CHEMISTRY AND THE PETROLEUM INDUSTRY.*

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So important has become the petroleum industry in our own generation that it is impossible to put forward any but the barest summary of the impact on it of the chemist—and yet in all its phases it has been a lively centre of chemical activity, and promises in the near future to become more than ever a most important branch of applied chemistry.

It is of some interest to look back through barely two spans of human life to the development of the industrial application of mineral oil. To those who regard the origins of things as of some importance, attention might well be directed to the Cantor Lectures of the late Sir Boverton Redwood in 1886. At that time by distillation was merely comprehended the boiling of oil and the condensation of its vapours—little or no attempt was made at effecting close fractionation. Chemical refining of products was a more or less brutal attack by means of strong sulphuric acid. There were scant references to a new line of approach to modern developments, that is to say, the " cracking " of heavy hydrocarbons as practised at Nobel's Refinery at Baku, whereby substantial yields of aromatic hydrocarbons were obtained. Very significant was the statement that " by far the most important of the uses to which the products of petroleum are as yet applied is that of illumination." At the close of his lectures Redwood suggested " that the degree of mental culture of a nation may be measured by the quantity of mineral oil consumed "—a prophecy which reads somewhat grimly during the course of two subsequent World Wars. It is, however, patently obvious that our everyday life in peace depends for its very existence, its amenities, and its luxuries on petroleum, and in war-time, with even more emphasis, the very narrow margin between survival and defeat depends on supplies of aviation spirit, gasoline, liquid fuel, and lubricants. Just before 1939 over thirty million motor vehicles transported man, his food, and his raw materials. It is not necessary here to dwell on the urgent need of mechanized warfare, of military aviation, and of the imperative demands of navies.

The production of petroleum in the world, in round figures, is of the order of 250 million tons a year. Considering the quantity of petroleum produced ever since the beginning of the industry (about 80 years), the whole of that production, if put into one tank, would amount to

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* This article is based on a lecture given in 1942 to the Royal Institute of Chemistry.

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less than a cubic mile. It will be interesting to take one or two comparative figures. The amount of water which goes into one of the largest of the Thames reservoirs is 50 million gallons a day, or 80 million tons a year. In other words, even by comparison with the water required for one city, the world's production of petroleum is relatively small.

TABLE I.
Production.

World production of petroleum, 1886	3,000,000 tons
World production of petroleum, 1927	170,000,000 tons
World production of petroleum, 1938	268,000,000 tons
Annual production of natural gas (approx.) . .	3,000,000,000,000 cub. ft.
Annual production of cracked gas	300,000,000,000 cub. ft.
Coal gas made for the United Kingdom in 1937, of which one-tenth was produced by the Gas Light and Coke Co.	550,000,000,000 cub. ft.

TABLE II.
Percentage Production of Petroleum by Countries, 1940.

United States	63
Other countries (Russia, Mexico, South America, Iran, Iraq) . .	34
British Empire	3

Further figures are given by Egloff for the year 1941 :—

TABLE III.

	World crude oil production.	
	1000 barrels.	Per cent.
United States	1,400,000	62·5
Mexico	41,200	1·8
Canada	10,000	0·4
Central and South America . .	300,000	13·5
Europe	295,000	13·1
Asia	113,000	5·0
Oceania	71,600	3·2
Other countries	8,000	0·4
World total (approx.) . . .	2,250,000	—

TABLE IV.
Production of Oil Shale, 1938.

	Tons.
United Kingdom	1,500,000
Estonia	1,450,000
U.S.S.R. (estimated, 1936) . .	700,000
France	130,000

Production.

Modern search for oil lies mainly in the province of the geologist and his colleague, the geophysicist, but the chemist also plays his part, and the

latest petroleum science—that of geochemistry—is becoming important, as witness the careful analysis of superjacent soil, and of underlying formations for adsorbed gaseous hydrocarbons, symptomatic of underground seepages.

It would be out of place here even to outline the intricacies of the drilling technique.   But it may be briefly indicated that metallurgical science is called into play to determine the appropriate steels to be used capable of withstanding immense stresses and able to cope with outstanding problems of corrosion, and that the colloid chemist has to' decide on appropriate mixtures of clays and weighting material, to coat the hole effectively to withstand sudden gas pressures, to hold in suspension drilled-out material, and to possess rather specialized physical properties of viscosity and thixotropy.   And, furthermore, it should be noted that the chemist in the oil-fields has a multiplicity of functions apart from those related to the actual sinking of the well.   He is a very essential colleague of his geological confrères.   Samples of oil and gas and bitumen go to him—he must be able to determine the physical constants of the fluid in the oil horizon, gas–oil ratios, for example, viscosities under very high pressures, solubilities, retrograde condensation phenomena, plant efficiency in absorption or compression units.   More and more he is concerned in the design and operation of the multifarious types of fields plant.

Gas.

When the oil formation is struck, there is usually encountered considerable gas pressure, and a mixture of oil and gas rushes out.   This solution may be regarded as crude mineral oil.   In effect it is a mixture of solids, liquids, and gases, not only in true physical solution, but also co-existing in the colloidal state.   The gas component is in the main methane, but also present are ethane, propane, the butanes, and pentanes, with relatively small amounts of hydrogen sulphide, water vapour, carbon dioxide, nitrogen, and, in some cases, helium.   Some analyses follow :—

TABLE V.

	CH_4.	C_2H_6.	C_3H_8.	C_4H_{10}.	N_2.	CO_2.	H_2S.	He.
A typical " dry " gas (sp. gr. 0·65) . .	84·7	9·4	3·0	1·3	1·6	trace	—	—
A " wet " gas (sp. gr. 1·38) . . .	18·0	—	—	78·7	3·3	—	—	—
A sulphurous gas . .	40	21	18	9	—	—	12	—
A helium-containing gas.	15	—	—	—	83	—	—	2

It should be noted that a " dry " gas contains little that is liquefiable under ordinary conditions of temperature and pressure, whilst a " wet " gas may contain considerable amounts of hydrocarbons available for incorporation into motor fuel.   Natural gas contains many components which are of value, and every effort is made to conserve them.   In the first place, the fluid mixture passes straightaway from the well into a high-pressure separator.   This is, in effect, a long cylinder in which separation takes place at, for example, 2000 lb./sq. in.   At that pressure

the free gas will be mainly methane; if, then, the pressure is released in a series of vessels, stage by stage, for instance, to 600 lb., and then to 65 or 50 lb., there is a rough separation in each unit of the various gases which are incidental to the production of the crude oil.

Unfortunately, the largest proportion of the gas is methane, and this is without doubt a recalcitrant hydrocarbon. The higher homologues, however, are more amenable to treatment.

It will be noticed from the analyses in Table V that a rare component of certain natural gases (*e.g.*, from certain Texas fields) is helium. This gas is now separated by means of intensive refrigeration and used as the lifting agent in lighter-than-air dirigibles.

Brief reference should here be made to the utilization of the great bulk of the C_3 and C_4 fractions, both of natural and cracker (*q.v.*) gas. This material is readily liquefied under moderate pressure, and constitutes " bottled gas "—sold under various names, *e.g.*, calorgas, propagas, and the like. In 1941, the United States consumed 460,000,000 gallons of this liquid, and it is of some import to realize that the sales were quadrupled in five years.

The gas coming away from the crude will carry with it a certain amount of hydrocarbon material of higher boiling-point, and, to conserve this material, the gases are stripped in a counter-current system against a solvent heavy oil, just as in the familiar benzol recovery plant in the coal-

TABLE VI.

Production of Liquefied Petroleum Gases in the U.S.A.

Year.				Gallons.
1920	.	.	.	200,000
1930	.	.	.	18,000,000
1940	.	.	.	300,000,000
1941	.	.	.	460,000,000

TABLE VII.

The Main Constituents of Natural Gas.

					M. p., ° C.	B. p., ° C.
Methane	.	.	.	.	−182	−161
Ethane .	.	.	.	.	−172	− 89
Propane	.	.	.	.	−187	− 42
n-Butane	.	.	.	.	−135	− 0·6
*iso*Butane	.	.	.	.	−145	− 10
n-Pentane	.	.	.	.	—	+ 37

tar industry. Solid adsorbents may replace the stripping oil, or, more simply, a compression system may be employed. In this way is made available a very light spirit—natural gasoline—useful for improving the volatility of straight-run petrol and, furthermore, of value as an anti-knock component of motor spirit. (See Figs. 1, 2, 3, 4.)

After the crude oil is thus separated, it still contains some gas in solution, and this is taken out by a converse or stabilizing process in which the crude is heated and the so-called permanent gases in solution, up to

butane, are removed. In turn, they themselves, with various refinery and cracked gases, are stripped of anything they have taken with them in the way of liquefiable content.

The Engine and its Fuel.

Mention should here be made of the behaviour of the various light fractions of mineral oil in the internal-combustion engine. Until com-

TABLE VIII.

Engine Tests of the Commoner Lower Hydrocarbons, etc.

	Octane number. C.F.R.* rating, A.S.T.M.
ISO-OCTANE	100
CH_4	110
C_2H_6	104
C_3H_8	100
n-C_4H_{10}	92
iso-C_4H_{10}	99
n-C_5H_{12}	61
iso-C_5H_{12} { 2-Methylbutane	89
{ Dimethylpropane	83
n-C_6H_{14}	25
n-C_6H_{12}	80
2 : 3-Dimethylbutane	95
2-Methylpentane	70
3-Methylpentane	80
n-C_7H_{16}	0
2 : 2-Dimethylpentane	93
n-C_8H_{18}	-17
iso-C_8H_{18}	100
i.e. 2 : 2 : 4- and 2 : 2 : 3-Trimethylpentanes	102
n-C_9H_{20}	-45
C_2H_4	81
C_3H_6	85
n-C_4H_8	83
n-C_5H_{10}	80
n-C_6H_{12}	78
Ethyl*cyclo*butane	68
*cyclo*Pentane	83
*cyclo*Hexane	86
Methyl*cyclo*hexane	71
Neohexane	96
C_2H_2	80
C_6H_6	108
C_7H_8	104
For comparison there may be given corresponding data for alcohols, ethers, and ketones :—	
CH_3OH	98
C_2H_5OH	99
n-C_3H_7OH	90
n-C_4H_9OH	87
iso-C_3H_7OH	104
iso-C_4H_9OH	88
$CH_3 \cdot CO \cdot CH_3$	100
$C_2H_5 \cdot CO \cdot CH_3$	99
$CH_3 \cdot O \cdot C_3H_7$	73
$C_3H_7 \cdot O \cdot C_3H_7$	—
N-HEPTANE	0

* See Egloff and Arsdell, *J. Inst. Petrol.*, 1941, **27**, 211 *et seq.*

paratively recently any mixture of straight-run hydrocarbons derived from natural gas and from crude oil would function satisfactorily in the engine, simply because the engine was so designed as to possess a low compression ratio.   As the demand for extra efficiency grew more clamant and higher compression ratios were demanded, it was found that such fuels as were indicated above—i.e., straight-run distillates—failed.   It will be seen in the sequel that " cracking " helped to ease the situation; but it is rather important to realize that the entity of straight spirit contains components—good and bad—from the point of view of engine performance.   Bad are the normal paraffins above C_5—i.e., n-hexane and its homologues.   Good are the iso-paraffins—isopentane and its homologues—and it is of interest to note that in the scale of behaviour first set forth by Graham Edgar, n-heptane was the worst and iso-octane the best, and in fact the octane number of a fuel takes its place on the scale

$$n\text{-heptane} = 0.$$
$$iso\text{-octane} = 100.$$

It is clear, therefore, that careful fractionation, under the highly specialized technique now obtaining, will suffice to split straight hydrocarbon spirit into material of superlative or negligible performance in the engine.

It is appropriate here to consider the entirely revolutionary impact of lead tetraethyl on the octane rating of motor spirit—especially straight run from the crude and by synthesis from the lower hydrocarbon gases. It would be out of place to discuss the manufacture of this material $Pb(Et)_4$.   It, however, is made in colossal quantities, and used in very small concentrations (e.g., 4 c.c. per gallon of spirit).

Annually in recent years 66,000,000 lb. of lead tetraethyl were produced (in effect, enough to raise 20,000,000,000 gallons of spirit 7 points in octane rating).

Reverting again to the degassed and stabilized crude, this material now passes to the refinery proper, wherein the separation into further commercial products is effected.

Distillation.

Fig. 5 shows a modern distillation unit, and it will be noted that there are six main components—the pipe-heaters, the primary flash-tower, the main fractionating column, the vacuum column, the pre-heaters, and condensers.   In such a unit the crude oil can be run at circa atmospheric pressure to remove gasoline, kerosines, and gas oils, and under a good vacuum to yield lubricating oils and the waxes, together with a final pitch residue.

Progressing from the earlier days, when distillation merely consisted in evaporation and condensation, when sharp fractionation was unknown, and when re-distillation sufficed to produce the simple cuts of gasoline and kerosine, the industry has striven to attain perfection of plant operation and control, which can only be achieved by the application of accurate and scientific procedure.   The battery of boilers, so arranged that a gravity flow could be maintained from one to the next and a gradually increasing temperature could be maintained from still to still, with the crudest means of separation, gave place to a series of stills equipped with

elementary columns, and finally to the pipe-still, first developed actually in the cracking plants of a generation ago. (Incidentally, the coal-tar industry was a pioneer here.) The pipe-still possessed accurate control of temperature, heat, input pressure, and velocity of flow. Automatic controls were fitted to control rates of flow, temperatures, and levels.

Whilst in the earlier developments of distillation little more than a primary " topping "—*i.e.*, the removal of the lighter components—gasoline and kerosine—was aimed at, in recent years the complete splitting up of the crude into the whole range of merchantable commodities has been achieved, and in effect this is carried out in three successive stages : firstly, a flash evaporation, using waste heat from highly heated residues, which brings about the removal of the lightest fractions. Secondly, the residue from this stage is further heated in a pipe-still and discharged into the main column, provided with a multiplicity of " decks " or bubble-cap plates in which a rather astonishingly complete separation occurs : Overhead is gasoline—at various decks different products can be segregated, and eventually at the bottom of the tower emerges a residue that may represent, for example, 40 per cent. or 50 per cent. of the crude. Auxiliary heating in the form of live steam may be introduced into the tower. Broadly, the result is that the " white oils " are removed in this column—ranges of gasolines, white spirits, and light solvents, ranges of burning oils up to lighthouse and signal oils, ranges of gas oils—all cut according to desired specifications. The residue is again heated in a further pipe-still, and now passes into a column under reasonably high vacuum. Here takes place the final separation into heavy gas oils, lubricating-oil distillates (often containing solid paraffin waxes), and a final residue of pitch.

It should be pointed out as well that distillation may be employed even in the separation of low-boiling material usually regarded as gaseous—that, for example, *iso*butane may be separated quantitatively from a mixture of the two isomeric butanes.

It should be emphasized here that a peculiar degree of separation may be effected by " superfractionation " ; as an example, intensive reflux and a multiplicity of " decks " in the column will achieve the isolation of *iso*pentane from its congeners.

Cracking.

The cracking operation must now be considered. Up to the beginning of the first world war, all petrol was straight-run from the crude, and the average crude yielded about 20 per cent. of motor gasoline. The increasing demand for motor spirit for aviation, road transport, etc., became so great that it was impossible to meet that need with the amount of crude oil available, the methods then in use, and the impracticability of making more heavy residue than could be commercially used. Therefore, the problem of simplifying the heavy oils by breaking them down to lighter fractions became very urgent, and so the cracking procedure, as we know it to-day, came into existence. In effect, cracking is merely the thermal decomposition of the heavier hydrocarbon molecules into less complicated ones, but it must not be imagined for a moment that from 100 gallons of cracking stock there will be produced 100 gallons of petrol. By no means ;

something like 60 gallons of petrol is possible by ordinary thermal cracking. The residue will be much heavier oil, together with gas and coke.

Fig. 6 gives an idea of the immensity of the cracking operation. Here is shown one of a series of plants in which 5 or 6 million gallons a day of heavy oil are processed. Apart from the question of quantity, however, there is the question of quality. Since the last war, the whole aspect of quality of petrol has changed. Compression ratios of internal-combustion engines have gone up, and the yield of power per gallon of petrol consumed has also increased. A gallon of gasoline to-day will do twice as much work as a gallon did 20 years ago. With the modern small, high-compression, high-speed internal-combustion engine, there is a vastly increased efficiency in the utilization of motor spirit. It is a fact that nowadays there is not very much straight-run petrol used. This is a sad commentary on Nature's raw material; in point of fact, Nature is not a particularly good manufacturer. Most of what Nature makes can be improved upon to a very considerable extent. So that if Nature's inherent petrol were used to-day, the motoring world would have to go back 20 years, to the time of the T model Ford, with its compression ratio of 3 to 1. The fact that in a modern engine a compression ratio of 7 or 8 to 1 can be used is just an example of how the oil industry has met the challenge of the automobile engineer. Furthermore, far higher compression ratios are likely to confront us to-morrow.

Actually, up to 30 per cent. increase in power for take-off or climbing has been made possible by replacing 87 octane spirit by 100 octane rating.

Not only is heavy oil cracked into lighter, but the straight-run petrol or light distillate itself is cracked or " reformed " to improve its property of withstanding detonation in the engine.

In effect cracking and reforming are operations necessary for the upgrading of fuel for the internal-combustion engine. But, although the products are superior as anti-knock materials, there are serious problems that follow in train. Firstly, there are produced hydrocarbons of lower stability, with greater capacity for oxidation and proneness to gum formation. Such bodies could be removed by intensive acid treatment— with resultant loss of valuable fuel. And so has been developed the practice of anti-oxidant or inhibitor addition, whereby the chain reactions that lead ultimately to unpleasant end-products are checked. Such materials as the cresols, the amino-phenols, and aromatic dihydroxy derivatives substantially reduce these tendencies.

Perhaps of even greater importance to-day is the concomitant production of unsaturated hydrocarbon gases as a result of this thermal treatment—for example, ethylene, propylene, the butylenes, and amylenes. These are the authentic chemical bricks of our new synthetic chemistry— the chemistry of rubber, of plastics, and of polymers of various degrees of molecular complexity. As will be seen in the sequel, such chemical bricks are of outstanding importance and value.

So, indeed, does cracking not only upgrade straight-run petroleum products, but also provides the starting-out material for synthesis, and, in fact, it is reasonable to envisage deliberate high-temperature cracking as a means of producing nothing else but reactive gases.

In recent years sheer thermal cracking has given place to catalytic pyrolysis in which, under the influence of contact media such as silica and certain silicates, and in the presence of free hydrogen under considerable pressure, a variety of operations proceeds; in effect cracking reactions can to a large extent be controlled and directed into chosen paths. In addition, straight-chain linear paraffins may be " cyclized " or converted into substituted aromatic hydrocarbons, with concomitant dehydrogenation. Isomerization may also proceed. Indeed, with specific catalysts such as boron trifluoride or aluminium chloride *n*-butane may be converted in good yield to *iso*butane, a reaction of considerable importance in the alkanation process (*q.v.*).

" *Destructive* " *Hydrogenation.*

In addition to the pyrolytic treatment of heavier hydrocarbon and the reforming of lighter material, should be mentioned two rather recent developments. Under conditions of catalysis at very high pressure (*e.g.*, 200 atm. of hydrogen) practically 100 per cent. yield of gasoline is obtainable from a heavy cracking stock. Furthermore, by varying temperature and catalyst, spirit of high aromatic content may be achieved. It will be seen that by such means the transition paraffin $\longrightarrow$ olefine $\longrightarrow$ *cyclo*paraffin $\longrightarrow$ aromatic is entirely feasible, and that, from a petroleum starting-out material, all and every type of hydrocarbon derivative can be synthesized.

Products.

Only the briefest reference can be made to the white spirits for paint manufacture, the range of kerosines for heating and lighting, from the familiar " paraffin oil " to the long-time burning oil used in lighthouses and railway signal lamps, to the range of gas oils used as fuel and for gas enriching, to the range of lubricants from light spindle oil to heavy steam cylinder stocks, to the soft waxes for match impregnation, high-melting waxes for candles, waterproofing, and, finally, to the asphaltic residue for road surfacing and construction. Table IX shows the main course of these operations and the subsequent treatment of the accompanying gases.

The story of the straight distillation products of crude oil could, if time or space permitted, be extended into many chapters : into the range of fuels for the light and heavy diesel engine (surely better called the compression-ignition engine) ; into the realms of mineral lubricating oil, with the manifold problems of viscosity–temperature relationships; of physical and chemical stability, of dewaxing, of addition compounds designed to lower very materially friction under excessively high bearing pressures ; of solvent extraction that makes it possible to extract from any crude oil a lubricant of high efficiency and an extract of rather peculiar properties ; of waxes of all degrees of melting points and consistencies and asphalts of all varieties of those qualities that make for the permanence of road surfaces. Such a story would be outside the limits of the present paper. But it must be recognized, however, that in their proper place all these problems are within the scope of the petroleum chemist.

TABLE IX.

Crude Oil ex Well

Stabilized Crude

Paraffin Gases Mainly C_1 to C_4

Distillation

Whole range of Distillates, *e.g.*, Petrol, White Spirit, Kerosines, Gas Oils, Wax Distillates for Lubricants and Pitch Residue

Amount of further Paraffinoid Gases

Cracking and Reforming of Selected Distillates

Pyrolysis for Aromatic Hydrocarbons

Dehydrogenation to Reactive Olefines

*iso*Butane for Alkanation

Isomerization of *n*-butane

Cracked Spirit

Olefine Content of Cracked Gas (C_2 to C_4)

Residues

Catalytic Polymerization over Phosphates

Polymerization by Cold Sulphuric Acid

Treatment with *iso*Butane (the Alkanation Process)

Motor Spirit of High Octane Number

Selected Polymer Cut

Di*iso*butylene

Other C_4 Olefine Hydrocarbons

Hydrogenation

Hydrogenation

Polymerization over Phosphates

Mixed *iso*-Octanes

iso-Octane

High Octane Motor Spirit

iso-Octane

Refining.

The chemical and physical refining of the crude cuts from mineral oil has naturally extended all the abilities of the scientific personnel of the industry.   Few indeed of the raw products are usable as such ; some, of course, by virtue of sheer costs cannot be further treated—most residue fuels, marine diesel oils, gas, oils and the like are put on to the market much in the form in which they left the stills.   It is perhaps questionable whether or not refining has not overshot the mark.   Consider, for example, the removal of sulphur derivatives from gasoline.   Not so long ago a sulphur content of 0·01 per cent. was regarded as a reasonable figure. Egloff on many occasions has pointed out the futility of such a specification—in point of fact, it is only when the effect of certain thio-derivatives on lead tetraethyl is considered that a real case can be made out for reasonably complete sulphur removal.   Again, in the refining of kerosine or lamp oil, due consideration must be given to the effect of deleterious compounds on the wick, on the chimney, on smokiness, and on combustion generally.   A high degree of purity is likewise demanded for solvent oils, used, for example, in the paint and varnish industry.   Very special considerations arise when lubricating oils are considered.   These derivatives must possess chemical and physical stability in high degree, they must be characterized by a good viscosity index—that is to say, a flat temperature—viscosity curve—and ability to withstand higher and higher bearing pressures.

But it is at least important to decide *prima facie* what must and what must not be removed from a product to fit it for its purpose in our economic life—and it must be confessed that in the past far too much attention has been paid to appearance, colour, smell, and other purely æsthetic considerations.

Taking the individual products *seriatim* : Gasoline is entirely a motor fuel and its refining must be judged only from the point of view of its performance in the engine.

Clearly, colour and smell, and appearance are beside the point, except in so far as they indicate the presence of bodies that foul and corrode the engine and interfere with its efficiency.   Because most gasolines are now " leaded " to increase efficiency, sulphur derivatives must be removed— this can be achieved in a variety of ways.   These derivatives are hydrogen sulphide, mercaptans, and thio-ethers.   Simple soda washing removes hydrogen sulphide and part of the lower mercaptans.   Mercaptans are readily oxidized to disulphides, and rendered thereby odourless, but the total sulphur content remains.   Solvent extraction by means of such bodies as salts of amino-acids definitely removes these substances, as does complete oxidation with alkaline hypochlorite.   Where, however, lead tetraethyl is not used it is really quite immaterial whether sulphur is present or not.   There is, however, another aspect of the refining of gasoline that becomes important when cracked spirits or blends thereof are considered. It may at once be agreed that cracked material is less stable than the straight-run product, not so much by its content of olefines, because these hydrocarbons are in effect as resistant to change as are the paraffins.   It is rather the far more reactive compounds—probably diolefines—that

oxidize readily into gummy products. Such chain oxidations can be inhibited by the addition of quite minute quantities (0·005–0·01 per cent.) of anti-oxidants such as benzylaminophenol, the mixed cresols, quinol, xylenols, catechol, and certain fractions (*guiacol*) of wood tar. The net result is that such inhibited spirits withstand change for so long a storage period as a year.

The alternative process in the past was an intensive treatment with sulphuric acid, which not only brought about serious losses, since the harmless olefines were removed as well as the reactive hydrocarbons, but also was obviously a costly operation in terms of the reagent expended. So from the point of view of the refining of gasoline the essentials are : (1) removal of all sulphur derivatives if lead tetraethyl is to be added; (2) replacement of undue acid treatment by the addition of anti-oxidants. Questions of colour do not arise, since so much gasoline to-day is dyed.

The refining of kerosine is mainly concerned with burning properties and the removal of those bodies that cause charring of the wick, discoloration and fouling of the lamp-glass, and smokiness. The petroleum chemist is inclined to ascribe these defects to the presence of the thio-compounds, reactive unsaturated hydrocarbons, and aromatic derivatives. Again, of old, drastic acid treatment generally sufficed, but there were cases in which even excessive acid failed to yield a clear-burning kerosine. Such a case was found in Roumanian oil, but here a successful treatment was discovered by Edeleanu, who showed that extraction with liquid sulphur dioxide, owing to the preferential solubility of aromatic, unsaturated, and thio-derivatives, yielded a heavy separable extract, whereas a supernatant insoluble " raffinate " was formed of eminently excellent burning properties. Edeleanu treatment by " solvent extraction " has proved its worth for other petroleum derivatives than kerosine.

Brief reference must be made here to refining processes dependent on adsorption. For many years removal of colour from paraffin wax has been achieved by filtration through special varieties of animal charcoal— and, of course, other industries use this useful decolorant. But there are adsorbents of wider significance. Of such are ignited bauxite and a number of mineral clays such as floridin, tonsil, and the like. These materials not only remove colour, but also highly polar components of the crude distillates, sulphur derivatives, and, in general, the various deleterious bodies present in the unrefined fractions.

In a similar way high-grade light solvent oils, replacing, for example, turpentine, are marketed, and are entirely free from objectionable and reactive material.

Lubricating Oils.

Some attention must now be given to the refining of the heaviest fractions, which contain lubricating oils and solid waxes. These fractions come between the " white oils " and the asphaltic residues ; if the crude oil is not asphaltic the whole residue may constitute a lubricating oil base.

Although every crude oil yields a fraction (or a residue) mainly composed of oils possessing the quality of lubricants or friction inhibitors— yet these cuts differ markedly one from the other. Some are, in the main, paraffinic, often containing solid waxes in suspension with correspondingly

high set points; others are chiefly of asphaltic origin.   All contain oxidizable and reactive impurities.   It has already been shown that stringent acid refining has been replaced by processes largely physical and, in fact, solvent extraction to remove unwanted components is now very intensively practised.   Such solvents are phenol, dichloro–ethyl ether (chlorex), furfural, nitrobenzene, sulphur dioxide–benzol, and dimethyl formamide.

These solvents divide the crude lubricant into an unwanted extract (which, however, is likely to find commercial application by the very reason of its reactivity and particularly its oxidizability) and a " raffinate." Chiefly these two fractions differ in their viscosity–temperature relationships.   The expression Viscosity Index (V.I.) has been coined to express this, and is based primarily on an arbitrary figure of 100 for paraffin base oil and of 0 for certain Californian asphaltic oils.   It is, of course, clear that for the lubrication of the automobile engine an oil whose viscosity changes least from the starting-up temperature to that of normal working is most likely to be favoured by the driver.

Although in fact solvent extraction is widely used as a means of improving viscosity index, it is of interest to note that high pressure hydrogenation is also effective for this purpose.   Here it should be indicated how slender is our knowledge of the molecular structure of these high-boiling and complicated hydrocarbons.

Reasonable surmise seems to show that highly condensed multinuclear systems are characteristic of asphalt base crude that have a low viscosity index—on the other hand, long side-chains attached to similar condensed systems have a high V.I., and are conveniently described as possessing a high degree of paraffinicity.

Lubricating oil stocks which are highly asphaltic can be freed of asphalt content by a preliminary treatment with liquid propane which precipitates resinous and pitchy materials.

It has been indicated that solvent extraction processes remove reactive material, and therefore the refined oils are less liable to deposit sludges and gums in service, but at the same time this intensive refining is just as likely to eliminate those polar bodies on which true lubrication depends, for modern ideas on the *rationale* of lubrication point to the fundamental idea that a dual system is involved, that of the lubricated surface and that of the lubricant itself.   Polar bodies must be present to, in effect, unite with the rubbing surfaces, and so it has come about in cases where high pressures are involved reactive bodies of high polarity are deliberately added to the refined oil, which becomes merely the carrier.   Such bodies may contain chlorine, phosphorus, and sulphur.

Synthetic Lubricating Oils.

Some advances have been made in the field of synthesis of lubricating oils, and more are likely to emerge in the future.   Just as with other artificially produced fractions, it appears probable that specific properties can best be met by creating specific hydrocarbon entities.   So far as our knowledge goes, the essential components of mineral lubricants are long side-chains attached to ring structures, a combination of catenary and cyclic molecules.   Empirically, something has been done in the direction of polymerization of olefinic bodies under the influence of aluminium

chloride. Incidentally, some of these polymers which may possess a molecular weight of 20,000 have a remarkable effect on viscosity index.

Curiously enough, such high-molecular-weight hydrocarbons—usually synthesized from a long side-chain attached to an aromatic nucleus—have been applied to the problem of lowering the setting point of lubricating oils derived from paraffin containing crudes. These substances apparently operate by being selectively adsorbed on the growing faces of the wax crystals, stopping the development of large impermeable units.

Utilization of Petroleum Gases.

In what follows, main consideration will be given to the development of the various methods of utilizing petroleum gases, the very bricks of the new synthetic oil industry.

The earliest attempts to utilize the lower paraffin hydrocarbon depended on drastic thermal treatment. This operation was known as pyrolysis. Methane, unfortunately, proved most recalcitrant and yields were low, although mainly of an aromatic nature. At the same time reference should be made to the vastly important formation of acetylene therefrom. In recent years the process has been confined to the higher homologues. Fig. 11 shows a typical set up, in which the higher paraffinic gases (C_3 and C_4) are heat-treated. Mention should be made here, however, of the partial pyrolysis of these gases leading to the production of the corresponding olefines. Such dehydrogenation is effected by the joint impact of heat and catalysis.

Reverting, however, to the gases produced in the cracking and reforming processes, a typical analysis shows :

TABLE X.

	Mol., per cent.
CH_4	58
C_2H_4	7
C_2H_6	13
C_3H_8	11
$C_4H_8 + C_4H_{10}$	5

From the point of view of refinery procedure, these are concentrated into C_3 and C_4 fractions (the lighter gases C_1 and C_2 at the moment being of fuel value only, although this is obviously only a temporary phase). Clearly the last to be utilized on a vast commercial scale will be methane, and this amounts to something of the order of 10,000,000 tons per annum from petroleum sources alone. It is on the C_4 fraction, however, that most work has been done. This contains n-butane, isobutane, the two normal butenes and isobutene in proportions that vary with the cracking conditions. Also present is butadiene (under high-temperature cracking conditions particularly—the so-called vapour-phase process).

An early commercial operation was concerned with isobutene, and it must be remembered that in this connection " early " means only a few years ago. When treated with 65 per cent. sulphuric acid at ordinary temperatures this hydrocarbon is absorbed and converted into tert.-butyl alcohol.

On raising the temperature of the acid alcohol mixture to 100° C. a split takes place—"nascent" *isobutene* is regenerated and immediately forms the dimer and, to a less extent, the trimer. Schematically, the change is as follows, there being a final hydrogenation process leading to *iso*-octane :
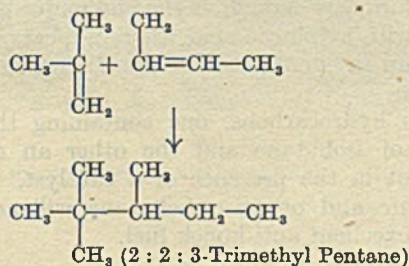
Dimerization of isobutene.

$$CH_2{=}\underset{\underset{CH_2}{\mid}}{\overset{\overset{CH_3}{\mid}}{C}} + CH_3{-}\underset{}{\overset{\overset{CH_3}{\mid}}{C}}{=}CH_2 \text{ (2 mols : \textit{iso}butene)}$$

$$\downarrow$$

$$CH_3{-}\underset{\underset{CH_3}{\mid}}{\overset{\overset{CH_3}{\mid}}{C}}{-}CH_2{-}\overset{\overset{CH_3}{\mid}}{C}{=}CH_2 \text{ (1 mol : di\textit{iso}butene)}$$

$$\downarrow$$

Hydrogenated

$$\downarrow$$

$$CH_3{-}\underset{\underset{CH_3}{\mid}}{\overset{\overset{CH_3}{\mid}}{C}}{-}CH_2{-}\overset{\overset{CH_3}{\mid}}{CH}{-}CH_3$$

iso-Octane
(2 : 2 : 4-Trimethyl Pentane)
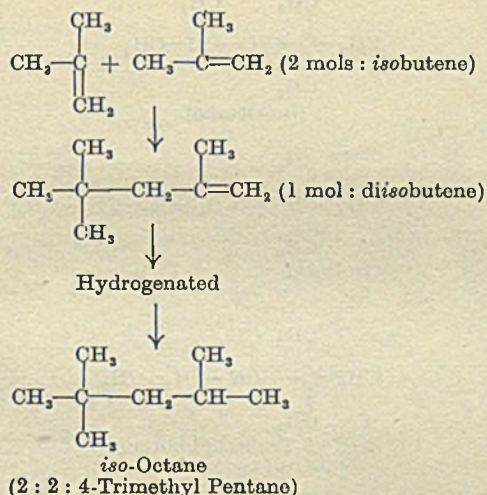
In Fig. 12 is shown a unit plant for polymerizing *iso*butene ; Fig. 13 illustrates the hydrogenation plant for the last stage.

The remaining butenes must now be considered. Using hot sulphuric acid, a co-polymerization of the total butenes ensues.

Co-polymerization of iso*Butene and* n-*Butene, followed by Hydrogenation.*

$$CH_3{-}\underset{\underset{CH_2}{\mid}}{\overset{\overset{CH_3}{\mid}}{C}} + \overset{\overset{CH_2}{\mid}}{CH}{=}CH{-}CH_3$$

$$\downarrow$$

$$CH_3{-}\underset{\underset{CH_3}{\mid}}{\overset{\overset{CH_3}{\mid}}{C}}{-}\overset{\overset{CH_2}{\mid}}{CH}{-}CH_2{-}CH_3 \text{ (2 : 2 : 3-Trimethyl Pentane)}$$

Actually there is a whole range of catalysts that bring about the polymerization or the co-polymerization of these olefines. Chief amongst these is a variety of phosphates, *e.g.* hydrogen, copper, and cadmium, and further various well-known naturally occurring compounds of alumina and silica.

A further development arose when it was discovered that *iso*butane would smoothly unite in the presence of sulphuric acid or of hydrogen fluoride with the butenes and yield *iso*-octane in one operation.

Addition of iso*Butene to* iso*Butane.*

$$CH_3-\underset{\underset{CH_2}{|}}{\overset{\overset{CH_3}{|}}{C}} + CH_3-\underset{}{\overset{\overset{CH_3}{|}}{CH}}-CH_3$$

$$\downarrow$$

$$CH_3-\underset{\underset{CH_3}{|}}{\overset{\overset{CH_3}{|}}{C}}-CH_2-\overset{\overset{CH_3}{|}}{CH}-CH_3$$

(*iso*-Octane)

and further :

$$CH_3-\underset{\underset{CH_3}{|}}{\overset{\overset{CH_3}{|}}{CH}} + CH_2{=}CH-CH_2-CH_3$$

*iso*Butane   *n*-Butene

$$\downarrow$$

$$CH_3-\underset{\underset{CH_3}{|}}{\overset{\overset{CH_3}{|}}{C}}-\overset{\overset{CH_3}{|}}{CH}-CH_2-CH_3$$

2 : 2 : 3-Trimethyl butane
(also an *iso*-octane)
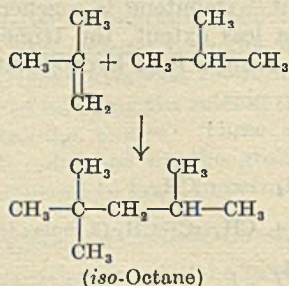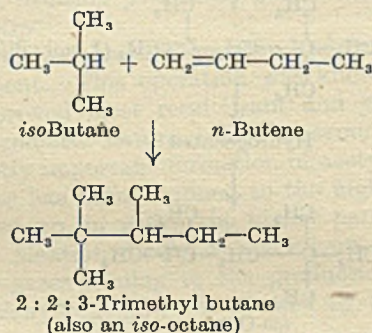
This reaction, not yet quite fully explained, and possibly not quite developed to the full, is one of the most elegant syntheses accomplished in the field of petroleum chemistry. It is conveniently termed " alkanation," although the expression alkylation is perhaps more commonly used, especially in America.

The alkanation reaction has been fully studied in the case of *iso*butane, coupled with the two normal butenes, with di*iso*butene and, in fact, with the whole C_4 cut. Curiously enough, if the end major product (*iso*-octane) is similarly treated with sulphuric acid, there appears, in effect, to occur a reverse reaction, and the final products are similar to those encountered in the initial reactions.

