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MODERN METHODS OF MOTOR FUEL PRODUCTION.

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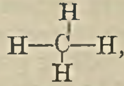
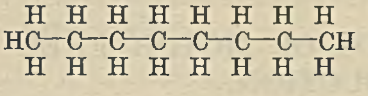
Hydrocarbons in Petroleum.

CRUDE petroleums, the materials that are the basis for such a variety of commercial products as motor fuels, kerosines, furnace oils, lubricants, waxes, fuel oils, and asphalts, are mixtures in various proportions of different gaseous, liquid, and solid hydrocarbons, each of which has its own density, boiling point, melting point, fluidity, combustion characteristics, and stability when heated. As the name *hydrocarbon* suggests, these various compounds consist of the element carbon, as represented by diamond, graphite, and coke, and the element hydrogen, which is the lightest known gas. In a compound, which is a substance characterized by definite values in regard to density, boiling point, melting point, viscosity (if a liquid), and crystal form (if a solid), each molecule, representing the smallest mechanically subdivisible particle of the material, is composed of a fixed number of atoms in a particular pattern or structural arrangement. To understand petroleum processes properly, one should have some knowledge of the various types of hydrocarbons, as well as information as to which types are found in petroleum oils and their refined products, and which types impart the most desirable properties to motor fuels, lubricants, and other petroleum products.

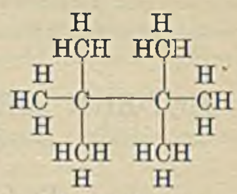
To form hydrocarbons, the element carbon, having the chemical symbol "C," and the element hydrogen, with the symbol "H," combine by virtue of their valences, or combining strengths, the valence of the hydrogen atom being taken as one. Since a carbon atom is able to combine with four hydrogen atoms to form methane, having the formula CH_4 and the presumed atomic arrangement  $H-\overset{H}{\underset{H}{C}}-H$, it has a valence of four. This compound, known as methane, is the principal constituent of natural gas. Some of the carbon atoms in hydrocarbons combine with hydrogen, and some with each other. Because carbon atoms can combine in this manner, it is possible to form a large number of molecules of different size and structure. In fact, almost every arrangement that can be indicated on paper represents a possible compound.

Molecules of hydrocarbons are said to be *saturated* when the carbon atoms are combined by just one of their four valences, and their remaining valences are absorbed by hydrogen atoms. When the carbon atoms in a saturated hydrocarbon are in rows, they form paraffins or alkanes. Some of these compounds have an extended structure, and others have a more compact arrangement, as indicated in the two formulæ given below:



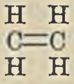
$$\begin{array}{cccccccc} \mathrm{H} & \mathrm{H} & \mathrm{H} & \mathrm{H} & \mathrm{H} & \mathrm{H} & \mathrm{H} & \mathrm{H} \\ \mathrm{HC}- & \mathrm{C}- & \mathrm{C}- & \mathrm{C}- & \mathrm{C}- & \mathrm{C}- & \mathrm{C}- & \mathrm{CH} \\ \mathrm{H} & \mathrm{H} & \mathrm{H} & \mathrm{H} & \mathrm{H} & \mathrm{H} & \mathrm{H} & \mathrm{H} \end{array}$$

Normal Octane.
Extended-chain structure.



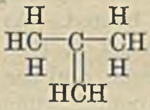
An *iso*-Octane.
Compact or branched-chain structure.

In some compounds there is not sufficient hydrogen to satisfy all valences of the carbon atoms, and adjoining carbon atoms exert more than one valence on each other. Such compounds are said to be *unsaturated* with respect to hydrogen, and are designated as olefins or alkenes. Typical olefin structures are shown below:



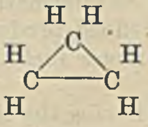
$$\begin{array}{cc} \mathrm{H} & \mathrm{H} \\ \mathrm{C} & {=}\,\mathrm{C} \\ \mathrm{H} & \mathrm{H} \end{array}$$

Ethylene.

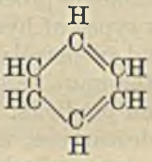


*iso*Butylene.

The compacting of carbon atoms may result in the formation of molecules having the so-called ring structure; these compounds are known as *cyclo*-paraffins and aromatics as represented in the formulæ given below:



*cyclo*Propane
(a *cyclo*paraffin).



Benzene
(an aromatic).

The properties of a hydrocarbon depend on the number of carbon atoms its molecules contain, the ratio of carbon to hydrogen atoms, and their positions with respect to each other. In general, as the carbon atoms increase in number, the relative density, boiling point, and melting point increase. This rule, however, applies only to compounds having similar structures. The compacting of a given number of hydrogen and carbon atoms influences the density and also the boiling point. The hydrogen deficiency in unsaturated hydrocarbons also affects their properties, sometimes in one direction, sometimes in another.

Refining of Petroleum.

The primary step in refining a crude petroleum involves its separation into portions, or *fractions*, having different boiling-point ranges. The crude oil is pumped through a coil of pipe disposed in a furnace, and the temperature of the oil is raised to about 500–700° F. The heated oil is then introduced into a *fractionating column*; and therein hydrocarbons having different boiling points separate or stratify so that the lower-boiling gaseous and gasoline hydrocarbons are recovered from the upper part of the column, while progressively higher-boiling fractions, such as kerosine, furnace oils, and lubricants, are recovered from lower exits, heavy liquid fuel oils or asphalts being drawn off as a residue. By this initial procedure a rough separation of groups of hydrocarbons is accomplished, and the properties of the different groups are the sum of the properties of the individual compounds present. Fig. 1 shows the general flow of charge and products in a primary fractionation of crude petroleum. The gasoline boiling-range fractions produced in the primary distillation of the great majority of crude petroleums are not suitable for use in high-compression automobile and airplane engines. These light fractions, boiling from about 100° to 400° F., are composed for the most part of saturated hydrocarbons of open and extended structures; and such compounds are notoriously bad "knockers" in high-compression engines. Engine tests with hydrocarbons of known structure have shown that, in general, the better types from an anti-knock standpoint are those having either an unsaturated character or a more compact molecular structure, or both. Such hydrocarbons, if present at all in the primary, or "straight-run," gasolines, are there in only minor amounts, so that knocking tendencies are principally determined by the hydrocarbons of a straight-chain saturated character.

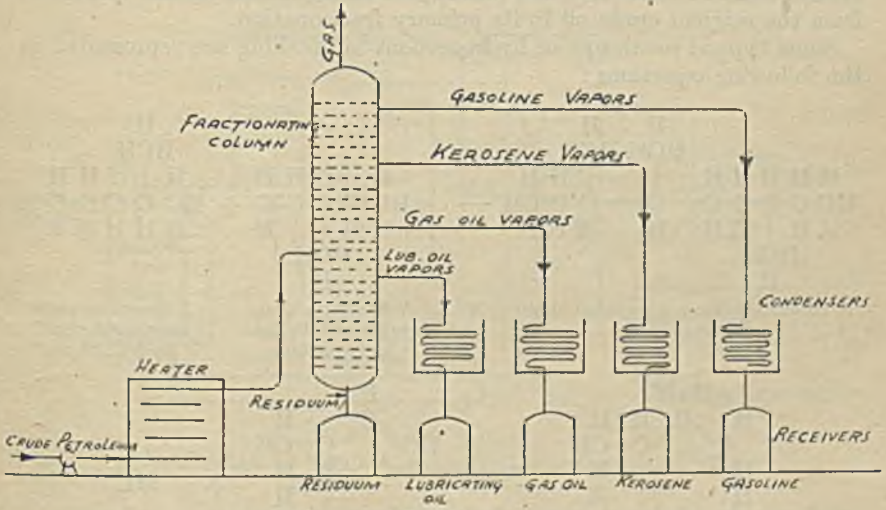


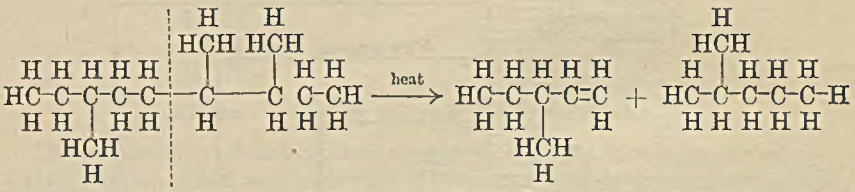
Fig. 1.

PRIMARY FRACTIONATION OF CRUDE PETROLEUM.

Cracking.

The major object in petroleum refining at the present time is the production of maximum yields of gasoline having high anti-knock properties, and lubricants for use in various types of machinery. The basic process utilized for increasing the yield of gasoline is the cracking process, in which the higher-boiling fractions from the primary crude petroleum distillation are heated to high temperatures to decompose large hydrocarbon molecules into smaller ones. As the carbon atoms in hydrocarbons increase in number, the molecules become more unwieldy and less stable; so that when they are heated at elevated temperatures and pressures for a time, they break down into smaller and more stable molecules having lower boiling points and constituting cracked gasoline. In the breaking-up of heavier molecules, hydrogen atoms are split off, carbon atom combinations are disrupted, and transient carbon–hydrogen groupings are recombined to form compounds having different properties. The net result is the production of both low-boiling unsaturated chain compounds and ring compounds, so that the anti-knock value of a cracked gasoline is practically always higher than that of the primary, or straight-run, gasoline produced from the original crude oil in its primary fractionation.

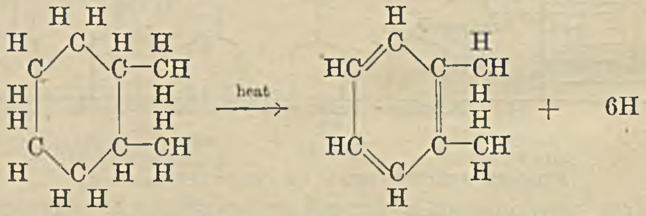
Some typical break-ups of hydrocarbons in cracking are represented in the following equations :



A 12-carbon-atom saturated chain hydrocarbon.

A 6-carbon-atom unsaturated chain hydrocarbon.

A 6-carbon-atom saturated chain hydrocarbon.



A 6-carbon-atom saturated ring hydrocarbon.

A 6-carbon-atom unsaturated ring hydrocarbon.

Hydrogen.

The first reaction involves a break between carbon atoms with a formation of two lower-boiling molecules, one saturated and the other unsaturated, while the second equation represents a typical dehydrogenation reaction. The net result of the two reactions is an improvement in the anti-knock values of the products, both because the compounds formed have lower boiling points and because they are unsaturated.

While the above two types of reactions are typical of those occurring during the cracking of hydrocarbons, other reactions of a more complicated character occur, corresponding in some instances to the complete degradation of the heavier molecules and separation of highly carbonaceous solids having the characteristics of coke. In the present discussion, emphasis is being placed on the rôle of cracking and auxiliary processes in producing hydrocarbons of higher anti-knock value, due to their more condensed structures. However, suitable motor fuels must also possess a definite volatility as shown by their boiling-point ranges, and must also have only small amounts of gum-forming components and sulphur. A detailed discussion of the total properties required in commercial motor fuels would be outside the scope of this paper.

Fig. 2 shows the flows in a typical commercial thermal cracking unit.[1] A topped crude (a residuum from a primary petroleum distillation) is introduced directly into a fractionating column, where it undergoes fractionation together with the cracked products. Cracked gasoline and a furnace oil are recovered from the upper portion of the column, while light- and heavy-oil fractions are withdrawn from the lower levels and pumped to separate heaters, wherein they are subjected to temperatures best adapted to their cracking. The combined products from the two heaters are passed to a reaction chamber, in which time is given for the cracking reactions to progress to an optimum point. The total cracked products are released into a flash-chamber at lower pressure, from which residual fuel oil is drawn, and the remaining vaporous products are sent to the fractionating column for further distillation. The gas mixture vented from the gasoline receiver contains many of the compounds used in synthetic processes, to be described later. These gases are essentially the lighter hydrocarbon fragments produced by the breaking down of large hydrocarbon molecules, and contain hydrogen and both paraffins and olefins.

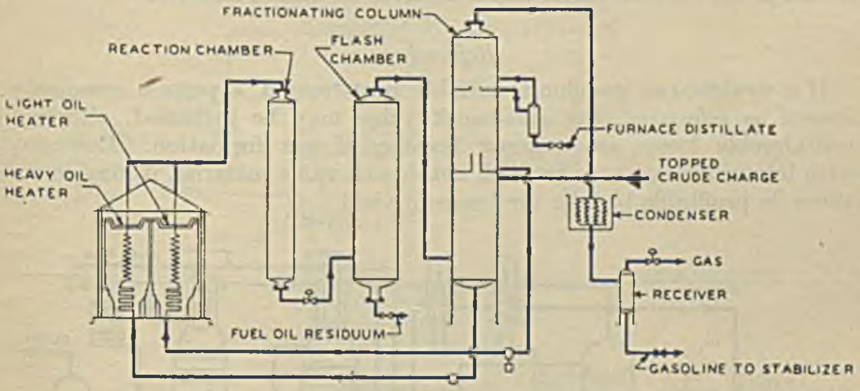


Fig. 2.

FLOW DIAGRAM OF TWO-COIL SELECTIVE DUBBS CRACKING UNIT.

As a result of the cracking of the higher-boiling fractions of petroleum not needed for other uses, the yield of gasoline, including both the straight-run and the cracked varieties, may be as high as 50 or 60 per cent. by volume of the original crude oil. Since the average crude oil contains about 25–30 per cent. of gasoline boiling up to 400° F., it is evident that the thermal cracking process doubles the yield of gasoline. Temperatures varying from about 850° to about 1000° F., and pressures varying from about 100 lb. to about 500 lb. per square inch, are used in most of these processes.

The applicability of the thermal cracking process to the production of gasoline is limited by the character of the hydrocarbons cracked, particularly their carbon-hydrogen ratios. By the best application of thermal cracking, a yield of 60–65 per cent. by volume of 70–75 octane-number motor fuel can be obtained. If attempts are made to increase the octane number by using more severe cracking conditions, such as higher temperatures, higher pressures, and longer times in processing, the yield of gasoline drops off. When less severe cracking conditions are used, higher yields may be obtained, but with correspondingly lower octane numbers.

The anti-knock values, or *octane numbers*, of gasolines are determined by comparing their knocking tendencies with mixtures of normal heptane, a knocking paraffin hydrocarbon which is given a zero rating, and *iso*-octane, a non-knocking paraffin hydrocarbon which is given a rating of 100. The percentage of *iso*-octane in the blend that knocks to the same extent as the gasoline under test is taken as its octane number.

Reforming.

If a straight-run gasoline is suitably heat-treated, a process commonly known as *reforming*, the anti-knock value may be increased, although considerable losses are suffered because of gas formation. However, with intensified demands for high anti-knock value material, it may sometimes be profitable to take the losses in yield.

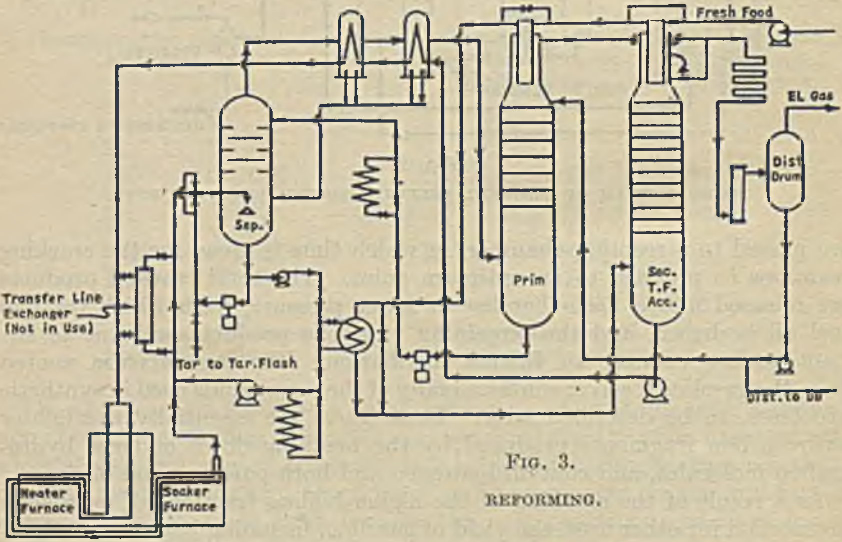


FIG. 3.

REFORMING.

Fig. 3 shows the flow in a commercial plant which is used for reforming a 300° F. end boiling-point gasoline to obtain very high anti-knock-value material for blending in aviation fuels.[2] The gasoline is preheated by passing it through heat exchangers positioned in the upper portions of successive fractionating columns. It is then introduced directly into the second column, wherein it undergoes fractionation with the products of the reforming process. The residual portions from the second column are then further preheated by heat exchange with the vapours from a tar separator, and the preheated charge is then divided and passed in parallel flow through a two-sectional heater, in which the temperature is raised to 1100° F. and the pressure maintained at 400 lb. per square inch. A plant of this character ran continuously for six months, during which time the octane number of a million 42-gallon barrels of gasoline was raised from 62 to 92. At the same time 90,000 barrels of liquid butylenes (four-carbon-atom olefin hydrocarbons) were produced, which were further processed to increase the gasoline yield.

The gases produced in the cracking and reforming process contain varying proportions of hydrogen, methane, and paraffin and olefin hydrocarbons containing two-, three-, and four-carbon atoms per molecule.

