the Greater Seminole area in the first half of 1941. These include Tecumseh Lake, North Little River, North St. Louis, and South Maud. Prue sand output is being developed at East Stroud.

Oklahoma's discoveries and the extensions for the first half of 1941 are listed; also the status of new wells by fields and the monthly output for the same period. The half-yearly production is tabulated by fields for the period 1939–41. G. D. H.

1032.* Eastern Texas—Hawkins Responsible for Intense Prospecting Activity. R. M. Sanford. *Oil Gas J.*, 31.7.41, 40 (12), 101.—During the first half of 1941 there was general wildcatting in Eastern Texas, arising from developments at Hawkins and three new oil discoveries. The new discoveries are East Long Lake, Laneville., and a new deep oil horizon in the Willow Springs gas-field.

The Hawkins field has been proved over 3500 acres. At Willow Springs a considerable gas area has been proved in the deep Pettit lime of the Trinity, and oil has been found in the west side of the field. East Long Lake gives oil from the Woodbine, on a structure which is probably separated from the Long Lake field proper to the south-west.

The half-yearly production and the monthly production by fields are tabulated for the periods 1939-41 and January-June 1941 respectively.

G. D. H.

1033.* North Central Texas—Ellenburger Production Assumes Major Importance. R. M. Sanford. *Oil Gas J.*, 31.7.41. 40 (12), 102.—Several strikes in the deep Caddo lime and conglomerate sections of the Bend series during the first half of 1941 are expected to be of major importance, but these may be surpassed by the Mississippian lime horizon. Several shallow discoveries and most of the Mississippian lime strikes are located on the merge of the Bend Arch and the Red River Uplift. The Caddo lime strikes are on the same trend, and the Bend conglomerate discoveries are on the south flank of the Red River Uplift, where Ellenburger production was developed also, as well as on the south-west flank of the Muenster Arch.

The Mississippi lime generally lies immediately below the Bend series, and where favourably situated it is prolific, wells coming in at 1000 brl./day being common. The Ellenburger is prolific at K.M.A., and the old Electra field now gives Ellenburger oil.

Eighteen new fields or new producing horizons have been found in West Central Texas during the first half of 1941. There were six new strikes in the Noodle Creek district. Many strikes were gas—Boyston, Greynolds, Hudson, Gordon, and Kirk. There has been much wildcatting at depths of 150-5000 ft. in areas with two to twelve possible zones of production in view.

The discoveries in North and West Central Texas are listed for the first half of 1941, and the completions are tabulated by fields for the same period. The half-yearly production is given by fields for the period 1939-41, and the monthly production is given for January-June 1941.

G. D. H.

1034.* North Louisiana, Arkansas, Mississippi—Wilcox Trend Play Sustained by Important Discoveries. G. Weber. *Oil Gas J.*, 31.7.41. 40 (12), 109.—In the first half of 1941 five Wilcox fields were found in North Louisiana. The new production is from thin, lenticular sands deep in the Wilcox, whereas old Wilcox fields such as Urania, Tullis, and Georgetown produced from the top of the formation. The new production is not always associated with Wilcox highs.

The Athens gas-condensate field has been limited by a failure, and at Lisbon the first Smackover production was completed in a deep gas-condensate well near the top of the structure. On the south-east side deep wells failed to get production in the Travis Peak or Cotton Valley formations.

In the early part of 1941 the two most active fields in South Arkansas were McKamie and Dorcheat, two high-pressure gas-condensate pools. A new gas-condensate field was found 5 ml. east of Dorcheat. Deep production was also obtained in the Travis Peak and Cotton Valley.

In Sharkey County, Mississippi, a wildcat gave some oil from the Eutaw, and then there was salt-water intrusion. Tinsley was extended to the south-east in the first half of 1941, and the reserves were nearly doubled by the discovery of thick Woodruff sand sections.

The new discoveries in North Louisiana and Arkansas during the first half of 1941 are listed, and the monthly production by fields in the same period is given for these two areas and Mississippi. The status of wells completed during January-June 1941 is given by fields for Mississippi, Arkansas, and North Louisiana, and the half-yearly output is tabulated for the period 1939-41.

G. D. H.

1035.* Canada—North Turner Valley Development Aids Production Increase. V. Lauriston. *Oil Gas J.*, 31.7.41. 40 (12), 112.—Alberta's oil production during the first half of 1941 was 4,784,600 brl., 1,150,000 brl. more than in the same period of last year. At the end of June there were 154 oil-wells at Turner Valley, and 17 in other fields. In the first five months Turner Valley gave 23,615,227,000 cu. ft. of

gas. Viking-Kinsella 2,242,036,000 cu. ft., Medicine Hat-Redcliff 1,480,097,000 cu. ft., and Wainwright 55,993,000 cu. ft.

The most important recent feature of development at Turner Valley is the steady northward extension of production. Gas conservation has been enforced.

Early drilling in the Steeveville-Princess area 120 ml. east of Calgary yielded gas in the Madison limestone, and light crude was found at the top of the Madison early in 1941. The well had a high gas/oil ratio and water troubles.

Vermillion, in East Central Alberta, is the largest producing area outside Turner Valley. Several wells give heavy crude. G. D. H.

1036.* Rocky Mountain Area—Improving Markets Permit Large Production Increase.

T. R. Ingram. *Oil Gas J.*, 31.7.41, 40 (12), 114.—No major discoveries were made during the first six months of 1941 in the Rocky Mountain area. A deeper sand, the Sundance, was found to be productive, in addition to the Morrison at Wilson Creek, Colorado. The gas production from Wasatch sands was extended at Powder Wash.

Wyoming had extensions at Wertz, Mahoney, and Rock River.

A small discovery was made in Montana, north-west of Kevin-Sunburst. There was a small show in the sunburst at 1833 ft., and 20 brl./day were pumped from the Ellis-Madison contact at 2062 ft. An important extension seems to have been made to the Rimrock pool on the west side of the Kevin-Sunburst field. This also gave oil from the Ellis-Madison contact, at 2448 ft.

Gas was discovered in the top of the Madison at 3824 ft., in the Twin Rivers district, 10 ml. north-west of Cut Bank.

The Fulcher basin gas-field in North-west New Mexico was extended. Gas comes from the Picture Cliff sand at 1900 ft.

In South-west Wyoming in the first half of 1941 a number of wells were completed in the Bairoil district (Wertz, Lost Soldier, Mahoney, and East Mahoney), which gave 48% of the State's total new production, some of them probably being capable of 10,000 brl./day initially on open flow.

The new discoveries in the Rocky Mountain area are listed for the first half of 1941. The monthly production and status of wells are given by fields for the same period, and the half-yearly production is tabulated for the period 1939-41. G. D. H.

1037.* Permian Basin, Panhandle—Deep Palaeozoic Trend Offers Great Reserve Possibilities.

R. M. Sanford. *Oil Gas J.*, 31.7.41, 40 (12), 117.—In the past six months a deep Lower Palaeozoic trend has been discovered which offers production in the southern part of the Permian Basin.

Eleven new discoveries have been made by wildcatting, the most promising being Ownby, Rhodes, Sand Hills, and O'Neil-Wright.

A deep-seated structural high extends north from northern Pecos County parallel to two established producing trends in the district. Production has been found at five points along it from the Lower Ordovician—Sand Hills, South Sand Hills, Sand Hills south extension, Abell, and Apco. Some details are given of geological conditions on this high.

The Slaughter field has been proved over 50,000 acres.

The new discoveries during the first half of 1941 are listed, the status of the wells completed is given by fields; the monthly production is tabled by fields. The half-yearly production is also tabulated for the period 1939-41. G. D. H.

1038.* Kansas—Extensions and Linking of Pools Overshadow Discoveries.

R. Ingram. *Oil Gas J.*, 31.7.41, 40 (12), 123.—At the end of June the production was 241,000 brl./day. Three wildcats were being drilled along the Barton Arch towards the Nebraska State line, and the Ray pool was giving 1000 brl./day.

The main activity in the first half of 1941 was in or near developed areas. An extension to the Hall-Gurney pool was near new wells in the Greenvale pool to the south-east. West Bemis-Shutts and Burnett, Midway and Keesling, and Kraft and West Kraft were joined. Important extensions took place at Big Creek, Gorham, Trapp, Beaver, Eberhardt, Krier, East Big Creek, and Davidson.

In and around the Zenith pool, a stratigraphic trap associated with the Barton Arch.

and a pool with several pay zones, the Viola, has been most sought for recently. Seward, Shaeffer, Macksville, and Ahnert are new pools found in Stafford County.

The Louth pool in Eastern Kansas, in the Forest City basin, gives oil and gas from the Bartlesville and Burgess sands, and the second break in the Mississippian lime, all wells being about 1450 ft. deep.

In Eastern Kansas the production was raised by water-flood projects in Chautauqua, Neosho, Woodson, Montgomery, Labette, Wilson, Miami, Allen, and Elk Counties. These projects have been getting under way for several years.

At Falls City, Nebraska, in the Forest City basin, oil was found in the Lower Hunton late in June.

The oil and gas discoveries in Kansas and Nebraska during the first half of 1941 are listed. For the same region the monthly production and the status of wells are given by fields for this six-month period, and the half-yearly output by fields is tabulated for the period 1939-41.

G. D. H.

1039.* Appalachian—Many Deep Tests Drilled with but Meagre Success. Anon. *Oil Gas J.*, 31.7.41, 40 (12), 131.—The first half of 1941 had 30% more completions than the same period of 1940. Tests have been made below the usual horizons, and both the Lower Devonian and Silurian have been found productive in several sections.

In Beaver County, South-west Pennsylvania, a deep test had a showing of gas in the Oriskany at 5437 ft. Another found many gas-pockets in the shale just above the Marcellus. On the Chestnut Ridge gas-wells have been completed in the Oriskany sand, and Onondaga chert. On the next large anticline to the east a showing of gas has been found in the Onondaga chert. The Bradford sand has given gas at 3507 ft. on the Fayette anticline in Franklin township.

Fair oil producers, mainly in the Clinton, were drilled in Perry, Muskingum, and Licking Counties of South-east Ohio. In Wayne township, Columbiana County, gas was found in the Oriskany at 4426 ft.

Many successful wells were drilled in the Elk-Poca Oriskany gas-field. A well deepened to the Clinton in the Elk district gave gas. A gas-well in the Poca district is now giving 5 bbl. of oil/day from the Oriskany at 4975 ft. The Big lime has also given a little oil.

In Braxton and Clay Counties gas has been found in the Gordon stray and Injun sands, respectively. A number of tests in Jackson County have given gas from the Oriskany. The Gordon sand has provided several large gas-wells in the Proctor district of Wetzel County.

G. D. H.

1040.* Drilling in Ontario, Canada. Anon. *Oil Gas J.*, 31.7.41, 40 (12), 133.—The activity this year has been restricted largely to efforts to develop additional gas reserves. In areas adjacent to the Brownsville field drilling failed to develop production. Five wells with an aggregate production of 452,000 cu. ft./day were drilled in Windham Township, Norfolk County, indicating possibilities of a fairly substantial field producing from the Clinton formation. Twenty small shallow producers with an aggregate open flow of 1,053,000 cu. ft./day were drilled in the Haldimand-Norfolk-Brant areas. Individual outputs ranged from 10,000 cu. ft. to 195,000 cu. ft./day.

G. D. H.

1041.* Upper Pennsylvanian and New York Fields. Anon. *Oil Gas J.*, 31.7.41, 40 (12), 133.—The first half of 1941 saw the start of the decline in the prolific production of the Music Mountain pool, south of the main Bradford pool. In the northern Oriskany sand fields, which straddle the New York-Pennsylvanian line, the chief activity was a search for "pimples" passed over when the larger pools were brought in.

A well with an initial open flow of 16,200,000 cu. ft. of gas was brought in in Cameron township, Steuben County. One small gas-well was brought in in the old Medina field of Chautauqua and Wyoming Counties. In the very north-west of Pennsylvania a show of light oil was found near the top of the Trenton at 4437 ft., and there was a show of oil, gas, and salt water in a sand believed to be the St. Peter at 5181 ft.

G. D. H.

1042.* Indiana, Ohio—Gas Demand, Wabash River Play Increase Drilling. Anon. *Oil Gas J.*, 31.7.41, 40 (12), 134.—193 oil-wells, 334 gas-wells, and 230 dry holes were drilled in Ohio during the first six months of 1941. Wildcatting has not been very successful, and has been mainly in the untested eastern part of the State. A test in the old Wooster pool had small oil-showings in the Trenton and St. Peter, but they did not respond to shooting and acid treatment. The Clinton was tested below the 5000-ft. level in Belmont, Harrison, Carrol, Mahoning, Tuscarawas, and Guernsey Counties. Only the Harrison County test in Washington township found a gas-pay which warrants further testing in the vicinity. Wells in the Clinton sand of the Clayton pool ranged up to 275 brl. initially. The Newark field was the most active gas-field. Completions in the Brush Creek pool of Muskingum and Morgan Counties had open-flow volumes ranging up to 10,000,000 cu. ft./day in the Clinton sand.

Indiana had no major discovery in the first six months of 1941. Continued development of the numerous sands in the Griffin field maintained the level of the State's output. Wildcatting gave two new gas-pools, one in the Devonian in Greene County, the other in the Cypress sand of Daviess County. Oil was found in the Cypress sand in the Columbia pool; the Palestine sand in Gibson County; the Salem of the Sheldbourne pool; the Aux Vases sand in Posey County; the McClosky sand in Gibson County; the Cypress sand of the West Bufkin pool; the Travis in Elkhart County; the Pennsylvanian of the Vernon pool; the Devonian of the Elkhart pool; and the Cypress of the South Bufkin pool.

The status of completions in Ohio and Indiana is listed by fields.

G. D. H.

1043.* Michigan—Winterfield, Reed City and Gas Play Revive Interest. O. C. Pressprich. *Oil Gas J.*, 31.7.41, 40 (12), 137.—The decline in oil production in Michigan continued during the first half of 1941. The Mount Pleasant district showed the least decline, whilst the greatest decline was in the south-west, where the Traverse is the main pay. Dundee-Monroe production has been developed in the Winterfield and Reed City fields, the latter looking like a major pool. The Walker pool was extended. Shallow development continued in Van Buren County, and the production rose from 73,060 to 92,432 brl. between January and June. In the same period Reed City production rose from 470 to 73,998 brl., and Winterfield from 1187 to 76,717 brl.

Two gas-fields were discovered in Isabella County, one being in the Michigan stray sand. Oil was discovered in the Traverse lime in Allegan, Ottawa, Kent, and Van Buren Counties, and the Beran in Bay County.

A deep test in Bay County is below 9000 ft., and has given considerable gas and distillate when blowing wild, and has not yet reached the Trenton.

G. D. H.

1044.* Search for Wilcox Production Spreads in North Louisiana. G. Weber. *Oil Gas J.*, 7.8.41, 40 (13), 12.—Seven separate oil-producing areas have been opened in La Salle parish, and an eighth, in northern Avoyelles parish, is believed capable of commercial production. Two gas-pools have also been found. Most of these areas are in the initial stage of development.

Some years ago the area was explored for oil in the top of the Wilcox, and Tullos, Urania, Georgetown, and White Sulphur Springs were the fields discovered. In 1940 the Olla field demonstrated the deeper possibilities at a depth of 450 ft. from the top of the Wilcox. At Little Creek oil is found 1750 ft. below the top of the Wilcox.

In this area the Wilcox has a regional dip to the south-east. Productive sands are generally thin and lenticular, and correlation between fields is not attempted. At Olla nine sands are productive at 450–1260 ft. below the top of the Wilcox. Little Creek has at least two distinct sands. Nebo has ten sands. The sands pinch out up-dip, and are not continuous even within the fields where they are developed. The sands are erratic, rendering wildcatting hazardous, although the wells, being shallow, are not costly. Production shows no direct relationship with local highs on the top of the Wilcox.

The nature of the sands makes completion difficult. The detection of oil horizons is not easy, and in addition to electrical logging, gas detectors, coring, and cutting examination are used. Wells at Olla and Nebo make 25–30% of water. The pressures are low, and about half the wells require artificial lift.

A map is given, and a table of the recent Wilcox discoveries (name, date, depth to Wilcox, and to producing horizon, daily average production and gravity of the oil), and one of the dry wildcats drilled to the Wilcox in North Louisiana in 1940 and the first half of 1941. G. D. H.

1045.* Cuba. Anon. *Oil Gas J.*, 7.8.41, **40** (13), 22.—A new completion in the Motembo field has given 684 brl. of naphtha in a day, and the field now yields more than 1,000,000 gal. of naphtha/month. Distillate production at Motembo has risen steadily in the past few years, and is now about 455 brl./day. Last year the gasoline output was 135,715 brl. G. D. H.

1046.* Well Logs and Field Data of Active Oil Areas—South-east Wyoming. Anon. *Oil Gas J.*, 21.8.41, **40** (15), 48B.—The south-east quarter of Wyoming has given about 500,000,000 brl. of oil, more than three-quarters of Wyoming's production. Of this, 300,000,000 brl. have been obtained from Salt Creek. Early Wyoming production was discovered via seepages, but later development was based on surface structures, many of which stand out strongly. Salt Creek has ten pays from the Upper Cretaceous down to the Mississippian. Lance Creek is the second largest field, and has a series of producing horizons from the Frontier (Upper Cretaceous) down to the Minnelusa (Permian). Big Muddy produces from the Shannon, Wall Creek, and Dakota sands (Cretaceous).

In 1930 deep drilling and geophysical prospecting were begun.

Much territory with good possibilities and favourable structures remains to be prospected, and deeper drilling may reveal deeper production in known fields. Formerly a deterrent to deep drilling was the fact that in the west part of the State the Embar and Tensleep gave black oil. The deeper horizons of the Permian and Pennsylvanian are of two facies, pointing to an intervening high, with the possibility of stratigraphical traps as well as ordinary structures. G. D. H.

1047.* Two Geophysical Units Active in Brazil Coastal Areas. Anon. *Oil Wkly.*, 21.7.41, **102** (7), 44.—Considerable attention is being paid to the coastal areas of Bahia and Alagoas, where there is a 20-mile-wide north-easterly trending belt of sediments. Oil has been found in beds of Triassic to Cretaceous age. In some places the sediments may be 5000 ft. thick.

There are two producers at Lobato. Two dry wells have been drilled at Camamu to 2600 and 1170 ft. A third is drilling below 1800 ft., and near Aracaju (Sergipe) a well is under way below 2600 ft.

The region of Acre, near the Peruvian border, has yet to be studied, and the same is the case with the Parana basin, which is reported to be traversed by several geoanticlines, and has sediments resembling those productive in Bolivia and Northern Argentina. Poor transport and extensive igneous flows have hitherto discouraged development. G. D. H.

1048.* Slaughter—West Texas Area Fast Approaching Record in Acreage and Activity. G. M. Wilson. *Oil Wkly.*, 4.8.41, **102** (9), 35.—Between 400 and 500 wells have been completed at Slaughter, which has 1000–1500 proved locations yet to be drilled. It probably covers at least 55,000 acres. The discovery well, completed in 1936, has given 84,000 brl. of oil with very little fall in bottom-hole pressure. The main producing area runs east-west for about 14 ml., and the maximum breadth is 9 ml.

The discovery is due to sub-surface geology and seismography. Oil accumulation is governed more by stratigraphic than by structural conditions. The structure appears to be generally monoclinal, dipping at 25 ft./ml. from north to south, but there may be a nose at the eastern end. A few local highs may be present. Variations in porosity and permeability seem to govern accumulation.

Pleistocene, Cretaceous, and Triassic sands, shales, and caliche are the first 2000 ft. of beds penetrated. In the Permian are the Red Bed sands, shales, and salt, and the Big Lime limestones which are oil-bearing in a porous zone about 800 ft. below the top. The oil zone is 70–100 ft. thick, and composed of sugary dolomite. Porosity ranges

from 5 to 16%, with an average of about 12-14%, and varies from well to well. The permeability is very low, and each well has to be acidized into production.

The oil is of 32° A.P.I. gravity and very corrosive. Its 34% of straight-run gasoline is very favourable for tetraethyl lead treatment.

Some evidence seems to indicate that the field is under a combined water- and gas-drive. Present development does not indicate a well-defined gas-cap in any part of the field. The bottom-water surface appears to have a south-easterly dip.

Most operators have used a 35-4-acre spacing. Drilling, casing and completion technique and equipment are described.

Gas/oil ratios range from 100 to 1500-2000 cu. ft./brl., with the average about 800. Most wells flow, but there are 23 pumpers, mainly on the edges. Recovery estimates of 4000-9000 brl./acre have been made.

Some believe that there may be further producing zones in the Lower Permian, and perhaps as deep as the Ellenburger.

G. D. H.

1049.* Cuba's Motembo Field Production Increases. Anon. *Oil Wkly*, 4.8.41, 102 (9), 68.—The Motembo field may give more than 7,000,000 gal. of oil this year, as compared with 5,700,000 gal. last year. About 200 wells are productive.

G. D. H.

1050.* New Sand Indicated for El Roble; Drilling Progress. Anon. *Oil Wkly*, 4.8.41, 102 (9), 68.—A well at Roble has found an oil flow at 8500 ft., indicating a new sand. Hamaca 1, in Southern Anzoategui, was abandoned at 3472 ft. Mercedes 1, in Guarico, has been suspended, and a second well is to be drilled about 0.5 ml. to the south.

G. D. H.

1051.* Palaeozoic Possibilities of Northern Mississippi and Alabama. F. F. Mellen. *Oil Wkly*, 11.8.41, 102 (10), 28.—North-east Mississippi and North Alabama cannot produce oil from the Mesozoic and Tertiary, which yield fresh water, but the underlying Palaeozoic has yielded more oil-shows than any other non-productive region in U.S.A. Gas only has been produced in two small fields, Fayette and Amory. In 1890 a small show was found at Goyer (Alabama) at 1509 ft. in the Ordovician.

In the east is the Sequatchie anticline, with the Knox dolomite series of Ozarkian age, and nowhere in this region has this series been drilled through to the Cambrian. Overlying are 500-800 ft. of Ordovician limestones (Stones River and Black River series). These limestones are productive in Tennessee and Kentucky, and give good shows in the present region. The Trenton series consists of silty shales and limestones, and smells of oil, but is of low permeability. The Silurian is represented over most of the area by about 100 ft. of limestones and shales. This is followed by the Chattanooga black shale, which is petroliferous. Next comes the Maury green shale. The Mississippian is 1000-1500 ft. thick, the lower part being dominantly limestone, and the upper containing limestones, sandstones, and shales with considerable lateral variation. The former part has many evidences of oil, and the latter has possible stratigraphic traps. The Pennsylvanian is represented in Alabama by the Pottsville only, and is formed chiefly of non-marine sandstones, shales, and coals. One of the sandstones gives gas at Amory. Some of the sands are very hard and impermeable.

Upper Cretaceous beds rest unconformably on the Palaeozoic, overlapping on to early Ordovician beds in the north and on to progressively younger beds to the south. The asphalt deposits of this region are related to the old pre-Tuscaloosa land-surface—they are all within a few hundred feet of the base of the Tuscaloosa—show up-dip migration of the parent oil, and often indicate areas where lower horizons may merit exploration.

The area is bounded by the Sequatchie anticline on the east and the Nashville Arch to the north. The South-easterly dip increases to the South-east. The Warrior coal-basin is one of the main structural features. At the surface a number of structures of small closure have been mapped. Most of the domal or anticlinal structures of North Alabama and North-east Mississippi are faulted. Where the Palaeozoic does not outcrop it is uncertain whether the Cretaceous and Eocene structures reflect deep-seated Palaeozoic structures.

The St. Peter is the logical objective in the north of the Warrior basin and to the north. The Ordovician limestones seem to have possibilities, and the same is true of Mississippian horizons. Many shallow tests in the Warrior basin have had oil- and gas-showings in the Pennsylvanian.

Fifty-six Palæozoic tests have been drilled in Mississippi and 200 in North Alabama. Most have had oil- and gas-shows, and a few could have produced a little oil. Some wells found large quantities of water, pointing to good permeability.

Tables give the Palæozoic tests in North Mississippi, and the analyses of St. Peter water and of natural gas. Maps and a cross-section are included. G. D. H.

1052.* Kansas Development Surges to Record Levels. F. B. Taylor. *Oil Wkly*, 25.8.41, 102 (12), 31.—Since the beginning of the year new all-time production peaks have been set up six times, and nineteen fields have been discovered. The daily average in July was 241,950 bbl. Drilling activity and average daily allowables have increased. Unlike many oil-producing provinces, there is relatively little chance of finding production at greater depths in case the normal section is barren. The Arbuckle is the chief producing horizon and also the deepest stratum which is normally productive. In a few cases the subjacent Basal sand, Reagan or Granite wash yields oil, but generally the Arbuckle rests on the basement complex. Usually the Arbuckle is at 5000 ft. or less.

In the main the major production of Kansas comes from the Arbuckle (101 fields), Kansas City-Lansing lime (70 fields), Mississippi chat (17 fields), Topeka sandy lime (15 fields) and Viola lime (12 fields). Oil is also obtained from the Bartlesville, Basal sand, Hunton, Misener, Mississippi lime, Gorham, Wilcox, Simpson, Oswald, Reagan, Conglomerate, Burgess, Pre-Cambrian, Stalnaker, Tarkio, Admire, Dodge, and Granite wash.

The Arbuckle oil has little gas, and so requires pumping, but flowing conditions obtain in the Kansas City-Lansing, Mississippi chat, and Viola lime.

Exploration is extending out into the Dodge City basin. Half a dozen fields are producing, and fair shows have been frequent in wildcats. Dead oil has been found in the Salina basin, but no production commercially. Shallow gas has been found in North-west Kansas.

Repressuring and water-flooding are being applied in South-west Kansas, where some new shallow fields have been discovered.

Data about the new fields are tabulated and the history of Western Kansas development is tabled by fields. The footage drilled is listed by years, and diagrams show the results of drilling, the reserves, and daily average production from year to year.

G. D. H.

1053.* Radioactivity and Petroleum. E. N. Tiratsoo. *Petroleum*, 1941, 4 (3), 58.—Helium, one of the end-products of radioactive change, is found in certain natural gases, and is associated with petroleum. Although some of this may be derived from the original cosmic atmosphere, the majority is presumed to be formed as a result of the radioactive decay of minerals in the earth's crust.

Considering an igneous source of radiation in juxtaposition to a Palæozoic crude, it is calculated that the energy released by 1 gm. rock since Devonian times is equivalent to 77 million calories. The effect of such an enormous quantity of energy on the associated oil needs investigation.

The action of α -particles on a pure member of the C_nH_{2n-2} series is to eliminate H_2 or lower saturated hydrocarbons, thus building up higher members by addition or condensation.

With the lower saturated hydrocarbons there are two ways in which these can be converted to liquids:

1. by repeated doubling by successive ionization;
2. by direct condensation of a sufficiently large number of "nascent unsaturates."

Similar results have been obtained by the action of ultra-violet light on aliphatic hydrocarbons.

Hence there is a method by which the higher hydrocarbons can be built up from the lower ones, whereas the thermal processes usually invoked cause only degradation. However, the chief obstacle to any radioactive theory of the origin of petroleum lies in the question of the disposal of the hydrogen formed by the action of α -particles on water as well as on hydrocarbons. It has been shown that the Gulf-Coast crudes tend to become more paraffinic as they grow older, and it has been suggested that this may be a "hydrogenation" process. On the other hand, a theory has been put forward that the hydrogen unites directly with carbon from plant and animal organisms to form hydrocarbons.

Thus the origin of petroleum is postulated as follows. Any organic substance containing, C, H, and N atoms breaks up by α -radiation to simple hydrocarbons and nitrogen. The hydrocarbons by further α -ray action are converted into a succession of higher members with the liberation of CH_4 and H_2 —the latter gas eventually hydrogenating the oil. For the source of radiation it is only necessary to look to the sediments themselves, there being striking evidence that layers immediately underlying an oil-bed are extraordinarily rich in radioactive material.

The effect of α -rays on solid hydrocarbons has also been studied, and it was found that the melting point of the solid is raised and H_2 is liberated. X-ray analyses show that the crystals of saturated hydrocarbon are dispersed, melted, and then condensed as complex colloids by the action of the α -rays.

One other type of material must be considered: the asphaltic and carbonaceous. The widespread occurrence of uranium in these lends colour to a theory which explains them as the altered end-product of a series evolved by radiation from a simple ancestor.

D. L. S.

1054.* Recent Discoveries in Alberta Suggest Wide Extension of Fields. J. S. Irwin. *World Petrol.*, May 1941, 12 (5), 32.—A reflection survey and seven deep wells have indicated a north-west-south-east uplift in the Steeveville district, and a major gas reserve has been proved in the basal Colorado (Cretaceous) at 2750–2950 ft. Gas and oil under high pressure have been found at the unconformable contact between the Madison and Lower Cretaceous at 3250–3330 ft., but a blow-out followed by salt-water incursion discouraged further testing for oil. Two wells have demonstrated oil and gas in quantity in Devonian limestone at 3970–4215 ft. and in the Madison at 3220–3290 ft.

There are considerable areas in Western Canada where the oil- and gas-bearing Cretaceous, Mississippian, and Devonian horizons lie at 2750–4200 ft.

At present there is no market for the gas. The gas from the Cretaceous has 150 gal. of naphtha per million cubic feet.

G. D. H.

1055.* Leasing Campaign Sweeps the Dakotas. Anon. *World Petrol.*, May 1941, 12 (5), 42.—4,000,000–7,000,000 acres have been leased in North and South Dakota, and recently activity has centred on the Lemmon geosyncline of the middle third of the two States.

In 1940 two stratigraphical tests were drilled, a third is under way, and a deep test has been planned.

There are many overlaps between the Upper Cretaceous and the Mississippian. The Big Snowy group of the Upper Mississippian on the western limb of the Williston basin of western North Dakota and Eastern Montana is considered to have commercial possibilities, for it is productive in two deep tests on the Baker-Glendive anticline. The Minnelusa, which has oil-showings in South Dakota, is another objective in the Williston basin, and the Sundance-Ellis may be sought where it wedges out on the north-east limb of the basin in North Dakota and Manitoba. The Devonian had 90 ft. of oil saturation in a deep test on the Baker-Glendive anticline. The Permian Minnekahta limestone may have oil possibilities deep in the basin.

In Saskatchewan three areas are under consideration—Lone Rock, 20 ml. south-west of Lloydminster, Muddy Lake, 7 ml. south of the Unity-Vera field, and north-east of the Battleview-Vermillion field.

G. D. H.

1056. Mesa Oil-field. S. G. Dolman. *California Oil-fields: Summary of Operations*, 1938, Vol. 24, No. 2.—The area designated Mesa Oil-field comprises 800 acres within

the city limits of Santa Barbara, California, although the proved area does not as yet exceed 115 acres. Only the eastern half of the field is at present productive, the western half having been drilled and abandoned. The first successful well to be drilled was completed in May 1929, in the Palisades tract, but the area as a whole was not a commercial success, only 20,909 bbl. of oil being produced before it was completely abandoned in June 1930.

In September 1930 the Vista del Oceano tract was discovered, and it is recorded that in March 1940 four wells were still producing in the area. In March 1934 Fair Acres, the most important tract of the Mesa field, was discovered. The first well (Cole No. 1) started flowing at approximately 1500 bbl. per day, but after flowing uncontrolled for two weeks the head of gas was dissipated and the well placed on the pump, making only 150 bbl. per day. Of a total of sixty-five wells drilled, most of them behaved similarly to Cole No. 1, and all but eighteen have now been abandoned.

Summarily, 107 wells have been completed in the three areas of Mesa field. The average depth is 2000 ft. The total production for all areas to 1st January, 1940, was 4,303,591 bbl., and the average production of oil per well per day at the same date, for the whole field, 10.4 bbl. Of the oil produced, approximately 70% has been used for fuel oil and 30% for road oil and asphalt.

H. B. M.

1057. Capitan Oil-field. S. G. Dolman. *California Oil-fields: Summary of Operations*, 1938, Vol. 24, No. 2.—The Capitan oil-field is located on an old Spanish grant land known as Canada del Corral Rancho, and comprises a proved area of some 200 acres on the sea-coast about 20 miles west of Santa Barbara. It lies partly in terraced, cultivated land and partly in the foothill pasture-land.

The report states that seventeen wells have been completed in the Vaqueros and seventeen in the Sespe zones by Shell Oil Co.; General Petroleum Corporation of California has completed thirteen wells in the Vaqueros and eight in the Sespe zones. Production charts give total monthly production of oil, gas, and water from Vaqueros and Sespe zones, respectively. Peak production was reached in the Sespe area between August 1935 and January, 1936, when wells "Erburu" 11, "Covarrubias 1" 3, and "Covarrubias 1" 4 were in flush production.

On the whole, however, production from this zone has been erratic, and differences in performances of wells in the same area hard to explain.

Until 1938 water from both zones showed no appreciable increase. Since that date Sespe water has increased, while oil production has declined. In the case of Vaqueros zone, however, increase of water has accompanied a marked decrease in oil production. This condition probably indicates coning of bottom water due to excessive oil production, and steps have already been taken to remedy it.

H. B. M.

1058. Santa Maria Valley Oil-field. R. G. Frame. *California Oil-fields: Summary of Operations*, 1938, Vol. 24, No. 2.—The Santa Maria Valley oil-field lies $1\frac{1}{2}$ miles south of the city of Santa Maria, Santa Barbara County, California. On 1st January, 1939, the proved area of the field was 4760 acres, the greater part of which is controlled by the Union Oil Co. of California, which also owns the only pipe-line through which oil is pumped to the port of Avila, 35 miles north-west of the field. General structure in the field is truncated and overlapped strata dipping in a southerly direction. These may be considered to form either the south flank of a large anticline known as the axis of the San Rafael uplift, or as the north slope of a syncline more than two miles deep, in the central portion between Santa Maria and Orcutt.

Oil prospecting in the area immediately surrounding the Santa Maria Valley field was in the past active, as is evidenced by some fifteen wells drilled without discovery of oil in commercial quantities. Also some twenty-five core-holes were drilled to obtain geological information, but no indications of favourable structure were found, probably owing to the angular unconformity between the Miocene strata and overlying Pliocene formations.

It was not until 1934, when wells No. "Moretti" 1 and No. "Enos" 1 were completed and brought into production, that evidence was gained of favourable structure in the area. Now productive limits on the north and east of the field have been fairly well defined, to the north by the drilling of several dry holes and demarcation

of the site where Monterey beds pinch out between the Sisquoc and the Franciscan formations. South and west limits are as yet undetermined.

Unfavourable marketing conditions have always curtailed production from Santa Maria Valley. The only means of transport available are the 8-inch pipe-line to Avila, or truck to a loading terminal near Casmalia, 16 miles away.

On 1st January, 1939, potential daily yield from the field was 112,360 bbl., but the actual maximum daily yield for one month was only 11,658 bbl. in September 1938. Up to 1st January, 1939, a total of 5,039,932 bbl. of oil had been produced, and estimates of ultimate production range from 112 million to 500 million bbl.

H. B. M.

Geophysics and Geochemistry.

1059.* Future of Geophysics. W. T. Born. *Bull. Amer. Assoc. Petrol. Geol.*, July 1941, 25, 1256-1263.—The above subject formed the address given by the author, as president of the Society of Exploration Geophysicists, to a joint meeting of petroleum geologists, palaeontologists, and mineralogists and exploration geophysicists at Houston in April 1941. He states that the petroleum industry may take pride in the fact that it is to-day in a position of being able to supply easily whatever demands are made upon it by reason of the present national defence programme, mainly owing to the successful activities of geologists and geophysicists and others concerned with exploratory activities of the petroleum industry in the past. These past successes enable the future to be met with a difficult but orderly exploration programme, rather than by a frenzied, inefficient scramble for immediately needed oil. The author emphasizes the necessity for the geologist and the geophysicist to learn to complement each other's efforts, and considers the best teams of the future will be an "optimistic" geologist and a "pessimistic" geophysicist—pessimistic in the sense that he will scrutinize his results with care, and refuse to allow himself or others to regard them as better than they are. In view of present-day successful studies it is considered that the re-survey of old areas for minor structures will be continued. The author is of opinion that areas already seismographed will again be surveyed, but at greater depths than previously, and considers that fruitful knowledge would be obtainable from a survey over a number of known stratigraphic traps, in the hope that the opportunity of comparing the results obtained with known conditions might enable similar conditions in the same areas to be recognized. He stresses the value of accurate mapping on two or more closely adjacent beds too close together to be resolved with present technique.