The union of two hydrocarbons, one containing the tertiary carbon atom characteristic of *iso*butane and the other an olefine, is, as just explained, carried out in the presence of a catalyst. But by the mere impact of temperature and pressure *iso*butane will add on ethylene to yield neohexane, an excellent anti-knock fuel.

$$C-\underset{\underset{C}{|}}{\overset{\overset{C}{|}}{C}} \ . \ + \ \overset{\overset{|}{|}}{C}{=}\overset{\overset{|}{|}}{C}$$

$$\downarrow$$

$$C-\underset{\underset{C}{|}}{\overset{\overset{C}{|}}{C}}-C-C$$
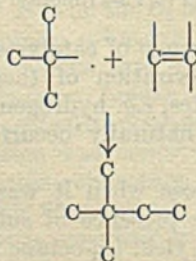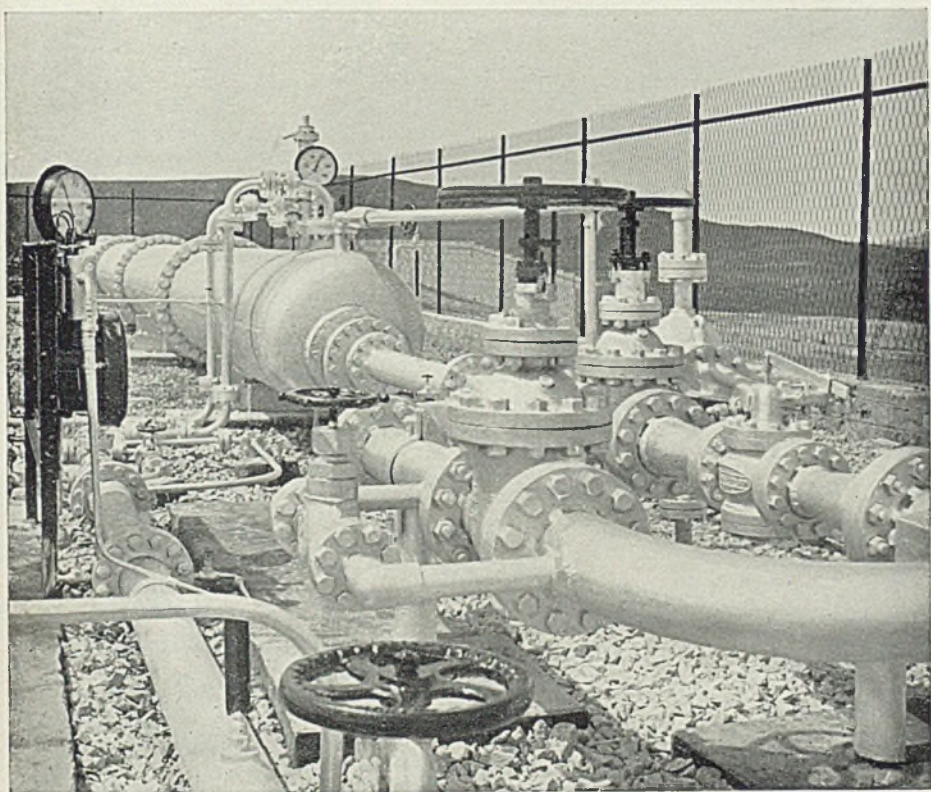
Fig. 1.

A HIGH-PRESSURE WELL-HEAD GAS SEPARATOR.
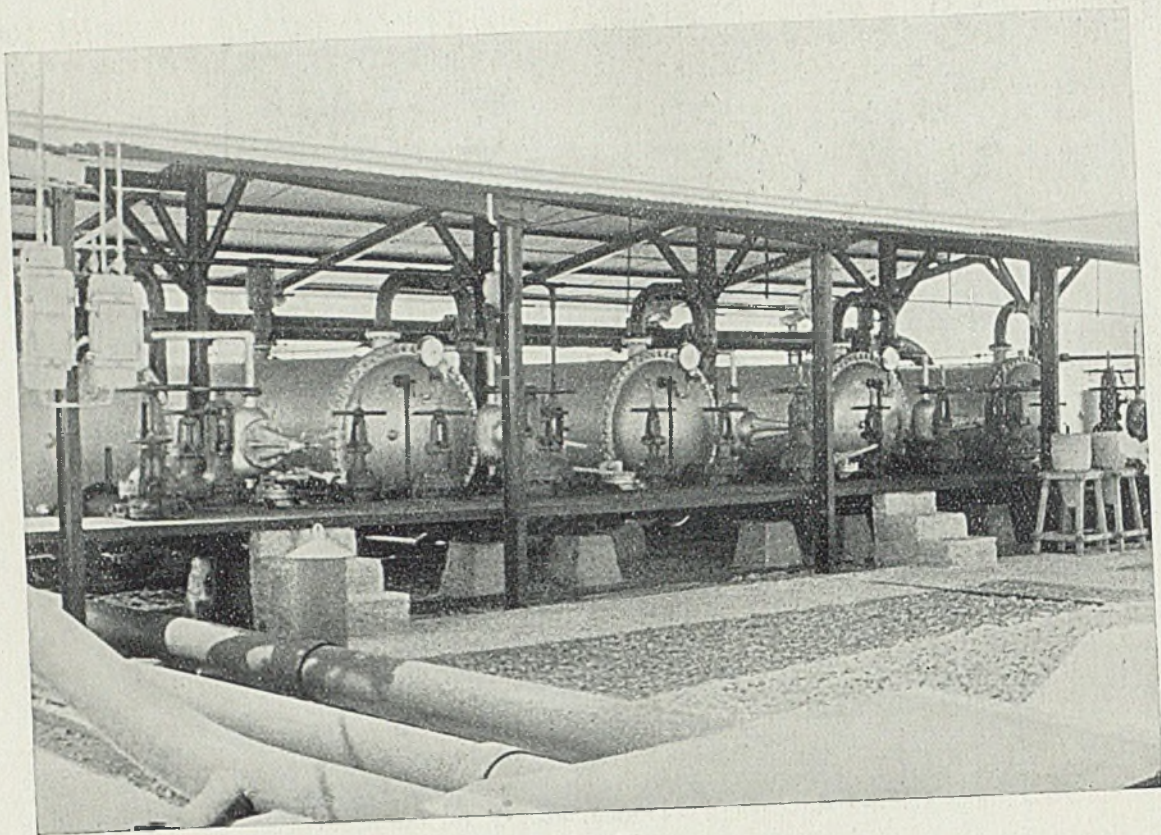
FIG. 2.
MULTI-STAGE GAS SEPARATOR.
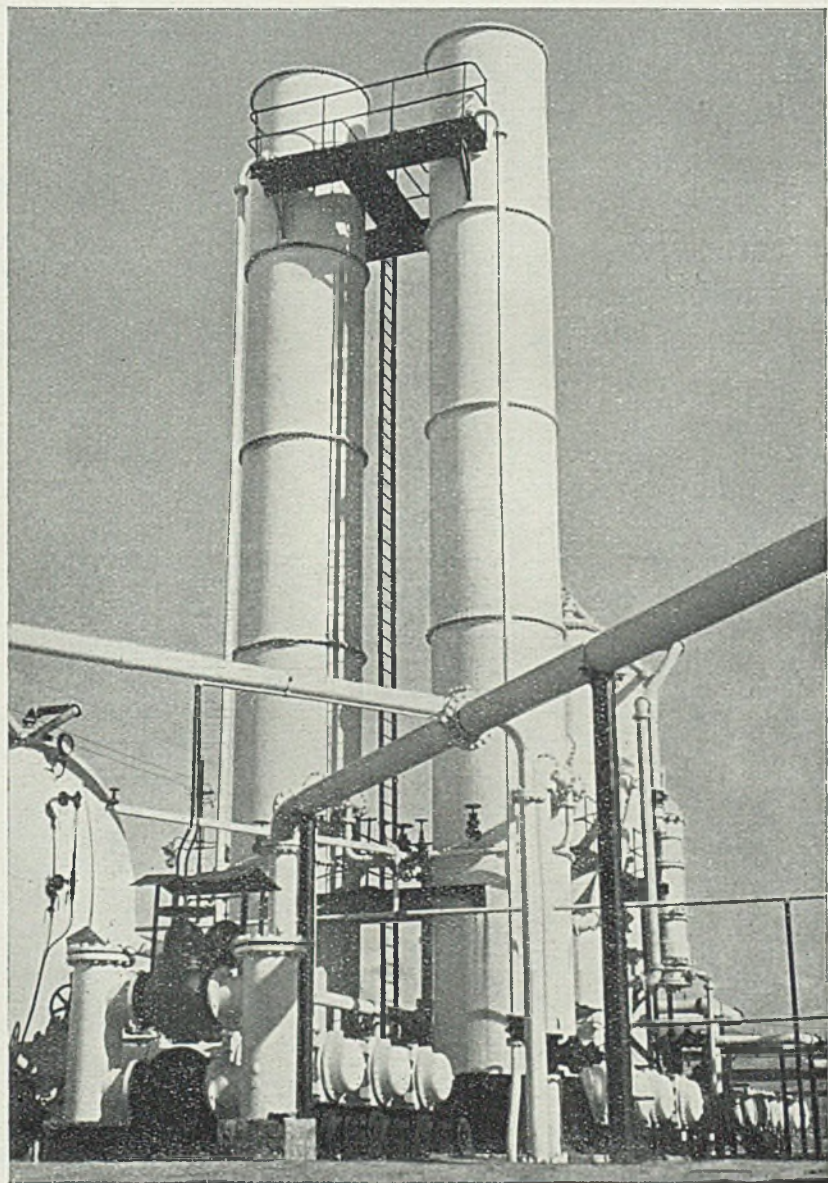
FIG. 3.
TOWERS IN A GAS-ABSORPTION PLANT.
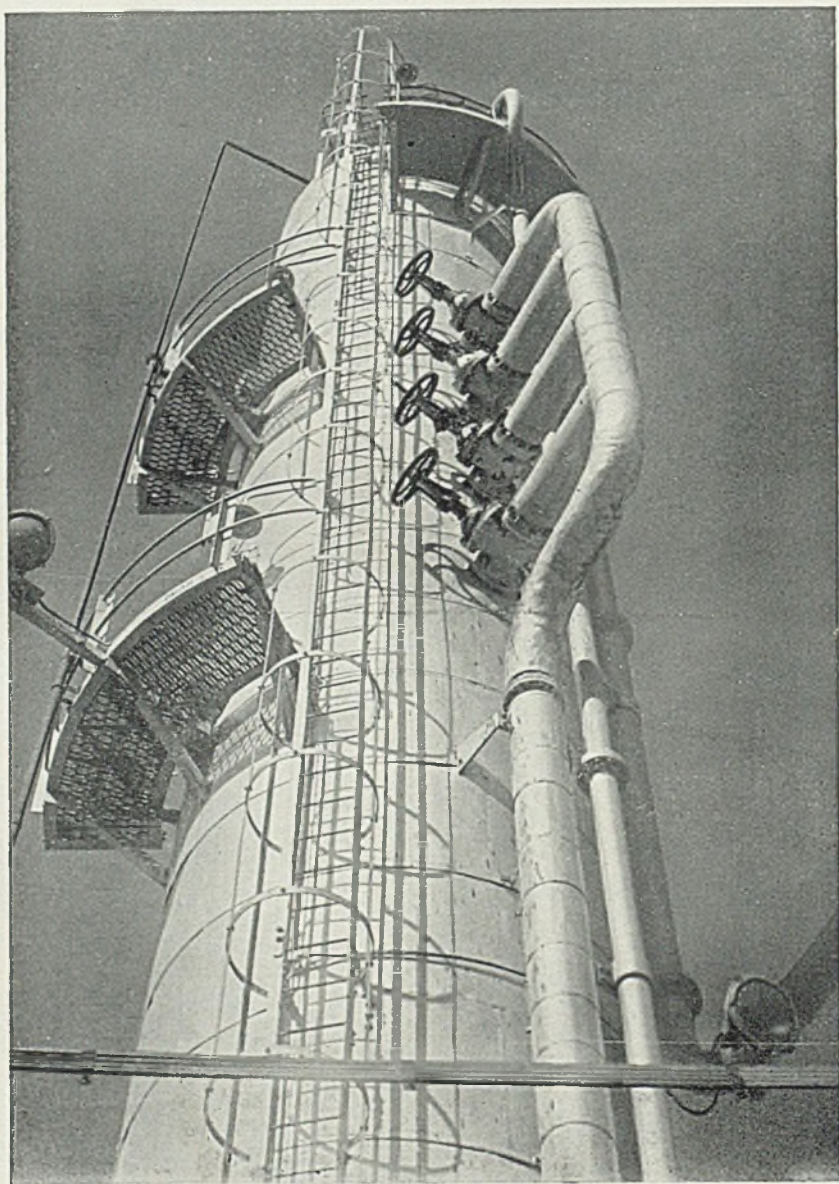
FIG. 4.
COLUMN OF A STABILIZING UNIT.
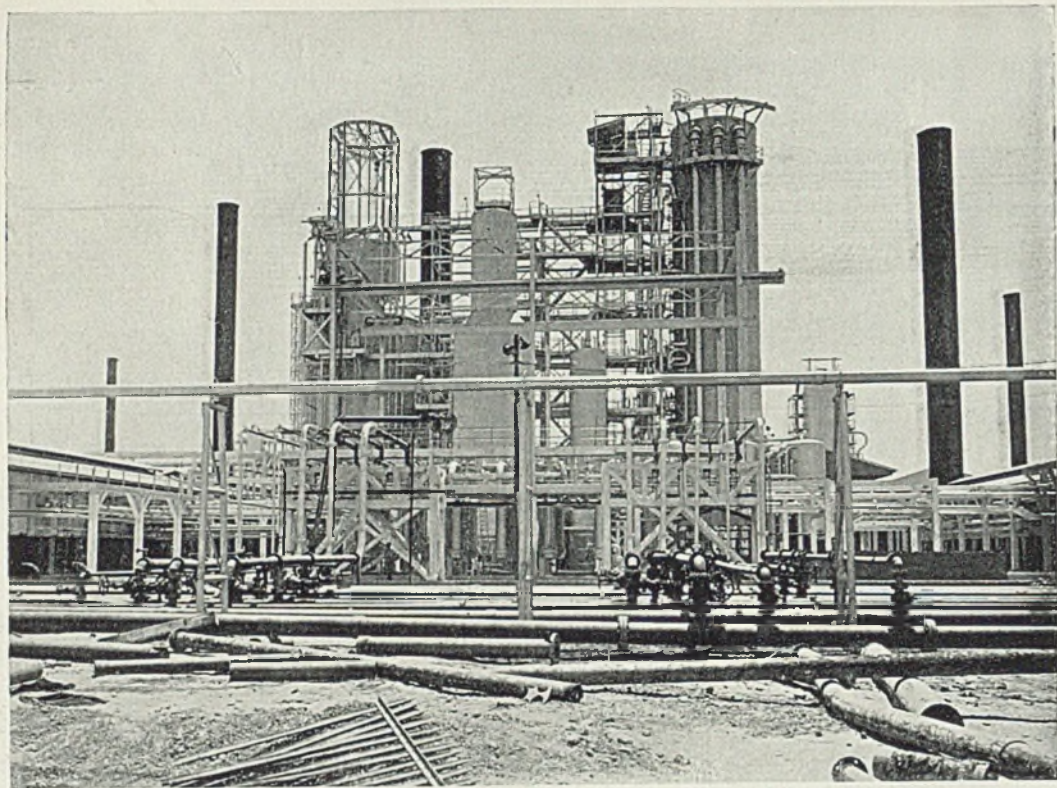
Fig. 5.

A MODERN DISTILLATION UNIT (3,000,000 TONS OF CRUDE PER ANNUM).

The column in the middle is the primary flash tower, on the right is the main tower that removes the white oil, and on the left is the vacuum column. The height of the main tower is well over 100 feet, its diameter 20 feet, and it possesses 25 decks.
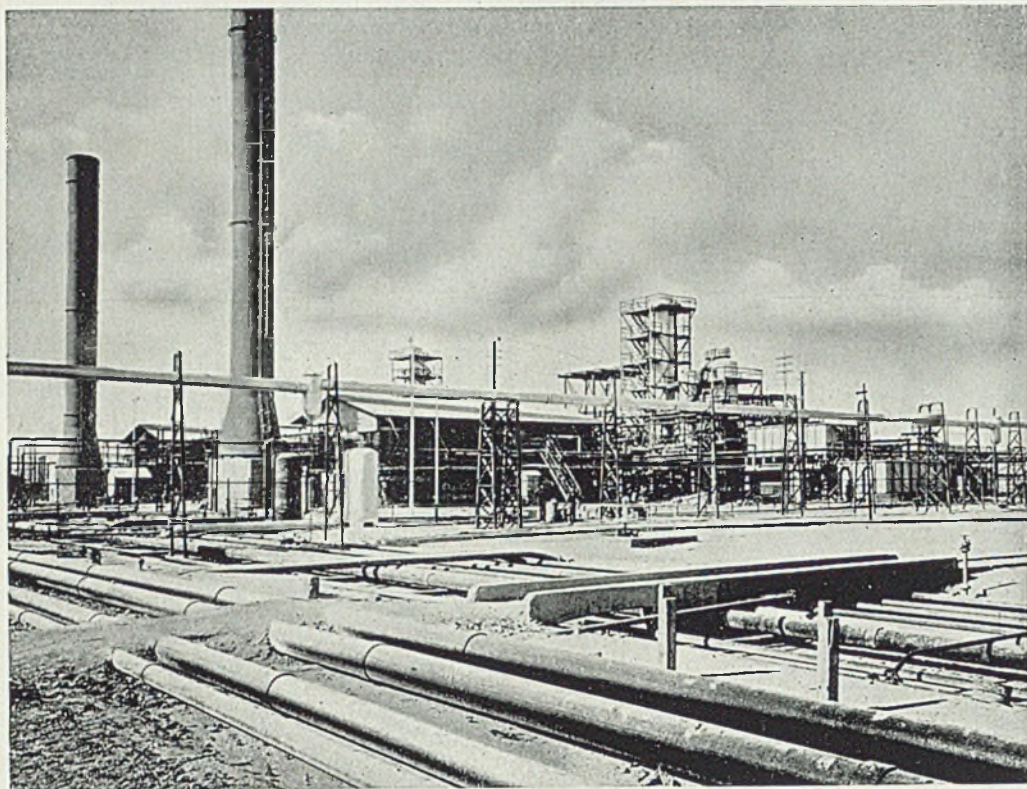
FIG. 6.

A SERIES OF THERMAL CRACKING UNITS.
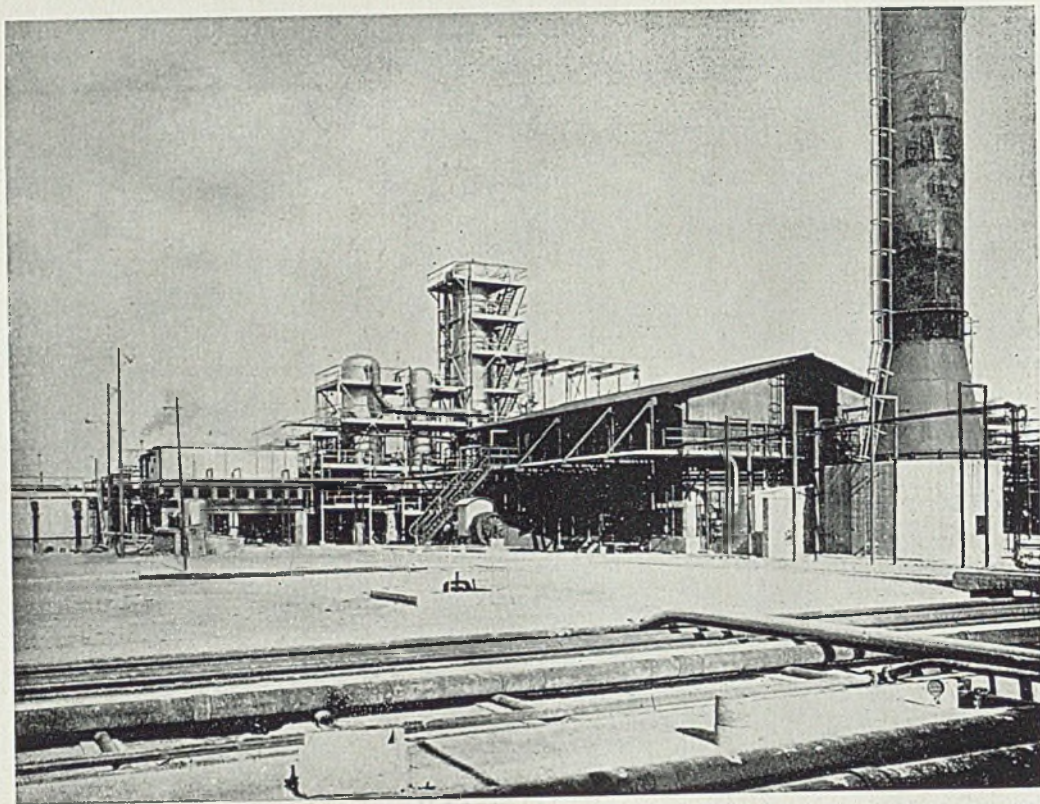
Fig. 7

A NAPHTHA REFORMING UNIT.
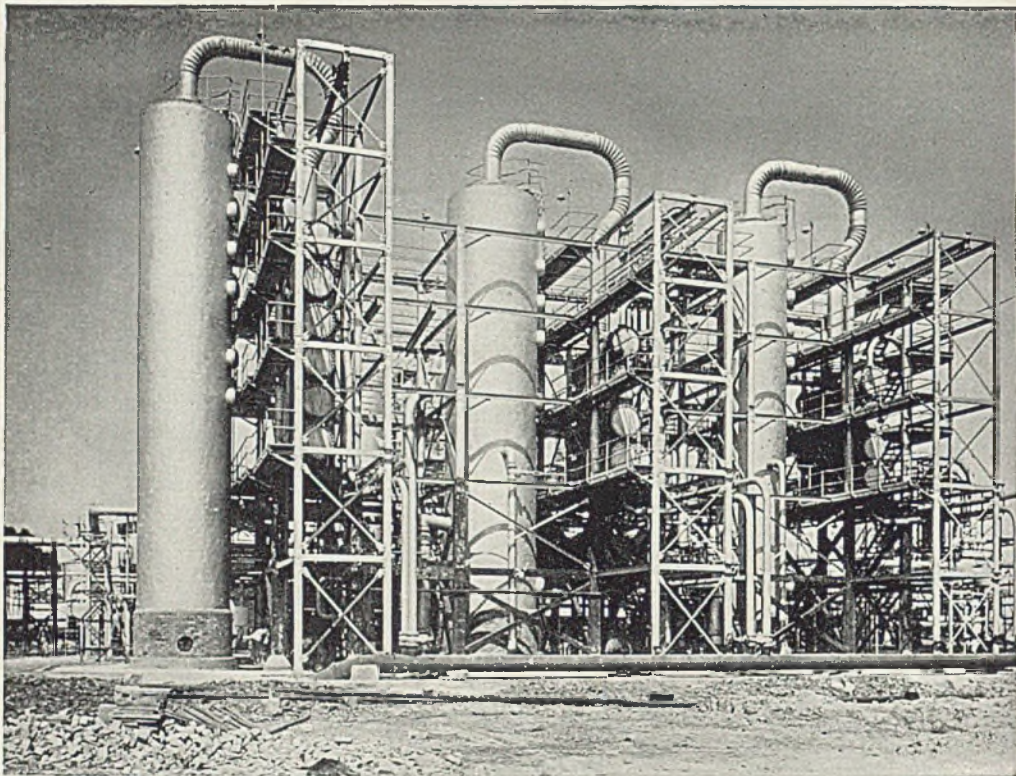
FIG. 8.
A RE-RUN UNIT FOR LIGHT PRODUCTS.
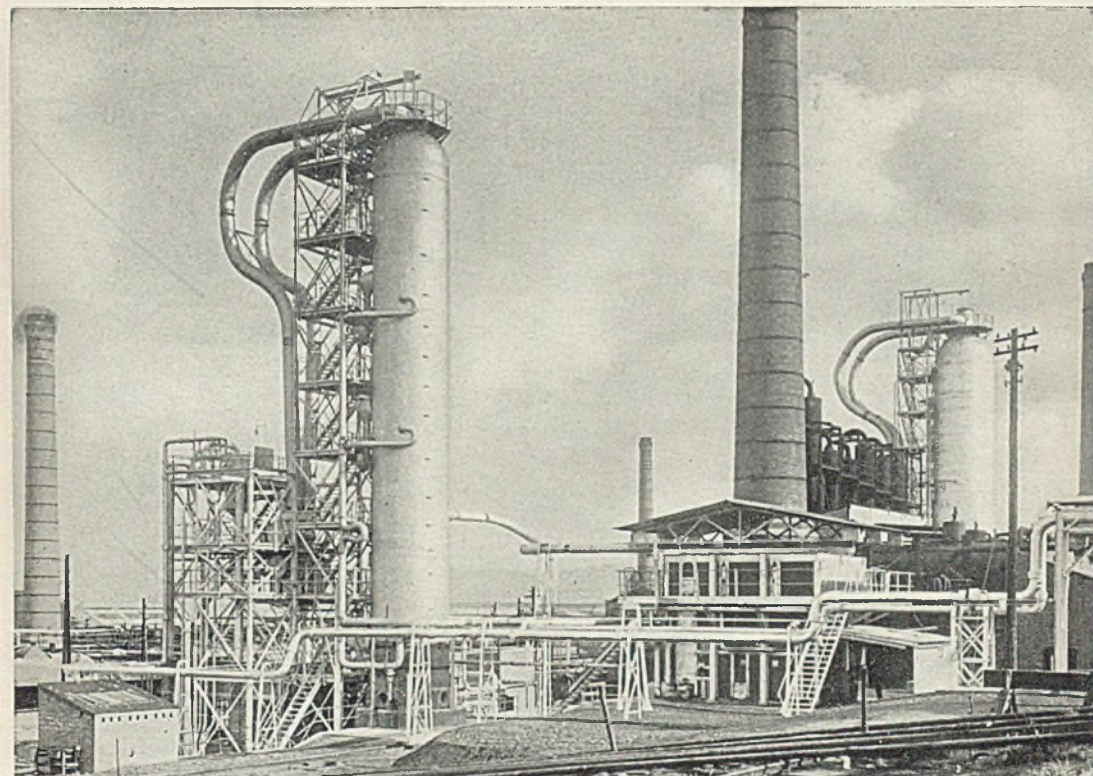
FIG. 9.
HIGH VACUUM DISTILLATION UNIT FOR LUBRICATING OILS.
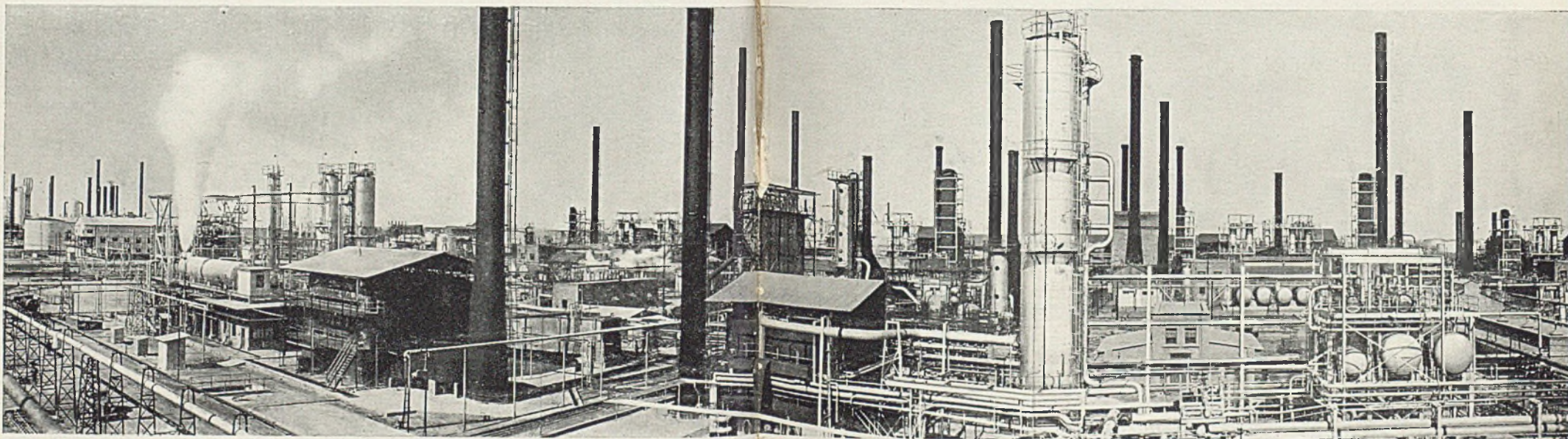
FIG. 10.
A PANORAMA OF A MODERN REFINERY SHOWING PART OF THE GAS UTILIZATION SECTION.
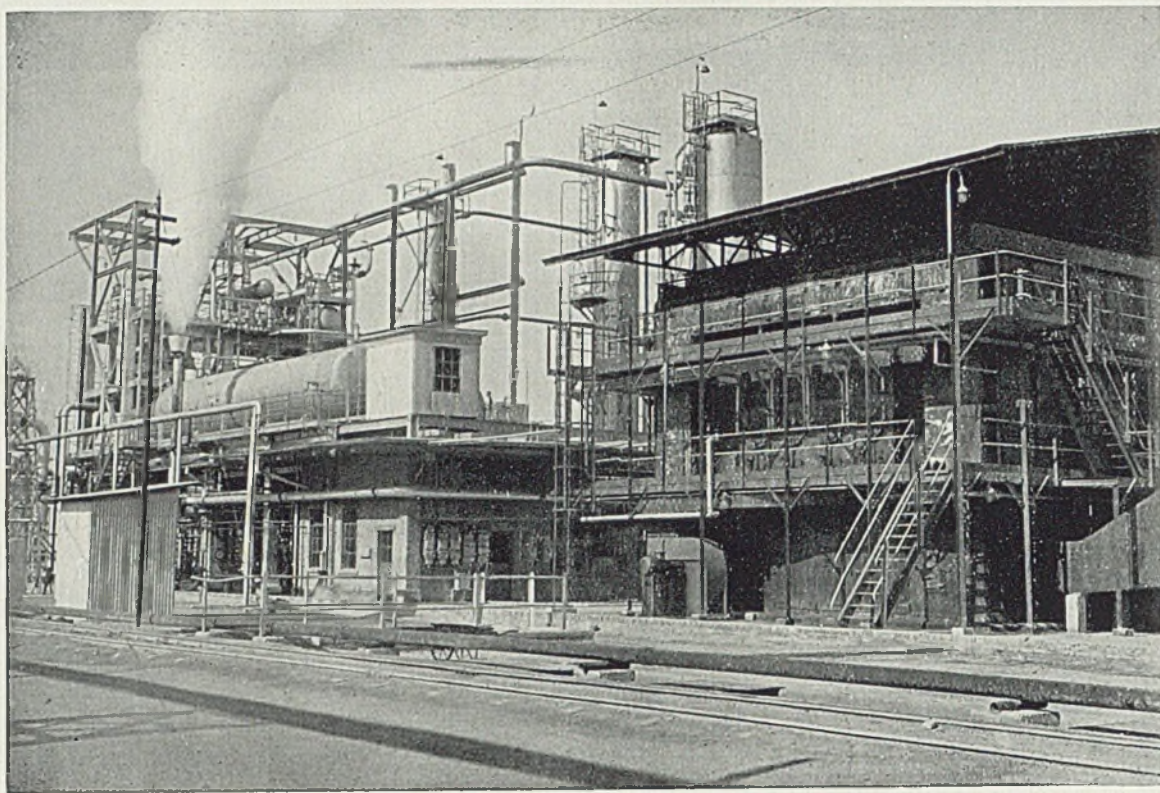
Fig. 11.

PYROLYSIS PLANT SHOWING FURNACE CONSTRUCTION.
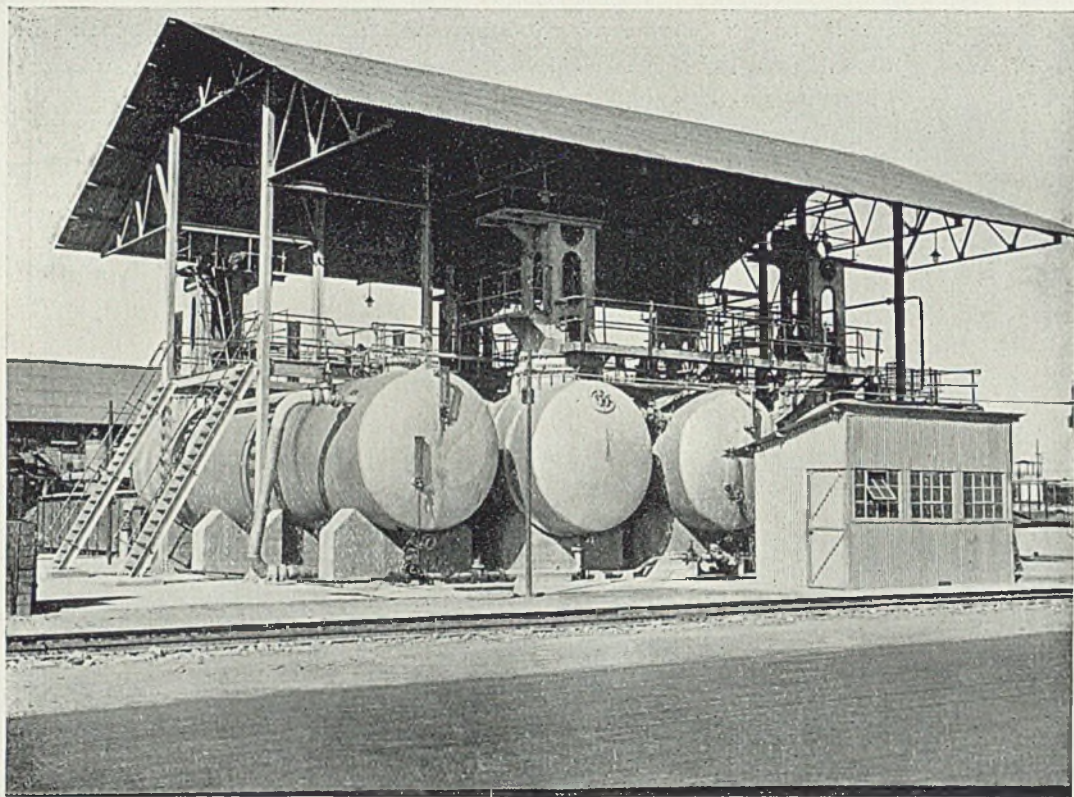
Fig. 12.

REACTION VESSELS FOR THE MANUFACTURE OF DI*IS*OBUTENE.
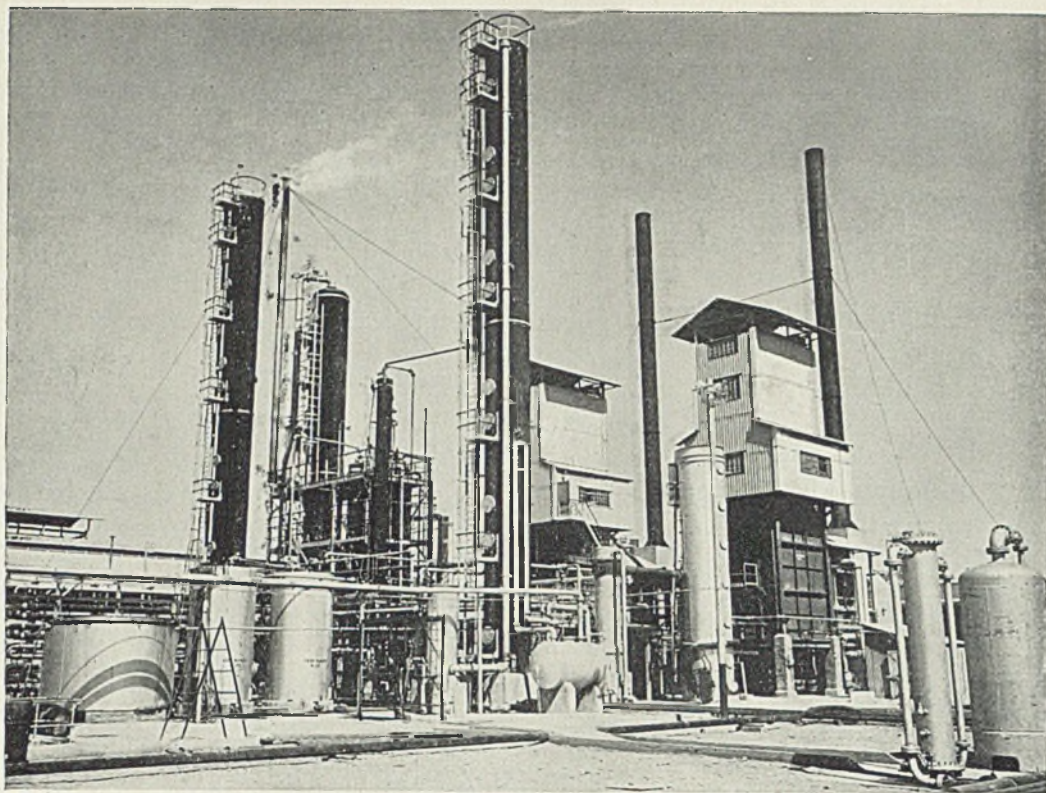
Fig. 13.

HYDROGENATION UNIT FOR THE CONVERSION OF DI*ISO*BUTENE TO 2 : 2 : 4-TRIMETHYL PENTANE.