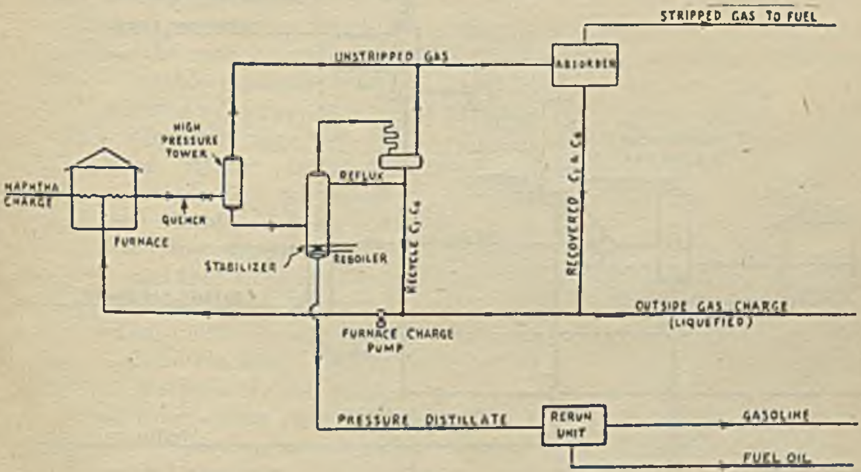


FIG. 4.

SCHEMATIC FLOW OF NAPHTHA–GAS REVERSION UNIT.

The gaseous paraffin hydrocarbons containing two-, three-, and four-carbon atoms per molecule include ethane (C_2H_6), propane (C_3H_8), and butanes (C_4H_{10}); and the gaseous olefins include ethylene (C_2H_4), propylene (C_3H_6), and butylenes (C_4H_8). Large amounts of the paraffins are present in natural gases, petroleum-distillation gases, and cracking process gases; and the last named contain important quantities of the olefins listed. When these gases are converted into liquid products, the yields of motor fuel from crude oils are considerably augmented. It has been found that when they are heated at high temperatures (above 1000° F.) and high pressures (300–500 lb. per square inch), they undergo decompositions and recompositions similar to those occurring in oil cracking, although the yields of liquid products are relatively low. An effective method for obtaining gasoline from hydrocarbon gases is to crack them together with naphthas which are being reformed to improve their anti-knock ratings.

Fig. 4 shows the flow in a plant designed to reform naphtha (in this case a gasoline fraction) and, at the same time, convert a mixture of hydrocarbon gases consisting principally of three- and four-carbon-atom paraffins into liquid hydrocarbons (gas-reversion).[4] The naphtha is partly cracked in passing through the primary heater section. The separately heated hydrocarbon gas is then introduced into the stream of naphtha, and the mixture is finally heated at an increased temperature to complete the naphtha-reforming and gas-cracking reactions. After a relatively cool quench oil is introduced to arrest the conversion reactions, the products are fractionated in distilling and absorbing equipment to recover gasoline, and undecomposed three- and four-carbon-atom hydrocarbons are recycled for further conversion treatment.

Fig. 5 shows a modified flow for simultaneous naphtha reforming and gas conversion in which the naphtha charge is first used as an absorbing oil to take up the more soluble three- and four-carbon-atom hydrocarbons in the process gases and carry them in solution to the heating unit, while a cooled intermediate gas-oil fraction is used to absorb similar gases from an outside gas charge and then used as a quenching medium.[4] The more soluble three- and four-carbon-atom hydrocarbons are thus introduced to the plant, and later converted together with the naphtha. The desired gasoline product is recovered from the bottom of the stabilizer, from the top of which gases are passed to the primary naphtha absorber. From this final step light gases are vented as residue gas, since they are of little value in the production of gasoline.

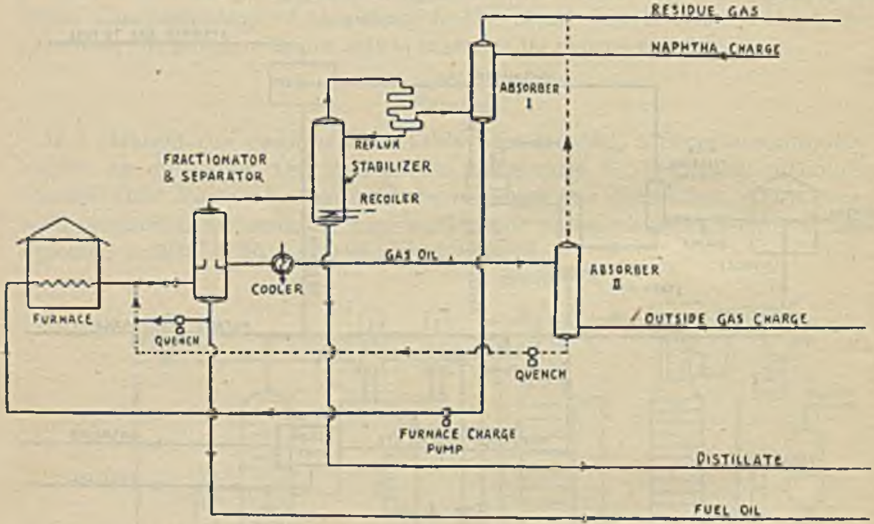


Fig. 5.

SCHEMATIC FLOW OF NAPHTHA POLYFORM UNIT.

Catalytic Cracking.

The processes thus far described are of a purely thermal character, depending on the use of temperature, pressure, and time in suitable relationships for their successful operation. At the present time increasing use is being made of *catalysts* to accelerate various hydrocarbon conversion reactions in the direction of increased yields and improved qualities of products. The word catalyst comes from a Greek verb meaning literally to "loosen up," and refers to the fact that small amounts of certain materials introduced into a reaction zone markedly speed up the reactions. Catalytic materials used in hydrocarbon processes are usually innocent-looking powders or granules which exemplify the old adage "a little bit goes a long way"; for when they are present in relatively small amounts in a conversion process, the conversions take place more rapidly, and temperature, pressure, and time can all be reduced to get the same effects. When the reactions are completed, the catalyst has usually undergone no perceptible change; and how it performs its function is still a matter of dispute among scientists.

Much experimenting was done in attempts to find catalysts that would increase the rate of the more desirable reactions occurring in cracking before suitable materials were found, since there are practically no rules for predicting what type of catalyst will accelerate a given reaction. Metals, oxides, sulphides, salts, ores, and earths were all tried with varying degrees of success. At the present time the best materials appear to be certain types of clays and manufactured aluminium silicates or composites of silica and alumina. Such materials can be made porous and absorbent; they are refractory at the high temperatures employed in cracking processes; and they function for a long time without too great loss in activity. Furthermore, they "loosen up" the cracking reactions so that types of low-boiling molecules are formed that are different from those formed in non-catalytic cracking; and it has been found that higher octane-number cracked gasolines are obtainable.

Catalytic cracking processes in a sense supplement the strictly thermal processes employing no catalysts. The cracking processes, both thermal and thermal-catalytic, are still the principal processes used for increasing the yield of gasoline from petroleum. The development of these processes in their present degree of commercial efficiency has been due to the combined efforts of the research chemists and engineers of many organizations, such as the Universal Oil Products Co., and the large oil refiners.

The catalyst may be used in different ways to accelerate and give direction to cracking reactions. In the earliest-devised and perhaps the simplest method of operation, the catalyst in the form of small granules or pills is placed in the reaction chamber following the tubular heating element, and the preheated oil vapours are passed through the stationary bed of catalyst particles, usually in a downward direction. Carbon and tarry substances are slowly deposited on the catalyst particles as cracking proceeds; and as their surfaces gradually become coated with these materials, they become less active and the reactions revert to those of a strictly thermal character. When such a point is reached, the oil vapours are diverted into an auxiliary chamber containing clean catalyst, and the carbon-coated particles in the other chamber are contacted with heated air to burn off carbonaceous material from their surfaces and restore their activity for further use.

This method is illustrated in Fig. 6, which shows the essential flow in such a "fixed-bed" catalytic cracking plant.[5] A gas-oil charge is preheated by exchange with the cracked products from the catalyst towers, is vaporized, and is heated to catalytic cracking temperature during passage through a pipe heater; then it is passed alternately through one or the other of two towers containing granular catalyst particles to effect the production of high-anti-knock-value gasoline. A fractionating column and a stabilizer for removing any excess of dissolved gaseous hydrocarbons complete the plant.

In an improved commercial modification of the catalytic cracking process, known as the "fluid process," the catalyst is employed in the form of a very fine powder, which is carried upward in a stream of heated oil vapours during their passage through a reactor in which cracking takes place. The carbonized powder is separated by settling in an enlarged chamber, assisted by centrifugal or electrical influences, and the cracked products are fractionated to recover gasoline and other cracked products. For the decarbonization of the separated catalyst powder, it is carried upward in a stream of heated air through a regeneration zone, and then separated and re-used for further cracking. This process can be operated continuously without shifting the stream of oil vapours from one reactor to another as in the fixed-bed operation.

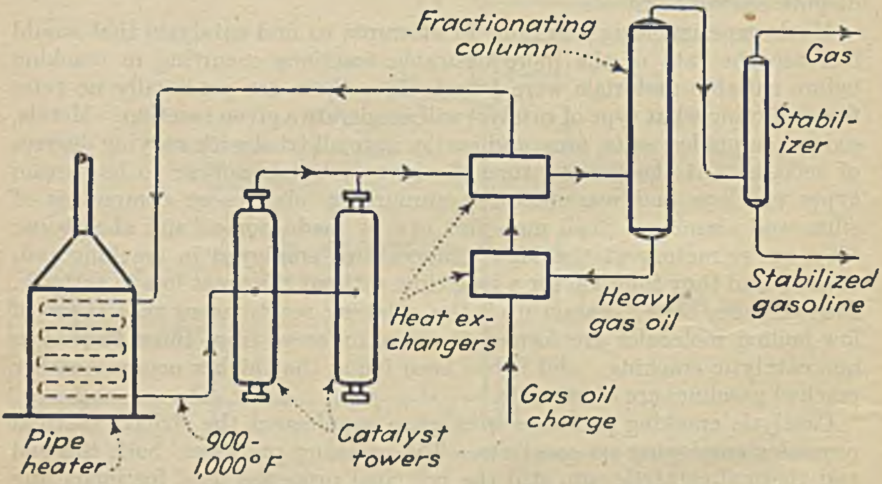


FIG. 6.

CATALYTIC CRACKING OF GAS-OIL STOCKS BY THE STATIC BED PROCESS.

Fig. 7 shows the essential flow of a process of this character, with the exception of the fractionating equipment.[3] In still another modification of the catalytic cracking process, a mass of granular catalyst particles moves downward through the cracking zone, counterflow to a rising stream of heated oil vapours. The carbonized particles are separated and elevated by mechanical conveyers, after which they move downward countercurrent to a rising stream of heated air in a regenerator. They are then separated from the combustion gases and conveyed back to the top of the reactor to complete their cycle and make possible continuous operation.

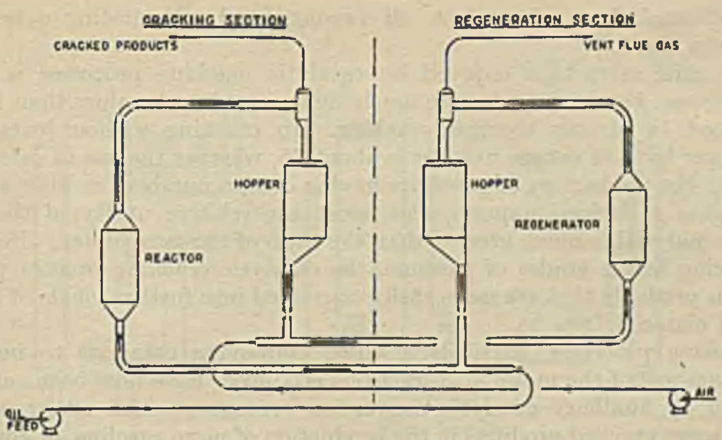


Fig. 7.
CATALYST FLOW IN FLUID CRACKING PROCESS.

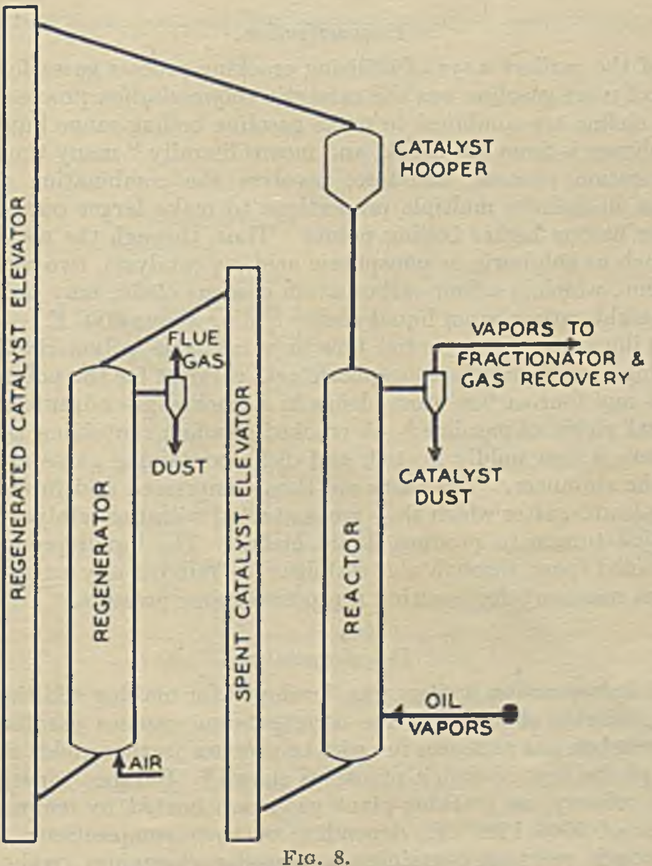


Fig. 8.
MOVING BED CATALYTIC CRACKING PROCESS.

The essential flows of catalyst, oil vapours, and regenerating gases are shown in Fig. 8.[7]

The chief advantage enjoyed by catalytic cracking processes is that gasoline can be obtained having much higher anti-knock values than those produced in strictly thermal cracking. In cracking without catalysts the upper limit of octane number is about 75, whereas the use of catalysts permits the production of gasolines having octane numbers as high as 90, this being a decided improvement, since the relative utility of the 90-octane material is much greater than the ratio of the two values. Besides producing better grades of gasoline, the catalytic cracking process yields gaseous products that are more easily converted into further yields of high-octane material.

Cracking processes, particularly those employing catalysts to modify the character of the motor-fuel fractions produced, have now been supplemented by auxiliary catalytic conversion processes, which either utilize the gaseous cracked products in the production of more gasoline, or convert primary or cracked gasoline fractions into higher anti-knock value materials. Some of these processes will now be reviewed.

Polymerization.

One of the earliest ways of utilizing cracking process gases for the production of more gasoline was the catalytic *polymerization* process, in which gaseous olefins are combined to make gasoline boiling-range liquids. The word polymer is from the Greek, and means literally " many times." The polymerization process, therefore, involves the combination of several molecules in definite multiple proportions to make larger ones of similar character having higher boiling points. Thus, through the use of certain acids, such as sulphuric or phosphoric acid, as catalysts, two molecules of a butylene, which is a four-carbon-atom gaseous olefin, may be combined to form eight-carbon-atom liquid olefins boiling above 200° F.

Fig. 9 illustrates the essential flow in a catalytic polymerization plant employing a solid granular phosphoric acid catalyst for the polymerization of three- and four-carbon-atom olefins in a cracked-gas mixture to produce additional yields of gasoline.[5] A cracked gasoline containing such olefins in solution is first mildly heated, and olefin-containing gases are distilled out of the stabilizer. The gases are then compressed and forced through the pipe-heater, after which they are contacted with the catalyst in a series of catalyst towers to produce liquid olefins. The liquid products, after being cooled, pass through the stabilizer to remove any excess of gases over that necessary for assuring a proper vapour pressure.

Dehydrogenation.

The *dehydrogenation* process was developed for making additional yields of polymerizable olefins from the corresponding gaseous paraffins present in hydrocarbon gas mixtures in order to produce further yields of gasoline. In Fig. 10 the flow of such a process is shown.[6] Butanes separated from natural, refinery, or cracking-plant gases are heated to temperatures of the order of 1000–1100° F., depending on their composition; they then pass through reactors containing a granular chromium oxide catalyst,

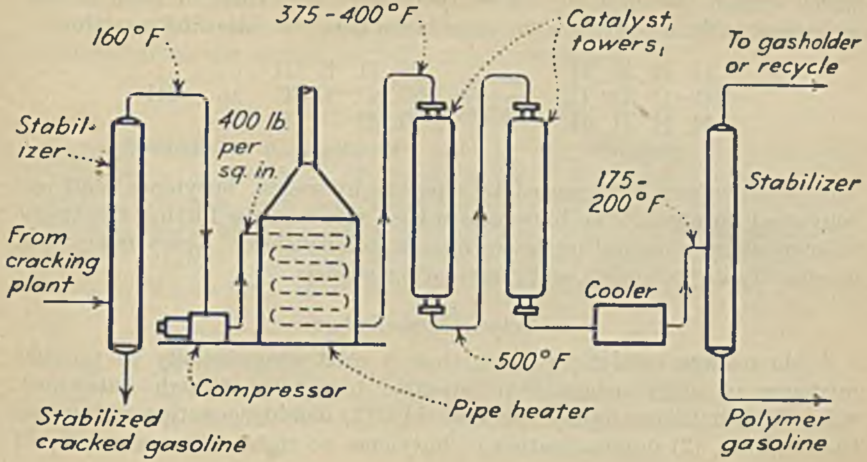


FIG. 9.

FLOW SHEET FOR CATALYTIC POLYMERIZATION OF REFINERY GASES.