Various methods of employment are discussed, but it is not thought probable that a new prospecting method is likely to spring suddenly into being. Most of the development and experimental work in the field of geophysical prospecting during the past fifteen years has been aimed towards improving instrumentation and field technique, which have reached a high state of perfection, although understanding of many of the phenomena encountered is still lamentably imperfect and more time and money should be spent on research work on fundamental problems. The recent introduction of radioactivity logs of boreholes and the sonic method to locate fluid levels in production are an application of the technique used in seismic surveying and, whilst the aid given by the geologist is already extensive, that of the geophysicist will increase in importance and become applicable outside the field of exploratory work.

R. J. W.

1060.* Geodynamic Prospecting for Oil or Gas. S. J. Pirson. *Petrol. Engr.*, Midyear 1941, 12 (10), 34.—Geodynamic prospecting purports to measure the rate of gas leakage from subterranean oil accumulations and from source-beds still in the process of forming oil and gas. In a dry or partly water-saturated horizon permeation, diffusion and effusion of gas take place. According to theory and a number of field measurements, the maximum rate of leakage occurs above the accumulation, not as a ring around it, except in special circumstances. The soil-analysis haloes observed seem due to changes in the adsorptive properties of soil by vertical migration of oil-field waters. It is estimated that to discover a field by geodynamic prospecting requires only one-fifth of the stations demanded by soil analysis.

In geodynamic prospecting a first profile should be run at right angles to the expected geological trend, with stations not more than 500-1000 ft. apart. If anomalous high leakages are observed, short profiles are run on each side at a distance of about 1500 ft. This process is continued until no more anomalous values are obtained. Holes $1\frac{1}{2}$ -2 in. in diameter and 2-3 ft. deep are used, but they should be at least 50 ft. from places open to contamination, and not in ground saturated with water. At each station may be two or more holes into which piezometers are placed, and these measure the partial-pressure rise of a given gas over a known period (normally 24 hr., but for low leakage up to 10 days may be necessary). The piezometers are then sealed and sent to the laboratory for final checking and measurement.

The results are expressed as the rate of flow of gas through unit area in unit time. The highest readings observed so far are of the order of 30 cu. mm. of C_2H_6 /sq. ft./day. These were obtained in Devonian oil- and gas-fields in Pennsylvania, and if the rate had been constant since Devonian times two trillion cu. ft. of gas/sq. ml. would have escaped, and would have depleted the fields unless there had been replenishment. According to this view, an oil-and-gas accumulation would be due to the presence of a barrier, the cap-rock, in the path of oil and gas leaking from the source-bed.

Geodynamic prospecting is a direct method for finding oil- and gas-pools under pressure. Depth determinations and separation of individual horizons are also possible within reasonable limits.

G. D. H.

1061.* New Cycle of Petroleum Exploration. J. L. Adler. *World Petrol.*, June 1941, 12 (6), 64.—The first quarter of 1941 has produced evidence of the existence of a new cycle of petroleum exploration, and this may have received its initial impulse from the realization that the flush production in Illinois and Indiana—the only discovery of major importance east of the Rockies in the past 10 years—would be short-lived. It was also apparent that there is an advantage in having ample production in regions near the retail market. Restriction of foreign development has released funds, personnel, and to some extent materials for home exploration, and the demand for American oil has also risen. Efforts have been made to discover reserves before restrictions and increased costs make exploratory work difficult.

Surface geology is being used in areas where the more exact differentiation of outcrops permits the delineation of less prominent structural features than could be found by less detailed work. Core-drilling is of value where the oil-bearing series is covered unconformably by a relatively thin veneer. This type of drilling is becoming deeper, and, in addition to cores, provides data by means of electrical logs and chemical logs, and is useful on complex structures.

Magnetic methods have been of value in North Louisiana and Mississippi, but disappointing on the whole in Alabama, Georgia, and Florida, where, it must be admitted, lack of a considerable amount of sub-surface information renders interpretation of magnetic data difficult.

No generally recognized results of importance have been obtained with electrical transients. A revival of gravitational prospecting is due to the development of gravimeters which are capable of rapid operation, and so provide data at a very low cost. Very weak anomalies have been found in some cases to be significant.

Geochemical well-logging is of value in preventing the abandonment of a well just short of a possible producing horizon, or of an area because of a dry hole just outside the limits of future production.

Soil analysis is still considered too expensive for blanket surveys, but it is useful in determining the relative merits of prospects discovered by other means.

The analysis of plants for traces of elements has been suggested as a clue to the presence beneath the soil of formations which contain the same elements.

G. D. H.

1062.* Effectiveness of Exploration Methods. W. R. Ransome. *World Petrol.*, June 1941, 12 (6), 68.—The seismograph has discovered the majority of the geophysically located fields, and 200 seismograph crews are now at work in U.S.A., not many fewer than at the peak in 1937. Lahee has estimated that one out of every five wildcats drilled in 1940 on geophysical indications was a producer, whereas only

one in twenty-four was successful when located without the aid of geology and geophysics.

The ratio of dry holes to producers in geophysical prospecting seems to have become stable, but the size and value of the fields are decreasing. Thus, whilst technically more efficient, geophysics is declining in economic effectiveness.

In an effort to discover low-relief structures, various improvements in technique have been made, and it has been found that lateral changes in velocity can be of such a size as to mask small and even large structures if suitable allowances are not made.

Geochemistry makes the discovery of stratigraphic traps easier.

G. D. H.

1063.* Direct Evidence Required to Discover Stratigraphic Traps. J. W. Merritt. *World Petrol.*, June 1941, 12 (6), 70.—The historical sequence of oil-finding methods is described, from seepages, search for folds, core-drilling, to geophysical methods. Stratigraphical traps are more difficult to find, for although the traps may be localized to some extent by geological studies, the drill must be used to find the location of the actual site of the deposit.

Within the past few years search has been made for traces of hydrocarbons escaping through the imperfectly sealing cover rocks, and characteristic patterns of hydrocarbon values have been found over producing areas. The high values generally occur over the margin of the deposit, irrespective of whether the trapping is structural or stratigraphic.

Geochemical well-logging has also been developed, and indications of the presence of an oil-horizon may be noted when it is yet 500–1000 ft. below, or some distance away laterally.

In geochemical surveying samples are taken over the area concerned and analysed for hydrocarbons. The results are plotted on a map and then interpreted.

G. D. H.

1064.* Water Prospecting with the Gravity-Meter. E. V. McCollum. *World Petrol.*, June 1941, 12 (6), 74.—The gravity-meter is admirably suited to work in swamps, bays, shallow or deep lakes, where reconnaissance data are required, since good coverage at relatively low cost is possible. Transport by boat is easy, and readings are obtained by setting the instrument on improvised piers, constructed on the spot, tree-stumps, etc. At times a boat with a central well, through which tripod legs can be lowered, is used, and in water of 20–25 ft. depth considerable areas have been worked using portable towers or piers.

The latest method is to place the instrument in a submersible chamber, and readings are taken electrically on a panel in the boat.

Twenty-five stations or more per day may be covered at times.

G. D. H.

1065. Galitzin-Type Gravity Meter. G. I. Welch. *Rev. sci. Instrum.*, 1941, 12 (4), 179.—The factors governing the design of a gravity meter are discussed and the construction and characteristics of the gravity meter developed by the author are given. This instrument when used in the field gives results which are accurate to 0.06 milligal.

J. W. H.

Drilling.

1066.* Derrick-Carrying Portable Rigs Speed Drilling in California. T. P. Sanders. *Oil Gas J.*, 24.7.41, 40 (11), 38.—Two recent portable rigs are compared from the viewpoint of design rather than that of performance. One is a Shell rig and the other is a General Petroleum rig. The chief difference between the two rigs is in the derricks. The Shell derrick is a standard-type 87-ft. steel structure mounted on an 18 × 18 ft. base, which is made of steel I-beams and covered with wood flooring. Beneath the floor at each corner track-laying wheels are bolted to the frame. The derrick in upright position, with the hoist, engine, and the engine-house, is moved as a unit, being drawn by a tractor. The General Petroleum rig, on the other hand, has a 90-ft. telescoping derrick which folds over the engine and draw-works so that the

rubber-tyred unit can be pulled by a truck. While the Shell rig maintains the standard derrick to which all drillers have become accustomed, it offers certain limitations in regard to moving. Its width does not allow highway transportation, and its height makes it necessary to consider power-lines and other overhead obstacles.

Most of the wells drilled to date with the new Shell rig have been about 1900 ft. deep, but the rig is designed for all work up to 4000 ft. 4-in. drill-pipe is used, and the Mount Poso wells are completed with 8½-in. combination strings of casing, as it is considered likely that large-volume electrical pumping equipment may be installed when water production becomes heavy.

Since the General Petroleum rig will handle 16,000 ft. of small-sized tubing, it is to be used for servicing the 11,500 ft. Rio Bravo wells when work of this kind becomes necessary. Its ability to move rapidly and without restrictions on the highway favours its use for such service. However, as long as the deep San Joaquin Valley wells continue to flow the rig will be used exclusively for the drilling of shallow wells.

Both the new drilling rigs were designed primarily to reduce moving expense. Success in this respect can be judged by the fact that either rig can be moved to a new location and set up ready for drilling in as little as 5 hours after the drill-pipe has been laid down.

A. H. N.

1067.* Mechanical Rotaries Used for Drilling New Oklahoma Field. H. F. Simons. *Oil Gas J.*, 24.7.41, **40** (11), 44.—The practices of the new field at Guthrie are described. The rigs used, whilst not identical, all fall within one of three classes. The most commonly found rig at Guthrie is the two-engine compounded type with the engines setting one behind the other between the draw-works and pump. The engines can be run separately, with the front one driving the hoist and the rear one the pump; at Guthrie the engines are generally run compounded while drilling to obtain enough speed on the pump and rotary table. Engines on all these rigs use butane for fuel. Typical rigs as used by different companies are briefly described.

Contractors are furnishing the derricks. The companies have insisted, however, that a high substructure be used, so that the connections need not be placed in a cellar, but will be only a little below ground level. The substructures are set on 26 × 26 ft. concrete bases with heavy corners. The derricks are moved off immediately after completing the well.

All the rigs use 4½-in. internal upset drill-pipe for making the hole down to the point where the pay-string of 7-in. casing is run. For completion a string of 3½-in. internal upset drill-pipe is used. Some contractors carry a few joints of 6½-in. drill-pipe for making the approximately 300 ft. of 12¼-in. surface hole in which is run the 10¼-in. pipe. Size of hole drilled below the surface pipe is either 8½ or 9-in. to total depth (5450 ft.). The 7-in. run in the hole varies from 22 lb./ft. to 28 lb./ft., depending on the operator. Some of the strings have been composed of 45-ft. joints, whilst others have used the shorter 30-ft. pipe. The pipe in the pay-string may be either seamless or welded. The same is true of the surface strings, where either seamless or welded pipe may be used.

A. H. N.

1068.* Washover in Small Hole Shown Possible by Kansas Well. H. F. Simons. *Oil Gas J.*, 31.7.41, **40** (12), 146-147.—One of the problems accompanying the introduction of slim-hole drilling in Kansas has been the recovery of tools lost in the hole, an occurrence which is certain regardless of the care taken to keep the equipment in the best possible condition. Where small holes are being drilled, the clearance between the tool-joints and the hole is not great, and difficulty may be experienced in getting an overshot or washover string down over the fish. A recent fishing job in Kansas has shown that it is possible to recover 3½-in. drill-pipe from a 6¼-in. hole. The fishing job was occasioned by the sticking of an open-end string of pipe due to the hole sloughing while a cement job was being attempted to regain circulation. The washover job is detailed.

Total time consumed in fishing was 12 days, but 4 days were spent in getting over the fish, due to the fact that the original back off took place opposite a cave. The hole would probably have been cleaned up in less time than 8 days had it not been for this misfortune. While 12 days is more than is normally spent on a Kansas fishing job before skidding the rig or side-tracking, in this case the expenditure was worth while,

because of the tough drilling. The successful completion of the job also proves definitely what was only believed previously—that it is possible to washover a fish in a small-diameter hole.

A. H. N.

1069.* Reducing Hazards in Handling Rope. F. L. Spangler. *Oil Gas J.*, 7.8.41, **40** (13), 34.—Injuries to men handling wire rope are of three kinds. First there is the danger of deep-seated puncture wounds or skin lacerations caused by the sharp ends of broken wires sticking out from worn ropes or by the exposed ends of the rope or of the wire-ends in a spliced section. Then there is the lashing or looping of an unmanageable rope, which can take off a man's limb or decapitate him if he is caught in its coils. As an example of the third type of injury, a man's glove may be caught by a broken wire or strand and his hand be pulled into a drum or sheave. Specific cases are discussed in the light of answers given by various companies to a questionnaire.

The reports from three companies say that preformed rope seldom wickers, regardless of the extent of wear, and is therefore much less dangerous to handle than non-preformed rope. Other advantages of preformed rope from a safety standpoint are revealed by a company which reports: "We are now using preformed rope exclusively; it does not unravel when cut and it does not kink when used for hoisting."

The need for proper training of men handling rope is emphasized by four companies, and one says that rope-handling should be reduced to the absolute minimum. Two pointed out the need for proper lubrication to prevent rust, proper training of men in good splicing, winding, or clamping of rope before cutting, so that the "ends" will not explode and the wires fly out, and brazing the rope-ends to make them blunt and eliminate the danger of exposure to sharp wire-ends. Drivers of winch-trucks should realize their responsibility in preventing injuries from rope-handling and should be trained with this in view.

A. H. N.

1070.* Cathead Most Dangerous Point On Rotary Drilling Rig. H. F. Simons. *Oil Gas J.*, 14.8.41, **40** (14), 42–43.—This paper is based on a report on accidents issued by the Bureau of Mines, from which it appears that the cathead is the most dangerous point on the rig. The line-shaft and cathead may be running at 200 r.p.m. and the rope pulling some object moving only 1 ft./min. around the cathead. If the rope becomes tangled it begins to move at 760 ft./min. if a 14-in. cathead is being used. Unless the man running the cathead is prepared for the emergency, he becomes fastened in the cathead by one arm or hand, and is jerked from the floor and spun round at 200 r.p.m.

The type of injuries when the man is not killed are shown in the report mentioned above. Out of thirteen reported accidents on the cathead, the injuries included six to the shoulder and arms and seven to the hands and fingers. In these thirteen accidents there were four fractures and five amputations.

The most common mistake made by cathead men is the grasping of the rope with the right hand turned palm downward. This places the back of the hand between the rope and the cathead should it become fouled while either placing the rope on the cathead or taking it off. With the palm upward, opening the hand releases the rope and the fingers are removed from danger. Another common fault is the throwing of large loops of rope on the cathead instead of placing tight loops on it.

As the cathead depends on friction for its operation, the faster the line-shaft is turned, the greater is its power. Cathead men prefer a fairly high speed, as the rope is easier to handle, although they know that the danger is thereby increased. A moderate speed and an additional coil of rope on the cathead increase the work slightly, but also decrease the danger. The use of too many coils on the cathead, so that the weight of the operating end of the rope is sufficient force to pull a fairly heavy object on the working end, is also dangerous.

Laying of the hand on the coils is not dangerous, although it may appear to be. This permits the strain on the working end of the rope to be released or reduced while leaving the rope on the cathead.

A. H. N.

1071.* Effective Mud System for Deep Drilling. N. Williams. *Oil Gas J.*, 4.9.41, **40** (17), 32–33.—A particular system as used by one company on the Gulf Coast is

described and unusual efficiency is claimed for it. Rigs of this company call for two 20-in. mud pumps. These are so manifolded that either can be used in regular mud circulation to the well or for mud mixing or other service. Also both pumps can be operated together in mud circulation, either in parallel when volume of mud is required, or in compound when greater pressure rather than volume is needed.

The pumps take suction from separate but adjoining suction pits, which in this case are of excavated earthen construction, each about 12×20 ft. in size. Like the pumps, either pit can be used separately for mud-suction to the well, or for mixing of mud, depending on the use to which the respective pumps are being put at the time; or suction can be taken simultaneously from both pits, if it is desired to operate the pumps in parallel for mud circulation.

A gate connects the two pits. For use of either pit independently of the other, the gate is kept closed. With the gate opened the mud can be emptied from either pit to the other. Each pit has a gate-controlled opening from the common mud ditch, which permits discharge of the mud stream from the well into either or both pits, as desired. Thus, by opening or closing the gates in various combinations, the mud circulation can be diverted in any number of different ways through the pits to the suction pits.

By closing the gate from the mud ditch to the first pit, opening the gate to the second pit, and closing the gate between the two pits, the mud circulation can be confined to the second pit; or, by opening the gate connecting the pits, the mud can be circulated in succession from the second pit to the first pit, and thence to the suction pump of the first pit. With the gate from the mud ditch to the first pit open, the gate from the ditch to the second pit and that between the pits closed, the mud circulation can be confined to the first pit. By opening the gate between the pits, the mud can then be circulated successively from the first pit to the second pit, and thence to the suction of the pump of that pit.

Operations under normal and abnormal drilling conditions are described, together with a steam-jet degasser using baffles in an inclined tube.

A. H. N.

1072.* Interesting Results from Deep Experimental Drilling Programme. S. Fox. *Oil Wkly*, 21.7.41, 102 (7), 17-19.—Experience with drill-casing has thus far been completely satisfactory. The cost of casing built up for drilling is approximately 12 cents/ft. more than regular casing, which is considerably less per ft. than the cost of drill-pipe, maintenance, and depreciation. In addition this immediate saving is also increased by economies of operation made possible by use of the drill-casing.

Among these is the matter of time. The average time of drilling has decreased by approximately 10 days/well since the company began the drill-casing programme. This decrease is due not so much to a reduction of actual drilling time itself, but is credited to the greater speed and efficiency of the method made possible by use of drill-casing.

It is concluded that results from this new drilling practice have been entirely successful, and initial mechanical difficulties were quickly overcome. Although several joints of pipe may be damaged in the drilling of a well, they are easily repaired. Abrasion occurring from the contact of the pipe with the walls of the hole necessitates replacement of a few worn couplings, but no apparent damage is done to the body of the pipe. The drill-casing withstands the drilling stresses satisfactorily without pipe twist-offs. It is reasonable to expect that the use of drill-casing will have application to other fields with good results.

A. H. N.

1073.* Gas Box Saves Mud in High-Pressure Drilling Area. G. B. Nicholson. *Oil Wkly*, 21.7.41, 102 (7), 26.—The apparatus consists of a 28-ft. wooden tunnel or box, inside dimensions 4×6 ft., and an 8-ft. chimney erected 6 ft. from the end nearest the mud pits. Blowing mud is directed into the box by 4-in. pipes leading directly from the mud-return annulus, its volume restricted by chokes of desired size placed on the pipes near the entrance. Sturdily constructed and heavily reinforced, the box absorbs the force of the fluid stream and confines the blow, separating the gas and expelling it into the air while turning mud into the pits. Closed on the mud pit, and except for a large exit door leading out at a 90° angle, the lengthy tunnel allows

time for separation, despite the turbulence, and gas is drawn by vacuum from the chimney near the end by blowing steam through it.

The gas-box is used only when a well attempts to blow out and the shale-shaker and degasser are not sufficient to handle the pressure and volume of gas and fluid. At that time valves on the mud line are manipulated to direct flow into one of the two parallel 4-in. lines leading from the well to the box, the fluid by-passing both shale-shaker and degasser with flow around the casing-head sealed off, forcing all circulation returns to enter the mud pipe. The apparatus is located sufficiently distant from the rig for safety and non-interference with operations, and at the entrance to the box, valves on both mud lines contain positive chokes to regulate flow and govern the amount of back pressure held against flow from the casing. As only one line is used at a time, chokes are easily changed to obtain proper control. A short distance beyond the choke-valves the 4-in. open-end line delivers drilling fluid into the box.

A. H. N.

1074.* Automatic Pressure Control Aids Drilling of Wild Well. Anon. *Oil Wkly*, 28.7.41, 102 (8), 17.—The procedure used in drilling under pressure, with an ingenious automatic back-pressure maintenance equipment, of a formation with an abnormally high pressure, is detailed in this exhaustive paper. The rig, designed and equipped with hydraulic rotary and pull-down yoke for control of the flush-joint drill-pipe through drilling packer, used a 136-ft. steel derrick, draw-works with hydromatic brake, and steam drilling engine. The rotary table was equipped with hydraulic cylinders which permitted it to be raised for a grip on the kelly, and then lowered under controlled pressure to maintain feed on the bit and secure the pipe against being blown out of the hole.

For coming out of the hole or running pipe, a hydraulically actuated pull-down yoke was set, and the drilling crews were trained in its use, so that they would be thoroughly familiar with the operations should well conditions require snubbing of the string.

To provide space for the various controls required in maintaining back pressure on the mud in the hole, a balcony or auxiliary operating platform was fabricated from steel salvaged from the first derrick over the hole. This space, 30 ft. long by 8 ft. wide, was set at derrick-floor level and to the right of the driller's stand, so that signals between driller and control operator could be observed at all times.

The platform carried the mud-choke manifold, individual and plainly labelled controls for the master gate, mud-return main, flow-lines, drilling blowout preventer, emergency blow-out preventers, gauges and recording chart for checking input and outflow mud pressures, and a booster pump for stepping up hydraulic pressures in the ram-actuating systems of the blowout preventers.

Maintenance of uniform working pressure on the well at all times was attained through use of an 18-in. pump which constantly "floated" on the mud column, a modified boiler feed-water type of regulator being tied in with the mud line so that any variation was communicated to the throttle of the pump and the flow varied accordingly.

The four adjustable chokes, one each on the 2-in. lines taking flow from the 4-in. mud line at the well, were set to maintain approximately the desired back pressure on the well under normal operating conditions, leaving the floating pressure-maintenance pump to make up for any fluid lost into the formation, and to compensate for void created as the drill-pipe was withdrawn through the drilling blow-out preventer when coming out of the hole.

Use of the pressure-maintenance pump gave accurate compensation for even minute fluctuations in mud-stream volume or pressure, and eliminated the necessity for attempting to maintain this uniform pressure through hand manipulation of the various chokes on the mud-distribution panel. With the actuating line for the pressure-control diaphragm tied to the ascending mud column below the master gate, any variation occurring was felt at the diaphragm while the mud stream was still under full annulus conditions, and before any branches or split streams could affect actual pressures and show fictitious readings of the conditions.

The paper is well illustrated both diagrammatically and photographically.

A. H. N.

1075.* Acidizing before Cementing Helps Form an Effective Bottom-Hole Water Block. F. B. Taylor. *Oil Wkly*, 4.8.41, 102 (9), 17.—Control of formation water has long been a problem in Kansas production. Arbuckle lime, the dominant producing stratum in the western part of the State, normally carries excessive volumes of water. As there is no dissolved gas to expand and take the place of the crude produced, formation water immediately begins to move laterally towards the well, and generally intrudes into the borehole within a few months.

Various methods have been employed to plug off the water section as it progressively rises, for production of large quantities of water does not mean that the crude oil in the reservoir has been exhausted. Recently some companies have been devoting their efforts towards creating a non-permeable cement bottom-hole water-block after the stratum has been opened somewhat by controlled acid treatment. While the method is yet too young to have been applied extensively, results so far obtained have been distinctly promising.

Through application of this new technique, a cement block that extends back into the formation through opened crevices is obtained, instead of a cement plug in the bottom of the hole that adheres merely to the face of the water section. The permeability of the water zone is lowered to practically zero by forcing cement into the pore spaces made available by the acid treatment. As the block extends into the formation itself, it is effective beyond the point of greatest pressure differential while the well is being produced; thus it not only acts as a plug, but also influences the formation of a water-cone by retarding water migration in the vicinity of the well, and acts to reduce further coning in the event of the cone having already become established. Details of the method are given.

A. H. N.

1076.* California Test is Deepest by Electric Power and had Longest Uncased Hole. Anon. *Oil Wkly*, 4.8.41, 102 (9), 23.—Two records without parallel in the drilling of deep wells were achieved by Honolulu Oil Corporation in the drilling of its No. 25-P deep test to 14,622 ft. in the old Buena Vista oil-field in Kern County, California.

First, from 3101 ft. to bottom, a distance of 11,521 ft. drilling was in open hole. This amount of uncased hole is believed to have been hitherto unequalled, and attests the care and precision of workmanship on the derrick floor, as well as the high degree of expert supervision over a miscellaneous number of items, such as drilling fluids, rate of penetration, maximum capacities of equipment employed, and a number of other factors.

Second, except for small standby units, electric power was used in the drilling, making it the deepest well ever drilled with electric power.

Details are given.

A. H. N.

1077.* Floating Barge Expedites Shallow Marine Drilling. G. M. Nicholson. *Oil Wkly*, 11.8.41, 102 (10), 19.—A non-submersible barge constructed especially for drilling to the 2300-ft. oil-producing sand in the West Lake Verrett field, South Louisiana, and for deep work-over jobs is described. Assembled with the objective of allowing fast completions facilitated by ready mobility when changing locations, the entire rig assembly is mounted on a single barge, and includes a 126-ft. derrick and attendant equipment such as a rotary and draw-works driven by diesel-power equipment, mud pump, mud tanks, and pipe racks, with all apparatus transported in a single operation necessitating little expense, and eliminating time consumed in sinking or refloating the barge, as is usually the case with marine-drilling barges. Use of the barge avoids waste which would be incurred in occupying larger and more expensive equipment on wells where load requirements are light.

The barge and equipment are described and illustrated photographically. The barge requires only $4\frac{1}{2}$ ft. of water when fully loaded to its moving weight, exclusive of its complement of $3\frac{1}{2}$ -in. drill-pipe on the auxiliary barge, allowing a deck clearance of 18 in. above the water level. Only a short time is required for its movement, it being a simple task to raise the corner spuds and move rig during cementing time for work on another well, such as swabbing or squeezing, then moving back to the original well in time for completion.

A. H. N.

1078.* Semi-Permanent Boiler-Setting Permits Alignment. Anon. *Oil Wkly*, 18.8.41, 102 (11), 19-20.—One company whose work justifies semi-permanent mountings of the boilers has worked out a system of boiler substructure or skeleton foundation which, simply laid on planks over the ground, affords uniform and rigid support at comparatively low cost.

Alike in design, squat, triangularly braced substructures are used at both ends of the boiler unit, the raw material being discarded joints of standard drill-pipe, cut to length with cutting torch and welded into a series of joined A-frames. The supports for the smoke-box end are made as a series of A-frames with a continuous rail under each series of legs. A continuous rail is also used across the apex of each frame, each section of supports being made as long as desired, but always more than one boiler. Diagonal bracing is used by stepping in a joint of pipe at the leg of one A-frame and bringing the opposite end of the brace to the top rail, central between each pair of frames. The next brace starts at the leg of the next frame, on the opposite side, and is brought to the centre and welded. Adequate cross braces are welded between the legs of each frame to prevent spreading when weight is applied.

Details are given.

A. H. N.

1079.* Rig in Centre of Crater Helps Kill Wild Well. Anon. *Oil Wkly*, 18.8.41, 102 (11), 33-35.—Setting up of a drilling derrick in the middle of a well crater and the drilling of more than 500 ft. of hole were particularly interesting phases of methods used in bringing a well under control late in July, after it had blown wild since March 31, 1939. The well, located in the McFaddin field of Victoria County, Texas, was bottomed at 4260 ft. and had penetrated several high-pressure gas-sands when it blew out. Surface fittings were soon cut out, and the well cratered.

The series of operations that finally led to the setting up of a small derrick in the middle of the crater in order to drill down beside the original hole and then successfully kill the well, are illustrated photographically. The operations leading to the killing of the well lasted approximately 3½ months, ending in the latter part of July this year. Despite the hazardous nature of this particular job, no injuries were suffered by any of the workmen.

A. H. N.

1080.* Derrick Substructure Centralizes Load at Corners. Anon. *Oil Wkly*, 1.9.41, 102 (13), 21-22.—An unusual derrick substructure is used by one company for drilling deep wells in the Gibson field, Louisiana Gulf Coast, conveying all pipe and rotary loads to the four corner columns by means of heavy horizontal trusses that eliminate need of rotary or other vertical supporting posts under the derrick, and allowing increased working space around the casing-head valves. Cost of this company's standardized method of concrete flooring for the area under the derrick is reduced, as less concrete is required by this substructure for floor and for the shallow cellar which is made possible by high ceiling clearance. The base has been used on several wells with depths in excess of 11,000 ft., drilling with only the heaviest available equipment through high-pressure formations, and supervising engineers state that its design offers strength equal to conventional substructures, with apparent absorption of rig vibrations.

In eliminating rotary posts, the substructure supports the derrick and the pipe-load standing in the derrick or held in the rotary only at the four corners, with the load transferred to the corner posts by means of six all-welded, carefully fabricated trusses, four extending between the derrick legs and two parallel rotary trusses crossing near the centre. All trusses are constructed of heavy channels welded to steel plates, and consist of horizontal top and bottom cords with angular and perpendicular bracing between. The trusses extending between derrick corners on the tool-ramp and mud-pump sides, as well as the two rotary trusses under the derrick, are 5 ft. high, allowing ample clearance to haul in equipment and for persons to walk underneath, although clearance on draw-works and window-sides is only 2 ft. 3 ins. The derrick floor is elevated to 10 ft., providing abundant space for easy manipulation of valves and facilitating washing of the concrete floor. Mud return lines which leave the casing-head comprise the only horizontal piping, while the sole vertical pipe extending through the floor is the rat-hole conductor pipe, with vertical supports eliminated. A. H. N.

1081.* Underreaming to Straighten Hole in Well Drilled on Townsite Lot. H. L. Flood. *Petrol. Engr*, August 1941, 12 (12), 27-28.—A procedure, tried for the first time, for straightening a well with excessive deviation is described. Although the maximum deviation had not become unduly excessive, the operator preferred to straighten the hole, and thus avoid the possibility of drilling into one of the nearby wells.

The principal points of interest in the hole-straightening operation rest in: (1) the fact that the deviation was corrected before surface pipe had been set, and (2) the use of successively larger underreamers (to 30 in.) to create a wide enough shoulder to permit "re-spudding" a new hole that would have a more nearly vertical axis.

The expanding wall-scraper tool used on this job consists of an alloy-steel body containing a piston to which two blades are connected, the latter being mounted in such a way that the blades retract into the body while running in or out of the hole. At the desired time the piston may be forced downward by increasing the pump pressure on the mud, thus expanding the blades outward and upward against the wall of the hole. As the drill-pipe rotates, the blades cut their way to a fully expanded position, and are held in this cutting position by pressure against the shoulder that has been created in the formation. If the formation has a soft consistency, the blades are held in their expanded position by pump pressure.

In the first underreaming operation the 12½-in. hole was enlarged to 15-in. diameter from depths of 1350-1400 ft. The 15-in. reamer blades were then removed from the tool and the hole was again enlarged, using 19-in. blades, from 1360 to 1400 ft. The third step consisted of enlarging the hole from 19 in. to 24 in. from depths of 1365-1400 ft. Finally, the 24-in. blades were replaced with 30-in. reamer blades, and the hole was enlarged to the latter diameter for a distance of 72 ft. (from 1370 to 1442 ft.).

A. H. N.

1082.* Well Completions Improved by Concentration of Prepared Bentonite in Drilling-in Fluid. W. A. Sawdon. *Petrol. Engr*, August 1941, 12 (12), 38.—Recent practices established by some of the companies in a number of fields in California, as well as in a number of other districts throughout the United States, indicate the advantage of changing the mud before entering the sand. This drilling-in mud in many cases consists entirely of prepared bentonite and water, and in others (where a little more weight is necessary) of well-conditioned mud fluid to which sufficient prepared bentonite is added after proper thinning to allow for the high concentration of the bentonite.

The object of changing the drilling fluid when drilling through the sand is to obtain a mud that will deposit a cake on the face of the sand that will not only prevent water loss while drilling, but will be so thin, soft, and easy to remove that no washing will be necessary. The fluid, composed entirely of prepared bentonite and water, not only possesses these properties in the highest degree, but also provides the viscosity and gel strength necessary to bring up cuttings and hold them in suspension in the event of circulation being stopped. For use when drilling low-pressure sands, such a fluid has the advantage of low weight and, due to its extreme colloidal properties, will have a tendency to prevent loss of circulation into very porous or fractured sand.

Where drilling-in requires weight to some extent the prepared bentonite can be concentrated in the fluid to give the desired qualities, and weight material added to provide the necessary weight. Although this discussion is confined to the fluid used for drilling through the oil-producing zone or zones, there are instances in which the circulating fluid used for drilling the entire well has been composed of prepared bentonite and water, weight being added if and when formation pressures have to be overcome. The use of prepared bentonite for drilling-in at several fields shows applications under different conditions.

The actual variants of the methods used in different fields are described, with a discussion of specific problems met.

A. H. N.

1083.* Removable-Type Hydraulic Jet-Gun Used in Acidizing. C. A. Pitts and C. F. Seeber. *Petrol. Engr*, August 1941, 12 (12), 44.—Most hydraulic guns are attached to the tubing, thus rendering it necessary to make a round trip with the tubing to recover the gun at the end of the treatment. To eliminate this, a gun has been devised that may be dropped in the tubing and caused to seat on a special seating

nipple. This gun is retrievable by one of two methods. It can either be retrieved with a measuring line, or pumped out when it is possible to reverse circulation. The special seating nipple supplied is so designed that any standard A.P.I. insert barrel will fit it. This eliminates any trip with the tubing.

The advantages of this removable-type gun are many. Cementing off bottom of wells through tubing and subsequently jetting out the excess cement above the pay zone without removal of the tubing from the hole is becoming a standard practice in some areas. Furthermore, by simply changing the tip of the jet-gun it is possible to accomplish any type of jetting job in minimum time and at minimum expense to the operator.

The hydrodynamics of the jetting action are discussed. A coefficient of discharge equal to 9.976 has been realized.

Many successful jetting jobs have been run under various conditions and for different purposes. For each type of job a particular type of acid and a particular method of operation are used. The two principal classes of uses for jets are: (1) for vertical drilling and (2) for horizontal drilling. For vertical drilling a special jet-tip is used, which has one large orifice pointed the correct number of degrees from vertical, and one small orifice pointed horizontally. This allows cement or limestone to be drilled at a rate comparable to cable-tool drilling, and saves the operator the expense of moving in cable tools or other drilling equipment. A cementing plug is being developed that is drillable with acid jet-guns, thus making it possible to service any well when casing leaks are present. The casing can be bridged below the leak, the acid-soluble plug and Cal-Seal used, a squeeze made through the leak and the pipe cleaned out with the jet-gun.

In a special method, known as water control, wells are jetted horizontally to open the water-bearing formation; cement is then carefully balanced into the formation, leaving a plug that covers both water and oil-pay, after which, with this special drilling jet-tip, the excess cement is removed a few inches at a time. As soon as any permeability is reached—indicated by loss or gain of fluid at the surface—drilling is stopped and the well tested for production.

A. H. N.

1084.* Horizontal Wells Are All in Pay—and Flow by Gravity. L. Ranney. *Petrol. Engr*, August 1941, 12 (12), 127.—The vital point of such development is and always has been absolute control of the drilling bit, and the ability to turn the well up or down at will. In drilling some 7500 ft. of horizontal oil-wells, always under control, it is believed that the technique has been fairly well mastered. In fact, turning a hole to follow a predetermined course presents no greater difficulty at 3000 ft. than at 100 ft. from the mouth—no whipstocks are used. A surveying instrument has been developed, integral with the core-barrel, that automatically surveys the hole whenever a core is taken.

In an experiment conducted in South-eastern Ohio six wells were drilled horizontally from a shaft in the First Cow Run Sandstone. These 3-in. wells were drilled in opposite pairs, half of them to property lines. While a 50-ft. core was being pulled from one well, the drill rods (and duplicate tools) were being run into the opposite well. This was accomplished by a new machine, known as the "rod puller," which moves the rods at the rate of 100 ft./min. The drill-rods, in 10 ft. lengths, were not disconnected until both wells were completed. In deep holes this reduces drilling time by at least 75%.