To recapitulate :

$$2 \text{ molecules } \textit{isobutene} \longrightarrow \text{di}\textit{isobutene} \longrightarrow \textit{iso}\text{-octane}$$
$$n\text{-butene} + \textit{isobutene} \longrightarrow \text{co-dimer} \longrightarrow \textit{iso}\text{-octanes}$$
$$\left.\begin{array}{l}\textit{isobutene} \\ n\text{-butenes}\end{array}\right\} + \textit{iso}\text{butane} \longrightarrow \textit{iso}\text{-octane.}$$
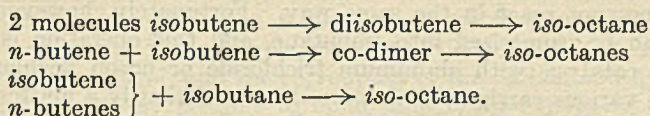
Clearly the last operation gives the greatest yield of *iso*-octane from the C_4 fraction, and that in one operation.
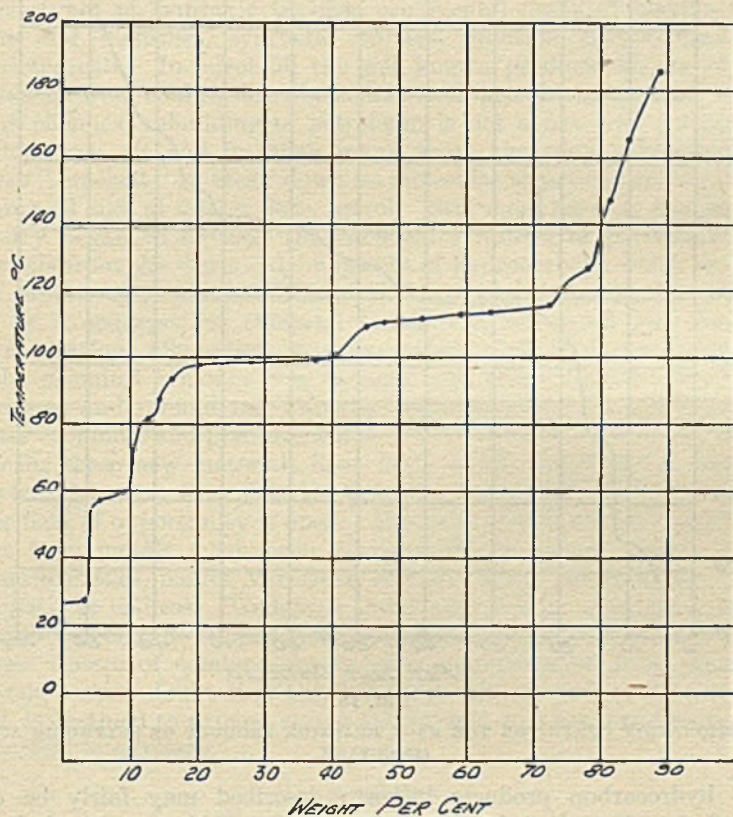
FIG. 14.

FRACTIONATION CURVE FOR THE PRODUCT BUTENE–*ISO*BUTANE.

It is of some interest there to indicate how a careful fractionation of, for example, the crude product 2 : 2 : 4-trimethylpentane prepared from *iso*butene and *iso*butane shows not only the preponderance of the *iso*-octane, but also other accompanying hydrocarbons and how, similarly, the back reaction between sulphuric acid and *iso*-octane itself yields a material the distillation curve of which may well be compared with the former graph.   (Figs. 14 and 15.)

It is important at this stage to stress the characteristic behaviour of the tertiary carbon atoms in *iso*butane and its allies, not dissimilar from

o

the reactivity of the carbon atoms in the aromatic nucleus. Normal butane does not react in the same way. Fortunately, however, normal butane can be isomerized into *iso*butane, and this operation is brought about by catalysis with aluminium trichloride or boron trichloride supported on various carriers; such procedure is obviously a matter of great importance in the syntheses briefly outlined above.
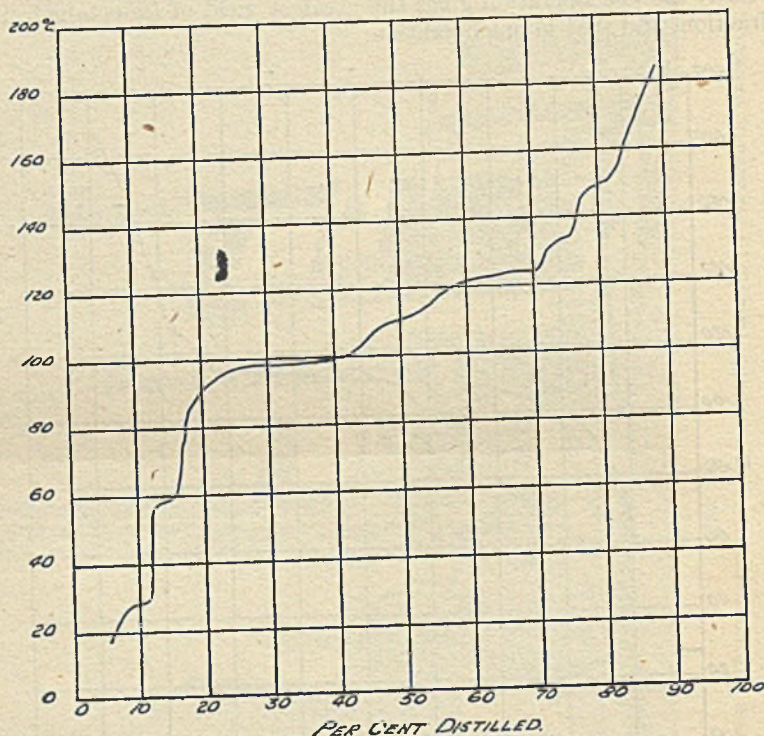
FIG. 15.

FRACTIONATION CURVE FOR THE BACK REACTION PRODUCT OF SULPHURIC ACID–
ISO-OCTANE.

The hydrocarbon products hitherto described may fairly be called motor fuels. But there is a vastly important field of synthesis leading to a remarkable out-turn of organic materials of the most diverse nature— and broadly all these are derivatives of the olefines. As was shown earlier in this lecture the unsaturateds are readily produced by the dehydrogenation of the paraffins over various catalysts.

Although, without doubt, the principal use of petroleum will always be as a source of fuel, lubricants, and road-surfacing asphalt, chemical developments in recent years have opened up entirely new vistas of usefulness. The chemist views petroleum not only as a mixture of petrol, kerosine, etc., but as an assembly of carbon and hydrogen atoms put together by Nature like so many bricks to form edifices of certain specific designs known as paraffins, naphthenes, and aromatics. He realizes, moreover, that it is possible to break down these structures which may

be useful only as fuel, into their component bricks, and with these bricks to reconstruct new edifices of a design and pattern suitable for quite different purposes. For example, by demolition of heptane, one of the hydrocarbons in petrol, and the regrouping of the carbon and hydrogen it contains, it is entirely possible to build toluene for explosives or styrene for flexible glass or butadiene for synthetic rubber.

By combining these derived hydrocarbons with oxygen there can be made alcohol, glycerol, and acetaldehyde, the parent materials for the newest types of synthetic textiles, ornamental moulded plastics, resins, paints and varnishes, synthetic rubbers, flotation agents, insecticides, and detergents. In effect all the well-known products known of old as originating from coal tar are obtainable from petroleum bricks.

The chemical rebuilding of petroleum is not a new and revolutionary development. It had its birth many years ago when unwanted heavy oil was " cracked " to break down its molecular structure, and so to create burning oil and, at a later date, petrol. Still more recently the petroleum industry began to develop the chemical synthesis of particular desired materials from the disrupted fragments of hydrocarbons which so far had been waste by-products. From cracker gases *iso*butene was isolated and by a sequence of chemical treatments converted into *iso*-octane. Polymerization, alkanation, hydrogenation, cyclization, aromatization— all the chemical armoury was brought into commission to break down, re-arrange and rebuild less valuable hydrocarbons into hydrocarbons of greater economic and practical value.

So far these new materials have been mainly employed as high-grade fuels to improve or to replace the natural product, but to-day an infinitely wider field of opportunity is open. Hitherto most industrial commodities, apart from metals, have been of vegetable or animal origin; one can instance textiles, paints, varnishes, solvents, dyes, drugs, rubber, plastics —the list is endless. To-day, a great and rapidly expanding chemical industry is being developed from petroleum, whereby every one of these various classes of commodities is being manufactured from mineral oil, and one cannot doubt that this industry, still, as yet, in its early child-hood, is destined to expand surely and rapidly to a scale and scope almost impossible to envisage.

Synthetics.

Ethyl alcohol has been in commercial synthetic production for a decade or more, and absorption of ethylene in sulphuric acid has been invariably the favoured process. It is significant, however, that the direct hydration of the hydrocarbon is attracting attention; and, further, as B. T. Brooks has pointed out, the use of relatively dilute sulphuric acid under elevated conditions of temperature and pressure leads to a continuous production of alcohol, with avoidance of reconcentration.
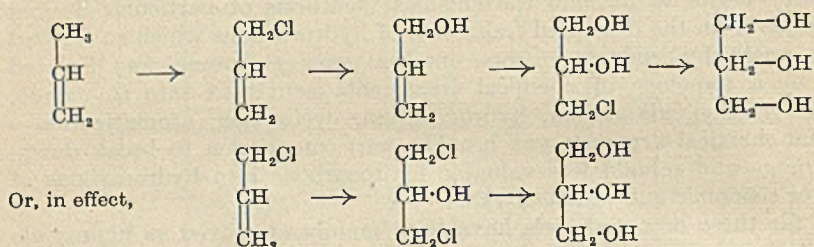
Oxidation of ethanol to aldehyde, the condensation of the latter to aldol, and subsequent dehydration to butadiene are preliminaries in the synthesis of rubber.

Clearly these derivatives depend on a source of reasonably pure ethylene, and this, in turn, depends on the effective separation of the constituents of cracked gases.

To some extent, and for certain specific purposes, ethylene may be separated from accompanying propylene by its lower solubility in sulphuric acid—it being, of course, premised that a separation between the C_1-C_2 and the C_3-C_4 groups has been effected by fractionation of the cracked gases under pressure.

The use of ethylene as an intermediate in the manufacture of mustard gas and in the synthesis of lead tetraethyl might be mentioned at this stage.

Propylene is readily converted into *iso*propyl alcohol, a useful solvent, *via* propyl hydrogen sulphate, and the alcohol itself passes by catalytic dehydrogenation into acetone. Obvious steps lead to ketene and to acetic anhydride. An extremely interesting observation by E. C. Williams has lead to the commercial synthesis of glycerol and β-methyl glycerol. Alkyl chloride is formed by the chlorination of propylene at high temperatures. Hydrolysis of this leads to alkyl alcohol. After hydrochlorination the chlorhydrin is produced, which, with alkali treatment, yields ultimately glycerol :

$$
\begin{matrix}
CH_3 & & CH_2Cl & & CH_2OH & & CH_2OH & & CH_2-OH \\
CH & \rightarrow & CH & \rightarrow & CH & \rightarrow & CH \cdot OH & \rightarrow & CH_2-OH \\
CH_2 & & CH_2 & & CH_2 & & CH_2Cl & & CH_2-OH
\end{matrix}
$$

Or, in effect,
$$
\begin{matrix}
CH_2Cl & & CH_2Cl & & CH_2OH \\
CH & \rightarrow & CH \cdot OH & \rightarrow & CH \cdot OH \\
CH_3 & & CH_2Cl & & CH_2 \cdot OH
\end{matrix}
$$

Similar reactions proceed in the case of *iso*butene.

The importance of this set of reactions lies, of course, in providing a source of glycerol competitive with the usual hydrolysis of fats.

Further derivatives from propylene and prepared by well-known methods are : Acetone, *iso*propyl ether, methyl ethyl ketone, *tert.*-butyl alcohol, allyl alcohol, methallyl alcohol, acrolein and epichlorhydrin. Of special interest to the petroleum chemist is di*iso*propyl ether—known recently to be a potent anti-knock material.

*iso*Butene has already been mentioned as the source material of di*iso*butene which on hydrogenation yields *iso*-octane. But on chlorination it provides methallyl chloride, the homologue of allyl chloride. From methallyl chloride proceeds the alcohol and the oxidation product methacrolein, that in turn can be oxidized to *iso*butyric acid.

Amongst the earliest successful attempts to develop the synthesis of derivatives of petroleum was the production of ethylene glycol *via* the chlorhydrin readily obtained by the reaction between ethylene and chlorine water. Glycol soon attained a commanding place as the most convenient and economical " anti-freeze," and still retains that position. To-day the more important of the glycol series include diethylene glycol, ethylene glycol methyl ether (methyl cellosolve), ethylene glycol butyl ether (butyl cellosolve), diethylene glycol methyl ether (methyl carbitol), diethylene glycol ethyl ether (carbitol), dioxan, dichloroethyl ether (chlorex—an important solvent in the refining of lubricating oil fractions), ethylene oxide, ethylene dichloride, ethylene chlorhydrin, the ethanolamines, and ethylene-

diamine. Brief reference also may be made to the nitrated glycols as explosives. The dehydrogenation of *iso*propyl alcohol to acetone is now an accomplished fact, and new low cost levels for acetone have been achieved. Acetone may be condensed to diacetone alcohol, and this dehydrated to mesityl oxide, and then further hydrogenated to methyl *iso*butyl ketone. Also well known in the reactivity of these materials is the pyrolysis of acetone to ketene :

$$CH_3 \cdot CO \cdot CH_3 \longrightarrow CH_2 = CO + CH_4$$
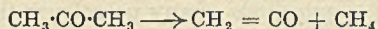
Ketene with acetic acid yields acetic anhydride—an outstandingly important intermediate in synthetic chemistry. Furthermore, ketene readily polymerizes to diketene, and this yields in turn aceto-acetic esters.

The alkyl halides deserve a brief mention. Ethyl chloride is a very important intermediate in the production of lead tetraethyl. It may be synthesized *via* ethylene and hydrogen chloride. Ethylene dichloride made directly from ethylene, and the halogen is used in the manufacture of thiokol rubber by interaction with sodium polysulphides. Specially may be mentioned the chlorinated pentanes which have been for some years the source of material for the production of amyl acetates and alcohols as solvents.

Ethyl chloride, reacting under the influence of such catalysts as aluminium chloride on benzene, yields ethyl benzene, which is clearly the intermediate in the formation of styrene, and hence the styrene resins and rubbers.

The chlorination of propane under pressure giving (1 : 3)-dichloropropane is the first step to *cyclo*propane—a useful anæsthetic. Derivatives such as *tert.*-butyl phenol are of interest in the manufacture of specialized resins, and similarly *tert.*-amyl alcohol readily alkylates phenol yielding *tert.*-amyl phenol.

Of somewhat more recent interest is the manufacture of detergents. A chloro-derivative of a long-chain paraffin is converted into an alkyl-aryl compound, which on sulphonation yields an acid. The sodium salt is found to possess excellent wetting properties. In general, all detergents comprehend a hydrophobic long carbon chain, together with a hydrophilic group, usually a sodium sulphonate.

Mention should here be made of the co-polymerization of dienes and olefines (both simultaneously produced in the high temperature cracking of petroleum) under the influence of, for example, aluminium or boron trichloride. For example, *iso*butene itself yields a series of highly polymerized hydrocarbons, from liquid material of use in improving the viscosity index of a mineral lubricating oil to a material of very great molecular weight, resembling rubber itself, and known as Vistanex.

It has already been indicated that the paraffins *tel quel* are not as reactive as the olefines, nevertheless they are of considerable interest. Methane, for example, yields the *mono* to the *tetra* chloro- (and nitro-) derivatives. The C_5 chloro-derivatives are source material for alcohols, esters, and amines. Further, by oxidation the paraffins are starting-out material for alcohols, aldehydes, ketones, and fatty acids, soaps, edible glycerides, detergents, and wetting agents.

The pyrolysis of methane to acetylene should be stressed. It is not

generally known that natural gas, the world over, represents about ten million tons a year of available hydrocarbon (mainly methane), most of which is lost or burnt at the fields and refineries as fuel. From this vast quantity it is reasonable to assume that the production of not only acetylene, but also aromatic hydrocarbons will be found profitable.

And, of course, from acetylene are derived acetic acid, a wide range of polymers and plastics. What is really important here is that high-temperature cracking or pyrolysis of any petroleum fraction from methane to hydrocarbons of high molecular weight yields in effect a " synthetic " coal tar, and that all the well-known derivatives thereof—dyes, solvents, resins, plastics, explosives, detergents, and the like—are equally producible and obtainable from mineral oil, and obviously in greater quantity and more diverse in application.

It has already been pointed out that the *iso*-paraffins are more reactive than their normal isomers—and it has been shown that only *iso*butane reacts with the butenes to form octanes by addition. Reaction of the higher normal paraffins with aluminium chloride as a catalyst brings about a substantial conversion into the reactive tertiary carbon derivative. It is possible that under conditions of high-temperature cracking, such isomerization may proceed normally. True it is that the normal occur-rence of, *e.g.*, *iso*butane in the natural gas is insufficient to convert the whole of the butenes in the cracked gases corresponding to the ordinary cracking procedure in a modern refinery without the isomerization process—now becoming an integral part of refinery operation.

Cyclization.

It has already been indicated that meticulously accurate fractionation of the low-boiling components of motor spirit is likely to result in a division of the raw material to high octane fuels such as *iso*pentane, methyl*cyclo*pentane, and the like, from the thoroughly bad pro-knock fuels like *n*-hexane and its homologues—fit, of course, only for cracking (reforming) and cyclization. This latter process needs some elucidation. It is clear that *n*-heptane, for example :
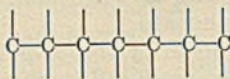
tends to form a ring structure by elimination of hydrogen.
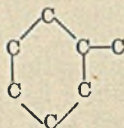
Under strenuous conditions of temperature, aided by catalysis, normal heptane loses hydrogen and yields methyl *cyclo*hexane—which again will give toluene on further loss of hydrogen. Such are the consecutive processes of cyclization and aromatization. When it is realized that *n*-heptane is one of the worst pro-knocks, whilst the *cyclo*paraffin methyl-*cyclo*hexane is rated far higher in the scale, and toluene even higher still, it is clear that these processes are of vast importance in the industry.

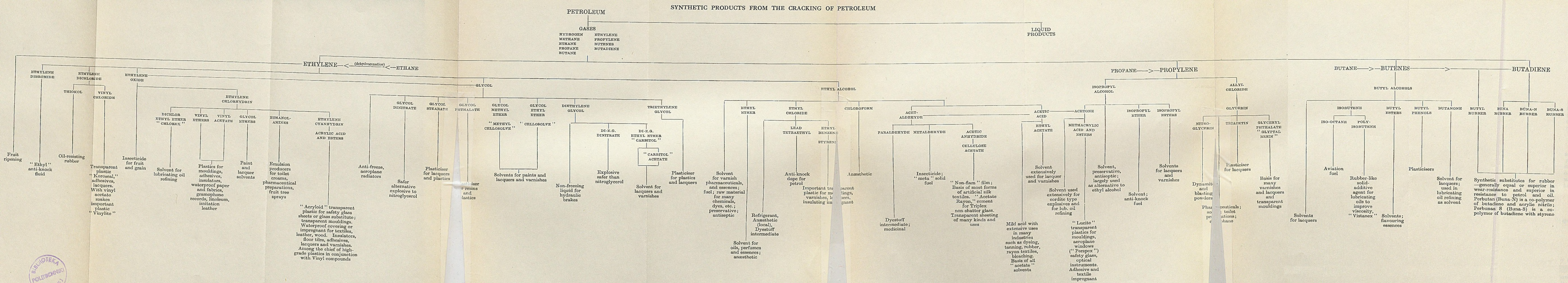# SYNTHETIC PRODUCTS FROM THE CRACKING OF PETROLEUM

PETROLEUM

GASES		LIQUID PRODUCTS
HYDROGEN	ETHYLENE	
METHANE	PROPYLENE	
ETHANE	BUTENES	
PROPANE	BUTADIENE	
BUTANE		

ETHYLENE — (dehydrogenation) — **ETHANE** … **PROPANE → PROPYLENE** … **BUTANE → BUTENES** … **BUTADIENE**

ETHYLENE branch

- **ETHYLENE DIBROMIDE**
  - Fruit ripening
  - "Ethyl" anti-knock fluid
- **ETHYLENE DICHLORIDE**
  - **THIOKOL** — Oil-resisting rubber
  - **VINYL CHLORIDE** — Transparent plastic "Koroseal," adhesives, lacquers. With vinyl acetate makes important plastic "Vinylite"
- **ETHYLENE OXIDE**
  - **ETHYLENE CHLORHYDRIN**
    - **DICHLOR ETHYL ETHER "CHLOREX"** — Insecticide for fruit and grain / Solvent for lubricating oil refining
    - **VINYL ETHERS / VINYL ACETATE** — Plastics for mouldings, adhesives, insulators, waterproof paper and fabrics, gramophone records, linoleum, imitation leather
    - **GLYCOL ETHERS** — Paint and lacquer solvents
    - **ETHANOL-AMINES** — Emulsion producers for toilet creams, pharmaceutical preparations, fruit tree sprays
    - **ETHYLENE CYANHYDRIN**
      - **ACRYLIC ACID AND ESTERS** — "Acryloid" transparent plastic for safety glass sheets or glass substitute; transparent mouldings. Waterproof covering or impregnant for textiles, leather, wood. Insulators, floor tiles, adhesives, lacquers and varnishes. Among the chief of high-grade plastics in conjunction with Vinyl compounds

GLYCOL branch

- **GLYCOL DINITRATE** — Safer alternative explosive to nitroglycerol
- **GLYCOL STEARATE**
- **GLYCOL PHTHALATE** — Plasticiser for lacquers and plastics
- **GLYCOL METHYL ETHER "METHYL CELLOSOLVE"**
- **GLYCOL ETHYL ETHER "CELLOSOLVE"** — Solvents for paints and lacquers and varnishes
- **DIETHYLENE GLYCOL** — Anti-freeze, aeroplane radiators
  - **DI-E.G. DINITRATE** — Explosive safer than nitroglycerol
  - **DI-E.G. ETHYL ETHER "CARBITOL"**
    - **"CARBITOL" ACETATE** — Non-freezing liquid for hydraulic brakes / Solvent for lacquers and varnishes
- **TRIETHYLENE GLYCOL** — Plasticiser for plastics and lacquers

ETHYL ALCOHOL branch

Solvent for varnish pharmaceuticals, and essences; fuel; raw material for many chemicals, dyes, etc.; preservative; antiseptic

- **ETHYL ETHER** — Refrigerant, Anaesthetic (local), Dyestuff intermediate
- **ETHYL CHLORIDE**
  - **LEAD TETRAETHYL** — Anti-knock dope for petrol
- **ETHYL BENZENE**
  - **STYRENE** — Important transparent plastic for mouldings, varnishes, lacquers, insulating impregnant
- **CHLOROFORM** — Anaesthetic
- **ACET-ALDEHYDE** — Dyestuff intermediate; medicinal
  - **PARALDEHYDE / METALDEHYDE** — Insecticide; "meta" solid fuel
  - **ACETIC ANHYDRIDE**
    - **CELLULOSE ACETATE** — "Non-flam" film; Basis of most forms of artificial silk textiles. "Acetate Rayon," cement for Triplex non-shatter glass. Transparent sheeting of many kinds and uses
- **ACETIC ACID** — Mild acid with extensive uses in many industries such as dyeing, tanning, rubber, rayon textiles, bleaching. Basis of all "acetate" solvents
  - **ETHYL ACETATE** — Solvent extensively used for lacquer and varnishes
- **ACETONE** — Solvent used extensively for cordite type explosives and for lub. oil refining
  - **METHACRYLIC ACID AND ESTERS** — "Lucite" transparent plastics for mouldings, aeroplane windows ("Perspex") safety glass, optical instruments. Adhesive and textile impregnant

PROPYLENE branch

- **ISOPROPYL ALCOHOL** — Solvent, preservative, antiseptic; largely used as alternative to ethyl alcohol
  - **ISOPROPYL ETHER** — Solvent; anti-knock fuel
  - **ISOPROPYL ESTERS** — Solvents for lacquers and varnishes
- **ALLYL CHLORIDE**
  - **GLYCERIN**
    - **NITRO-GLYCERINE** — Dynamite and blasting powders
    - **TRIACETIN** — Pharmaceuticals; toilet preparations
    - **GLYCERYL PHTHALATE "GLYPTAL RESIN"** — Plasticiser for lacquers

BUTENES branch

- **BUTYL ALCOHOLS**
  - **ISOBUTENE**
    - **ISO-OCTANE** — Aviation fuel
    - **POLY-ISOBUTENE** — Rubber-like solid-additive agent for lubricating oils to improve viscosity, "Vistanex"
  - **BUTYL ESTERS** — Solvents for lacquers
  - **BUTYL PHENOLS** — Plasticisers
  - **BUTANONE** — Solvent for lacquers; used in lubricating oil refining as solvent

BUTADIENE branch

- **BUTYL RUBBER**
- **BUNA RUBBER**
- **BUNA-N RUBBER**
- **BUNA-S RUBBER**

Synthetic substitutes for rubber—generally equal or superior in wear-resistance and superior in resistance to petrol and oil. Perbutan (Buna-N) is a co-polymer of butadiene and acrylic nitrile; Perbunas S (Buna-S) is a co-polymer of butadiene with styrene

TABLE XI.

n-Heptane	.	.	Octane rating 0
Methylcyclohexane	.	.	71
Toluene	.	.	104

Furthermore, it should be remembered that toluene has its own particular value as the starting out material for T.N.T.   In fact, the " reforming " process is being widely used to-day to bring about the synthesis of such aromatic hydrocarbons which can be segregated from, for example, accompanying paraffins by their superior solubility in specific solvents or by simple azeotropic distillation.   From selected cracking stock so high a percentage as 25 of aromatics can be obtained.

The schematic representation in the diagram facing p. 185 shows the present position of synthetics from cracked gases and from the dehydrogenated paraffins.   It may confidently be anticipated that this somewhat sparse list of products will be immensely increased in the near future.

Synthetic Products of High Molecular Weight derived from Petroleum.

Some attention must now be given to the production of rubber and plastics, as the latest syntheses from hydrocarbon sources.

In the U.S.A. very extensive plans are being made to replace the serious losses experienced by the United Nations in rubber imports from the Far East.   This rubber shortage is extremely acute, and likely to continue so for the duration of the war and for a considerable time after. Clearly the only solution is collaboration between the major rubber users (mainly automobile tyre manufacturers) and the producers of raw materials. At first sight petroleum should be the natural source for butadiene, but considerable stress is being laid on the importance of ethyl alcohol as the primary raw material.   The American targets for the production of synthetic rubber are sufficiently impressive.   According to Egloff such vast amounts as a million tons a year of various substitutes are contemplated.

Synthetic Rubbers.

The Buna group of substitutes are condensation products of butadiene with acetonitrile or styrene as co-polymerization agents.   Tables XII and

TABLE XII.

Butyl Rubber from Cracked Gas.

C₄ cut from cracked gas

isoButene

Pyrolysis of heavy oil

Gas   Other products

Fractionation

Butadiene   Other gases
(small proportion only)

Co-polymerization

Butyl rubber
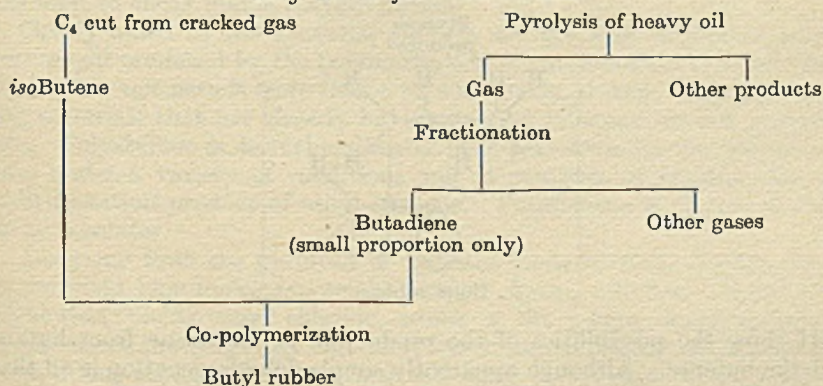
TABLE XIII.

Buna Rubber from Cracked Gas.

```
                        Cracked gas
                            |
                        Fractionation
                            |
            ┌──────────── → or in ──────────────┐
            |                    |                       |
    Ethylene and others     C₄ gases            Liquid oils
            |                    |                       |
        Ethanol             Butadiene           Fractionation
            |          through dehydrogenation    producing
        Aldehyde          of butane                   |
            |                                  Benzene      Other
        Aldol                                              products
            |                                      |
        Hydrogenation                          Ethyl benzene
            to                                     |
    1 : 3-butylene glycol                          |
            |                                    Styrene
        Dehydration to
          butadiene
            |
            └───────────────────┬──────────────────┘
                                |
                        Emulsification and
                          polymerization
                                ↓
                            Buna S.
```
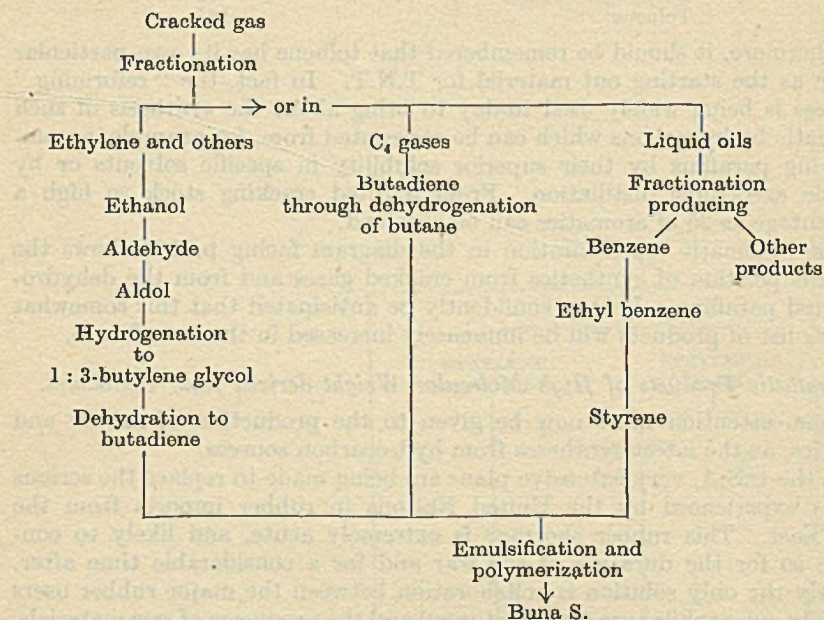
Schematically :—
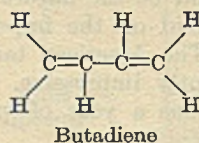
Butadiene

plus

Styrene
produces

Buna rubber
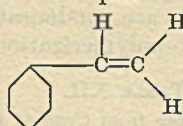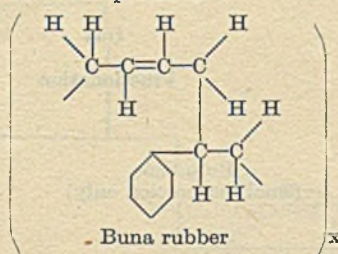
XIII show the possibilities of the production of butadiene from butane and the butenes. Although apparently simple dehydrogenation is all that

is needed, in fact, the removal of hydrogen under the influence of catalysts is by no means easy, and the alternative route through alcohol (either produced from fermentation processes or from ethylene) to aldehyde, aldol, and final dehydration offers good prospects of success.

Styrene is derived from ethyl benzene, and this, of course, may be regarded as a petroleum derivative. The dehydrogenation of ethyl benzene proceeds at elevated temperature (*circa* 700° C.) in the presence of catalysts. Alternatively, the removal of hydrogen chloride from the chloro-derivative of ethyl benzene yields almost pure styrene. Acrylonitrile again may be synthesized from acetylene—either a coal-lime (carbide) product or a resultant of the high temperature pyrolysis of methane.

$$\text{Lime} + \text{coke} \rightarrow \text{Calcium carbide}$$
$$\downarrow$$
$$\text{acetylene}$$
$$\downarrow$$
$$CH_3 \cdot CHO \text{ aldehyde}$$
$$\downarrow$$
$$CH_3 \cdot CH\ OH \cdot CH_2 \cdot CH\ O \text{ aldol}$$
$$\downarrow$$
$$CH_2 {=} CH {-} CH {=} CH_2 \text{ butadiene}$$

acrylonitrile
$$CH_2 {=} CH \cdot CN$$
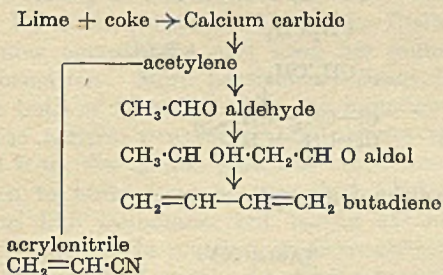
Further, acetylene polymerized to vinyl acetylene and added to hydrogen chloride yields chlorobutadiene, which is spontaneously polymerizable to Neoprene. The Thiokols are cross-linked ethylene halides with the sulphur yielded by sodium polysulphide.

Usually the mixture of butadiene and the co-monomer—*e.g.*, acrylonitrile or styrene or methylmethacrylate—is emulsified with water and a wetting agent. Polymerization catalysts, such as peroxides, perborates, or persulphates are added. Modifying agents that control the degree of polymerization and the length of the chain of the linear polymer are employed; such bodies as mercaptans, carbon tetrachloride, or xanthogen disulphide may be used. After several hours and at a temperature *circa* 50° C. a latex is produced, which may be coagulated and treated much as natural latex would be. Inhibitors such as phenyl β-naphthylamine are used to check undue polymerization.

Closely allied to the synthetic rubbers are the high molecular weight resins—all produced by the polymerization or condensation of small units. Space does not permit more than a cursory glance at some of these intriguing materials that are already having a great influence on our everyday life. Polystyrene is derivable directly from petroleum by the polymerization under a variety of conditions and of catalysts of styrene—the dehydrogenation product of ethyl benzene. Polystyrene is of special value as an insulator.

Acetylene from the pyrolysis of methane leads to vinyl alcohol, whose esters yield high-molecular-weight resins. Again, ethylene, *via* ethylene dichloride, yields vinyl chloride, which is the parent material for the synthesis of the polyvinyl chlorides, which can be readily polymerized to form a long straight-chain polymer that may, by selection of co-polymers,

be converted into micro-filaments suitable for weaving. Tubing and hoses also are made of this material and are satisfactory in resisting the action of brine, hydrocarbons, solvents, and acids. From another angle, naphthalene (also a pyrolysis product of petroleum) oxidizes to phthalic acid, which yields complex esters with polyhydric alcohols, *e.g.*, glycerol. Such esters are the basic components for the production of lacquers.

Further, ethylene polymerized under high pressure and in the presence of boron trifluoride yields polythene—a material of superlative insulating properties.

Brief references may be made to Pope's method for the production of mustard gas :

<div align="center">

TABLE XIV.

$CH_2:CH_2$
$CH_2:CH_2$ $+ S_2Cl_2$
$\downarrow$
$Cl-CH_2-CH_2$
$Cl-CH_2-CH_2$ $\rangle S$

</div>
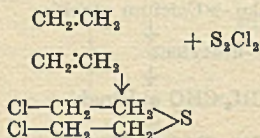
And, further, the well-known acrylic resins :

<div align="center">

TABLE XV.

$CH_2:CH_2 + OH \cdot Cl$
$\downarrow$
$CH_2 \cdot OH \cdot CH_2Cl$
$\downarrow$ $+ NaCN$
$CH_2 \cdot OH \cdot CH_2 \cdot CN$
$\downarrow$ $+ CH_3OH + H_2SO_4$
$CH_2 = CH \cdot CO \cdot OMe$
$\downarrow$ polymerization
Methacrylate resins.

</div>
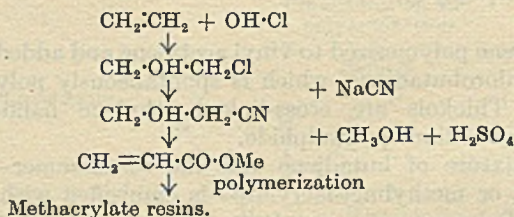
The Chemist in the Refinery.

Attention has obviously been directed to the vastly important part played by the chemist in the oil-fields. From what has gone before it will be obvious that in the modern refinery and research station he plays an even more important part. Certainly most of the operations therein are *quasi*-engineering. The works chemist must be most closely in touch with his engineering colleague and, in fact, must attain engineering knowledge and experience. It is, indeed, very difficult to discriminate between one or the other in terms of works practice. But at the same time, the chemist must be an interpreter, he must be able to foreshadow impending developments and to indicate the conditions under which the most diverse reactions will proceed. As a case in point, dimerization of *iso*butene may be considered. From the point of view of the chemist, all that is needed is the self-addition of two molecules of *iso*butene. In practice a catalyst is needed, and this may suitably be strong sulphuric acid—agitation is necessary—temperature must be controlled within certain limits—corrosion must be countered. The chemist and the engineer form a potent combination in laying down plant and procedure. And so in every operation in the refinery this collaboration must go on,

and the chemist must always co-operate to the fullest extent with the engineer, even if, as may happen, there arises that most effective entity, the chemical engineer.   This entity is not only concerned with the successful running of processes, but must be able to put into practice new and improved methods, operations, and plant.   Clearly, the works chemist must be familiar with refinery operations, and must think in terms of full-scale operations.   In turn he must feed the research chemist with suggestions as to future investigations.   The research chemist working in the research laboratories is concerned not only with new methods of refining, with the nature of products, patents, and patentable processes, but with the whole range of merchantable materials that may be derived from his own raw material.   But there is yet another aspect of his work.   He must be widely read and closely in touch with the latest chemical and physical investigations.   He must always watch out for fresh developments, new syntheses and new compounds, and keep his industrial colleagues fed with recent information.   More particularly these days must he realize that the future both of himself and of the industry depends on the up-building of these simple structures—the olefinic gases, and even the radicals derived from the simple paraffins—into worth-while products.

He must learn to build from his chemical bricks not only relatively simple structures like *iso*-octane, but bodies extending to a molecular weight of over 100,000.   He must move from elementary molecules into the domains of the colloidal state.   In effect, the research chemist in the organization of the petroleum industry must be a leader of thought.

The impact of war not only brings about new needs, but a greater urgency in satisfying these needs.   All that has gone before in the development of new and better ways of meeting the requirements of the internal-combustion engine for improved fuel has really been directed to war efforts, especially in the air.   Every technical journal in describing this or that improvement in quality has implicitly been regarding their value as a munition of war.   Just as everyman's radio was a legacy of the last world war, so will higher efficiency in the aero engine be one result of this.   And in fact almost every need of civilized life may and will be met by material derived from mineral oil.