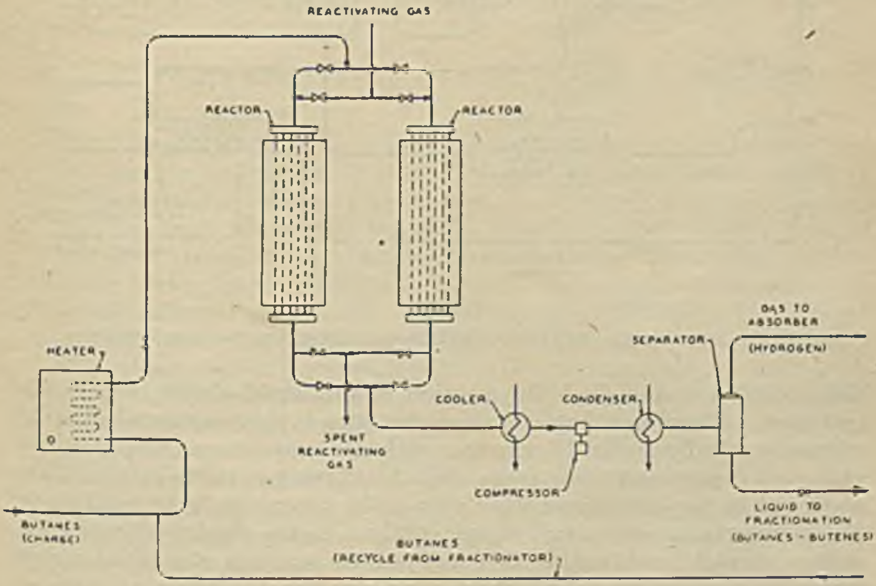
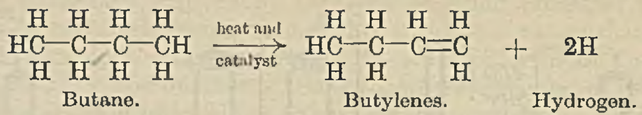


FIG. 10.

CATALYTIC DEHYDROGENATION PROCESS.

which causes the splitting off of two atoms of hydrogen from butane molecules to form butylenes, in accordance with the following equation:



$$\underset{\text{Butane.}}{H\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}H} \xrightarrow[\text{catalyst}]{\text{heat and}} \underset{\text{Butylenes.}}{H\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{C}=\overset{H}{\underset{H}{C}}} + \underset{\text{Hydrogen.}}{2H}$$

The products are fractionated to separate hydrogen, butylenes, and unconverted butanes. The butanes are then returned for further treatment to bring about a high ultimate conversion to butylenes. Reactors are used alternately in processing and reactivating periods.

iso-*Octane Manufacture.*

A three-stage catalytic process that is used commercially to produce mixtures of eight-carbon-atom paraffins (octanes) of high anti-knock value from butanes employs, successively, (1) dehydrogenation of butanes to butylenes, (2) polymerization of butylenes to eight-carbon-atom liquid olefins (octenes), and (3) hydrogenation of the liquid olefins to paraffins (octanes). The process flow in a plant operating in this manner is indicated diagrammatically in Fig. 11, together with the temperatures and pressures employed in successive conversion steps.[6] Chromium oxide catalysts are employed in the dehydrogenation step, solid phosphoric acid catalyst in the polymerizing steps, and nickel catalyst in the final hydrogenation steps. Careful fractionation is employed to separate the unconverted materials for recycling to gain further contact with the catalysts, in order to assure the highest possible yields of the octanes. As indicated in the diagram, the highest octane-number product is produced from the more

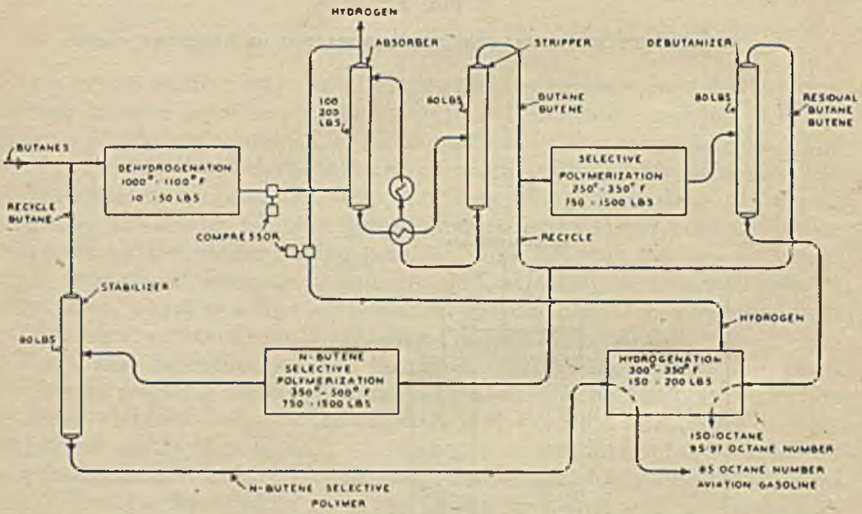


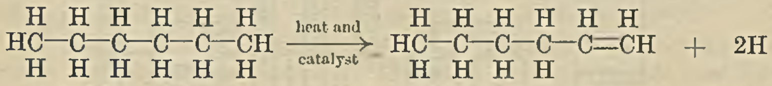
Fig. 11.

ISO-OCTANE PROCESS VIA DEHYDROGENATION–POLYMERIZATION–HYDROGENATION.

readily polymerized olefin, *iso*butylene, which, on account of its branched structure, yields polymers of more highly branched structure than those produced from the normal or unbranched butylenes.

Hydroforming.

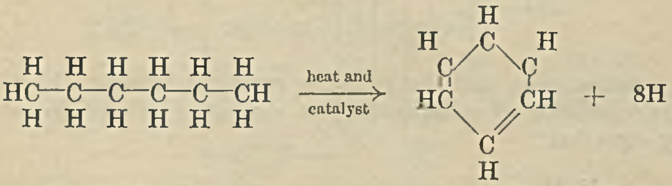
Several catalytic processes are used to convert open-chain saturated hydrocarbon constituents of gasolines into closed-chain hydrocarbons, and thereby raise their anti-knock values. When an open-chain hydrocarbon having at least six carbon atoms in a row is contacted with a dehydrogenation catalyst, such as chromium oxide, under mild conditions of temperature and for a short time, two hydrogen atoms may be split off, thus :



$$\begin{array}{c}\mathrm{H\;\;H\;\;H\;\;H\;\;H\;\;H}\\ \mathrm{HC{-}C{-}C{-}C{-}C{-}CH}\\ \mathrm{H\;\;H\;\;H\;\;H\;\;H\;\;H}\end{array} \xrightarrow[\text{catalyst}]{\text{heat and}} \begin{array}{c}\mathrm{H\;\;H\;\;H\;\;H\;\;H\;\;H}\\ \mathrm{HC{-}C{-}C{-}C{-}C{=}CH}\\ \mathrm{H\;\;H\;\;H\;\;H}\end{array} + 2\mathrm{H}$$

Paraffin (hexane). Olefin (hexene). Hydrogen.

If, however, higher temperatures and longer times are used, the removal of hydrogen rapidly progresses until eight hydrogen atoms are lost, and a compound of ring structure is formed, thus :



Paraffin (hexane). Aromatic (benzene). Hydrogen.

The formation of the ring-structure hydrocarbons corresponds to a great increase in anti-knock value, and so open-chain hydrocarbons or gasoline fractions containing them (and in consequence having knocking properties) may be treated by contacting them with chromium oxide catalysts at temperatures of the order of 1000–1100° F. to obtain hydrocarbons having higher anti-knock values. This process is known as *dehydrocyclization* or *cycloversion.* When the cyclization process is applied to certain gasolines or naphthas, the activity of the catalysts may diminish rapidly, on account of the separation of carbon or heavy tars accompanying extensive decompositions. As a means for overcoming this difficulty, it has been found that, if a certain amount of hydrogen is mixed with the vapours of the oils being dehydrogenated, the character of the decomposition reactions is modified and the activity of the catalyst is maintained over longer periods. This process, which is essentially reforming in the presence of added hydrogen, is known as the *hydroforming* process, and the usual process flow employed is indicated in Fig. 12.[3] Parallel reactors containing granular catalysts are used so that the mixture of oil vapours and hydrogen may be passing through one, while catalyst in the other is being reactivated by burning off carbon deposits accumulated during a period of service. Hydrogen is separated and recycled, and the hydrocarbon products are fractionated into butanes and light and heavy liquid hydrocarbon fractions. The final solvent-extraction step shown in the diagram is employed to concentrate aromatic hydrocarbons when this is desirable. The hydroforming process is most frequently applied to straight-run gasoline fractions comprising principally paraffin and *cyclo*paraffin hydrocarbons, and the principal reactions brought about involve the dehydrogenation of *cyclo*paraffins to aromatics as represented in the following equation :

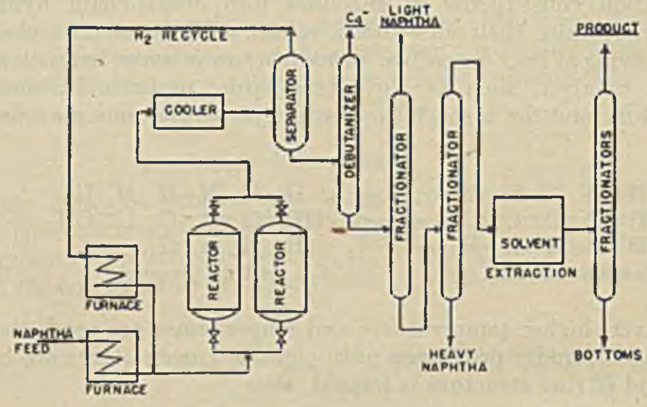
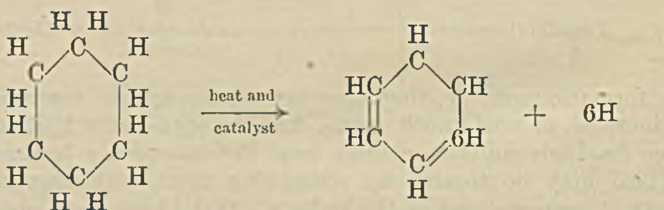


FIG. 12.

HYDROFORMING PROCESS.

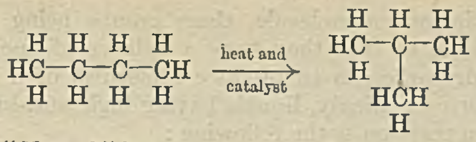


*cyclo*Paraffin (*cyclo*hexane). Aromatic (benzene). Hydrogen.

A certain amount of ring-compound formation occurs, however, as a result of the dehydrocyclization of the paraffins. The catalysts used in hydroforming processes usually contain molybdenum oxide.

Isomerization.

A means for producing gasoline of improved octane number from both hydrocarbon gases and hydrocarbon liquid fractions is the *isomerization* process, in which the structure of paraffin hydrocarbon molecules is altered in the direction of increased compactness. This type of hydrocarbon conversion reaction is exemplified by that occurring when normal butane is contacted with certain catalysts, such as aluminium chloride, thus :



$$\begin{array}{cccc} \mathrm{H} & \mathrm{H} & \mathrm{H} & \mathrm{H} \\ \mathrm{HC} & -\mathrm{C} & -\mathrm{C} & -\mathrm{CH} \\ \mathrm{H} & \mathrm{H} & \mathrm{H} & \mathrm{H} \end{array} \xrightarrow[\text{catalyst}]{\text{heat and}} \begin{array}{ccc} \mathrm{H} & \mathrm{H} & \mathrm{H} \\ \mathrm{HC} & -\mathrm{C}- & \mathrm{CH} \\ \mathrm{H} & | & \mathrm{H} \\ & \mathrm{HCH} & \\ & \mathrm{H} & \end{array}$$

"Normal" butane. "*iso-*" butane.

The normal, or straight-chain, structure of carbon atoms is changed by isomerization catalysts into an "*iso*," or branched-chain, structure, without any change in the number of carbon and hydrogen atoms in the molecule. The word isomer is also Greek, and means literally "same parts." Several advantages accrue from the transformation: (1) the boiling point is lowered; (2) the anti-knock value is improved; (3) the "*iso*" compounds are more reactive with other hydrocarbons, so that more hydrocarbons can be built up or synthesized from them.

The isomerization process is most readily utilized to convert normal butane into *iso*butane, and Fig. 13 shows a simple plant flow for the purpose.[3] Thus normal butane, separated from natural gas, still gases, or cracked gases by distillation, is passed through a heater to raise its temperature to about 250° F., and then passed through a reactor containing granular isomerizing catalyst. Hydrogen chloride (HCl) gas is supplied in small quantity to assist in the conversion.

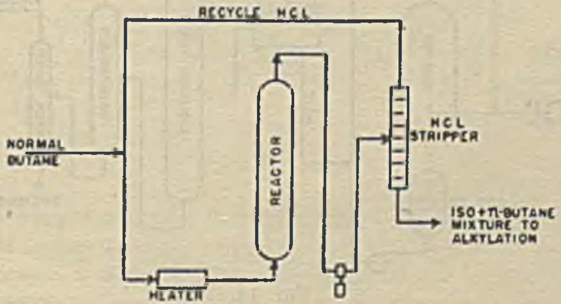


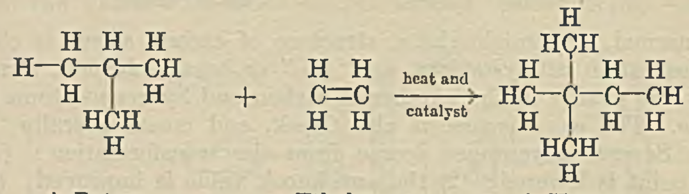
FIG. 13.

ISOMERIZATION OF *N*-BUTANE.

The isomerization process can be used to a limited extent in the treatment of liquid hydrocarbon fractions to improve their anti-knock values. It can be applied best to low-boiling liquid fractions containing only saturated hydrocarbons—*i.e.*, paraffins and *cyclo*paraffins. When unsaturated hydrocarbons such as olefins and aromatics are present, even in small amounts, they may react with and damage the catalyst so that it ceases to function soon after the process has started.

Alkylation.

The principal value of the isomerization process is in the production of *iso*butane from normal butane, since the reactivity of *iso*butane permits its *alkylation* by olefins to produce liquid hydrocarbons of extremely high anti-knock ratings. The alkylation process involves the joining of alkyl groups to a hydrocarbon molecule, these groups being paraffins minus one hydrogen atom, so that they have a valence of one. The effect of alkylating a hydrocarbon is to produce molecules of a highly compact structure and, correspondingly, liquids having high anti-knock ratings. A typical alkylation reaction is the following:



$$\begin{array}{c} \mathrm{H\ \ H\ \ H} \\ \mathrm{H{-}C{-}C{-}CH} \\ \mathrm{H\ \ |\ \ H} \\ \mathrm{HCH} \\ \mathrm{H}\end{array} + \begin{array}{c}\mathrm{H\ \ H}\\ \mathrm{C{=}C}\\ \mathrm{H\ \ H}\end{array} \xrightarrow[\text{catalyst}]{\text{heat and}} \begin{array}{c} \mathrm{H}\\ \mathrm{HCH}\\ \mathrm{H\ \ |\ \ H\ \ H}\\ \mathrm{HC{-}C{-}C{-}CH}\\ \mathrm{H\ \ |\ \ H\ \ H}\\ \mathrm{HCH}\\ \mathrm{H}\end{array}$$

*iso*Butane (a gaseous paraffin). Ethylene (a gaseous olefin). *iso*Hexane (a liquid paraffin).

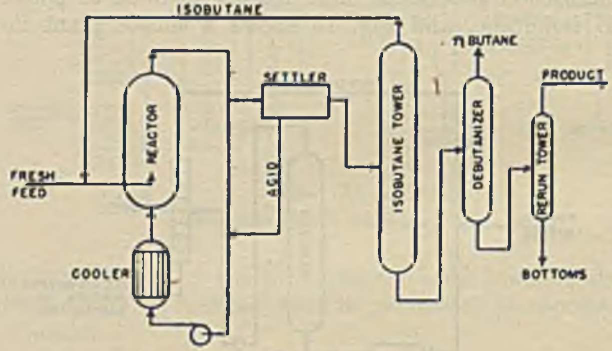


FIG. 14.

ALKYLATION PROCESS.

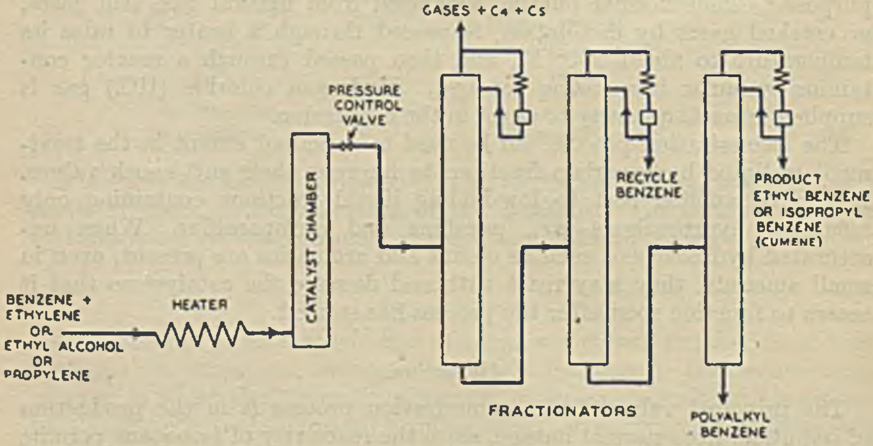
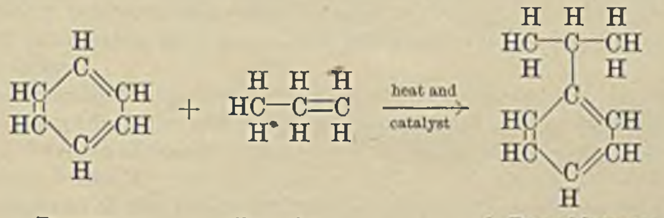


FIG. 15.

PROCESS FOR ALKYLATION OF AROMATICS.