In all the drilling operation the tools were never stuck or frozen; the holes were surveyed every 50 ft. and corrected when necessary; there were no fishing jobs; two men operated the drilling machine, with 20 h.p.; during all the experimental period, including stops and shutdowns for supplies, the average rate of drilling was 55 ft./7-hr. shift; when tools and supplies were on hand, often more than 100 ft. of hole was drilled per shift. To the south the bottom of the sand was level and the holes were flat, but to the north the sand was wavy and the holes followed the waves. The mixture of oil and return drill-water passed through a separator; the oil was saved in a closed tank, and then pumped to the surface. During the entire experiment no man suffered even a minor accident; tests by a methane detector in the centre of the work-chamber never showed more than 0.1% of gas; ventilation was by a blower at the surface and an 8-in. suction pipe. The cost of drilling, including

experimentation, was 90 cents per ft. of hole ; 100 ft. of light 3½-in. casing was grouted in each well.

The greatest surprise was the result of shooting, which affected a vast area.

A. H. N.

1085. Patents on Drilling. J. F. Chappell. U.S.P. 2,245,571, 17.6.41. Appl. 16.2.39. Fishing tool.

R. W. Jones, Jr. U.S.P. 2,245,592, 17.6.41. Appl. 21.11.39. Well-pipe support and gripping device.

R. C. Baker. U.S.P. 2,245,638, 17.6.41. Appl. 25.7.39. Circulation and expansion joint for well devices.

J. R. Betts. U.S.P. 2,245,750, 17.6.41. Appl. 25.11.38. Well-boring bucket and method of boring wells.

J. Johnson. U.S.P. 2,245,786, 17.6.41. Appl. 3.2.40. Jarring tool.

J. F. Bagby. U.S.P. 2,245,847, 17.6.41. Appl. 22.6.39. Pipe or hose-coupling.

J. W. Weir and H. S. Montgomery. U.S.P. 2,245,886, 17.6.41. Appl. 11.7.38. Method of drilling wells using mud and acid.

G. K. Clair. U.S.P. 2,245,960, 17.6.41. Appl. 10.3.39. Rotary well-drilling apparatus.

H. W. Graham. U.S.P. 2,246,038, 17.6.41. Appl. 23.2.39. Integral joint drill-pipe section.

R. Ring. U.S.P. 2,246,319, 17.6.41. Appl. 13.1.40. Well-surveying instrument with an electrolytic recorder.

R. W. Smith. U.S.P. 2,246,417, 17.6.41. Appl. 18.6.38. Means for borehole orienting and surveying.

C. W. Froome and F. C. Boyd. U.S.P. 2,246,418, 17.6.41. Appl. 14.3.38. Art of well-drilling with a drill-pipe made in the form of a spiral.

P. Jones. U.S.P. 2,246,519, 24.6.41. Appl. 18.3.39. Drift recorder for drilling wells.

H. Allen. U.S.P. 2,246,709, 24.6.41. Appl., 21.8.39. Blow-out preventer.

G. J. Barrett and S. Robichaux. U.S.P. 2,246,711, 24.6.41. Appl. 16.11.39. Cutting-tool shaped to enter a pipe and cut by rotation.

F. L. Pivoto. U.S.P. 2,246,812, 24.6.41. Appl. 26.9.38. Welded-on blade-bit.

F. Huntsinger. U.S.P. 2,247,173, 24.6.41. Appl. 27.3.39. Drilling collar.

D. Silverman and R. W. Stuart. U.S.P. 2,247,417, 1.7.41. Appl. 6.3.40. Electric logging a well during drilling.

J. T. Phipps. U.S.P. 2,247,560, 1.7.41. Appl. 27.5.40. Jar with a shell and mandrel telescopically arranged.

H. W. Cardwell. U.S.P. 2,247,606, 1.7.41. Appl. 25.2.38. Draw-works with a friction clutch.

R. A. Mitchell. U.S.P. 2,247,729, 1.7.41. Appl. 25.8.39. Combination cable-tool and wire-line core-barrel.

E. R. Armstrong. U.S.P. 2,248,051, 8.7.41. Appl. 28.12.38. Offshore drilling rig supported on a buoyancy unit and vertical, extensible supports.

D. Scaramucci. U.S.P. 2,248,124, 8.7.41. Appl. 4.10.39. Well-casing attachment to be connected to the end of a casing.

D. Scaramucci. U.S.P. 2,248,125, 8.7.41. Appl. 4.10.39. Wash-down and cementing attachment for well casings.

E. L. Crawford. U.S.P. 2,248,160, 8.7.41. Appl. 12.8.38. Well apparatus comprising a drill-stem and a sleeve with helical springs.

P. H. Granger. U.S.P. 2,248,169, 8.7.41. Appl. 26.7.40. Oil-well tool to be used in combination of a well casing and a string of tubing adapted to be moved vertically within the casing.

A. C. Catland. U.S.P. 2,248,339, 8.7.41. Appl. 23.10.39. Roller cutter for rotary-well drilling.

A. C. Catland. U.S.P. 2,248,340, 8.7.41. Appl. 26.7.40. Rock-bit for rotary-well drilling.

A. Osolin. U.S.P. 2,248,434, 8.7.41. Appl. 26.3.38. Mud-gun.

S. P. Hart. U.S.P. 2,248,457, 8.7.41. Appl. 21.7.38. Treatment of oil-wells to prevent heaving shale troubles by means of casein and a hardening material.

J. G. Phillips. U.S.P. 2,248,908, 8.7.41. Appl. 2.8.40. Self-expanding well-plug used in cementing.

D. W. Auld and L. J. Weber. U.S.P. 2,248,910, 8.7.41. Appl. 29.8.39. Pressure retaining core-barrel and coring assembly.

R. L. Crandall. U.S.P. 2,249,117, 15.7.41. Appl. 23.12.39. Cable spooling device with a relatively stationary cable-guide pulley and a cable drum.

C. J. Haynes. U.S.P. 2,249,358, 15.7.41. Appl. 30.12.39. Fishing tool for an object suspended on a cable.

E. F. Westall. U.S.P. 2,249,511, 15.7.41. Appl. 1.9.36. Apparatus and method for cementing wells.

J. T. Phipps. U.S.P. 2,249,578, 15.7.41. Appl. 18.11.39. Roller bit for oil-well drilling.

P. W. Thomure. U.S.P. 2,249,585, 15.7.41. Appl. 22.4.40. Device for pulling pipes and the like from well.

A. Boynton. U.S.P. 2,250,463, 29.7.41. Appl. 28.11.38. Cable-pull overshot of a releasable type.

E. W. Dodge. U.S.P. 2,250,574, 29.7.41. Appl. 1.3.39. Explosive rotary jar for deep-well equipment.

R. G. De La Mater. U.S.P. 2,250,628, 29.7.41. Appl. 28.1.39. Walking-beam assembly.

K. E. Waggener. U.S.P. 2,250,688, 29.7.41. Appl. 30.9.40. Cut indicating inside cutter for well-pipes.

W. J. Crites and W. C. Rodgers. U.S.P. 2,250,703, 29.7.41. Appl. 18.11.38. Apparatus for locating casing seats by electromagnetic means measuring the magnetic permeability in the well-bore.

R. H. Landers. U.S.P. 2,250,836, 29.7.41. Appl. 27.5.40. Pipe-clamp.

L. S. Dewees. U.S.P. 2,251,040, 29.7.41. Appl. 9.1.39. Means for measuring rotation of apparatus within drill-pipe or the like.

R. E. Chapman. U.S.P. 2,251,113, 29.7.41. Appl. 29.12.39. Device for pulling pipes or well-casings.

C. J. Gardner. U.S.P. 2,251,125, 29.7.41. Appl. 2.1.40. Safety device adapted for passage through well-pipes and having spring-controlled anchoring means.

G. R. Watson. U.S.P. 2,251,309, 5.8.41. Appl. 16.9.37. Multiuse winch-tool for well drills.

W. G. L. Smith. U.S.P. 2,251,428, 5.8.41. Appl. 23.12.39. Drill-pipe protector comprising two semi-cylindrical metal frames.

L. P. Kinnear. U.S.P. 2,251,679, 5.8.41. Appl. 29.11.37. Core-drill apparatus with a coring barrel.

L. F. Athy and H. R. Prescott. U.S.P. 2,251,817, 5.8.41. Appl. 18.4.38. Method of borehole logging by means of A.C. acting on a vibratory means.

A. B. Severn. U.S.P. 2,251,897, 5.8.41. Appl. 11.5.39. Thread protector for threaded pipes.

B. S. Smith. U.S.P. 2,251,900, 5.8.41. Appl. 24.9.38. Well surveying by means of passing current through a conductor within the hole and subjecting the conductor to a magnetic flux.

C. E. Burt. U.S.P. 2,251,977, 12.8.41. Appl. 23.12.39. Well-cementing apparatus.

N. W. Thompson. U.S.P. 2,252,050, 12.8.41. Appl. 30.9.39. Apparatus for circulating drilling fluids.

T. A. Creighton. U.S.P. 2,252,168, 12.8.41. Appl. 17.6.40. Well-bit.

R. De Long. U.S.P. 2,252,620, 12.8.41. Appl. 20.5.40. Coring device of the side wall type.

R. Cross and W. M. Cross, Jr. U.S.P. 2,252,669, 12.8.41. Appl. 9.9.37. Method of drilling oil- and gas-wells using a brine drilling fluid capable of precipitating cellulose or cellulose hydrate from a zinc chloride solution of cellulose.

H. W. Thornburg. U.S.P. 2,252,741. 19.8.41. Appl. 10.2.38. Spudding mechanism for cable-tool drills.

A. L. Armentrout. U.S.P. 2,252,912, 19.8.41. Appl. 6.3.39. Well-tool for use on a well-string comprising a cutting head.

V. Parkin. U.S.P. 2,252,978, 19.8.41. Appl. 22.6.38. Drill-stem protector.

J. O. Tow. U.S.P. 2,252,996, 19.8.41. Appl. 14.11.39. Gun perforator.

G. K. Clair. U.S.P. 2,253,487, 19.8.41. Appl. 27.2.40. Portable well-derrick base made of two portable sections.
A. H. N.

Production.

1086.* Recent Developments Point to Wider Use of Casing Pumps. Anon. *Oil Gas J.*, 24.7.41, 40 (11), 50.—Advances in the quality of the rod-strings and in the operation of the pumping units extended the safe setting depth of the casing pumps, and this was increased by the introduction of the small-diameter casing pump. While it might be impossible to lift the desired volume of fluid with a 2-in. pump in 2½-in. tubing string, it was possible to lift it with a 2½- or 3-in. pump in a 5-in. casing string.

Study of this type of pumping has led to an interesting disclosure, but one which might be expected when the principles involved are considered. The smaller the diameter of the tube through which a fluid is flowing, the greater the losses due to friction. The pressure drop in a 2-in. pipe is seven times greater than that in a 3-in. pipe; a comparison of carrying capacities shows that a 4-in. pipe will carry 5.3 times as much fluid as will 2-in. pipe at the same pressure.

Operation of the casing-pump requires that the working barrel be packed off from the casing, so that the casing can be used for the fluid passage or production string. The casing pump is run in the well on the rod-string the same as an insert-type tubing

pump. There are several methods used for setting the packer, depending on the manufacture of the particular pump used. Garbutt rods or J-tools are provided for recovering the pump for repair of the valves. A. H. N.

1087.* California Truck-Mounted Unit Capable of Servicing 10,000-ft. Wells. T. P. Sanders. *Oil Gas J.*, 31.7.41, **40** (12), 162.—The derrick is of two-piece tubular construction. Both upper and lower sections are made of chrome-molybdenum alloy steel tubing electrically welded. The crown block is integral with the upper section. Both sections are tapered to obtain greater rigidity, and the bottom section has a built-in guide section on which the upper section is raised and lowered. The guide section acts as a brace, increasing the leg capacity and increasing torsional rigidity.

The derrick is raised and extended by a built-in mechanical device driven by the hoist-engine. Raising is accomplished with two large-diameter screws operating two internally lubricated bronze-alloy drive nuts which are ball-bearing mounted. This raising mechanism is irreversible except under power, so the tower cannot fall should a power failure occur while it is being raised. After the two telescoped sections have been raised to the vertical position the upper section is extended by means of a small winch (also driven by the hoist engine) which spools a wire rope to raise the upper section into position. The derrick can be locked in either the high or low position by means of a pawl-and-lug mechanism operated from the ground. Design is such that the load is transferred from the legs of the upper section to those of the lower section without bolting.

One of the first duties required of the new Shell unit was the lifting of a heavy drilling derrick with all machinery intact so that track-laying wheels could be placed under it for moving. The complete derrick-and-rig unit weighed 85 tons, and when the heavy side was lifted the load on the well-servicing derrick was 130,000 lbs. This operation, though spectacular, did not call for as much lifting power as is required for pulling large-diameter tubing from a deep well. A. H. N.

1088.* Repressure Plants Permit Oil Production, Otis Fields. H. F. Simons. *Oil Gas J.*, 7.8.41, **40** (13), 39.—The development of the Otis field is reviewed up to date, when it is entering the stage where gas recycling is being used. The original bottom-hole pressure in the reservoir was 1178 lb./sq. in. with a gauge pressure at the well-head of 1064 lb./sq. in. and the weight of the static gas column computed at 114 lb./sq. in. after being corrected for deviation. On 1st May, 1941, the bottom-hole pressure had declined to 660 lb./sq. in.

The original gas content of the reservoir was estimated to be 207,900,000,000 cu. ft. of gas. Original oil content was estimated to be 6,044,343 bbl. at reservoir conditions and 5,912,577 bbl. of stock-tank oil, of which 50% should be recovered. Up to 1st May, 1941, 99,200,000,000 cu. ft. of gas and 1,410,868 bbl. of oil were produced, leaving approximately 108,700,000,000 cu. ft. of gas, of which 93,700,000,000 should be recovered; total oil recovery on that date was 1,410,868 bbl., leaving approximately 1,545,420 bbl. to be produced. The estimate of recoverable gas is based on no venting of the gas produced with the oil and an abandonment pressure of 50 lb./sq. in.

Total pipe-line sales of gas on 1st May, 1941, amounted to 64,000,000,000 cu. ft., measured at 16.4 lb./sq. in. and 60° F. Another 6,100,000,000 cu. ft. had been used to that time in plant and well operation, and 29,100,000,000 cu. ft. has been vented by the combination wells. If the practice of venting were continued, an additional 43,100,000,000 cu. ft. would be consumed uselessly and the future recovery of gas reduced to 50,600,000,000 cu. ft. Gas-oil ratio has been approximately 20,900 cu. ft./bbl.

With such a high gas-oil ratio the production of 1,410,868 bbl. of oil resulted in the voiding of reservoir space equal in volume to 66,400,800 bbl. In other words, 13.83% of the original gas content in the reservoir has been employed in producing a volume of oil which originally occupied only 0.3% of the total reservoir space. Further interesting data are recorded.

The plants used are solely for repressuring, and include no equipment for gasoline recovery. These are briefly described and illustrated. A. H. N.

1089.* East Texas Makes Progress in Hydraulic Oil-Well Pumping. G. Weber. *Oil Gas J.*, 14.8.41, **40** (14), 44.—The hydraulic pumping system substitutes hydraulic

power-transmission for mechanical methods in energizing subsurface well-pumps. The subsurface production unit—an engine-driven, double-acting, reciprocating, bottom-hole pump—is connected by a hydraulic power-line with the surface power source, consisting of a triplex pump driven by a conventional prime mover. The triplex pump takes suction from the lease-tank of clean crude oil, discharging it to the power-line. At high pressure the fluid is moved to the production unit or subsurface engine, returning to the surface with the fluid which it has served to lift.

As a rule, the surface unit is located near the lease-tank battery. By thus obviating the necessity for the operator to visit individual wells, much time is saved in pumping a lease. On multiple-well leases the power-oil from the triplex pump is discharged to a header at pressures ranging from 700 to 1500 lb./sq. in. Individual power-lines to all wells in the system are connected to this header. On some units each line is equipped with two valves: a block-valve for use in shutting down and starting the well pump, and, down-stream from the block valve, a metering valve. The metering valve is set to admit power-oil to each well in the quantity required to lift its allowable together with salt water in a fixed production period. Such valve-settings remain fixed until increased salt water withdrawals require their resetting. Thus an entire lease can be pumped during a certain period each day. On some leases a small measuring tank is installed to allow the checking of water and oil percentages from individual wells. This periodic check aids in maintaining full allowable production from each well in the system.

Pump-strokes can readily be counted by observing the slight fluctuations of the gauge-needle on each power-line at the surface unit. This allows a constant check on pump performance. Well conditions, such as froth, pump-off, and erratic pump performance due to possible clogging or binding, can be noted at the surface unit, and necessary steps can immediately be taken to correct such conditions with minimum service cost and loss of production. Approximate bottom-hole pressures can also be determined from these manifold gauges.

A. H. N.

1090.* Preliminary Examination of the Possibilities of Flooding Old Burbank, Oklahoma, Field. R. L. Ginter. *Oil Gas J.*, 14.8.41, 40 (14), 56.—In studying the possibilities for increased production in the old Burbank field, Oklahoma, by water-flooding methods, data have been procured and calculations made which are of significance at this time, when consideration is being given to applying this secondary method in Oklahoma to deeper horizons than are exploited in the Nowata area. For the last five years water-flooding in Oklahoma has been largely concentrated in the Nowata field of Nowata and Rogers Counties in the north-eastern part of the State, where oil has been produced for thirty-five years from a sand body at depths between 450 and 550 ft. In looking for areas where water-flooding may be applied profitably, the opportunity for applying this method in the old Burbank field has been examined. This field, which is about 60 miles north-west of Nowata, was opened for development in 1922, and produces from depths of approximately 2700 ft. Results of studying this field to determine what can be accomplished by water-flooding are presented.

A. H. N.

1091.* Complete Tedious Workover Job in Deep Well on Gulf Coast. N. Williams. *Oil Gas J.*, 21.8.41, 40 (15), 49—50.—An unusually tedious and exacting deep-well work-over job, involving an attempt to restore production from a horizon in which the well had ceased flowing prematurely due to salt-water head, was recently completed by one of the major companies in the Old Ocean field, Brazoria County, Texas. Although the attempt was unsuccessful, efforts of the operators were rewarded when the well was eventually completed as a good producer in a slightly shallower deep sand.

The well was originally completed last January in a sand horizon topped at 10,132 ft., where 7-in. casing, cemented at 10,889-ft., was perforated. The hole had been drilled to a total depth of 10,990 ft. On potential gage the well flowed at the rate of 485 brl. daily through a $\frac{1}{2}$ -in. choke. Recoverable reserves of the well were estimated at that time to be approximately 250,000 brl., but only 20,000 brl. of this had been produced when the well went dead. The work-over job is detailed.

A. H. N.

1092.* Electric Pumping Units Gaining Favour in West Virginia Fields. H. S. Brubaker. *Oil Gas J.*, 21.8.41, 40 (15), 52.—Electric pumping units have many advantages over the older methods. Some of these are: (1) lower first cost; (2) minimum of maintenance; (3) uniform daily pumping, if desired seven days a week or several times a day, if necessary; (4) can be operated automatically with time switches and do not require attention more than once a week; (5) conservation of natural gas which can be sold to gas companies or used for repressuring when necessary; (6) require no cooling water in their operation, hence no freezing troubles in the winter.

The average oil-well pumper is paid about \$125/month and is given charge of from five to seven wells, so that the labour item alone on gas-engine pumping is from \$18 to \$25/month. With the present wage-and-hour law in effect, pumping is frequently limited to 40 hr. a week, and very few companies pump on Sundays; however, the automatic electric unit will pump seven days/week, which gives an increase in oil production.

A. H. N.

1093.* Economics of Paraffin Removal by Electrical Heating. C. R. Rider and B. Turner. *Oil Gas J.*, 28.8.41, 40 (16), 40.—Operators in the Texas Panhandle using sucker-rod pumping equipment are, at present, utilizing five distinct methods to remove paraffin accumulations from the tubing. They are as follows: (1) *Steaming*.—In general, some operators steam down the tubing at regular intervals, whilst others use steam and hot water between the tubing and casing. (2) *Rod Scrapers*.—Scrapers are generally passed at 30-, 60-, or 90-day intervals, depending on the extent the well tends to "paraffin up." (3) *Chemicals*.—When chemical paraffin solvents are used, the usual practice is to pour a predetermined quantity into the tubing after the well has flowed off. (4) *Back-pressure Method*.—This method involves pumping against a back-pressure valve which is inserted in the lead line, generally near the well-head. (5) *Intermittent Electrical Heating*.—Basically, the method supplies heat to melt the paraffin in the tubing by passing a direct current through the tubing and rods, and using them as elements of a resistance heater. The tubing is insulated from the tubing head and casing by special insulation. At a point in the well below which paraffin is known to form, contact is made between the tubing and casing to complete the circuit to the surface. Heat is generated in the tubing and rods, rather than in the casing, because the former have a smaller metal area, with consequent higher resistance.

Current is supplied at the surface by a high-amperage, low-voltage generator. Contact is made to the well-head by means of removable cables, the tubing being used as the positive, and the casing being used as the negative terminal.

After applying the current to the tubing for a period varying between 1 and 2 hr., the generating truck is disconnected and the melted paraffin pumped out of the tubing. In addition to the five methods outlined as being used to remove paraffin accumulations, numerous variations and combinations of these methods have been tried and are being used. Obviously, wide differences in opinion exist among the various operators as to the most economical method of combating the paraffin problem.

Detailed costing shows the advantages of the electrical heating method.

A. H. N.

1094.* Gas Volume Determined With Portable Measuring Device. H. F. Simons. *Oil Gas J.*, 28.8.41, 40 (16), 50.—To facilitate the taking of volume and pressure tests on the wells on a repressuring operation in the Glenn Pool of Oklahoma, the engineers in charge designed and built a special tester. This includes the orifice, manometer, and spring gauge mounted so that all instruments can be connected on the producing wells and a reading obtained in less than 2 min. Orifice plates have been installed on the input wells, and it is only necessary to have the manometer and spring-gauge mounted for testing them.

A U-tube of copper pipe and flexible brass tubing 1 in. in diameter is used for directing the gas through the orifice and back into the line; the flexible tubing is used, as the spacing of the openings on the line bypass is not the same in all cases, and if a U-tube of pipe were employed it would place the connections in a strain. On the bottom of each end of the U are $\frac{3}{8}$ by 4-in. brass nipples and unions. The nipples are equipped with wings so that the connection can be made without the aid of a wrench.

The unions can also be made up by hand, and the only place a wrench is needed is in removing the steel-plugs from the tees in the bypass.

A 16-in. section of the 1-in. copper pipe is above the union on the inlet side and ahead of the orifice, which is held in a special union. One of the problems in designing the instrument was determining the shortest possible length of pipe to be used ahead of the orifice union and still have assurance of the accuracy of the readings. Copper tubing $\frac{1}{8}$ in. in diameter is employed for connecting to the manometer and the pressure gauge, and is soldered to prevent leaks.

To obtain a reading it is only necessary to remove 2 $\frac{5}{8}$ -in. plugs from the by-pass on the flow-line, insert the connections on the assembled instrument, tighten them by hand, and close the stop-cock on the line so that the flow from the well is directed through the by-pass. It takes about 2 min. to get a test, and the engineer operating the instrument can walk and carry the instrument and gauge more than thirty wells per day. As there are eighty wells to be tested weekly, it is apparent that an efficient method is necessary if the engineer is to have any time for other work. A. H. N.

1095.* Water Flood Proves Successful in West Central Texas Pool. R. M. Sanford. *Oil Gas J.*, 28.8.41, 40 (16), 53.—West Central Texas, with its many shallow fields, ranging in depth from 200 to 1500 ft., offers one of the most promising secondary oil-recovery areas in the United States. Comparatively little secondary-recovery work has been done in the district, and practically no water-flooding has been undertaken. It is possible, however, that in future appreciable work will be undertaken along these lines.

An experimental tract in the old shallow Woodson field in Throckmorton County has responded favourably to water-flooding, and as a direct result five separate fields, comprising some 600 semi-depleted wells, are now being made ready for water-flood projects.

The field had produced approximately 3000 bbl./acre up to the start of the water-flood six months ago. Core tests showed that about 500 bbl. oil/acre-ft. were still remaining in the formation. The operators expect to recover about 60% of the remaining 500 bbl./acre-ft. or about 4200 bbl. oil/acre, based on an average pay thickness of 14 ft. This would make a total oil yield under both primary and secondary-recovery practices of 7200 bbl./acre. These calculations and recoveries have been found applicable to the other projects being prepared for flooding; thus their ultimate recoveries will be about the same as this experimental flood project.

In December 1932 the total monthly oil production of the Woodson field was about 650 bbl. In 1934 total field production had fallen to an average of 160 bbl./month. From 1935 to 1940 the field was definitely in the stripper-well class and making an average of 120 bbl. oil/month. The field production is now up to 1000 bbl./month, and a total oil production of 1500 bbl. is expected for August. This steady rise in monthly production is being obtained entirely from the 39-acre lease under flood, and a much greater increase is expected after the entire field is placed under flood.

The experimental flood has cost an average of \$750–1000/acre to water-flood some Oklahoma fields and \$3300/acre to flood the 1700-ft. fields of Pennsylvania.

A. H. N.

1096.* Co-operative Application of Modern Well Workover Programme Reduces High Gas-Oil Ratios Sharply. G. M. Wilson. *Oil Wkly*, 21.7.41, 102 (7), 20–23.—As the prorated per-well allotment of oil production for each well is based on the amount of gas produced along with each barrel of oil—5000 cu. ft. of gas/bbl. being considered the maximum at the present time, and above which daily allotments are reduced proportionately—various methods have been employed in performing certain remedial work to shut off part of the gas, and thus reduce the gas-oil ratios of the penalized wells. By means of corrective work that had its inception in the latter part of 1937 through the co-operative work of the Goldsmith Pool Engineering Committee, and in the taking of more than ordinary precautions in completing subsequently drilled wells in the field, the average weighted gas-oil ratios have been brought down to approximately 1500 cu. ft./bbl., with comparatively few wells now exceeding the 3000 cu. ft. ratio limit set by the field rules. This does not include a few wells in certain parts of the field that are classed as gas wells, and which do not produce any appreciable amount

of oil. Many wells the gas-oil ratios of which were as high as 50,000-100,000, with a few wells even exceeding this mark, have been subsequently worked over under the programme and brought down to below the penalty-free ratio of 5000.

Details of the programme are given.

A. H. N.

1097.* Dehydration in High-Pressure Gas Operations as Applied to Repressuring and Pressure Maintenance. R. A. Carter. *Oil Wkly*, 21.7.41, 102 (7), 29.—*Paper Read Before Natural Gasoline Association of America.* Hydrate formation and its prevention are studied from the point of view of pressure maintenance and repressuring. Partial dehumidification is certainly the most reliable and trouble-free method of solving the hydrate problem, and two methods have been successfully employed. A method using a solid material such as activated alumina has given good results. This method is described and illustrated.

Methods using liquids, particularly ethylene glycol, are also detailed. The operating cost of either the activated alumina or liquid system is small when installed in a repressuring or pressure-maintenance plant. Generally no additional operating labour is required, and the make-up chemicals are almost negligible. The initial investment cost on either of these systems is, however, a substantial amount; but since each such installation is a separate problem, it is not practical to assert that one method is less costly than the other. For relatively small rates of flow, however, it has generally been found that the solid material, such as activated alumina for dehydration, is lower on investment cost; whilst for larger flows the liquid dehydration systems have the advantage for initial installation expenditure.

A. H. N.

1098.* Proper Direction of Crank Rotation is Important. F. Swindell. *Oil Wkly*, 28.7.41, 102 (8), 46-47.—Most speed reducers are so designed that the driven sheave can be placed on either end of the high-speed shaft, so it is not surprising that many installations of this type are being operated with the crank rotating in the wrong direction. This may result in the use of from 3 to 10% more power than is necessary and in excessive bearing wear due to the induction of unnecessary friction. By the use of a simple rule anyone involved in this problem may determine the proper direction of rotation.

The rule for determining the proper direction can be stated thus: If the distance from the centre or saddle bearing to the upper pitman or tail bearing is the same or nearly the same as the distance between the centre line of the same post and the centre of the slow-speed shaft on the speed reducer, the unit should be operated in counter-clockwise or reverse motion; if the latter distance is much greater than the former, clockwise or forward motion should be used. It is suggested that it would be a good practice for all manufacturers of this type of equipment to specify the desired direction of rotation in their installation instructions.

A. H. N.

1099.* Completion Costs Cut by Cleaning with Compressor. G. M. Wilson. *Oil Wkly*, 11.8.41, 102 (10), 17-18.—A method of cleaning out flowing wells during completion operations by use of a compressor is being used with good results and a definite saving in initial cost of the wells by one company operating in the Wilmington field of Southern California. A portable, low-volume, high-pressure compressor is used to remove mud, water, and dead oil from either the casing annulus or the tubing string, after which live oil and gas are allowed to enter from the formation.

The same procedure cannot be applied to every well, since many variable factors are involved. Production may be obtained in most parts of the field, from any one or several of four distinct zones. The method of completion, whether single or multiple zones, sizes of casing and flow-strings, gravity of the oil, and the anticipated rate of production in that particular part of the field based on wells in the same area all tend to influence the exact procedure to be followed, so each new well is treated almost as a special case. Oil gravities in this field vary from 14° to 26° A.P.I. in the Ranger and Upper Terminal, and between 26° and 31° in the Lower Terminal. The method is detailed.

Since the adoption of this extremely flexible system of cleaning up and putting the new wells on production, much less time is involved in cleaning up around the well; very little oil is sprayed up in the derrick, and the possibility of polluting the nearby harbour and tide-water drainage systems is greatly decreased.

A. H. N.

1100.* Automatic Scrubbers and Multiple-well Metering Effect Saving. G. M. Wilson. *Oil Wkly*, 18.8.41, 102 (11), 17-18.—A new and successful method of automatically separating, desanding, metering, and moving crude oil through the gathering system to the lease shipping tanks is being used with economical and consistently good results by a company operating in the Wilmington field of Southern California. Of still greater interest is the fact that the production from more than one well may be continually metered into a common gathering-line system 24 hr./day through but a single registering meter and shipping pump. Centralized units of four wells each are in common use, whilst an eight-well unit is being designed and built for early installation.

Production in this field comes from both flowing and pumping wells, the oil gravities from the several zones varying between 14° and 31° A.P.I.

A typical unit consists of four producing wells that deliver the gross fluid into as many scrubbers grouped together at a convenient centralized location. Gas, water, and sand are separated out in the scrubbers. As the rising oil level in any particular scrubber reaches a certain height, a float automatically closes an electrical switch, which opens the oil-discharge line to the pump and starts the electric motor-driven centrifugal pump. As the oil leaves the pump it passes through a specially designed multiple-head registering meter, after which it passes out into the oil-gathering lines. A system of special solenoid and electric relay switches, mounted on a nearby switch-panel, regulates the order of emptying of each scrubber, and also makes it impossible for more than one to be discharged through the pump at the same time.

The method and apparatus are described in some detail, together with safety and other precautions. A. H. N.

1101.* Analysis of Lifting Performance in Natural-Flowing Wells. S. F. Shaw. *Oil Wkly*, 18.8.41, 102 (11), 21.—The flow of oil by virtue of gas energy is discussed in great detail in this comprehensive paper. The complexity of the problem is great even when compared with the difficult analysis of air-lift of water where the gas is nearly perfect and solubility complications do not exist to any great degree. After the well is opened to production, the variables that accompany the performance of a flowing well are as follows: Quantity of oil produced over a given period; quantity of gas produced; bottom-hole flowing pressure; and discharge pressure, or back pressure, at the tubing head. If the flow is through the tubing, and the fluid in the annular space has been displaced by gas to the bottom of the tubing string, close approximations of the flowing pressure can be ascertained by adding the weight of the column of gas to the casing pressure at the well-head, without the necessity of running a pressure-bomb. If any doubt exists as to flowing pressure being correct, a pressure-bomb should be run to obtain accurate pressure data.

In a well on natural flow, after the tubing is suspended in position the only changes that can be made in the flowing conditions that lie within reach of the operator are those of enlarging or reducing the size of the choke, which changes affect all four flowing conditions mentioned. Enlarging the choke usually results in the production of an increased quantity of oil and gas; the well-head discharge pressure, or back pressure, usually declines; the flowing pressure at the bottom of the tubing declines; and the casing pressure also declines, provided the annular space between the tubing and casing is free of liquid and that no packer has been set.

In natural flow, as in gas-lift flow, there are four principal rates of flow, as follows: (1) point of no flow, due to insufficient gas being present to lift the oil above the top of the eductor; (2) the rate of maximum efficiency or rate of minimum output factor; (3) the rate of maximum capacity, or rate of minimum flowing pressure; (4) the point of no flow caused by excessive quantity of gas.

The rate of no flow due to insufficient quantity of gas is, as a rule, of theoretical importance only, and for natural flow need not be considered. The rate of maximum efficiency is one of considerable importance, but lies in the region of production where there is surging in the flow column, therefore it cannot easily and satisfactorily be located directly by tests, except to plot the tests and locate the point on the flow-graph. The rate of maximum capacity is probably the easiest of all significant rates to locate, and in many respects is the most important rate to determine in gas-lift operations. There are, of course, innumerable other rates of flow, but such rates are at the expense either of efficiency or of capacity, and have little significance in connection with oil-well testing operations. After stressing the need for accuracy in measur-

ing the variables, the paper discusses actual well studies under conditions where no back pressure is imposed and where such pressures are used.

In wells where the reservoir rock is of a low degree of permeability, much care must be exercised when opening the choke for the purpose of obtaining higher flowing rates, otherwise the well may unload to the point where the gas in the casing flows out through the tubing, reducing the flowing pressure to a low point, and afterwards allows considerable oil or water to rush into the well and load it up, during which time there will be no flow from the eductor, and the well may then run for a long time in heads or refuse to flow at all. Such changes must be made gradually, to prevent heading action.

A. H. N.

1102.* Time Switches Control Periodic Pumping of Marginal and Prorated Wells. G. M. Wilson. *Oil Wkly*, 25.8.41, 102 (12), 17-20.—Through installation of electric time-switches, which automatically start and stop pumping operations at predetermined intervals suitable to individual well characteristics, the mechanical difficulties usually associated with continued operation of marginal wells after they have been pumped off are being avoided, and prorated wells are being shut down on producing their daily allowable, or started when desired without manual attention. By relieving the pumper of these starting and stopping duties, he is given additional time to cover his territory and properly service a greater number of wells. Thus, less frequent pulling of jobs and appreciable reductions in other lease expense are resulting.

When fluid level is at or near the pump intake, free gas has a tendency to by-pass the fluid as the latter enters the pump-barrel, usually resulting in the cutting and scoring of the balls and seats. Pump-barrels sand up much easier (if the well produces from a sand formation), and because the travelling valve "pounds fluid" on each down-stroke, emulsion troubles usually result.

The time-clock, containing a mechanism which trips a switch at any desired number of points around the face of a clock-dial, is contained in a small metal box which is bolted beside the standard supporting the main pump-switch. As the hand on the clock makes contact with one of the predetermined points, it closes an electric circuit energizing the magnetic switch in the main switch-box, thus starting or stopping the pump-motor. It is possible to operate the switch manually should it be necessary at any time.

Many wells that have been equipped with this automatic system have actually begun to show a slightly higher daily rate of production than previously. When a formation is producing fluid at as nearly a constant rate as possible, thus maintaining a more or less constant differential pressure between the sand-face and the well-bore, the movement of oil and gas towards the well from back in the formation will proceed at a more nearly uniform rate. Any tendency for the gas to by-pass the oil in the sand interstices, especially in fields troubled with higher-than-normal gas-oil ratios, will thus be minimized, resulting in a more efficient use of the driving energy of the gas.

A. H. N.

1103.* Flow of Distillate Wells Requires More Complicated Equipment and More Careful Handling than Oil. E. Sterrett. *Oil Wkly*, 25.8.41, 102 (12), 22-23.—Equipment for successfully producing a distillate well is much more complicated than that which will handle, for example, an East Texas field oil-producer. Added equipment and more delicate adjustments to maintain the desired pressure, temperature, and flow balances impose on the switcher duties which require close supervision, and, in consequence, the number of such wells which one man can flow is limited both by the attention required and the fact that distillate wells are usually wide-spaced.