The synthetic developments of the petroleum industry foreshadowed in this lecture have been brought about by the far-seeing efforts of the pioneers responsible for its progress.   It would not be out of place to mention here names like Redwood, Edeleanu, Engler, Holde, Midgley, Boyd, Kettering, Brooks, Williams, Grosse, Weiss, Ipatieff, Egloff, Oberfell, and Ellis.   All these men have earned an honourable place in the hierarchy of petroleum science—to all of them is due the grateful appreciation of long-lasting work well done.

STANDARD TEMPERATURE FOR SPECIFIC GRAVITY DETERMINATION AND VOLUME CORRECTION.

The following note has been prepared by Sub-Committee No. 1 of the Standardization Committee under the Chairmanship of Mr. H. Hyams, and has been approved by the Standardization Committee and by the Council of the Institute. It is being published in the *Journal* to express the view of the Institute of Petroleum that 60° F. is the standard temperature to which the volume of petroleum products should be corrected when necessary, rather than 20° C. adopted in some other industries.

THE function of I.S.A. 28 (Technical Committee 28 of the International Federation of National Standardising Bodies) is to promote uniformity in methods of testing petroleum throughout the world. One of its sub-committees, I.S.A. 28a-2, is responsible for Density and Specific Gravity. In the early part of 1939 that sub-committee prepared the second draft of a method for the determination of specific gravity of liquid petroleum products, in which specific gravity was defined as the ratio of the weight *in vacuo* of a given volume of the substance at 20° C. to the weight *in vacuo* of an equal volume of water at a temperature of 4° C. It is clear that the intention of the method was to have specific gravities of products reported in terms of densities—grammes per ml. at 20° C. The reason given for the proposal to use 20° C. as the standard or reporting temperature was because this temperature had been generally adopted as the standard or reference temperature in chemical and scientific literature.

When the draft specification was brought to the attention of the A.P.I., the latter felt that the matter was of considerable importance because, if 20° C. were adopted as the temperature for reporting specific gravities, it might also become widely used as the standard temperature to which oil volumes should be adjusted or corrected. It is, of course, known that 60° F. is the temperature which is used exclusively in the oil industry in the United States both for reporting gravities and volumetric quantities.

Discussions on specific-gravity determination and on measurement of oil by volume and by weight have been reported in this journal and in the *Proceedings of the First World Petroleum Congress* held in 1933. The views of the Institute of Petroleum on the reference temperature for specific gravity determinations and the standard temperature to which volume of bulk oil should be corrected are perfectly clear. The brief notes below indicate that on these questions the A.P.I. and the I.P. are in step.

1. *Density and Specific Gravity.*

The standard method for specific gravity determination laid down in the 1935 edition of I.P. " Standard Methods for Testing Petroleum and its Products " stipulated that results should be expressed in terms of sp. gr. 60° F./60° F. signifying that the specific gravity in question is " the ratio of the mass of any given volume of the substance to the mass of a quantity of water which, at 60° F., occupies a volume equal to that of the substance at 60° F." The method also specified that " 60° F. shall be employed in petroleum technology as the standard temperature for specific gravity

determinations." The revised 1942 I.P. Specific Gravity Method retains specific gravity 60° F./60° F. at 60° F.; it says, " In general, the standard temperature employed in the oil industry is 60° F. and the results are normally expressed thus, sp. gr. 60° F./60° F."

The B.S.I. has indicated its preference for density in terms of grammes per millilitre at 20° C. and has produced a specification, No. 718–1936, covering Density Hydrometers for this purpose. This method and these instruments are not applicable to the petroleum industry either in the United States or the British Empire.

2. *Standard Temperature for Volume Computations.*

There have been discussions at meetings of the World Petroleum Congress and of the Institute of Petroleum on measurement of oil by volume and by weight, when the question of standard units and temperatures was ventilated. The view of the Institute is that the Imperial gallon should be retained as the unit of volume in British territories, and that we should remain in line with our American friends by specifying 60° F. as the standard temperature to which oil volumes should, when necessary, be corrected.

I.P. Standardization Sub-Committee 1 is responsible for standardizing matters connected with measurement of petroleum products. That that Committee is keeping to these principles of (1) specific gravity 60° F./60° F. at 60° F. and (2) volume measurements at 60° F. is demonstrated by the following recent or contemplated actions :—

(a) In the paper on " Expansion of Crude Petroleum, Petroleum Products and Allied Substances " appearing in the Committee's name in the October 1941 issue of this *Journal*, the specific gravities of products have all been reduced to the common basis sp. gr. 60° F./60° F.

(b) The Committee proposes to reconstruct Table 4 of U.S. Bureau of Standards Circular C. 410, *National Standard Petroleum Tables*, replacing the U.S. gallon by the Imperial gallon as the unit of volume. The I.P. table will, however, still be entered against specific gravity 60° F./60° F. at 60° F.

(c) Table 2 of U.S. Bureau of Standards Circular C. 410 is to be recast by the Committee so as to facilitate its entry directly against specific gravity 60° F./60° F. at 60° F. instead of A.P.I. gravity at 60° F. Table 2 of the American Circular sets out the volume at 60° F. occupied by unit volume at indicated temperature. The standard temperature of 60° F. will be retained in the reconstructed I.P. table.

ABSTRACTS.

AUTHOR INDEX.

The numbers refer to the Abstract Number.

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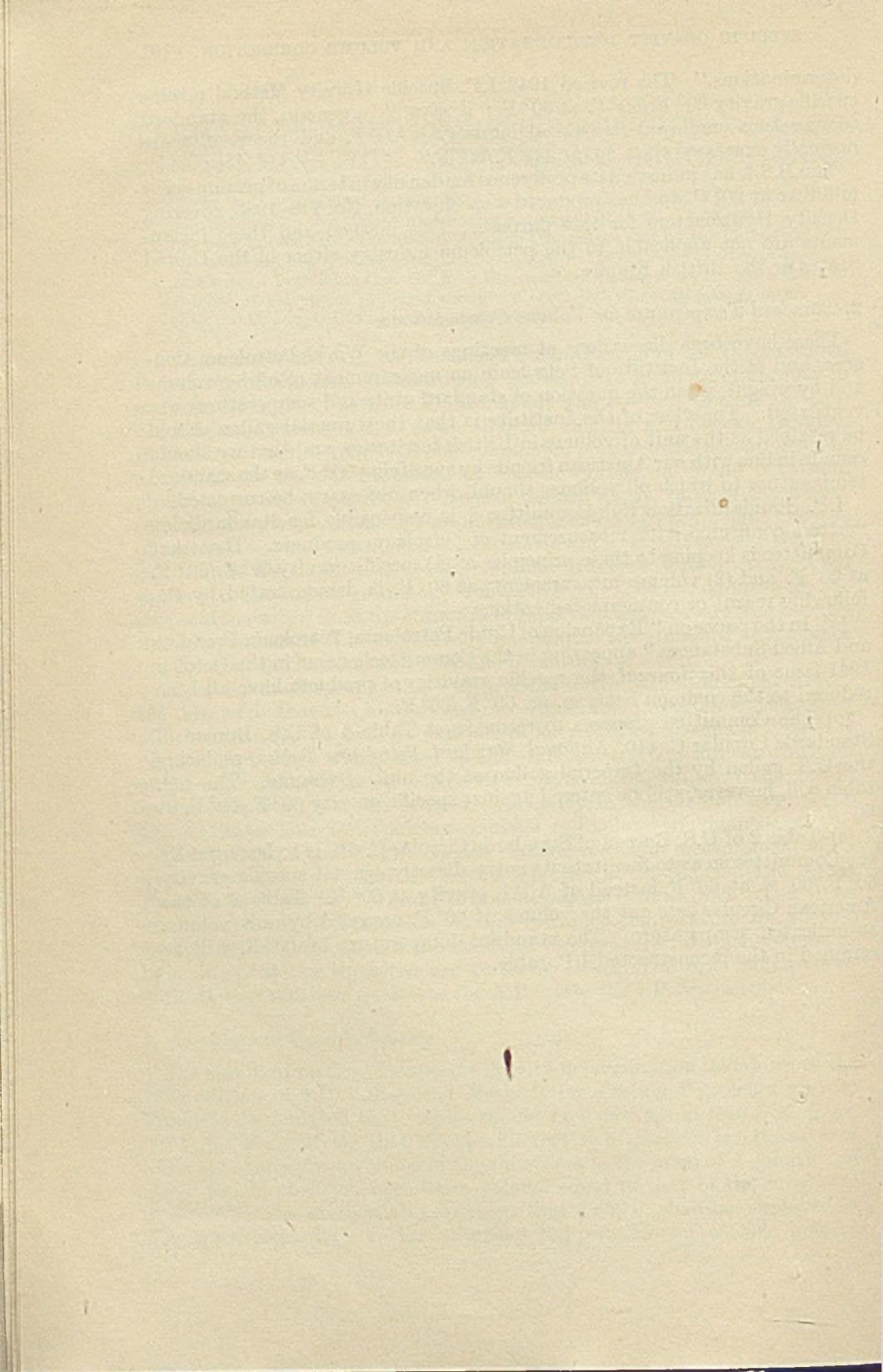
Geology and Development.

604.* **Recent Developments in Formation Logging.** L. C. Uren. *Petrol. Engr*, February 1943, **14** (5), 63.—For a long time there has been an interest in the rate of penetration in drilling, and several automatic and semi-automatic drilling-time recording instruments have been developed. The rate of penetration depends on lithology, the type and condition of the bit, the pressure on the bit, the rate of rotation of the drill, the skill of the driller who feeds the drilling, and on the rate of mud circulation in the case of soft beds. In spite of the number of factors involved, the character of the formation appears to be the dominant factor controlling the rate of penetration. The rate of penetration log often compares closely with the self-potential log of the same interval, doubtless due to the relation of both logs to formation porosity and permeability. Correlation is possible by means of drilling time records, and the records may also be used in investigating bit performance and the effects of varying the drilling control conditions.

The diameter of the well tends to be larger where the formations are soft than where they are hard, thus caliper logs giving the variation in diameter of the well provide indications of the lithology. These logs also give data of value in cementing, gravel-packing, and packer installation. Fair accuracy in correlating formations is obtainable by means of caliper logs, and places which are favourable for using side-wall coring apparatus may be selected. G. D. H.

605.* **New Field Indicated in Alberta, Canada.** Anon. *Oil Wkly*, 15.3.43, **109** (2), 46.—Near Vauxhall, 20 ml. north-east of Taber, an important oil showing has been found in a well. About 1400 ft. of oil is standing in the hole, but the well's possibilities cannot be estimated until it has been shot and acidized. G. D. H.

606.* **Wildcat Work Continues Active in Colombia.** Anon. *Oil Wkly*, 15.3.43, **109** (2), 46.—The production decline in Colombia is due not only to loss of markets, but also to drilling up of the established producing areas at Infantas, La Cira, and Petrolea. Geophysical work continued in 1942, and some of the wildcats in the Magdalena valley and on the Barco concession, were encouraging.

In 1942 Colombia produced only about 10,600,000 brl. of oil, compared with 24,400,000 brl. in 1941. G. D. H.

607.* **Large Bitumen Deposits Reported in Turkey.** Anon. *Oil Wkly*, 15.3.43, **109** (2), 47.—Several large bituminous deposits have been found in Turkey. The Izmit deposits are reported to amount to 30,000,000 tons, those at Manisa to 15,000,000 tons, and those at Bolu to 7,000,000 tons. The bitumen content runs as high as 11%. On treatment the Izmit bitumen yielded 10% of gasoline, 14% of kerosine, and 12% of paraffin wax. G. D. H.

608.* **Small Recovery Reported in New Zealand Drilling.** Anon. *Oil Wkly*, 15.3.43, **109** (2), 47.—Extensive geological and geophysical work, supplemented by some deep drilling, has failed so far to establish commercial oil production in New Zealand. Three wells at Taranaki gave 93,915 gal. in 1941. G. D. H.

609. Oil Zones of the United States : Cambrian and Lower Ordovician. Anon. *Oil Gas J.*, 18.3.43, **41** (45), 68-A.—The principal oil and gas pays of Lower Ordovician or greater age are the Simpson dolomites and sandstones, the Arbuckle and Ellenburger limestones, Cambrian sandstones, and basal sands, conglomerates, and weathered pre-Cambrian rocks.

The pre-Cambrian reservoirs of the Texas Panhandle are supposed to have obtained their oil from the abutting Permian rocks, and in Western Kansas, Southern Oklahoma, and Pecos County, Texas, the oil-bearing granite, granite wash, or residual soil is overlain by Cambrian and/or Lower Ordovician rocks.

Cambrian sandstone production is relatively rare, being found in Kansas (mainly in Russell County) and Texas (Pecos County). It is possible that more oil may be found where the cover of Ordovician is thicker. The Arbuckle is the most important producing horizon of Western Kansas, and the Ellenburger is increasing in importance in North and West Texas, suggesting a 600–700-ml.-wide belt of potential pay running north-east from West Texas. Erosion prior to deposition of the overlying Simpson has provided porous reservoir zones near the top of the limestone. In the Ozarks there are several unconformities in the limestone suggesting the possibility of several pays deep in the limestone.

Simpson sandstones are important pays in Oklahoma (Seminole district, Nemaha ridge, etc.) and the Red River area and Pecos County of Texas. The Simpson dolomites give a little oil in the Seminole and Oklahoma City areas.

Beds roughly equivalent to the Simpson have shown signs of production in Illinois. An equivalent of the Arbuckle may prove productive in Kentucky. In the east and coastal areas the Cambrian–Lower Ordovician is too deep or too altered to yield oil.

A map shows the producing, favourable, and unfavourable areas for Cambrian and Lower Ordovician beds.   G. D. H.

610. Well Completions Show Further Decline in February. Anon. *Oil Gas J.*, 18.3.43, **41** (45), 103.—1110 wells were completed in U.S. in February, as compared with 1221 in January. The dry holes numbered 349, against 417 in January, indicating a marked decline in wildcatting, which may be partly due to weather conditions. 638 oil-wells were completed in February, whereas there were 687 in January, pointing to a lack of locations in newly discovered and undeveloped fields.

A table summarizes operations in February by States and districts, with the total completions, numbers of oil, gas, and dry wells, the footage, and the well distributions in various depth ranges, together with the number of wells under way at the end of February.   G. D. H.

611.* West Texas' Day Is Coming. Anon. *Oil Wkly*, 22.3.43, **109** (3), 11.—West Texas has prospects of deeper pays and new fields, and its current producing rate is capable of being increased quickly, although its location has been the cause of drastic production curtailment to 100,000 brl./day below its pre-war output. Its production can be increased by 200,000–250,000 brl./day from developed leases, and maintained at this rate for a year or more. Texas is likely to produce most of the 400,000 brl./day additional oil which will be required at the end of this year.

New pipe-lines to the east mean that Texas can expect steadily increased transportation facilities.

In January 1942 West Texas gave 300,000 brl./day from 13,136 wells. In January 1943 the output was only 200,000 brl./day, due to the curtailed allowable, and so West Texas has unused pipe-line allowables totalling nearly 15,000 brl./day, although all of this could not be used for deliveries to the Gulf Coast area.

The construction of a pipe-line from West Texas to the West Coast has been suggested, for it is doubtful whether California can sustain its present output of 775,000 brl./day without additional drilling and the discovery of new fields.

Many West Texas wells will need rehabilitation, for wells with uneconomically low allowables have not been kept in good condition. Owners with properties capable of large increases in production do not view large production increases with favour because of taxation.

A table gives the number of wells, monthly allowable, monthly production, monthly production per well, pipe-line runs in month, and storage at end of month for various dates since the beginning of 1941.   G. D. H.

612.* Too Few Wildcats Completed in February but Oil Finding Results Fair. Anon. *Oil Wkly.*, 22.3.43, **109** (3), 13.—During February the wildcat drilling was at two-thirds only of the rate necessary to give the 4500 wildcats sought by the Petroleum Administrator for 1943. Nevertheless the results came close to fulfilling hopes, since there were two above-average discoveries. It is possible that as much as 100,000,000 brl. of reserves were found and made available for development in U.S. through February discoveries, although conservative estimates might limit the figure to 50,000,000 brl.

461 wildcats were completed in January and February 1943, 68 being productive, against 87 producing wells out of 477 wildcats in the same period of 1942. The 1943 discoveries included 51 new oil-fields, eight new oil-pays, and eight new gas-fields, This year there has been increased wildcatting in California, Kansas, Michigan, New Mexico, and Oklahoma, but decreased wildcatting in Illinois, Louisiana, Mississippi, and Texas.

In February 1943 a new oil-field and a new pay have been found in California. The Eocene shore-line accumulation at Guijarral Hills may have a reserve of 25,000,000–50,000,000 barrels, and may cover 400 acres. The new pay was found at Del Valle is at 7900–7975 ft. and 7990–8065 ft. The new Russell field of West Texas is about $4\frac{1}{2}$ ml. south-west of Wasson. The oil is in a thick section of broken lime on an anticlinal structure. The remaining February discoveries have reserves under a few million barrels each, according to present indications.

Tables set out by States details of the wildcat completions in February 1943 and January–February 1943; the trend of wildcat completions; the name, location, dates of spudding and completion, depth, completion horizon, age and character of the producing formation, oil gravity, type of structure, method of discovery, and a preliminary estimate of the reserves for the oil and gas discoveries of February.

G. D. H.

613.* Inspection and Analysis of Formation Samples. L. C. Uren. *Petrol. Engr,* April 1943, **14** (7), 72.—Formation samples may be bailer samples, bit samples, chip samples, cable-tool cores, mud-flush samples, rotary cores, wire-line cores, side-wall cores, diamond drill cores, side-wall samples, and pressure-type cores. Each has its own inherent advantages and disadvantages. Bailer and bit samples are of rather uncertain value, and the same is true of mud-flush samples. Side-wall cores can be taken from points which the drill has passed, and are small, but dependable. Diamond drill cores are the most dependable cores, and give a very large percentage recovery. Pressure-core barrels give samples which can be brought to the surface without reduction of pressure or loss of fluids.

Excess bit pressure in coring may crush and shear the core, and in certain circum-stances cause fusion of some minerals. In rotary drilling the drilling fluid may be driven into the core, and surface-tension effects may also lead to displacement of oil from the outer part of the cores. Release of pressure in bringing the core to the surface may result in " bleeding." The oil content of a recovered core may be regarded as a minimum.

At the surface the core should be removed from the barrel as soon as possible, the clay sheath scraped or washed off carefully, and the core fragments arranged correctly in suitable trays on which the top and bottom of the cored interval are marked, and with spacing blocks for obvious gaps.

The fluid content of the core should be noted, with a test for oil. The positions of partings are recorded, together with such features as fault planes, joints, cross-bedding, solution cavities, etc., the dip, and type of lithology. Representative samples are selected for laboratory examination, protected from loss of fluids in transport, and carefully labelled.

At the laboratory the samples are again inspected, and any loss of fluid is noted. A portion of each sample is taken for fluid-content determinations, and a second portion for permeability measurements. Permeability may be measured parallel to and perpendicular to the bedding, generally on carefully prepared cylindrical specimens from which all fluids are removed in a Soxhlet extraction apparatus. G. D. H.

614. Large Reserve Decline Shown by Allocations to Discovery Year. W. V. Howard. *Oil Gas J.*, 1.4.43, **41** (47), 14.—In 1942, 1,760,884,000 brl. of oil were estimated to

have been added to the U.S. proven reserves. Of this 919,496,000 brl. were added by revision of estimates of oil in older fields. Extensions to older fields added 515,580,000 brl., and discoveries of new sands and new fields added only 322,808,000 brl., 58,108,000 brl. being attributed to new sands.

The allocation of all the recoverable oil in a field to the year of discovery shows the trend of discoveries more clearly than does the inventory method.

During the 1920's production rose so rapidly that despite large discoveries the ratio of reserves to annual production declined steadily from about 23 to under 15. The discovery of East Texas in 1930 and Conroe, K.M.A., Silica, and Trapp in 1931, together with declining demand, raised the ratio of reserves to annual production to more than 26.

Prospecting increased in 1934 after a period of depression, and a series of important discoveries followed until the reserves totalled nearly 24,000,000,000 brl. in 1938, since when they have declined, for production has exceeded discoveries by nearly 3,000,000,000 brl.

Reserve and production and discovery data are tabulated by years since 1895, and curves show the reserves at the end of each year, the production and discoveries in each year, the ratio of reserves to production, and the price per brl. over a similar period. G. D. H.

615. Rich Oil Sand Discovered with Condensate at Katy Field. Anon. *Oil Gas J.*, 1.4.43, **41** (47), 17.—A good oil-sand has now been found in the big Katy gas-distillate area of Waller and Harris Counties, Texas. The oil-discovery well, 2½ ml. from the nearest Katy gas production, gave 153 brl. of oil in a day from 6622 to 6625 ft. The well found gas and distillate in three sands at 7338–7345 ft., 7116–7121 ft., and 6847–6851 ft., each of these sands having a considerable gas output potential. While the oil may merely be a pocket, it is generally believed to represent a new and important oil-pool. The oil-sand may skirt the perimeter of the Katy field, or may be co-extensive with gas-condensate sands of the field, which now has 23 wells. G. D. H.

616.* Problem of Exploration during the War. E. De Golyer. *Oil Wkly*, 5.4.43, **109** (5), 39.—The U.S. oil requirements in 1942 were about 1,400,000,000 brl., 1% more than in the preceding year, despite restrictions. Conservative estimates indicate that 1,500,000,000–1,600,000,000 brl./yr. will be needed during the next two or three years. At the beginning of the war the reserves were about 20,000,000,000 brl., but the prospect of increasing demand when the rate of discovering new reserves is low is disturbing. The unused 300,000–400,000 brl./day productive capacity of the Permian Basin represents oil which is not especially suitable for use at present, and oil which is not readily transportable to the required points. Since 1938 the reserves discovered in new fields annually have been less than the yearly production, the average figures being respectively 640,000,000 brl./yr. and 1,380,000,000 brl./yr. The unsatisfactory exploratory results are not due to reduced exploratory effort, for since 1939 over 3000 wildcats have been drilled each year, and more than 300 geophysical and core-drill crews were employed throughout 1942. In the 1939–1942 four-year period the average number of new fields found each year was 215, compared with an average of 130 for the preceding four years. During the 1939–1942 period the average new oil discovered per field was 3·2 million barrels, against an average of 15·6 million barrels/field in the preceding four-year period. In 1942 the average size was estimated to be 1·2 million barrels.

The present first-rate prospects are said to be comparable to the second- and third-rate prospects of the middle thirties.

Various techniques have successively shown peaks as regards the number of discoveries made. Past exploration has been concerned chiefly with structural traps, and the sizes of the structures now being found make it clear that the search for stratigraphic traps must be intensified. The search for stratigraphic traps will call for many more wildcats. All available geological information should be carefully studied before drilling these wildcats, and core tests may be necessary.

An adequate exploration programme will require more materials, more man-power, and greater expenditure. The supply of materials should not prove too difficult, but increased man-power requirements are a more serious problem, for the type of man required is also sorely needed by the armed forces. G. D. H.

617.* New Oil Reserves Must be Found. A. Duessen. *Oil Wkly*, 5.4.43, **109** (5), 47.—
If the war demand for oil continues to accelerate there will probably be a shortage
by the end of 1943, with the possibility of a serious situation in 1944 and 1945 if
the war continues, for the discovery rate is not keeping pace with the production.
Last year, according to A.P.I. estimates, the oil discovered in new fields amounted to
260,054,000 brl., while the production was 1,385,479,000 brl. However, the revision
of reserves from year to year is more important in adding to the inventory at the
year end than the amount of new oil actually assigned to wells in new fields. In
spite of the possibilities in this revision, the 1942 discoveries are not reassuring.

The effectiveness of geophysics as an impetus to discovery seems to have reached
its limit. Wildcatting must be stimulated, for even dry wildcats may give informa-
tion which leads to discoveries later. The use of geophysics and the increasing cost
of wildcats in recent years have tended to make wildcatting a major company opera-
tion. In the past wildcat operators with little capital have taken risks and found
much oil, and it is necessary to encourage such operators to continue, since much
oil will come from the type of random drilling which they carry out. An intense
wildcat campaign is now needed in Texas and Louisiana, the most promising areas
for new oil, with considerable activity in Kansas and California, and to some extent in
Mississippi, Alabama, and Florida also.

An increase in the price of oil is urgently needed if the present reserve situation
is to be corrected at any time in the near future. In the last World War there was
a similar critical situation, but the price of crude was allowed to rise to $3 per barrel,
and so at the end of the war and shortly after there was an over-abundant supply.

Americans must also be encouraged to develop the oil reserves of Mexico and
South America, in order to have a nearby oil source when the U.S. domestic supply
fails. It is probable that American ingenuity will be needed to discover these reserves.

G. D. H.

618.* Wildcat Drilling and Discovery Rates in 1942. F. H. Lahee. *Oil Wkly*, 5.4.43,
109 (5), 57.—See Abstract No. 621.

619. A Survey of the Nation's Oil Reserves and Needs. W. B. Heroy. *Oil Gas J.*,
8.4.43, **41** (48), 34.—The first estimate of the recoverable oil in the known U.S. fields
was made in 1908, and from then until 1927 the estimates of remaining reserves in-
creased at a moderate rate to about 5,000,000,000 brl. During the next decade the
reserve estimates rose to over 12,000,000,000 brl. From 1937 to 1939 the rate of
increase reached its maximum, and the total rose to about 18,500,000,000 brl. During
the last three years the rate of increase has fallen, so that the reserve estimate now
stands at a little over 20,000,000,000 brl.

The reserves attributed to newly discovered fields have shown a downward trend
since 1937, but it must be noted that the annual reserve increases due to extensions
and revisions are three to five times as large as the increases shown as resulting from
new discoveries. In 1937 the initial estimate of newly discovered oil was the highest
ever at 929,000,000 brl.; in 1942 the initial estimate was only 260,000,000 brl.
Practically all the increases in reserves, and especially those resulting from new
discoveries during the past few years, have been in the south-west, in Texas and
Louisiana, the reserves of these two States having risen by over 2,000,000,000 brl.
in two years.

Of the 400,000 U.S. producing wells about 12% flow, and about 15% are capable
of good yields in spite of being on artificial lift. The remaining 73% are stripper
wells yielding only 15% of the total production. 40% of Texas' wells flow, 10% of
California's and 34% of Louisiana's, the three States possessing over 90% of the
country's flowing wells. As a whole the oil-fields have a normal annual decline of
400,000 brl./day in productive capacity, calling for new fields and wells in order to
maintain the productive capacity. Since 1937 the initial oil production from new
development has declined seriously from 24,222,121 brl./day to 2,841,300 brl./day,
and from 1077 brl./well/day to 259 brl./well/day. G. D. H.

620. Discovery Thinking. A. I. Levorsen. *Oil Gas J.*, 8.4.43, **41** (48), 38.—If the
same rate of increase in production continues in the next twenty years in U.S.A.

as has held in the past twenty years, and if the discovered reserve is to be thirteen to fourteen times the annual production, it will be necessary to discover 50,000,000,000 brl. of new oil—a greater amount than has been discovered since the beginning of the oil industry. Although much oil has been found by random drilling, and much will be found in that way in the future, the only rational way of making available the undiscovered reserves is by the application of scientific methods and reasoning.

The present decline in discovery rate may be due to approaching exhaustion of ultimate reserves or to insufficient discovery effort. Most of the effort is being expended on searching for extensions, for deeper sands, and in working and re-working progressively smaller areas in developed provinces. Attention must be directed to new oil provinces. Many oil provinces are associated with the up-dip wedging out of reservoir porosity. These wedge-belts include the Oriskany and other Devonian and Mississippian sands in the Appalachian area; the Clinton sand and Trenton lime pays of Ohio; " Corniferous " production flanking the Cincinnati arch; Chester production in Illinois; Cromwell and Wilcox production in the Seminole area, and Simpson, Bartlesville, and Burbank production in north-east Oklahoma; Pennsylvanian sands in North Texas and the Laredo district; the reef and sand belts of the Permian Basin; the Etchegoin of the Midway–Sunset province; the Eocene and Miocene of the Coalinga area and much of the east side production of the San Joaquin Valley. There are thousands of miles of buried up-dip wedge belts of porosity in rocks known to produce elsewhere, and yet which are only partly explored to-day, or completely unexplored. A wedge-belt is a clue to a province, whereas a local fold is a clue to a pool. Much of the evidence of the existence of these wedges is already known.

Each set of beds separated by an unconformity is independent of the underlying and overlying unconformably separated beds and has its own oil and gas geology. No area can be considered as completely explored until many wells have been drilled through all the layers of geology down to the basement rocks, and every sedimentary region of the U.S. has unknown and unexplored geology waiting to be drilled. Each layer has its own wedge-belts of porosity, its own lithological changes, and its own structural history.

The only way of reducing the above conditions to practical application is by the preparation and study of facies maps, lithological maps, isopachyte maps, palæogeographic maps, palæogeological maps, quantitative and qualitative sedimentation studies, and detailed stratigraphic analysis of all the porous sediments. Much will be a matter of restudying data and material already possessed by the oil companies. Broadly trained and speculatively minded geologists will be required for this work.

Many pools produce from limestone reefs or reef-like deposits, suggesting that many similar pools remain to be found. Pools are still being found by surface mapping, while others are being found by careful re-study of areas in the light of more up-to-date information.

Extensive fundamental research is needed in petroleum geology. G. D. H.

621. Wildcat Drilling in 1942. F. H. Lahee. *Oil Gas J.*, 8.4.43, **41** (48), 40. During 1942 3219 wildcats were drilled, with a total footage of 12,172,851 ft., and the 493 producers accounted for 10,007,066 ft. In the southern States district 6,633,895 ft. were drilled in 1424 holes, of which 232 were producers with a total footage of 1,296,558 ft.

Assessing the reasons for drilling the wildcats shows that 460 drilled on geological or geophysical advice were successful and 587 dry. Twelve producers and 80 dry holes were located for reasons unknown. Thus the percentage success for technical locations was 4·9.

During 1942 wildcat drilling was above the 1941 level in California (163 to 124), Kansas (330 to 267), Mississippi (60 to 52), Oklahoma (254 to 246). During 1942 there were fewer wildcats than in 1941 in Illinois (549 to 591), Louisiana (189 to 202), Michigan (216 to 231), and Texas (1076 to 1210). Except in California, the average wildcat depth was greater in 1942 than in 1941. The degree of success of technically located wildcats as compared with those located non-technically was 3 in 1937, 2·2–3·2 in 1938, 1·5–2·2 in 1939, 3·7 in 1940, 5 in 1941, and 3·7 in 1942.

109 out of 566 wildcats located in 1942 on the results of seismic work were successful,

and a further 52 out of 163 located on a combination of seismic and geological data were successful.

Analysis of data for Arkansas, California, Illlinois, Indiana, Kansas, Lousiana, Michigan, Mississippi, New Mexico, Oklahoma, and Texas, which possess 95% of the proved U.S. oil reserves, indicates a marked drop in the rate of discovery since 1937, in spite of increasing numbers of wildcats, except in 1942. In 1937 109·4 brl. of new reserves were discovered per foot of wildcat drilling, but only 21·7 brl./ft. in 1942. The decline in success is due to the increased difficulty of finding the new geological traps because they are fewer, deeper, and associated with less pronounced geological structure and sands of lower permeability.

A series of tables and diagrams give details about wildcat drilling.   G. D. H.

622. Some Factors Influencing Declining Rate of Crude-Oil Discoveries. L. F. McCollum. *Oil Gas J.*, 8.4.43, **41** (48), 41.—Recent P.A.W. estimates of U.S. crude-oil needs in 1943 are slightly under 4,000,000 brl./day, with a peak of perhaps 4,200,000–4,600,000 brl./day late in the year. In 1942 375,000,000 brl. of oil were discovered in the Mid-Continent–Rocky Mountain–Gulf Coast areas, in 1941 655,000,000 brl., and in 1940 1,185,000,000 brl. There has been a decline in the average size of discoveries since 1930, and apart from the slump period of 1931–1933 the number of discoveries has risen continuously since 1900. Shortage of materials and spacing regulations may be responsible for the decline in total completions in this area from 23,148 in 1941 to 12,929 in 1942. The wildcat completions fell from 3255 in 1941 to 2956 in 1942.

The petroleum industry has lost about 15% of its personnel to the armed forces, and the loss of geophysical personnel may be 30%.

During the past few years there has been a lack of correlation between the number of dry holes drilled, the discoveries, and the price of crude oil. The decline in discoveries is probably due neither to material shortage, man-power shortage, nor to price. Examination of the discovery rate in the Mid-Continent–Rocky Mountain–Gulf Coast region shows the importance that new prospecting territories and new exploration methods have played in maintaining the discovery rate. It appears that without the opening of new prospecting territory discovery rates in the past 40 years could not have been maintained. It is clear that there has been a rapid increase in the amount of oil discovered soon after the inception of each new method, and each method is now in a period of lessened effectiveness. The above two factors have been the major causes of the decline in the discovery rate during the past few years.

Exploration in new regions and with new methods may increase costs. The search for new finding tools must be intensified.   G. D. H.

623. Maintaining an Adequate Level of Geophysical Exploration. F. Goldstone. *Oil Gas J.*, 8.4.43, **41** (48), 56.—Published estimates suggest that the U.S. yearly discovery rate of new oil has been declining for the past five years at least, and some time in the recent past consumption exceeded the finding rate of ultimately recoverable oil in new fields for the first time. It is necessary to discover new fields, and the exploration programme must be planned so that it will be virtually certain to attain the minimum objective without precluding the spectacular results which have frequently rewarded those willing to take the maximum risks. In most areas geophysics offers the best means of reducing structural uncertainties.

In 1942, 225 seismograph crews and 50 gravity crews were operating, and most of these were in areas of proved production; there was little exploration in present unproductive areas. But in spite of great activity, discoveries failed to equal withdrawals. In order to try to overcome this failure existing geophysical technique must be applied with greater precision in well-explored productive territory to detect even the smallest promising geological features, and such a tendency is already evident in the increased number of small fields discovered. The cost of discovery will probably rise to thirty cents per barrel.

Proved methods must be applied in new territories. Attempts must be made to discover methods which can be applied in areas where drilling only awaits adequate structural guidance, but where the existing geophysical methods have so far been incapable of giving such guidance.

No policy involving less effort than in 1942 offers reasonable assurance of maintaining the discovery rate of new fields. The 4500 wildcats recommended for 1943 should ensure the testing of virtually all the structural prospects and many stratigraphic traps, with sufficient wells left to follow up exploration in new areas.

About 40% of the technically trained geophysics staff has been lost to the forces and war-work, and further losses will involve the cutting down of field crews. Supplies are a less serious problem than man-power. G. D. H.

624. Oil Zones of the United States ; Middle Ordovician to Devonian. Anon. *Oil Gas J.*, 8.4.43, **41** (48), 88 B).—The Trenton limestone of Ohio and Illinois and the Viola limestone of Oklahoma and Kansas are of Middle Ordovician age, the former giving most oil on the northern part of the Cincinnati Arch, and the latter most oil north and south of the Wichita–Arbuckle uplift and round the south flank of the Central Kansas uplift. The Medina (Lower Silurian) sandstone provides much gas in New York and Ohio. The Lower Devonian Oriskany sandstones yield much gas and a little oil, and deeper in the Appalachian Basin the sandstones of the Chemung and Catskill (Upper Devonian) have given much oil, but over a large part of the area they are replaced by thin sands and thick shales. The bulk of Michigan's production comes from the Traverse, Dundee, and Monroe limestones of the Lower and Middle Devonian. In Central Kentucky the " Corniferous " is the principal pay, formerly being thought to be of Onondaga age. Some of the pay section is in the Niagaran (Middle Silurian), the equivalent of which is the productive Hunton of Oklahoma. Good Devonian production is found round the margin of the Illinois Basin. Recently Silurian limestone oil production has been found in Ward County, Texas.

Uplifts during the late Ordovician continuing through the Devonian either prevented the deposition of Middle Ordovician to Devonian beds over them, or else permitted their erosion if such beds were deposited. Hence there is little chance of finding commercial oil accumulations in these pays over the Bend Arch and the West Texas highs. Extensions of Viola production and the introduction of Devonian pays may be found to the north-west of the Eastern Kansas producing area, and in the basins of Kansas and Oklahoma. In the Rocky Mountain States the Jefferson limestone of Devonian age has shown some oil, though not yet in commercial quantities. G. D. H.

625. Fell Cites Figures Showing How Low Price Subdues Exploration. Anon. *Oil Gas J.*, 22.4.43, **41** (48), 32.—Curves show a sympathetic relationship between the current price per barrel of crude oil and the number of wells drilled, but it takes one to two years for the increase in price to give a considerable increase in the number of producing wells.

Drilling contractors are now charging 75 cents to $1/ft. more than a year ago, and the cost of moving to a new location has been trebled.

In Kansas it is suggested that an increase in price of at least 50 cents/brl. is necessary if wildcatting is to be maintained. There 352 wells were completed in the first quarter of 1943, 174 being oil-wells and 7 gas-wells. 94 were wildcats, of which 15 were producers which may have averaged $30,000 per well, while the failures were $15,000 per well. If the wildcat producers drain 40 acres each with a recovery of 4000 brl./acre, the expected 2,400,000 brl. will have caused the spending of $1,535,000 on wildcatting, and therefore the cost of discovery is 63·9 cents/brl. If lifting costs are 30 cents/brl., royalties, rentals, and bonuses 35 cents/brl., the total costs excluding taxes and salaries is $1·29/brl., against a crude selling price of $1·17/brl. G. D. H.

626. Western Kentucky Offers Opportunity for Prospecting. H. H. Nowlan. *Oil Gas J.*, 22.4.43, **41** (50), 90.—There seems to be plenty of space in Illinois, Indiana, and Kentucky for a large number of wildcat plays, and whether the wells are successes or failures the information derived is of service in working out additional favourable wildcat plays.

Now Louden, Salem, Clay City, and other large pools in the Illinois Basin are declining, and knowledge of the basin is increasing as more wildcat tests are completed and as many small pools are being opened. Comparable conditions obtained in Oklahoma in the early 1920's, and were followed by an increase in wildcatting which brought increased discoveries and further large pools.