Although *iso*butane can be alkylated by olefins at elevated temperatures without using catalysts, better results are obtained at lower temperatures when acids are employed to catalyze the reactions. Fig. 14 gives a simple process flow employed in alkylating *iso*butane to produce liquid gasoline hydrocarbons.[3] The feed is a proportioned mixture of *iso*butane and an olefin such as ethylene, propylene, or a butylene. A liquid acid is thoroughly mixed with the hydrocarbons in the reactor; the acid is allowed to separate from the hydrocarbons in a settler, and is returned to the reactor; and the hydrocarbon products are fractionated to recover unreacted *iso*butane for recycling, normal butane for isomerization, and the desired liquid *iso*paraffin product.

The alkylation process can also be applied to aromatic hydrocarbons to produce hydrocarbons valuable as motor-fuel constituents and in synthetic-rubber manufacture. A typical process of this character consists in alkylating benzene with propylene, thus:



Benzene. Propylene. *iso*Propyl benzene (cumene).

*iso*Propyl benzene has a very high anti-knock value in aviation gasoline mixtures and is better than benzene in such fuels.

Fig. 15 indicates a process flow applicable to the accomplishment of the above reaction.[7]

A mixture of an aromatic hydrocarbon, such as benzene and a compound capable of forming an alkyl group, is passed through a preliminary heater and through a catalyst chamber wherein the reaction of alkylation occurs. The products from the catalyst chamber are released through a pressure-control valve and fractionated in a stepwise manner. In the first step light gases are removed, in the second step unreacted benzene is taken overhead, and in the third step the desired alkylated product is recovered. The separated gases and the benzene may be returned to the primary stage of the process for further reaction.

The foregoing discussion has endeavoured to indicate the types af hydrocarbons which give the best anti-knock properties to a motor fuel and to develop briefly some of the processes employed in petroleum refining to produce the more desirable hydrocarbon types. In such a limited treatment it is not possible to include many details which are more or less common practice in the commercial operation of the various processes discussed. However, it is felt that the discussion will give some idea of the character of present-day petroleum refining processes which are aimed at improving both the quantity and the quality of internal-combustion engine fuels. Such processes are in a continual state of flux, and those that are in operation at the present time may become obsolete a few years hence, owing to the rapid progress of chemical and engineering research. In any event it is certain that processes will always be available for producing fuels for whatever improved types of engines may be developed.

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[6] Berkman, Morrell, and Egloff, "Catalysis" (Reinhold Pub. Co.), p. 1031, dehydrogenation flow; p. 1035, *iso*-octane process flow.

[7] C. R. Wagner, *Oil Gas J.*, 25.3.43, **41** (46), 82.

THE CORRELATION OF CETANE NUMBER WITH OTHER PHYSICAL PROPERTIES OF DIESEL FUELS.

Report by the Diesel Index Panel of Standardization Sub-Committee No. 4—Gas, Diesel and Fuel Oils.

INTRODUCTION.

THE problem of correlating the cetane number of a diesel fuel with other physical properties is one of some importance, as has been recognized by the introduction of a considerable number of formulæ designed to permit the assessment of ignition quality. The present lack of general engine-test facilities serves to accentuate the desirability of obtaining a reliable relationship between cetane number and any of the more easily determined physical properties, such as aniline point, specific gravity, viscosity, and boiling range.

It is generally recognized that, as a rule, cetane number increases with increased paraffinicity, and since the physical properties mentioned above are all related to chemical structure, it was a logical step to look for some correlating formula.

The purpose of this paper is to report the work carried out by the Diesel Index Panel of I.P. Sub-committee No. 4. The Panel has reviewed such correlation methods or formulæ as have been put forward from time to time with a view to determining what degree of accuracy can be expected by the calculation of cetane number as opposed to actual engine determination.

IGNITION QUALITY FORMULÆ.

The first accepted formula correlating ignition quality of a diesel fuel with other physical properties was the so-called "diesel index" (Becker and Fischer, *J. Soc. Aut. Engrs*, Oct. 1934, p. 376), which expressed a relationship between the product of the A.P.I. gravity and aniline point, and ignition quality.

$$\text{(1) Diesel Index} = \frac{\text{A.P.I. Gravity} \times \text{Aniline Pt. (° F.)}}{100}.$$

Since this relationship was formulated, a considerable improvement has taken place in the technique of cetane-number determination, and although diesel index is still widely used, it is recognized as being only a rough guide to actual ignition quality.

Since the introduction of diesel index, many other formulæ have been suggested, among which may be mentioned:

$$\text{(2) Calculated Cetane No.} = \frac{\text{Diesel Index} \times \text{Mid. Boiling Pt. (° F.)}}{790} + 13$$

(Esso Laboratories Research Division, Linden, N.J.).

(3) Esso Laboratories Research Division chart relating cetane number with A.P.I. gravity and mid-boiling point, or viscosity (Fig. 1).

(4) Calculated Cetane No. $= \dfrac{\text{Mid-Boiling Pt. (° C.)}}{5 \times (\text{S.G.})^4} - 56$

(Anglo-Iranian Oil Co.).

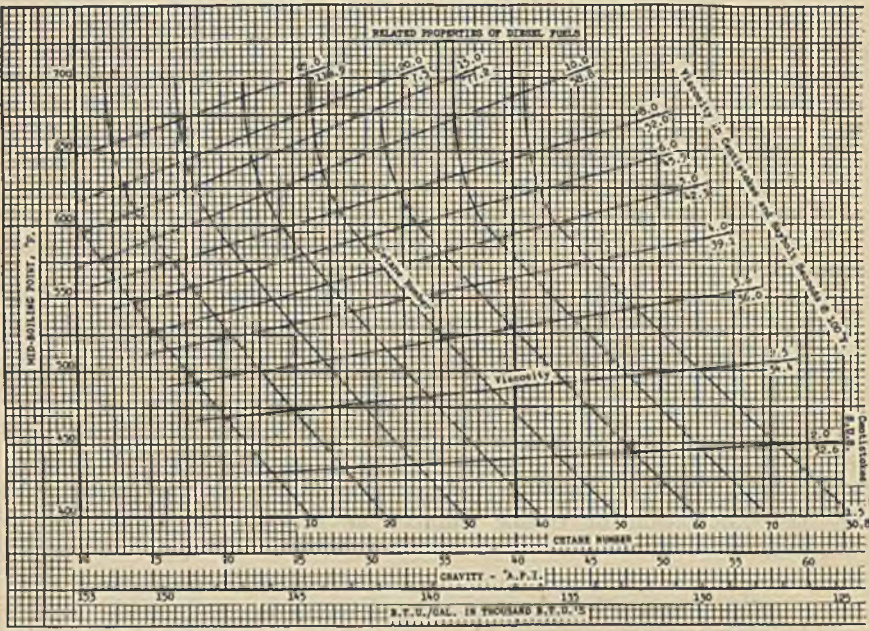


Fig. 1.

RELATED PROPERTIES OF DIESEL FUELS.

It will be seen that the above formulæ differ from the diesel index formula in that mid-boiling point is included—that is, the temperature in the I.P. distillation test at which 50 per cent. of the sample has distilled over.

Sub-Committee No. 4 of the Institute of Petroleum recently conducted an investigation into these and other correlation methods to determine with what accuracy cetane numbers could be predicted. At the same time it was hoped to produce an improved formula or chart which would give better results than any of the expressions hitherto suggested. The data on which this work was based were obtained on sixty-two samples which had been examined over the last three years in the Standard Inspection Laboratory's monthly diesel check sample programme, and these data were later extended by the inclusion of information concerning eleven samples tested by Shell, and ten by the Anglo-Iranian Oil Co. Nineteen samples on which data had previously been published by Schweitzer and Hetzel (*J. Soc. aut. Engrs*, 1936, **38,** p. 206) were also included.

A modification to equation (2) above was suggested by Esso European Laboratories, and this formula was also considered, viz. :

$$\text{Calculated Cetane No.} = \frac{\text{Diesel Index} \times \text{Mid-Boiling Pt. } (^\circ\text{ F.})}{810} + 14.$$

A further modification which was included in the work was obtained by revising the chart shown in Fig. 1, the new proposed version of which is shown in Fig. 2.

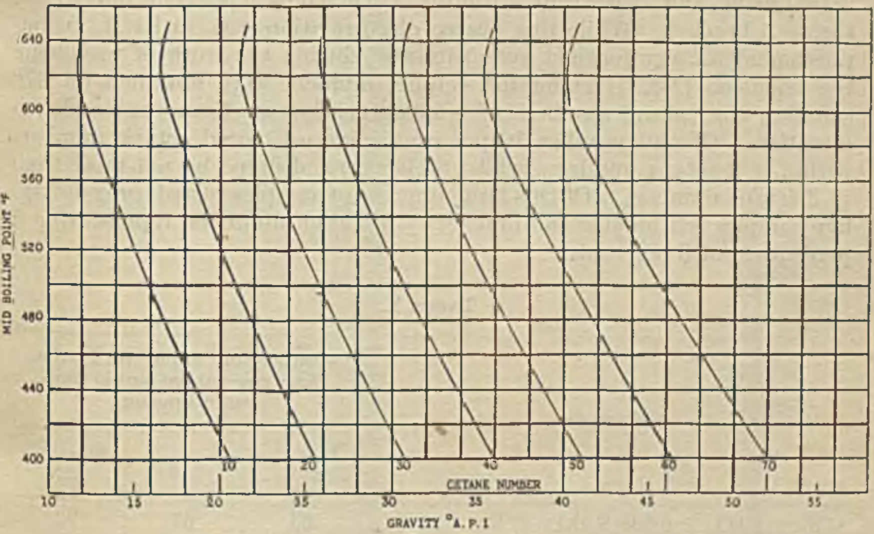


FIG. 2.

RELATED PROPERTIES OF DIESEL FUELS.

In connection with the work of Sub-Committee No. 4, the following formula was suggested as being simple and fairly accurate :

(5) Calculated Cetane No. $= \frac{2}{3}$ Diesel Index $+ 14$.

This formula was found to give reasonably good results, but a modification, again incorporating the mid-boiling point, was found to be an improvement, and did, in fact, give the best results of any formula so far investigated :

(6) Calculated Cetane No. $= \frac{2}{3}$ Diesel Index $+ 0{\cdot}068$ Mid-Boiling Pt. (° F.) $- 22$
(Esso European Laboratories).

This formula can be applied graphically or by the use of the alignment chart shown in Fig. 3.

Even with this formula, however, in only two-thirds of the cases examined could the cetane number be predicted within ± 3 cetane numbers. In other words, for three cetane-number predictions made on fuels selected at random, it is to be anticipated that two will be between ± 3 cetane numbers, whilst the third result will be outside this bracket.

Consequent on the work of the Diesel Index Panel, Esso Laboratories Research Division evolved a further equation, again correlating cetane number with mid-boiling point and A.P.I. gravity in the following way :

(7) Calculated Cetane No. = 175·4 Log (Mid-Boiling Pt., ° F.) + 1·98 (A.P.I. Gravity) − 496.

This formula was applied to the data already considered by the Sub-Committee, and, as will be seen from Table I, 60 per cent. of the samples showed a calculated cetane number within ± 2 cetane numbers of the actual value, and 77 per cent. within ± 3, while only 6 per cent. fell outside the ± 5 bracket. While this degree of correlation was, in itself, an improvement on any formula yet examined, during the work of producing the equation (No. 7) estimated cetane numbers were obtained on 579 samples, the cetane numbers of which were known from engine determination. Of this number 70 per cent. gave estimated cetane numbers within ± 2 cetane numbers, whilst 83 per cent. differed by not more than ± 3 cetane numbers. Of this large number of samples tested, only thirty-five samples fell outside the bracket ± 5 cetane numbers, representing a percentage of 6 per cent.

TABLE I.

Formula.	Accuracy of Cetane No. Prediction; percentage within indicated bracket.		
	± 2.	± 3.	Outside ± 5.
C.N. = $\frac{2}{3}$ D.I. + 0·068 M.B.Pt. (° F.) − 22 .	53	67	92
Modified Esso Lab. chart :			
C.N. v. ° A.P.I. and M.B.Pt. (° F.) (Fig. 2) .	45	67·5	92
C.N. = $\frac{2}{3}$ D.I. + 14	45	60	87
C.N. = $\frac{\text{D.I.} \times \text{M.B.Pt. (° F.)}}{810} + 14$ . .	39	63	92
Esso Lab. chart :			
C.N. v. ° A.P.I. and M.B.Pt. (° F.) (Fig. 1) .	34	52	84
C.N. = $\frac{\text{D.I.} \times \text{M.B.Pt. (° F.)}}{790} + 13$ . .	23	5	82
Esso Lab. chart :			
C.N. v. ° A.P.I. and viscosity	24·5	45	67
C.N. = D.I.	42	53	72
C.N. = $\frac{2}{3}$ D.I. + 0·068 M.B.Pt. (° F.) − 0·685 ° A.P.I. + 10·5	41·5	61	91·5
C.N. = 0·18 × ° A.P.I. − 10·5 . . .	10·5	17·5	—
C.N. = 0·372 A.P. − 7 (A.P. = Aniline Pt. ° F.)	40	53	82
C.N. = $\frac{\text{M.B.Pt. (° C.)}}{5 \times (\text{S.G.})^4} - 56$ (Anglo-Iranian Oil Co.)	29	39	69
C.N. $\propto \frac{TA}{S^2}$ (T = M.B.Pt., A = Aniline Pt., S = Spec. Grav.)	34	54·5	80
C.N. $\propto \frac{TA}{S^4}$	32	59	84
C.N. = 175·4 Log (M.B.Pt., ° F.) + 1·98 (A.P.I. Gravity) − 496	60	77	94

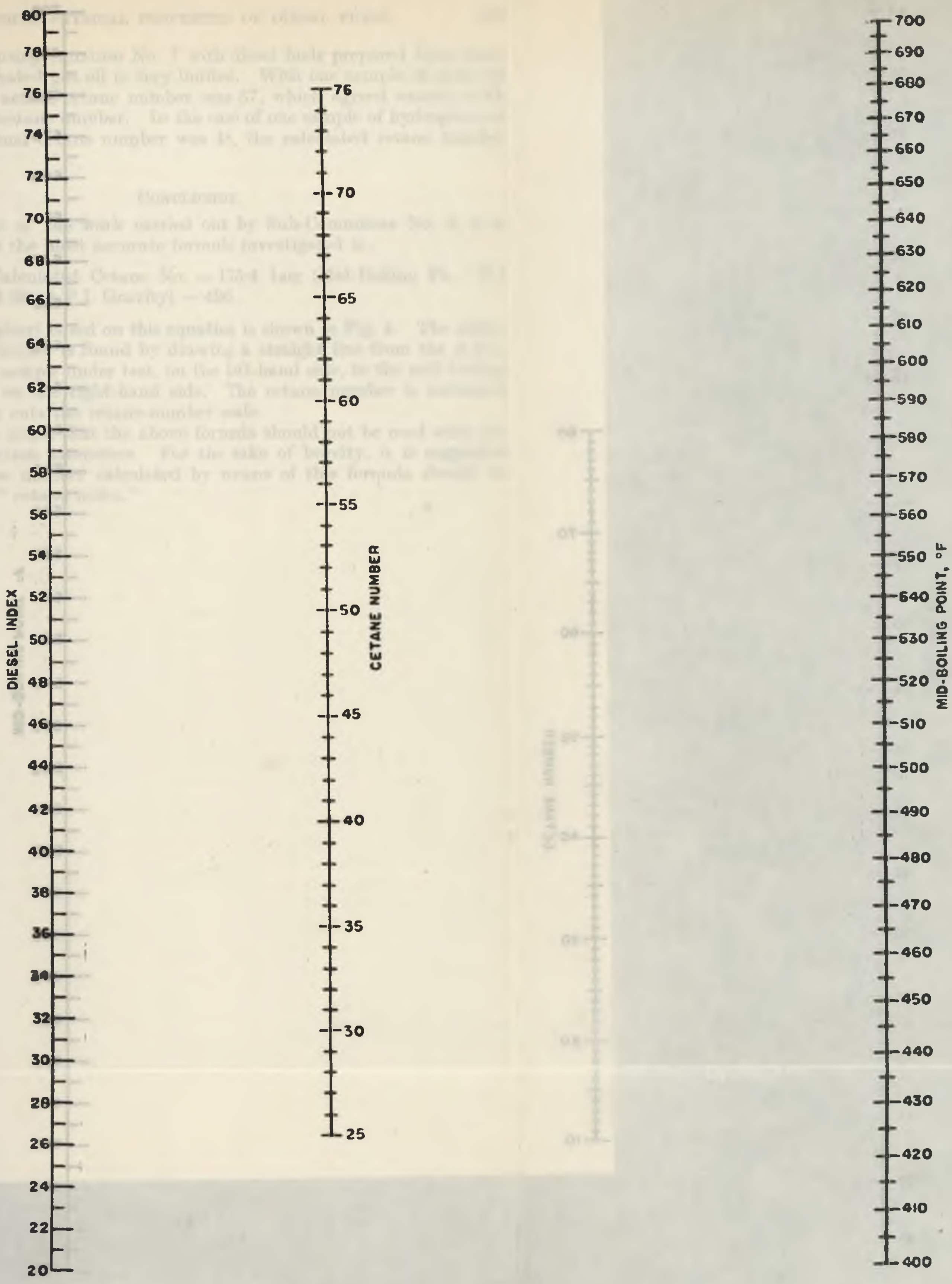


FIG. 3.

CETANE NUMBER–DIESEL INDEX–MID-BOILING POINT RELATIONSHIP.