One well, for example, producing from the Paluxy in the Chapel Hill field, under proration regulation, can make more than 5000 bbl. of distillate/month, and furnish upwards of 15,000,000 cu. ft. of dry gas.

To secure this flow, the switcher must watch six sets of equipment, each adjustable to deliver required amounts, and each governing its successor and being dependent on its predecessor in the production line for proper functioning.

The flow equipment of this particular well is described in some detail and illustrated photographically.

A. H. N.

1104.* Portable Concrete Forms Asset When Multiple Foundations Are Poured. Anon. *Oil Wkly*, 25.8.41, 102 (12), 26.—Locating and levelling forms for concrete bases for heavy engines and pumps must be carefully planned and carried out, if the eventual setting of the power units is to present the mathematically exact line which is evident in the well-planned and set-up power plant. With stations depending on internal-combustion units the number may amount to a dozen or more, greatly increasing the chance of one form slipping or drifting slightly and thus forcing the corresponding engine base a trifle out of alignment with the others.

The paper describes an ingenious method used for putting down concrete bases for twelve 600-h.p. 12-cylinder gas-engine compressor units, the method resulting in the casting of all bases in a continuous structure with the desired precision.

The forms were built up as four separate panels, each composing one side of the completed unit, and fitted together rigidly at the corners with accurate dovetailing to maintain sharp, clearcut foundation corners. The separate panels, assembled into a form at a site just back of the location of an engine unit, were designed with brackets on alternate vertical braces of the two transverse sides, through which heavy beams were run and securely fastened. These arms or handles extended 5 ft. in each direction beyond the corners of the structure.

A. H. N.

1105.* Suggested Method of Measuring Input Profile of Intake Wells. E. P. Bowler. *Oil Wkly*, 1.9.41, 102 (13), 25.—The method of measuring the input profile of a well as outlined in this paper was developed in an attempt to give the producer a practical and economical method by which he might determine the exact amount of water entering each succeeding portion of his sand-body. An exact replica of the field conditions as illustrated in this paper has been developed in a laboratory set-up, and each principle explained herewith has been tried and found to be both theoretically and practically sound in so far as this model arrangement is concerned.

The principle on which this method is based is the use of two immiscible fluids such as water and crude oil. It consists essentially of lowering a string of pipe inside the water-well tubing until the lower end of the pipe extends down into the pocket below the bottom of the sand. The lower end of the pipe is open. At the surface the top of the string of pipe is connected to the water-line and the well is allowed to maintain its normal input/day through the inner string. The 2- or 1½-in. water-well tubing at the well-head is now connected to a high-pressure, low-capacity pump, which in turn is connected to a crude-oil supply.

For simplicity it is assumed that the well is tubed with 2-in. seamless pipe anchored with a hook-wall packer which is cemented a short distance above the top of the sand. The well has 24 ft. of sand. The inner string consists of 1-in. pipe lowered through the 2-in. tubing, and allowed to extend into the pocket below the bottom of the sand. At the beginning of the experiment the water is injected into the entire sand-body and a measurement taken of the rate of input on the flow-meter arrangement in the water-line. This would represent normal intake/day for the well. A pressure in excess of the water-line pressure is now built up at the oil-pump, and the oil is allowed to flow into the well through the annular space between the well-tubing and the inner string, impressing itself on top of the water. The oil-water contact level is maintained successfully at 1, 2, 3, etc., ft. below the top of the sand, and the rate of water intake is measured. The oil flows into the sand and acts as a packer for the portion of the sand it covers, in so far as the water is concerned. Thus, the effective permeability of the sand to water is measured foot by foot.

The contact level is determined by means of passing current under constant voltage through the fluid occupying the space between two electrodes. As the oil travels downwards, the resistance increases. An ammeter at the surface thus indicates the level which can be accurately maintained by manipulating the oil-valve.

The paper is detailed in treatment and well illustrated.

A. H. N.

1106.* Throttle Control of Pumping Engines. F. Swindell. *Oil Wkly*, 1.9.41, 102 (13), 40.—It is pointed out that when the flow of power is irregular under governor operation, it can usually be made much smoother by the use of a set throttle. Many engines when delivered are not equipped with an arrangement for dependably setting the throttle, but in these cases a device can be installed easily and cheaply.

The workings of a governor control are described.

In throttle operation the governor is set at some point above the maximum speed that the engine will develop under normal operating conditions. Usually, this should not be over 50 r.p.m., depending on the sensitiveness of the governor. For instance, if the maximum speed is 1000 r.p.m., then the governor is set at 1050 r.p.m. With the well pumping under normal conditions the throttle is then set to permit only that amount of fuel which will enable the engine to run at 1000 r.p.m. Care should be taken that the well is fully pumped up when the throttle is adjusted. With this condition obtaining, if the sucker-rods should part, or any other of the equipment should break, so that the load on the engine is materially reduced, its speed will increase until it reaches 1050 r.p.m., at which speed it operates against the governor until such time as the switch is turned off or the fuel supply becomes exhausted. Thus, the safety provision of the governor is available under throttle operation.

A graph presents the results of a field study of governor-versus-throttle operation wherein the prime mover was a 4-cylinder gas engine; the well was equipped with $\frac{3}{4}$ -in. rods and a 2 $\frac{1}{2}$ -in. insert-type pump set at approximately 4600 ft. All operating conditions, as nearly as could be observed, remained the same throughout the study, except for the changing from governor to throttle operation. One test was made immediately after the other, and all the work was completed within a few hours. Both the speed and the h.p. graphs show definite advantages obtained with throttle control. The fluctuations and maximum values were less in the latter case.

A. H. N.

1107.* Cycling Plant in Swamp Area Permits Profitable Operation of Isolated Wells. F. H. Love. *Petrol. Engr*, August 1941, 12 (12), 29-30.—The plant is small, having but one compressor and handling only 8,000,000 cu. ft. of gas/day. Two producing wells (whose depths exceed 10,000 ft.) are connected to the plant, and gas is returned to a single injection well. The output of the plant, which operates on the straight retrograde separation principle, is approximately 200 bbl. of condensate/day.

The plant and injection well are on the west side of the Atachafalaya River, and the producing wells are on the east side, about 600 ft. distant. Lines from the wells to the plant pass through the river, and during cold weather, when the river-water temperature falls to as low as 49° F., it is necessary to heat the gas before it enters the river and again when it emerges on the other side, to prevent hydrate formation. Immediately before entering the river the gas-streams from the two producing wells merge in a common line and pass through a water-bath-type heater. On the west side of the river, which is the side nearest the plant, the gas-flow passes through a second heater of the same type. The first unit heats the gas to a temperature of 110° F. By the time the gas reaches the west side of the river this temperature has been reduced to about 80° F. and in the second heater this is increased to 100-105° F. Certain details of the plant are given.

A. H. N.

1108.* Essential Factors in Planning Paraffin Solvent Treatments. G. F. Williams. *Petrol. Engr*, August 1941, 12 (12), 93.—It was observed that debris taken from the mud anchors of pumping wells contained carbonate scale particles cemented together by paraffin. These wells responded to a slight degree by washing out with salt water. Further, it was found that they could be filled with oil or water, a condition not normal in old, partly depleted pumping wells. As time passed, the wells made less and less fluid, although wells of this area were usually prone to increase in salt-water production as daily oil output decreased.

With the foregoing facts in mind, the theory was developed that the proper paraffin solvent spotted on the face of the pay would dissolve at least one part of the plugging agent on or near the sand-face. Any oil increase here would prove that progress was being made in solving the problem economically.

A pumping well was first selected because the carbonate scale had been removed already by a commercial scale-removing chemical treatment, resulting in a production increase of from 5 to 70 bbl./day. This scale was known to contain paraffin as an additional plugging material.

In making the paraffin removal treatment, 50 gal. of commercial paraffin solvent was pumped into the casing using a low-pressure pump, followed in this particular

case with the casing volume of water. The water was lighter than the solvent, but heavier than the oil. The tubing with rods in place remained open during the treatment, but the tubing and casing were both closed-in overnight after the application of the solvent. The well was put on the pump the following morning, and averaged 100 brl. daily for the next 30 days, an increase of 30 brl./day, attributable to the solvent treatment. The total increase in production in the 30-day period was 900 brl. The approximate cost of the entire treatment was \$75 for solvent plus \$25 for labour. Other cases are given in detail.

Generally speaking, in making treatments such as those described, the following points should be remembered: (1) In order for a treatment to be successful, the well's flow must be impeded by paraffin; (2) the paraffin must be soluble in the particular solvent used; (3) in making a treatment, a considerable quantity of oil must be used in flushing down the solvent—for this purpose operators have been using oil from the identical well being treated; (4) when the circulation method of treatment is being used, a sufficient circulating time, generally 12–24 hr., should be allowed. A. H. N.

1109.* Design and Installation of Hydraulic Well-pumping System. H. L. Flood. *Petrol. Engr.*, August 1941, 12 (12), 102.—Essentially, an hydraulic pumping system consists of two major parts: (1) the surface, or hydraulic power unit supplying clean power oil to (2) the subsurface, or production unit. The power-unit pumps clean crude oil down the well under sufficient pressure to operate the production unit, which consists of an hydraulic reciprocating engine directly connected to a reciprocating pump. The production unit is usually run as an insert pump, seating in a shoe in the well-tubing in the conventional manner. The tubing on which the pump is run serves to conduct the power oil from the surface to the subsurface unit, and is termed the power-oil tubing. The discharged power-fluid mixes with the crude oil produced from the formation, and is returned to the surface in the annular space between the power-oil and well-tubing strings.

The paper details the actual designing undertaken in a specific case, giving the major considerations taken into account.

The fluid produced from the wells, including the spent power-oil, is gathered and delivered to the central plant through the gathering system already serving the wells prior to the pumping installations. The total volume of fluid produced first enters the elevated gas-oil separator. The fluid, after the gas is separated, gravitates to the base of the vertical gun-barrel, containing 6 ft. of water, through which the oil is washed as it passes upward in the tank. Additional gas coming out of solution in the gun-barrel is removed through the outside gas separator or boot.

Only that quantity of the oil produced which is required to supply the power-unit enters the horizontal settling-tank from the vertical gun-barrel; the remainder passes directly to the stock-tanks. Thus, only a relatively small volume of the total oil is subjected to conditioning as power-oil. The effective settling time in such a large vessel as the horizontal tank is thus materially increased.

The inlet to the settling-tank is perpendicular to the axis of the tank on top at one end of the tank, and the outlet or suction line to the triplex pumps is at the other end, 2 ft. from the top, and parallel to the tank axis. Consequently, the oil enters the tank in a downward direction, then has its flow altered to horizontal, and is withdrawn 2 ft. from the top on the other end.

A. H. N.

1110.* Air-Cooling in Pressure Maintenance Plants. E. O. Bennett. *Petrol. Engr.*, August 1941, 12 (12), 124.—Good clean water, free from sediment and chemicals that will deposit in engine-jackets under normal operating temperatures, is absolutely essential for continuous trouble-free operation of large gas-engines. In some locations where compressor plants have been built during the last two or three years no water is available. Some of these locations are in hot, dry areas in which the normal midsummer temperatures rise above 100° F. and the humidity is very low.

Evaporative-type coolers work well at such locations and do an efficient job of jacket cooling; but losses due to windage and evaporation may make their use uneconomical, and a system in which water losses are minimum must be used. Such a system naturally suggests that the jacket-water be circulated in a closed system and that atmosphere be used to remove heat from the closed system. In its simplest form this is known as radiator cooling.

Such an installation is described. Three coolers are connected in parallel between intake and discharge headers, and serve to cool the engine and compressor jacket-water from two 400-h.p., direct-connected, gas-engine-driven compressor units.

An unusual feature of these cooling units is that the engine lubricating oil as well as the jacket-water is cooled by the same propeller fan in each unit. The air is pushed by the fan through a water-cooling section 8 ft \times 8 ft. and about 3 in. thick. Immediately in front of the water-cooling section there is an 8 ft. \times 8 ft \times 1½ in. section for the engine lubricating oil.

The engine jacket-water circulates through a closed system, and the water is treated for corrosion with an inhibitor. These units have now been running for 2 years, and the jackets have been entirely free of scale or corrosion. The 800-h.p. cooling sections require less than 1 gal./week of make-up water, and have satisfactorily handled the cooling in the hottest weather yet encountered.

A. H. N.

1111.* Directional Drainage. S. C. Herold. *Petrol. World*, July 1941, **37** (7), 46.—The ease of decreasing or increasing diagonal flow up the structure where the sands are fairly homogeneous laterally and unbroken by faults depends almost entirely on the pattern of well locations at depth and on the allocation of production at various wells. The existence of a gas-cap on the crest of the structure facilitates this control of diagonal flow by preventing drainage from the opposite side of the structure over the top of the fold.

In order to illustrate diagonal flow, the simple case of two groups of wells located on more or less the same structural contour at some short distance apart can be cited. Such groups will not only pull the fluids directly up the structure, but will also pull from the converging diagonal direction down the structure. The latter will cause more rapid encroachment of edge-water in those directions, for both groups are taking fluids from properties located there. Any wells which happen to be located on those properties will lend to this encroachment. Edge-water will appear there sooner than on properties immediately below the groups. This circumstance has frequently been noted in practice in the fields of California.

Again, if eight of sixteen wells are evenly spaced over 160 acres, and if each is allowed its maximum of 150 bbl. of oil, diagonal drainage can be enhanced by confining the total allowable amount to one or more of the wells at one side or in one corner of the area. Co-operation with another area at some short distance away will establish the situation of the two groups previously cited.

Where the productive sands are heterogeneous laterally, or broken by faults, controlling directional drainage is restricted.

A. H. N.

1112.* Cotton Valley Project. Anon. *Refiner*, August 1941, **20** (8), 317.—A descriptive and pictorial record is presented of the Cotton Valley project in an extensive feature of the present issue of the *Refiner*. Recycling at Cotton Valley is the outgrowth of an agreement between operators and royalty owners. The agreement in turn was incorporated in an order of the Louisiana Department of Conservation. Thus the sands below the base of the Travis Peak formation were unitized for production. The plant serves for maintaining pressure and for recovering condensable liquids from the D and Bodcaw sands. Other sands which may become productive within the formations included in the agreement will also be operated under unitization.

For operating purposes the deeper sands have ceased to have production by leases of ownership. This has come under the management of the Cotton Valley Operators' Committee, which built and operates the plant.

Participation in the agreement is on an acreage basis. The owner of a lease shares in expense and profit in whatever ratio his acreage total bears to the area under the agreement. Cost of the plant was prorated on this basis. Likewise royalty owners will share in return in whatever ratio their surface holdings bear to the total surface within the unit.

Thus the total content of two distillate-bearing sands became available for recovery through one plant and under a common operation. Output is taken from wells as dictated by engineering studies rather than by lease lines. After recovery of liquids the gas is put back in the two formations in wells that offer the most advantageous means of maintaining pressure.

Content of the deeper sands at Cotton Valley is within the retrograde range, wherein all hydrocarbons are in the vapour stage. Condensation therefore takes place upon reduction of pressure. Conventional production methods whereby wells are flowed into separators, which prevailed in the field from 1937 until 1941, results in condensation within the reservoir, since withdrawal of gas brings consequent reduction of pressure within the reservoir.

Original liquid content of the two sands was estimated at 47,000,000 bbl. of distillate. The period during which wells were produced without maintenance of pressure is calculated to have resulted in 14,000,000 bbl. of this total being lost, since pressure maintenance is not calculated to restore the original reservoir pressure.

One other sand is known to hold content similar to the two now under development. Additional sands are considered likely sources of similar hydrocarbon content. In addition to distillate-bearing gas from the two deep sands, the recycling plant takes casing-head gas from the series of rim wells, which are classed as oil producers and not included in the unit agreement. This gas is part of the daily sales for commercial use.

A. H. N.

1113.* What Shall be Done About Proration? Part II. O. W. Willcox. *World Petrol.*, August 1941, 12 (8), 36-41.—The purpose of this series of articles is to acquaint the petroleum industry of the United States with developments which show the ultimate form which may be given to a system of industrial proration, with limitation and control of production in the interest of both the industry and the general public welfare.

In a fully developed system of industrial proration there is no such thing as a marginal producer who is in danger of becoming submarginal when prices swing downward, because his colleagues and his Government (with the public approving) join hands to keep him afloat by means of special concessions.

The first and most important task confronting an industry that meets in plenary conference to devise a nation-wide, all-inclusive system of proration is to divide the business on a basis that will not be arbitrary or discriminatory. The method adopted in most prorated sugar industries is the so-called peak-year scheme, according to which the highest annual tonnage production attained by a factory during its past history is taken as its rated capacity, and its relative share in the total production is computed on that basis. However, a strict application of this arithmetical proportion was generally found to be inconsistent with the two main objects that had to be achieved: a low fixed price to the consumer and preservation of the weaker members. As a way out it was generally decided to give to the weaker members certain preferences and concessions. It is extremely interesting and important to note the nature and extent of such concessions. Some relate to details peculiar to the sugar industry, but others are capable of broad application to any industry, including the petroleum industry, and are suggestive of a new order of social economics that is vastly different. These concessions range from granting the weak concerns exemptions from restrictions in production, loans for modernizing their equipment, relief from export obligations and transportation hardships, etc. Although the burden of these reliefs fall on the stronger concerns, it has been found to be to the advantage of these concerns in the long run as prices and markets are stabilized.

The paper details the working of a Central Sales Agency which regulates the industries' affairs.

A. H. N.

1114.* Some Problems of Horizontal Steady Flow in Porous Media. M. P. O'Brien and J. A. Putnam. *Petrol. Tech.*, July 1941, A.I.M.M.E. Tech. Pub. No. 1349, 1-13.—Data on the physical and thermodynamic properties of hydrocarbons have become available during recent years. These are obtained under equilibrium conditions, and their application to flow problems involves the assumption that equilibrium exists during that flow. It is shown that by making the usual thermodynamic assumptions and employing existing data on permeability to two-phase flow, Darcy's law may be applied to obtain the flow characteristics for representative combinations of flowing medium and the geometry of the porous medium. The following cases are investigated numerically: isothermal flow of propane in a horizontal sand-filled channel; adiabatic flow in a horizontal porous medium; isothermal radial flow of a mixture of crude oil

and natural gas, and adiabatic flow with the other conditions the same as for the isothermal radial flow.

The numerical results are not directly applicable to field problems, but the methods are generally valid. The analysis seems to justify the practical conclusion that the flow of multi-component hydrocarbons in porous media is approximately, but not exactly, isothermal, and that deviations from isothermal conditions have a relatively small influence on the weight rate of flow.

G. D. H.

1115. Patents on Production. T. M. Ragan. U.S.P. 2,245,712, 17.6.41. Appl. 13.6.39. Electrically controlled well-packer.

P. C. Norman. U.S.P. 2,245,870, 17.6.41. Appl. 28.3.39.—Method and apparatus for paraffin treatment in wells.

J. P. Ratigan. U.S.P. 2,245,938, 17.6.41. Appl. 20.11.36.—Sucker-rod elevators.

C. S. Crickmer. U.S.P. 2,245,963, 17.6.41. Appl. 5.2.40.—Tubing coupling.

W. L. Church. U.S.P. 2,246,416, 17.6.41. Appl. 25.7.38.—Well-pump with a venturi passage.

A. Boynton. U.S.P. 2,246,500, 24.6.41. Appl. 8.12.39.—Differential stage lift-flow device, bellows type.

B. S. Smith. U.S.P. 2,246,542, 24.6.41. Appl. 1.11.38.—Means and method of locating levels in wells.

O. M. Davis. U.S.P. 2,246,577, 24.6.41. Appl. 17.10.38.—Pump adapted to be inserted in a well.

S. M. Zandmer. U.S.P. 2,246,611, 24.6.41. Appl. 12.10.36.—Method of testing oil- and gas-wells to increase production.

A. D. Garrison. U.S.P. 2,246,725, 24.6.41. Appl. 10.6.38.—Treatment of oil-wells to convert water-wet sands into oil-wet sand.

A. D. Garrison. U.S.P. 2,246,726, 24.6.41. Appl. 28.10.39.—Treatment of oil-wells to increase production.

A. Nelson. U.S.P. 2,246,751, 24.6.41. Appl. 16.1.40.—Submersible motor for deep-well turbine-pumps.

H. C. Otis. U.S.P. 2,246,811, 24.6.41. Appl. 22.5.37.—Well-flowing device.

M. De Groote. U.S.P. 2,246,842, 24.6.41. Appl. 27.6.40.—Process for breaking petroleum emulsions.

L. T. Monson and W. W. Anderson. U.S.P. 2,246,856, 24.6.41. Appl. 26.11.40.—Process for resolving petroleum emulsions.

C. W. Fisher. U.S.P. 2,246,881, 24.6.41. Appl. 25.8.39.—Well-packer for bottom-hole packing purposes.

G. A. Humason and W. J. Clay. U.S.P. 2,247,023, 24.6.41. Appl. 23.9.38.—Universal flow-device for wells.

L. Davis. U.S.P. 2,247,188, 24.6.41. Appl. 3.10.40.—Screen and liner puller.

C. D. Wagner. U.S.P. 2,247,325, 24.6.41. Appl. 5.8.40.—Casing-pump assembly.

R. R. Turner. U.S.P. 2,247,564, 1.7.41. Appl. 18.7.38.—Coupling protector for a pump-rod.

C. F. Prutton. U.S.P. 2,248,028, 1.7.41. Appl. 9.6.38.—Treatment of wells to provide a perforated lining made of resin forced between casing and well-face.

- B. Young. U.S.P. 2,248,211, 8.7.41. Appl. 25.2.39.—Well-tool with a packer on it.
- W. R. McKay. U.S.P. 2,248,302, 8.7.41. Appl. 10.3.37.—Oil-well pump.
- C. A. Rasmussen. U.S.P. 2,248,305, 8.7.41. Appl. 16.5.38.—Producing apparatus for oil-wells.
- M. De Groote and A. F. Wirtel. U.S.P. 2,248,342, 8.7.41. Appl. 22.11.40.—Process for breaking petroleum emulsions.
- S. J. Thomas. U.S.P. 2,248,834, 8.7.41. Appl. 22.1.40.—Sand-trap and filter for oil-wells.
- T. S. Park. U.S.P. 2,248,894, 8.7.41. Appl. 27.11.39.—Sucker-rod guide placed in tubings.
- A. Boynton. U.S.P. 2,248,949, 15.7.41. Appl. 31.1.39.—Differential-type pneumatic piston-pump.
- A. Boynton. U.S.P. 2,248,950 and 2,248,951, 15.7.41. Both appl. 8.12.39.—Differential stage-lift flow-devices using valves on the side of tubings.
- J. R. Gillbergh. U.S.P. 2,248,982, 15.7.41. Appl. 4.1.39.—Method and apparatus for determining the character and points of ingress of well-fluids.
- H. J. Quintrell. U.S.P. 2,249,170, 15.7.41. Appl. 14.10.38.—Liner hanger with an anchor.
- H. J. Quintrell. U.S.P. 2,249,171, 15.7.41. Appl. 19.12.39.—Bridging-plug packing-sleeve for oil-wells.
- H. J. Quintrell. U.S.P. 2,249,172, 15.7.41. Appl. 19.12.39.—Circulation bridging-plug and a setting-tool.
- A. Boynton. U.S.P. 2,250,464, 29.7.41. Appl. 8.12.39.—Differential stage-lift device for wells.
- A. Boynton. U.S.P. 2,250,465, 29.7.41. Appl. 8.12.39.—Differential stage-lift flow device, velocity control.
- P. G. Maugham. U.S.P. 2,250,642, 29.7.41. Appl. 6.11.40.—Transfer elevator for sucker-rods.
- W. A. Rice. U.S.P. 2,250,775, 29.7.41. Appl. 15.8.39.—Apparatus for developing wells by means of a piston closing by-pass holes.
- A. L. Crowder. U.S.P. 2,250,792, 29.7.41. Appl. 1.6.40.—Pump with a double-acting plunger.
- W. J. Lumbert. U.S.P. 2,250,871, 29.7.41. Appl. 27.9.38.—Well-screen made of separate cylindrical sections with bevelled openings.
- W. B. Reed. U.S.P. 2,251,290, 5.8.41. Appl. 2.7.38.—Bottom-hole hydropneumatic power unit.
- C. M. Blair, Jr. U.S.P. 2,251,393, 5.8.41. Appl. 17.8.40.—Composition of matter and process for preventing water-in-oil emulsions resulting from acidization of calcareous oil-bearing strata.
- C. A. Rasmussen. U.S.P. 2,251,421, 5.8.41. Appl. 13.3.39.—Flow apparatus for oil-wells.
- O. C. Mays. U.S.P. 2,251,712, 5.8.41. Appl. 4.3.38.—Means for shooting oil-wells, consisting of a multiple container bomb, the containers having explosives to different degrees of strength.
- A. L. Parker. U.S.P. 2,251,715, 2,251,716, 2,251,717, and 2,251,718, 5.8.41. Appl. 26.1.39, 20.3.39, 29.3.39, and 3.6.39, respectively.—Tube couplings of various types.

A. Arutunoff. U.S.P. 2,251,816, 5.8.41. Appl. 11.5.38.—Submersible electric motor for deep-well pumps.

F. H. Eckert. U.S.P. 2,251,868, 5.8.41. Appl. 13.1.40.—Pumping apparatus for wells.

A. W. Steenburg. U.S.P. 2,252,047, 12.8.41. Appl. 15.9.39.—Well-pumping system and apparatus.

S. T. Tschappat. U.S.P. 2,252,240, 12.8.41. Appl. 16.3.39.—Packing device around a well-tubing.

L. C. Miller. U.S.P. 2,252,270, 12.8.41. Appl. 5.11.38.—Perforating device for a well-casing.

C. H. Mathis. U.S.P. 2,252,271, 12.8.41. Appl. 20.5.40.—Product and process for plugging formations.

W. F. Hollister. U.S.P. 2,252,597, 12.8.41. Appl. 29.3.40.—Well-pump.

F. M. Hudson. U.S.P. 2,252,767, 19.8.41. Appl. 4.5.36.—Standing valve-puller.

A. J. Lageson. U.S.P. 2,252,773, 19.8.41. Appl. 25.8.38.—Pump for pitless wells.

E. B. Hall and A. L. Armentrout. U.S.P. 2,252,973, 19.8.41. Appl. 10.3.39.—Method for testing and producing the fluids of the earth formations encountered in wells.

L. H. Pierce. U.S.P. 2,253,046, 19.8.41. Appl. 9.11.40.—Discharge apparatus for pumps in wells.

A. Pranger. U.S.P. 2,253,092, 19.8.41. Appl. 22.6.37.—Packer.

E. E. Peake. U.S.P. 2,253,396, 19.8.41. Appl. 31.8.39.—Intermittent flow-device for oil well-tubing strings.

E. C. Tanner. U.S.P. 2,253,404, 19.8.41. Appl. 30.6.39.—Submersible electric motor.

G. H. Brodie. U.S.P. 2,253,415, 19.8.41. Appl. 8.9.39.—Means for centring tubular well-strings.
A. H. N.

Transport and Storage.

1116.* Cathodic Method of Controlling Corrosion in Open-Tank Condensers. N. G. Miller. *Nat. Petrol. News*, 9.7.41, 33 (28), R. 222.—Since the corrosion of metal in contact with water is electrolytic in its action, corrosion can be prevented, theoretically, by maintaining the metal at a negative potential with respect to electrolyte solution. Promising results have been obtained in practice by inserting artificial anodes in, for instance, a condenser tank, making the element to be protected the cathode. Four installations in open-tank condensers are described, and the apparatus required and the economics of the process are discussed.
H. G.

1117.* Calibrating Displacement Meters on Volatile-Liquid-Petroleum Fractions. E. W. Jacobson. *Oil Gas J.*, 19.6.41, 40 (6), 48.—The author describes, with diagrams, an apparatus, for the calibration of displacement meters on volatile-liquid-petroleum fractions, such that errors caused by evaporation, change in temperature, and entrainment of gases in the test liquid are eliminated. The necessity for an apparatus of this type is consequent on the need for using, as calibrating liquid, one similar to that which the displacement meter is designed to measure. The effect of calibration with liquids of different viscosities on the degree of accuracy is illustrated in a number of graphs.

The author also describes a simplified commercial type of prover which has been extensively used on a meter-testing programme at the Gulf research laboratory.

T. T. D.

1118.* Conclusions Based on A.P.I. Coating Tests. K. H. Logan. *Petrol. Engr.* March 1941, **12** (6), 100.—In 1940 the American Petroleum Institute concluded an investigation of protective coatings for pipe-lines, that involved forty-six combinations of materials under fifteen soil conditions, at a cost of \$100,000, and lasting 10 years. The present article discusses the results, but in view of the large number of variables, only the outstanding features are dealt with. The A.P.I. final report classifies the coatings into six groups, according to physical type. These groups are: (1) cold applications, (2) enamels, (3) mastics, (4) shielded coatings, (5) reinforced coatings, (6) shielded reinforced coatings. The first group provided inadequate protection against severe soil conditions. One or more of the better coatings in each of the other groups are used to illustrate the relevant phenomena. Continual decreases in the insulating powers of the coatings are shown by condensed tables, and in another table an attempt is made to compare the effectiveness of the coatings in terms of the condition of the pipe. Another table illustrates the protective effects of inhibitive primers.

The main conclusions reached are that:—

- (1) there is a continual decline in all coating efficiency with increasing age;
 - (2) various reasons prevent protection from being complete, even with the best coatings;
 - (3) therefore, instead of attempting to get complete protection by coating, the pipe-line owner would do better to apply a reasonably good coating and supplement it by means of cathodic protection.
- J. C.

1119.* Laboratory Tests of Cathodic Protection in Soils. W. R. Hill. *Petrol. Engr.* March 1941, **12** (6), 69.—The controversy concerning the electrical conditions required for the effective cathodic protection of metal structures in contact with soil, and the desire to obtain more complete data, prompted the S.O.C. of California to carry out a series of laboratory tests, under various conditions, with a large number of steel samples.

In designing the test-cell, etc., an attempt was made to eliminate the common errors, due to variations in current density, variation in soil moisture content, and so on.

The following four soils of widely differing corrosiveness were used:—

- (1) a corrosive low-resistance clay from an alkali flat;
- (2) a dry, high-resistance loam;
- (3) a extremely corrosive clay;
- (4) a typical loam.

The results obtained are illustrated graphically, by curves, of the effect of moisture content on soil resistivity, of corrosion rate against current density and of metal-to-soil potential readings taken during the runs.

Although the choice of a criterion for measuring the effectiveness of a cathodic protective installation is complicated by the effect of soil conditions, the data indicate an inverse relationship between soil resistivity and current density.

J. C.

1120.* Electrical Examination of Coatings on Buried Pipe-lines. J. M. Pearson. *Petrol. Engr.* Midyear 1941, **12** (10), 82.—A description is given of an electrical method of determining the state of a coating on a buried pipe-line, and of locating the actual holes and the ends of coated sections. The method used consists of applying an A.C. current of 0.005–0.010 amp. at 1000 cycles per second from a microphone “hummer” or similar apparatus and locating the electrical leaks with an amplifier. The A.C. current is connected between the pipe and a ground rod 100 ft. away, all current returning to the pipe from the earth, either through holes in the coating, or as charging current via the electrical capacity, or between pipe and ground through the sound part of the coating. At holes in the coating the increased voltage drop in the soil is indicated by the amplifier which is carried along the line, producing a maximum tone. A generally poor coating is indicated by a high reading at right angles to the line, that over the line being low. On location of the leak, the pipe is uncovered, the amplifier grounded to earth, and the coating explored with the free end of the input wire. The conductivity of the coating is measured with the same apparatus, giving a general indication of the state of the coating.

C. L. G.

1121.* Accurate Voltage Control is Feature of New Holiday Detector. D. E. Stearn. *Petrol. Engr*, Midyear 1941, **12** (10), 160.—Present types of holiday detectors for pipeline examination are generally of the power unit, high-voltage generating unit, or exploring electrode type, and rely for the indication of the holiday on the noise or light produced by the discharge, which is frequently difficult to detect. There is usually no convenient method of measuring or controlling the applied voltage, there is usually a variable leak through the lengthy H.T. wire, there is no indication of the condition of the batteries, and the effectiveness of inspection depends entirely on the speed and alertness of the operators.

An instrument has now been designed—the Electronic Holiday detector—in which the discharge is energized sufficiently to cause a change in meter reading, extinguish a green light and illuminate a red light, ring a bell alarm, produce a registration on a counter, mark the location on the pipe, and perform any other electrically controllable action.

It utilizes a high-voltage generator of comparatively low va. capacity, yet high enough to maintain a few thousand volts between the exploring electrode and the pipe while supplying the current normally flowing in the high voltage inspection circuit. Thus the danger of shock or of carbonizing the coating is eliminated. The detector can be used for inspecting interior coatings or insulating coverings of low electrical resistance. In tests it located holidays previously overlooked by two crews with normal holiday detectors, the faults being largely at pieces of carbonized coating materials, at folds of one coating material over another at a different temperature, at thin spots or pits and bare spots produced by a dragging shoe in the coating lead. The results indicate the importance of wrapping the finished coating. The speed of testing is high, a 2000-ft. section being examined in 66 mins. by a crew of three, during which time 360 holidays were located.

C. L. G.

Gas.

1122. Survey of Odorizing Practice in Gas Transmission. R. W. Parker. *Petrol. Engr*, Midyear 1941, **12** (10), 114.—A survey of gas odorization practice of the major natural gas companies was recently made and has now been analysed. 70% of the gas sold by distributing companies is odorized, the practice being generally regarded as essential and the expense as justified. The trend is to trunk-line installations rather than district odorizers, present equipment being regarded as satisfactory. The requirements of a satisfactory odorant are considered as: (1) harmless and non-toxic; (2) inexpensive; (3) non-fatiguing to sense of smell; (4) non-corrosive and insoluble in water; (5) no noticeable product of combustion; (6) penetrating odour similar to that of city gas, and (7) stability in transportation. The odorants in general use are Calodorant (mixture of hydrocarbons and an organic sulphur compound), Pentalarm (mainly amyl-mercaptan), and ethyl mercaptan. At the optimum rates of 2 gal. Calodorant or 1 lb. of Pentalarm per million cubic feet, the cost is less than \$1.00 per million cu. ft. of gas. Distribution of odorant is by direct injection of which the main types are the lubricator, differential controlled, or pressure differential controlled, and the by-pass method, of which the main types are the diffusion wick and liquid seal. Control of odorant concentration is by colorimetric analysis using copper oleate, or by calibration or measurement of liquid or by-pass gas volumes.

C. L. G.

1123.* Density of Natural Gases. M. B. Standing and D. L. Katz. *Petrol. Tech.*, July 1941, A.I.M.M.E. Tech. Pub. No. 1323, 1-10.—Pools with pressures of 7500 lb./in.² and the use of pressure-maintenance and recycling plants have increased the need for gas density data for high pressures. The experimental technique is outlined whereby density data have been obtained on sixteen saturated hydrocarbon vapours in the range 35-250° F. and 1000-8220 lb./in.² The data are tabulated and graphed.

The compressibility-factor chart for natural gases has been revised and extended to 10,000 lb./in.² Relationships are presented by means of which the density of hydrocarbon gases containing more than 83% of combined methane and heptanes plus may be obtained from temperature, pressure, and gas gravity (air 1.0) directly.

The relatively large quantity of high-boiling constituents present in high-pressure vapours in equilibrium with crude oils makes it necessary to include in the analysis of the gas the molecular weight, density, and possibly boiling range of the heptanes and heavier fraction.

G. D. H.

Cracking.

1124.* Rate of Cracking of Paraffin Wax. L. B. Bragg. *Industr. Engng Chem.*, 1941, **33**, 376.—Commercial paraffin wax of 122° F. (50° C.) melting point was cracked in a small-flow-type apparatus at temperatures of 788–900° F. (420–482° C.) and pressures of 490–1870 lb. per sq. in. gauge.

The reaction rate constants were corrected to give the initial cracking rate, and may be represented by the Arrhenius equation

$$\log k = \frac{E}{RT} + C$$

where $E = 64,356$, $C = 16.713$, and $R =$ gas constant $= 1.985$. Pressure does not appear to have any effect on the rate of cracking within the pressure range used; the reaction may therefore be assumed to be unimolecular.