A year ago conditions were at a low point in Western Kentucky, when in August 1942 the Smith Mills pool, Henderson County, was opened. It now has 51 wells in the Cypress sand at a depth of 2300 ft., with initial outputs up to 1200 brl./day. The productive area may cover 1000 acres. Production is by water-drive from a blanket sand on a structure with at least 30 ft. of closure, and probably 60–80 ft. This pool has directed attention to an area of about 2500 sq. ml.

Production along the Wabash River is on an anticlinal nose in a graben. At the Barrett Hill pool and Sebree pool oil is in a fault zone on horsts. In other pools oil occurs under ordinary structural conditions, including numerous stratigraphic traps.

The important Rough Creek fault zone has most of its faults striking N.W.–S.E., with transverse N.E.–S.W. faults cutting these. The maximum throw is over 3000 ft. Electric logs for a series of wells on a line from Salem (Illinois) to Calvin, Mount Vernon (Indiana), Smith Mills (Kentucky), and Hopkins County show formations from the base of the Pottsville to the Ste. Genevieve. The base of the Pottsville lies on the eroded Chester in which there are seven productive sands in Illinois and Kentucky.

The most active area is now north of the Rough Creek fault zone, and the most important developments are the Smith Mills, Robards, Uniontown, and Wathen pools. The area south of the Rough Creek fault zone may be explored later in 1943.   G. D. H.

627. March Completions Show Increase over February. Anon. *Oil Gas J.*, 22.4.43, **41** (43), 94.—1292 wells were completed in U.S.A. in March, 182 more than in February. 39 of the increased number of completions were in California, where there is considerable redrilling of old heavy oilfields. Oklahoma had 32 more completions than in February. As regards drilling depths, the greatest increase was in the 2500–5000 ft. range, which is a reflection not only of the location of the drillable spots, but also of current crude prices which tend to render deeper drilling unduly costly. 73 wells were less than 1000 ft. deep, 602 1000–2500 ft. deep, and 25 over 10,000 ft. deep.

A table gives by States the numbers, types, and footage of completions, together with the numbers in different depth ranges.   G. D. H.

Geophysics.

628.* Limiting Values of Gravitational and Magnetic Anomalies Due to a Subterranean Structure Bounded by a Single Differential Surface. J. W. Fisher. *Geophys.*, 1941, **6** (1), 1–12.—The case of two layers is considered, each homogeneous in density and magnetic susceptibility, and the lower extending downwards to an infinite depth. It can be shown that, whatever the nature of the folding of the differential surface separating the two layers, there will be certain maximum possible values for the anomalies, and that these will depend solely on the assumed difference in density or susceptibility and on the greatest and least depths of the bounding surface. Accordingly, the following limiting values have been calculated for this case : (1) vertical gravitational anomaly ; (2) first horizontal derivative of the vertical gravitational anomaly ; (3) second horizontal derivative of the vertical gravitational anomaly ; (4) horizontal directing tendency recorded by the Eötvös torsion balance ; (5) vertical magnetic anomaly ; (6) first horizontal derivative of the vertical magnetic anomaly perpendicular to the magnetic meridian and also parallel to the magnetic meridian ; (7) second horizontal derivative of the vertical magnetic anomaly.

A knowledge of these theoretical maxima enables one, by comparison with the maximum observed values of the corresponding quantities, to fix certain limits to the depth of the bounding surface.   S. E. C.

629.* The Gulf Gravimeter. R. D. Wyckoff. *Geophys.*, 1941, **6** (1), 13–33.—Recognition of the inherent limitations of the pendulum method of gravity survey led, in November, 1932, to the consideration at the Gulf laboratory of the problems of gravimeter design. To minimize delay, two types were investigated and constructed, the astatized and the unastatized. By the end of 1934 it was possible to make a choice between them, and the unastatized type was selected for development. This instrument, modified from time to time, has been used ever since, and it completely supplanted the pendulum equipment in 1936.

A gravimeter should be designed so that its probable error does not exceed 0·1 milligal, thus making the minimum sensitivity approximately 10^{-7} g. The difficulty with the unastatized type using a mass supported by a helical spring, is the measurement of the extremely minute displacements. The practical effect of astatization, on the other hand, is to render the system non-linear, with the result that each change in adjustment changes the sensitivity and scale value of the instrument.

An astatized gravimeter, constructed by modifying a Galitzin vertical seismograph, was used for determining the characteristics of springs, and another astatized instrument with bifilar suspension was built as a field instrument. No field tests were made, however, with these instruments.

The difficulty of measuring minute displacements in the unastatized type was overcome in a very simple manner. A ribbon helix is used for the spring, and this produces a rotation of about 1 second of arc per 10^{-7} change in g. The rotation of the suspended mass is observed by means of an attached mirror, so that there are no levers or other connections with the moving system. A special multiple reflection mirror arrangement permits reading the undeflected beam together with multiple reflections readable beyond the sixth. Using the fourth reflection and an optical lever 22 inches long, 0·1 milligal corresponds to a 0·001 inch displacement of the index under the micrometer microscope. The total range is 25–30 milligal, but the zero is readily adjustable by means of a torsion head without appreciable change in calibration constant.

The actual construction of this type of instrument, with which observations have been made at more than 200,000 stations since 1936, is described in some detail.

S. E. C.

630.* The Gulf Underwater Gravimeter. T. B. Pepper. *Geophys.*, 1941, **6** (1), 34–44.—Gravimeters require a firm support, a fact which makes work over water-covered areas difficult. The first attempt to overcome this problem was the utilization of tripods, which enabled observation to be made on calm days in water as deep as 18 feet. The equipment, however, was cumbersome and the method was slow and costly. It was therefore decided to design an instrument which would operate on the bottom and, after considering various schemes, work was started on a gravimeter contained in a pressure housing and with all controls, including levelling, operated by remote control from the surface. The design of this instrument is described in some detail. Photographic recording is used, and about 10 observations can be made on a standard film. In calm water the record can be read with an accuracy of about 0·02 milligal. At the time of writing the paper, a maximum of 17 stations per day had been taken, the average being 6.

S. E. C.

631.* The Effect of Density on Seismic Reflections. S. S. West. *Geophys.*, 1941, **6** (1), 45–51.—In seismic prospecting it is generally assumed that only velocity changes are significant, but it is pointed out here that density changes can be quite as important in producing seismic reflections. The empirical correlation of reflections with abrupt changes in the velocity-depth curve, therefore, may sometimes lead to serious errors. In order to illustrate this point, detailed data were obtained from 10 wells in New Mexico, and this was sufficient to permit the calculation of the true reflection coefficients and their comparison with reflection coefficients based on the assumption of equal densities. In 5 out of 6 cases the effect of change of density was such as to reduce the amplitude of the reflection so seriously as to make it scarcely detectable.

S. E. C.

632.* Resolution Control in Seismic Surveys. R. F. Beers. *Geophys.*, 1941, **6** (1), 52–63.—Seismic reflections originate in stratified media at discontinuities of density, modulus of elasticity, velocity of propagation of longitudinal waves, acoustic impedance, etc. It is therefore possible by means of direct measurement to obtain detailed information regarding the nature and properties of rocks encountered in the path of the seismic waves. The ability of the reflection seismograph to resolve these details is affected considerably by conditions at the shot-hole—depth, dimensions of the shot-hole cavity, and length of time during which the seismic impulse persists.

In making measurements it is customary to use measuring devices consistent with

the dimensions to be measured. In seismic work, therefore, the wave-length should be of the right magnitude, and this may be controlled by controlling the duration of the seismic impulse at the shot-point. For instance, in the East Texas Basin the length of this impulse can be varied between the limits of 0·02 and 0·04 second. The choice of length of impulse is governed by the characteristics of the geological section and the detail required. The shorter the impulse the more detail obtained, but in a section rich in reflecting horizons this may easily lead to confusion.

In this problem of resolution the influence of the recording instruments must also be considered. Control may be established at the point of generation of the impulse, but resolution may still be lacking, due to wrong instrument characteristics. The cases are discussed of instruments, both critically damped and undamped, which have natural periods longer than, equal to, and shorter than the period of the ground motion.　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　S. E. C.

633.* A Numerical Method of Computing Dip Data Using Well-Velocity Information. K. H. Waters. *Gephys.*, 1941, **6** (1), 64–73.—Well-shooting data are used in a series of computations for the making of charts which, with a knowledge of the time and differential time of a reflection, will give the depth and position of the reflecting point and the angle and azimuth of dip. The velocity laws considered in these computations have the common characteristic that the velocity is the same at any point in a horizontal plane at a given depth. The method is applicable to steeply dipping strata.

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634.* A Transformed Wave-Front Chart. R. A. Peterson. *Geophys.*, 1941, **6** (1), 74–80.—In the computation of the position of a seismic reflecting interface, a " wave front—wave path " chart may be constructed showing the position of the wave front for progressive intervals of time and of the wave path for various values of the angle of emergence. By this means it is possible to read the position of the reflecting interface directly from the chart, but the presence of four superimposed sets of closely spaced co-ordinates makes this a tiring process if much repeated. A transformation is described here whereby the co-ordinates representing wave fronts and wave paths are replaced on the chart by a mechanical arm pivoted at the shot-point and carrying a scale showing the wave-front position for progressive intervals of time. The sine of the angle of emergence is read on a circular scale over which the lower end of the arm passes. There are therefore only two sets of co-ordinates on the chart, and the fatigue in using it is considerably reduced.　　　　　　　　　　　　　S. E. C.

635.* Application of the Fourier Integral to some Geophysical Problems. W. T. Born and J. M. Kendall. *Geophys.*, 1941, **6** (2), 105–115.—Fourier integral analysis is discussed, and a special type of Henrici rolling sphere harmonic analyzer for evaluating $\int F(x) \cdot \sin ax \, dx$ and $\int F(x) \cdot \cos ax \, dx$ is described. The use of this method for obtaining true ground motion freed from instrumental frequency and phase distortion is dealt with in some detail. It may also be applied to the prediction of instrument performance and the possible variations in the shape of a reflection pulse with instruments of different characteristics.　　　　　　　　　　　　　　　　S. E. C.

636.* The Effect of the Placement of a Seismometer on its Response Characteristics. H. Washburn and H. Wiley. *Geophys.*, 1941, **6** (2), 116–131.—Experience shows that it is often necessary to bury certain types of seismometers to obtain good results, a not very convenient arrangement when a large number is in use. Experimental work was carried out, therefore, to find the best conditions for a surface " plant," and the effect of the different surface conditions which are met in the field. The apparatus consisted of two seismometers of the dynamic type with small moving masses. The instruments were rigidly bolted together, one serving as a driver unit to impart motion to the seismometer and the ground, and the other serving as a detector of the resulting ground velocity. The experiments showed that the ground and the seismometer act as a resonant system, the characteristics of which are affected by a number of factors : size of base, weight, method of planting of the seismometer, and the condition of the ground surface. It is concluded that an instrument for field

work should be light in weight and with a base area which is a compromise between an area large enough to flatten the response appreciably and an area small enough to facilitate rapid operation. Numerous experiments were carried out with plants in different types of ground and at different seasons of the year. These indicate that when designing a seismometer the elastic constants of the ground must be taken into account and, if properly designed, it is possible to use surface plants in many areas.

S. E. C.

637.* **The Attenuation Constant of Earth Materials.** W. T. Born. *Geophys.*, 1941, **6** (2), 132–148.—In theoretical work it is frequently assumed that the losses causing attenuation of waves are viscous in character. Since the surface rocks of the earth are solid, it is surprising that more attention has not been paid to the subject of solid friction, and experiments were therefore made to determine to what extent losses in small samples are viscous or are due to solid friction. A bar was cut from the rock sample, and a small coil of wire was cemented at each end; the bar was supported at its midpoint, and the coils were arranged to oscillate in a magnetic field. A variable frequency oscillator supplied current to one coil for driving the bar, and the resulting motion at the opposite end was detected by the other coil which acted as a pick-up. It was found that in dry samples the losses are of the solid friction type, but that when damp there are additional losses of a viscous character. These experimental results were obtained on relatively few, well-consolidated samples, and the extension of the findings to the crust generally is open to doubt, on account of the effects of depth of burial and the plasticity of unconsolidated sediments. It is shown, however, by a consideration of the relative amplitudes of the various reflections found on a seismograph record that the laboratory data are consistent with the values calculated for maximum total decrement. Curves showing the frequency characteristics can be plotted on the basis of this work, and these show that the earth acts as a low-pass filter.

S. E. C.

638.* **The Range of Amplitudes in Seismic Reflection Records.** J. M. Kendall. *Geophys.*, 1941, **6** (2), 149–157.—The relative amplitudes of incoming waves are plotted as a function of time, examples being taken from six widely separated areas. Correction for divergence is made, and the amplitude of the recorded waves is then found to decrease exponentially with time. By exploding charges of various sizes in a shothole the relatively great increase in charge needed to produce even a small increase in usable length of record is demonstrated.

S. E. C.

639.* **Average Vertical Velocities from Refraction and Reflection Profiles.** W. R. Ransome and F. Romberg. *Geophys.*, 1941, **6** (2), 158–167.—A combined refraction–reflection profile was shot in 1937 in the district of Infante, Guarico, Venezuela, on a location where elevations were extremely flat, weathering relatively uniform, and where the profile could be shot along the strike. Vertical velocities are calculated from the data so obtained. Two years after the completion of the survey it was possible to obtain vertical velocities direct from measurements made in a well drilled during the intervening period. The maximum difference between measured and calculated velocities is only 5%, and it is therefore suggested that, where well shooting is not possible, velocities can be obtained in the manner outlined in this paper. S. E. C.

640.* **Network Adjustment by Least Squares—Alternative Formulation and Solution by Iteration.** M. O. Gibson. *Geophys.*, 1941, **6** (2), 168–179.—If in any adjustment of a network comprising observed differences in values of adjacent points, (1) the sum of the corrected observations around any circuit is zero, and (2) the sum of the corrections at any junction is zero, then the corrections are least square corrections. On this basis it is shown how the adjustment of networks can be considerably simplified and, in many cases, the amount of work reduced, The principles may be applied also to electrical circuits.

S. E. C.

641.* **The Calculation of Gravity Anomalies Due to Bodies of Finite Extent.** S. Levine. *Geophys.*, **6** (2), 180–196.—In contrast to the usual indirect procedure, where various mass distributions are tried until a calculated anomaly resembling field results is

obtained, direct methods of interpretation have been developed, as, for example, by Jung and by Schwinner and Ansel. The latter divide geological bodies into a group of tabulæ, and then derive formulæ for calculating their gravitational anomalies. This process, for bodies of finite extent, is cumbersome. A graphical method has therefore been developed in which curves are drawn representing the boundaries of the body, the area enclosed by them being a measure of the gravitational effect of that body. This area can be measured with a planimeter. The rapidity of the method is emphasized.   S. E. C.

642.* Geophysical activities in California. W. A. Sawdon. *Petrol. Engr*, March 1943, **14** (6), 66.—At present most of the Californian geophysical work is in and around the Sacramento Valley, where there have been gas discoveries but no oil finds of commercial importance. The reflection seismograph is the geophysical instrument most commonly used, although there are five gravity meter crews operating. Geophysical activity has gone on in the Los Angeles Basin, the Santa Maria, Ventura, and Sacramento Valleys, but the greatest amount of seismic reflection work has been carried out in the San Joaquin Valley. At first large features were sought in the San Joaquin Valley; then smaller features down to depths of 7000–8000 ft.; and later features down to 10,000–11,000 ft. Very careful interpretation is needed in order to determine small or complexly faulted structures and stratigraphic traps at these great depths. Detailed work has been concentrated in the most promising areas, such as southwest of Fresno, where the Raisin City, Helm, and Riverdale fields have been found. In these investigations the shot-lines and points are closely spaced.

This type of work is very costly, and will probably result in a higher ratio of dry holes to discoveries.   G. D. H.

Drilling.

643. Chemical Influences in Drilling Mud Evaluated by Viscosity Measurements. A. W. McCray. *Petrol. Engr*, January 1943, **14** (4), 66.—The structure of clays and drilling muds is explained. In order to understand the origin of the forces acting between clay particles, it is necessary to consider the structure of the clay minerals. There are two main clay minerals, kaolinite (common clay) and montmorillonite (bentonite, widely used in rotary drilling muds). Both develop in plate-like forms, and the edges are breaks in the crystalline structure. Thus, unsatisfied atomic bonds exist at the edges of the clay crystals, and these bonds are satisfied by ions present in the water. If no salt, or acid, or base is present to supply the needed ions, then the bonds are satisfied by hydrogen ions supplied by the water itself. In the latter case the clay is known as hydrogen clay. If common salt is present in the suspension to supply sodium ions, the clay is known as sodium clay. If potassium hydroxide is present to supply potassium ions, the clay would be called potassium clay, and so on.

A balance, or equilibrium, exists between the ions associated with clay particles and the free ions in the water. There is a tendency for the ions satisfying the bonds at the edges of the clay crystals to dissociate from the clay. They leave the clay, yet linger nearby so that an overall positive–negative balance is maintained. Any of the same kind of ions existing free in solution in the water repel their kind and drive the ions back to close union with the clay. Accordingly, it can be seen that at some intermediate concentration of ions (or electrolyte) the number of dissociated ions around a clay particle will be the greatest. These ions dissociated from a clay particle have a positive charge, and they leave the clay with a net negative charge. Thus a static electrical field is built up around each clay particle, and its characteristics depend on the nature and amount of electrolyte added to suspension.

The static electrical field surrounding each clay particle is responsible for the forces of attraction and repulsion that exist between the particles. These forces were first suspected because of gelling and other static phenomena. Because of the nature of the charge distribution about the clay particles, it is possible, under certain conditions, for two particles to repel each other at certain distances of separation and attract each other at other distances of separation. Curves are presented for the energies of attraction and repulsion.

Experiments on viscosity of muds were made, and the following were the main conclusions: (1) The shape of the viscosity versus R.P.M. curve is an indication of

(*a*) whether the colloidal clay particles attract or repel each other when uniformly dispersed within the suspension, and (*b*) the strength of the attraction or repulsion forces. (2) The amount of dilution required to make the viscosity of a chemically treated clay independent of the rate of flow is a measure of the effective range of the particle charge, or the mobility of the chemical ions within the suspension. (3) The ability of a colloidal clay suspension to gel is dependent on both the amount of chemical added to the suspension and the concentration of colloid within the suspension. (4) Viscosity characteristics are not an indication of the ability of a clay suspension to form a gel, but higher viscosities may be expected in suspensions that gel because of the greater charges associated with the solid particles.   A. H. N.

644.* Calculating Pump Sizes and HP. of Driver. F. B. Applegate. *Petrol. World*, January 1943, **40** (1), 44.—This forms the third and final paper on duplex power-pumps for oil-industry service, and in it formulæ derived from experimental and test data are given. Examples are worked out. Design of discharge and suction piping are discussed.

The total discharge pressure on the pump is made up of static pressure and the friction loss in the line. This total pressure is limited either by the allowable working pressure of the pipe or by the pressure in the line receiving the oil. In either case the difference between the total pressure and the static pressure will be the allowable friction loss. The discharge line must be proportioned so that this friction is not exceeded when the pump is delivering its rated capacity of oil at its maximum viscosity. When preparing the design of the discharge line, the effect of a closed or partly closed valve should be recognized and proper provision made to avoid damage to the pump or driver in case a valve is closed before the pump is shut down. A closed or partly closed valve in the discharge line will build up the pressure in any pump, but the magnitude of this pressure and its effect is not the same in all types of pumps. A centrifugal pump will build up a pressure equal to the shut-off pressure generated by its impeller, which is not sufficient to damage either the pump or the driver. A direct-acting steam pump will automatically slow down or stall, and the stalling pressure in a pump, properly proportioned, will not cause damage. A power-pump will continue to operate at speed, and will continue to build up pressure until the overload causes a motor to burn out, stalls the engine driving the pump, or damages both the pump and the driver; hence the importance of installing a suitable relief in the discharge line near the pump cylinder. A spring-loaded relief valve is cheap insurance against damage to the pump and driver, resulting from the possible closing of valves in the discharge line.

Some of the major points to observe in the design of suction piping are : (1) Locate the pump in a position that will permit using a suction line of the minimum length ; (2) the diameter of the suction pipe should not be less than that of the suction opening on the pump. To keep friction losses to the minimum : (3) For long lines use pipe at least one size larger than the suction opening on the pump ; (4) use the minimum number of valves and fittings ; (5) use gate valves in preference to globe or angle valves—long-radius bends or long-radius ells in preference to short-radius bends, tees or standard ells. To avoid pockets or high spots in which gas or vapours will accumulate : (6) Slope the suction line up towards the pump with a uniform grade of at least 6 in. in 100 ft. ; (7) when a change in pipe size is necessary, use eccentric reducers and install the reducer so that the top line of the pipe and the reducer are continuous. When long suction lines cannot be avoided, a suction air-chamber should be installed close to the suction flange of the pump cylinder. The volume of the suction air-chamber should not be less than six to eight times the displacement of the pump. The object of a suction air-chamber is to induce a uniform flow in the line by providing an elastic element to absorb inertia and cushion the effects of acceleration and decelleration.

If these points are observed and the joints on the suction side of the pump are made air-tight, few, if any, operating troubles will occur as the result of an inadequate supply of liquid to the pump.   A. H. N.

645.* Rotatable Mixing Jets in Mud Tank Assure Thoroughly Mixed Chemicals. Anon. *Oil Wkly*, 15.2.43, **108** (11), 28.—A length of 3-in. pipe, laid along the full length of the tank near the one side was perforated with a series of small holes spaced at

approximately 12-in. intervals. Over each hole was welded a short nozzle of $\frac{1}{2}$-in. pipe. Mounted several inches above the bottom of the tank, the pipe is held in place by several iron clamps, but the clamps are not cinched up tightly, and the pipe is free to be turned, by means of a handle located outside the tank, through an arc of about 90°. One end of this pipe enters the tank through a water-tight packing gland, and a short steel handle welded to the exposed section of the pipe permits it to be rotated.   A. H. N.

646. Shell Soundproofs Test Well. L. P. Stockman. *Oil Gas J.*, 25.2.43, **41** (42), 55.—A new well is being drilled from a derrick which is sheathed. This sheathing, in addition to being practically fireproof, was deemed necessary in order to reduce drilling noise to a minimum due to the proximity of dwellings about one block away. The 132-ft. steel derrick for 1 Verne community was erected during daylight hours and in the conventional manner. Next 2 × 6-in. timbers were laid vertically 2 ft. apart from the ground to the top of the derrick on all four sides, and coarse wire mesh screen was then nailed on to these vertical timbers. Next came a series of horizontal timbers to provide anchorage for sheet transite which at present encloses every piece of equipment except the portable electrical equipment. The area between the wire screen and the transite has been filled with rock wool for a thickness of about 4 in. This insulation eliminates practically all the noise incident to drilling. In order to provide ventilation and at the same time keep the derrick free of gas, a series of enclosed fans and air vents has been provided. When this test got under way it was decided to permit the pumps and shakers to remain in the open, but it was soon found that a slight humming noise was audible some distance from the well, and accordingly the pumps and shakers were completely insulated by erection of a soundproof shed. Los Angeles city ordinances prevented the company from enclosing the principal electrical equipment, but with this exception everything on the property is enclosed and soundproof. A high board fence has been erected around the rig, and admittance is by a special pass only.

Drill-pipe is pulled off the rack in the conventional manner, except that in Shell's Verne community well a door for the A-frame opening has been provided that slides vertically along a track that keeps the door from swaying. The door which extends down to the base of the derrick is operated from the cathead by a line running from the top of the door to a pulley just below the run-around, and thence to the derrick floor. After drill-pipe has been placed on the derrick floor or laid down on the rack, the door, which is also insulated in the same manner as the entire derrick, is again dropped, being kept in place by the runners or tracks along which it moves. Electrical equipment was decided upon for convenience, and because it dispensed with steam and was more suitable for noiseless drilling and at the same time provided positive direct control. Large pumps are being used, and the shakers and mud-tanks are enclosed in a compact unit. Two 2500-brl. tanks have been erected and lead lines have been laid from the well to the tanks. In order to keep the well under control at all times, the company is using three blowout preventers. Extraordinary safety measures have also been taken to permit the derrick man to get out of the enclosed derrick in case of emergency. Shell spent approximately $9000 rigging up this well before it was spudded. The precaution taken in the drilling of this miocene test is cheap protection against what might prove a costly undertaking if the well should get away, not to mention the possible effect of such a condition on future drilling within the corporate limits of the city of Los Angeles.   A. H. N.

647. Mud Conditioning in Embar Field. H. F. Simons. *Oil Gas J.*, 4.3.43, **41** (43), 39.—Mud-conditioning is one of the principal factors in the drilling to the deep Ellenburger pay (approximately 7900 ft.) in the new Embar pool of Andrews County, Texas. One company has developed a tank which is included in the mud system and which performs a number of tasks. The tank permits the ready addition of chemicals to the mud and can be used for batch mixing if necessary. However, its main purpose is to separate the shale and cuttings from the drilling mud before the mud enters the regular circulating pits. It is also used as a temporary storage while getting and cleaning out pits. The rig with which the tank is used is the regular two-motor compound type with the pump located back of the prime movers. The pits used customarily with such rigs are L-shaped, the flow-line from the well entering

the pit which is parallel to the drilling equipment. The mud then flows the length of this pit and makes a turn (generally through a boarded ditch) into the second pit, and thence to the pump suction. This is the pit system used at Embar. The mud system is described in detail.

The outlet from the tank is through a funnel located in the centre. This funnel is about 18 in. in diameter to the top and reduces down to 7 in. The top of the funnel is approximately 3 in. below the bottom of the flow-line entering the tank. The mud coming into the tank sets up a slow circular motion, with the quietest portion being that towards the centre and, consequently, most of the cuttings settle out, and virtually clean mud passes out through the funnel. The tank is also equipped with two fluid-operated jets located on opposite sides from each other. These jets are connected to lines leading to the reserve pit into which the shale is ejected. A platform on the derrick side of the tank is equipped with a mud-gun, the necessary connections and valves for operating the jets and the gun, a fresh-water line, and a barrel for mixing chemicals. This barrel lies on its side, with a portion of the uppermost side removed. A valve at the lower end allows regulation of chemical flow into the mud.

Mixing and jetting of the muds and details of its properties are given.   A. H. N.

648. Simple Maintenance of Electrical Equipment may Prevent Costly Shutdowns. E. H. Lamberger. *Oil Gas J.*, 4.3.43, **41** (43), 46–48.—Concise directions are given on the proper maintenance practices are precautions are to be taken in working with motors and generators and their parts, such as current collectors and commutators and bearings, with control equipment and transformers.   A. H. N.

649. Steam Consumption of Reciprocal Pumps. W. L. Nelson. *Oil Gas J.*, 11.3.43, **41** (44), 46.—The steam required to pump 100 g.p.m. of liquid at a pressure of 100 lb./sq. in. gauge pressure using 125-lb. (gauge) steam is approximately 1000 lb./hr. This constant is based on the fact that the volume displaced from the liquid cylinder of a pump is the same as the volume of steam required to fill the steam cylinder if the steam pressure is the same as the liquid discharge pressure—and corrected, of course, for the inefficiency of the pump. The steam quantity can be easily converted to pounds by means of its density or specific volume.   A. H. N.

650. Troubles from Salt Sections, Hard Formations, Impede Embar Drilling. H. F. Simons. *Oil Gas J.*, 11.3.43, **41** (44), 57–59.—Mud treatment required by a salt section in the Permian formations, tool-joint failures, and cherty formations just above the Ellenburger pay horizon are the principal difficulties encountered in drilling wells in the Embar pool of southern Andrews County, Texas. This field is one of the major West Texas discoveries of the last year, has two good producing horizons and one not so good, in addition to the usual gas-bearing formation in the Yates. The geology of the field is discussed. Drilling practices are then reviewed.

If all the salt section is not cased off, the salt-water mud used consists mainly of native clay and material which will increase the viscosity slightly. Such a fluid will show a high water loss (50–80 c.c. in 30 minutes) and a correspondingly thick filter cake. This mud allows the salt to go into solution, which forms cavities in the upper part of the hole, and permits the shales to be continuously wetted with consequent sloughing. Another difficulty which arises from the formation contents going into solution with the water in the mud is the failure of the drill-pipe. There are a number of sulphurous compounds involved, and undoubtedly some hydrogen sulphide. The drill-pipe failures exhibit many of the characteristics of hydrogen sulphide embrittlement. Mud problems are further discussed.

The field is being drilled with 3½-in. drill-pipe with no troubles attributable to it. Rotating speeds are low, from 90 to 150 r.p.m., with some drillers using only 70 r.p.m. for drilling the anhydrite. Practice is to core and drill completely through the pay and then run the 5½-in. pipe to bottom. The float and cement are then drilled out of the pipe, but the guide or float shoe is left intact. The drilling of the cement is done with 3-in. flush drill-pipe. The casing is then gun-perforated. Rigs used in the field are mostly late-model power rigs using either two gas or diesel engines. One rig has a three-engine hookup. Total horse-power of engines on rigs at Embar

runs from 370–600 h.p. The 126-ft. derricks are set on substructures. As it takes from 70–90 days to drill the deeper Ellenburger wells and 45–50 days to drill the Tubb wells, the rigs are well assembled.

<div align="right">A. H. N.</div>

651. Slim-Hole Drilling in Barnhart Field in West Texas. H. F. Simons. *Oil Gas J.*, 18.3.43, **41** (45), 48.—The slim-hole programme followed generally in the field was inaugurated in the first well, which set 627 ft. of $10\frac{3}{4}$-in. casing, 2225 ft. of $7\frac{5}{8}$-in. casing, and 9017 ft. of $5\frac{1}{2}$-in. pipe. The discovery well had over 7000 ft. of open $6\frac{3}{4}$-in. hole before the oil string of casing was run in it. The string of pipe run to 2225–2250 ft. shuts off the salt section between 1080 and 2180 ft., the gas sand found at 2200 ft., and eliminated considerable mud trouble. While drilling the hole for the intermediate string, loss of circulation is not uncommon. The drilling of a well to below 9100 ft., with 7000 ft. of open hole is something of an accomplishment, and when the hole drilled is only $6\frac{3}{4}$-in. in diameter, a great amount of care must be taken to prevent troubles. The drill-pipe used is $3\frac{1}{2}$ in. in diameter, and a stuck string of pipe is really difficult to free. It would be practically impossible with present mud technique to drill the well without casing off the salt, anhydrite, and gas-bearing zone already mentioned by running the intermediate string.

With the upper zones, which might complicate the mud problem, cased off, there is still not complete freedom from mud troubles. Generally the hole stands up quite well, with the exception of the interval from 3800–4700 ft., which is shale, and sandy and limy shale. There are some sands in this interval which flow salt or sulphur water and which cause the mud to have a high viscosity and water loss if not controlled. A mud weighing 9·6 lb./gal. will hold the water in the formation, and a further seal is obtained by using 20–25 sacks of " Impermex " plus quebracho and caustic soda while drilling this section. This gives a low-water-loss mud which plugs off the formation. Mud is maintained at 9·6–9·8 and at a viscosity of 33 or 34 seconds A.P.I. until 8800 ft. is reached. If the mud is not properly maintained, and if the pits are not kept clean and free from shale and cuttings, trouble with sticking pipe may be encountered. Keeping the water loss as low as possible helps, and prevents the greenish-grey shale around 4700 ft. from caving due to being wetted.

At 8800 ft. the mud is prepared for drilling the pay section by removing as much of the solid materials as possible, and then adding 3000 lb. of " Impermex," 1200 lb. of caustic soda, and 500 lb. of quebracho. This brings the water loss down to 2–4 c.c. in 30 min. at 100 lb. pressure, which prevents infiltration of water into the formation. The pay is then drilled and an electric log run to bottom, after which the casing is run. The pay is quite soft, and a substantial increase in the drilling rate is noted when it is encountered.

Casing programme and other details are given. It takes from 70 to 80 days to drill a well.

<div align="right">A. H. N.</div>

652. Patents on Drilling. C. D. Cantrell. U.S.P. 2,309,625, 2.2.43. Appl. 3.10.40. Sampling apparatus for obtaining representative samples of fluid flowing through a conduit.

C. S. Sanders. U.S.P. 2,309,791, 2.2.43. Appl. 13.9.40. Method and apparatus for cementing wells, using rotation and wobbling of casing.

R. E. Fearon. U.S.P. 2,309,835, 2.2.43. Appl. 14.2.41. Well-logging apparatus and method for detecting structural characteristics.

J. R. Gardner. U.S.P. 2,309,839, 2.2.43. Appl. 31.8.40. Float collar for well-pipes.

J. E. Reed. U.S.P. 2,309,866, 2.2.43. Appl. 5.8.41. Safety-joint bumper sub.

D. N. Shaffer and E. C. Hamm. U.S.P. 2,309,872, 2.2.43. Appl. 20.11.40. Hydraulic trip tool-jar for jarring well-tools.

D. H. Weinstein and L. H. Metzner. U.S.P. 2,309,877, 2.2.43. Appl. 8.1.38. Device for determining inclination of well-bores.

E. M. Irwin, B. H. Rule and G. E. Lewis. U.S.P. 2,309,905, 2.2.43. Appl. 27.1.39. Device for surveying well-bores with means to transmit signals to the surface.

H. H. Vanderzee. U.S.P. 2,309,999, 2.2.43. Appl. 23.5.39. Rotary drilling apparatus with hydraulic drill-rod feeding means.

J. W. Haddock. U.S.P. 2,300,001, 2.2.43. Appl. 27.3.40. Apparatus for cleaning holes by high gas-pressures.

D. B. Grable. U.S.P. 2,311,225, 16.2.43. Appl. 8.1.40. Pipe rotating apparatus, in the form of pipe-tongs with special gripping arrangements.

H. N. Marsh. U.S.P. 2,311,312, 16.2.43. Appl. 17.2.42. Continuous mud-weight indicator.

J. J. Jackosky. U.S.P. 2,311,757, 23.2.43. Appl. 25.2.38. Thermometric method and apparatus for exploration of boreholes.

G. McCray. U.S.P. 2,311,768, 23.2.43. Appl. 12.11.40. Casing centering apparatus for use in boreholes.

C. L. Deckard. U.S.P. 2,311,932, 23.2.43. Appl. 2.3.42. Hinged-finger adjustable pipe-rack.

C. L. Deckard. U.S.P. 2,311,933, 23.2.43. Appl. 2.3.42. Safety pipe-rack for use in derricks.

A Shacklette. U.S.P. 2,312,126, 23.2.43. Appl. 14.9.42. Shock absorber for use on walking beams of drill-rigs.

J. R. Yancey. U.S.P. 2,312,205, 23.2.43. Appl. 9.8.41. Oil-well equipment, including a casing-head and oil-well foundation equipment.

M. Lintz. U.S.P. 2,312,343, 2.3.43. Appl. 1.2.41. Vibrating screen.

H. C. Pollitz. U.S.P. 2,312,477, 2.3.43. Appl. 3.8.40. Vibrating screen.

R. A. Steps. U.S.P. 2,312,600, 2.3.43. Appl. 2.1.41. Well mechanism for cementing pipe in a well.

F. L. le Bus. U.S.P. 2,312,656, 2.3.43. Appl. 28.6.41. Whipstock deflecting tool for oil-wells.

P. W. Appleby. U.S.P. 2,312,789, 2.3.43. Appl. 1.2.39. Well-tool for cleaning the walls of a well by means of fluids under pressure.

O. L. Derrick. U.S.P. 2,312,804, 2.3.43. Appl. 13.2.40. Guide for kelly-bars and drill-stems.

L. A. Douglas. U.S.P. 2,312,805, 2.3.43. Appl. 19.6.41. Means for laterally entering subterranean strata and withdrawing the pore content thereof.

J. A. Bermingham. U.S.P. 2,312,862, 2.3.43. Appl. 26.1.40. Method and apparatus for completing wells by underreaming and using a liner screen.

W. J. Opocensky. U.S.P. 2,313,168, 9.3.43. Appl. 25.4.40. Inclination and directional device for boreholes.

R. B. Sprague. U.S.P. 2,313,177, 9.3.43. Appl. 3.12.40. Blowout preventer and valve.

G. D. Johnson. U.S.P. 2,313,243, 9.3.43. Appl. 9.10.40. Elevator link for handling pipe or casing.

P. M. Rea. U.S.P. 2,313,263, 9.3.43. Appl. 24.5.41. Overshot fishing-tool.

H. Allen. U.S.P. 2,313,308, 9.3.43. Appl. 6.1.41. Casing-head.

J. C. Arnold. U.S.P. 2,313,310, 9.3.43. Appl. 4.8.40. Well-bore radiation logging apparatus.

R. E. Lea. U.S.P. 2,313,384, 9.3.43. Appl. 28.4.39. Means for determining the tectonics and nature of subsurface geology by means of using the drill-stem as an electrical logging apparatus.

R. A. Phillips and M. L. Clopton. U.S.P. 2,313,576, 9.3.43. Appl. 6.5.40. Core-drilling device for rotary systems.

H. E. Grau and C. A. Lunden. U.S.P. 2,313,743, 16.3.43. Appl. 15.4.40. Pipe tong.

W. J. Crites. U.S.P. 2,313,806, 16.3.43. Appl. 24.3.41. Coring apparatus for rotary systems of drilling.

W. T. Caldwell. U.S.P. 2,313,861, 16.3.43. Appl. 14.2.40. Drill-pipe joint.

J. P. Selberg. U.S.P. 2,313,897, 16.3.43. Appl. 30.1.41. Portable derrick of the type having two sections.

E. L. Alexander and A. W. Braithwaite. U.S.P. 2,314,323, 23.3.43. Appl. 9.1.41. Rat-hole drilling attachment for rotary drilling rigs.

J. E. Hoffoss. U.S.P. 2,314,352, 23.3.43. Appl. 23.11.40. Coring apparatus for rotary drilling systems.

H. S. Kelly. U.S.P. 2,314,502, 23.3.43. Appl. 11.1.41. Dual-purpose travelling block.

R. L. Huntington. U.S.P. 2,314,540, 23.3.43. Appl. 30.12.41. Apparatus for measuring volume of bottom-hole portion of well-bores.