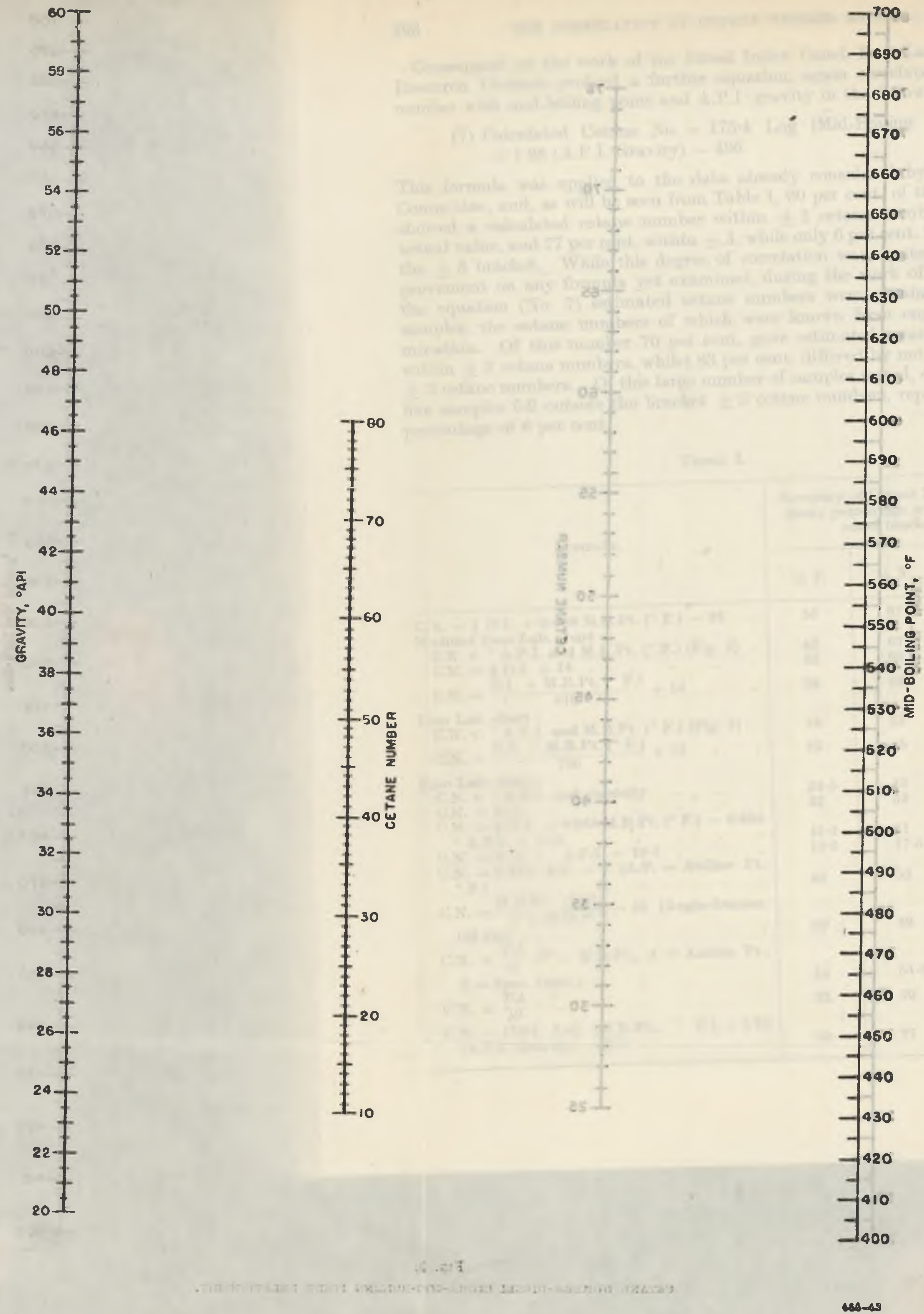


Fig. 4.

CETANE NUMBER–GRAVITY–MID-BOILING POINT RELATIONSHIP.

Experience using equation No. 7 with diesel fuels prepared from shale oil or hydrogenated gas oil is very limited. With one sample of shale oil examined the actual cetane number was 57, which agreed exactly with the calculated cetane number. In the case of one sample of hydrogenated gas oil the actual cetane number was 48, the calculated cetane number being 51.

CONCLUSION.

On the basis of the work carried out by Sub-Committee No. 4, it is concluded that the most accurate formula investigated is :

$$(7)\ \text{Calculated Cetane No.} = 175{\cdot}4\ \text{Log (Mid-Boiling Pt., }^\circ\text{F.)} + 1{\cdot}98\ \text{(A.P.I. Gravity)} - 496.$$

An alignment chart based on this equation is shown in Fig. 4. The calculated cetane number is found by drawing a straight line from the A.P.I. gravity of the sample under test, on the left-hand side, to the mid-boiling point in ° F. on the right-hand side. The cetane number is indicated where this line cuts the cetane-number scale.

It should be noted that the above formula should not be used with oils containing ignition promoters. For the sake of brevity, it is suggested that the cetane number calculated by means of this formula should be known as the " cetane index."

THE 1944 EDITION OF THE I.P. "STANDARD METHODS FOR TESTING PETROLEUM AND ITS PRODUCTS."

By The Editorial Sub-Committee.

It is intended in this paper to review briefly the new edition of the I.P. "Standard Methods," in order to open a discussion on the subject. No attempt will be made to cover the changes in detail, since they have been fully dealt with already in the Report of the Chairman of the Standardization Committee, which is published in the book itself. Reference will be made only to the more salient modifications and innovations, and it is hoped that a vigorous discussion will follow, and that questions will be answered individually by the Chairmen of the various Sub-Committees concerned.

In the present revision the work has differed widely in nature from that of the 1942 edition. The 1942 book represented the first revision for seven years, during which period much of the machinery of Sub-Committees and Panels had become rusty and creaking, if not altogether motionless. In addition, the decision was taken to rewrite all the current methods according to a standard format. Most of the technical innovations then introduced were sponsored by the Editorial Sub-Committee, so we must, therefore, be forgiven for looking back with particular affection upon the 1942 book. In the case of the present edition, however, the work of revision has proceeded upon formal and correct lines, so that we cannot claim any technical responsibility. Phœnix-like, completely reconstituted Sub-Committees and Panels have arisen, and have been exceedingly active in the production of new methods and in the revision of old ones. Our work has therefore been restricted to its true function, which is, in the main, that of ensuring that new methods appear in the correct format, thus producing uniformity in the book as a whole, preventing anomalies which may arise when numerous Committees work almost independently of each other, and generally seeing the book through the press.

In our opinion, the most notable feature of the new edition is the extension of its scope. It is now the acknowledged intention of the Standardization Committee to cover, as far as is possible, not only methods for the whole gamut of products derived from petroleum, but also methods for materials which incorporate petroleum products and which are frequently analysed in petroleum laboratories. Thus a number of methods now appear for materials not catered for previously. Thirteen methods, sponsored by a new Sub-Committee, are included for chemicals derived from petroleum, three methods for bituminous emulsions appear, and one method for petroleum gases, whereas previously no method applicable particularly to any of these products was given. Thus the first steps have been taken in a development likely to become of major proportions in the future.

Since the methods for derived chemicals represent an entirely new venture, we shall refer to them first. The Sub-Committee, in its exploratory discussions, was faced with some difficult problems, and it decided to limit itself for the present to methods for chemicals derived from petroleum and actually commercially available in this country. A number of chemical, physical, and technological tests have been produced for such products. The wetting-power test for detergents represents a tightening up of Drave's original procedure, and has proved of value in the development of a new synthetic detergent now being manufactured in this country. The method for surface and interfacial tension differs from du Noüy's original method by the substitution of a rectangular glass plate for the usual platinum ring, and thus avoids the intricate corrections which were sometimes necessary. In addition to its application to derived chemicals such as petroleum detergents, this method has been found very useful for some of the usual liquid petroleum products. Another method which should have a wide application is that for the determination of molecular weight by depression of the freezing point. Other material produced by this Sub-Committee comprises chemical methods for the acetate content of solvents, alkalinity of esters, ketones, etc., halogen content, iodine value, and peroxide value of ethers. The B.S.I. method for unsaponifiables in drying oils has been adopted and methods are given, in addition, for estimating the drying time of aromatic petroleum residues, the naphthenic acids in soda-neutralized oils, the residual odour of lacquer solvents, and the inorganic salts in alkyl sulphates. Thus it will be seen that a substantial effort has been made to provide analytical methods for the newer members of the petroleum family.

The Apparatus Sub-Committee represents another venture which has also started from scratch. It has carried out the considerable task of revising the whole of the thermometer and hydrometer specifications. The " war-time " specifications, published in this edition, have been produced in co-operation with the manufacturers, and although the new instruments are generally simpler in design and will be easier to make, the necessary accuracy has not been prejudiced thereby. A number of new thermometers has been specified, and this Sub-Committee has co-operated with others on general questions of apparatus revision.

The new sampling method is in some respects the most noteworthy of all the revisions in the book. This method, or really group of methods, has been completely rewritten and has been made more comprehensive, and it is hoped that the new arrangement will enable the modernized procedures for the sampling of the various petroleum products to be located rapidly by the user. A procedure for liquefied petroleum gases, utilizing a metal pyknometer, has been added to the comprehensive specific-gravity method. Only minor modifications were found necessary for the remainder of this method, which was considerably extended and completely rewritten for the 1942 edition.

The crude oil Sub-Committee has worked out a scheme, which appears as an appendix to the book, for the evaluation of crude oils. It includes an abbreviated scheme of inspection, which utilizes methods which were already in existence, and is adequate for routine examination, and a more detailed scheme which requires specialized apparatus and technique. The detailed evaluation has involved the adoption of a new vacuum fractional distillation method so that yields of desired cuts may be predicted. This method is considered to give results comparable to those given by modern refinery practice. A new method, of the conventional type; is also given for the batch distillation of residual oils, but a single-flash pipestill method would be preferred, and will be adopted in the future, when the difficulties of standardizing such an apparatus and technique have been overcome. A method for estimating salt in crude oils, etc., has also been included.

New methods for light distillates are the water tolerance of motor fuels, which determines how much water may be added to an alcohol fuel before separation into two layers occurs, the estimation of tetraethyl lead by hydrochloric acid extraction, and the residue on evaporation of kerosines, etc. For the latter estimation the A.S.T.M. method for gum content of gasoline is used, except that the temperature of evaporation is higher. A third procedure involving the use of a sealed bulb has been added to the aniline-point method. Important modifications have been made to the cold test for motor fuel, colour by means of the Lovibond Tintometer (the B.D.H. pattern instrument having been made obligatory), Abel flash-point, and gum (existent) in motor fuel. In the oxidation stability test for gasoline (formerly called " gum " stability) the definition of " break-point " has been amended, and the Reid vapour-pressure method has been extended to cover fuels containing water-soluble constituents.

The Sub-Committee for gas and fuel oils, etc., has introduced a method for the low-temperature filtration of gas oils, etc., which provides a simple means of determining the tendency of fuels to clog gauzes at low temperatures. An important modification has been made to the wording of the introduction to the diesel index, to make it quite clear that there is no direct correlation with cetane number. A number of fuel-oil stability tests have been under investigation, and although not ready for the present book, it is anticipated that two or three tests of this nature will be standardized in the next edition.

In the field of engine-testing the main modification has been the elimination of the use of a throttle plate in the knock-rating method for motor fuels. New secondary reference fuels have been calibrated for aviation-fuel testing. Consideration has been given to the existent mechanical tests for lubricants but so far no test has been selected for standardization.

Turning to the work of the lubricating oil Sub-Committee, a major modication has been made to the absolute viscosity method, and it is now made clear that the total permissible error is ± 0·6 per cent., this of course having an appreciable influence on the magnitude of the possible error in viscosity index. 40 per cent. sucrose solution is no longer allowed as a primary viscosity standard, whilst the types of instrument permitted are now only the three described. A straight-necked flask has been permitted as an alternative to the Kohlrausch flask in the Redwood method. For the determination of acidity, alkali blue may be used as an alternative to phenolphthalein, and will be found a superior indicator for dark oils. Modifications have been made to the methods for ash content, Ramsbottom carbon residue, diesel-fuel diluent, dielectric strength, sludging value of transformer oils, and oxidation test for lubricating oils. The method for estimating free acid and free alkali in greases has been substantially altered to cover cases in which both free acid and alkali are present together, whilst for the drop-point of greases the B.S.I. apparatus has been taken over with the recommendation that the metal cup be used.

The asphaltic bitumen Sub-Committee has sponsored a new method, that for the determination of breaking point (Fraass), which indicates the temperature at which a film of the bitumen first cracks when subjected to a specified rate of strain. The decision having been taken to specify methods for the examination of bituminous emulsions, a beginning has been made with methods for residue on sieving, coagulation of binder and long-period storage stability, and with the extension of the water-content and sampling methods to cover emulsions. Although no methods have been standardized in connection with the use of petroleum products in soil-stabilization processes, much work on this subject has been accomplished. For the present it has been decided to publish the recommended methods in the *Journal*, and to reconsider them later in the light of further experience. It is anticipated that they may in the future make a significant extension to Standard Methods. For the asphaltic bitumen penetration test the A.S.T.M. needle has now been specified, and for the ring-and-ball softening point the tapered ring, with the proviso that the straight ring or the A.S.T.M. new shouldered ring may be used, if preferred, for non-referee tests.

A new and simple method, using a rotating thermometer, has been introduced for determining the congealing point of petroleum waxes. This will give a satisfactory result with all petroleum waxes, and hence the scope of the setting-point method has been limited to paraffin waxes and scales, the procedure formerly specified for difficult samples having been deleted. Although no method for the determination of oil in wax has been standardized, the need for such a method is recognized, and the search for a simple and accurate procedure goes on.

A few of the methods which appeared in the 1942 book have been deleted through obsolescence. These are the potential gum in motor fuel, asphaltum (soft asphalt) in asphaltic bitumen and distillation of crude oil (the A.S.T.M. 300 ml. Hempel method).

It is the wish of the Standardization Committee to reduce the present multiplicity of official petroleum tests and to work towards the ideal of a single collection of official Anglo-American test methods. As a step towards such co-ordination, the Chairmen of the various Sub-Committees have corresponded with their opposite numbers in the A.S.T.M., and, as the present edition testifies, wherever possible A.S.T.M. and B.S.I. methods have been adopted without or with the minimum of modification. However, progress has been slow and it is necessary to do a great deal more towards this end, which is so desirable in view of the close coupling of the British and American petroleum industries.

In concluding this brief review we wish to thank all those unnamed members of the petroleum industry who have assisted us in the preparation of the new edition.

INSTITUTE OF PETROLEUM.

A Meeting of the Institute of Petroleum was held at Manson House, 26, Portland Place, London, W.1, on Friday, 24th March, 1944, at 4 p.m. The President, Professor F. H. Garner, was in the Chair.

Mr. Cantor read the following paper :—

> "The 1944 edition of the I.P. Standard Methods for Testing Petroleum and its Products." By the Editorial Sub-Committee. (See pp. 198–201.)

DISCUSSION.

The President said that the subject for discussion was the new edition of "Standard Methods of Testing." He wished to express the appreciation of the Institute of the work of the members of the Committee, particularly that of the Chairmen of the various Sub-Committees. A closer liaison with the A.S.T.M. D.2 Committee was being effected, and the Chairmen of the Sub-Committees could, and usually did, get in touch with the Chairmen of the Committees of the A.S.T.M. The most valuable work was done while the methods of test were in process of being drawn up, rather than when they had been published. In this tribute he wished to associate all the members of the Sub-Committees and the Panels and working groups. It said a great deal for their energy and devotion that so many men working in the laboratories of the oil companies and Government laboratories were able to devote so much time to the work under present conditions, even although nearly all the work was directly related to problems arising out of the use of petroleum products for war purposes.

When the Sub-Committees had completed their work the Editorial Sub-Committee prepared the methods for publication. They had on previous occasions expressed their indebtedness to the Editorial Sub-Committee for this work, which could only be adequately appreciated by those who were in close contact with it. For the new edition, a number of new test methods had been incorporated. The Editorial Sub-Committee had made a number of valuable suggestions as regards the form for drawing up methods of test and such matters as the type of illustration to be used. These had been adopted, and would be put into force as and when the opportunity offered. It was said that no book was free from errors, and in the present book there were some corrections to be made. One was to rectify the omission of Dr. Howes' name from the list of members of the Standardization Committee. It was very desirable that certain of the methods should be in complete accord with the A.S.T.M. methods, and alterations had to be made in the Knock Rating of Motor Fuels, I.P.—44/44(T) consequent on the omission of the throttle plate. A revised edition of this method of test in line with A.S.T.M. method D357–43T would be published at an early date with the *Transactions* of the Institute. Members had had an opportunity of reading the report of the various Sub-Committees, and he hoped it might be possible to keep the Institute even more closely in touch with the work of the Standardization Committee, perhaps by reports in between the annual reports when occasion justified it.

One new development was the Sub-Committee on Nomenclature, under the Chairmanship of Dr. Broom. The object of this Sub-Committee was to draw up definitions which might be of general use. These were not intended to be legal definitions, but there had been a general demand for some simple definitions even in the case of primary products; in particular, this demand had come from the users of the products concerned.

He could not close these few remarks without expressing the high appreciation which was felt by the Standardization Committee for the work of the staff of the Institute, particularly of Miss Gilley.

Mr. J. S. Jackson opened the discussion and emphasized that the Standardization Committee were genuinely anxious to have criticism of the "Standard Methods." Criticism was always stimulating, and was an indication of life and interest; in fact, progress in such matters as the development of standard methods mainly arose from criticism.

The introduction of tests for bituminous emulsions constituted something of an innovation. In this connection there had been effective co-operation with the Road Emulsion and Cold Bituminous Roads Association, which would ensure that these emulsion methods would be generally acceptable.

The report of the Soil Stabilization Panel would appear in the near future and would, he hoped, constitute a valuable contribution to our knowledge of the subject.