H. E. T.

1125. Patents on Cracking. P. Subkow. U.S.P. 2,245,735, 17.6.41. Appl. 12.8.35.—In a process for simultaneous cracking and polymerization of hydrocarbons, a mixture of hydrocarbons within the gasoline range and hydrocarbons of four and less carbon atoms is heated to a temperature between 700° and 930° F. in the presence of a mixture of different catalysts. One of the catalysts is designed to promote reforming of hydrocarbons in the gasoline range, and the other is active to promote polymerization of hydrocarbons having less than four carbon atoms.

L. C. Huff. U.S.P. 2,246,592, 24.6.41. Appl. 5.7.35.—A conversion process which comprises subjecting a residual petroleum oil to cracking in a cracking zone and simultaneously cracking a recycle stock at higher temperatures and in a second cracking zone. Cracked products from both zones are discharged into a reduced pressure vaporizer and separated into vapours and a liquid residue. The vapours are then fractionated to condense the heavier fractions, and the liquid residue removed and reduced to an asphaltic material by further distillation. The condensate from this further distillation is contacted with the vapours undergoing fractionation as a refluxing medium, and the condensate and reflux condensate are thereby combined. The resultant condensate mixture is supplied to the second cracking zone as recycle stock.

K. Swartwood. U.S.P. 2,246,607, 24.6.41. Appl. 19.1.35.—Conversion of hydrocarbon oils by heating relatively clean reflux formed in the process to cracking temperature under pressure in a heating coil and discharging the products into a separating chamber. Heavy charging oil is introduced into the chamber and partly vaporized. The mixed materials are then separated into vapours and unvaporized oil, and the latter subjected to independently controlled cracking conditions. The resultant vapours are combined with commingled cracked vapours and charging oil vapours, and the whole subject to vapour phase cracking conditions in a third heating zone. Vapours of the last step are fractionated to condense heavier fractions, and the latter supplied to the first-named coil as reflux condensate. Finally the fractionated vapours are condensed.

W. J. Sweeney. U.S.P. 2,246,959, 24.6.41. Appl. 18.11.37.—Catalytic cracking of hydrocarbons to produce a motor fuel containing gasoline constituents. A liquid starting material consisting of gas oil containing gasoline constituents is used as a basis of the operation. All constituents boiling within the gasoline range are removed, so that the resulting uncracked gas oil has an initial boiling point between 450° and 478° F. The resulting gas-oil fraction is then converted in the presence of a catalyst to produce a motor fuel having a higher anti-knock value than a gasoline motor fuel produced under substantially the same conditions.

N. Menshih. U.S.P. 2,247,097, 24.6.41. Appl. 18.5.38.—Method of catalytically cracking hydrocarbon oils. The oil is first vaporized and intimately contacted with a pulverized siliceous catalyst dispersed in a normally gaseous stream. The mixture is maintained at cracking temperature for sufficiently long to effect cracking, and the catalyst afterwards separated from the cracked products.

A. E. Pew. U.S.P. 2,248,118, 8.7.41. Appl. 8.10.37.—Process for cracking the vapours of a mineral oil by heating to a temperature range within which no efficient cracking occurs except in the presence of a particular catalyst. The heated vapours are afterwards flowed through a mass of adsorptive catalytic material. While the oil vapours are so flowing, sufficient heat is applied to more than compensate for that adsorbed by the net endothermic cracking reaction, and the temperature of the oil vapours thus raised.

W. L. Benedict. U.S.P. 2,249,595, 15.7.41. Appl. 20.7.40.—Improvement in the catalytic cracking process for the treatment of higher-boiling hydrocarbons to produce substantial yields of high anti-knock gasoline. A reforming catalyst powder is mixed with a hydrocarbon oil comprising a major proportion of hydrocarbons boiling within the gasoline range, and the mixture subjected to reforming conditions of temperature and pressure. The reaction products are separated into a non-vaporous residue containing spent reforming catalyst, etc., and vaporous products. The non-vaporous residue is then withdrawn from the process, and the vaporous reaction products mixed with the higher boiling hydrocarbons and catalyst powder undergoing cracking treatment.

F. A. Howard. U.S.P. 2,251,571, 5.8.41. Appl. 19.10.37.—Method of cracking normally liquid hydrocarbons by preheating them to the desired cracking temperature and feeding the preheated hydrocarbons to a granular mass of catalyst. A mixture of light hydrocarbons, having a higher thermal stability than the normally liquid hydrocarbons, is also preheated to a temperature above the desired cracking temperature. Preheated light carbons are introduced into the catalyst mass at spaced points along the path of travel of the normally liquid hydrocarbons to supply heat and to maintain the desired extent of conversion without indirect heat exchange. The reaction products are finally removed from the catalyst mass and a hydrocarbon mixture boiling within the gasoline range recovered.

T. B. Prickett and G. S. Dunham. U.S.P. 2,252,729, 19.8.41. Appl. 25.1.38.—Production of low-boiling hydrocarbons from a composite hydrocarbon material of wide boiling range and containing a large proportion of heavy or unvaporizable components. The initial material is heated under conditions designed to retard effective cracking while effecting substantial vaporization. The partly vaporized material is passed into a separating zone, and liquids and vapours are separated. Unvaporized material is withdrawn from the zone and superheated, the superheated vapours being continuously passed to a conversion zone containing a solid adsorptive incombustible material and maintained under conditions designed to effect cracking of higher-boiling to lower-boiling hydrocarbons. Products from the conversion zone are then passed to a fractionating zone wherein desired low-boiling products are withdrawn as vapours. A higher-boiling liquid fraction is withdrawn and subjected to pyrolytic conversion. Those portions of the conversion which boil below 500° F. are passed into the fractionating zone. A small portion of liquid is then withdrawn having an initial boiling point higher than the end-point of the low-boiling products. Thereafter the liquid is sent to the top of the separator in order to control the boiling range of vapours passing to the catalytic conversion zone.

G. C. Connolly. U.S.P. 2,253,285, 19.8.41. Appl. 29.3.38.—Cracking hydrocarbon oil by passing it in contact with an adsorptive catalytic mass consisting principally of silica and alumina formed by acid treating a zeolite compound containing an exchangeable base in an amount suitable for use as a water softening agent.

H. B. M.

Hydrogenation.

1126. Nature of Oils Obtained from the Hydrogenation of a Few Typical Bituminous Coals. C. D. Le Claire. *J. Amer. chem. Soc.*, 1941, **63**, 343-351.—The belief that the benzene soluble and insoluble parts of Pittsburgh coal are similar in their essential chemical structure, and that the oils formed by their hydrogenation are chiefly polycyclic hydroaromatic hydrocarbons, is supported by evidence produced in this work. Pittsburgh, Pocahontas No. 3, High Splint, and Illinois No. 6 were studied in order to determine the dependence of the nature of the hydrogenation products on the rank and type of certain bituminous coals. The hydrogenations were carried out in the presence of Adkins catalyst at 350° C., a temperature that gave good yields of petroleum-ether soluble products and avoided extensive degradation of the hydrocarbon structures.

The lower-rank coal of high oxygen content gives on hydrogenation units which have, on an average, lower molecular weights than the units from higher rank coals of low oxygen content.

On hydrogenation, the extract and residue from the benzene extraction of coal give hydrocarbons which are similar in nature to those obtained from the hydrogenation of the unextracted oil.

The maximum yields of petroleum-ether-soluble products are obtained by hydrogenation of the medium-rank coals. T. C. G. T.

1127.* Coal Hydrogenation. E. Berl, H. Biebesheiner, and W. Koerber. *Industr. Engng Chem.*, 1941, **33**, 672.—This paper describes the results obtained on the hydrogenation of natural bituminous coals and wood charcoal, and the subsequent hydrogenation of bitumen and residual coal made from these natural bituminous coals by extraction with tetrahydronaphthalene under pressure at 250° C. The catalysts employed in the hydrogenations were iron oxide, iron, and iodine. H. E. T.

1128. Patent on Hydrogenation. H. Baehr. U.S.P. 2,247,465, 1.7.41. Appl. 22.12.38.—Dehydrogenation of aliphatic hydrocarbons of the paraffin series containing at least 2 but not more than 10 carbon atoms in the molecule and polymerization of at least part of the dehydrogenation products formed. The initial materials are heated to a temperature between 250° and 600° C., together with a coal, the reaction being carried out under a pressure of more than 25 atmospheres. H. B. M.

Polymerization.

1129. Patents on Polymerization and Alkylation. M. M. Holm. U.S.P. 2,245,038, 27.6.41. Appl. 14.10.40.—Improvement in the process of alkylation of isoparaffins with olefins by means of an acid alkylation catalyst. Two zones of reaction are maintained in series, and the concentration of isoparaffin to be alkylated kept at at least 50% by liquid volume of the hydrocarbon phase in the first zone. In this way a high degree of dispersion is effected between relatively immiscible acid alkylation catalyst and hydrocarbon phases.

P. Subkow. U.S.P. 2,245,733, 17.6.41. Appl. 12.8.35.—Process for reforming and polymerizing hydrocarbons. Hydrocarbons boiling within the gasoline range are passed in a restricted stream through a heated zone to a gasoline-reforming temperature. The resultant gaseous and vaporous mixture is then passed through a polymerizing zone maintained at a temperature lower than the reforming temperature. Finally the mixture is passed in a restricted stream through a heating zone, where it is reheated to a gasoline reforming temperature and reformed therein.

P. Subkow. U.S.P. 2,245,734, 17.6.41. Appl. 12.8.35.—Production of reformed and polymer gasoline by heating a mixture of hydrocarbons, including hydrocarbons in the gasoline range having an end-point not exceeding 650° F., to an elevated gasoline reforming temperature. The products of reforming are then cooled, and a vapour of reformed gasoline fractions is separated out at a temperature between 400° and 500° F. Normally gaseous hydrocarbons are next introduced into the vapour stream, and the mixture is passed through a polymerizing zone to produce polymer and reformed gasoline.

R. F. Ruthruff. U.S.P. 2,251,580, 5.8.41. Appl. 4.12.39.—Conversion of olefinic hydrocarbons into hydrocarbons of higher boiling point by polymerization. The olefinic hydrocarbons are contacted at high temperature with a catalyst consisting as an active ingredient of an adsorption complex of phosphoric acid on hydrous stannic oxide.
H. B. M.

Synthetic Products.

1130. Patents on Synthetic Products. M. H. Arveson. U.S.P. 2,246,654, 24.6.41. Appl. 30.12.39.—The patent describes a method of effecting continuous catalytic conversion of hydrocarbons in an apparatus consisting of a number of catalyst tubes mounted in a reaction chamber. Certain of the tubes are kept full of catalyst while others are being emptied and filled with catalyst material. While each tube is emptied and filled the passage of vapours through it is prevented. Removal of the spent catalyst material is effected without interruption of the flow of hydrocarbon vapours, and the catalyst is introduced into the reaction zone equally without interruption of the flow of hydrocarbon vapours.

V. Bayerl. U.S.P. 2,247,594, 1.7.41. Appl. 5.7.39.—Process for the recovery of hydrocarbons from a gaseous mixture containing same and fixed gas. The mixture is passed through an adsorber for hydrocarbons, the unadsorbed fixed gas discharged, and the adsorbed hydrocarbons dispelled from the adsorber by means of steam. These are then compressed and condensed and the hydrocarbons recovered from the uncondensed portion of the expelled gas by passing through the adsorber. Importance of the invention lies in introducing the uncondensed portion of the expelled gas mixture into the adsorber with the steam before the beginning of the expulsion of adsorbed hydrocarbons from the adsorber.

C. L. Thomas. U.S.P. 2,249,584, 15.7.41. Appl. 30.1.39.—A hydrocarbon-oil conversion process which entails subjecting the oil, together with normally gaseous paraffins of at least 3 carbon atoms in the molecule, to catalytic dehydrogenation, to produce normally gaseous and normally liquid olefins. From the resultant products an olefinic gas and an olefinic liquid are separated, and the latter is then cracked to produce gasoline and additional gaseous olefins. These are then polymerized to form normally liquid hydrocarbons boiling in the gasoline range.

R. G. Garofalo. U.S.P. 2,250,991, 29.7.41. Appl. 24.4.37.—Preparation of high-molecular-weight hydrocarbons by mixing a heavy asphaltic fraction with a light hydrocarbon solvent at a temperature sufficient to dissolve substantially all the non-plastic oily fractions contained in the heavy asphaltic fraction, but to leave plastic and bituminous material as an undissolved fraction. The solution of non-plastic oily fraction is separated from the undissolved fraction, and the latter distilled without substantial oxidation. The plastic fraction is recovered as a distillate, and the bituminous material as a distillation residue.
H. B. M.

Refining and Refinery Plant.

1131. Developments in Petroleum Refining Technology in the United States, 1914-19. A. J. Kraemer. *U.S. Bur. Mines. Information Circular*, No. 7172, June 1941.—This review of developments in petroleum refining in the United States from 1914 to 1919 is based on the somewhat scanty information found in the literature of that period. It concerns chiefly cracking processes, for, apart from these, little development was made in petroleum refining, operators being concerned for the most part in enlarging their plants and erecting new ones to meet the growing demand for petroleum products.

At the end of 1919 cracking was still in its infancy, although the desirability of decomposing hydrocarbons of high molecular weight to form compounds of lower molecular weight and greater volatility had long been recognized. At the beginning of 1914 the Burton cracking process was the only one in commercial operation, and continued to be the only successful one for six or seven years after its development.

It is estimated that in 1915 the output of gasoline by the Burton process amounted to 3 million bbl. At first there was considerable opposition to cracked gasoline, but later it was realized that it functioned as well as the straight-run product.

Other cracking processes receiving attention at the time were the Rittman process, developed primarily to provide an additional source of benzene and toluene for the manufacture of munitions, and various aluminium chloride processes. Then followed the Cross cracking process and the Dubbs cracking process, the latter being apparently the only one employed during 1914 and 1919 and still in operation in the United States.

H. B. M.

1132.* Mechanical Properties of Solids. E. N. Da C. Andrade. *Engineer*, 1941, 171 (4457 and 4458), 380-383, 394-395.—The strength of solids is examined in relation to crystal structure. Surface effects, the geometry of glide, strength of metal single crystals, evidence from X-rays, and polycrystalline metals are each dealt with in detail.

J. G. W.

1133.* Controlling Water-Side Corrosion. N. Newton, W. H. Atwill, D. R. Johnson, C. N. Rhoades, V. L. Nealy, and J. T. Kemp. *Nat. Petrol. News*, 25.6.41, 33 (26), R. 194-R. 207.—A collection of papers read at the Symposium on Corrosion held in connection with the Midyear Meeting of the A.P.I.

Sulphuric Acid Treatment of Bicarbonate Waters to Prevent Scaling. N. Newton.—A method of treatment of cooling waters containing a high content of CaHCO_3 with H_2SO_4 is described. Acid is used at the rate of 4 lb. per 1000 gal., reducing the CaHCO_3 from 514 p.p.m. to 50 p.p.m. CO_2 is removed by blowing air through the treated water. The treatment prevented the formation of new scale and slowly removed old scale.

Water Circulated to Cooling Towers Treated with Chromate. W. H. Atwill.— $\text{Na}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$ is added at the rate of 500 p.p.m. and NaOH in sufficient quantity to convert the dichromate into the normal chromate and give a pH of 8.0. Sodium hexametaphosphate is added in quantity to give a concentration of PO_4 of 5-10 p.p.m. The phosphate is said to increase the corrosion resistance of the chromate film.

A Deaerator Retards Corrosion by Removing Dissolved Gases. W. H. Atwill.—Water for cooling systems is passed through a system of trays in a tower maintained at low pressure, thereby removing dissolved gases. 98% removal of oxygen is claimed. Installation costs are said to be high but maintenance costs low. The process is claimed to have had a very marked effect in reducing cooler tube corrosion.

Chlorination Controls Bio-Fouling of Water. D. R. Johnson and C. N. Rhoades.—Where cooler water is drawn from open ponds with earth bottoms, fouling by biological growths may become serious. Efficient control is claimed to have been obtained by treating the water with chlorine at the rate of 43 lb. chlorine per 24 hr., water-flow being at the rate of 5000 g.p.m.

Cathodic Protection Prolongs Bundle Life. V. L. Nealy.—An installation for the cathodic protection of a shell-and-tube condenser of the two-pass type is described. Steel plates supported on steel rods form the anodes, which are disposed between the tubes. Direct current is obtained from a motor generator supplying 1.75 amps. at voltages adjusted to the salinity of the water. Each condenser is earthed separately.

Corrosion Classified by Visible Effects. J. T. Kemp.—An illustrated article amply described by the title.

H. G.

1134.* Use of Demulsifying Agents in Acidizing Oil Wells. J. B. Stone and L. L. Burge. *Oil Gas J.*, 19.6.41, 40 (6), 43.—The only economical way of combating emulsion formation in the acidizing of wells is by the addition of "demulsifiers" to deal with the trouble *in situ*. The agent is usually added either to the acid or to the oil used to flush the acid from the tubing; sometimes one agent is used in the acid and another in the oil.

Since emulsion formation may take place with either fresh or spent acid, and the behaviour of different crudes may be very diverse, it is necessary to have a convenient method of determining which is the most suitable agent to add. A test for this purpose has been developed which may be carried out on the field using a portable

kit: To a 4-oz. bottle containing 20 ml. of acid, or acid spent against limestone from the producing horizon, are added the appropriate quantity of demulsifier and 80 ml. of oil, and the bottle is shaken vigorously fifteen or twenty times. By comparison of the rates of breakdown of the emulsion using different agents, the appropriate demulsifier for the crude in question can be selected.

Results of tests using agents of five different chemical types on a number of crudes are given, but the actual compositions of the demulsifiers are not quoted. Finally, reference is made to the necessity for keeping agitation of the spent acid and oil to a minimum, if emulsion troubles are to be entirely avoided. T. T. D.

1135.* Use of Natural Gas in Oil Refineries. F. S. Kelly, Jr. *Oil Gas J.*, 19.6.41, 40 (6), 52.—Refineries are among the biggest consumers of natural gas, and although the introduction of modern plant has resulted in a constant decrease in heat requirements per unit of through-put, the demand for natural gas has increased as still gases—the alternative source of heat—are utilized for polymerization to higher-octane gasolines, etc. The author stresses the advantages, from the economic viewpoint, of still further replacing still gases as fuel by natural gas, to free the valuable olefins found in the former, but not the latter, for use as raw material for synthesis.

A typical still gas with a heating value of 1878 B.T.U. per cu. ft. can be priced at 18.8 cents per 1000 cu. ft. if used as a fuel. In a thermal polymerization plant the value of the products would be 34.6 cents for polymer gasoline and 10.7 cents for residual fuel gas—i.e., for every 1000 cu. ft. of still gas burnt as fuel there is a potential loss of 26.5 cents gross revenue. Extrapolating from this, the author estimates the loss of potential gross revenue through burning still gases as fuel to be \$31,500,000 per annum for refineries in the Mid Continent, Gulf Coast, and California areas only.

T. T. D.

1136. Steels and Alloys Developed for High-Temperature Refining. B. B. Morton. *Oil Gas J.*, 26.6.41, 40 (7), 60.—An historical paper, the first half of which deals with the development of tests for the study of metal behaviour at high temperatures. Petroleum refiners found, at an early date, that at elevated temperatures metals behaved somewhat like plastics, in that "creep"—i.e., continuous elongation in the direction of maximum stress—took place. In collaboration with other industries, the "creep," the "rupture," and the "relaxation" tests and their variations were devised. Intensive studies, by means of these tests, led to an accumulation of data, from which the author picks out the salient facts, and part of which he presents in the form of charts and of curves.

In addition to possessing adequate mechanical strength, metals must also be resistant to oxidation and corrosion, and the second half of the paper therefore consists of a brief review of the effects of different alloying elements on the high-temperature properties of steels and of alloys. Chromium confers on steel resistance to oxidation and to sulphur attack, whilst molybdenum improves resistance to creep and to the action of organic acids. Nickel chromium steels are very resistant to sulphur, possess the best load-carrying abilities, and are used for the heat-resisting parts of furnaces. Tungsten and silicon are useful alloying elements, whilst carbon, although having a profound effect on the mechanical properties of steels at low temperatures, does not appear to increase the creep resistance above about 900° F. J. C.

1137.* Compact Unit for Reconditioning Absorption Oil Employs Direct-fired Heater. J. C. Albright. *Petrol. Engr.* Midyear 1941, 12 (10), 74.—In recent years the use of kerosine instead of mineral seal oil as absorption oil has rendered possible the removal by distillation with direct-fired heaters of the tarry residuum, without cracking of the absorption oil. This residuum generally results from carry-over of crude in the field separators, and causes emulsions and the fouling of bubble-plates. A reconditioning unit at a Wilmington refinery consists of a tubular heater, a flash-tower into which the heated oil is sprayed, containing a dephlegmator, condensers, and separators. The absorption oil used is a 360–456° F. cut of A.P.I. gravity 38.2°, and is reconditioned when colour and gum content indicate the necessity. The residual matter from the distillation is used as road-oil on refinery roads. C. L. G.

1138.* Reforming Unit Designed for Illinois Naphtha. J. V. Hightower. *Refiner*, August 1941, 20 (8), 291-293.—The total virgin naphtha fractions from the crude still, together with all the crude still gas, constitute the charge to the reformer. The naphtha fractions run first to intermediate storage and then to the reformer, but the crude still gas is compressed directly into this unit to avoid vapour losses. Average operating data show an over-all liquid recovery of 96.6% of the crude charged. The remainder consists of residual gas which is burned to provide the larger part of the refinery fuel requirements.

Operation of the reformer is relatively simple, requiring one man per shift. It involves the low-pressure, high-temperature reaction characteristic of vapour-phase cracking, with the additional feature of gas recirculation. The unit represents substantial process simplifications over previous designs, particularly in elimination of the compressor formerly used to supply gas to the gas-heating coil. A diagram illustrates the principal features.

The reformer feed consists of three products from the crude still: the still gases, light naphtha (75–220° F.), and heavy naphtha (190–410° F.). The still gases enter the reformer just above the main condensers, and pass through the recovery system. The light naphtha is fed into the stabilizer together with the reformed naphtha, so that the final gasoline from the unit is a stabilized blend of the light virgin naphtha, the reformed naphtha, and whatever recoverable fractions were present in the crude still gases.

The heavy naphtha is charged from tankage into the absorber, countercurrent to the rich gases flowing from the reflux drum of the fractionator tower. The flow of the materials and of heat are detailed.

The furnace is double-end fired, with two combustion chambers separated by a convection section. Burners of the combination oil-gas type are used in conjunction with refractory muffles, six burners being used to heat the vaporizer-superheater coil and six to heat the cycle-gas coil. The furnace has a steel self-supporting stack. The tube-backs are supported on structural steel and are independent of the roof. The tubes in the vaporizer-superheater coil are all 3½-in. O.D., 4–6 chrome, ½ molyb.-steel, with box-type headers cast of the same alloy. In the cycle-gas coil the tubes are all 2½-in. O.D. with box-type headers of 4–6 chrome, ½ molyb.-steel. With the exception of the last twelve tubes in this coil, which are chrome-silicon alloy, the tubes are 4–6 chrome, ½ molyb. The tubes in both coils have ¼-in. walls. The transfer line from the coils to the reactor is 4–6 chrome, ½ molyb. A. H. N.

1139.* Copper Alloys in Refining. W. L. Archer. *Refiner*, August 1941, 20 (8), 301–306.—To explain the corrosion problem as influenced by sulphur and oxygen contained in the oils and waters processed, each element is discussed separately. To predict corrosion results in large-scale refiners, it is stated that laboratory work under accelerated or artificial environments is usually misleading. One of the most promising schemes that has been attempted with success is the installation of pilot plants alongside and paralleling regular equipment in those phases of the process where corrosion data are needed. The small units are operated in exactly the same manner as the production units. Runs are made for definite time periods; the pilot equipment is then opened and examined while production continues unabated. Careful, methodical attention is given to the experimental equipment, and much is learned. Considerable data are gained at moderate expense through this plan, and until more work is completed in the complex subject of corrosion studies, all reports of materials in their relation to attack by small amounts of impurities in relatively inert, and large volumes of either petroleum hydrocarbons or water must, of necessity, be conservative.

Not much pure copper is used for corrosion-resistant installations in the refinery. Rather the copper alloys, many of which contain small additions of other elements, are to be found. The brasses, the bronzes, and copper nickel alloys are the most prevalent types. Because of the many copper alloys available, an attempt must be made at simplification of the whole copper set-up. The brasses are combinations of copper and zinc. The bronzes are generally copper with tin or aluminium or silicon. When the latter two elements are included in the composition to form the bronzes, modifying and descriptive terms are employed as aluminium bronze or silicon bronze. Thus a bronze without a prefix of aluminium or silicon may be assumed to be a regular tin-bearing bronze.

Five groups of copper alloys predominate in refinery service. These are: (1) brass—copper with zinc; (2) bronze—copper with tin; (3) (a) cupro-nickel—copper with nickel, (b) nickel silver—copper, nickel and zinc; (4) aluminium bronze—copper with aluminium; (5) silicon bronze—copper with silicon.

The above listing has been simplified in the extreme, for the bronzes always contain phosphorus as well as tin; the silicon bronzes always contain about 1% manganese, tin, or zinc. These alloys are then considered in detail in connection with their services in the refinery, their properties, and limitations. Welding copper alloys are finally discussed.

A. H. N.

1140.* Economics of Gasoline Plant Design. I. A Mathematical Analysis of Heat Exchanger, Furnace, Cooling Tower, and Fuel Gas Costs. C. Hetherington and R. L. Huntington. *Refiner*, August 1941, **20** (8), 307-309.—Through use of the calculus, the engineer who is designing a gasoline plant can save much time in arriving at the proper relationship of the cost and size of the respective units which make up a complete plant. In this paper such an example is worked out by summing up the several cost items in terms of one variable, followed by a differentiation of this total cost with respect to the particular variable. By this procedure the optimum economic cost can be determined much more quickly than by the more tedious method of plotting up the variables on many graphs. To indicate the scope and nature of the problem the following set of data is reproduced: (1) rich oil 4400 lb./min., specific heat = 0.5, entering at 90° F.; (2) lean oil 4000 lb./min., specific heat = 0.6, entering at 350° F.; (3) gas is worth 8 cents/1000 standard cu. ft. of 1000 B.T.U./standard cu. ft. gas, or 8 cents/million B.T.U.—60% of the heat is absorbed in the furnace; (4) the combined investment in a furnace or boiler plant and cooling tower is \$1000/million B.T.U. capacity/hr. and the fixed charges amount to 20%/yr., assuming 350 days of operation/yr.; (5) heat exchangers of the approximate size required cost \$10/sq. ft. of heating area with a coefficient of heat transfer equal to $\frac{75 \text{ B.T.U.}}{\text{hr.} \times \text{sq. ft.} \times ^\circ\text{F.}}$.

A. H. N.

1141.* Unit Costs for Compressed Air and Steam. J. R. Darnell. *Refiner*, August 1941, **20** (8), 314-316.—Due to errors in calculations in the article "Unit Costs of Compressed Air and Steam," *Refiner and Natural Gasoline Manufacturer*, January 1941, pages 50, 51 and 52, unfavourable comparisons were made to the disadvantages of compressed air power. The article is reproduced as corrected by the author, J. R. Darnell.

In this reproduction the first paragraph of the original manuscript has been omitted, corrections have been made as to cost of producing compressed air power, and a corrected Table I substituted.

The original paper was abstracted in Abstract No. 319.

A. H. N.

1142. Patents on Refining and Refinery Plant. F. B. Allen. U.S.P. 2,245,549, 27.6.41. Appl. 17.5.38.—Method of handling hot fluid viscous petroleum coke. The process includes flowing the material through a conduit, discharging it therefrom in a solid stream, and discharging a number of disintegrating jets of water under pressure into the solid stream material, thereby breaking it into small particles. The disintegrated material is collected in a body of water placed below the jets.

T. P. Simpson and J. W. Payne. U.S.P. 2,245,016, 27.6.41. Appl. 25.5.39.—Improved method of refining solvent refined petroleum oils with porous adsorptive materials. The adsorptive material carries an outer layer deposit of activated carbon produced from petroleum carbonaceous matter.

G. W. Nederbragt. U.S.P. 2,246,982, 24.6.41. Appl. 21.1.39.—Separation of hydrocarbon mixtures substantially free from asphalt into fractions of different characters. A fraction of the mixture having a relatively slight paraffinic character is solidified from a solution thereof with a paraffin solvent, and a fraction having a relatively highly paraffinic character is also solidified with a non-paraffinic solvent. The solidified fractions and the unsolidified hydrocarbons from one of the solidification

steps containing fractions of slightly and highly paraffinic character are employed as solute in the other solidification step.

R. E. Burk. U.S.P. 2,247,148, 24.6.41. Appl. 24.12.38.—Treatment of cracked petroleum distillates for colour. The sulphur content is first estimated, and the constituents causing coloured particles reduced by subjecting the distillate to elevated temperature with an amount of iron carbonyl less than that which would correspond to the amount required to react with total sulphur.

W. A. Smith. U.S.P. 2,247,926, 1.7.41. Appl. 9.3.38.—Improvement in the refining of hydrocarbons which lies in reducing the viscosity where necessary, and afterwards subjecting the product at the same time to the action of sulphuric acid and an aryl nitro in which the NO_2 group is attached directly to a benzene ring.

W. E. Forney. U.S.P. 2,248,496, 8.7.41. Appl. 9.7.36.—Oil-stock which is to be refined is passed through a series of contacting zones in one direction and sulphuric acid introduced into the last zone of the series. A gas containing olefin is introduced into the first zone, and the gas reacted with the sulphuric acid to produce a mixture of alkyl sulphates and sulphuric acid. The mixture is then passed counter-current to the oil through the series of zones to extract oil from the non-paraffinic constituents, and the extracted oil discharged from the last zone of the series. The alkyl sulphate extract is discharged from the first zone.

H. H. Gross and W. Smisloff. U.S.P. 2,248,498, 8.7.41. Appl. 24.2.39.—In the process of dewaxing oils by continuous filtration, the steps comprise mixing a dewaxing solvent with the oil, chilling the mixture to precipitate wax, passing the chilled mixture to a filter to remove precipitated wax and segregating a fraction containing comparatively little wax-crystal modifying material. Prior to filtering the wax-oil ratio is increased in order to control character and thickness of the cake and facilitate a higher production rate.

W. P. Gee. U.S.P. 2,248,668, 8.7.41. Appl. 11.2.39.—Dewaxing oils by means of a continuous rotary filter. A dewaxing solvent is mixed with the oil and the mixture on chilling and filtering deposits a thin cake on the filter which it is difficult to discharge. The chilled mixture is then passed to a filter to remove precipitated wax and to produce a dewaxed filtrate. Prior to filtering a predetermined quantity of wax is incorporated in the oil in order materially to increase the ratio of wax to oil. In this way the character and thickness of the filter cake are controlled, and at the same time the cake is rapidly formed and removed from the filter.

W. J. Ryan and N. T. Kendall. U.S.P. 2,249,276, 15.7.41. Appl. 18.9.40.—Process for the treatment of cracked petroleum hydrocarbon distillates of high sulphur content. The distillate is subjected to the action of sulphuric acid of 55–60% strength and the gum forming bodies thus removed without substantially affecting other constituents. Afterwards the oil is treated with caustic alkali solution at a temperature of at least 150°F ., while under substantial superatmospheric pressure. In this way sour sulphur compounds are removed and a sweet product remains.

W. J. Ryan and M. T. Kendall. U.S.P. 2,249,277, 15.7.41. Appl. 18.9.40.—Treatment of cracked petroleum hydrocarbon distillates. A highly cracked naphtha distillate is subjected to the action of aqueous caustic alkali at a temperature of at least 150°F ., while under substantial superatmospheric pressure. Sulphur compounds are in this way removed from the oil. Then the distillate is treated with sulphuric acid (55–60%) to remove gum-forming bodies without substantially affecting other constituents of the oil.

E. Kolthoff and A. E. Catanach. U.S.P. 2,250,915, 29.7.41. Appl. 29.5.40.—Method of sweetening sour hydrocarbon oils by contacting with a suspension of ferric hydroxide and lead sulphide in caustic alkali solution.

M. S. Arguss and W. H. Sowers. U.S.P. 2,251,773, 5.8.41. Appl. 12.1.39.—Process in the solvent refining of mineral oils. An oil containing paraffinic constituents and naphthenic hydrocarbons is separated into fractions respectively higher in paraffinic and naphthenic compounds by extracting with compounds selected from the group consisting of morpholine and its constituents.

C. M. Blair. U.S.P. 2,252,959, 19.8.41. Appl. 31.5.40.—Treatment of pipe-line oil to reduce the inorganic salt content. Fresh water is mixed with the oil in such a way as to produce an admixture in which a major proportion of the original water droplets co-exist, but are not combined with the droplets of added water. The admixture is heated to breaking temperature and thereafter subjected to gentle agitation to effect coalescence to a larger extent of water droplets. The coalesced water masses will thus remove the greater part of the salt content of the original oil. A chemical demulsifying agent is incorporated prior to agitation. Afterwards the admixture is allowed to settle and the oil and water phases are separated.

W. L. Benedict. U.S.P. 2,253,011, 19.8.41. Appl. 31.12.37.—Method of sweetening hydrocarbon distillates by treating with a slurry produced by suspending cuprous chloride in an aqueous ammonium chloride solution. The distillate is separated from the resultant reaction products and then further treated with cupric salt.

R. Rosen. U.S.P. 2,253,308, 19.8.41. Appl. 5.5.37.—Method of desulphurizing a normally liquid hydrocarbon mixture boiling within the gasoline range and containing organically combined sulphur. A hydrocarbon composition containing at least one carbocyclic hydrocarbon is added to the original material and the resultant mixture passed in contact with a dehydrogenating catalyst. The hydrogen sulphide is removed from the reacted mixture, the reaction being carried out in the absence of added free hydrogen.

H. B. M.

Chemistry and Physics of Petroleum.

1143.* Proposed Method of Designating Colour. F. Scofield, D. B. Judd, and R. S. Hunter. *A.S.T.M. Bull.*, 1941, **110**, 19-24.—In this tristimulus method it is proposed to specify the colour of an object by three numbers. These are either the luminous apparent reflectance or the luminous transmission, depending on whether the specimen is viewed by reflected or transmitted light, together with two numbers, α and β , specifying the chromaticity. The numbers α and β are related to the x and y co-ordinates on the I.C.I. system.

It is claimed that the proposed system possesses these definite advantages over the I.C.I. system:—It is superior for colours subtending a large visual angle, owing to the uniformity of chromaticity spacing. The chromaticity diagram is plotted in rectangular co-ordinates with the origin at the neutral point, and the values of α and β can be transformed readily into polar co-ordinates, and, from the latter, numbers may be obtained corresponding to hue, lightness, and saturation. The values of α and β may be determined rapidly with photo-electric tristimulus colorimeter. Equations are given expressing α and β in terms of the readings relative to a standard obtained with the amber, green, and blue filters of the multipurpose reflectometer.

The paper gives a number of applications of the method, such as the indication of the depth of colour permissible in oils, varnishes, etc., the amount of fading of tinted paints, and the degree of yellowing of white paint and enamels.

In the case of the colour of lubricating oils the advantage of the tristimulus method over the A.S.T.M. Union colorimeter is shown diagrammatically.

J. F. T.

1144. Wetting Agents. F. E. Bartell. *Chem. and Ind.*, 1941, **60**, 26, 475-479.—The absence of suitable methods for evaluating wetting agents has retarded the development and technical application of these substances. This paper is a study of the methods of evaluation of surface-active agents from the surface-tension and interfacial tension lowering properties of these agents. The three systems—liquid-air, liquid-liquid, liquid-solid—are considered.

In the case of the liquid-air and liquid-liquid systems, the determination of the surface tension and interfacial tension of the liquid + surface-active solute gave erroneous results with the capillary, bubble-pressure, and ring methods, due to the time required to obtain equilibrium conditions. The pendant-drop and sessile-bubble methods were found to be the most suitable.