C. C. Scharpenberg. U.S.P. 2,314,560, 23.3.43. Appl. 5.5.41. Torque control in rotary well-drilling.

F. M. Owen. U.S.P. 2,314,733, 23.3.43. Appl. 15.4.38. Automatic cathead.

C. D. Cantrell, Jr. U.S.P. 2,315,590, 6.4.43. Appl. 14.7.41. Coring apparatus.

F. L. le Bus. U.S.P. 2,315,629, 6.4.43. Appl. 30.7.41. Wall-core scraper used on a drill-stem.

L. C. Mead. U.S.P. 2,315,807, 6.4.43. Appl. 17.2.41. Pipe wrench.

W. J. Crites. U.S.P. 2,315,840, 6.4.43. Appl. 11.7.38. Borehole thermometer using expansion fluid containers responsive to temperature change.

G. N. Stafford. U.S.P. 2,315,905, 6.4.43. Appl. 1.3.40. Jarring tool for deep-well drilling.

C. E. Burt, T. Sutter, and T. M. Ragan. U.S.P. 2,315,931, 6.4.43. Appl. 17.6.40. Liner hanger apparatus.

M. Williams. U.S.P. 2,315,995, 6.4.43. Appl. 15.2.41. Addition agent for enhancement of the properties of drilling-muds.

T. Mulholland. U.S.P. 2,316,013, 6.4.43. Appl. 23.3.41. Pipe-thread protector.

B. W. Sewell. U.S.P. 2,316,024, 6.4.43. Appl. 16.8.40. Method and means for taking cores.
A. H. N.

Production.

653. Secondary Recovery May Have Vital Rôle in the War Effort. P. D. Torrey. *Petrol. Engr*, January 1943, **14** (4), 1160.—The author is the chairman of the Standing Sub-committee on Secondary Recovery Methods, American Petroleum Institute, and in this paper he details some of the committee's findings. The general programme of the Standing Sub-committee on Secondary Recovery Methods at the time of its organization was : (1) To demonstrate that the petroleum industry has not been unmindful of its obligations to conserve the available oil resources of the nation. (2) To assemble information and compile data on many existing secondary recovery operations in the United States. (3) To provide theoretical and practical information to serve as a guide for the efficient recovery of oil. (4) To develop interest in the preservation of marginal properties and fields, which otherwise might be abandoned unless some method for the stimulation of production were applied.

The importance of secondary recovery operations in the production of oil is more apparent in certain of the eastern States than elsewhere. This may be demonstrated most impressively by citing an increase in production in New York of 600% since 1912 and an increase in production from the Pennsylvania part of the Bradford field of 800% since 1912. These substantial gains may be attributed directly to the application of secondary recovery methods. A summary of some statistics relating to the magnitude of secondary recovery operations in the United States, as compiled by the A.P.I.'s Standing Sub-committee on Secondary Recovery Methods, reveals that a minimum of 306,282 acres of oil-productive territory was affected, on which there are some 50,636 producing wells and 34,956 injection wells. These comprise some 1236

different projects in 254 separate fields, with an estimated plant investment of $281,496,000. The value of secondary recovery oil produced in the United States during 1942 is estimated to be $84,000,000.

The influence of secondary recovery operations on total production in Kansas and Oklahoma is becoming of greater prominence, as both water-flooding and systematic gas repressuring projects, initiated several years ago, are beginning to reach the peak stages of production. The successful results obtained in many of these projects cannot fail to encourage further expansion of secondary development. There can be little doubt that the production from secondary recovery operations in these States will have a stabilizing effect and will serve to reduce the rate of decline that can be expected from the primary production. Secondary recovery operations in the great productive areas of the South-western States are not nearly so important in relation to total oil production as in the Eastern and Mid-continent areas, although there are more gas repressuring projects in Texas than in any other State. In both Texas and Louisiana moderate secondary recovery programmes are serving to maintain many oil-fields in profitable operation, and thereby are preserving important reserves of oil that might otherwise be lost if the fields were abandoned.

The adaptability of fields to secondary recovery is briefly discussed. A short forecast on the future of secondary recovery ends the paper.   A. H. N.

654. Applying Engineering Methods to Pumping Wells. A. S. Ross. *Petrol. Engr*, January 1943, **14** (4), 124.—One of the most basic and important features of a pumping well is its speed of operation. This factor affects the peak load and the distribution of power throughout the stroke cycle. For example, on one well pumping with a standard rig at Smackover, Arkansas, dynamometer tests showed that by increasing the speed from 29 to 32 s.p.m. the peak load was decreased 1250 lb., with a small increase in polished rod h.p. and a corresponding increase in production. The problem is one of determining the speed that produces the best harmonic motion in the rod-string. This may be done very simply by use of Slonneger's formula—frequency = $\frac{237,000}{\text{depth, ft.}}$. Thus, for a 6,000-ft. well, frequency = $\frac{237,000}{6000}$ = 39·5. From this frequency of 39·5 it may be shown that pumping speeds of an uneven or half order, such as $\frac{39·5}{3·5}$ = 11·3 s.p.m., $\frac{39·5}{2·5}$ = 15·8 s.p.m., and $\frac{39·5}{1·5}$ = 26 s.p.m., produce the most harmonious or efficient motion in the rod-string. As the 3·5 order speed is too slow and the 1·5 order speed too fast, pumping speeds of 15–16 s.p.m. would produce the most desirable results. Following up this line of reasoning, a group of wells pumping from 6000 ft., which had given considerable trouble due to tubing breaks, was studied to determine the source of the failures. It was found that all breaks had occurred on wells pumping at 18, 19, or 20 s.p.m. When these wells were slowed to 16 s.p.m. the trouble was eliminated and no further breaks have occurred. Production was maintained by lengthening the stroke or enlarging the pump diameter, when necessary.

Having established the proper pumping speed, the length of the stroke and pump diameter should be chosen to obtain the desired production. The above formula and method have been found to give good results in wells below 3000 ft., but they should be checked with a dynamometer when possible, especially on shallower wells. Field studies have shown that dynamometer tests are of actual value, mainly as a basis of comparison between the conditions in a well before and after a change in operation is made. Certain characteristics can, however, be detected from the shape or general appearance of the card.

Another factor in the study of the pump action is the actual pump stroke obtained at the bottom of the well. This factor may be calculated with reasonable accuracy by Rieniet's formula or by the newer formula proposed by Dralle and Lamberger. Rieniet's formula :—

$$S_p = \frac{Q_B}{K} + S_s \left(\cos \theta \right) - 2\frac{W_t}{K}$$

Dralle and Lamberger formula :—

$$EPS = \frac{S}{\cos \left(0 \cdot 0004 LN \right)^{\circ}} - \frac{W_{oD}L}{2(10)^6} \left(\frac{1}{A_R} + \frac{1}{A_T} \right)$$

Where—EPS = effective plunger stroke; in., S = polished rod stroke, in.; cos $(0.0004LN)° = 1 - \dfrac{X^2}{2} + \dfrac{X^4}{2^4}$ and $X = \dfrac{0.0004LN}{57.3}$; L = length rods, ft.; N = strokes/ minute; A_R and A_T = cross-sectional area of rods and tubing, sq. in.; and W_{OD} = differential fluid load, (wt. of net fluid head on the full area of plunger), lb.

A simple empirical formula that may be used as a rule of thumb has been derived by Slonneger as follows :—

$$\text{Stretch in in.,} = \frac{Depth\ (ft.) \times stroke,\ in.\ \times s.p.m.}{303,000}$$

This formula, although not always applicable, may be used for medium depth wells when a normal pump and rod-size are used and at pumping speeds of 20 s.p.m. or higher.

Torque and horse-power calculations are also included. In conclusion, the main factors to consider in an engineering study of a pumping well are : (1) The speed of operation, which should be chosen to give the best harmonic motion in the rod-strings ; (2) the selection of the correct size pump for the fluid to be handled and the proper type pump for the well conditions ; (3) the valve action and service in the pump ; (4) the service given by the rods and tubing ; (5) correct counter-balancing of the pumping unit ; (6) the selection and operation of the prime mover ; (7) the spacing of the subsurface equipment.   A. H. N.

655.* An Estimate of California Gas Reserves. Anon. *Petrol. World*, January 1943, **40** (1), 28–33.—Natural gas occurs in California and elsewhere as well, in two ways or modes, first as a separate and distinct product unassociated with deposits of liquid hydrocarbons or petroleum, in which case it is called " dry gas," and secondly, as-sociated with liquid hydrocarbons in the underground reservoir, being produced concurrently with the liquid phase material and separated at the surface or casing-head of the well from the liquid oil, from whence comes its name, " casing-head gas." Since the gaseous and liquid hydrocarbons exist coextensively in the reservoir, and since there is no clear line of demarcation between gas and liquid material, the com-position of each phase depending on the temperature and pressure existing at the time of separation, the casing-head gas as customarily produced contains border-line material consisting of readily liquefiable hydrocarbons which can be removed by compression and absorption in a casing-head gasoline plant, leaving a " dry " casing-head gas in distinction from the " wet " gas which was produced and separated from the oil at the casing-head.

The total future production of gas from both dry gas and oil- and gas-fields has been estimated by methods appropriate to the type of occurrence involved, and the reserve figures shown are the summation of those estimated total future productions, and are not to be understood as amounts of gas available to utilities or other consumers, since no deductions have been made for field use or shrinkage occurring when casing-head gasoline is extracted from the wet casing-head gas.

Dry gas was estimated by the saturation method and by the pressure-drop volume method. Considering the State as a whole, the 1941 production was about one-thirtieth of the total reserve. However, this should not be interpreted as meaning that the reserves will provide for the State's needs for a corresponding period. Unless important new reserves are discovered or major changes made in modes of utilization and distribution, serious shortages may result in some areas long before the period indicated by the above ratio, because of the increasing rates of withdrawal for general service and war production purposes. A study has been made of the approximate purposes of the gas reserves which may be available for general public uses after the necessary use of gas in the fields by the producing companies. For this purpose the dry gas-fields have been considered as wholly available for public uses. In respect to the casing-head gas reserves, the ratios existing between the present rate of gas available to utilities and the present rate of production from the individual fields have been used. It should be pointed out, however, that these ratios may not obtain for the future. Based upon such ratios, however, approximately 70% of the casing-head gas reserves may be considered available for general public purposes. By combining dry gas reserves with approximately 70% of the casing-head gas reserves it will be

found that slightly over 10 billion m.c.f. of gas reserves exist in the State which at this time appear to be ultimately available for public usage. A. H. N.

656.* Consideration of Well Characteristics in Design of Intermitter Installations. F. Briggs. *Oil Wkly*, 15.2.43, **108** (11), 14–16.—General principles of intermitter design are explained. Of prime consideration in the design of a setting for an intermitter is the determination of the static fluid level or the bottom-hole pressure from which the fluid level may be calculated. This well characteristic is necessary for selecting the position of the intermitter valve, the accumulation chamber design, and the method and means for unloading the fluid from the casing preparatory to beginning the intermitting cycle. The next factor considered is the amount and pressure of the gas available. This gas, except in rare cases, is introduced into the producing well from an outside source, and must be sufficient in quantity for continual operation, of great enough pressure to lift the length of fluid column produced during a cycle. Depending on the amount of fluid, the average operating pressure in most intermitter wells ranges from 200 to 350 p.s.i.

Another valuable determination is that of the well's productivity index. This term represents the relationship between producing subsurface pressures and production rates. It is defined as the " brl./day of gross liquid produced/lb./sq. in. of pressure " from a specified depth in the well. This productivity index indicates where the working fluid level of the well will remain at the desired production is obtained. Correlating this information with the bottom-hole pressure figures, the chamber, valve setting, and packer position may be determined. These three factors are discussed in some detail. Certain unusual types of installations are also discussed.

Among the troubles of intermitters are paraffin and corrosion. The use of gas in lifting fluid often accelerates the accumulation of paraffin on the tubing walls at certain depths in the well, due to the cooling effect of the expanding gas approaching the surface. In all cases this condition can be remedied by regular scraping or washing with a solvent. Corrosion and hydrogen sulphide often detrimentally affect intermitters, especially those requiring the use of wire lines. In the past this was solved by using model lines, or wires of similar resisting properties. As most valves are constructed of high-alloy steels, the main problem has been in the protection of the connecting link between surface control and intermitter valve. Those operating by pressure control have been least affected by corrosive action. The unloading system of certain intermitters is not designed for operation in wells with high fluid levels. Where various manufacturer's equipment is used in conjunction in the process of unloading the well, satisfactory results are not always obtained. Such equipment will operate perfectly under fluid conditions for which it was designed. There are intermitters with proper valves for the unloading procedure. A. H. N.

657.* Calculation of Actual and Effective Counterbalance. Part 2. E. N. Kemler. *Oil Wkly*, 15.2.43, **108** (11), 19.—In this part of the paper Professor Kemler discusses in greater detail the problem of counterbalancing wells than he used in Part 1. Methods of determining velocities graphically are outlined. Torque and horse-power calculations using velocities are then given. An example is worked out in full to illustrate the method. A. H. N.

658.* Driving Unit Shift Avoids Belt Replacement. Anon. *Oil Wkly*, 15.2.43, **108** (11), 37.—In California, where purchased power is used, advantage is taken of the decline in production rate in many fields by the installation of a 3- to 5½-horse-power electric motor at the bandwheel, instead of at the far end of the belt-house. By using the compact type of motor and gear unit combined, and by setting the driving unit base directly on one beam of the bandwheel support, it is possible to supplant the wide belt with a comparatively short roller-chain drive. If the large sprocket on the bandwheel shaft be made in two parts, and split to clamp around the shaft, no dismantling is necessary in making the shift to the new drive.

When installing the gear-and-motor combination, one California company cuts the number of pumping strokes from 18 to 6/minute, reducing wear-and-tear on the lifting equipment, and thus extending its service lift over a period during which replacements would be difficult if not impossible to secure. Through the installation of thermo-

static protective devices on the motor, provision is made against damage through overload or running away of the unit in case of a rod break. Provision of push-button control enables the unit to be operated from a central station when desired, with pumping sequence arranged to give uniform current draft over the entire lease or company holdings.

A. H. N.

659. Combat Corrosion in West Texas. H. F. Simons. *Oil Gas J.*, 25.2.43, **41** (42), 61.—The paper deals with corrosion problems in the production department of a field claimed to be the worst in Texas, if not in the world, for corrosion. Many attempts have been made to solve this problem. The latest has been the installation of cement-asbestos fibre-pipe in the flow-lines for the purpose of reducing or eliminating corrosion there, and stray electric currents which may affect the tubing. So far it seems to be producing results, although sufficient time has not elapsed to credit the step with any outstanding success.

The cement-asbestos pipe was put into use after tests for stray currents were made in the field. So many electrical currents were found that the situation was more confused than clarified. Also, the results of surveys did not correspond with those usually found, and it was almost impossible to reach any conclusion from them. Insulating flanges had been installed in the field, and they are still in place, but it was hoped that the use of a non-conductor pipe might eliminate some of the currents and some of the corrosion. At the worst, no harm could result from such a step, and at least the corrosion in the lead lines would be stopped. Many of the operators in the field do not agree with the stray electric-current theory, but believe that corrosion is due to direct chemical attack by the water produced with the oil. This water not only contains the usual salts, but also has a high hydrogen sulphide content. To add a little substance to the contention of this group, the corrosion is mainly on the inside of the flow-lines and tubing, although there is some outside corrosion.

In some cases wells must be pulled as often as once a week to search for leaks in the tubing. When the leaks are large they are easily found, but when small a pressure test must be used. Operators in the field are equipped with modern pulling units and have special equipment for testing the tubing while standing in the derrick. On one well, two pulling jobs were recently necessary in one week. The first time a leak was found at about 1800 ft., and the second time a split was found at about 2800 ft. 200 ft. off bottom. Outside the tubing there was little corrosion in the hole and about the normal corrosion near bottom. The tubing used is H-40, $2\frac{1}{2}$-in. external upset, and is a little over a year old.

Various remedies are briefly discussed.

A. H. N.

660. Air-Drive Experiments on Long Horizontal Consolidated Cores. H. Krutter and R. J. Day. *Oil Gas J.*, 25.2.43, **41** (42), 64.—Results of experiments on relatively long cores show that (1) relative permeability to air as a function of per cent oil saturation for a given core is independent of pressure gradient in the saturation range up to 85%. (2) Air–oil ratio expressed in volume of oil for a given core is independent of pressure gradients within the saturation range of 55–85%. (3) The ultimate recovery obtained using air drive on an originally 100% saturated core depends on the pressure gradients used. The higher the pressure the greater the recovery until an optimum pressure is reached, after which no appreciable gain in recovery is obtained with further increase in pressure. (4) Approximately 50% recovery may be expected from a core initially 100% saturated with oil. There is a small variation in this amount, depending on the characteristics of the sand. (5) Constant high-pressure maintenance is shown to lead to a greater recovery than is obtained by a gradual stepwise increase in pressure. However, the relative difference is not so marked as in experiments using radial cores. (6) Gas drive, although more advantageous from the viewpoint of cost, did not result in any increased ultimate recovery when compared with air drive at the same pressure. (7) Relative permeability to methane as function of per cent oil saturation is the same as the relative permeability to air as a function of oil saturation. (8) Water drive following air drive showed a remarkable increase in recovery. The possibilities of the use of water drive following air drive deserves further laboratory study as well as field experimentation. (9) One experiment though insufficient indicates that air drive followed by water drive may be more efficient in ultimate recovery than an original water drive. (10) The presence of

connate water in the sand may quantitatively affect the results of 8 and 9, and therefore these experiments should be repeated to determine what effect connate water has on the results. A. H. N.

661. Determining Capacity of Reciprocating Steam Pumps. W. L. Nelson. *Oil Gas J.*, 25.2.43, **41** (42), 83.—The capacity of a regular duplex double-acting reciprocating steam pump is equal to about half the product of the stroke (inches) and the square of the diameter (inches) of the liquid cylinder. For simplex pumps the capacity is about half as much as the above—or is equal to about one-fourth the product of the stroke and the square of the cylinder diameter. Finally, belt or gear-reduction-driven pumps of either the duplex or triplex types have a capacity about $1\frac{1}{2}$ times greater (factor is 0·75) than that of the regular duplex. These rules are approximately only and have no theoretical background. They are based on observation only of actual capacities. A. H. N.

662.* Counterbalancing of Central Powers. E. Kemler. *Oil Wkly*, 1.3.43, **108** (13), 31.—The peak load or torque which can be imposed upon a central power can be several times the average load or the load necessary when the power is properly counterbalanced. The problem of determining the location and size of the counterbalance is a complicated procedure. Several methods are available, and each does the job in the same general manner. Most of those in use employ graphical methods and require that force diagrams be made. The disadvantage of these methods is that changes in the diagrams are necessary when wells are unhooked or hooked on. The method described uses the same data as the graphical method, but reduces everything to a tabulation basis, so that the data can be used for any well combination and the adding or taking off of a well only requires re-adding the data. When a power has a complicated pumping schedule, this method will save much time.

The torque on the power caused by any one well at any point will be the component of the rod-line pull at right angles to the crank times the crank arm. Since the ratio of crank radius to Pitman length is large, the well load can be considered as acting parallel to the zero position, where the crank is in line with the rod line. The torque is then equal to the well load times the sine of the angle between the crank and zero position multiplied by the crank radius. The method is illustrated by an example which is worked out in detail. A. H. N.

663. Calibration of Horizontal Cylindrical Tanks. H. David. *Oil Gas J.*, 4.3.43, **41** (43), 49–50.—A method for calibrating horizontal cylindrical tanks by means of depth and diameter measurements and using a chart is given. Flat ends are assumed. A. H. N.

664.* Special Plant Treats Heavy Crude Emulsions Efficiently. G. M. Wilson. *Oil Wkly*, 15.3.43, **109** (2), 14.—A centralized crude-oil-treating plant of special design, employing direct-fired heaters, the first of its type to be used for this purpose on the Pacific Coast, has been giving exceptionally successful service since its installation by a large producing company to treat the extraordinarily difficult emulsion problem in the heavy oil produced in one of the coastal fields. The plant wet-oil flow system is unusually flexible in moving the difficultly handled heavy crude.

Entirely automatic in operation, the plant treats oil which averages 14 gravity and the cut of which averages up to 20%. The oil itself is extremely viscous, more so that the average of crudes of like gravity in other fields, and emulsions are very difficult to break out. The plant originally consisted of 4 direct-fired heaters and a battery of 8 electric dehydrator units, but plant capacity has recently been increased from its original of around 12,000 brl./day to approximately 18,000 brl. daily by the addition of 2 heaters and 4 dehydrator units. Pumping equipment of the plant was also increased proportionately. A skimming pond of novel design plays an important part in holding treating costs and waste down to an absolute minimum with no impairment of plant dehydration efficiency. The pumping units are described.

The electric dehydrators are 28,000 volt, double-transformer units, each using two sets of concentric ring electrodes. As the water is separated out and falls to the bottom of the dehydrator units, it is automatically drained off at intervals through the operation of electrically controlled valves. Each unit has one of these automatic bleeders

mounted on the outside of the shell. Cleaned oil is removed from the top of each unit and is withdrawn through an overhead 10-inch collecting line, which runs the full length of the battery of dehydrators. Dry oil averages less than 2% cut, and after leaving the dehydrators goes over to the dry-oil receiving tank, where it joins the dry oil coming into storage directly from the field.

Pressure in the dehydrators is maintained at 35 lb./sq. in. Because of the slight differential between the gravity of this oil and that of water, it is necessary that temperature and pressure conditions be maintained as nearly constant as possible. The all-automatic features which control these conditions have been largely responsible for the high degree of efficiency and smooth operation of the plant. In addition to these automatic controls, a manual control for each individual unit is located in the control-room at one end of the bank of dehydrators. This room has two banks of control panels, one on either side of the room, with each of the panels corresponding in position to one of the units. Wiring is so arranged that any single unit or bank of units may be cut out of the system at any time. Likewise, either electrode of any one unit may be cut out, if desired, without affecting the operation of the remaining units.

Other parts of the plant, which has been working since January 1942, are described.
A. H. N.

665. Water Production Creates Corrosion Problems in Western Kansas. N. Williams. *Oil Gas J.*, 18.3.43, 43 (45), 41–43.—Increasing water production in Western Kansas fields is presenting additional difficulties for operators in combating corrosion. Special practices are being adopted for controlling the water and protecting equipment. In this article some of the conditions as they pertain to these practices are discussed. Constant pumping rather than intermittent pumping at higher rates has been found to reduce corrosion in the annulus. The reasons are explained. Sealing the annulus by packers has also been tried with qualified success.

The combating of corrosion inside the tubing has involved numerous complications, and no solution to the problem has yet been found. A number of operators have recently been experimenting with cement-lined tubing. In this, although the tubing is protected, wear on rods is great and more frequent breaks result. Rods can be worn completely in a surprisingly short time by the cement. Rod-guides of various materials and types have been installed on rod-strings to protect the rods, but these can be little larger in diameter than the rod couplings, and also soon wear too small to do any good. Also, some types jam up in the hole and cause trouble in pulling rods. Major benefits have been derived in the past by use of rods and couplings of high nickel content and having other corrosion-resistant alloys and qualities, but such rods are now almost unobtainable. As operators resort to rods made of less adaptable materials, corrosion becomes a more serious matter.

Some good is resulting from use of tapered rod-strings. The combinations usually run consist either of $\frac{7}{8}$-inch and $\frac{3}{4}$-inch, or 1-inch and $\frac{7}{8}$-inch strings. The larger size in each case is run on the bottom, where exposure to water is greater. It stands more corrosion or wear before breaking and requiring replacement. On the surface, operators are going almost 100% to asbestos-cement pipe for lead lines and all other lines in which water is handled. In the former use of steel pipe leaks became frequent, and most lines had to be completely replaced in from 1 to 2 years. No high pressures are involved, so the asbestos-cement type of pipe is strong enough. In some cases operators have devised couplings, bends, " T "s, and other fittings made of concrete, using about 50% cement and 50% fine sand.

Chemical treatment of the water in the wells as it is produced to neutralize the corrosive action has proved effective in many instances. The chemical mixture and method of treatment in these cases were developed by Cities Service Oil Co. which is not only treating a number of its own wells, but also some of other companies. The chemical mixture contains a concentrated caustic soda with colloidal material (tannic acid). Caustic soda is the neutralizing agent, but if injected without the colloidal agent to retain the water solids in suspension, it might cause the solids to precipitate and accumulate around the pump intake and clog the well. A. H. N.

666. Factors Affecting Expansion of Kansas Water-Flooding. P. Reed. *Oil Gas J.*, 18.3.43, 41 (45), 62.—The present trend in South-eastern Kansas is for water-flooding

to supplant gas injection because of its greater effectiveness. In explaining the relatively low efficiency of gas injection, Muskat observes that laboratory evidence leads to the conclusion that the total increased depletion of oil as a result of gas injection is at best only slightly greater than that which results from the natural primary recovery operations if the latter were continued to the physical limits of pressure depletion. Hence the major economic contribution of the gas injection operation is derived from the fact that it makes available at commercially profitable rates of production that oil which cannot be obtained during the primary recovery stage at sufficiently high rates to warrant continued operation. Even though other phenomena in the field may make it possible to obtain total ultimate recoveries exceeding those corresponding to the recovery curve, there seems little evidence that the gas-injection process in depleted formations can approach the efficiency of the water-flooding process.

Given the essential conditions for profitable flooding, such as a sufficient amount of residual oil in a sand, with desirable characteristics of uniformity and permeability, located where ample supplies of water are available, the operator must reach decisions regarding policies to be followed. More rapid recovery calls for higher development costs entailed in closer spacing of wells and heavier shooting. With this programme may go higher water-injection pressures and the practice of pumping rather than flowing producing wells. However, the comparative advantages of pumping and flowing continue to be debated. With a shorter period before the peak is reached, the larger oil production yields an income which returns the cost of investment more rapidly; consequently interest charges are reduced. Such advantages must be weighed against the desirable economies achieved by a slower policy.

In making an effort to see as far ahead as 10–15 years, it appears highly probable that the spreading of water-flood operations will sustain the present rate of production for over such a period. In this article conclusions of students of the technique have been cited to indicate the close relationship of price of crude oil to other factors involved in profitable water flooding. A substantial advance in price of crude oil would justify modification of water-flooding policies so as to exploit the new possibilities for profitable operation which will be presented by the changed economic situation. A. H. N.

667. Patents on Production. N. E. Gunderson. U.S.P. 2,309,697, 2.2.43. Appl. 26.12.40. Well cleaning, especially well screens, by means of pumping.

W. J. Crites. U.S.P. 2,309,827, 2.2.43. Appl. 2.1.42. Deep-well pump and having a rotatable inner tubing and a stationary outer tubing.

J. E. Hall. U.S.P. 2,309,897, 2.2.43. Appl. 5.8.39. Pump for oil-wells using pressures transmitted from the surface to actuate the pump.

G. A. Rayner. U.S.P. 2,309,922, 2.2.43. Appl. 19.5.41. Well-swab.

E. E. Claytor. U.S.P. 2,309,935, 2.2.43. Appl. 19.6.41. Process for breaking petroleum emulsions using the salts of basic amines.

J. D. Andree. U.S.P. 2,311,504, 16.2.43. Appl. 14.5.40. Pump-jack having a walking beam and pull-rod.

L. Yost. U.S.P. 2,311,805, 23.2.43. Appl. 24.3.41. Closure for submersible pumping unit.

J. R. Collins. U.S.P. 2,311,816, 23.2.43. Appl. 27.6.41. Valve-spacer for pump-rods in well-pumping apparatus.

H. J. Pankratz. U.S.P. 2,311,863, 23.2.43. Appl. 6.12.41. Oil-well pumps using an outer tubing for transmitting gas under pressure into the well-bore.

R. M. Rhoads. U.S.P. 2,311,868, 23.2.43. Appl. 1.10.40. Apparatus for controlling the flow of fluids which increase in volume on pressure drop.

R. M. Rhoads. U.S.P. 2,311,869, 23.2.43. Appl. 1.10.40. Apparatus for controlling well production of expanding fluids.

E. J. Weatherby. U.S.P. 2,311,893, 23.2.43. Appl. 17.3.41. Well-pumping apparatus with a rotary prime mover disposed in the well.

F. G. Beckman. U.S.P. 2,312,018, 23.2.43. Appl. 19.8.39. Method of and means for cleaning wells by drilling and then applying high-pressure jets to remove loosened earth.

T. W. Adair. U.S.P. 2,312,228, 23.2.43. Appl. 5.12.38. Pump for wells consisting of a cylinder having a plurality of piston chambers.

A. Boynton. U.S.P. 2,312,315, 2.3.43. Appl. 8.12.39. Differential stage lift-flow device using side valves.

L. E. Hughes. U.S.P. 2,312,337, 2.3.43. Appl. 29.1.40. Hydraulic well-pump using liquid-operated motor and double-acting pump.

A. A. Jens. U.S.P. 2,312,415, 2.3.43. Appl. 12.10.40. Method of welding the ends of supporting rods to end fittings of well-screens.

L. M. Trawick. U.S.P. 2,312,455, 2.3.43. Appl. 3.9.40. Intermitting system for flowing wells.

H. O. Williams and A. A. Jens. U.S.P. 2,312,458, 2.3.43. Appl. 1.8.38. Method of making deep well screens.

H. O. Williams and A. A. Jens. U.S.P. 2,312,459, 2.3.43. Appl. 1.8.38. Method of making deep well screens.

A. J. Penick and K. T. Penick. U.S.P. 2,312,476, 2.3.43. Appl. 26.5.39. Well-head.

E. J. Roach and E. E. Cooke, Jr. U.S.P. 2,312,487, 2.3.43. Appl. 18.11.41. Well control-head for oil production.

R. A. Salathiel. U.S.P. 2,312,731, 2.3.43. Appl. 19.10.38. Process and agent for breaking petroleum emulsions.

R. A. Salathiel. U.S.P. 2,312,732, 2.3.43. Appl. 19.10.38. Process and agent for breaking petroleum emulsions.

R. A. Salathiel. U.S.P. 2,312,733, 2.3.43. Appl. 19.10.38. Process and agent for breaking petroleum emulsion.

R. A. Salathiel. U.S.P. 2,312,734, 2.3.43. Appl. 19.10.38. Process and agent for breaking petroleum emulsions.

R. A. Salathiel. U.S.P. 2,312,735, 2.3.43. Appl. 19.10.38. Process and agent for breaking petroleum emulsions.

G. A. Hatfield. U.S.P. 2,313,066, 9.3.43. Appl. 8.1.40. Gas-lift device for wells.

A. J. Penick and K. T. Penick. U.S.P. 2,313,169, 9.3.43. Appl. 9.5.40. Well-head assembly.

P. P. Shelby. U.S.P. 2,313,176, 9.3.43. Appl. 19.7.40. Well-tester.

F. J. Spang. U.S.P. 2,313,178, 9.3.43. Appl. 27.7.40. Plug for oil and gas wells.

L. Spencer. U.S.P. 2,313,369, 9.3.43. Appl. 28.2.40. Formation tester and gun perforator.

G. F. Turechek. U.S.P. 2,313,402, 9.3.43. Appl. 28.8.39. Bullet retainer means for gun perforators.

R. L. Midgett. U.S.P. 2,313,762, 16.3.43. Appl. 6.12.39. Automatic well test seal.

R. P. Miller. U.S.P. 2,313,836, 16.3.43. Appl. 15.7.39. Pump for deep well production.

J. B. Stone. U.S.P. 2,314,022, 16.3.43. Appl. 31.7.40. Treatment of wells with a demulsifier to prevent and break oil-and-acid emulsions.

A. T. Watson. U.S.P. 2,314,113, 16.3.43. Appl. 3.12.40. Gas lift oil-well pump intermitter.

W. L. Kitsman. U.S.P. 2,314,583, 23.3.43. Appl. 19.5.41. Well-pumping apparatus using a pair of reciprocating pumps.

A. Boynton. U.S.P. 2,315,496, 6.4.43. Appl. 28.11.38. Perforator for wells by means of abrasives.

L. A. Douglas. U.S.P. 2,315,694, 6.4.43. Appl. 10.6.41. Means for testing subterranean strata for liquid and gaseous content.

W. J. Crites. U.S.P. 2,315,841, 6.4.43. Appl. 12.5.41. Well-pump having rotatable inner tubing.

A. Arutunof. U.S.P. 2,315,917, 6.4.43. Appl. 30.9.37. Submersible electric motor for deep well-pumps.

R. C. Baker. U.S.P. 2,315,921, 6.4.43. Appl. 18.3.40. Well-packer apparatus with a coupling means which can be disengaged. A. H. N.

Cracking.

668. Catalytic Cracking. P. H. Faust. *Refiner*, February 1943, **22** (2), 45–48.—A brief discussion on catalysts leads to the conclusions that (1) a catalyst functions only as an accelerator of an already possible reaction ; (2) the catalyst may exert its accelerating action among a group of reactions selectively ; (3) in any individual reaction, the catalyst only hastens the attainment of equilibrium—it cannot shift the equilibrium. A simple theory of chemical reaction with catalysts is described and operating variables are discussed.

Thermal and catalytic cracking are compared by comparing their products. Catalytic results in a gasoline of superior octane rating to that of thermally cracked gasoline. While the production of highly branched compounds is perhaps the most notable achievement of catalytic cracking, there are other factors, such as sulphur reduction, aromatization, and desirable positions of chain splitting, that combine to add superiority to the yield of the catalytic unit. Catalytically cracked gasoline, by virtue of its low sulphur and gum contents, is the only cracked product that may be burned in aviation engines. In the gases, high ratios of *iso*butane to normal butane, and of the entire butane–butylene (" B–B ") cut to total gas, are features of special importance now, since they combine to make catalytic cracking an ideal source of charge-stock for both alkylation and butadiene plants.

Considering the economics of the catalytic *versus* thermal problem, the advantages of catalytic cracking must be weighed against its higher cost, both of construction and of operation, for the savings in construction of a low-temperature and pressure unit do not counterbalance the extra expense involved in equipment for handling the catalyst. A. H. N.

669. Patents on Cracking. C. L. Thomas. U.S.P. 2,308,792, 19.1.43. Appl. 16.1.41. To produce high anti-knock gasoline a hydrocarbon oil is subjected under cracking conditions to contact with an undried, finely powdered synthetic catalyst prepared by precipitating a finely powdered, hydrated silica from an alkaline silicate solution and mixing with it a hydrous oxide precipitated from a solution of a metal salt.

J. D. Seguy. U.S.P. 2,310,123, 2.2.43. Appl. 17.11.41. In a hydrocarbon conversion process cracked vapours are fractionated, also charging oil, to separate light gases, heavy, readily liquefiable gases, and gasoline, and to condense and separate light reflux condensate and heavy reflux condensate. Light and heavy reflux condensates are cracked, and resultant conversion products are passed to a reaction and separating zone in which cracked vapours are separated from liquid residuum. Part of the residuum is combined with the heavy liquefiable gases, and the mixture is fed to a reduced pressure vaporizing and separating zone. In this zone vapours are separated from non-vaporous residue. The vapours are cracked, and conversion products are fractionated to separate olefin-containing gases and gasoline. Heavy and light reflux condensates are combined with the corresponding fraction separated in the first fractionating operation. Olefin-containing gases are polymerized to form gasoline boiling polymers. Polymers heavier than gasoline are separated from the polymerization products and passed to the reduced pressure vaporizing and separating operation.

J. K. Roberts and M. T. Carpenter. U.S.P. 2,310,183, 2.2.43. Appl. 16.7.38. Method of cracking hydrocarbon oils.

C. W. Tyson and E. V. Murphie. U.S.P. 2,311,318, 16.2.43. Appl. 15.10.38. In a method of catalytic cracking of hydrocarbon oil to produce lower-boiling hydrocarbons the oil is first heated to vaporizing and reaction temperature. The resultant vapours are introduced into a reaction vessel provided with a number of horizontally extending catalyst beds arranged one above the other in spaced relation. Vapours are passed through certain catalyst beds in series.

Standard Oil Development Co. E.P. 552,731, 22.4.43. Appl. 12.9.40. Hydrocarbon oils boiling substantially within the gas-oil range are catalytically cracked in the presence of hydrogen in the following manner. The reaction is carried out in the presence of a solid catalyst at a temperature between 700° and 1000° F., under a pressure between atmospheric and 400 lb./sq. in., and in the presence of a gas containing between 20 and 90 mol. % of free hydrogen. The reaction is carried to a point shortly before that at which a consumption of free hydrogen begins, and is then discontinued. The catalyst is then regenerated for use in a subsequent cycle of operations.

Standard Oil Development Co. E.P. 552,880, 29.4.43. Appl. 21.5.41. The patent relates to the cracking of hydrocarbon oils to form lower-boiling motor-fuel products, and has particular reference to the cracking of hydrocarbon oil in the presence of a finely divided catalyst suspended in the oil which is to be cracked.

J. W. Teter. U.S.P. 2,312,681, 2.3.43. Appl. 19.2.41. In the production of gasoline, a charge of hydrocarbons is maintained substantially in vapour phase in a cycle of movement in a closed stream. Hydrocarbons to be processed and a conversion catalyst are introduced into the stream, and the catalyst is maintained in suspension by the velocity of movement in the cycle. After maintaining the circulating stream at a temperature between 950° and 1050° F. under a pressure of about 100 lb. per square inch for a minimum period of 15 seconds, a part of the suspended catalyst is selectively separated from the stream and removed from the cycle. Part of the stream of hydrocarbons and suspended catalyst is discharged from the cycle and spent catalyst, and a gasoline fraction is recovered from the discharged part.

A. C. Jessup. U.S.P. 2,313,241, 9.3.43. Appl. 16.11.39. In the cracking of an oil material, the oil is subjected to the action of hydrogen gas introduced as such, under a pressure of several atmospheres, while in the presence of freshly reduced iron in a copper apparatus. The process is continued until the sulphur content of the oil is substantially lowered, and until a substantial amount of low-boiling hydrocarbons has been produced.