In considering this new edition, efforts had been made to eliminate obsolete methods, and he stressed the importance of a systematic pruning if the volume were not to become unwieldy.

Careful consideration had also been given to the question of alternative methods, and the Committee were of the opinion that, where rapid alternative methods were in general regular use, they should appear in the book along with the Standard " Referee " methods. The aim was to produce a volume which would contain all the " Petroleum " methods used in any well-equipped petroleum laboratory. With this aim in view, more methods which at present were scattered throughout other publications, such as B.S.I. Specifications, were being collected with a view to publishing them in the next edition of Standard Methods.

He regarded the inclusion of reports from the various Chairmen of Sub-Committees as a very useful development, providing the reader with an effective guide to additions and alterations.

Mr. Hurt said that he had taken the opportunity of running through the new edition alphabetically, and selecting those parts which particularly interested him.

He drew attention to the alternative method for acidity, employing alkali blue in place of phenolphthalein. This alternative method had been known to him for some time, but although probably the better method, it had not been employed by him as a general rule, for the following reason.

Acidity figures were collected and recorded by various people over a term of years. He had felt that use of a slightly different method might lead to slightly different results being obtained. In the event of discordance arising from this or any other cause, explanation would be made difficult. The phenolphthalein method had had the merit that it was the one sponsored by the Institute of Petroleum.

The method for aniline point recommended that " each sample shall be dried by shaking with anhydrous calcium chloride, or sodium sulphate," but no length of time for shaking was given. In an earlier edition of the book, the sample was prepared by standing over calcium chloride for seven hours at 120° F.—an inconvenient procedure. As he felt that both anhydrous calcium chloride and sodium sulphate were somewhat slow in their dehydrating action, inclusion of a minimum time of shaking seemed to be desirable.

The method for hard asphalt was a little vague as regards the quality of the filter-paper. Whatman No. 40 was suggested, but not definitely laid down. Some years ago, following variation of his results from similar ones determined abroad, he decided to use No. 44 Whatman filter-paper, which had the property of retaining the very finest precipitates. Thus his results would tend to be higher than those obtained by using a paper of less retentive properties. It had occurred to him that a Gooch crucible could well be used in place of filter-paper, except that by its use, and in the absence of solution in benzene, material other than asphalt not soluble in 60–80 petroleum spirit would be recorded as asphalt.

Method I.P. 83/44 " Halogen Content Determination (Proposed)," was disappointing in that it referred only to " nearly pure organic halogen compounds derived from petroleum," and not to halogenated compounds present as additives in mineral oil. With the advent of heavy oil containing additives, such as 10 HD and 30 HD, the development and standardization of methods for detecting and possibly estimating them were desirable. Recently he had had occasion to estimate the phosphorus in an HD oil, and found that the combustion of the usual 1 gm. in a Mahler Bomb, in conjunction with a colorimetric method for phosphorus determination, was satisfactory.

Under the Air Ministry Oxidation Test he was somewhat surprised to note the omission of a method for calibration of the manometers. The old DTD 109 specification gave a method which, if cumbersome, was satisfactory. The present book gave no guidance in this direction.

In regard to the method for determining the unworked consistency of greases, he emphasized the point of employing a tin of adequate diameter where soft greases were concerned. He added that the American pound tin, being usually different in diameter from the English variety, could lead to discordance.

Mr. E. A. Evans said that alkali blue was introduced to overcome the difficulty of end-point when using phenolphthalein. When the free acidity was low, as in unusued oils, there was usually no difficulty with phenolphthalein, but when the acidity rose, as in the case of used oils, it was much more difficult to obtain a sharp end-point with phenolphthalein. It might be suggested that acidities of 1·0 and over had nothing whatever to do with new oils and should not be catered for in "Standard Methods." Admittedly "Standard Methods" did apply essentially to unused materials, but it was hoped that some of the methods at least could be utilized for used products of petroleum.

So far as was known, the two indicators gave precisely the same acidity reading, although there was a bigger spread in the results when using phenolphthalein than when using alkali blue. It should be noted that when using alkali blue the oil was treated with a mixture of benzene and alcohol, but when phenolphthalein was used, only alcohol was added.

The halogen test was introduced into Standard Methods for nearly pure halogen containing organic compounds. The time was not quite ripe to standardize a method for the estimation of halogens in oils containing additives. He thought that the number of additives used in lubricants was comparatively small numerically. Of course the number which had been suggested in the literature was enormous. Perhaps it was that comparatively few of the compounds which had been suggested had survived practical trials.

The estimation of phosphorus had been fairly well agreed by those people who were dealing with phosphorus containing additives. For estimating tributyl phosphite, the zinc oxide method was usually accepted. Some people had difficulty with it, but in general it was reasonably satisfactory, and it might be accepted later as a Standard Method.

The estimation of sulphur-containing additives was complicated by the presence of naturally occurring sulphur in the oil. Frequently, the amount of "additive" sulphur was a good deal less than natural sulphur. Therefore, other methods must be adopted to ascertain whether sulphur additive is present.

Organo-metallic additives were being used extensively. It should be a fairly simple problem for a chemist to estimate the content of metal by orthodox procedure.

The estimation of unworked grease penetration was not regarded very favourably nowadays, owing to the difficulty of obtaining a sample in the unworked condition. Influences were at work to condemn the use of the measurement of the unworked consistency. Of course there might be cases where it would be an advantage to know the value of unworked consistency, but these cases should be regarded as exceptional.

The calibration of the air flow in the oxidation test was now left to the personal choice of the individual operator. There were a number of very well known methods. therefore there was no special reason why one should be selected as standard.

Dr. E. B. Evans said that Mr. Hurt had directed attention to a point which had perhaps been insufficiently standardized in the Aniline Point method, and he would direct the attention of Sub-Committee No. 3 to it.

Mr. J. S. Jackson said that there had been some misunderstanding about alkali blue. He had now ascertained that the grade available in this country was 6 B, and it had been shown that this grade was entirely satisfactory.

Mr. Emery desired to congratulate the Institute on the adoption of alkali blue, although in fact it was nothing new, having been suggested by Lewkowitsch at least as far back as 1904. He asked for comments on the test for saponifiable matter. Surely one test would cover both saponifiable and unsaponifiable matter. As far as the volumetric method was concerned, he was afraid that when he first started he used absolute alcohol as the solvent material, but it did not take him very long to discover that much the same result was forthcoming if industrial methylated spirit was used. During the last ten years he had been using industrial methylated spirit, and he would be interested to learn if others had done so. It might be an alternative method. The boiling time was stipulated as three hours, but saponification of straight fatty oils was virtually complete in five minutes, certainly in a quarter of an hour. It would be interesting to have an opinion on these points.

So far as the estimation of halogen was concerned, frankly he disliked a method which involved a piece of special apparatus used for that estimation only. He had been using a method which seemed to him satisfactory—namely, the use of a fusion with two parts of potassium hydroxide and one part sodium peroxide, and asked for comments.

Mr. E. A. Evans said that the alcohol which was available years ago was not sufficiently good for saponification values. It tended to go brown very quickly, consequently one had to resort to better-class alcohol, and the only one which was available in those days was absolute alcohol. Of course, things had changed in recent years; a very good industrial alcohol was now available, and was sufficiently stable to caustic potash for saponification values. It might be proper to suggest that the term "industrial alcohol" might not define the solvent sufficiently accurately. Therefore, the chemist must take such precautions as he considered necessary. It was true to say that many pure fats could be saponified in the course of a few minutes, but of course there were some which were not so readily responsive. The reason why boiling for three hours was incorporated in "Standard Methods" was to ensure that a very viscous oil containing as little as 2·5 per cent. of fatty oil would be completely saponified. If a particular chemist was dealing exclusively with a mineral oil containing, say, 30 per cent. of rape oil, he was probably justified in boiling for only half an hour. Standard Methods were intended to cover as wide a field as possible.

Whilst it might be true that alkali blue dated back to 1904, it must be remembered that the manner in which we were using alkali blue in 1944 was somewhat different. The principal difference was that we sensitized the indicator immediately before use.

Mr. Emery said that as far as the saponification value was concerned, if one saponified for a very long boiling time the net result was increased attack by caustic on the glass, so that what one lost on the swings one gained on the roundabouts by long boiling. What was wanted in order to make this method really good was a perfectly alkali-resistant glass.

Mr. E. A. Evans said that there was really no difficulty. Any error which was due to the action of the alkali on the glass was taken care of in the blank estimation.

Mr. Cantor said that he did not speak from experience of the particular fusion method mentioned by Mr. Emery, but similar fusions with lime and magnesia and so on were likely to give low results owing to loss of volatile chlorine compounds and that might be a difficulty.

Mr. E. A. Evans said that he had used the peroxide method for a number of years, and had found it perfectly good, but it depended entirely, like all these fusion mixtures, on the care with which the product at the bottom of the vessel was covered. The original method was published in the *Journal of the American Chemical Society* about 1908.

Mr. Beecroft had something to say from the point of view of the user.

When the 1942 edition was published it was regarded as a very welcome step forward, and the close collaboration between I.P. and A.S.T.M. was particularly gratifying, since his Company had prepared a series of standard methods taken from I.P. third edition and the A.S.T.M. However, when the 1944 edition was about to be published, fears were expressed as to how far this would effect these methods, and even how far these new 1944 methods could be considered as a stable basis in view of the proposed annual publication of "Standard Methods." This annual publication was thought to be unwise from the users' angle where oil testing was an auxiliary subject, but if the present procedure of directing attention in the Foreword to the alterations and additions in the Report of the Standardization Committee is continued, then the user would only have to turn to the first few pages to learn where the modifications lay.

The new edition had only come to hand that afternoon, and so reactions were necessarily incomplete, but the following items were commented upon. The question of acidity had been raised, and he agreed that phenolphthalein, though very useful, was not completely successful for dark used oils, and stated that the indicator phenoltetrachlorphthalein had been used in one of their laboratories with success. The *p*H range was very close to that of phenolphthalein, and the colour change was good, although it was mentioned that no actual black oils had been used.

The smaller crucible now recommended for ash contents was in use in their laboratories, and gave very good results. A "Drip Rod" was included with the tared beaker plus oil. He asked why 1·0 N alcoholic potash was preferred to 0·5 N for saponifiable matter (Method A), since the ultimate concentration was 0·5 N. There had been little trouble with the keeping properties of 0·5 N, although possibly for solutions kept over prolonged periods 1·0 N would be preferable. In agreement with other speakers, this was an example of where industrial alcohol was used, and this use he believed to be a fairly common practice.

It was suggested that with specific-gravity determinations using the drilled-stopper specific-gravity bottle, the method was speeded up and made more accurate when, (*a*) the liquid was put into the bottle at the temperature at which the gravity was required and then allowed to stand in the bath for only five minutes, and (*b*) the bottle was then chilled very slightly and the capillary height fell ½ to 1 cm. This latter precaution ensured no evaporation loss in the subsequent thorough drying and weighing of the bottle, particularly when volatile liquids were used. Also there was no mention in the new edition of a method for determining the gravity of water-soluble products, and the flotation method for solids lighter than water did not appear to be particularly good—what was wrong with the displacement method using a sinker?

In using the Redwood instrument he questioned the practicability of the very lengthy preheating time, particularly when a temperature of 140° F. was required. Viscosity determinations in their laboratories were now almost solely confined to the Fenske viscometer, and the I.P. permitted an increased range to that allowed by the A.S.T.M. for the various tubes, but insisted upon greatly increased minimum preheating times by, in some cases, 400 per cent. The A.S.T.M. minimum times had been used as a basis and satisfactory duplications obtained. The method he used was to commence the first run in line with A.S.T.M. time limits, and frequently a second or duplicate run with the same instrument and the same oil had been finished before the I.P. time had elapsed. Should there have been any discrepancy, a third run could then be carried out, which would then be in accordance with I.P. times.

A rather curious anomaly concerned the apparatus for water evaluation, in that it was only the 10-c.c. receiver which had a stopcock. Why was this so?

Confirmation was given of the fusion test for halogens, previously referred to by other speakers, and that led to a request for specific inhibitor tests which the users could apply so that they would be able to classify the inhibitors without going too deeply into the identification.

The question of doping had now become increasingly important, and surely it was not unreasonable for the consumer to know to what types these dopes belonged, so that he could check his supplies and be satisfied that they were uniform. This particularly applied when oils were used which gave very satisfactory results. A second point was that a strong feeling existed that a number of these tests were tests which the industry had now outgrown and the uses for which were now out of date. Even fluid film lubrication was a case where the viscosity did not nowadays appear to bear the same relationship to the practical working of the oil, as it had in the past. This was particularly so since dopes had become prevalent, and petroleum technologists were asked if it were not possible to produce a simple machine which would give direct fluid lubrication values.

The question of boundary lubrication had been dealt with satisfactorily, and he felt that if fluid lubrication had been a new field, then the viscometer would not have been the final piece of testing apparatus.

Another illustration of an out-of-date test was the flash-point determination; for most purposes this appeared to mean very little, and were there not, in fact, other tests which had outstripped their usefulness? The consumer carried out these tests, but was he not, in fact, wasting his time?

Mr. Maskell said that the first speaker, Mr. Jackson, had mentioned the desirability of eliminating obsolete methods of test. He himself thought that a number of tests could be cut out. If we were going to keep adding new methods, revision of the old was necessary, and methods which were not now in use should be deleted. He was glad to hear Mr. Jackson making the point he had, with regard to the retention of certain alternative methods of test. He thought it was important that some of these which were in general use should be retained for a time, to give the user an opportunity of experimenting before switching over from his present method to the new standard. As regards the new method for determination of acid value, a lot of practical work had been carried out by the Panel before the introduction of the alkali-blue indicator was finally decided upon. When such a new method of test as this had been adopted, and had been found to give general satisfaction to users, then was the time for the old method to go out, but until then the original method should remain as an alternative.

The question had been raised regarding the oxidation tests, and whether a standard method for calibration of the air gauges should not have been given. In fact this point had been discussed, but it was purposely omitted, because there were a number of suitable ones available for carrying out the calibration, and it was not considered necessary to specify a particular method. Provided the result was the same—that is to say, provided that the air flow was correct—it did not matter what method was used to determine it.

Several speakers had mentioned the test for saponification value and thought that this called for some revision. He himself believed that there were several points about this method which could with advantage be looked into, but in justification of the Panel dealing with this test, as with certain other tests for lubricating oil, it should be stated that time was the limiting factor, and that the work of the Panel had been such that they had up to the present had no opportunity of considering the method for saponification value. With regard to the use of phenoltetrachlorphthalein as indicator, this had not been tried, although the Panel did experiment with a number of other possible indicators, eventually coming to the conclusion that alkali blue was by far the best for all types of oil, although phenolphthalein was fairly satisfactory in certain cases.

Dr. Anfilogoff said that on the question of additives Mr. Beecroft had suggested that the customer wanted to be sure that he was getting value for money. It seemed to the speaker that this was a matter where some measure of safeguard was required by the petroleum industry, and he did not see the necessity for formulating tests for the additives the oil companies, after a great deal of research, had seen fit to put into the oil. As far as he knew, the oil companies did not, as yet, go to the user and sell oil on the basis of price versus additive content. If, to satisfy the user, they had to provide him with information that the additive was of a given elemental chemical analysis, or was a defined chemical compound, this would mean little to the user in determining the value he was receiving, unless he was able to undertake a similar extensive range of engine tests to those which the supplier himself had undertaken in order to justify the inclusion of the given additive in his oil. Indeed, some harm to the industry might result if the precise formulæ of the given additives required to be common knowledge. This seemed to be a case where the industry could satisfactorily be left to give of its best to its customers.

Dr. Anfilogoff said that he had understood a previous speaker to declare that the indicator suggested in the place of phenolphthalein was proposed because it gave more accurate results on used-oil acidity determinations. He could not really visualize a set of service conditions where laboratory accuracy of the order suggested was required on a used oil. He had not been able quite to follow the point.

Mr. Beecroft said that he had put it forward as an indicator satisfactorily used in some of their laboratories. Surely the inclusion of alkali blue meant that a greater accuracy was sought. One further point was that a lot of tests had now to be done by relatively unskilled people, and it was far better to have something which gave the most pronounced end-point. Incidentally they favoured the A.S.T.M. method of acidity.

Mr. Maskell said that they employed the A.S.T.M. method for used oils in his laboratories, but although this was perfectly satisfactory for the purpose, he did not think it was as good as the new I.P. Standard Method for unused oils.

The **Chairman** said that two points remained still unanswered, one of them in connection with specific gravity, and the other the water estimation.

Mr. J. S. Jackson said that the Apparatus Sub-Committee had not yet dealt with the Water Estimation methods. They hoped to overhaul and possibly simplify the apparatus specification considerably.

Mr. Beecroft stated that when they found oils which had 1 per cent. of such and such an additive giving good results, they wanted to be certain further supplies were uniform in their inhibitor content.

Dr. Anfilogoff replied that he thought, almost certainly, the supplier could be trusted in a case like that.

Dr. E. B. Evans said that he thought Mr. Beecroft preferred the method of chilling the gravity bottle to prevent loss by evaporation, but the best method with volatile materials was to use the Regnault bottle, and avoid evaporation that way. He did not think there was any particular advantage in using the drilled-stopper bottle for volatile products. It depended on the accuracy required, but the hydrometer usually gave sufficiently accurate results. The point with regard to soluble products had not been considered, but was it necessary to determine the gravity of greases which were appreciably soluble in water ? As regards the flotation method for waxes, he personally might not wish to use the method, but it was quite widely used for routine examinations in some laboratories. He wished to emphasize Mr. Jackson's remark that criticism of the methods was very welcome, and that this applied not only to the methods published in the Handbook, but to proposed methods published in the *Journal*, and to suggestions for standardizing new methods. A few of such proposed methods had already appeared in the *Journal*, and a number more would doubtless appear in the future.