With solid-liquid systems the change in interfacial tension due to the addition of the surface-active agent is numerically equal to the change in adhesion tension. The

latter is shown mathematically to be a measure of the degree of wetting of a solid by a liquid, and can be determined from the surface tension of liquid to air and the angle of contact of solid to liquid. Six methods are considered for the measurement of contact angles, and, of these, the sessile-drop and bubble methods are suitable for the majority of systems, the pressure of displacement method is the only one possible when the solid is in a finely divided condition, the tilting-plate and vertical-rod methods are practicable in the case of rods, wires, and fibres, whilst the capillary tube method is of limited value. The paper concludes with a discussion on the reproducibility of contact angles. J. F. T.

1145.* Uses of Wetting Agents. S. Lenher. *Chem. and Ind.*, 1941, **60**, 27, 497-500.—This paper is a compilation of the commercial uses of wetting agents in aqueous systems in the following industries: Textile, Leather Manufacturing, Fur, Petroleum, Paper, Metal Processing, Paint, Cleaners and Cleaning, Cosmetic, Ceramic, Rubber, and in Agriculture. J. F. T.

1146.* Homologous Series of Alkanes. G. Calingaert, H. A. Beatty, R. C. Kuder, and G. W. Thomson. *Industr. Engng Chem.*, 1941, **33**, 103.—From a careful review of the literature, the temperature coefficients of the density for normal and branched-chain alkanes have been obtained, by selection, from smoothed data.

The molecular volumes in the liquid state at 20° C. of the normal alkanes from butane to eicosane are shown to be represented by the relation $V = 30.392 + 16.375N$

$$+ \frac{74.44}{N^2} \text{ where } N = \text{number of carbon atoms.}$$

The molecular volumes in different homologous series of branched-chain alkanes, with the possible exception of the initial members of each series, differ from those of the corresponding normal isomers by a constant quantity, which is characteristic for the series. The use of an alignment chart (nomogram) to detect erroneous or suspicious density values in the literature is illustrated. H. E. T.

1147.* Catalysis Serves the Petroleum Industry. H. S. Taylor. *Industr. Engng Chem.*, 1941, **33**, 582.—A review of the rôle played by catalytic processes in the petroleum industry, and the relation of these processes to present-day demands on the petroleum chemist. H. E. T.

1148.* Furfural as a Solvent. F. Trimble. *Industr. Engng Chem.*, 1941, **33**, 660.—As a selective solvent, furfural has become of considerable industrial importance in two widely divergent fields—namely:—

- (1) the treatment of lubricating oils to remove aromatic and sludge forming components;
- (2) the refining of crude resin.

In spite of its wide industrial importance as a solvent, data on the solvent properties of furfural are incomplete. The present paper seeks to remedy this defect.

In order that the data obtained might be of value in industrial processes, it was considered advisable to prepare the compound of a purity that might easily be attained commercially, rather than to strive for the utmost purity, and thus obtain data which might not be of any practical value.

The furfural used was obtained by carefully fractionating the commercial product three times in an all glass apparatus under a pressure of 12 mm. It had the following properties:—

Boiling range at 25 mm., °C.	64-65
Specific gravity d_{25}^{25}	1.1584
Refractive index n_D^{20}	1.5255
Moisture, %	0.0
Acidity (calc. as acetic acid), %	0.002-0.003.

The solubilities of (a) organic acids, (b) inorganic salts, (c) various organic compounds, in furfural were determined at 25° C., and the results obtained are given in tables.

Further, the mutual solubilities of furfural and petroleum ether were also determined.

The results of this work indicate that, in general, inorganic salts are almost insoluble in furfural at ordinary temperatures, exceptions being the hydrates of barium hydroxide, calcium nitrate, and ferric chloride. Anhydrous zinc chloride was very soluble. Sulphates were insoluble, but chlorides exhibited a slight solubility. H. E. T.

1149.* Natural Gas Hydrates. W. I. Wilcox, D. B. Carson, and D. L. Katz. *Industr. Engng Chem.*, 1941, **33**, 662.—Natural gases under pressure unite with water to form crystalline hydrates at temperatures considerably above 32° F. This paper reports data obtained on the temperatures, and pressures up to 4000 lb. per square inch, at which three natural gases form crystalline hydrates.

The phase data on hydrates of pure hydrocarbons were enlarged by the equilibrium temperatures and pressures for the hydrate formation from compressed liquid propane.

In addition, the concept was introduced of handling vapour-solid equilibria in the same manner as the vapour-liquid equilibria data have been used to predict the phase relations of fluid hydrocarbon systems. H. E. T.

1150.* Rate of Reaction in the System Mineral Oil-Oxygen. D. J. W. Kreulen and D. Th. J. Ter Horst. *J. Inst. Petrol.*, July 1941, **27** (213), 275-292.—This paper deals with a study of the reaction velocities in the system mineral oil-oxygen. Of the two methods available for the measurement of the rate of reaction in the system liquid-gas, that according to Luther and Plotnikow modified by Reinders and Vles was employed. The average reaction was followed by measurement of the mean dipole moment as a function of time. During the oxidation the specific dispersion remained practically constant, indicating that no cyclization occurred during the experiments. From the figure representing the increase of the average dipole moment plotted as a function of time it is apparent that no appreciable increase of polar compounds can be observed until an induction period, with an initial period of very slow reaction, is passed. Beyond this induction period there exists a linear relation between μ and the time of oxidation.

In the second part of the paper the influence of copper and tin on the rate of reaction and on the length of the period of induction is examined. B. M. H. T.

1151.* Preparation of Methyl Chloride From Natural Gas. Yu G. Mamedalier, V. V. Dementiera, A. M. Kuliev, and A. A. Bakhshier. *J. Appl. Chem. U.S.S.R.*, 1939, **12**, 1826-1839. Translated by A. A. Boehtlingk. *Foreign Petrol. Tech.*, April 1941, **9** (4), 151-164.—Previous work by these authors dealt with a detailed investigation of the reaction of the chlorination of natural gas up to carbon tetrachloride. In the present work the reaction was directed towards the highest yield of methyl chloride. The method consisted briefly in passing natural gas and chlorine into a Pyrex glass, quartz, or metal tube placed in an electrically heated tubular furnace. The reaction tube was provided inside with a pocket for the thermocouple. The entire volume of the reactor in the heated zone was charged with the catalyst. At a temperature of 350-500° C., 80-85% of the chlorine and methane passed through the reactor were used up exclusively for the formation of methyl chloride. A lowering of the temperature facilitated a sharp decrease of the reaction velocity constant, and 93% of the condensate was composed of chlorine at a temperature of 300° C. At increased temperature, a decomposition of chlorine derivatives of methane took place, which led to a lowering of the yield of methyl chloride and simultaneously to an increase in its concentration in the condensate.

Of the catalysts investigated the best were copper dichloride with pumice stone, copper dichloride with the addition of cerium chloride, iron shavings, and aluminium shavings.

The yield of methyl chloride depends directly on the ratio of the reacting gases. The best yields were obtained at a gas ratio of $\text{CH}_4 : \text{Cl}_2 = 10 : 1$. At a ratio of $\text{CH}_4 : \text{Cl}_2 = 2 : 1$, more than 50% of the condensate was composed of higher chlorine derivatives of methane. B. M. H. T.

1152.* Catalytic Hydration of Olefins. Application of Sulphuric Acid as a Catalyst for the Preparation of Trimethyl-carbinol from *iso*Butylene in a Continuous Plant.

E. K. Remiz and A. V. Frost. *J. Appl. Chem. U.S.S.R.*, 1940, **13** (2), 210-214. Translated by A. A. Boehlingk, *Foreign Petrol. Tech.*, April 1941, **9** (4), 165-172.—In order to define the most favourable conditions for carrying out the hydration of *isobutylene* when using solutions of sulphuric acid as catalysts, the following factors were investigated: concentration of sulphuric acid, reaction temperature, concentration of the admixture of silver sulphate activating the reaction, and the velocity of the gas-feed.

From the data obtained it appears that the reaction of hydration of *isobutylene* to trimethylcarbinol proceeds with the highest yields within the temperature range of 85-93° C., the latter being the most favourable temperature. The best results are obtained when using for the catalyst aqueous solutions of sulphuric acid containing 10-30% by weight of the monohydrate with the addition of 2% silver sulphate. Under corresponding velocities of feeding the *isobutylene*, the yields of trimethylcarbinol can be brought up to 50 gm. per hour in the presence of 1 litre of the catalyst at a conversion amounting to 4% of the amount of gas passed. The concentration of the alcohol which is condensed in the receiver reached 10-12% by weight.

B. M. H. T.

1153. Sulphonation of *isobutylene*. I.—2-Methylpropene-1 : 3-Disulphonic Acid and Related Compounds. C. M. Suter and J. D. Malkemus. *J. Amer. chem. Soc.*, 1941, **63**, 978-981.—The dioxane salt of 2-methylpropene-1 : 3-disulphonic acid (A) was prepared by passing *isobutylene* into a suspension of dioxane sulphotrioxide in ethylene chloride at 0° C. and precipitated as a granular white hygroscopic solid by allowing to stand for several days or heating to about 60° C. The sulphonic anhydride was prepared by refluxing with thionyl chloride and found to be stable to hydrolysis. The disulphonyl chloride was prepared by heating the dioxane salt, a metal salt, or the sulphonic anhydride with phosphorus pentachloride; it was also synthesized from methallyl chloride. Evidence is put forward for the structure of A.

R. D. S.

1154. Kinetics of Oxidation of Typical Hydrocarbons. R. A. Day, Jnr., and R. N. Pease. *J. Amer. chem. Soc.*, 1941, **63**, 912-915.—Measurements were made of the ignition and cool-flame characteristics of some highly branched paraffins (*n*-heptane, 2 : 2 : 3-trimethylbutane, 2 : 2 : 4-trimethylpentane, and 2 : 2 : 3 : 3-tetramethylbutane), two naphthenes (*cyclohexane* and *cyclopropane*), benzene, and propane. Rates of slow oxidation were also measured for a number of hydrocarbon-oxygen mixtures. Oxygen was used instead of air, so that cool-flame formation and ignition occurred well below atmospheric pressure and the rates of oxidation could be measured conveniently by pressure change. Both series of measurements put the hydrocarbons in the same order as that of the critical compression ratios in internal-combustion engines. Benzene and *cyclopropane* gave no cool flames. Comparison between *n*-heptane and 2 : 2 : 4-trimethylpentane (*iso-octane*) made at 225° C. showed the former to react 3 to 8 times as fast as *iso-octane*. Other data also conformed with the superiority of *iso-octane* as an anti-knock fuel. 2 : 2 : 3 : 3-tetramethylbutane, which has no secondary or tertiary carbon atoms, behaved similarly to its isomer, *iso-octane*, which has both. The extent of the branching appears to be the important factor rather than the group exposed.

R. D. S.

1155. Densities and Refractive Indices of Unsaturated Hydrocarbons. M. L. Huggins. *J. Amer. chem. Soc.*, 1941, **63**, 916-920.—This paper is an extension of the author's previous work on the liquid paraffins (*J. Amer. chem. Soc.*, 1941, **63**, 116-120; *J. Inst. Petrol.*, 1941, **27**, Abstr. No. 950), and is based on data collected by other authors. It shows that the former simple additivity relations for molal volume and molal refraction are not accurate within experimental error, and that certain modifications to these equations give greater accuracy. The constants in the refraction equations deduced agree with the assumption that each bond (according to the atoms linked by the bond and the number and nature of other atoms attached to the atoms joined by the bond) contribute characteristic amounts to the total molal refraction. If two double bonds are adjacent or conjugated, the effect of other atoms is specially important. Owing to the more complex nature of unsaturated compounds, the agree-

ments between calculated and observed values was not so good as in the case of the paraffins. R. D. S.

1156. Catalytic Dehydration and Dehydrogenation of Butyl and Amyl Alcohols. V. I. Komarewsky and J. T. Stringer. *J. Amer. chem. Soc.*, 1941, **63**, 921-922.—The dehydration and dehydrogenation of aliphatic C_4 and C_5 alcohols to diolefins under the catalytic effect of chromia-alumina catalysts are described. The alumina acted as dehydrator and the chromia as dehydrogenator. Alumina alone produced a pure dehydration of alcohol to olefin. R. D. S.

1157. Ultra-Violet Absorption Spectrum of 1:3-cyclopentadiene. L. W. Pickett, E. Paddock, and E. Sackter. *J. Amer. chem. Soc.*, 1941, **63**, 1073-1077.—The ultra-violet absorption spectrum of 1:3-cyclopentadiene vapour was measured between 32,000 and 66,000 cm^{-1} . It consists of an intense band with maximum about 43,000 cm^{-1} on which is superimposed a number of narrow bands, and a prominent group of narrow, discrete bands between 50,000 and 54,000 cm^{-1} . There appear to be two band systems, both of which involve four prominent vibration frequencies which seem to be totally symmetrical vibrations. The absorption spectra of solutions of cyclo- and dicyclo-pentadiene in optically pure hexane were also measured. R. D. S.

1158.* Molal Volume Relationships among Aliphatic Hydrocarbons at their Boiling Points. G. Egloff and R. C. Kuder. *Phys. Chem. J.*, 1941, **45** (5), 836; *J. Inst. Petrol.*, July 1941, **27** (213), 260-274.—The molal volumes at their boiling points of sixty-three aliphatic hydrocarbons comprising fourteen different homologous series have been correlated with a number of carbon atoms in the molecule by means of equations of the type

$$V = a(n + 4.4)^c + K$$

in which a , c , and K are constants, and n is the number of carbon atoms in the molecule. The standard deviation of the calculated from the observed values is 0.48 ml.-mol. (0.30%). The boiling-point molal volume of forty-three aliphatic hydrocarbons comprising nine homologous series have been correlated with the boiling point. A standard deviation of 0.79 ml.-mol. has been obtained by means of equations of the type

$$\text{Log } (V - K) = At + B$$

where K , A , and B are constant, and t is the boiling point in $^{\circ}\text{C}$. The effect of the molecular structure on the boiling-point molal volume is discussed. J. W. H.

1159. Fluorescence of Hydrocarbons and of their Mixtures with Naphthacene. F. Weigert. *Trans. Faraday Soc.*, 1940, **36**, 1033-1035.—In the study of the biological properties—e.g., carcinogenicity of hydrocarbon—an attempt was made to utilize the green and blue fluorescence of the studied hydrocarbon as an easy colour test to decide whether the hydrocarbon was present in crystals or in a molecularly dissolved state. T. C. G. T.

1160. Emulsions—Part I. Mechanism of Emulsification of a Standard Emulsion in Sodium Oleate Solution. A. R. Martin and R. N. Hermann. *Trans. Farad. Soc.*, 1941, **37**, 25-29.—Using pure carbon-dioxide-free N/30 sodium oleate solution, the authors have prepared emulsions (60% by vol. of oil) of paraffin, benzene, n -nonyl alcohol, etc., by the method of intermittent hand-shaking and subsequent homogenization in a cream-mixer. It was found that liquids giving unstable W/O emulsions could be made to give O/W emulsions by increasing the rest period between shakes, and the mechanism by which this occurs is discussed. Liquids with an interfacial tension greater than 42 dynes per cm. can give O/W emulsions by the modified procedure, but those with a lower value (including the higher paraffins) give O/W emulsions by the standard procedure. It is pointed out that in order to understand the process of emulsification it is necessary to distinguish between the reduction of the liquid to droplets and the subsequent stabilization of these droplets by the emulsifying agent. By determining the average diameter of the droplets, the percentage of sodium and oleic acid at the interface, and the percentage area per molecule adsorbed, it was

shown that the interfacial film is monomolecular. In standard paraffin and benzene emulsions the film consists of acid-soap, whilst in nonyl alcohol emulsions there appears to be a composite film of sodium oleate and alcohol. Emulsions of undecyl alcohol were found to exhibit unusual viscosity phenomena, being extremely viscous. This was attributed to the fact that the m. p. of the alcohol was 12° C. and the probability that the composite film of oleate and alcohol may be solid. H. G. W.

1161. Emulsions—Part II. Partial Coagulation of a Standard Emulsion by Salts. A. R. Martin and R. N. Hermann. *Trans. Faraday Soc.*, 1941, **37**, 30–38.—Experiments on the partial coagulation of a standard emulsion of xylene and other oils in sodium oleate solution by "Analar" salts of bi- and higher-valent metals in N/10 solution are reported. In these cases the quantity of salt added was insufficient to react with all the soap present. In the discussion it was shown that the differing amounts of oil separated on partial coagulation must vary with the nature of the added salt, and consequently the reactions between these salts and sodium oleate were studied. With a copper salt, for example, it was found that a basic copper oleate was precipitated by reaction with the alkaline sodium oleate in the aqueous phase. Copper oleate was also formed at the interface, and this, together with some from the aqueous phase, goes into colloidal solution in the oil, peptized by the oleic acid present at the interface, leaving some basic copper oleate in the water. The amount of oil thrown out depends on the amount of oleic acid withdrawn for peptizing the metal oleate, and is large for aluminium salts (high coagulating power) and small for zinc (low coagulating power). Dilution appears to have little effect on this phenomenon. The more highly dissociated nitrates and chlorides are more effective than the sulphate. Emulsions of the higher aliphatic alcohols are very sensitive to salts, since there is little reserve of soap in solution to maintain the interfacial film. H. G. W.

1162. Photolysis of Mercaptans. N. P. Sherrett and N. W. Thompson. *Trans. Faraday Soc.*, 1941, **37**, 81–82.—Lower alkyl mercaptans are photolysed predominantly by the primary process $R-SH \rightarrow RS + H$, and not by the process $RSH \rightarrow RH + S$. T. C. G. T.

1163. Some Factors Covering the Stability of Oil-in-Water Emulsions. A. King. *Trans. Faraday Soc.*, 1941, **37**, 168–180.—The stability can only be effectively measured by the rate of coalescence of the disperse phase. There are three fundamentally different classes of emulsions: (1) oil hydrosols (unstabilized), (2) those stabilized by electrolytes, and (3) those stabilized by materials in the ordinary sense, which may be (a) colloidal materials or (b) finely divided solids. Emulsion stability is not, in general, a function of the degree of dispersion—e.g., coarse emulsions made with gelatinous alumina are very stable (2 years or more). Low interfacial or surface tensions are not important factors in stability, but only the adsorption which accompanies them. If no chemical action occurs between electrolyte and emulsifying agent, the electrical charge on the dispersed droplets does not determine stability or type. High viscosity can only be regarded as a symptom, and not a cause of stability in emulsion systems. Densities and chemical properties of the two phases affect ease of emulsification and stability. It appears that the more extended is the layer of agent at the interface, the more sensitive it is to the influence of electrolytes. The effect of temperature is specific for the different types of emulsions, and cannot be used as an accelerated method of stability comparison. It is also well known that different mechanical methods of preparation lead to great differences in dispersion and stability—e.g., homogenization compared with hand-shaking for soap emulsions gives ten times the specific area of interface and 1.8 times the stability. With solid-stabilized emulsions a gelatinous structure and a basic nature increase stabilization, and aged inert aluminium hydroxide is considered the best. It has been found that sodium oleate increases the power of carbon black to give more stable W/O emulsions. It is concluded that the strength and compactness of the interfacial film are really the most important factors favouring stability. H. G. W.

1164. Stabilisation of Water-in-Oil Emulsions by Oil-soluble Soaps. R. C. Pink. *Trans. Faraday Soc.*, 1941, **37**, 180–184.—The author has examined the effect of water

on benzene solutions of a number of polyvalent metal soaps, and has found that oil-soluble soaps, which are precipitated from solution when shaken with water, give stable W/O emulsions if the precipitated soap (1) is practically insoluble in both phases in the presence of water, (2) remains at the interface and is partly wetted by both liquids, and (3) if there is sufficient lateral adhesion between the solid particles. Mg and Ni oleates and Mg stearate give stable emulsions but not the oleates of Ca, Ba, Sr, Ni or Zn. Another factor of importance in stabilization is that the reduced interfacial tension brought about by the soap permits easy subdivision of the water in the oil, and thus, by bringing the phases into intimate contact, assists in the precipitation of the stabilizing film. Where the metal soaps are insoluble in oil W/O emulsions can be obtained indirectly by inversion of the O/W type. H. G. W.

Analysis and Testing.

1165.* Determination of the Thermo-Viscosity of Light Distillates. L. R. Brown. *A.S.T.M. Bull.*, 1940, **107**, 23-24.—It is suggested that the kinematic viscometer described in A.S.T.M. be adopted for determination of the viscosity of gasoline and kerosine in place of the Saybolt thermoviscosimeter, and it is shown that satisfactory correlation exists between the viscosity in centistokes at 100° F. and Saybolt thermoviscosity at 60° F. for a variety of kerosines and similar distillates having thermoviscosities up to 550.

The thermo-viscosity can be derived from the viscosity in centistokes from the relationship :—

$$\text{Thermo-viscosity at } 60^{\circ} \text{ F.} = 262 (\text{centistokes at } 100^{\circ} \text{ F.}) - 39.$$

A. O.

1166. Method for Determining the Components of Asphalts and Crude Oils. O. G. Strieter. *Bur. Stand. J. Res. Wash.*, 1941, **26** (5), 415.—The author points out that the usual procedure for determining the percentage of asphaltenes, resins, and oily constituents in asphaltic bitumen is not satisfactory owing to the variable results which may be obtained by the use of petroleum naphtha. It is proposed to use pentane instead of naphtha, and ethyl ether instead of carbon disulphide.

Details are given of the method of procedure, which consists of precipitating the asphaltenes with pentane, extracting, in a Soxhlet, a mixture of fuller's earth and the residue from evaporation of the pentane solution, and finally extracting with ethyl ether.

The method can be employed with crude oils as well as asphaltic bitumen. A. O.

1167. Determination of Freezing Points and Amounts of Impurity in Hydrocarbons from Freezing and Melting Curves. B. J. Mair, A. R. Glasgow, Jr., and F. D. Rossini. *Bur. Stand. J. Res. Wash.*, 1941, **26** (6), 591-620.—In the work of the A.P.I. on the isolation and identification of hydrocarbons from petroleum the freezing point of the "best" lot of each hydrocarbon has usually been determined by means of time-temperature freezing or melting curves, and the purity has been estimated from the time-temperature freezing curves by a method published in 1920. The work described in this paper was carried out to check the reliability and interpretation of such measurements.

The apparatus used for obtaining time-temperature freezing and melting curves is described and the method discussed. The curves obtained are analysed, and a procedure is outlined for determining from them the freezing point of a given substance and the amount of impurity it contains. The procedure was applied to a number of different known solutions of hydrocarbons ranging from 0.006-0.115 mole fraction in concentration of solute. The substances used as the main components were 2 : 2 : 4-trimethylpentane, *n*-dodecane, and toluene, whilst the solutes included *n*-heptane, methylcyclohexane, 1 : 2 : 4-trimethylcyclohexane, and *m*-xylene.

For the systems examined, the values for the freezing point of a given substance obtained from both freezing and melting curves were always in accord within their respective limits of uncertainty. The estimated amount of impurity was, on the average, in error by not more than about 10% of itself. D. L. S.

1168.* Rotating Disc Viscometer. P. S. Rigden. *J. Soc. chem. Ind.*, 1941, **60** (1), 18-20.—The viscometer has been designed for the rapid determination of the viscosity of tars during the process of fluxing back harder materials with oils, and for investigating the effect of the addition of filler on the viscosity of a binder within the viscosity range of $10-10^{-4}$ poises. The instrument consists of a spindle carrying a disc which is immersed in the material in a container of fixed dimensions and is rotated by weights suspended over pulleys. The disc and spindle may be detached from the main shaft, thereby making for rapidity in use and facilitating cleaning.

Calibration curves showing the variation of viscosity with different weights and with varying depth of material in the container are given. J. F. T.

1169.* New Test Apparatus Enables Navy to Set Service Standards for Grease. R. C. Adams and H. E. Patten. *Nat. Petrol. News*, 9.7.41, **33** (28), R. 218.—Special test apparatus devised at the Engineering Experimental Station of the U.S. Navy Department is described. In the high-temperature service test a standard ball-bearing is packed in a controlled manner, weighed, and inserted in a device for rotating it at controlled speed and temperature and measuring the torque developed. The torque-time curve obtained in 1 hr. is said to be characteristic. The bearing is re-weighed at the conclusion of the test to estimate leakage. The low-temperature service characteristics of the grease are examined by cooling a packed bearing and determining the time required for one revolution under the influence of a predetermined applied torque. The stability test consists of carrying out the above tests before and after beating the grease at 400° F. for 7 hr. in a standard apparatus. A method for the quantitative estimation of dirt is described. H. G.

1170. Construction of Glass Bellows for Fractionating Columns. D. J. Pompeo and E. Meyer. *Rev. Sci. Inst.*, 1941, **12** (7), 368.—In the construction of vacuum-jacketed distillation columns it is necessary to provide some means of taking up the differential expansion between the inner and outer tubes of the column. This expansion is conveniently allowed for by the provision of flexible glass bellows, the design and construction of which are described. J. W. H.

Motor Fuels.

1171. Co-operative Fuel Research Motor-Gasoline Survey, Winter 1940-41. E. C. Lane. *United States Bur. Mines, Report of Investigations*, No. 3576, June 1941.—This report is the eleventh of a series made in accordance with an agreement between the Co-operative Fuel Research Committee and the Bureau of Mines. It presents analytical data on 2020 samples, representing the products of approximately 120 companies.

For purposes of classification, samples are again divided into regular-price, premium-price, and third-grade gasolines, and each group is averaged separately.

Of tables comprising the report, No. 1 gives data on gravity, sulphur content, Reid vapour pressure, octane number, and distillation characteristics. Averages of Table 1 are assembled in Tables 2, 3, and 4. Table 5 gives minimum, maximum, and average figures for each characteristic of each group of gasoline, and Table 6 gives the same figure for the previous winter survey.

Comparison of these tables with those issued for the winter of 1939-40 indicates that the average octane number for both regular- and premium-price gasolines was 1.7 units higher in 1940-41, and for third-grade gasoline 1.4 units higher. The average vapour pressure for the regular- and premium-price gasolines is 0.4 lb. higher, and for third-grade gasoline 0.2 lb. higher than for the winter of 1939-40. Average temperatures in distillations for each grade of gasoline are slightly lower than corresponding values in the previous survey, except in the case of initial boiling point.

Survey of average anti-knock and volatility qualities during the 5-year period 1935-36 to 1940-41 indicates that the average octane number of regular-price gasoline has risen from 69.6 to 74.4, for premium-price grade from 76.7 to 80.2, and for third-grade gasoline from 57.5 to 65.6, the present third-grade gasoline being now only 4 octane numbers below that of regular-price gasoline in 1935-36. Change in volatility

over the same period is shown by increase in vapour pressure, and decrease in the temperatures of the 10, 50 and 90% recovered points of the average winter gasolines.

H. B. M.

1172.* A.S.T.M. Standard Aviation Gasoline Specifications. Anon. *Nat. Petrol. News*, 9.7.41, **33** (28), R. 214.—The complete specifications for Grades 75, 91, and 100 (octane number) aviation gasoline are given, together with detailed methods of testing. The tests comprise: Knock value, lead content, net calorific value, distillation, acidity of distillation residue, vapour pressure, corrosion (copper strip and copper dish), gum (accelerated ageing test with oxygen) sulphur, freezing point and water tolerance.

H. G.

1173.* Notes on an Extended Test of Creosote Mixture in C.I. Engines. W. Allen. *J. Instn. auto. Engrs*, March 1941, **9** (6), 73–82.—Prior to the war, Rochdale Corporation Transport Dept. made tests of creosote/gas-oil mixtures in one bus with a direct-injection diesel engine. Vertical retort tar was found preferable to horizontal retort or coke-oven tar, both of which had a high naphthalene content. When petroleum base oil is mixed with creosote, tar acids dissolve asphalt from the former and produce a gummy precipitate, particularly at the lower atmospheric temperatures. Tests showed that below 30% creosote there were appreciable deposits, reaching a maximum at 15%. Between 30% and 50%, deposits were not appreciable, even at 22° F. On the other hand, mixtures containing over 30% creosote may lead to starting difficulties in cold weather, due to reduced ignition quality.

Following the outbreak of war the entire bus fleet was put on a creosote/gas-oil mixture. The procedure used for blending, settling and centrifuging is described. During exceptionally cold weather some trouble was experienced with autovac failure and sticking of fuel-injection pump elements. Temporary relief was effected by heating the fuel system, but it was concluded that, for winter use, the creosote should be washed to remove tar acids. This reduces the volume of oil available by about 25%. The unwashed creosote also gave rise to some corrosion of filter gauzes and fuel pump delivery valve springs.

Washed creosote (neutral oil) has been in use since March 1940, and the majority of the original troubles have been overcome. When the engines are first started up, the exhaust fumes are in the form of a dense white vapour, which gradually clears. This may be troublesome in a badly ventilated garage. It is concluded that there are distinct possibilities in the use of creosote/gas-oil mixtures during the present fuel shortage, and troubles have been fewer than with the use of creosote in gasoline engines.

K. A.

1174.* British Methane—An Alternative Fuel. Anon. *Petroleum*, 1941, **4** (3), 64.—The potential sources of methane in the United Kingdom are: (1) gas escaping from coal in collieries, (2) bacterial treatment of sewage, (3) combustion of coal in coke-ovens and gas-works, and (4) natural gas—so small in this country as to be negligible.

The purity of gases from various collieries would be 80–90% methane, and there are some mines pouring 500,000 cu. ft. of the gas per day unused into the atmosphere.

Sludge gas produced from sewage is about 70% methane and 30% CO₂, and at present is used in this form by some sewage works for the generation of their own power and electricity.

Coke-oven gas contains about 30% methane and is at present largely wasted.

Methane has a very high octane number and can be used at a compression ratio of 17–20. It can be used in gas-bags on the roof of cars in a similar manner to town gas, or can be compressed into cylinders at 3000 lb. pressure. The normal-size cylinder of gas is equivalent to 2½ gal. of gasoline. If methane could be transported as a liquid, wide possibilities would be open for this fuel.

It is suggested that methane could be utilized for locomotives, as in Italy, and numbers of other possibilities are suggested, particularly for the gas in liquid form.

D. L. S.

1175. **Patents on Motor Fuels.** W. J. Ryan and M. T. Kendall. U.S.P. 2,246,760, 24.6.41. Appl. 22.3.39.—Preparation of a stable fuel oil having a Saybolt furoil viscosity of over 25 sec. at 122° F. The fuel has incorporated a heavy viscous oil residue produced in cracking a hydrocarbon selected from the group of hydrocarbons consisting of paraffin and mixed-base hydrocarbons, and containing colloidal carbonaceous material which precipitates therefrom in storage and on moderate heating. The oil residue is blended with 20–40% by volume of naphthene-base petroleum hydrocarbons of approximately the same viscosity, and in sufficient amount to inhibit substantial precipitation of the carbonaceous material.

U. B. Bray. U.S.P. 2,247,476, 1.7.41. Appl. 8.1.37.—Preparation of a motor fuel containing a small quantity of high-boiling oxygenated gum solvent of the dibutylphthalate type, together with a small quantity of a solvent extract from petroleum, adapted to minimize formation of gummy and resinous products and prevent sticking of valves and rings.

E. R. Kanhofer. U.S.P. 2,248,357, 8.7.41. Appl. 31.7.39.—Production of motor fuel of high octane rating and low olefin content by fractionally distilling crude petroleum, and separating therefrom a light straight-run fraction containing gasoline components of low anti-knock value and a heavier predominantly saturated fraction. The light fraction is then reformed and the products supplied to a catalytic conversion zone containing a cracking catalyst. The gasoline products are subjected to the action of the catalyst at a temperature between 500° and 800° F., in admixture with a quantity of the heavier fraction, and for a sufficient length of time to saturate the major portion of the olefin content of the gasoline products. The resultant vaporous conversion products are fractionated and condensed.

G. Armistead. U.S.P. 2,248,842, 8.7.41. Appl. 23.10.37.—Treatment of hydrocarbons to produce motor fuel of high anti-knock value. A crude oil is fractionated to separate from it a naphtha distillate, a virgin gas-oil and hydrocarbon oil of higher boiling than the virgin gas-oil. The virgin gas-oil is then subjected to cracking conditions to effect substantial conversion to lower-boiling products. These conversion products are then again fractionated to produce a motor-fuel condensate, a gas-oil condensate, and normally gaseous hydrocarbons. The gas-oil condensate is then separately subjected to cracking conditions and converted into lighter products, including motor-fuel constituents. Higher-boiling hydrocarbon oil is merged with the hot products of this cracking operation; the products of this merging operation are subjected to cracking conditions to effect conversion to motor-fuel constituents, and finally a motor-fuel product is recovered from fractionation.

I. H. Kinneberg. U.S.P. 2,249,613, 15.7.41. Appl. 31.10.38.—Conversion of hydrocarbon oils into substantial yields of motor fuel of high anti-knock value. The oil is subjected at a temperature above 500° F. to contact with a catalyst produced by precipitating a hydrous silica, washing, and treating to remove alkali metal ions, depositing metallic aluminium thereon, drying, forming into granules, and calcining.

R. B. Marschner. U.S.P. 2,252,928, 19.8.41. Appl. 10.8.39.—Production of high anti-knock fuel from a low anti-knock fuel containing a substantial amount of naphthenic hydrocarbons. At least a portion of the naphthenic hydrocarbons are nitrated in the low anti-knock fuel, and the product of nitration subjected to catalytic dehydrogenation to reduce the naphthenic hydrocarbons to aromatic amines in an amount sufficient to increase substantially the anti-knock value of the fuel.

A. Belchetz. U.S.P. 2,253,486, 19.8.41. Appl. 20.5.39.—Catalytic conversion of high-boiling hydrocarbons into low-boiling hydrocarbons within the gasoline boiling range. A stream of the high-boiling hydrocarbons having a solid incombustible catalyst suspended therein is passed through a zone for a sufficient time and at the desired temperature to effect conversion to low-boiling hydrocarbons, and also to leave a low-carbonaceous deposit on the catalyst. The used catalyst is separated from the conversion products, suspended in an oxygen-containing gas, and the suspension passed through a regeneration zone to burn off carbonaceous material deposited on the catalyst. The improvement lies in introducing the used catalyst into the regeneration zone, thus enabling it to be used again.

H. B. M.

Gas, Diesel and Fuel Oils.

1176.* Fuel and Oil for Motor Transport. T. A. Boyd. *Industr. Engng Chem.*, 1941, **33**, 324.—A review of the present-day situation with respect to the production and supply of gasoline and diesel oil for motor transport. H. E. T.

1177. Patents on Gas, Diesel and Fuel Oils. K. D. Uitti. U.S.P. 2,246,643, 24.6.41. Appl. 30.9.39.—Gases and gasolines produced in hydrocarbon oil conversion are de-ethanized while scrubbing the former with absorber oil to absorb C_3 and C_4 components of the gases. The resultant gas-containing liquid is then stripped to remove normally gaseous hydrocarbons, and a substantially gas-free liquid thus formed. A portion of the gas-free liquid is supplied to the de-ethanizing step as absorber oil, and at least a portion of the hydrocarbons subjected to polymerization. Residual paraffin gases from polymerization are dehydrogenated and the gaseous products thereof scrubbed with more gas-free liquid. The liquid thus enriched is supplied to the stripping step.

V. Vorhees. U.S.P. 2,247,535, 1.7.41. Appl. 16.6.37.—In the conversion of heavy hydrocarbon oils into gasoline, the activity of the catalyst is progressively diminished by decomposition of the carbonaceous material. To counteract this the hydrocarbon oil is initially subjected to separation into a soluble and an insoluble fraction, and the soluble fraction subjected to the action of the catalyst. The resulting products are then fractionated into gasoline and a heavier-than-gasoline fraction, and the insoluble fraction subjected to pyrolytic cracking substantially without catalysts. Products of pyrolytic cracking are fractionated into gasoline and a heavier-than-gasoline fraction, and both fractions recycled directly to the pyrolytic cracking operation for further conversion into gasoline.

E. M. Nygaard. U.S.P. 2,251,156, 29.7.41. Appl. 23.10.40.—Preparation of an improved diesel fuel having admixed therewith a small proportion of an aromatic diazo-thioether. Incorporation of the thioether decreases the ignition delay period of the fuel.