J. F. Sturgeon. U.S.P. 2,315,024, 30.3.43. Appl. 8.9.39. In a process for cracking a hydrocarbon oil heavier than gasoline to produce a substantial yield of gasoline, the oil is subjected at a temperature between 850° and 1200° F. to contact with a catalytic material. This material is prepared by compositing a major proportion of precipitated silica hydrogel with a relatively smaller portion of another precipitated hydrogel selected from those of alumina, zirconia, and a mixture of alumina and zirconia, to form a hydrogel composite. The hydrogel composite is frozen and thawed to convert it into a powder and an aqueous solution. The powder is recovered, washed to remove water-soluble impurities, dried and calcined.

G. Egloff. U.S.P. 2,315,192, 30.3.43. Appl. 17.5.40. In a conversion process a hydrocarbon oil is subjected to catalytic cracking in admixture with a slurried catalyst in a primary zone. The conversion mixture is introduced into a vaporizing zone wherein vapours and gases are separated from residue. Vapours and gases are subjected to fractional condensation to form a relatively heavy reflux condensate, a lighter reflux condensate, gasoline distillate, and a normally gaseous product. The gasoline distillate is recovered. Normally gaseous products are combined with at least a portion of the lighter reflux condensate, and the mixture is catalytically cracked with a slurried catalyst in a second cracking zone. Resultant products are passed to the vaporizing zone. At least part of the heavy reflux condensate is cracked with a slurried catalyst in a third cracking zone, and the resultant products are passed to the vaporizing zone.

H. B. M.

Hydrogenation.

670. Patents on Hydrogenation. Charles Weizmann. E.P. 552,115, 24.3.43. Appl. 12.7.40. Aromatic hydrocarbons having eight carbon atoms are prepared by passing butylene (C_4H_8) over a metallic hydrogenation and dehydrogenation catalyst at a temperature between 500° and 800° C., preferably at atmospheric pressure.

G. C. Connolly. U.S.P. 2,310,278, 9.2.43. Appl. 20.5.38. In a process for the destructive hydrogenation of hydrocarbon oils a mixture of the oil and hydrogen containing gas is passed through a hydrogenating zone, and while still in the zone it is contacted with a catalyst. The catalyst is a carrier composed of silica and alumina formed by impregnating silica hydrogel with a compound of aluminium convertible to the oxide, and thereafter converting the aluminium compound to the oxide. The carrier thus formed is impregnated with an active hydrogenating catalyst.

B. B. Corson and M. W. Cox. U.S.P. 2,311,979, 23.2.43. Appl. 15.3.40. Hydrocarbons are dehydrogenated by subjecting them at a temperature in the approximate range of 450–750° C. to the action of an alumina-chromia catalyst containing a sufficient quantity of an alkaline-earth metal oxide substantially to reduce the carbon-forming tendency of the catalyst at that temperature.

J. C. Morrell and A. V. Grosse. U.S.P. 2,313,162, 9.3.43. Appl. 25.3.39. Aliphatic hydrocarbons are dehydrogenated by contacting them under suitable conditions with an oxide of an element from the left-hand column of Group 5 of the Periodic Table, supported on an activated alumina consisting of a calcined aluminium hydrate of high adsorptive capacity. H. B. M.

Polymerization and Alkylation.

671. Patents on Polymerization and Alkylation. Standard Oil Development Co. E.P. 552,196, 26.3.43. Appl. 24.9.41. Improvements in the process for production of normally liquid, branched-chain, paraffinic hydrocarbons by reacting at least one *iso*paraffin with at least one mono-olefin in the presence of concentrated sulphuric acid under alkylating reaction conditions are as follows. At least two alkylating zones are maintained in series; substantially different concentrations of sulphuric acid are maintained in each zone; into one of the zones is introduced at least one mono-olefin having a different degree of alkylation activity from the olefins introduced into other alkylation zones; olefin activity and acid concentration are so correlated that the olefin having the greatest degree of alkylating activity is in contact with the acid of lowest alkylating concentration; partly spent sulphuric acid from one zone is used in another zone utilizing acid of lower alkylating concentration.

Shell Development Co. E.P. 552,381, 5.4.43. Appl. 26.5.42. In a process for the production of motor fuel by alkylating an *iso*paraffin with a normally liquid olefin, a hydrocarbon mixture containing the olefin and the corresponding *iso*paraffin and normal paraffin is distilled to separate a fraction containing the *iso*paraffin and the olefin, but substantially free from the normal paraffin. The *iso*paraffin to be alkylated is reacted with the olefin in the separated fraction in the presence of an alkylation catalyst and a substantially *iso*paraffinic hydrocarbon product is recovered.

Phillips Petroleum Co. E.P. 552,413, 7.4.43. Appl. 29.3.40. In a catalytic process for the conversion of olefinic hydrocarbons having not more than five carbon atoms in the molecule into volatile olefin polymers with the minimum formation of high-boiling polymers, the olefinic hydrocarbon is passed through a contact zone containing a stationary solid polymerization catalyst. Pressure in this zone is sufficient to maintain the olefinic hydrocarbons in the liquid state, and temperature is such that volatile olefin polymers are formed, but not above the critical temperature of the olefinic hydrocarbons. In admixture with entering olefinic hydrocarbons, an untreated portion of olefin polymers formed in the contact zone is returned to this zone. The remaining portion is passed to a separating zone, where volatile olefin polymers are separated from it.

D. R. Carmody and E. L. D'Ouville. U.S.P. 2,308,560, 19.1.43. Appl. 30.12.39. An *iso*paraffinic hydrocarbon is converted into hydrocarbons of higher molecular

weight by alkylating the original material with at least one normally gaseous olefinic hydrocarbon in the presence of a catalyst consisting of a complex formed by the reaction of a hydrocarbon with an aluminium halide. The complex has a heat of hydrolysis between 60 and 75 large calories per gram atom of active aluminium.

R. F. Marschner and D. R. Carmody. U.S.P. 2,308,561, 19.1.43. Appl. 18.6.41. *Iso*paraffinic hydrocarbons are alkylated with olefinic hydrocarbons by contacting them with the olefinic hydrocarbons in the presence of a catalyst containing an aluminium–halide–paraffinic hydrocarbon complex having 23–32% by weight of bound hydrocarbons, and a hydrogen halide activator.

R. F. Marschner. U.S.P. 2,308,562, 19.1.43. Appl. 31.3.42. An aviation gasoline of high octane number and balanced volatility characteristics is obtained by contacting a low-boiling *iso*paraffinic hydrocarbon with a normally gaseous olefin in the presence of an aluminium halide–paraffinic hydrocarbon complex. By maintaining a mol ratio of normally gaseous olefin reacted to *iso*paraffin hydrocarbons present of at least 0·77 a mixture containing at least mono- and di-alkylates is obtained.

C. L. Thomas. U.S.P. 2,313,103, 9.3.43. Appl. 25.3.39. Hydrocarbons are synthesized by alkylating an *iso*paraffin with an olefin in the presence of fluorosulphonic acid. H. B. M.

Refining and Refinery Plant.

672. Refiners Shift into High in Quick Conversion Programme. H. D. Ralph. *Oil Gas J.*, 6.8.42, **41** (13), 12.—The present American refinery programme for production of war products is discussed from a non-technical viewpoint. 75% of the refining industry is reported to be contributing, and the latest developments include about 30 so-called nucleus plants and an increasing number of the smaller refineries. Whilst emphasis is laid upon butadiene and 100-octane gasoline, other essential products such as toluene, benzene, *iso*butylene, etc., are not being neglected. J. C.

673. Conversion of Refineries to War Producton Explained. H. S. Norman. *Oil Gas J.*, 6.8.42, **41** (13), 13.—A summary, made available by the report of the Petroleum Industry War Council's Committee on synthetic rubber, is given of the recommendations of the leaders of the American industry for the quick conversion of existing refineries for the production of maximum quantities of war materials. The main objective is the modification of existing facilities so as to produce sufficient codimer to satisfy all available hydrogenation equipment, the product to be used for 100 octane aviation gasoline. Methods of operation of U.O.P. and Kellogg–Polyco poly. plants for this purpose are dealt with briefly, and a short account is also given of methods for securing the elevated temperatures necessary for maximum yields of butadiene. The third important product is ethyl benzene for styrene to be combined with the butadiene for synthetic rubber. The recommendations also include provision for the use of ethyl alcohol derived from grain. J. C.

674. How to Break Piping Bottlenecks. G. W. Hauck. *Refiner*, February 1943. **22** (2), 33–38.—The development of steel and cast-iron flanges is discussed. The use of cast iron instead of steel makes available the lap joint for many services where this type of joint with its advantages is preferred. But an important cautionary note is necessary. Care must be exercised in bolting up any lap joint equipped with a cast-iron flange, in order to prevent breakage. Pipe fitters are accustomed to finding all lap joints with steel flanges, and they cannot apply extremely heavy bolt loads or sledge bolts when cast-iron flanges are employed. Several additional cautions are suggested : (1) cast-iron flanges should never be used on the ends of any type of expansion pipe bend. Such flanges, as well as those on the piping adjacent to the expansion pipe bends, should always be of steel, to preclude breakage. (2) Cast-iron flanges are not recommended for lines handling hazardous fluids, or where fire hazard legislates against their use. (3) Do not exceed code limitations concerning pressure and temperature in using cast-iron flanges.

Unions, valves, and several fittings are further discussed and suggestions made in order to conserve material and solve engineering problems with minimum experiment. A few simple substitutions are : a reducing screwed flange can often be made

by tapping a blind flange, either concentric or eccentric as desired. This is practical provided the tapped opening is not too large in pipe size to preclude a sufficient length of thread for a satisfactory pipe joint. A piece of plate, if available, can be fashioned into a slip-on welding flange, or a lap-joint flange if the thickness is increased, particularly in the latter, to compensate for the lack of hub. Similarly, a blind flange can be fabricated from steel plate. These are not recommended necessarily as good practice, but they are satisfactory in certain instances, especially in emergencies. Instead of a 4 × 3-in. screwed elbow required for an extension of a pipe-line during a shutdown, perhaps a 4 × 3 × 3-in. screwed tee with a 3-in. plug would answer the purpose. If this happened to be a flanged job, and the reducing fitting were not in stock, a straight fitting and a reducing flange might suffice. If it were a welded job and the reducing fitting unavailable, a straight fitting and a reducer might satisfy the need. Usually, the answer is in the affirmative. To-day the bushing comes into its own as never before. Many sizes of reducing screwed fittings have been eliminated, due to the simplification programme. At other times the desired reducing fitting may not be available. Use the nearest size of reducing fitting, or a straight fitting with bushings to break these bottlenecks.   A. H. N.

675. Compression Combined with Close Fractionation. Anon. *Refiner*, February 1943, **22** (2), 39–43.—A new plant is described in which a variety of natural gasolines and liquefied petroleum products is being finished under controlled fractionation. This plant draws raw materials from an old field, which is stated to be submerged with the completion of a flood-control and hydro-electric project along the Washita and Red Rivers. Oil and gas are produced in the conventional manner. The gas is gathered from the separators and traps, and flows to the gasoline plant through a single large transmission line with only enough pressure held back by the regulators to dump the oil from the separators into the lease flow-tanks. The pressure on the plant field scrubber inside the yard averages approximately 2 inches of vacuum, but varying up or down from that pressure, depending on how well the flowing schedule is adhered to by the producers. The plant was built from a combination of used and new equipment. The old equipment, including the compressor units and the single high-pressure absorber, was removed from an idle plant formerly operated in the South Oklahoma City field. The equipment made especially for the Cumberland field plant includes the distillation unit, the four fractionators which are operated in series, and the pumps, reflux tanks and the commodity receivers. The plant is designed to operate as a combination compression and absorption project, operating at 300 lb. in the final stage of compression. This pressure is maintained so that a substantial percentage of the gasoline fractions can be obtained by the compression method and so that the residue above field and plant-fuel requirements can be introduced into a transmission system.

The major items of the plant are described.   A. H. N.

676. Formula for Determining Length of Pipe in a Reverse Bend. Anon. *Refiner*, February 1943, **22** (2), 44.—A formula is derived for calculating the length of pipe in a reverse bend, and examples are worked out as illustrations of its use.   A. H. N.

677. Maintenance Kinks Prolong Motor Life. E. Sterrett. *Refiner*, February 1943, **22** (2), 49–54.—The paper is a long discussion on correct maintenance, inspection, and other practices which may result in prolonging the lives of electric motors.
     A. H. N.

678. The Stabilization of Crude Oil. F. L. Kallam. *Refiner*, February 1943, **22** (2), 55–63.—The development of stabilization of crude oil is reviewed year by year from 1926 onwards. Apparently the record does not justify the claim that the oil industry is alert on technical advance. The paper will be concluded in further instalments, and 48 references to the literature are appended.

By 1936 the natural gasoline industry had already realized the advantages of stabilizing its gasoline before shipment and the fact that such operation actually results in an increase in production. In the same way, it is predicted that both the producer of crude oil and the pipe-line company will realize the advantages of stabil-

ized crude oil as a means of reducing evaporating losses in storage and transportation. Just how fast the industry will take up stabilization of crude oil is difficult to determine. It has already invested millions of dollars in vapour-saving devices for large storage tanks, so that stabilization is not so greatly needed as would have been the case had these investments not been made. There is no doubt that stabilization would result in a lower production of pentanes and heavier fractions in the gasoline plant, as these constituents would be retained to a greater extent in the crude oil. Since gasoline plants recover most of their production from field separators operating under 5 lb. pressure or less, the effect of stabilization would not be very great so long as the wells were produced by the conventional methods.

Stabilization of crude oil would call for large investments in fractionating towers and would add to lease operating costs. It is therefore improbable that the fractionation of crude in the field is apt to take place soon except on leases producing large quantities of high-gravity volatile oil, or in those districts where the oil is likely to be subjected to long periods of storage under hot-weather conditions. Disadvantages of stage separation for natural-gasoline manufacture are that both high- and low-pressure gathering systems are necessary in order to process the gas products from the separators. Although the gas volumes for low-pressure separators are usually so small that it is not economical to process them in a low-pressure gas-gathering system, they cannot generally be disregarded, on account of their high gasoline content. The use of stage separation does tend to decrease the amount of natural gasoline produced/brl. of oil, since the approach towards differential liberation of gas tends to hold a higher percentage of the gasoline in the crude oil.   A. H. N.

679. Patents on Refining and Refinery Plant. W. F. Rollman and L. S. Bonnell. U.S.P. 2,309,540, 26.1.43. Appl. 17.2.40.—A reduced crude petroleum oil is coked by heating it to a temperature of about 900° F. and then feeding it in atomized form to a coking zone at a feed rate of 0·5 volume of cold oil per drum volume per hour. To the bottom of the coking zone is fed 20% by weight of steam at a temperature of 900° F. The vaporous product is withdrawn from the upper end of the coking zone and a spongy, dry coke from the lower end of the zone.

J. H. McCullough, E. R. Birkhimer and L. N. Leum. U.S.P. 2,309,651, 2.2.43. Appl. 13.2.41. Acidic organic compounds are removed from hydrocarbon oil by introducing an aliphatic alcohol containing less than 4 carbon atoms per molecule into a stream of the hydrocarbons. The oil stream is countercurrently contacted with a stream of an aqueous solution of an alkaline reagent in which the alcohol is more soluble than in the hydrocarbon oil. In this way the alkaline reagent will admix with the alcohol in the oil-stream and the mixture will act upon the oil-stream to remove acidic organic compounds.

W. A. Schulze and G. H. Short. U.S.P. 2,309,871, 2.2.43. Appl. 31.8.40. Carbonyl sulphide is removed from liquefied petroleum gases by passing the fluids after removal of hydrogen sulphide over a reagent consisting of a solid absorbent material impregnated with a primary amine.

W. T. Hancock. U.S.P. 2,310,630, 9.2.43. Appl. 13.1.41. In a process for refining petroleum oils, heated gasoline-containing cracked hydrocarbons are subjected to polymerization and polymerized hydrocarbons are continuously fractionated to produce a vaporous fraction containing hydrocarbons of the gasoline range and a liquid fraction having a boiling range higher than gasoline. The liquid fraction is then mixed with solvent petroleum oil having a higher boiling range, and afterwards vaporized and separated from the solvent oil to leave residual oil containing impurities removed from the hydrocarbons of the liquid fraction. A stream of the residual oil is re-circulated and admixed with the liquid fraction being produced by fractionation of polymerized hydrocarbons.

J. H. Carpenter, R. B. Kennedy and H. J. McClanahan. U.S.P. 2,310,837, 9.2.43. Appl. 18.9.41. In the fractional distillation of petroleum oil in the presence of steam and ammonia in a distillation zone to obtain overhead and bottoms the overhead is condensed in a condensing zone, fixed gas is separated in a separating zone, and a portion of the condensate is returned to the distillation zone as reflux for the distilling operation. An improvement comprises passing condensate from the condensing

zone to an enlarged settling zone where the condensate is held in a relatively quiescent state. Aqueous matter settled from the condensate is removed prior to passing it to the separating zone.

J. M. Barron. U.S.P. 2,310,922, 16.2.43. Appl. 18.2.41. In a hydrocarbon oil-conversion process crude petroleum is separately distilled to separate residual constituents from lighter components. Straight-run lighter components are cracked, and residual constituents from the crude petroleum are combined with hot cracked products. Afterwards the admixed products are converted to coke in a coking zone. Vapours from the coking zone are subjected to a primary dephlegmation to form a tarry condensate adapted for fuel oil. Dephlegmated vapours are fractionated to separate a reflux condensate from lighter products, and the condensate is afterwards subjected to thermal cracking. Resultant products are separated into vapours and residue, and the former are combined with vapours from the coking operation for subsequent fractionation.

P. V. Brower and L. Love. U.S.P. 2,311,328, 16.2.43. Appl. 6.11.41. In a sweetening process in which sour hydrocarbon distillate is treated with an aqueous alkaline plumbite solution and sulphur, an alkyl phenol concentration of 8–15 gr./litre is maintained in the plumbite solution.

J. T. Ward. U.S.P. 2,311,421, 16.2.43. Appl. 21.4.38. An apparatus is described suitable for heating hydrocarbon fluids to conversion temperature, and including a heating chamber, means for supplying heat thereto, and a row of spaced horizontally extending heater tubes arranged along a boundary surface of the heating chamber. Some of these heater tubes are spaced at greater distances from each other and from the boundary surface than the rest of the heater tubes in the row.

V. A. Kalichevsky, E. T. Scafe, and K. F. Hayden. U.S.P. 2,311,593, 16.2.43. Appl. 6.12.40. Sulphur constituents, such as elemental sulphur, hydrogen sulphide, and mercaptans, are removed from hydrocarbon oil fractions by contacting the oil with solid anhydrous alkali particles of colloidal sizes.

F. H. Bottomley. U.S.P. 2,312,020, 23.2.43. Appl. 18.12.40. In the refining of gasoline it is first treated by contacting it with an adsorbent clay at a relatively low temperature, to effect polymerization of unstable gum-forming constituents. Resulting polymers are separated from the gasoline, which is afterwards heat-treated to a temperature between 650° and 750° F. Finally the gasoline is contacted with adsorbent clay to effect desulphurization.

E. W. McNealy. U.S.P. 2,312,112, 23.2.43. Appl. 2.11.40. In a process in which a flowing stream of cracked petroleum oil is continuously contacted with an acid-treating agent, the addition of the treating agent is controlled in the following way. The differential temperature of the stream of oil is determined between two points in the stream, at least one of the points being beyond the point of contact of the stream with the acid treating agent and sufficiently beyond the other point to enable the measurement of a temperature rise in the stream resulting from the heat of reaction of the acid treating agent and the oil. Addition of the acid treating agent can thus be controlled in accordance with vibrations in this differential temperature.

K. Korpi. U.S.P. 2,312,560, 2.3.43. Appl. 2.3.40. In a conversion process hydrocarbons are heated to a temperature between 600° and 1000° F. for a sufficient length of time to effect the reaction, and in the presence of a catalyst prepared by adsorbing phosphoric acid on a carrier and afterwards neutralizing the acid with approximately one-sixth to two-thirds equivalents of a caustic alkali per mol. of the acid.

L. M. Henderson and G. W. Ayers. U.S.P. 2,312,820, 2.3.43. Appl. 14.3.41. During the removal of weakly acidic organic sulphur compounds from otherwise substantially neutral hydrocarbon fluids, the fluids are contacted with an aqueous alkaline solution containing a hydrolyzable salt of an unsubstituted organic acid having at least one carboxyl group attached to aliphatic carbon, but having one or more alkyl hydrogens replaced by halogen.

F. E. Frey. U.S.P. 2,314,040, 16.3.43. Appl. 6.10.32. In a process for the conversion of normally gaseous hydrocarbons into normally liquid hydrocarbons, the gaseous mixture containing butane, butene, propane, propylene, ethane, ethylene,

methane, and hydrogen is scrubbed with a liquid menstruum composed principally of hydrocarbons of three and four carbon atoms per molecule. In this way butanes, butenes, propane, propylene, ethane, and ethylene are separated from undissolved methane and hydrogen. Afterwards these are converted at elevated temperature to produce liquid oils.

F. E. Frey. U.S.P. 2,314,335, 23.3.43. Appl. 28.3.39. In a process for producing derivatives of paraffin hydrocarbons, a paraffin of the type CH_3Cl_3 is treated with an elementary halogen. In this way a substitution of halogen for hydrogen takes place forming isomeric alkyl halides. The halides so formed are treated at a temperature between 175° and 700° C. for a period of time such that olefins and hydrogen halide are formed and alkyl halides of the type CH_2XCR_3 are relatively unaffected. Olefins and hydrogen halide are separated from the products of this treatment.

R. P. Ferguson. U.S.P. 2,314,446, 23.3.43. Appl. 1.4.41. In the refining of petroleum oil the oil is treated with a mineral acid to remove objectionable compounds. The acid-treated oil is then heated in the presence of a colour adsorbent to a temperature between 350° and 650° F. The oil–clay mixture is maintained at this temperature for between 5 and 30 minutes, and an alkaline reagent is then added. Finally, the mixture is cooled and the colour adsorbent and alkaline reagent are separated from it.

A. B. Doran. U.S.P. 2,314,576, 23.3.43. Appl. 15.10.40. During desulphurization, a sulphur-containing oil is contacted with an adsorptive agent containing a compound of an acidic oxide of manganese in which the valence of the manganese is not more than four with a metal the sulphide of which is highly insoluble in the oil.

S. Pilat. U.S.P. 2,315,131, 30.3.43. Appl. 30.9.34. In a process for separating a hydrocarbon oil into fractions having different properties, the oil is subjected to the precipitating action of a quantity of gaseous hydrocarbon treating agent consisting substantially of at least one of the hydrocarbons having less than three carbon atoms per molecule. The precipitating action is exerted under a superatmospheric pressure below the condensation pressure of the gaseous treating agent. The quantity used is sufficient to cause the formation of two liquid oil-containing phases of different specific gravities.

K. M. Watson. U.S.P. 2,315,144, 30.3.43. Appl. 11.5.39. Hydrocarbon oil of relatively high sulphur content is improved by contacting it with a dehydrogenation catalyst under dehydrogenation conditions to form olefins and aromatics therein with the simultaneous production of hydrogen. Sulphur-containing dehydrogenated hydrocarbons are subjected to hydrogenation with hydrogen formed in the dehydrogenation process. In this way sulphur is converted into hydrogen sulphide and substantial saturation of olefins is effected.

W. A. Schulze. U.S.P. 2,315,662, 6.4.43. Appl. 7.6.41. Carbonyl sulphide is removed from hydrocarbon fluids essentially free of hydrogen sulphide and mercaptans by contacting the fluid with a solid reagent consisting of an adsorbent carrier impregnated with an aqueous solution of a soluble cadmium salt. The impregnating solution has a p_H between 8 and 14.

W. A. Schulze. U.S.P. 2,315,663, 6.4.43. Appl. 7.6.41. Carbonyl sulphide is removed from hydrocarbon fluids essentially free of hydrogen sulphide and mercaptans by contacting the fluid with a solid reagent comprising an adsorbent carrier impregnated with an aqueous solution of a soluble cupric salt. The impregnating solution has a p_H between 8 and 14.   H. B. M.

Chemistry and Physics of Hydrocarbons.

680. Phase Behaviour of the Acetylene–Ethylene System. S. W. Churchill, W. G. Collamore, D. L. Katz. *Oil Gas J.*, 6.8.42, **41** (13), 33.—High-temperature cracking leads to hydrocarbon gases often rich in ethylene and containing appreciable quantities of acetylene. These gases, because of their high reactivity, are favoured as base stocks for many hydrocarbon products, and their behaviour is therefore of importance. The phase behaviour of mixtures of these gases has therefore been examined, and the data are presented in tabular and graphical form. With paraffin mixtures the critical

temperatures and pressures lie between or above those of the constituents. However, for acetylene/ethylene mixtures, curves of composition against critical loci, and isobaric diagrams of temperature plotted against composition for equilibrium vapour and liquid phases definitely establish the existence of azeotropic mixtures. Ethane/ethylene mixtures do not form such azeotropes, but ethane and acetylene do, suggesting that the acetylene is the primary cause of the formation of the constant-boiling mixtures.

<div align="right">J. C.</div>

681.* Properties of Normal Paraffins. Part 1. L. Ivanovszky, A. V. Brancker. *Petroleum*, October 1942, 5 (10), 168.—Melting point is selected as the most accurately determinable and the most important property commercially of paraffin waxes, and is made the basis of a study of the relationship between melting point and molecular weight in the normal paraffin series. Specific gravity, refractive index, and aniline point are considered less suitable for such a purpose. In general, melting points of waxes follow the simple mixture rule, but only approximately when the molecular weights differ widely. The presence of *iso*paraffins accounts for some divergence from additivity which is dependent on all the hydrocarbons of the waxes belonging to a single homologous series.

The accuracy of the available melting-point and molecular-weight data for paraffins is considered critically, and the conclusion reached that much of the data does not correlate, whilst some is obviously wrong. Within the range of 19–29 carbon atoms 1 C atom corresponds approximately to $\pm$ 6° F. in melting point, $\pm$ 0·0013 in n_D at 90° C and $\pm$ 0·0025 in specific gravity at 90° C.

When melting point is plotted against molecular weight for *n*-paraffins, two smooth curves are obtained for odd and even numbers of carbon atoms which converge at about C_{22}, and the various formulæ which have been proposed to express this relationship are tabulated and examined. Among the formulæ studied are those of Merckel, of Moullins, of Etessam–Sawyer, of Ivanovszky–Brancker, and an earlier formula of Ivanovszky. It is shown that the formulæ of Ivanovszky–Brancker (derived from the simple assumption that the melting point/molecular weight curve is a hyperbola) and of Etessam–Sawyer lead to the identical result that T plotted against M is a straight line, if the formulæ are valid.

A comprehensive table is given of experimental values for melting points of *n*-paraffins and of the values deduced from the molecular weights using the various formulæ, but the applicability of the formulæ is considered and judged in a succeeding article.

<div align="right">J. C.</div>

682.* Properties of Normal Paraffins. Part 2. L. Ivanovszky, A. V. Brancker. *Petroleum*, November 1942, 5 (11), 188.—The applicability of the various formulæ relating to melting point and molecular weight for the normal paraffins, in particular those of Ivanovszky and of Ivanovszky–Brancker, is tested against the available experimental data and the reliability of the latter critically examined. It is considered that with increasing molecular weights melting points trend towards a limit of 404–415° K., and paraffin hydrocarbons of about 23,000 molecular weight, produced by the Fischer–Tropsch synthesis, are stated to have melting points within this range. The phenomenon of alternation in properties of odd and even members of the paraffin series is discussed from the point of view of melting point. (The Ivanovszky formula gives two straight lines.) Heat of crystallization and entropy of crystallization each give two straight lines against number of C atoms, and odd and even members of the paraffin series apparently differ in crystalline character, but for the higher members the evidence appears questionable.

A short discussion of the constitution of wax-like hydrocarbons shows that there is a fair amount of evidence for the presence of *iso*paraffins in waxes. It is concluded that the present formulæ indicate either this possibility or the phenomenon of alternation in the paraffin series. Whilst the present formulæ reproduce experimental results fairly well, modifications in the values of the constants will be required as more accurate experimental data become available.

<div align="right">J. C.</div>

683. A Simple Apparatus for Small Scale Catalytic Hydrogenation. C. R. Noller and M. R. Barusch. *Refiner*, February 1943, 22 (2), 64.—This is a reprint from a paper published in *Industrial Engineering Chemistry*, Industrial Edition, November 1942.

<div align="right">A. H. N.</div>

684. Patent on Chemistry and Physics of Hydrocarbons. E. E. Claytor. U.S.P. 2,309,935, 2.2.43. Appl. 19.6.41.—Petroleum emulsions of the water-in-oil type are resolved by means of an emulsifier consisting of the salt of a basic amine. The amine salt is obtained from an alkylated naphthalene sulphonic acid in which at least one alkyl group substituted in the naphthalene nucleus contains between 3 and 10 carbon atoms, and a heat-polymerized basic hydroxyamine. H. B. M.

Analysis and Testing.

685. Determining the Specific Gravity of Gas by the Effusion Method. G. M. Stearns. *Oil Gas J.*, 17.12.42, **41** (32), 51.—The method is based on the law of effusion of gases which states that under like conditions of pressure and temperature two gases will flow through a small orifice at rates that are inversely proportional to the square roots of their respective specific gravities. The apparatus described is simple, convenient to handle, and portable, and allows a volume of air and an equal volume of gas to be driven, in turns, through a small opening, by means of identical water pressure. J. C.

686. Balance Method of Determining Specific Gravity of Natural Gas. G. M. Stearns. *Oil Gas J.*, 24.12.42, **41** (33), 47.—The balance method described, although less convenient than the effusion method, gives more accurate results. It is dependent on a combination of Boyle's law and Archimedes' principle. The apparatus consists essentially of a bulb attached to a beam and counterbalanced with an adjustable weight, the beam being suspended on a frictionless support and fitted with a pointer. The whole is contained within an air-tight case fitted with a window and a manometer. Sufficient gas is introduced into the case so that its buoyant effect on the bulb causes the bulb just to balance the weight, and the gas pressure is measured. Exactly the same procedure is carried out with air, and the specific gravity is obtained from the formula S.G. $= \dfrac{Pa}{Pg}$, where Pa is the absolute pressure at which the beam balances in air and Pg the absolute pressure at which it balances in the gas. The method is considered capable of accuracy to three decimal places. J. C.

687.* Equipment for Viscosity Measurement. L. A. Steiner. *Petroleum*, April 1943, **6** (4), 50–53.—The accuracy and precision of capillary viscometers are discussed on the basis of experimental results obtained with a number of calibrations and checking of such instruments. Both types of errors, systematic and irregular errors, are detected and discussed. Certain viscometers had a precision of 0·02%, others were very much poorer. The fact that a tube complies with specified dimension and has no visible defects is no guarantee of its proper working. Selected viscometers calibrated in their whole range are, however, well capable of producing figures within the accuracy requirements of the " standard methods " of the Institute of Petroleum or of the American Society for Testing Materials.

Five types of viscometers are discussed, and at the end of the paper they are compared. The suspended level viscometer is free from any necessity of adjustment of volume, and if the level chamber has a proper form, efflux times can be repeated with excellent accuracy without any particular skill. The wall of the top bulb retains, however, a different amount of oil according to whether the efflux time is short or long. Because of its three limbs, the probability of breakage is larger, and the percentage of breakages comparatively high unless cemented into fittings. Errors due to misalignment are comparatively small, but tend to make viscosity figures lower than the correct figure. The " Fenske " viscometer is charged in such a way that the filling error is small, but there is no possibility of checking up whether or not it is charged properly. The oil drains from the walls for quite a long time, thus changing the level in the bottom bulb. The calibration constant varies with temperature—consequently much skill and patience are necessary to calibrate accurately for the whole range. Errors due to faulty alignment are negligible. The viscometer combines speed, medium accuracy, and easy handling.

The U-tube is less affected by impurities than the two other types, and enables supervision of correct volume, the adjustment of which requires a certain amount of

skill. Influence of faulty alignment may be reduced to a negligible amount by proper fittings. It is a comparatively slow instrument if accuracy is required. The French standard viscometer has interchangeable capillaries which can be inspected and tested for themselves. The position of the actual level has to be read on a scale, and the accuracy is therefore limited. Otherwise it is extremely simple, quick, easy to handle, and to clean. The Danish viscometer incorporates two measuring ranges in a single instrument. The level adjustment is quick; accuracy is, however, limited for the same reasons as with the French method. A. H. N.

Motor Fuels.

688. Patents on Motor Fuels. Standard Oil Development Co. E.P. 551,961, 17.3.43. Appl. 28.11.41.—Isomerization of normal paraffins to *iso*paraffins is carried out in the presence of one halo sulphonic acid. Free or elemental hydrogen and also boron halide may be employed. Chlorsulphonic acid, fluorsulphonic acid, and bromsulphonic acid are examples of suitable catalysts for the process. The boron trihalide promoter may be either boron trichloride or boron trifluoride, or a mixture of these two halides. The process is useful for the isomerization of a large variety of feed-stocks, including normal butane, normal pentane, normal octane, and the higher straight-chain paraffinic homologues.

International Catalytic Oil Processes Corp. E.P. 552,372, 5.4.43. Appl. 28.8.41. High-octane-number motor fuel is produced by heating a thermally cracked naphtha having an end-point below 450° F. to a temperature of 850–1100° F. and contacting it with a catalyst comprising silica and an oxide of a metal of the group consisting of aluminium, magnesium, copper, beryllium, and thorium. The reaction is carried out at a pressure of from atmospheric to 200 lb. per sq. in. and under a space velocity of 4 to 60 volumes of liquid naphtha per volume of catalyst per space hour. In this way a volume-% yield within the range 94 to 99% is obtained.

O. A. von Smekal and M. A. Pokorova. E.P. 552,420, 7.4.43. Appl. 5.8.41. A process is described for the production of spirit suitable for use in internal-combustion engines from tar, tar oils, tar residuums, oil residuums, and the like. The original material is mixed with air which has been subjected to the action of an electric discharge, such as an electric spark, and afterwards it is submitted in the form of a fine mist and in separate successive quantities or puffs, to the action of heat, *e.g.*, by contact with a heated surface.

O. A. von Smekal and M. A. Pokorova. E.P. 552,422, 7.4.43. Appl. 5.8.41. A suitable apparatus for the production of spirit for use in internal-combustion engines from tar, tar oils, tar residuums, oil residuums, etc., is described.

W. J. Sweeney. U.S.P. 2,310,327, 9.2.43. Appl. 28.10.39. Gasoline of low acid heat and high-octane-number lead response is produced as follows. The oil to be converted is passed through a cracking zone containing an active cracking catalyst to convert a substantial part of it into motor-fuel constituents. Afterwards a light naphtha fraction is separated from the cracked products. This is substantially free of aromatic constituents and contains a substantial amount of olefinic constituents having a high acid heat. The fraction thus segregated is passed in a mixture with *iso*paraffins in contact with an active alkylating catalyst capable of accelerating the union between *iso*paraffins and olefins to form a saturated product.

W. H. Smyers and T. Cross, Jr. U.S.P. 2,310,376, 9.2.43. Appl. 15.8.36. Liquid fuel for internal-combustion engines of the Otto cycle multi-cylinder type is prepared by mixing hydrocarbons of such varying volatility and forming such varying air–fuel ratios as to cause material variation in knocking tendency of the several cylinders in operation. The fuel also contains a small quantity of a mixture of volatile lead alkyls consisting of tetra ethyl lead, triethyl methyl lead, diethyl dimethyl lead, ethyl trimethyl lead, and tetra methyl lead. In this way variation in cylinder knocking is eliminated and the anti-knock value of the fuel is raised.

K. M. Watson. U.S.P. 2,311,273, 16.2.43. Appl. 6.4.40. In a hydrocarbon oil-conversion process a bed of freshly reactivated cracking catalyst is maintained in the temperature range 750–850° F. During the processing period a stream of hydrocarbons heated to a temperature between 900° and 1050° F. is continuously passed through

this bed. At the beginning the catalyst is maintained at a relatively low conversion temperature to produce a substantially saturated gasoline. Afterwards it is kept at a higher conversion temperature to produce an unsaturated gasoline. Substantially unsaturated gasoline and saturated gasoline are collected separately.

A. Voorhies. U.S.P. 2,311,498, 16.2.43. Appl. 16.9.39. The net heat of combustion of an aviation fuel containing between 20% and 55% of aromatic hydrocarbons is increased to at least 18,500 B.t.u. per pound without substantially affecting the octane number of the fuel, in the following way. A sufficient quantity of a hydrocarbon having an octane number at least equal to the fuel and a hydrogen content in excess of 13·5% is added to the fuel to bring the hydrogen content of the mixture to at least 13·5%.

T. H. Risk, L. M. Henderson and A. B. Wilder. U.S.P. 2,312,360, 2.3.43. Appl. 15.12.39. A motor fuel consists of a base stock of saturated hydrocarbons boiling above 140° F. but within the gasoline range, and between 5% and 25% by volume of an addition agent. The addition agent consists of olefinic hydrocarbons boiling within the range 100–140° F. and having an octane blending value not less than 110. The octane number of the base stock is such that the addition agent and base stock will produce a final motor fuel of not less than 70 octane number.

S. S. Allender. U.S.P. 2,314,435, 23.3.43. Appl. 18.12.39. In the production of gasoline from a butane fraction containing *iso*butane and normal butane, the original material is fractionally distilled to separate *iso*butane and normal butane. A portion of the normal butane is isomerized to form a mixture containing essentially *iso*butane and normal butane. The mixture is passed back to the butane fractional distillation process to separate *iso*butane and normal butane. The remainder of the normal butane is dehydrogenated to produce a product consisting of normal butane, butenes, 3-carbon atom hydrocarbons, and lighter gases. The dehydrogenation product is separated into a butane–butene fraction and a mixture of 3-carbon atom hydrocarbons and lighter gases. Total *iso*butane obtained from the original butane mixture and from the isomerization is subjected to alkylation with normal butenes contained in the butane–butene fraction to produce a mixture of alkylation products and unconverted butanes. The mixture is returned to the original butane fractional distillation to separate *iso*butane, normal butane, and a substantially saturated alkylate, and to furnish a refluxing medium for the fractional distillation of the butane fraction.