The size of the Standards Book had increased very much in the last two editions. Sub-Committee No. 3 had quite a lot of work on hand, including determination of mercaptan content, hydrogen sulphide content, and so on, and the same remark applied to other Sub-Committees. There was, however, the risk of over-standardizing, and this could be a great disadvantage. Analysis was, after all, an art as well as a science, and methods were capable of continual improvement. Premature standardization restricted such development and improvement. The co-operation of the user was required to improve " proposed " methods before they got to " standard " methods, and this applied especially to those methods which were published in the *Journal*, but had not yet got to the stage of " proposed " methods in " Standard Methods." Criticism of such methods, and also suggestions as to other methods which should be standardized, would be appreciated. There was sometimes a strong temptation to include methods which were in fairly wide use, but on which further comment from the industry as a whole was very desirable, before their inclusion.

Mr. E. A. Evans said how much he had appreciated the remarks from the visitors. It was very helpful indeed to have criticisms from people outside the Petroleum Industry. It would be a pity to let them go without dealing with some of the points they had raised. One speaker had referred to the difficulty of determining the specific gravity of those greases which were wholly or partly soluble in water. What useful purpose was to be served by attempting such a determination ? All the soda greases were more or less soluble in water, consequently an emulsion would immediately be formed. He begged him not to waste his time, or that of the people he was trying to train, by introducing tests which were of no immediate value.

Apparently one visitor did not readily associate viscosity with film lubrication. The two were very closely allied, and could not be dissociated. Boundary lubrication, of course, was quite different, and could be dissociated from viscosity.

He thought that Dr. Anfilogoff had sufficiently stressed the position of additives. The time was not really ripe for the user to bother his head about the actual composition of an additive. There was a good deal of necessary secrecy about the composition of certain additives, and it was hardly to be expected that the industry would relax its secrecy in the interests of curiosity. The user was not really in a position to benefit very greatly from a knowledge of the particular additive, because it would be impossible in the short time at his disposal to carry out sufficient investigation to prove its merits. For the time being users must accept gracefully the reputation of their suppliers that certain additives had certain properties. It would not be very long before the user had sufficient practical experience with a particular lubricant to prove that it had special qualities.

Dr. Anfilogoff pointed out that there was one fundamental difference between their method of producing the Standard Methods of Test Book, and that of the A.S.T.M. Committee, in that the A.S.T.M. Committee D.2 had produced, in conjunction with their Standard Methods of Test, a booklet, as far back as 1934, entitled " The Significance of Tests of Petroleum Products," which booklet contained therein, not only the scope of the test, but what was equally important, what that test meant to the user. He ventured to suggest to Dr. Evans that rather than increase the size of the present book, that they should stop short with what they had got, add, where necessary, to the scope of the tests, and, at the same time, provide the significance of the given tests to the user thereof. Provision of the significance of the tests would be doing the industry a far greater service than by offering in the next edition an extra fifty tests.

Mr. H. Hyams desired to comment firstly on the general question of criticism of the methods as they appeared both in the 1944 and the 1942 editions. He wondered whether they were going to get the maximum benefit from the comments which were likely to come forward at a meeting such as this almost immediately following the issue of the book. Criticism and comment would most probably come from people abroad, who did not have an opportunity of studying the methods for some months after they appeared; and if these two books were produced hard on each other's heels, containing a great deal of relatively new matter, they would not be likely to get the repercussions for some little time to come.

Another point raised by one speaker had been partly dealt with by Dr. Evans, the Chairman of the Panel responsible for specific-gravity methods. However, as the Chairman of the Sub-Committee which covered that Panel, he, Mr. Hyams, desired to approach the subject from a slightly different angle—namely, from that of quantitative measurement of bulk oil. He not only agreed with Dr. Evans regarding the futility of any sort of specific-gravity test for grease, but was strongly opposed to refinements of methods which, in fact, were meaningless. The purpose of the specific-gravity test, qualitatively, had very little meaning in these days, whereas twenty or twenty-five years ago one did associate the gravity test with the quality or performance of a product. The limits laid down qualitatively were nowadays so wide that accuracy meant little. The test had, however, a considerable significance from the quantitative point of view. When one talked about the gravity of a petroleum liquid from the quantitative point of view, one associated the term with the need for converting volumes into weights, where frequently a fairly high degree of accuracy was demanded but was not easy to attain. The bottle or pyknometer method yielded results of a relatively high order of accuracy; was there, then, any point in introducing further refinements, as one speaker had suggested, when, taking into account all the other errors which might be introduced in the measurement of a bulk quantity of an oil, all that could be hoped for was an accuracy of the order of one part in one or two thousand ? Refinements in the specific-gravity method which resulted in the improvement of the " reproducibility " or " repeatability " figures from 0·0005 to 0·0002 or 0·0001 were, therefore, meaningless from a practical aspect. It was the intention of Sub-Committee No. 1 to see that what was set down in Standard Method 59/44 for qualitative work should be usable in part in another publication, for which they hoped to be responsible, on the whole question of measurement of oil quantitatively. He was certainly satisfied that the specific-gravity method as it appeared in the book to-day was, from the point of accuracy, and for qualitative purposes, adequate.

Mr. Beecroft supported the suggestion for including in the standard book an introduction on the significance of the tests.

Mr. Rosenfeld stressed the considerable interest of motor-vehicle operators in the properties of used crankcase oils, in view of existing limitations of supplies, and also for economical reasons. He, therefore, suggested that the Lubricants Sub-

Committee might consider the possibility of including, in a future edition of the "Standard Methods," suitable methods of testing used lubricating oils.

Mr. E. A. Evans said that Mr. Rosenfeld was particularly concerned with the oil-cleaning research which was going on at the Automobile Research Laboratory. He was naturally anxious to obtain some sort of uniformity in the method of expression of impurities in used oils. Clearly the term "carbon" had no particular meaning. The impurities in the used oil should be more definitely defined. Mr. Rosenfeld was seriously disturbed at the lack of uniformity, particularly when he was trying to describe things in his report which would be intelligible to a great number of people.

Dr. Broom said that perhaps this last point might engage the activities of the Nomenclature Sub-Committee. It would be remembered that there was a suggestion that that Sub-Committee should cover all the terms which appeared in the "Standard Methods," which might well mean that they ought to reconsider their terms of reference in the future to take this matter into account.

In listening to the general discussion that evening, he could not help thinking back on some of his reactions when he joined the Industry in 1930. He formed the opinion, rightly or wrongly, at that time that as far as lubrication was concerned, there was a great deal more art than science in it, and he did not know that he had changed that opinion so very much at the present time. Possibly they, as producers and marketers, viewed this matter differently from the user, who wanted to check up the material, but presumably in most cases it would be the material which had been proved satisfactory in service, and therefore the user, he imagined, was mainly concerned with seeing that he continued to get substantially identical material. As to the actual properties of additives and things of that nature, and their composition and so on, he rather agreed with a previous speaker that it was not so much the additive itself which was in question. The additives were put in to confer certain properties on certain oils, and provided they fulfilled this purpose, that should satisfy the user. He stood rather aghast at the chemical and technical ability which would be required even to identify some of these things, let alone estimate them.

Dr. A. E. Dunstan said that he had the pleasant duty of asking the Meeting to convey its hearty appreciation of a monumental piece of work. He did not know whether the number of members of the Sub-Committees was as large as it was last year, when it stood at 146, which was getting on towards 10 per cent. of the total personnel of the Institute, but he could not think of any other body of technical and scientific men in which such a vast amount of good voluntary work was put into an effort of this kind.

He wanted to associate particularly with this vote of thanks the President, who was fortunately able to double with that high office the Chairmanship of the main Standardization Committee, and with him the Chairmen of the Sub-Committees and Panels, and his own three colleagues on the Editorial Committee. The real criterion of a good Chairman was said to be that he should know nothing at all about the subject, but be able to drive and induce his colleagues to do the work. That did not apply to Professor Garner for, in so far as knowing nothing of the subject was concerned, there were very few Chairmen who had his grip and grasp. But speaking of himself as Chairman of the Editorial Committee, the definition he had just given was a very good one, and therefore he wished particularly to include his colleagues on the Editorial Committee in a vote of thanks which should be extended to the President, the Chairmen of various Sub-Committees, and the Chairmen of the Panels, for what they had accomplished in the production of this very valuable publication.

The vote of thanks was put to the Meeting by Dr. Dunstan and carried with acclamation, and the Meeting terminated.

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.

813. The Antelope Hills Oil-Field. W. T. Woodward. *Calif. Oil Fields*, July–December 1942, **28** (2), 7.—The Antelope Hills oil-field is situated in the north-west part of Kern County, California, about 3 miles south-west of the North Belridge oil-field. It is a comparatively small field (190 acres), but is probably representative of a number of undiscovered pools lying at shallow depths around the fringe of the San Joaquin Valley. The first three wells drilled during 1942 proved the existence of three productive horizons: the " 67–6 " zone, a gas-producing zone of minor productivity; the " 23–6 " zone, an intermediate zone of mediocre productivity, and the lowermost " 45–6 " zone, a prolific producer of heavy oil.

Geologically the structure of the Antelope Hills oil-field is an anticline, the tilted axis of which has a north-west–south-east bearing. The north-east flank is more steeply dipping than the more gentle north-west plunge, but this comparatively simple structure is complicated by faulting.

Total production from the discovery of this field in April 1942 to 1st June, 1943, amounted to 410,596 brls. of oil, 174,820 brls. of water, and 265,569,000 cu. ft. of gas.

There has been no production from the one well completed in the " 67–6 " zone since November 1942. Oil from the other three zones is uniformly heavy, averaging about 17° gravity. On distillation it breaks down into approximately 4% gasoline, 14% kerosene, 2% stove oil, and 80% fuel oil. The sulphur content is approximately 0·56% by weight.

A majority of the development had been on a spacing of one well to 10 acres, but a spacing of one well to 5 acres has now been allowed, and it is anticipated that if this programme is adopted throughout the field, it will probably double its productive capacity. H. B. M.

814.* Relationships Between Price, Exploration Activity and Petroleum Discovery Volume. E. E. Rosaire. *Oil Wkly*, 3.1.44, **112** (5), 26; 10.1.44, **112** (6), 15.—It seems that current and future petroleum demands will at least equal, and probably soon surpass, the current optimum efficient producibility of the U.S.A. oil resources. In the face of increasing consumption the minimum goal should be that the average annual additions to reserves should equal the average annual withdrawals. For the past few years the annual discovery volume has been declining, though there is some disagreement as to whether it still approximates or is well below the annual production. There is, however, little doubt that there must be an increase in the annual discoveries in the future.

An increase in the price of oil is the method of stimulating the discovery rate most widely publicized. McCollum's data for the U.S.A. in the period 1900–1942 show a generally direct relationship between the average crude oil price, dry holes drilled (a measure of the finding effort), and discoveries, but in recent years this direct relationship has not been maintained. Some writers suggest that the price control of petroleum production is very remote. During the period 1915–1920, price rose nearly five-fold, while production increased by only 50%. From 1921 to 1929 the maximum range of prices was $1.17 to $1.88, yet output rose from 470,000,000 brl. in 1921 to 1,000,000,000 brl. in 1929.

There are indications of a lag in the appearance of an increased production due to price stimulation, and in the early twenties this amounted to five years, a lag which is too great to allow of favourable results being obtained during a short emergency.

Price stimulation cannot produce new fields in worked-out areas.

Discovery and price data have been examined statistically, and for the earlier years there are indications of a 1·5-year lag; for the period 1924–1930 (omitting East Texas) an 8-year lag gives the best fit; while for the period 1924–1941 the best fit results from the use of a 10-year lag relationship. The net effect is the correlation of the 1921 price peak successively with the discovery peaks of 1921–1922, 1927, and 1929–1930.

There is no rational obvious explanation of the 10-year lag in terms of ordinary prospecting practice, and the same is true of the 8-year lag relationship. The 1·5-year lag relationship is by far the most reasonable from the standpoint of actual exploration practice, and also shows a satisfactory fit over the 1901–1924 period, when, it is generally agreed, price was the dominant factor.

Data on purely exploratory tests are not available for the whole period 1901–1941, and thus the number of dry holes is used as a measure of the exploratory effort. Examination of the relationship between price and the number of dry holes shows outstanding correlation at 0 years on the 1901–1921 spread. This correlation appears at 1901–1915, and persists in diminished intensity even to 1901–1941. Other less pronounced relationships are suggested. The 0-year relationship has similar characteristics to the 1·5-year lag relationship between price and discovery volume.

For the first half of the 41-year period, activity was found to lead discovery volume. A lead of 1·0–1·5 years holds.

It can be argued that a rise in the current price will justify the industry in considering prospects of a lower level of promise. Activity leads discovery in a price-dominated period, but the reverse is true in a period of non-marginal success—*i.e.*, when technology creates an opportunity for discovery at a premium the industry is slow to recognize that such is possible, but once that opportunity is recognized industry-wide, the resulting activity continues past the point of maximum returns.

Under present conditions it seems that, failing a strike of the East Texas type, the discovery volume required to compensate for present withdrawals can only be expected to follow from a material increase in price or from a contribution from technology comparable with the introduction of the reflection seismograph in 1930. Such a contribution from technology could take the form of a new prospecting objective achieved, a new province established as productive, or a new method reduced to practice. G. D. H.

815.* Completions of 1943 Only Two-Thirds Normal, but Drilling Now Accelerated. Anon. *Oil Wkly*, 10.1.44, **112** (6), 45.—1701 wells were completed in U.S.A. in December 1943, 37 fewer than in November, and it seems that the 1943 total may be 19,101, compared with a total of 21,454 in 1942. The 1943 completions included 428 old wells drilled deeper. 9528 of the wells produced oil or distillate, 1534 produced gas, 5903 were dry, and there were 1708 injection or water-disposal wells.

In 1943, drilling declined below the 1942 level in Louisiana (39%), New Mexico (29%), Ohio (35%), Pennsylvania (34%), West Texas (30%), Texas Panhandle (45%), Upper Texas Gulf Coast (24%), and South Central Texas (39%). The 1943 completions exceeded the 1942 figures in California (79%), Arkansas (13%), Colorado (130%), Kansas (8%), Kentucky (154%), Montana (25%), Nebraska (39%), North Texas (22%), and Wyoming (28%).

The completions in December and during the whole of 1943 are tabulated and classified by States and districts, with some 1942 figures for comparison. G. D. H.

816.* Ecuador Increases Crude Oil Production. Anon. *Oil Wkly*, 10.1.44, **112** (6), 46.—In the third quarter of 1943 Ecuador produced 63,481 brl. of crude, 21% more than in the previous quarter. The total output is estimated at 231,000 brl. G. D. H.

817.* American Firm Drills Nicaraguan Wildcat. Anon. *Oil Wkly*, 10.1.44, **112** (6), 46.—40 km. north of Puerto Cabezas, Nicaragua, a wildcat was reported to have reached a depth of 3500 ft. at the end of October 1943. G. D. H.

818.* Two Prospects of Eastern Flank of Anadarko Basin Showing Oil. C. Hoot. *Oil Gas J.*, 13.1.44, **42** (36), 29.—Oil-stained cores have been obtained from two tests in McClain County, Oklahoma, on the east flank of the Anadarko basin. The wells are thought to be on a different trend from that outlined by the West Moore and Oklahoma City pools, and following the Nemaha Ridge round into Canadian County. It is about as far from the newly-established Noble, West Moore–West Edmond trend, as these latter fields are from the Moore, Oklahoma City, and Britton trend.

The Cottingham well topped the second Wilcox sand at 10,633 ft. Cores in the interval 10,630–10,646 ft. have shown sandy dolomite, coarse sand and tight sand, with some oil stains and good porosity in parts.

The tests to the north-west found Hunton lime at 9500 ft., and a medium-coarse limestone core at 9511–9521 ft. showed some oil-staining and fair porosity in parts.

Tight limestone with oil-staining was found in a core from 9521 to 9526 ft. A drill-stem test has been ordered. G. D. H.

819.* Wildcat Completions and Discoveries. Anon. *Oil Gas J.*, 13.1.44, **42** (36), 107.—Shows of oil have been found in two deep tests on the east rim of the Anadarko basin. Two wildcats completed in the week ended 8th January, 1944, found oil, one being a 15-brl. well in the Gray sand of Coleman County, West Central Texas, and the other a 76-brl. well in Bee County, Texas.

67 wildcats were completed in U.S.A. in the week ended 8th January, 1944, and a table gives by States and districts an analysis of these wildcat completions. G. D. H.

820.* Material Increase Forecast for 1944 New Well Drilling. Anon. *Oil Wkly*, 31.1.44, **112** (9), 84.—The *Oil Weekly's* estimate for U.S. 1944 completions is 23,535 wells, while the figure compiled from a cross-section of reports from oil companies is 25,476 wells. The need for more oil for winning the war is foremost among the factors pointing to increased drilling in 1944.

During the five years ended 1941 the number of producing wells increased by about 11,000 each year; in 1943 the increase was only 2800.

Florida became a producer in 1943, and one or two other States may become producers in 1944.

The upward trend in drilling seems likely to obtain in all important producing areas except Illinois–Indiana, where there may be a slight fall. An increase of 56% is indicated for Texas, while the national increase may be 25·28%. The 1944 footage may be 33·25% higher than in 1943, increasing the average well depth by 88 ft. to 3211 ft.

According to present plans the completions in 1944 will be about 120 in Trinidad, about 580 in Venezuela, and about 25 in Colombia. Operations seem likely to increase in the Near East.

District 3 will probably be most active in 1944, for transportation facilities have been improved. Substantial additions have been made to its refining capacity. It is predicted that 1769 wells will be drilled in California during 1944.

A table gives by States and districts the 1943 well completions and deepenings, and footage, with forecasts of the 1944 new wells, wildcats, and footage. G. D. H.