E. M. Nygaard. U.S.P. 2,251,157, 29.7.41. Appl. 23.10.40.—Preparation of a diesel fuel having admixed therewith a small proportion of an aromatic diazo-alkyl ether in sufficient amount to improve the ignition quality of the fuel. H. B. M.

Lubricants and Lubrication.

1178.* Oil-retaining Bronze Bearings. Anon. *Engineering*, 1941, **152** (3944), 128.—Tin-bronze bearings produced by the compression of powdered alloys into dies possess the valuable feature of comprising about 30% by volume, fine pores or capillary spaces. They are impregnated with oil by immersion before despatch, and thus can be made to absorb sufficient oil to maintain the working surfaces in a permanently lubricated condition throughout the working life. It is, however, recommended that before a bearing is actually fitted, it should be dipped into a suitable lubricating oil to ensure an oil film exists at the outset between the bearing and shaft.

Porous bearings have a particularly useful application in cases where oiling is difficult or is likely to be neglected. Several convincing examples of their reliability in practice are given. E. F. C.

1179.* Separation and Composition of a Lubricating Oil Distillate. M. R. Fenske and R. E. Hersch. *Industr. Engng Chem.*, 1941, **33**, 331.—An extensive study has been carried out on an 8% fraction from Pennsylvanian crude oil. The distillate was obtained by commercial distillation from the crude and then dewaxed to a 20° F. pour point and given a light clay treatment to about a 3½ A.S.T.M. colour.

The treated lubricating oil fraction was then subjected to a systematic separation procedure, in which the oil was first extracted by means of 98–99% acetone to yield portions of successively decreasing solubility, and then the fractions so obtained were distilled in a vacuum fractionating unit. The portions thus obtained, comprising 0.6–1.4% of the original oil, allowed the construction of three dimensional diagrams incorporating yield, viscosity index, and molecular weight or viscosity. These diagrams permit an estimation of the distribution of oil fractions with respect to molecular size and molecular type. Further, such three-dimensional diagrams when

employed in conjunction with graphs of boiling-point and aniline-point isotherms superimposed on the composition diagram, suggest methods for the segregation of any fraction of the oil.

Comparison of the physical properties of the fractions with those of synthetic hydrocarbons indicates that the oil fractions, while probably not pure compounds, are segregated into groups varying from monocyclic naphthenes (C_nH_{2n}) to polycyclic aromatics (C_nH_{2n-18}).
H. E. T.

1180.* Oxidation of Petroleum Lubricants. L. L. Davis, B. H. Lincoln, G. D. Byrkit, and W. A. Jones. *Industr. Engng Chem.*, 1941, **33**, 339.—The oxidation of petroleum lubricants is an autocatalytic reaction, the initial phases of which have been investigated by an oxygen absorption test. By means of this absorption test the effects of crude source, degree of refining, accelerators, and inhibitors may be studied. Two types of inhibitors are distinguished—true anti-oxidants and precipitants, the latter being only effective against metallic accelerators.

Oxidation products are proximately separable by solvents and adsorption methods. Further, ultimate analyses of insolubles and oil-soluble resins, obtained by stepwise separation from used oil, show decreasing oxygen contents.

The final choice of inhibitors must be determined by practical engine tests. Such tests emphasize the advantages of certain sulphur-bearing derivatives (sulphur-bearing esters of the "Methyl-S.linoleate type and sulphurized olefines derived from petroleum wax) over simple anti-oxidants.
H. E. T.

1181. Physical Aspects of Boundary Lubrication. O. Beeck. *J. appl. Phys.*, 1941, **12** (7), 512.—This article is a review of boundary lubrication research. Data are given on the fraction of the macroscopic area which is actually in contact between the sliding surfaces, the surface temperature of sliding metals, friction measurements under boundary conditions, and the effect of surface finish on boundary lubrication.
J. W. H.

1182. Frictional Phenomena, I. A. Gemant. *J. appl. Phys.*, 1941, **12** (7), 530.—This is one of a series of articles which will be published to form a monograph of viscous and related frictional forces. In Part I the fundamental mathematical friction equations are discussed and their application to flow between parallel walls is considered.
J. W. H.

1183.* Heavy-Duty Motor Oils. H. C. Mougey. *Nat. Petrol. News*, 20.11.40, **32** (47), 34-42.—In tracing the past and indicating the probable future trends in the development of both gasoline and diesel engine, the increasingly exacting demands made on lubricants are stressed. The definition of the term "heavy-duty" is the subject of discussion, but satisfactory lubricating oils must resist oxidation and chemical decomposition in the crankcase, be non-corrosive, and such decomposition products as are formed should cause no significant fouling of engine parts. A plea is made for the co-ordination of the development of fuel, lubricants, and engines.
H. G.

1184. Patents on Lubricants and Lubrication. B. H. Lincoln and A. Henriksen. U.S.P. 2,244,886, 27.6.41. Appl. 28.8.39.—Preparation of a lubricant consisting of a major proportion of mineral oil and a minor proportion of a sulphur-chloride treated condensation product of a halogenated paraffin and an aromatic hydrocarbon.

A. J. Morway. U.S.P. 2,245,702, 17.6.41. Appl. 24.11.37.—Preparation of a grease composition consisting of mineral oil and 10-40% of a soda-soap and barium-soap mixture, the soaps being in a proportion of about 10 to 1, to about 1 to 1. The lubricant is substantially anhydrous.

A. F. Caprio. U.S.P. 2,245,649, 17.6.41. Appl. 2.10.34.—Preparation of a steam-turbine lubricant consisting of 50 parts of chlorinated diphenyl and 50 parts of a triarylphosphate.

N. J. Gothard and G. Entwhistle, Jnr. U.S.P. 2,245,772, 17.6.41.—Appl. 21.9.39.—A lubricating grease is prepared by thickening a mineral-oil component with a

soap. The major portion of the mineral-oil component consists of extract obtained by the sulphuric acid-nitrobenzene treatment of a Pennsylvania type oil.

R. A. Potter. U.S.P. 2,246,415, 17.6.41. Appl. 10.4.39.—Preparation of a lubricant consisting of a mineral lubricating oil, from 0.5 to 45% of resin materials, and sulphur in solution in the lubricant in the order of 40% based on the resin content.

G. Kaufman and R. S. Barnet. U.S.P. 2,246,467, 17.6.41. Appl. 14.3.39.—Preparation of a substantially completely dehydrated lime-soap lubricant free from glycerine. The lubricant consists of a mineral lubricating oil, 10–30% of calcium fatty-acid soap and 0.5–3.0% of substantially neutral lanolin as a stabilizer. Equally a dehydrated lime-soap grease can be prepared from a naphthene-base mineral lubricating oil, lime-soap of higher saturated fatty acids, and 0.1–0.7% of glyceryl mono-stearate as a stabilizer. The lubricant is stable against oil separation and does not break down when heated to temperatures at or above its melting point.

E. J. Barth. U.S.P. 2,246,712, 24.6.41. Appl. 29.4.38.—Preparation of a lubricating oil consisting of petroleum lubricating oil to which has been added an effective amount of dilauryl phenol disulphide.

H. G. Berger, D. E. Badertscher, and F. M. Seger. U.S.P. 2,247,042, 24.6.41. Appl. 25.9.40.—An extreme-pressure lubricant is prepared by admixing with a hydrocarbon lubricating oil a small proportion of the product obtained by the reaction of perchloromethyl mercaptan with an organic amine.

H. G. Berger, D. E. Badertscher, and F. M. Seger. U.S.P. 2,247,043, 24.6.41. Appl. 25.9.40.—Preparation of an extreme-pressure lubricant by admixing a small proportion of the product obtained by the reaction of perchloromethylmercaptan and an aromatic hydrocarbon with a hydrocarbon lubricating oil.

H. G. Berger, D. E. Badertscher, and F. M. Seger. U.S.P. 2,247,044, 24.6.41. Appl. 25.9.40.—Preparation of an extreme-pressure lubricant consisting of a hydrocarbon lubricating oil to which has been added a small proportion of the product obtained by reacting perchloromethylmercaptan with an organic compound having the general formula ROX . R is selected from the group consisting of alkyl, aryl, alkaryl, and aralkyl radicals, and X from the group consisting of hydrogen and the hydrogen equivalent of a metal.

H. G. Berger, D. E. Badertscher, and F. M. Seger. U.S.P. 2,247,045, 24.6.41. Appl. 23.10.40.—Preparation of an extreme-pressure lubricant consisting of a hydrocarbon oil and a small amount of the product obtained by the reaction of perchloromethylmercaptan with a compound selected from the group consisting of organic compounds containing reactive hydrogen atoms and organic compounds containing reactive metallic atoms. The reaction product contains both sulphur and chlorine, and is present in the oil in sufficient amount to increase its load-carrying capacity.

H. G. Berger, D. E. Badertscher, and F. M. Seger. U.S.P. 2,247,046, 24.6.41. Appl. 23.10.40.—An extreme-pressure lubricant in which is admixed a small amount of the product obtained by the reaction of perchloromethylmercaptan with a compound of the general formula RSX . R represents a radical selected from the group consisting of alkyl, aryl, and alkaryl radicals, and X represents an element selected from the group consisting of hydrogen and metal.

M. T. Flaxman. U.S.P. 2,247,577, 1.7.41. Appl. 14.3.38.—Preparation of a lubricating oil containing 1–10% of an oil-soluble aluminium soap, and from 0.5 to 3% of an organic normally liquid amine having high vapour pressure at normal temperatures and having also fluidizing and spreading properties for the oil-soap mixture.

U. B. Bray and D. E. Carr. U.S.P. 2,247,475, 1.7.41. Appl. 23.11.36.—Production of an over-refined low-V.G.C., highly paraffinic lubricating oil containing an added petroleum-extract fraction obtained from a petroleum lubricating oil stock. The extract fraction is soluble in selective solvents for non-paraffinic materials of the petroleum lubricating oil stock, and is of relatively high molecular weight and of aromatic character. It has a gravity of the order 13–18° A.P.I., and is present in sufficient quantity to impart freedom from substantial corrosive and ring-sticking tendencies.

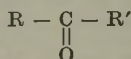
W. A. Smith. U.S.P. 2,247,927, 1.7.41. Appl. 11.4.38.—Removal of impurities from petroleum lubricating oils and motor and petroleum heating fuels, increasing their colour stability and reducing tendency to gum and sludge formation. The process consists in simultaneous treatment with concentrated sulphuric acid and an aryl amine.

R. Bulkley, L. A. Hamilton, and V. A. Kalichevsky. U.S.P. 2,248,848, 8.7.41. Appl. 24.1.39.—Preparation of a lubricating oil which is relatively stable against the formation of acidic products of oxidation. The composition consists of a completely refined lubricating oil, initially free from acidic constituents, and a small amount of oil-soluble sulphonic acids derived from the treatment of lubricating-oil fractions with sulphuric acid.

B. H. Lincoln, W. L. Steiner, and A. Henriksen. U.S.P. 2,248,925, 15.7.41. Appl. 29.3.39.—Preparation of a lubricating composition consisting of a major proportion of lubricating oil and a minor proportion of a halogen-bearing aromatic amine.

W. A. Smith. U.S.P. 2,249,333, 15.7.41. Appl. 10.5.38.—Method of improving lubricating properties of an oil without materially thickening it. The oil is brought into contact with air for a period of time dependent on the temperature of the oil and the efficiency of contact between the air and the oil, and in any case until samples show that approximately maximum film strength has been obtained. The oil is then immediately cooled.

E. Lieber. U.S.P. 2,249,564, 15.7.41. Appl. 15.7.38.—Preparation of an improved lubricant consisting of a mineral lubricating oil and a ketone of the following formula:—



R is a naphthenic radical having a molecular weight at least as high as that of the naphthenic radicals obtainable from kerosine, and R' is a closed-ring radical selected from the group consisting of polynuclear aromatic hydrocarbons and alkyl hydrogenated, oxy-, and nitrogen derivatives of aromatic hydrocarbons.

E. Lieber. U.S.P. 2,249,565, 15.7.41. Appl. 21.6.39.—Improved lubricating oil ingredients consist essentially of naphthenic ketones in which polycyclic radicals are combined with naphthenic acyl radicals of petroleum naphthenic acids.

E. W. Cook and W. D. Thomas. U.S.P. 2,249,626, 15.7.41. Appl. 13.3.41.—Preparation of a lubricating oil composition containing a 2 : 4-dialkylphenol sulphide in amounts sufficient to exert sludge-dispersing properties under heavy duty service without increasing bearing corrosion.

L. A. Mikeska and E. Lieber. U.S.P. 2,250,545, 29.7.41. Appl. 19.10.38.—Preparation of a lubricating composition consisting of a mineral lubricating oil and from 0.01 to 10% of a soluble organic xanthogen tetrasulphide.

J. M. Musselman and H. P. Lankelma. U.S.P. 2,251,686, 5.8.41. Appl. 28.9.39.—Preparation of a lubricant consisting of an oil of lubricating viscosity to which has been added a small amount of the product of reacting carbon disulphide with an amine, and reacting the product thereof with sulphur in order to combine at least three atoms of total sulphur.

B. H. Lincoln and A. Henriksen. U.S.P. 2,251,738, 5.8.41. Appl. 24.8.38.—Preparation of a lubricant consisting of a major proportion of a lubricant base and a minor proportion of a chloro phthalic acid.

M. S. Arguss, G. W. Ayers, and H. Schindler. U.S.P. 2,251,774, 5.8.41. Appl. 28.12.39.—In order to reduce the pour test of lubricating oils, an additive is used consisting of the condensation product of halogenated paraffinic hydrocarbon and hydrocarbon resin obtained from partly spent decolorizing adsorbent.

F. M. Watkins. U.S.P. 2,252,793, 19.8.41. Appl. 27.3.40.—Preparation of a lubricating composition consisting of a petroleum lubricating oil, 0.5–2.5% of basic calcium phenyl stearate, 0.5–3.0% of a solubilizer, and 0.5–1.0% of a thioamid.

J. E. Schott and L. R. Churchill. U.S.P. 2,253,399, 19.8.41. Appl. 5.4.38.—Preparation of a substantially liquid and non-stringy lubricating oil, particularly suitable for use in diesel engines. The oil consists of a hydrocarbon motor oil of suitable viscosity heated with approximately 1% by weight of aluminium stearate and from 5% to 20% by weight of the aluminium stearate of triethanolamine. The resultant oil has improved lubricating properties, but maintains viscosity and fluidity characteristics of the uncompounded oil. H. B. M.

Asphalt and Bitumen.

1185. Specification for Asphalt Enamel Protective Coatings for Steel Water Pipe. Anon. *Asphalt Institute Construction Series*, No. 55, 1941.—Specifications for asphaltic primer, asphaltic dip, asphaltic enamel, and bitumen-saturated asbestos-felt wrappers for protective coatings for steel water-pipe are given, together with methods of application of the materials and methods for determination of performance characteristics of the enamel. The performance tests are made on specimens prepared on mild-steel plates to which the enamel has been applied after sand blasting and treatment with primer. The tests comprise high- and low-temperature sag tests, peel test, impact tests, soil-stress resistance, and solubility test. A. O.

1186. Required Thickness of Asphalt Pavement in Relation to Subgrade Support. P. Hubbard and F. C. Field. *Asphalt Institute Research Series*, No. 8, 1941.—The paper gives curves for determining the thickness of asphaltic concrete surfacing required to carry wheel loads of 60–90 lb. per sq. in. on soils of different supporting values, as determined by the method described in Research Series No. 7. A. O.

1187.* Asphalt and its Constituents. R. R. Thurston and E. C. Knowles. *Industr. Engng Chem.*, 1941, **33**, 320.—The purpose of this paper has been to present the results obtained in an investigation of the photooxidation sensitivity of constituents which are commonly known to be present in asphalt. The asphalts used were separated into five main fractions :—

- (a) asphaltenes, by means of pentane ;
- (b) resin by means of propane ;
- (c) wax by means of methyl ethyl ketone–benzene solution ;
- (d) paraffinic and naphthenic constituents by extraction with acetone in an equilibrium extraction tower.

Extensive tests on these constituents indicate that they represent characteristic fractions of an asphalt.

Three petroleum residua were employed in the work, and the yields and some tests on one of them (Mexican asphalt of 257 penetration at 77° F.) are given in the following table :—

Constituents from Mexican Asphalt.

	Asphaltene.	Resin.	Naphthenic Oil.	Paraffinic Oil.	Wax.
Yield, %	25	25	26	21.5	1.3
C–H ratio	10.7	8.46	7.7	6.87	6.52
Mol. weight	1800	1215	390	730	625
Softening point °F.	decomp.	147	liquid	liquid	122
Kinematic viscosity, C.S.					
210 °F (98.9 °C.)	solid	—	18	67	37
100 °F (37.8 °C.)	solid	{ skin (solid) }	468	2300	solid
Viscosity-gravity const.	—	—	0.935	0.864	0.812

All the constituents absorbed oxygen, the resin and naphthenic oil being more readily oxidized than the remaining constituents. Constituent source was also a factor. Part of the absorbed oxygen was eliminated as water and carbon dioxide, and all residues showed an increase in weight.

The results obtained are, however, incomplete, particularly with respect to information relative to changes in the asphalt or constituents which accompany the photoxidizing action, and also on the effect of temperature on the rate of the photoxidizing action.

The data obtained are significant in showing that all of the constituents normally present in an asphalt are susceptible to photoxidation; whilst the resistance to photoxidation may be somewhat increased by selection of asphalt source, it is more important to protect an asphalt surface, as far as possible from exposure to sunlight.

H. E. T.

1188.* Performance Tests for Bituminous Emulsions. L. G. Gabriel and W. L. Peard. *J. Soc. chem. Ind.*, 1941, **60**, 78-84.—The difficulty of devising tests for performance of emulsions on the road is emphasized, and it is stated that no test can be used as the basis of a specification to give satisfactory results, owing to the effect of temperature and humidity on the evaporation of water from the aqueous phase. The defects of previous performance tests and the lack of correlation with actual road trials owing to difficulty in carrying out the latter are discussed. The authors suggest the use of small-scale "imitative" road tests, which could be expected to give good correlation with road results. They have, in fact, found that two tests: (1) the model road, and (2) the Setting Performance test, satisfy these conditions with reasonable accuracy. Primarily the stage to which the emulsion is allowed to proceed is defined as (a) setting and (b) binding; (a) refers to the stage when the particles adhere together to give a "coagulum," and (b) to the later stage when adhesion or otherwise occurs. Test (1) is made on a circular track, the mean radius being 21 in. and width of test 8 in., and this gives reasonable wear in 2-4 hr. The emulsion is allowed to set for $\frac{1}{2}$ hr. before testing. The percentage of total chippings retained is estimated. Test (2) consists of preparing an aggregate surface on a plate, followed by application of emulsion, blinding with chippings, and after setting for various periods of time, attempting to remove loose chippings with a special "comb-tool." The percentage area remaining covered after a given time is estimated. The setting characteristics are obtained by plotting these areas against the setting time, and the area enclosed by this "plot" is expressed as a percentage of the maximum possible area, representing 100% adhesion. The method is more satisfactory as a comparative than as an absolute method. The main factors producing the set of the emulsion on the road are: (1) evaporation, (2) lability, and (3) the coagulative effect of the stone aggregate. It is pointed out that the lability number itself does not give a measure of the setting time, and to do this cognisance must be taken of the original composition of the emulsion. A method of estimating the setting time from the lability value depends on the assumption that all emulsions dry at the same constant rate down to the water content of the lability value. It has been found that considerable differences in the lability value are obtained with some emulsions after contact with aggregate, and these values may not give a true index of behaviour on the road. It is shown that rolling has a considerable effect in hastening coagulation of bitumen, and that coagulation by stone is not electrolytic in character, but is produced by adsorption of soap and alkali from the emulsifier solution and consequent local coagulation of the bitumen. This coagulated bitumen is very permeable to the aqueous phase of the emulsion, and thus coagulation can proceed further. The unsatisfactory features of the Weber and Bechler test are discussed, and a new stone coagulation test is described in which the ratio of emulsion to stone is similar to that used in large-scale practice. The test consists of application of stone to a coating of emulsion on the bottom of an air-tight tray, followed by washing out the uncoagulated emulsion after 4 hr. and estimation of the percentage of bitumen coagulated. No single simple test gives direct correlation with road performance, but it is suggested that the combination of this latter test and the existing lability test, and the establishment of road correlation, would eventually place the position of performance tests for road aggregates and emulsions on a satisfactory footing.

H. G. W.

1189.* Addition Agents in Asphalt Improve Road Construction. Anon. *Nat. Petrol. News*, 27.11.40, **32** (48), R. 434.—The coating of mineral aggregates by asphaltic bitumen has been improved by a number of methods which are of two classes. In the first the spreading of the binder over the stone surface is facilitated by the pretreatment of the stone with dilute aqueous solutions of the salts of heavy metals such as lead, iron, aluminium, etc., and in the second, the addition of dopes to the bitumen has the same aim. By both methods the water resistivity of the coatings is improved.

H. G.

1190. Patents on Asphalt. D. B. Harrison. U.S.P. 2,247,371, 1.7.41. Appl. 7.6.38.—Production of asphalt from petroleum residual oil containing less than 10% asphaltenes by contacting the residual oil with sulphur dioxide and air at a high temperature, so that reaction of the sulphur dioxide and air with the residual oil is effected. The treated residual oil is blended with high boiling oil rich in resins.

A. B. Hersberger. U.S.P. 2,247,375, 1.7.41. Appl. 16.12.37.—The melting point of a material of bituminous origin is increased by mixing it with a halogenated organic compound and heating to a temperature between 200° and 400° F. under super-atmospheric pressure in the presence of an artificially introduced oxidizing gas. Afterwards the halogenated organic compound is removed by distillation. H. B. M.

Special Products.

1191.* Petroleum Becomes Source of Military Explosives. B. O. Lisle. *Refiner*, Aug. 1941, **20** (8), 294–300.—Chief of the explosives obtained from petroleum is trinitrotoluol. There is a number of other explosives which can be and are used in various ways, but trinitrotoluol is generally preferred because of its high power, great stability and dependability, and safety during handling. It is of especial value for use in munitions, as it can be used alone or mixed with other explosives, whilst its superior stability permits much longer storage of the shells or bombs.

The elementary chemistry of toluene is given, together with its physical properties. This is followed by a brief outline of the chief processes used for the synthesis of toluene. Simple fractionation of a crude such as that obtained from Borneo has already proved itself to be one of the cheapest, easiest, and most satisfactory sources of toluene for manufacture of explosives in the past, and there is no reason to doubt its effectiveness at present. With slight adaptation, existing petroleum distillation apparatus can be employed to treat this raw material with every satisfaction. Such apparently is the type process to be employed in the new toluene plant of the Shell Oil Co. at Houston. Another possible process to be used by this Company appears to involve radical changes in other hydrocarbon molecules. The process is not specified. Nitration is discussed.

It is also possible to produce an appreciable quantity of toluene at the Texas City plant of Pan American Refining Corporation by means of the new hydro-reforming unit constructed there. Although designed with a view to producing a wide range of high octane gasolines, typical charge and product inspections show substantial increases in octane number and volatility with a slight decrease in gravity, and thus indicate the presence of aromatics. Further analysis is understood to have shown an aromatic content of 40–50% of the product, and from 15% to 20% of the aromatics present are toluene, the balance consisting primarily of xylenes and higher homologues.

In addition to petroleum as a source of toluene, it has been reported that the discovery of a cheap method for producing high explosives from natural gas introduces a new potential source of earning power for natural gas producers. Said to be comparable to nitroglycerine, now utilized in dynamite and double-base military powders, the gas-derived explosive would use only a small fraction of total natural gas production even to fill war-time needs. Since the return/unit of gas utilized apparently would be considerably higher than in ordinary industrial or home consumption, several producers are said to be studying the large-scale application of the new process.

According to the American Petroleum Institute, chemists are using 350,000,000,000 cu. ft. of gas/year as a reactive agent between nitromethane and formaldehyde, to

form a product that can be acted upon by nitric acid to make a new explosive more stable than T.N.T.

An official statement made by the chief of Manufacturers for the National Defence Advisory Commission regarding the practicability of obtaining toluene from petroleum is quoted at the end of the paper.

A. H. N.

1192.* Carbon as a Material of Construction. M. J. Dorcas. *Refiner*, Aug. 1941, 20 (8), 311-313. *Paper Presented Before Western Petroleum Refiners Association.*—The term "structural carbon" refers to solid pieces of elementary carbon of either the crystalline graphite or the so-called amorphous forms. Like ceramic articles, many minor variations of grades, each with different properties and applications, are known. These variations of properties exist because of the use of different raw materials and varying methods of manufacture.

The basic raw material is some form of elementary carbon, such as coal, charcoal, lampblack. Usually petroleum coke is the starting-point. This basic carbon material is ground and sorted and mixed according to particle size with pitches and tars. The heated plastic mass is then formed by pressure—that is, extruded or moulded to the approximate shape and size of the desired finished piece. The "green" piece is then baked under suitable controlled conditions in a reducing atmosphere at a temperature much higher than a "red heat." The pitches and tars are thus carbonized or charred, leaving the entire piece in the original size and shape, and all of one solid, dense, hard, black, homogeneous piece of elementary carbon that might be called "black ceramic material." These carbon pieces, if heated to the maximum temperatures of the electric furnace, undergo a molecular metamorphosis and become graphite. Carbon and graphite are both elementary carbon—but are allotropic forms of the same element with different physical properties.

Carbon so prepared in pieces which may vary in weight from $\frac{1}{2}$ gm. to 10 tons is similar in some ways to ordinary ceramic material. It can be used for construction purposes much as ceramic or earthenware materials are. This raw material has some porosity similar to unglazed earthenware, and if used for pressure vessels some seepage of liquids may result.

The physical properties of the structural carbons usually made are described. These properties logically lead to a wide application. Carbon Raschig rings and bubble-caps withstand most acids and alkalis indefinitely. They do not soften with time nor do they spall due to thermal shock. Carbon bricks are used in a multitude of structures (e.g., pickle-tanks and vats and digester linings, ducts and furnace and ladle linings, pipe and fittings, including valve handles), for almost all corrosive solutions, including hydrofluoric acid. Pipe of graphite promotes high-efficiency evaporators and heat exchangers that give no metallic contamination to the materials handled. Mould-plugs, stopper heads, and sintering trays find metallurgical applications. Entire towers and plants for gas purification treating, distillation, etc., are made of carbon. They vary in size from $\frac{1}{4}$ -in. Raschig rings to Cottrell electrostatic precipitator towers constructed entirely of carbon and weighing half a million pounds.

The paper concludes with a study of specific applications of structural carbon to the petroleum industry—chiefly as tower packings, catalyst carriers, heat-exchanger parts, etc. An interesting application is as piston-rings, as graphite itself needs no lubrication in gas or liquid pumps in which hydrocarbon lubricants cannot be used.

A. H. N.

1193. Patents on Special Products. F. D. Stirlen. U.S.P. 2,246,552, 24.6.41. Appl. 6.12.39.—A fuel composition, consisting for the most part of normally fluid, readily inflammable hydrocarbons, is prepared by adding a sodium soap to the hydrocarbons. The sodium soap is only partly soluble in the hydrocarbons and adapted to congeal them. Thereafter an organic solvent for the hydrocarbons and the soap is added in sufficient quantity to bring the two components of the mixture into solution. Finally the solvent is removed by distillation and the residual hydrocarbon soap mixture thus solidified.

M. de Groote. U.S.P. 2,246,842, 24.6.41. Appl. 27.6.40.—Process for breaking petroleum emulsions of the water-in-oil type. The mixture is subjected to the action of a demulsifier consisting of a surface-active, positive, ion-containing amine charac-

terized by the fact that there is directly linked to an amino-nitrogen atom at least one hydrocarbon radical containing the carbon atom chain of an acyl radical of a detergent forming monocarboxy-acid, having more than 8 carbon atoms and not more than 32 carbon atoms. The amine is further characterized by freedom from acyl radicals, nitrogen-linked aryl radicals, and aliphatic radicals in which ether linkages occur at least three times.

L. T. Monson. U.S.P. 2,246,856, 24.6.41. Appl. 26.11.40.—Process for breaking petroleum emulsions of the water-in-oil type by subjecting the emulsion to the action of a demulsifying agent. The agent consists of a mixture of an acylated amino-ether containing a radical derived from a basic hydroxyamino-ether, also an acyl radical derived from a detergent-forming monocarboxy-acid, and a blown fatty oil, the ratio of the former to the latter being 9 : 1 to 1 : 9.

W. Herbert. U.S.P. 2,247,087, 24.6.41. Appl. 13.12.37.—Improvements in the catalytic conversion of gas mixtures containing carbon monoxide and hydrogen. Steps in the process comprise, in combination, application of super-atmospheric pressure, indirect cooling of catalysts, passing a solvent over the catalysts to free them from the paraffin which is formed, and recycling at least part of the end gas of the synthesis.

J. R. Averill. U.S.P. 2,252,957, 19.8.41. Appl. 6.9.40.—Production of petroleum sulphonates by subjecting non-pretreated crude petroleum, petroleum distillate, petroleum mineral oil, and mineral oil extract to the following processes :—

(a) A sulphonation-polymerization step.

(b) A washing step.

(c) A neutralization-alcoholic solvent step.

(d) Separation into a three-layer system consisting of unreacted oil, an aqueous alcohol solution of petroleum sulphonates, and concentrated salt brine. The unreacted oil and salt brine are then withdrawn.

J. T. Rutherford and R. J. Miller. U.S.P. 2,252,984, 19.8.41. Appl. 6.5.39.—Preparation of a compound consisting of a hydrocarbon oil and a polyvalent metal salt of a sulphur containing substituted acid of phosphorus having an organic constituent therein. The salt is present in sufficient amount to inhibit deterioration at elevated temperature.

J. T. Rutherford and R. J. Miller. U.S.P. 2,252,985, 19.8.41. Appl. 6.5.39.—Preparation of a composition consisting of a hydrocarbon oil and an alkaline-earth metal salt of a sulphur-containing substituted acid of phosphorus having an organic constituent therein. The salt is present in sufficient amount to prevent deterioration of the oil at high temperatures.

L. T. Cantrell and J. O. Turner. U.S.P. 2,253,227, 19.8.41. Appl. 5.9.36.—Preparation of an oil-soluble organic phosphorus compound suitable as an improvement agent for hydrocarbon oils. An olefin and a phenol are reacted in the presence of sulphuric acid, and at least part of the resultant product is treated with phosphorus trichloride to obtain a final inhibitor product containing 1-5% phosphorus.

L. T. Cantrell and J. O. Turner. U.S.P. 2,253,228, 19.8.41. Appl. 15.9.36.—Preparation of an oil-soluble organic sulphur compound suitable for use as an improvement agent for hydrocarbon oils. A sulphur chloride is reacted with a water-insoluble reaction product of a phenol and an olefin having anti-oxidant properties when added to a hydrocarbon oil. The reaction is carried out to such an extent as to cause sufficient sulphur to be incorporated in the final product to give it the property of inhibiting the corrosion of bearing metals by hydrocarbon oil. In addition, the improvement agent retains to a substantial extent the anti-oxidant value of the phenol-olefin reaction product.

H. B. M.

Detonation and Engines.

1194.* Engine Bearings. W. D. B. Brown, P. T. Holligan, and J. W. Warrington. *Auto. Engr*, March 1941, **31** (408), 83-88.—Operating conditions demand certain conflicting properties in the bearing metal. High load-carrying capacity demands

high compressive strength; this entails high hardness, which is not altogether desirable. The softer alloys suffer a marked decrease in hardness and strength at high operating temperatures. Two important properties are "embeddability" and "conformability." The former is the ability to engulf minute foreign particles by local flow without causing high spots and overheating. This property appears to demand low yield stress and low hardness. "Conformability" is the ability to yield under local pressure, so eliminating local oversteering. High ductility is conducive to this, because it allows the metal to yield without cracking.

A bearing material should thus possess the following, somewhat incompatible, mechanical properties:—

- (a) Low coefficient of friction.
- (b) Low hardness for maximum "embeddability."
- (c) High ductility for maximum "conformability."
- (d) High compressive strength for maximum load-carrying capacity.

Since all these requirements cannot be met by any one metal, the final choice of materials for a particular application must be based on consideration of all the relevant factors.

For highly loaded bearings there has been a tendency towards the use of thin white-metal linings in a steel shell, the thickness of the babbitt being of the order of 0.020 in. Ultra-thin linings are shown to have advantages, and a white-metal lining of 0.005–0.008 in. is considered ideal for many purposes. Where conditions call for a fairly high loading and a fairly good degree of embeddability, a tri-metal bearing may be used. This has a layer of lead bronze between the steel and white-metal.

The provision of correct bearing clearance is of major importance, particularly in high-speed engines. Too great a clearance causes pounding, and sometimes crankshaft distortion. Inadequate clearance restricts oil circulation, and therefore causes overheating and breakdown of the oil film. As a guide to correct clearance with pressure lubrication, 0.00075 in. per inch of bearing diameter is recommended for white-metal, and 0.00125 for copper-lead bearings.

In fitting thin-walled bearings an important factor is interference fit or "nip" (the amount by which the peripheral length of a half-bearing exceeds the semi-circumference of the bore of the housing into which it is to be fitted). A high proportion of bearing failures—often attributed to faulty adhesion of the white-metal—is attributable to movement of the bearing in its housing; this may be largely obviated by correct "nip." The degree of nip required in a particular application is best determined by experiment.

Pressure per unit of projected area is not a complete criterion of the pressure an oil-film will carry. For two bearings of equal projected area, that possessing the higher length-diameter ratio has two advantages: the lower rubbing speed causes less temperature rise, which may have an appreciable effect on bearing life, and the rate of drop of oil pressure between the supply point and the end of the bearing will be lower. With pressure lubrication, grooves are not required to spread the oil in the bearing, and they should be dispensed with wherever possible. The injudicious use of grooves and oil-feed holes provides escape points which may adversely affect bearing life.

The hardness, rigidity, and surface finish of crankshafts in relation to bearing materials are discussed, and the importance of oil cleanliness in relation to scoring of the bearing surface is emphasized. Main-line filtration, in preference to a by-pass filter, is advocated at least during the running-in period. The authors consider that engine tests are the only satisfactory criterion of the suitability of new bearing materials.

K. A.

1195.* Oxygen-boosting of Diesel Engines for Take-off. P. H. Schweitzer and E. R. Klinge. *Engineer*, 172, 1941, 90–92.—Tests were carried out with a C.F.R. four-stroke diesel engine unit to examine the effect of feeding to the air intake additional oxygen up to a total concentration of 55%. Combustion phenomena were examined by means of an ignition-lag indicator with electromagnetic pick-up units fitted in the combustion chamber and fuel-injector, also by the use of a cathode-ray oscillograph. Two main series of tests were carried out, one at a fixed timing of 4° advance, and the other under optimum timing conditions. The similarity of both sets of results showed fuel timing to be a relatively unimportant factor.

The B.H.P. was increased by 60% from 2.9 to 4.65 at 890 r.p.m. and the B.M.E.P. rose from 100 to 150 lb./sq. in. as the oxygen concentration was increased from the normal 21% to 45%. Beyond 40% oxygen the power increase was insignificant, and at 55% it approached zero. Maximum cylinder pressures and specific fuel consumption rose with added oxygen, although the foregoing power increase was achieved with only an additional 80 lb./sq. in. maximum cylinder pressure and a 25% higher fuel consumption. The maximum rate of combustion pressure rise and the ignition lag decreased generally with increasing oxygen content.

In conclusion, the possibilities of applying oxygen-boosting to assist the take-off of diesel-engined aircraft are examined. Based on the assumption of 6000 cruising h.p. and an engine weight of 2 lb. per h.p., a saving in engine weight of 4000 lb. could be effected, since the additional 33% power assumed as required for take-off could be obtained by feeding oxygen into the air intake.

E. F. C.

1196.* Method for Measuring Diesel Fuel Ignition Lag. A. E. Traver and W. S. Mount. *J. Soc. aut. Engrs*, 1941, **48** (5), 177-179.—The instrument described was designed to measure the delay period or ignition lag with the greatest possible accuracy. The device can be applied to any diesel engine where the injector can be fitted with an electrical pick-up or mechanical contactor, and where an outlet is provided in the combustion chamber for pressure measurements. The meter is essentially an electronic switch, which is turned "on" by the voltage impulse from the first closure of the injection contact points and is turned "off" by the first closure of the combustion contact points. It differs from other devices of this type in that cycle-to-cycle variations of lag are averaged by a condenser which is charged during the "on" period and continuously discharged through a micro-ammeter. Cyclic fluctuations in the point at which injection commences relative to crank angle, are compensated by starting the measuring period by means of the pickup attached to the injection valve. An adjustable zero-depressing arrangement in the meter circuit enables the full scale-range to cover a variation of only two degrees lag within the range of the fuel being tested.