R. E. Schaad. U.S.P. 2,314,460, 23.3.43. Appl. 29.3.39. To produce saturated hydrocarbons boiling within the gasoline range and of high anti-knock value, normally gaseous olefins are subjected to polymerization to form hydrocarbons of 6 or more carbon atoms to the molecule. C_6 hydrocarbons are separated from heavier polymers, and the latter are depolymerized to form olefins of less than 6 carbon atoms to the molecule. These are subjected to interpolymerization independently of the normally gaseous olefins to form mixed olefin polymers. At least a portion of these mixed polymers and the C_6 hydrocarbons are hydrogenated to effect substantial saturation.

P. Millar and G. H. Cloud. U.S.P. 2,316,011, 6.4.43. Appl. 28.10.39. A fuel for internal-combustion engines is prepared by adding 0·2 to 3% of a thiazole to a hydrocarbon oil boiling above the gasoline boiling range.

P. Millar. U.S.P. 2,316,012, 6.4.43. Appl. 28.12.39. To improve octane number of a hydrocarbon motor fuel, at least 1% by volume of a ketonic compound boiling in the boiling range of the fuel is added. The ketonic compound has the formula $R \cdot CO \cdot R^1 \cdot CO \cdot R^2$. R^1 and R^2 are terminal organic groups, and R^1 represents an aliphatic hydrocarbon radical separating carbon atoms linked to oxygen. Each oxygen atom is bound to only one carbon atom. The fuel is free from substantial amounts of any other oxygen-containing organic compounds.   H. B. M.

Gas, Diesel, and Fuel Oils.

689. Patents on Gas, Diesel, and Fuel Oils. P. Miller and E. Lieber. U.S.P. 2,310,306, 9.2.43. Appl. 10.10.39. Prior to ignition in a compression-ignition engine a diesel hydrocarbon fuel is contacted with solid free sulphur to mix with it a substantial ignition improving amount of free sulphur.

F. Schick. U.S.P. 2,310,812, 9.2.43. Appl. 6.7.38. Oils of high stability are prepared by blending a hydrocarbon oil of predominantly aliphatic character and relatively rich in saturated hydrocarbon components with at least 10% of a hydrocarbon oil of predominantly aliphatic character, and containing a substantially smaller amount of saturated hydrocarbons. The two oils have similar boiling ranges, and are members of the group consisting of diesel fuel oils and lubricating oils. After blending, the oils are contacted with a small amount of a chemical precipitating agent.

E. W. Fuller and E. M. Nygaard. U.S.P. 2,314,137, 16.3.43. Appl. 30.10.40. The ignition quality of a diesel fuel is improved by the addition of between 0·1% and 5% of an organic hydroxylamine, consisting only of carbon, hydrogen, oxygen, and nitrogen.   H. B. M.

Lubricants and Lubrication.

690. The Lubrication by Thin Metallic Films and the Action of Bearing Metals. F. P. Bowden and D. Tabor. *J. Appl. Phys.*, March 1943, **14** (3), 141–151.—An investigation has been made of the rôle of thin metallic films in reducing the friction and wear between metal surfaces. It is shown that with metallic films possessing suitable mechanical and surface properties, the coefficient of friction is very low, and may be similar to that observed on ice. In many cases the behaviour of these thin metallic films resembles that of ordinary lubricants, except that Amonton's law is not obeyed. From experiments on alloys it is concluded that the frictional behaviour of a copper–lead alloy closely resembles that of a copper surface on which a very thin film of lead has been deposited. The actual value of the friction of the allow is the same as that of a copper surface on which a lead film 10^{-4} cm. thick has been artificially deposited. The temperature coefficient of friction is the same in each case. The increase in friction with wear is also very similar, except that in the case of the alloy there is evidence that the potential supply of lead is greater, since it may continue to be expressed from the alloy during the sliding process. With a thin film of lead deposited on copper the supply is, of course, limited to the amount actually present on the surface at the beginning of sliding.

These results show the important part which may be played by thin surface films of metal in reducing the friction and wear of bearing alloys, and support the view that in certain bearing alloys the anti-frictional and anti-seizure properties may be primarily due to the spreading of thin films of the soft, low-melting constituent, over the surface of the harder constituent. In this connection the importance of surface tension is apparent. The soft, low-melting constituent must spread readily on the harder one to form a thin film. This is borne out by experiment. It was shown, for example, with lead, indium, and mercury films on steel, copper, and silver, that unless the soft metal readily wetted the harder one, it was, under severe conditions of sliding, relatively ineffective as a lubricant. Although it is desirable that these metallic films should adhere to and wet the substrate, the converse should be true about the other moving surface—*e.g.*, the journal of a bearing. Provided the metallic film does not break down, the smaller the adhesion and the less the tendency of the metallic film to spread on to this surface the better. As was pointed out in the first paper, one important function of a lubricant is to reduce the adhesion between the two moving surfaces and help to reduce the effective shear strengths of the metallic junctions.   A. H. N.

691. The Use of a Model Engine for Testing Internal Combustion Engine Lubricants. H. A. Cheetham and T. G. Hunter. *Min. and Pet. Tech. Mag.* (University of Birmingham), 1943, **32**.—The engine test of an oil is a long and expensive process, chiefly because of the high initial cost of the test unit and the large amount both of fuel and lubricant consumed during the runs. It was therefore thought that it might be possible to use a model engine to test the performance of the oil and keep the cost of such tests to a relatively low figure. An added advantage of the method was that small quantities of oil could be tested, such as laboratory prepared synthetic samples. In order to test these assumptions a series of experiments was conducted on a small engine designed for model motor-boat propulsion. The engine had to be modified in order to render it fit for experimental work of a quantitative nature. Both these modifications and the experiments undertaken are described. The general

conclusion is that the method for testing oils appears capable of giving satisfactory results.
<div align="right">A. H. N.</div>

692. Patents on Lubricants and Lubrication. Imperial Chemical Industries. E.P. 552,123, 24.3.43. Appl. 19.9.41. Deterioration in colour of petroleum oils is inhibited by incorporating in the oils a condensation product of one molecular proportion of an aliphatic polyamine containing two primary amine groups with from three to ten molecular proportions of an aliphatic aldehyde with at least three carbon atoms. The a-carbon atom has at least one hydrogen atom attached. It is intended that petroleum oils should include fuel oils, oils used in heat-transfer apparatus, electrical transformers, and greases, as well as the usual lubricating oils. Non-viscous oils, such as gasoline and kerosine, are not covered by the patent.

H. S. Chase and G. C. Gaine. U.S.P. 2,308,490, 19.1.43. Appl. 17.1.36. Lubricating oil is recovered from a normally liquid hydrocarbon mixture containing relatively light lubricating components and lighter diluent components by fractionally distilling the mixture. The yield of relatively light lubricating-oil stock is increased by conducting the fractional distillation in the presence of a small proportion of heavy lubricating-oil stock.

B. B. Farrington, J. O. Clayton, and D. E. Etzler. U.S.P. 2,308,502, 19.1.43. Appl. 2.8.40. Preparation of a lubricant consisting of a major proportion of a hydrocarbon lubricating oil and 0·1–2% by weight of a metal alkyl monocarboxylate having an alkyl hydroxy group no more than three carbon atoms removed from a carbonyl group of the carboxylate.

H. M. Fraser. U.S.P. 2,308,599, 19.1.43. Appl. 25.7.40. Preparation of a lubricant having incorporated in it a lead soap of a hydroxy-stearic acid.

B. H. Lincoln and G. D. Byrkit. U.S.P. 2,308,622, 19.1.43. Appl. 9.3.39. A lubricant is prepared by admixing with at least 90% mineral lubricating oil a small proportion of a halogenated polyarylated aliphatic compound having at least a portion of the halogen on the aliphatic group.

E. C. Hughes. U.S.P. 2,308,690, 19.1.43. Appl. 23.11.40. Preparation of a lubricant consisting of a mineral oil of lubricating viscosity and a small amount of tolidine.

E. C. Hughes. U.S.P. 2,308,691, 19.1.43. Appl. 25.11.40. Preparation of a lubricant consisting of a mineral oil of lubricating viscosity and a small amount of 4-aminodiphenylamine.

P. Miller and E. Lieber. U.S.P. 2,310,305, 9.2.43. Appl. 31.12.37. The quality of a lubricating oil is maintained during service by circulating at least part of it through an addition agent reservoir containing a supply of slightly oil-soluble improving agent in undissolved form having oxidation inhibiting properties.

B. H. Lincoln and W. L. Steiner. U.S.P. 2,310,721, 16.2.43. Appl. 29.2.40. From 0·001% to 1% by weight of ethyl abietate and 0·5–10% by weight of a chlorinated compound are added to a lubricant to produce a stabilized high-film-strength lubricating oil.

C. F. Prutton. U.S.P. 2,310,993, 16.2.43. Appl. 1.7.37. Preparation of a lubricant consisting of a petroleum lubricating oil, a calcium soap of an aromatic stearic acid, and a separate halogen-bearing organic compound.

H. W. Ritchey. U.S.P. 2,311,305, 16.2.43. Appl. 6.5.40. Mineral lubricating oil for severe service internal-combustion engines is prepared by heating a mineral oil to an incipient cracking temperature in the presence of phosphorus. In this way phosphorus is caused to enter the hydrogen molecule. Afterwards the phosphorized oil is oxidized under controlled temperature conditions to yield phosphoric acids in the oil.

Z. C. Zimmer and G. M. McNulty. U.S.P. 2,311,500, 16.2.43. Appl. 8.5.40. An extreme-pressure lubricant consists of a lubricating oil and a small but effective amount of an oil-soluble condensation product of sodium mercaptide and a chlorinated solvent extract of petroleum hydrocarbons containing between 10% and 50% chlorine.

The Atlantic Refining Co. E.P. 552,732, 22.4.43. Appl. 23.4.41. To improve resistance to oxidation and enhance lubricating characteristics a small quantity of a mixed ester of a phosphorous acid containing at least one and not more than two alkylaroxyalkyl radicals is added to a lubricating oil base.

Standard Oil Development Co. E.P. 553,140, 10.5.43. Appl. 3.11.41. A lubricant is prepared from a waxy mineral lubricating oil, a small amount of a synthetic pour depressor and a small amount of a natural pour sensitizer extracted from a spent clay used for treating petroleum lubricating-oil stock.

E. W. Cook and W. D. Thomas, Jr. U.S.P. 2,311,931, 23.2.43. Appl. 27.12.41. A small proportion of a compound of the following general formula is added to a lubricating oil :—
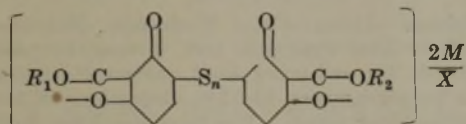
R_1 and R_2 are members of the group consisting of alkyl and *cyclo*alkyl radicals having 4 or more carbon atoms, n is a positive integer and not more than 2, M is a metal radical and X is the valence of M.

J. O. Clayton and B. B. Farrington. U.S.P. 2,312,207, 23.2.43. Appl. 12.4.41. A lubricant is prepared by adding at least 0·05% by weight of a salt of an organic-substituted arsenic compound to a hydrocarbon oil.

J. O. Clayton and B. B. Farrington. U.S.P. 2,312,208, 23.2.43. Appl. 12.4.41. At least 0·05% by weight of a salt of a substituted acid of boron containing an organic constituent is added to a hydrocarbon oil.

W. P. Tighe. U.S.P. 2,314,530, 23.3.43. Appl. 18.5.40. Anti-welding lubricants are prepared by providing in a mineral oil non-adsorbable sulphur compounds. The oil is subjected to the action of sulphur and heat and air until several per cent. of sulphur are taken up. Afterwards it is acidified, and adsorbable compounds are eliminated by subjecting it to the action of a finely divided adsorbent material at a temperature somewhat in excess of the boiling point of water.

A. W. Burwell. U.S.P. 2,314,769, 23.3.43. Appl. 7.6.41. An improved lubricity-increasing agent for use in oils consists of a mixture of low-molecular-weight aliphatic alcohol esters of relatively high molecular weight, saturated aliphatic carboxylic acids of mineral origin, and a minor proportion of lithium soaps of these acids. The acid number of the mixture does not exceed 2, and the final product is substantially non-corrosive to aluminium, magnesium, and alloys thereof.

C. M. Loane and J. W. Gaynor. U.S.P. 2,316,078, 6.4.43. Appl. 24.3.41. A lubricant consists of a hydrocarbon oil and a small amount of the phosphorus and sulphur-containing chlorine-free reaction product of a phosphorus sulphide and a polymer having a molecular weight above about 500 of a mono-olefinic hydrocarbon of less than 6 carbon atoms.

C. M. Loane and J. W. Gaynor. U.S.P. 2,316,079, 6.4.43. Appl. 24.3.41. Added to a mineral oil is a small amount of the product obtained by heating at a temperature above 200° F. an *iso*butylene polymer with an alkali metal hydroxide dispersed therein.

C. M. Loane and J. W. Gaynor. U.S.P. 2,316,080, 6.4.43. Appl. 24.3.41. An improved lubricant consists of a lubricating oil and a small amount of a phosphorus and sulphur-containing phosphorus–sulphide–olefin polymer reaction product having at least a portion of its titratable acidity reduced by reaction with a basic reagent.

C. M. Loane and J. W. Gaynor. U.S.P. 2,316,081, 6.4.43. Appl. 24.3.41. A lubricant is prepared from a mineral lubricating oil and a small amount of a neutralized phosphorus and sulphur-containing reaction product of a phosphorus sulphide and an aromatic hydrocarbon.

C. M. Loane and J. W. Gaynor. U.S.P. 2,316,082, 6.4.43. Appl. 24.3.41. A lubricant is prepared from a mineral lubricating oil and a minor amount of a neutralized phosphorus and sulphur-containing reaction product of a phosphorus sulphide

and a hydrocarbon obtained by reacting a phosphorus sulphide with a hydrocarbon and subsequently neutralizing the reaction product with a basic reagent.

C. M. Loane and J. W. Gaynor. U.S.P. 2,316,083, 6.4.43. Appl. 24.3.41. A lubricant is prepared from a hydrocarbon lubricating oil and a small amount of the product obtained by reacting a phosphorus sulphide with a hydrocarbon, neutralizing with a basic reagent, and subsequently treating the reaction product at a temperature above 100° F. with a compound having an active hydrogen atom to obtain a product having a substantially lower sulphur content than the initial reaction product.

H. B. M.

Asphalt and Bitumen.

693. Bitumen Emulsions. Anon. *Paint Technology*, February 1943, **8** (86), 18.— B.P. 514,818 granted to Colas Products, Ltd., covers the production of bituminous emulsion paints suitable for colouring road surfaces, especially concrete, and for camouflage purposes by pigmenting 10–12% dispersions of bitumen with pigments, using bentonite as suspending agent. The basic emulsion is prepared from 55 parts of 200 pen. Venezuelan bituman, 45 parts of a solution containing 2% casein, and 0·35% KOH. A typical paint is produced by diluting 22 parts of emulsion with 78 parts of water, stirring in 3 parts of bentonite, 2 parts of iron oxide, and 1 part of a 20% solution of aluminium sulphate. The high pigment bitumen ratio is required to give obliteration, but covering power is good—200–300 gm. per sq. metre. Another basic emulsion from 55 parts albino bitumen emulsified in 45 parts of the alkali caseinate solution can be diluted and pigmented as above. Using chromium oxide green as pigment, paints are produced suitable for reconditioning brick and concrete surfaces such as those of tennis-courts.

B.P. 515,198 granted to Deutsche Erdöl-Akt-Ges. of Berlin-Schöneberg covers the production of stable, quick-breaking emulsions from " unsaturated " bitumens, produced by removing from the bitumens saturated oily constituents and materials insoluble in chloroform. Emulsibility is indicated by high iodine value, high solubility in aniline, and insolubility or low solubility in petroleum ether. Suitable products are cracked asphalts from brown coal-tar oils, Esthonian shale low-temperature distillation tar pitches and selective asphalts from phenol extracts of brown coal-tar. The emulsion gives glossy, compact, adherent, non-sticky, and completely weather-resistant films. The best results are obtained by diluting a 40–60% emulsion to 10–20%, using resin soaps, and removing coarse particles (above 5 μ) which separate on standing by centrifuging.

C. L. G.

694. Patents on Asphalt and Bitumen. E.I. Du Pont de Nemours. E.P. 552,500, 12.4.43. Appl. 8.9.41. To obviate the disadvantages of certain asphaltic or bituminous materials and dyes and organic pigments soluble or partly soluble in organic solvents, which tend to exhibit the phenomenon known as " bleeding " when additional organic coatings are applied an intermediate sealing coat is applied before the finishing surface. The intermediate sealing coat comprises an organic film-forming vehicle and uncharged activated carbon.

O. K. Schmied. U.S.P. 2,310,712, 9.2.43. Appl. 8.6.40. A shipping container for a block of asphalt consists of an outer casing, an inner lining of foil, and a continuous strippable plastic film on the foil. The foil is stuck to the casing by a bond of substantial strength, and the film is adhered to the foil by a bond of less strength. The film adheres to the block of material more strongly than to the foil, and on removal of the block the film clings to the surface of the material, which is removed in its entirety from the surface of the foil.

R. C. Hawks and E. M. Skinner. U.S.P. 2,311,389, 16.2.43. Appl. 31.7.41. An apparatus for reducing molten asphalt to small pieces embodies an elongated sloping fluid channel sharply constricted transversely at the lower end, means to supply a smooth stream of cooling fluid to the upper end of the channel, and a device to discharge on this stream a number of horizontally spaced streams of molten asphalt. The channel is of sufficient length below the asphalt supply device to allow the molten asphalt to become brittle by cooling through heat exchange with the cooling fluid before it reaches the constricted portion of the channel.

S. S. Sorem and A. P. Anderson. U.S.P. 2,313,596, 9.3.43. Appl. 10.6.40. An unemulsified asphalt composition capable of forming a durable bond with galvanized-iron surfaces consists of asphalt and an amount of a finely divided material chosen from the group consisting of zinc, zinc oxide, lead, lead oxide, lead hydroxide, and aluminium hydroxide in excess of that required to neutralize asphaltic acids formed by oxidation of the asphalt. The product is non-corrosive for prolonged periods of time.

P. E. McCoy. U.S.P. 2,313,759, 16.3.43. Appl. 7.8.39. A bituminous composition is prepared from a mineral hydrophilic substance and a bituminous material free from added saponifiable and saponified material in the following way. The mineral hydrophilic substance is coated with the bituminous material, and adhesion of the bitumen is improved by dispersing in it a relatively water-soluble and oil-soluble heavy metal salt. The hardness of the bituminous material is not substantially affected by addition of the salt.

D. E. Carr and H. W. Ritchey. U.S.P. 2,314,124, 16.3.43. Appl. 16.6.39. A relatively non-photosensitive asphalt is prepared by mixing with a relatively photosensitive asphalt an organic aliphatic inhibitor of photo-oxidation. The inhibitor is characterized by a long hydrocarbon chain terminating in an oxygenated group. The asphalt forms a rust when a layer 0·025 inch thick is exposed to the light of a 1500-watt lamp at a distance of about 6 inches from the lamp for a period between 8 and 32 hours, and is subsequently immersed in a bath of water at approximately 140° F.   H. B. M.

Special Products.

695. Chemicals from Petroleum—Styrene. W. T. Ziegenhain. *Oil Gas J.*, 6.8.42, **41** (13), 37.—A short account of the production of styrene by the reaction of benzene with either ethylene or ethyl alcohol, followed by dehydrogenation. Physical properties of styrene are quoted, and the suggestion made that because of its high octane number its production on an increasing scale is warranted, apart from its war-time use for manufacture of Buna S.   J. C.

696. Insecticide Specifications. Anon. *Soap*, December 1942, **18** (12), 129.—New U.S. Federal specifications have been drawn up covering petroleum distillate base liquid insecticide (fly spray) 0–1–541, and liquid insecticide (household) 0–1–546, for Government use from 18th March, 1943. The former allows the use of any toxic product, the required knockdown being not less than 2% below the Official Test Insecticide and the required kill not less than 16% above the O.T.I. The latter specifies the inclusion of at least 0·15% of pyrethrin I, with the normally accompanying amount of pyrethrin II, and allows the addition of any other ingredients required to bring the toxicity up to the above standard. Full details of the specification and methods of sampling, inspection, and test are given.   C. L. G.

697. Drying Oils and Resins from Chlorinated Paraffins. Anon. *Paint Technology*, February 1943, **8** (86), 27.—According to B.P. 524,521 (J. W. C. Crawford, S. W. George, and I.C.I., Ltd.), hard-air-drying or stoving-paint films can be obtained from the condensation of olefins, derived by dehydrohalogenating chlorinated paraffins and malic, maleic, citraconic, glutaconic, or aconitic acids or anhydrides. The condensates can be esterified by heating with alcohols in the presence of strong mineral acid and modified esters produced by adding stearic, oleic, linoleic, etc., acids before or during esterification. The air-dried films are stated to be as hard as those of a copal varnish and the baked films as hard as store enamel. A method of preparing suitable olefins is described in B.P. 505,898. Esterification with monohydric alcohols gives soluble products, whereas with polyhydric alcohols resinous or rubber-like products, insoluble in the usual solvents, can be obtained by prolonged heating. Such products are useful in sealing or plastic compositions. If the olefins contain more than 21 carbon atoms per molecule, the esterification products require baking to give a satisfactory drying film, though some improvement in air-drying characteristics is given by heating at 100–200° C., if necessary under pressure and with added driers. A product of the above type prepared from Scottish Shale wax by chlorina-

tion, dehydrochlorination, condensation with maleic anhydride, and esterification with methyl alcohol gives a solution in xylene, containing driers, which dries hard after 24 hours to a pale, glassy but soft coating with good adhesion. Stoving gives considerably harder films, particularly after 3 hours at 100° C. Similar useful products are obtained from chlorinated paraffin wax.   C. L. G.

698. Anti-Corrosive and Anti-Fouling Paints. Anon. *Chem. Tr. J.*, 16.4.43, **112**, 357.—In a paper delivered to the Institution of Naval Architects on 15th April, G. D. Bengough and V. G. Shepheard reviewed the work of the Marine Corrosive Sub-Committee of the Corrosion Committee of the Iron and Steel Institute and the British Iron and Steel Federation, which has for the last few years been studying the combined problems of corrosion and fouling of ships' bottoms. Methods proposed for the suppression of corrosion and fouling are based on (1) special metals or alloys, (2) electrical systems, and (3) paints and compositions. Of these (3) is the only method in general use and normally consists of one or more anti-corrosion coats followed by one relatively thick anti-fouling coat. The adhesion of the first coat is assisted by (1) pickling, (2) weathering, or (3) weathering and immersion in water (during fitting out), each method being followed by scratch brushing before painting. The anti-corrosion composition may act in one or more of the following ways : impermeability, electrochemical action, and inhibitive action. The paint base, which provides impermeability, may consist of natural or synthetic drying oils or resins, bitumen, wax, chlorinated rubber, and driers. Electrochemical protection is afforded by metallic zinc or aluminium, which is particularly useful for the protection of small areas of steel where paint is stripped or loose. Inhibitive chemicals include oxidizing agents such as red lead or chromates which produce insoluble protective films, the former being less useful for under-water paints, owing to slow drying and tendency to encourage pitting on exposed areas of steel, but more suitable for boot topping and top-side regions. Zinc and barium chromates may be better inhibitors for continuously submerged areas, though they are not in general use, apart from the use of zinc chromate for seaplanes and flying-boats, etc. The toxic ingredients in antifouling compositions are usually compounds of copper, mercury, and arsenic, and occasionally an organic poison, these having a selective action on different organisms, particularly the organic poisons. Immersion tests in the sea have been carried out on 35 anti-fouling products, the life of such products varying from 5 to 56 weeks. Further investigation will be made of the optimum consistency or brushability of various types of bottom compositions. Considerable improvement in protective value is obviously necessary for the poorer grades. For most shipping routes the expensive poisons will not be necessary, but the following types of compositions will, in general, be required :—

  (1) A general all-purpose paint for the Royal Navy.
  (2) A high-duty paint for routes subject to severe animal or weed fouling.
  (3) A high-duty composition for the main inlet and discharge trunkings specially liable to mussel fouling.
  (4) A non-mercurial composition prepared from home produced chemicals.

In connection with (4), mercury is three times as effective as copper against barnacles and twice as effective against weeds. Many organic poisons are more effective than mercury compounds when added direct to sea-water, but are masked when incorporated in paints. Further work on the selection of suitable media and pigments is therefore necessary.   C. L. G.

699. Co-polymer Vinyl Resins. Anon. *Chem. Tr. J.*, 16.4.43, **112**, 359.—Progress in the production and application of vinyl chloride-acetate co-polymers was described by J. D. Benedito in a recent paper before the Canadian section of the Society of Plastics Industry. Four grades of Vinylite resin of the above type are marketed, varying in vinyl chloride content and molecular weight, viz. VYLF, 85–88% (5000) ; VYHH, 85–88% (10,000) ; VYNS, 88–90·5% (18,000) ; VYNW, 95% (25,000). With increase in molecular weight and vinyl chloride content, solubility in organic solvents is reduced and the product becomes tougher and of higher softening point, and when plasticized becomes more elastic. The largest single war-time outlet for the vinyl resins is the extrusion of plasticized compounds for cable insulants and jacketing, where they have

almost completely replaced natural rubber. Compared with rubber, they are more flame resistant, and are, in fact, non-inflammable ; they are more resistant to oxidation, ageing, and chemical attack, and have higher abrasion resistance. They have high dielectric strengths and insulation resistance values and can withstand cracking even at − 45° F. Other important applications include proofing of fabrics (service raincoats, ground sheets, tents for winter use) and linings for plating and pickling tanks and for concrete, oil, and storage tanks.

A recently developed modification gives better adhesion without loss of chemical resistance, and holds promise for use in plant against corrosive vapours and for the coating of magnesium and aluminium alloys. The moulding and extrusion of rigid vinyl products are likely to develop after the war for the production of tough abrasive resistant floor-tiles, and of rigid sheets for, *e.g.*, playing-cards, name-plates for machinery, records, radio dials, containers, etc. Their high tensile strength and natural elasticity suggest their use in post-war hosiery. while to-day filter cloths for corrosive slurries and felts, using the staple fibre as a binder, are made on the commercial scale.   C. L. G.

700. Charts on Plastics. C. A. Redfarn. *British Plastics*, May 1943, **14**, 738.—A series of charts, with explanatory notes, has been reprinted from the 1943 *British Plastics Year Book* showing the derivation, manufacturing processes, and applications of the following types of plastics : casein, cellulose, phenolic (moulding powders, laminated materials and miscellaneous products), urea, polymethyl-methacrylate, styrene, vinyl, and Nylon. A further large chart gives a comprehensive view of the basis, types, and applications of the principal plastics.   C. L. G.

701. Patents on Special Products. L. Liberthson. U.S.P. 2,307,743, 12.1.43. Appl. 7.1.41. An improved petroleum sulphonate product is obtained by intimately contacting in the presence of water a solution of a petroleum sulphonate stock, derived from the acid treatment of a petroleum lubricating-oil distillate, in a solvent for this sulphonate, with an alkali metal chlorite. Afterwards a petroleum sulphate product substantially stable during storage and substantially non-darkening when subjected to high temperatures is recovered.

L. Liberthson. U.S.P. 2,307,744, 12.1.43. Appl. 17.5.41. Preparation of a composition capable of forming substantially stable, non-foaming aqueous emulsions of the oil-in-water type. This consists of an aqueous phase emulsifying agent for the hydrocarbon of the water-soluble soap type and 0·25–1·0% of chromium oleate calculated on the emulsifying base.

C. M. Thacker. U.S.P. 2,309,718, 2.2.43. Appl. 1.12.37. Paraffinic gases are converted into higher-boiling hydrocarbons by contacting them at high temperature in the presence of sulphur with an oxidation catalyst. Resultant organic sulphur compounds are separated from the remaining reaction products, and are then contacted at high temperatures with a catalyst capable of splitting off hydrogen sulphide from the organic sulphur compounds.

C. Weizmann. E.P. 552,551, 14.4.43. Appl. 12.7.40. Entirely aromatic liquid products are produced from light olefins, such as propylene, butylene, or the impure olefins resulting from the cracking of mineral oils by passing the original material over the oxides of zirconium, hafnium, thorium, cerium, or the metals of the rare earths at a temperature between 600° and 800° C. and at approximately atmospheric pressure.

J. W. Orelup. E.P. 552,882, 29.4.43. Appl. 21.7.41. Petroleum products, more particularly relatively colourless products used as fuels, are effectively coloured by means of a composition consisting of diphenyl and an oil-soluble dye.

H. Baehr and W. Deiters. U.S.P. 2,312,064, 23.2.43. Appl. 22.4.39. Dihalogenated saturated hydrocarbons are produced by bringing an olefinic hydrocarbon into contact with an equimolecular amount of a halogen of the group consisting of chlorine and bromine. At least one of the starting materials is admixed with a gaseous hydrogen chloride and hydrogen bromide. The total amount of hydrogen halide present in the reaction mixture is at least equimolecular to that of the olefinic hydrocarbon present.

H. Pines and V. N. Ipatieff. U.S.P. 2,315,078, 30.3.43. Appl. 20.2.42. Substantial yields of alkyl *cyclo*hexane hydrocarbons are obtained from *cyclo*hexane hydrocarbons by reacting an alkyl *cyclo*pentane hydrocarbon with an olefinic hydrocarbon in the presence of a catalyst consisting essentially of hydrogen fluoride as its active ingredient. H. B. M.

Detonation and Engines.

702. Effect of Altitude on Knock Rating in C.F.R. Engines. D. B. Brooks. *Bur. Stand. J. Res.* (Wash.), 1942, 28 (6), 713–734.—Since the standardization of the A.S.T.M. Motor Method in 1933 and of the C.F.R. research method in 1939, knock ratings made by laboratories at higher altitudes have frequently failed to agree with ratings made by other laboratories at sea level.

The National Bureau of Standards was asked in 1941 to assist in determining appropriate conditions for knock rating by both these methods at altitudes by co-operative tests in altitude chambers.

A standard C.F.R. unit with ice-tower humidity control was installed. In the preliminary tests determinations were made for each modification of the induction system (venturi size, throttle plate) at a series of altitudes up to 8000 ft. of (*a*) compression ratio for constant absolute compression pressure, (*b*) compression ratio for standard knock intensity at two specified levels of octane number, (*c*) compression ratio at which the rating of a sensitive fuel was the same as that found for it at sea level. Additional tests were made using three additional cylinder assemblies to make certain that results were not biased by engine idiosyncrasies.

Results showed that :—

(1) Ratings made at constant knock intensity were independent of air pressure.

(2) Constant knock intensity was not obtained at constant absolute compression pressure.

(3) Compression ratio for constant knock intensity was a curvilinear function of air pressure.

(4) The micrometer setting for constant knock intensity was a linear function of air pressure.

(5) No advantage resulted from the use of more than three sizes of venturi for the Motor Method or one size for the Research Method.

Altitude curves were generally determined from sea level to 22 inches mercury, but were extended in one case to an equivalent altitude of 20,000 feet.

From the results obtained equations were developed to relate cylinder clearance volume for standard knock intensity to air pressure and to octane number for both methods of knock rating.

Equations were also developed to relate octane-number requirement to air pressure, and these were shown to agree with road test data. D. L. S.

703. Low Temperature Performance of Motor Fuels and Lubricants. F. H. Garner. *Min. and Pet. Tech. Mag.* (University of Birmingham), 1943, 8.—Professor Garner deals with the properties controlling performance of motor fuels at low temperatures under : (1) difficulty of starting, (2) poor warming-up and acceleration, and (3) dilution of the lubricating oil. Lubricating oils are then briefly studied from the viewpoints of ease of starting and pumping and of sludging and cylinder wear. Five selected references to the literature are appended. A. H. N.

Coal and Shale.

704.* Economics of Peat Fuel Utilization. G. Howell. *Petroleum*, October 1942, 5 (10), 164.—A plea is made for the utilization in this country of peat as fuel for steam raising and as a raw material for the production of coke, gas, and other derivatives. The technical aspects of the problem are examined, and the composition, distribution, and origin of peat are discussed.

Examples of the use of peat for steam raising are quoted from Germany and Sweden, and it is considered that with suitable furnaces the thermal efficiency of peat

can compare favourably with that of steam coal. Peat, moreover, offers three possible advantages not obtainable with coal : (a) a low ash content rarely exceeding 3%, (b) negligible sulphur content, (c) an ash so light that clinker is never produced. Whilst it is recognized that a variety of factors must be satisfied to obtain efficient utilization of peat, the conventional arguments against its use are considered to be based on scanty data, and it is claimed that the important difficulty of excessive moisture content is met by processes such as the " Peco," which dry peat down to 10% moisture.

The Ziegler process for the manufacture of peat coke as used in Russia, various Italian installations, German use of peat coke in metallurgy, and the possibility of large-scale " destructive " processes for peat in Canada are reviewed, and commercial yields of coke, gas, oil, wax, chemical derivatives, etc., from various processes quoted.

J. C.

705. Gas Industry Research. Anon. *Chem. Tr. J.*, 1.1.43, **112**, 6.—The research problems being investigated by the Gas Research Board include the hydrogenation and complete gasification of coal under pressure (jointly with Leeds University), for the production of large quantities of power gas of normal quality from a wide range of coals and with maximum flexibility in the amount of coke made. The process appears promising on the laboratory scale, and will be studied on a semi-industrial scale. The catalytic synthesis of methane is being studied and progress made in the study of the effect of operating conditions in the catalytic treatment of water gas and synthesis gas. Investigations are being made of the catalytic removal of organic sulphur compounds from these gases and from town gas. Work on the liquefaction of methane and other gases is likely to be of value for the separation of methane from coal gas, for use as fuel gas, or as an enricher, and of impurities and various constituents of coal gas of special application in the chemical industry. An investigation is also being made into the extent of increase of yield of benzole and toluene from coal by the cracking of tar injected into the charge during carbonization in a continuous vertical retort.

C. L. G.

BOOKS RECEIVED.

The Year Book of the Coke Oven Managers' Association. 1943. Benn Brothers, Ltd., the *Gas World* Offices, Bouverie House, 154, Fleet Street, London, E.C.4. 328 pages.

Proceedings of the Institution of Mechanical Engineers. Vol. 148, 1942. Pp. 220. Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1.

Explicacion del Nuevo Mapa Geologico de España. Vol. 2. **El Sistema Siluriano.** Part 1. **Text.** Part 2. **Species, Bibliography, and Classification Table.** Instituto Geologico y Minero de España. Pp. 592 and 256. Gráficas Reunidas, S.A., Hermosilla, 108, Madrid. By Primitivo Hernandez Sampelayo.

Notas y Comunicaciones del Instituto Geologico y Minero de España. No. 10, 1942. Gráficas Reunidas, S.A., Hermosilla, 108, Madrid.

Informe del Ministro de Minas y Petróleos al Congreso Nacional en sus sesiones ordinarias de 1942. Vol. 1 and Annex. Pp. 281 and 346. Imprenta Nacional, Bogota, Colombia.

INSTITUTE NOTES.

PRESIDENT.

Mr. Christopher Dalley, M.I.E.E., has been re-elected President of the Institute for the year 1943–44.

VICE-PRESIDENTS.

The Council has elected the following to be Vice-Presidents of the Institute for the Session 1943–44 :—

Mr. Ashley Carter.	Mr. A. C. Hartley.
Mr. G. G. Coxon.	Professor V. C. Illing.
Professor F. H. Garner.	Mr. J. A. Oriel.

HONOURS.

Among the Birthday Honours conferred by the King are the following :—

C.B.E.

John Mellor Pattinson (Associate Member).

O.B.E.

Professor F. H. Garner, Ph.D., M.Sc., M.I.Chem.E., F.I.C.

PERSONAL.

Dr. Gustav Egloff, Director of Research of Universal Oil Products Company, is the 1943 recipient of the Columbia University Medal of Merit, which is awarded annually to an outstanding scientific or technological leader in industry.

CONTRIBUTIONS TO THE *JOURNAL*.

Contributions from members of the Institute will be welcomed with a view to their inclusion in the *Journal*, either in the form of papers which have been submitted to meetings of branches, or original contributions on subjects of interest to the general body of members.

ELECTIONS.

The attention of members is directed to their prerogative of nominating members for election to the Council of the Institute. Nominations must be signed by ten Fellows, Members, or Associate Members, including the proposer.

CANDIDATES FOR ADMISSION.

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

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

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

ADAMS, Ivan Gifford Barr, Joint Managing Director, James Light & Son, Ltd. (*F. C. Baker ; H. E. Kessen.*)

BAINES, Archibald Ernest Walter, Technical Engineer, Wm. Neill & Son (St. Helens), Ltd. (*Harold Moore ; H. E. Charlton.*)

BRICE, Frank, Asst. Chief Clerk, Stanlow Refinery. (*G. Davidson ; J. G. Hancock.*)

DONE, Albert, Analyst, Shell Refining & Marketing Co., Ltd. (*G. Davidson ; T. T. Davies.*)

FENTON, Bert Vincent, Chemist, The Attock Oil Co., Ltd. (*T. T. McCreath ; J. G. A. Jeffrey.*)

HADLOW, Reginald Edward Eric, Installation Manager, Bristol Channel Oil Wharves, Ltd. (*S. J. W. Pleeth ; M. E. W. Miller.*)

MILLER, Andrew Craig, Research Engineer, Humber Limited. (*P. Draper ; H. Fossett.*)

PATON, Harold, Manchester Oil Refinery, Ltd. (*E. J. Dunstan ; H. E. Charlton.*)

SMITH, Reginald William, Petroleum Chemist, Shell-Mex & B.P., Ltd. (*S. J. W. Pleeth.*)

TAYLOR, John Ralph Carlisle, Petroleum Officer, Defence Dept., India.

WILSON, Peter Henry, Engineer, Bamag Limited. (*Dr. F. Kind ; H. E. Charlton.*)

APPLICATION FOR TRANSFER.

MASKELL, Laurence Ormes (Ass. Member). (*S. J. M. Auld ; E. A. Evans.*)

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