K. A.

1197.* Requirements of a Smokemeter. K. M. Brown. *J. Soc. aut. Engrs*, 1941, **48** (5), 188-192.—The ability to evaluate the density of the smoke in the exhaust of a diesel engine is becoming increasingly important. Various methods of measuring smoke are discussed. The light-absorption, photo-electric cell, sampling type of meter is considered to be the most satisfactory. The requirements of a satisfactory meter are listed and an instrument described which seems to fulfil them fairly adequately. Principal features are the unusually long measuring tube, the use of a flashlight bulb with reflector for a light source, and a vacuum pump to draw the sample through the tube.

It is pointed out that a measurement of smoke should be independent of the smoke-meter used, and a scale, based on light absorption per unit length of smoke-column, is proposed. Acceptance of this scale should enable smoke-readings to be similarly interpreted by everyone.

K. A.

1198.* 1940 Road Detonation Tests. J. M. Campbell, R. J. Greenshields, and W. M. Holaday. *J. Soc. aut. Engrs*, 1941, **48** (5), 193-204.—This paper was compiled from the Report of the C.F.R. Committee on a programme of co-operative road tests. These indicated that the A.S.T.M. octane number alone, or even a road octane number as determined by methods heretofore widely used, does not give sufficient information for present needs relative to fuel behaviour in service. Neither do test methods previously used provide sufficient information concerning the fuel requirements and knocking characteristics of engines.

A new method has been developed, in which the spark advance corresponding to incipient or border-line knock is determined for the fuel under test at frequent increments of speed; these observations were made on a range of cars during full throttle acceleration on a slight upgrade, using twenty-three representative fuels as well as the necessary range of reference fuels.

For each car these spark advance readings are plotted against speed, both for the reference and test fuels. By interpolating the test fuel data on the reference fuel

framework the octane number of the test fuel can be determined at any desired speed. Also, by plotting a previously determined curve of spark advance for maximum power and the characteristic curve of the distributor automatic advance it is possible to determine (1) the car octane requirement over the whole speed range, and (2) to what extent a given fuel meets the car's requirements.

In order to evaluate fuels of high anti-knock quality it has often been the practice to advance the ignition timing beyond that for maximum power. Tests with low- and high-compression heads showed that such a rating is not necessarily indicative of the performance in an engine designed to utilize the fuel effectively.

A summary of the ratings obtained by the new border-line knock method on the twenty-three representative fuels is presented, and the applications of the method to fuel and engineering development are briefly discussed.

K. A.

1199.* New High-Altitude Fuel System for Aircraft. W. H. and R. R. Curtis. *J. Soc. aut. Engrs*, 1941, **49** (1), 260-265.—The increased rate of climb of modern aircraft and their ability to fly at very great altitudes have accentuated vapour-lock problems. During a climb of 36,000 ft. the atmospheric temperature falls some 90° F., but the fuel temperature within the tanks may fall only about 10° F. Consequently, so much air and gas are released that, in ordinary fuel systems, vapour lock occurs at relatively low altitudes. Laboratory tests designed to simulate flight conditions have not entirely reproduced actual performance. It is believed that observed differences may be due to the effects of vibration in the aircraft.

Some conventional fuel systems are described. Analysis of their shortcomings led to the development of the Thompson Booster Pump. This is a modified centrifugal pump attached directly to the fuel tank and driven by an electric motor. By delivering fuel under pressure from the tank to the pump on the engine it enables fuel entering the suction side of the latter pump to be kept free from released vapour and air. An incidental advantage of the booster is that it facilitates priming of the fuel system before starting the engines.

K. A.

1200.* Spontaneous Ignition of Hydrocarbons. C. W. Sortman, H. A. Beatty, and S. H. Heron. *Industr. Engng Chem.*, 1941, **33**, 357.—Spontaneous ignition temperatures in air, and the corresponding time-lags, have been determined for a variety of hydrocarbons at atmospheric pressure by the oil-drop method. This method is due to Moore, and employs a steel crucible so arranged that varying air rates and oil-drop sizes may be employed.

Under some conditions of air and oil-drop size, the easily ignited hydrocarbons, such as cetane and heptane, show two separate temperature zones of non-ignition above the minimum ignition temperature, a phenomenon not previously recorded in the literature; under other conditions one or other of these non-ignition zones are eliminated.

The conditions of air and liquid feed have a marked effect on the ignition time lag, especially at low temperatures. Addition of tetramethyl lead completely inhibits igniting up to about 850-1000° F. (454-538° C.).

H. E. T.

Economics, Statistics and Education.

1201.* Petroleum and the War. R. E. Wilson. *Bull. Amer. Assoc. Petrol Geol.*, July 1941, **25**, 1264-1282.—The author of this interesting paper, particularly in view of its present-day importance, discusses the various branches of the industry from production to refining-production of 100-octane aviation gasoline, lubricating-oil requirements, heavy fuel oil for the Navy, transportation storage problems as found in the U.S.A. to-day, and compares the situation from the standpoint of the incomparably smaller petroleum reserves of Europe. It is pointed out that Germany and Italy have been carrying on their war operations, plus the industrial, agricultural, and civilian activities of these two countries, and also the occupied territory of Western Europe, with a total production of petroleum products, including synthetic products and imports, equal to only about 5% of the U.S.A. production of crude or consumption of refined products.

The policy of proration in the U.S.A. of the production branch of the industry is well prepared for any emergency, particularly in those States where sound conservative principles have permitted the building up of tremendous underground reserves available for any emergency at a moment's notice and without undue drilling of new wells. Refining capacity, whilst able to meet increases, is not quite as great as is production. Increased capacity for manufacture of 100-octane aviation gasoline as announced, whilst able to meet demands for the next 15-18 months, owing to installation of synthetic capacity equivalent to nearly twice home and foreign demand, increased expansion is required to meet every possible contingency in view of the very wide increase in aerial transport with development of programmes in hand. Lubricating oil requirements are sufficient, as increased home demand is balanced by loss of foreign markets. Reduction in number of Specifications (different) now in use will simplify the problem of supply.

In regard to heavy fuel oil for the Navy, stocks are sufficient for a naval war in the Pacific, but for a possible major effort in the Atlantic substantial stocks must be built up. Transport facilities in existing pipe-lines are at present sufficient and can take care of any reasonable expansion, but, if allowables of crude production are increased, new lines are required to get the crude to the refinery capacity available. Gasoline transportation by tank-car and pipe-line in the interior of the country appears to be capable of handling increased loads without difficulty. Tanker tonnage from west to east is inadequate, although twenty-five large tankers are due for completion this year—pipe-lines, however, may have to be laid into south-east if legal obstacles and obstructions can be overcome. Underground storage facilities, in exposed places, for aviation gasoline and fuel oil, as required by the two Services is being urged.

The author in his analysis of the Axis Powers reserves or supply position is definitely of the opinion that they are short of oil, and explains the large amount of preparation and storage arrangements required to permit a "blitz" on England, and considers that Italy is more of a liability to Germany than an asset; that demand for oil affects her industrial facilities, and that once England achieves air superiority enough to permit long range bombing and destruction of synthetic plants—invasion might not be required for England to win the war.

R. J. W.

1202.* Fuel and War. F. C. Sheffield. *Auto. Engr*, March 1941, **31** (408), 89-91.—The author strongly advocates immediate and intensive development of all available means for the replacement of imported liquid fuel by home-produced alternatives. In deploring the lack of large-scale development before the war he alleges obstruction by technical as well as official bodies. He considers that the post-war economic position of Great Britain will not permit the unrestricted importation of foreign fuel, and therefore contends that gas-producers should not be regarded as a "conversion" measure. German methods of persuading the population to give preference to home-produced fuels and to practise domestic economy are recommended for adoption in this country.

K. A.

1203.* Steam versus Diesel-electric Locomotives. E. E. Chapman. *Engineer*, 172, 1941, 101-103.—The general dimensions and power performances of certain American diesel-electric locomotives and comparable conventional steam locomotives are given.

Advantages claimed for the diesel-engined type are:—

- High thermal efficiency.
- Lower water costs.
- High degree of utilization—greater flexibility.
- Reduction of delay due to taking fuel and water.
- Higher sustained speeds.
- Lower stresses imparted to track structure.
- Dynamic braking.

Disadvantages are:—

- High initial investment cost.
- Lower life expectancy.
- Demand for higher degree of maintenance.
- Higher unit cost of fuel and higher lubrication costs.

In conclusion a *résumé* is given of the accomplishments of diesel-electric locomotives in main-line service. While it is not suggested that they will entirely displace the constantly improving steam locomotive in railway service, as more and more are built, unit cost should be reduced, so narrowing the present gap between relative initial investment costs. E. F. C.

1204. Crude Petroleum and Petroleum Products. Minerals Yearbook Review of 1940 with Final Statistics for 1939. A. G. White, G. R. Hopkins, H. A. Breakey, and A. T. Coumbe. *U.S. Bur. Mines*, Washington, 1941.—This report deals largely with the incidence of the present war on world markets for petroleum and its products during the year 1940. By the end of that year closing of French and Mediterranean markets, together with the effects of the British blockade, had cut off the flow of oil to practically all continental markets. Thus in the United States exports were reduced by 58 million bbl. as compared with 1939, and imports increased by 24 million bbl. It is pointed out that should this trend continue, it may happen that in 1941 there will be an approximate balance between exports and imports. In 1940 exports amounted to 131 million bbl. and imports to 83 million bbl.

Analyses of production figures during 1940 showed an increase of 87 million bbl. in the United States, no apparent change in Russia, a decrease in Venezuela of 21 million bbl., in Iraq of 5 million bbl., and in Rumania of 3 million bbl.

Stocks of gasoline in the United States at the beginning of 1940 were abnormally high in anticipation of a war export demand which, however, did not materialize. Stocks of distillate and residual fuel were, on the other hand, comparatively low.

Proved reserves of crude oil discovered and developed in the United States in 1940 amounted to 1,894,000,000 bbl., thus pushing figures relating to reserves in sight or extractable by known methods to the new peak of 19,025,000,000 bbl. There is, therefore, no imminent danger of exhaustion. Nevertheless reserves in relation to total demand on 1st January, 1941, represented only 13 years' supply, which is a drop from the number of years' supply in reserve the previous year. H. B. M.

1205. Developments in the American Petroleum Industry, 1914-19. H. C. Fowler. *U.S. Bureau of Mines, Information Circular*, No. 7171, June 1941.—Firstly the author of this paper warns readers against assuming too critical an attitude when reviewing the 1914-19 period of petroleum development. It must be remembered that in April 1917 America entered the World War, and thereafter every effort was made to produce more and more oil to meet the demands of the fleet, the American Expeditionary Force, domestic wartime activities, and needs of the Allies. The price of gasoline warranted expenditure on costly innovations and demand justified drilling on wildcat locations.

Nevertheless, it would seem that entrance of the United States into the war affected very little the upward trend of increasing scientific knowledge, already well begun. The conclusion is reached that whether or not America had joined the Allies, most of the new techniques of the period would have evolved at about their natural rate.

To gain some idea of the position of the industry during that period, it should be recalled that the value of then-called technology as an aid to scientific production had not yet been appreciated. Petroleum engineers had barely established a profession, and it was not until after the Armistice that the first United States Civil Service examination for "oil-recovery engineer" was held. In fact the average American oil worker, although skilled in drawing oil from proven deposits, had little use for geological deductions. He was a practical man, and had not yet learned to use or appreciate scientific methods as an aid to the solution of geological and engineering problems.

The American Petroleum Institute did not materialize until March 1919, and the Petroleum Division of the Bureau of Mines carried a tremendous load of responsibility. There were few technologists in the employ of the oil companies, and in consequence engineers of the Bureau were called upon to undertake what would now be considered the normal duties of company employees in addition to their basic studies.

The technical literature of the time reflected current opinion, hypotheses and deductions concerning the genetic source of petroleum and its accumulation, some writers supporting the organic theory of petroleum origin, others arguing from physical and geological observations that rock disturbances associated with volcanic action

presented the best explanation of the origin of petroleum. Intimately connected with this research was a desire to establish the genetic reason for the occurrence of salt domes.

At the beginning of the period drilling depths were relatively shallow, and surface structure the usual clue to the existence of underlying conforming structures. Well logs for the most part were inadequate and carelessly compiled, the chief argument against their systematization being that it was inequitable to compel a company to divulge private information which had cost large sums of money to acquire.

Cost of exploration during the period was approximately 20-25 cents a barrel, as compared with 10-12 cents in 1939.

While the reviewer makes no pretence to cover all developments in exploration, drilling, production, transportation, etc., in the American petroleum industry during these years, it is possible to gain from the report a well-founded conception of the status of all major departments of the industry at that time. Acquisition of additional or more detailed information regarding any particular phase of the industry will be facilitated by reference to the comprehensive bibliography appended to the report.

H. B. M.

1206.* Scope and Content of the Petroleum Engineering Curriculum. L. C. Uren. *Petrol. Tech.*, July 1941, A.I.M.M.E. Tech. Pub. No. 1350, 1-8.—Although a four-year course is usual in petroleum engineering, it is generally agreed that a longer academic training would be preferable. Probably the best plan would be a four-year undergraduate course, devoted mainly to the fundamentals, followed by a year or two of industrial experience, and then a fifth year spent on the study of some special aspect. Out of a total of 128 time units in the undergraduate course it is suggested that the following proportions should be used: mathematics 16, physics 12, chemistry 19, geology 19, drawing, surveying, and mapping 12, general engineering subjects 24, economics, English, public speaking 12, petroleum technology 14. It is believed that the student should be given a well-developed picture of the industry in which he proposes to seek employment, and this involves courses other than true fundamentals.

The courses for the undergraduate years are outlined, and typical specialized courses for the post-graduate year are given, covering engineering, administration and management, petroleum exploration, and research and development.

A closer liaison between colleges and oil companies is advocated, and each student should have some oil-field experience in his undergraduate years.

G. D. H.

BOOK REVIEW.

Aircraft Engines. Vol. 2. By A. W. Judge, A.R.C.Sc., D.I.C., Wh.Sc., A.M.I.A.E., etc., Late Senior Technical Assistant, Air Ministry. Pp. 446, 354 illustrations and figures. Demy 8vo. Chapman & Hall, Ltd. Price 30s.

This publication, issued a few months subsequent to the first volume, is devoted in the main to the descriptive side, whereas the previous volume dealt chiefly with theoretical and experimental aspects of aircraft-engine design. Certain sections of the volume under review, however, treat on some problems of design and theoretical subjects not previously dealt with.

The author first discusses the factors governing the selection of the most suitable types of engines for various classes of duty, and includes comprehensive data on ratings and weights of British and American engines, and comparative figures showing average power output per unit frontal area for all types. Torque and balance as affecting the selection of various designs are discussed at some length, and this section includes tables comparing inertia and balance data for engines of practically every type and number of cylinders.

Nearly a third of the book is devoted to descriptions of specific engines, first dealing with various types in general, and later with many of the most widely used in each type-group in more detail. A considerable portion of this section describes the more unusual types, including the many experimental and other compression ignition engines.

About 50 pages are devoted to detailed information dealing with the design of several of the main components, including cylinders, valves and valve-gear, pistons, airscrew reduction gear, etc.

The chapter on engine lubrication deals with general principles, the conditions obtaining in different types of engines, and the problems associated with the cooling and filtering of the lubricant. Several typical lubrication systems are described.

The ignition and exhaust systems are dealt with in two separate sections, and in addition to considerations of general requirements, detailed descriptions are given of the most widely used ignition equipment and different types of exhaust systems.

Some of the methods of providing drives for the many items of auxiliary equipment in modern aircraft, either direct from the engine or indirectly by means of air-compressors, hydraulic pressure, or electrically, are described, and various methods of starting are also dealt with. The book concludes with a short description of modern methods of engine testing.

An extensive bibliography to the experimental and practical considerations of aircraft engines is of special value.

The book is well arranged and exceptionally well illustrated, and although the later types of engines coming into service at the time of publication could not be dealt with, for obvious reasons, a very valuable source of information is here provided for all those concerned with, or interested in, the theoretical and practical aspects of aircraft engineering.

Erratum. Page 191. Fig. 142. Curves *A* and *B*. *A* should be *B*, and vice versa.
C. H. SPRAKE.

BOOKS RECEIVED.

British Standard Symbols for Use on Diagrams of Chemical Plant. B.S.I. Specification No. 974—1941. Published by the British Standards Institution, 28, Victoria Street, London, S.W.1. Price 2s. net.

This booklet lists a total of fifty-eight symbols, standardized for use on diagrams of chemical plant, representing in the main basic units of equipment. For the purpose of representing a composite apparatus, two or more of the basic symbols may be combined. For example, a still may be indicated by the combination of the basic symbols for a closed tank, a heater coil, and a plate-column. The

recommended symbols are classified in two groups: those representing plant units where the feed or discharge is affected by gravity are placed in Group I, and must be drawn upright to be correct in appearance; those in Group II may be drawn in any position. No symbols are listed for electric motors, internal-combustion engines, line-shafts, or other units of power-generating equipment, with three exceptions—namely, a boiler, a steam-engine, and a turbine. These have been included because their live or exhaust steam is often employed for process purposes.

The fifty-eight symbols proposed are arranged in a table of five columns. Symbol number is given in column one, its description in column two, and group-number in column three. The symbol itself is illustrated in column four, whilst the last column gives an illustrated example of its use in a diagram. The pamphlet concludes with a diagram of a hypothetical plant, indicating the way in which it is intended that the symbols should be used.

The use of standard symbols in diagrams relating to chemical plant will undoubtedly be an advantage in the fields of chemical engineering and in industries concerned with the treatment of materials. The proposed signs are simple, clear, and mainly pictorial in character, resulting in a diagram which may be rapidly interpreted.

S.A.E. Handbook, 1941. Pp. 829. Published by Society of Automotive Engineers, New York; April 1941. \$5.00.

The 1941 edition of the *S.A.E. Handbook* contains many new and revised standards, mainly relating to aircraft components. In the Lubricants Section additional information has been included on the method for estimating viscosity at 0° F. by extrapolation on A.S.T.M. Viscosity Temperature Charts D 341-39. Details are given of the maximum errors of the method with oils of different kinematic or Saybolt viscosities. A table has also been added showing ranges of kinematic, Redwood, and Engler viscosities corresponding to S.A.E. viscosity numbers. Other sections of the *Handbook* contain the code for tractor testing and tractor fuel specification.

Institute of Marine Engineers, Transactions, Vol. 52. Session 1940-41. Pp. 249. Published by the Institute.

This annual volume of *Transactions* contains three papers of particular interest to the petroleum industry: "*Oil Purifying with Continuous Lubrication*," by Prof. E. Forsberg, dealing with theoretical considerations affecting the efficiency of centrifugal separators; "*A Note on the Present Position of Modern Diesel Engines for Coasters, Fishing Craft, and Inland Waterway Ships*," by A. C. Hardy; and "*Marine Oil Burning*," by J. T. Tomlinson, dealing mainly with the engineering details of installation, arrangement of burners and pumps. A very interesting and long paper by Victor Dover deals with the subject of "*Marine Insurance*" from the point of view of the marine engineer.

Petroleum Development and Technology, 1941. *Transactions of the American Institute of Mining and Metallurgical Engineers*, Vol. 142 (Petroleum Division). Pp. 587. New York, 1941.

The technical papers, which occupy one-half of this annual volume, have previously appeared in *Petroleum Technology*, the quarterly publication of the A.I.M.E. Petroleum Division. The majority of them have therefore already been abstracted in *Journal of the Institute of Petroleum*. But it is valuable to have these papers collected together within the covers of a single book. Seven papers deal with production engineering, and fourteen papers with engineering research, more correctly described as physico-chemical researches, on muds, viscosity, capillarity, and phase behaviour.

The second half of the book is a statistical account of developments in the American fields (arranged by States) during 1940, and a necessarily brief summary of operations in other countries. Contributors to the latter section include Dr. Arthur Wade (Australia), G. S. Hume (Canada), Basil B. Zavoiro (U.S.S.R.), and D. C. Porterfield (Venezuela).

Professor H. H. Power of the University of Texas contributes a short article on petroleum engineering education, describing the programme of a four-year course. The subject of refining is restricted to a short five-page summary by W. Miller.

The Drilling Equipment Directory, 1941-42. Petroleum Directory Publishing Co., Tulsa, Oklahoma.

The directory is a handsomely bound book dealing with drilling equipment under separately tabbed sections. The sections deal with general reference data (including tables of equivalents and formulæ); rotary bits of various types and functions; cable tools; casing; cementing; drill-stem equipment; electric-power service; engines; rotary fishing-tools; mud admixtures and testing; power-transmission components; slush-pumps; rotary system small equipments; slim-hole and exploration (rotary) rigs; steam-generating apparatus; valves and fittings; well surveying; and wire-line and cordage.

The illustrations are excellent and the information offered is readily attainable by the method of indexing and sectioning used.

The utility of the directory is enhanced by the inclusion in every section of summaries of recent papers and of A.P.I. Codes relating to the proper use of the various equipments catalogued and to the many problems encountered in drilling, fishing, cementing, and other oil-field operations. In fact, the directory will be found a useful handbook apart from its commercial value to the manufacturer, buyer, and designer alike.

A.S.T.M. Standards on Petroleum Products and Lubricants. September 1941. Pp. viii + 398. \$2.00 per copy.

The 16th edition of this publication, issued annually by the American Society for Testing Materials since 1926, provides in compact form all the test methods, specifications, definitions, and charts developed through the work of A.S.T.M. Committee D-2 on Petroleum Products and Lubricants. The 1941 book includes sixty-nine methods of testing, eleven specifications, and two lists of definitions of terms. In addition, four proposed new methods, approved for publication as information and for comment, are given covering tests for neutralization number (by electrometric titration, and for crankcase oils), potential gum in aviation gasoline, and conversion of kinematic to Saybolt Furol viscosity. A revised diesel fuel-oil classification is also included.

Important new standards in the volume provide specifications for aviation gasoline and tests for knock characteristics of aviation fuels, standardized method of determining the ignition quality of diesel fuels, and procedures for testing the aniline point of petroleum products and for carbonizable substances in paraffin wax. During the year some thirteen standards were revised—full details are given in the annual report of Committee D-2 published in the compilation.

Copies of this 400-page book in heavy paper binding with two tables of contents, one listing the standards in order of numeric sequence, can be obtained from A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia, Pa., at \$2.00 per copy, with a price of \$1.50 in effect for ten or more copies.

A sample of the book is expected at the Institute's offices in Birmingham during December 1941, and will be obtainable at 10s. 6d. post free.



INSTITUTE NOTES.

NOVEMBER, 1941.

Roll of Honour.

The Council deeply regrets to have to record the loss of the following member, who has made the supreme sacrifice whilst serving in His Majesty's Forces :—

Sergeant-Pilot C. W. WOOLGAR, R.A.F.

(Associate Member)

Killed on active service, September, 1941.

PRISONER OF WAR.

Dr. M. BA THI, B.Sc. (Student Member) has been reported as a Prisoner of War in Germany.

MEMBERS SERVING WITH H.M. FORCES.

The Institute has received notification of the following changes or additions to lists already published :—

S. H. Evans, Australian Imperial Forces.

R. E. Jones, A/C/U., Royal Canadian Air Force.

H. Macniven, Lieut., R.A.O.C.

G. A. Richards, Pte., I.C.

W. B. Rowntree, R.A., promoted to Lieut.-Colonel.

STUDENT'S MEDAL AND PRIZE.

The Council offers a Medal and Prize (up to the value of Five Pounds in books or instruments) for the most meritorious essay submitted by a Student Member of the Institute on one of the subjects listed below.

Entries must be received by the Secretary of the Institute not later than 31st May, 1942.

The maximum length of the essay is not specified, but in general essays should be from 4000 to 6000 words in length.

Entries must be typed, and one carbon copy must be furnished in addition to the original copy. The Council is prepared to give financial assistance to students who experience difficulty in getting their MSS. typed.

1. Palæogeographical Conditions which have Favoured Oil Accumulation.
2. The Interpretation of Geophysical Data in Terms of Geology.
3. Geochemical Methods of Prospecting.
4. Metals for Drilling Equipment.
5. Bottom Hole Testing Methods and their Interpretation.
6. Syntheses from Petroleum Gases.
7. Modern Techniques of Process Control in the Refinery.
8. Recent Methods for the Chemical Refining of Gasoline.

9. Mixed Solvent Refining.
10. The Production of Fuels alternative to
 - (a) Gasoline, or
 - (b) Fuel Oil.

BURGESS PRIZE.

Entries are also invited for the Burgess Prize (of value up to Five Pounds in books) for an essay dealing with one of the subjects given below. The conditions of entry for the Burgess Prize are the same as for the Student's Medal and Prize.

1. The History of the Petroleum Industry of any Producing Country (excluding U.S.A.).
2. The Price of Crude Oil.

The Council reserves the right to withhold the award of either of these prizes, or to award prizes of such lesser value as it may decide.

NEW MEMBERS.

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

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

As Fellows.

CAMERON, William	...	...	...	...	...	Scotland.
MIDDLETON, Charles Roger	...	...	...	...	...	England.
MORTEN, Denis	...	...	...	...	...	"
MORTON, Frank	...	...	...	...	...	Trinidad.
SHEPPARD, George	...	...	...	...	...	England.

As Members.

BEAN, Sidney Herbert	...	...	...	...	...	England.
BROWN, Harry Eugene	...	...	...	...	...	"
CANTOR, Joseph	...	...	...	...	...	"
GIBSON, Arthur Reginald	...	...	...	...	...	"
HALL, Frederick John Spencer	...	...	...	...	...	"
LAIDLAW, Ian Grant	...	...	...	...	...	Trinidad.

As Associate Members.

COWLES, Richard Edwin	...	...	...	...	...	Australia.
DARTNALL, Herbert James Ambrose	...	...	...	...	...	England.
DON, John Smart Aikman	...	...	...	...	...	"
FORREST, Archibald John	...	...	...	...	...	"
GIBSON, Harold	...	...	...	...	...	"
LINNARD, Horace	...	...	...	...	...	"
MORGAN, Ralph Victor	...	...	...	...	...	"
SHIELS, Leo Osmonde	...	...	...	...	...	Australia.
WALTON, Norman Lorraine	...	...	...	...	...	England.

Transferred to Associate Members.

BROWN, Thomas	...	...	...	...	...	England.
STIBBS, Edward George	...	...	...	...	...	Trinidad.
de VERTEUIL, Louis Rene	...	...	...	...	...	"

As Students.

BAILEY, Darrel Guy Fallen	...	...	...	...	...	England.
RALPH, Noël Albert	...	...	...	...	...	"

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.

CHATTERLEY, Leslie George, Resident Engineer, Valvoline Oil Co. (*J. M. Marshall ; James Smith.*)

FEATHERSTONE, Arthur James, Terminal Superintendent, Ocean Terminal, Texas Oil Co. (*R. F. Hurt ; N. L. Anfilogoff.*)

WILSON, Alexander, Managing Director, British Oil & Turpentine Corporation, Ltd. (*H. W. Chetwin ; J. G. Hunter.*)

Candidates for Admission as Students.

ASHFORTH, G. K., Dept. of Oil Engineering & Refining, Univ. of Birmingham.

BOESE, A. C.

CLAYTON, P. B.

DOD, G. F.

DRYER, S. R. C.

FOSTER, D. V.

GARRETT, P. A.

HICKS, A. E.

LINDNER, J. N. D.

WALL, T. G.

WINWARD, A.

All the above candidates are proposed by *Prof. A. W. Nash* and seconded by *Dr. A. H. Nissan*.

NOMINATIONS FOR COUNCIL.

Every Fellow, Member or Associate Member of the Institute may send in writing to the Council the name of a Fellow or Member whom he desires to recommend for election to the Council. This nomination must be signed by at least nine other Fellows, Members or Associate Members, and delivered to the Secretary not later than 31st December, 1941. No member may sign more than one nomination paper. Nomination papers may be obtained from the Secretary.

ARTHUR W. EASTLAKE,
Honorary Secretary.

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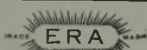
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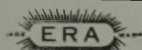
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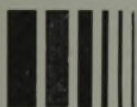
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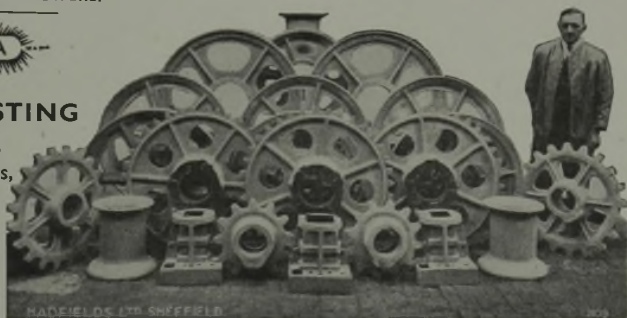
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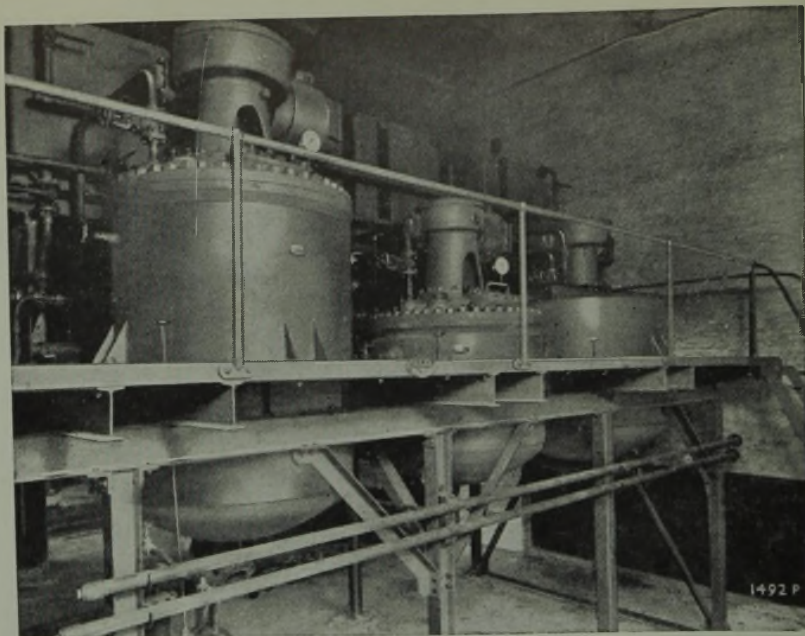
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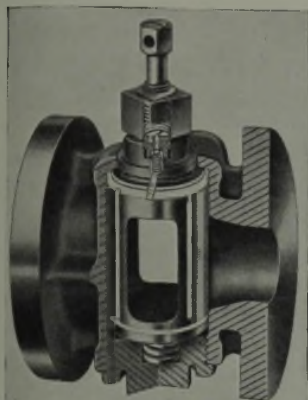
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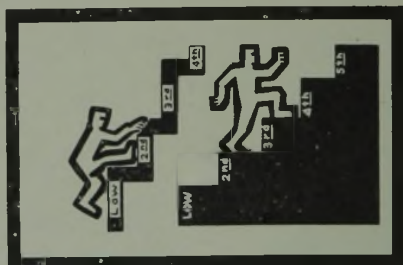
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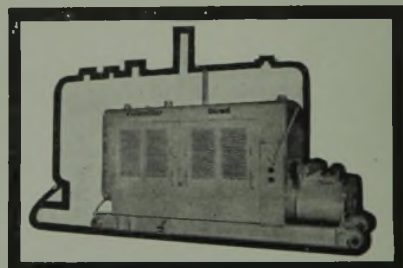
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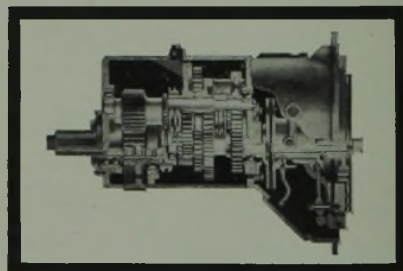


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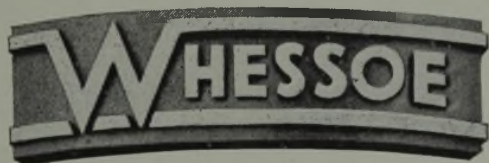
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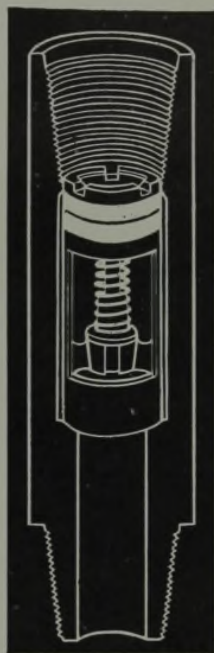
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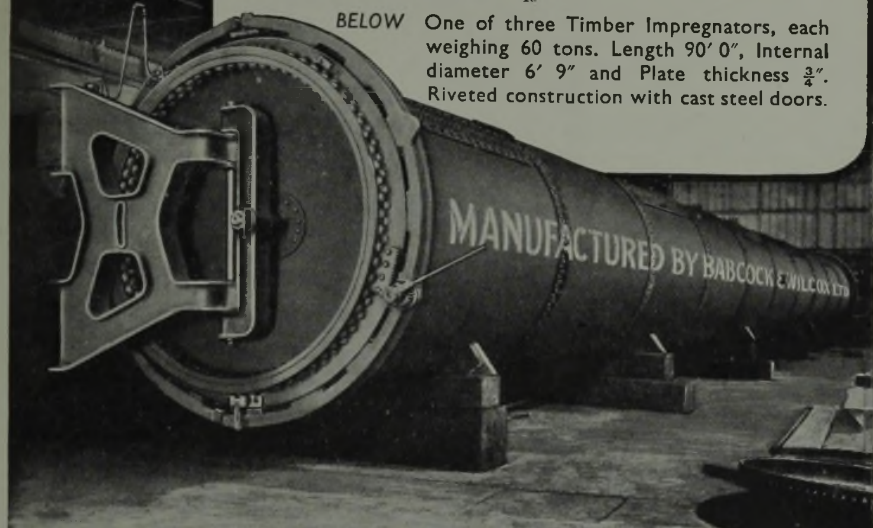
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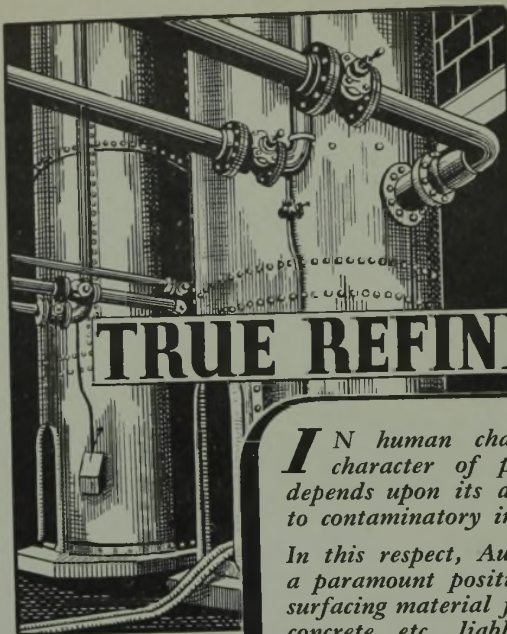
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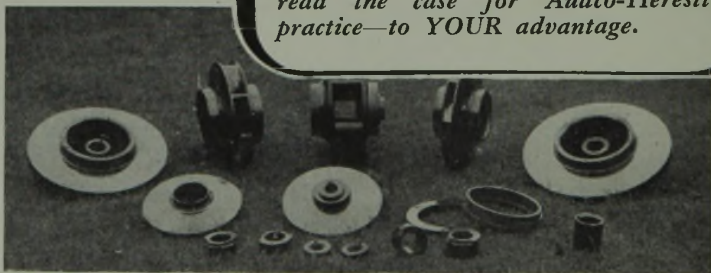
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