821.* Record Number of Wildcats but New Sources Drop Off. Anon. *Oil Wkly*, 31.1.44, **112** (9), 94.—Although the U.S. oil industry drilled a record number of wildcat tests in 1943, fewer new sources of supply were discovered than in 1942 and 1941. However, several of the strikes may prove better than was currently indicated.

The 3599 wildcats, including field outpost tests, gave 643 producing wells. 348 new oil-fields were found, 152 new producing horizons in known fields, and 143 extensions. The new fields represent 275 oil-fields, 55 gas-fields, and 18 distillate fields, while 129 of the new pay horizons gave oil, 13 gas, and 10 distillate.

221 of the successful wildcats were in Texas, the most significant discoveries being in South-west Texas, South Central Texas, and the Lower Gulf Coast. In this South Texas region most of the hits lay on two trends—the Carrizo–Wilcox trend and the Frio–Vicksburg trend.

Along the Upper Texas Gulf Coast important extensions and new pays were proved in old salt-dome fields. Several thousand acres of production were added to the Katy gas-field, and a commercial oil-pay was found on the flank of the dome. In East Texas the major discoveries were Paluxy production at Manziel, and Rodessa and Pettit production at New Hope.

14 oil discoveries, three new gas-fields, four new oil-pays, and two new gas-pays were found in West Texas. Ellenburger discoveries initiated considerable wildcat activity along a north–south trend west of the Pecos uplift. North Texas had 45 oil discoveries, 17 new oil pays, and 2 new gas pays.

A 500,000,000-brl. reserve discovery is believed to have been made in the Elk Basin field at the north end of the Big Horn Basin, Wyoming. The proved acreage is 4500 acres, and the average initial production of the 22 wells was 2189 brl./day from the Tensleep. The Gebo dome at the southern end of the Big Horn Basin also seems to be of major rank. The discovery well initially gave 4320 brl. from the Embar. The Madison was not tested. In the northern part of the Frannie field the Madison line has been proved productive, and a very substantial Madison reserve has been found in the Oregon Basin field, which produces from the Embar and Tensleep, and has two areas of closure.

The Californian discoveries may be considered to have added 24,000,000 brl. to the State's reserves; semi-wildcat extensions and new pays may have added 37,500,000 brl., and wells in existing fields may have added 15,500,000 brl. The production in 1943 was 283,000,000 brl.

82 wildcats added a reserve of about 1,000,000 brl. to the Indiana reserves. Of the nineteen strikes in Kentucky, Hitesville with McClosky, Waltersburg, and Cypress production is the most important. 5,098,000 brl. was added to the State's reserves. No major fields were found in Illinois in 1943. The Mt. Carmel, Dale-Hoodville, Iola, and Albion pools all have four pays under development. Michigan had no outstanding discoveries. Two new Traverse fields were opened: Rose Lake and Goodwell.

Hopeful shows and valuable geological data were all that accrued from the 31 wells drilled in Nebraska. The best chance for new fields seems to be in the south-central part of this State, where the Pennsylvanian carries oil shows in beds of good porosity, permeability, and distribution.

A third of the 44,800,000 brl. of reserves discovered in Kansas in 1943 is credited to the Carmi field. A trend of production has been defined running north-west from the Central Kansas uplift into the Dodge City basin. A second uplift has been defined running north from the Lindsborg field into Saline County and into the south-east portion of the Salina basin.

The West Edmond strike of Oklahoma is regarded as a stratigraphic trap accumulation. It produces from the Hunton, and there are indications that the Bartlesville may prove productive. New Anadarko Basin production was found at West Moore, where an 8800-ft. well found an excellent second Wilcox pay. The structure is a deeply buried, faulted anticline west of the Nemaha Ridge. Many structures have been seismographed in this area, but not yet tested.

No big finds were made by Arkansas' six successful wildcats. Six discoveries were made in Mississippi.

Five productive levels were proved in the Vinton Dome field of South Louisiana, and this may lead to much re-exploration of salt domes in the Upper Gulf Coast region. A major discovery was made in the Tuscaloosa in the Holly Ridge area. Six minor discoveries were made in New Mexico during 1943. Commercial quantities of helium were found in a deep gas well in San Juan County.

Tables show by States and districts the numbers of new fields and pays found annually from 1938 onwards, and the average depths of the discoveries each year; the numbers, footage, and average depths of successful and unsuccessful wildcats and outpost tests; the depths of the different types of pays in new fields, and of new pays in old fields. G. D. H.

822.* Wildcat Completions and Discoveries. Anon. *Oil Gas J.*, 3.2.44, **42** (39), 158.—The 69 wildcat completions in U.S.A. in the week ended 29th January, 1944, included 6 oil-, 1 distillate-, and 4 gas-producers. At West Moore in Cleveland County, Oklahoma, a 223-brl. well was completed in the second Wilcox sand. It lies on a second trend running parallel with the Nemaha Ridge. 1½ ml. north-east of production at Fullerton, the East Fullerton pool has been opened in Andrews County, West Texas, by an 850-brl. well in the Clear Fork at a depth of 6900 ft.

A table summarizes the U.S. wildcat completions by States and districts for the week ended 29th January, 1944, and gives cumulative totals for 1944. G. D. H.

823.* Wells Completed in United States in Week Ended February 5th, 1944. Anon. *Oil Wkly*, 7.2.44, **112** (10), 53.—The results of U.S. wildcat and field completions in the week ended 5th February, 1944, are tabulated by States and districts.
G. D. H.

824.* January Completions Show Gain Over Last Year; 3000 Rigs Now in Operation. Anon. *Oil Wkly*, 14.2.44, **112** (11), 50.—An average of 371 wells per week were completed in U.S.A. in January 1944. The December 1943 figure was 442 per week, and that for November 386 per week, but the January 1944 figure was materially higher than in any month of the first half of 1944. All States showed seasonal decreases in completions in January 1944, but there were only minor declines in some States and districts, including Indiana, Kansas, South Louisiana, New Mexico, West Texas, and the Texas Gulf Coast.

January 1944 had 7·4% more completions than January 1943, but the changes varied widely in different States and districts. There were decreases in the Panhandle, South-west Texas, and South Central Texas, but sharp gains in East Texas, West Texas, and the Gulf Coast, and smaller increases in North and West Central Texas, giving a net gain of 13% for the State. Gains were also recorded in California (30%), Kansas (20%), Michigan (40%), Kentucky (82%), New Mexico (33%), Mississippi (166%), Wyoming (60%), and smaller gains in Illinois, Indiana and West Virginia.

The January 1944 completions are analysed in tabular form by States and districts.
G. D. H.

825.* Alberta Field Sands Not Uniform, Core Tests Show. Anon. *Oil Wkly*, 14.2.44, **112** (11), 51.—Estimates of the oil content and commercially exploitable area of the Athabaska tar-sands are being revised downwards as a result of core drilling. The richest section appears to be more or less restricted to the vicinity of the Abasand Company development on Horse River, at Fort McMurray, where the sand is coarse, free from clay and silt, and carries up to 60% of bitumen. Cores in other supposedly favourable locations show that the character and content of the formation are neither uniform nor predictable. On Wheeler Island there is much 200-mesh sand and considerable amounts of clay. The Steep Bank area has extremely low reserves, much of the section having been thoroughly leached. There are alternating beds of saturated, leached, and low-porosity sands, and 3–4-ft. beds of clay. G. D. H.

826. Extensive Developments Under Way in Ecuador. Anon. *Oil Wkly*, 14.2.44, **112** (11), 51.—Several American-financed companies are reported to have taken over some of the "study concessions" in the coastal region of Ecuador in the States of Guayas and Manabi. Submarine seepages indicate favourable prospects for commercial production from lower Tertiary strata, and it is understood that some offshore locations will soon be drilled. G. D. H.

827.* Second Gaspe Well to be Spudded Immediately. Anon. *Oil Wkly*, 14.2.44, **112** (11), 51.—C.N.L. No. 1 well on the Gaspe Peninsula had reached 2124 ft. in November, 1943. It encountered near-surface oil shows with a strong gas flow at a depth of 33 ft., in sandy Devonian shale. C.N.L. No. 2 is to be drilled 8 ml. west of No. 1.
G. D. H.

828.* Wells Completed in United States in Week Ended February 12th, 1944. Anon. *Oil Wkly*, 14.2.44, **112** (11), 59.—The field and wildcat well completions in U.S.A. during the week ended 12th February, 1944, are tabulated by States and districts.
G. D. H.

829.* Deep Drilling Planned in Dominican Republic Area. Anon. *Oil Gas J.*, 17.2.44, **42** (41), 38.—A deep test is to be drilled in the west central part of the Dominican Republic, near the Haitian border. Since the promulgation of the new petroleum laws in April 1942, six wells have been drilled on the Maleno and Higuerito anticlines in the south-west of the Dominican Republic. All the wells were less than 3000 ft. deep, and did not produce oil, although some of them found a little oil.

1 El Mogote, the deepest well drilled in the Dominican Republic, was abandoned at 7505 ft.

The Republic has intermontane geosynclinal valleys containing possible oil accumulations. The known structures are generally elongated anticlines with steeply dipping flanks. G. D. H.

830.* Wildcat Drilling Has Failed to Keep Up with Increasing Needs of Discoveries. W. V. Howard. *Oil Gas J.*, 17.2.44, **42** (41), 41.—Records show that there has been an apparent increase in wildcatting since 1937, despite a stationary price for crude oil. These records are not confirmed by the National Scouts and Landmen's Association, which shows no increase, except in newly-developed areas. On analysis, all the apparent increase seems due to changes in the definition of the term "wildcat," and except in the newly-opened areas wildcatting has not increased since 1937, when the oil reserves were nearly 3,000,000,000 brl. more than now, and production was 15% less than the current rate.

Data on wildcatting in U.S.A. are tabulated annually from 1937 onwards, according as the drilling has taken place in areas with no outstanding discoveries, in old areas with outstanding discoveries, or in new areas. G. D. H.

831.* Six Oil Discoveries Reported Last Week. Anon. *Oil Gas J.*, 17.2.44, **42** (41), 110.—Six oil-, one distillate-, and four gas-discoveries were made among the 68 U.S. wildcat completions in the week ended 12th February, 1944. In Canadian County, Oklahoma, a prolific Hunton lime area was extended 1 ml. by a 300-brl. well. Production has been found in the Muddy sand at 5888–5969 ft. in Larimer County, Colorado. A 186-brl. well at a depth of 3868–3873 ft. has extended production to the south-west of the Blue Ridge salt dome field in Fort Bend County, Texas.

The results of U.S. wildcat completions in the week ended 12th February, 1944, are summarized by States and districts. A further table gives a summary of the U.S. wildcat completions for the period November 1943 to January 1944.

G. D. H.

832.* Good Exploratory Start for Year but Wildcat Successes Few. L. J. Logan. *Oil Wkly*, 21.2.44, **112** (12), 34.—324 exploratory tests were completed in U.S.A. during January 1944. The corresponding figure for 1943 was 261. 40 of the January 1944 tests were productive, but none appeared to be exceptionally important.

2 ml. north-west of the Schuler field a well found gas and condensate in the Reynolds lime at 7861–7863 ft. California had a gas discovery in the Chico Creek area of Butte County. 13,000,000 cu. ft./day was obtained from 4265 to 4390 ft. Several minor oil-field extensions were made. The north Mt. Erie field of Wayne County, Illinois, found oil in the Aux Vases at 3107–3115 ft. Structural conditions are not yet known. New producing horizons were opened in five Illinois fields during January. Two new oil-fields were discovered in Posey County, Indiana. South New Harmony produces from the Hardinsburg sandstone at 2444–2469 ft., and the Upton discovery from the Tar Springs at 2143–2150 ft. A shallow oil-field was opened in Butler County, Kentucky, and new pays were discovered at Raleigh and Smith-Mills. A Misener sand discovery was made at 3179–3187 ft. in Rice County, Kansas, and a Viola lime strike at 3363–3368 ft. in Saline County.

The Holly Ridge field of North Louisiana has been extended 2 ml. north-west. A new shallower pay has been opened in the Wilcox at 3012–3024 ft. The well was drilled to 5025 ft., and found the Tuscaloosa dry. A new gas-distillate producer has either extended the Cotton Valley field 3 ml. to the north-west, or opened a separate new field. Two new oil-fields were found in Michigan, the Wise field and the Deep River field, both producing from the Dundee. Three small fields were opened in Oklahoma. A 1212-brl. well was completed in the Strawn 1¾ ml. north-west of the Walnut Bend pool, North Texas. Three new oil-fields and a gas-field were discovered in West Texas, and a Frio sand oil-field in Wharton County, upper Gulf Coast of Texas.

West Cosden, Bee County, La-Salle, Jackson County, Canales, Jim Wells County and Chapa, Live Oak County, were the four new oil-fields discovered in the lower Gulf Coast of Texas. Canales produces from the Frio at 7233–7236 ft., and may become a large field.

The results of wildcatting in U.S.A. in January 1944 are tabulated by States and districts and the discovery wells are tabulated with pertinent data. G. D. H.

833.* Mexican Production in 1943 was 35,200,000 Barrels. Anon. *Oil Wkly*, 21.2.44, **112** (12), 51.—During 1943, Mexico produced 35,200,000 brl. of crude, compared with 34,716,000 brl. in 1942.

5,766,000 brl. of oil was exported in 1943, and domestic sales amounted to 27,600,000 brl. G. D. H.

834.* Wells Completed in United States in Week ended February 19th, 1944. Anon. *Oil Wkly*, 21.2.44, **112** (12), 61.—Data on the U.S. field and wildcat completions in the week ended 19th February, 1944, are tabulated by States and districts.
G. D. H.

835.* Mexico's Production Opens Year With Rise. Anon. *Oil Gas J.*, 24.2.44, **42** (42), 56.—In January 1944 the properties managed by Petroleos Mexicanos produced an average of 107,540 brl./day, compared with an average of 104,062 brl./day in December 1943. A further 3000–4000 brl./day was produced by independent companies. A year ago the Pemex average was 74,609 brl./day, while in October 1943 it was 110,300 brl./day.

The bulk of the Mexican production comes from the Poza Rica field, where the average was 57,990 brl./day in January, 1944.

A table gives the production figures of the principal areas in January and December 1943 and in January 1944. G. D. H.

836.* Net Decline of 18·6 Million Barrels Shown in Reserves by A.P.I. Annual Report. J. P. O'Donnell. *Oil Gas J.*, 24.2.44, **42** (42), 61.—According to A.P.I. estimates, new reserves (new fields and new pays) discovered in U.S.A. in 1943 amounted to 282,418,000 brl., while revisions in previous estimates and extensions to old fields added 1,202,368,000 brl. Thus the total addition to reserves was 1,484,786,000 brl., while the 1943 production was 1,503,427,000 brl. The *Oil and Gas Journal's* estimates for newly discovered oil in 1943 was 212,145,000 brl., and for extensions to old fields 584,487,000 brl.

A table gives the A.P.I. estimates by States, together with the 1943 production and the proved reserves at the beginning and end of 1943, while U.S. totals are given yearly from 1937 onwards. G. D. H.

837.* January Well Completions Show Seasonal Slump. Anon. *Oil Gas J.*, 24.2.44, **42** (42), 142.—The total completions in U.S.A. in January 1944 generally showed a sharp seasonal drop from the December 1943 figures, but in West and South Texas, Montana, Wyoming and California, substantially more wells were completed in January than in December.

A table summarizes the January well completions by States and districts, giving total footage, the numbers of wells in various depth ranges, and the numbers of oil, gas, and dry wells. G. D. H.

838.* Fourteen Oil Discoveries Reported Last Week. Anon. *Oil Gas J.*, 24.2.44, **42** (42), 143.—Sixty-seven wildcats were completed in U.S.A. in the week ended 19th February, 1944. Fourteen produced oil, 1 distillate, and 2 gas, the remainder being dry.

The results of wildcat completions during the week ended 19th February, 1944, are tabulated by States and districts. G. D. H.

839.* A.P.I. Announces Annual Petroleum Reserves Figures. Anon. *Oil Wkly*, 28.2.44, **112** (13), 14.—During 1943, U.S.A. produced 1,503,427,000 brl. of oil, and according to the A.P.I. 1,484,786,000 brl. of new oil reserves was proved. At the end of 1943, the proved reserves were estimated to be 20,064,152,000 brl. The A.P.I. attributes 282,418,000 brl. of new oil to new pools discovered in 1943, and 1,202,368,000 brl. to upward revision of previous estimates and to extension of known fields.

The chairman of the A.P.I. committee states that undoubtedly great reserves of crude oil remain to be discovered or proved in U.S.A., and the country will be able to meet the nation's requirements for oil products from domestic sources " for many generations to come " if permitted " an adequate and fair price for its products."

Tables give details of the A.P.I. reserve estimates. G. D. H.

840.* World Production Regains 1941 Level. Anon. *World Petrol.*, March 1944, **15** (3), 43.—The world oil production in 1943 is estimated to have been 2,246,955,000 brl., compared with 2,054,410,000 brl. in 1942 and 2,250,028,000 brl. in 1941. More than half of the rise in production in 1943 was due to increased output in U.S.A.

Venezuela produced considerably more oil in 1943 than in 1942, but did not reach its 1941 output. There was probably a substantial rise in output in the Near and Middle East, although the 1941 figure was not reached, and the Russian production in 1943 may practically have regained the 1941 level.

It seems likely that the world production in 1944 may be 10% greater than in 1943.

The estimates of the world production and the production of the major producing countries are tabulated for 1941, 1942, and 1943. G. D. H.

841.* Permian Basin Pays Are Many and Deep. P. F. Osborne. *World Petrol.*, March 1944, **15** (3), 44.—Oil was discovered in the Upper Permian of the Permian Basin in 1920, and the Permian has now given 1,750,000,000 brl. of oil from 19,000 wells in 150 fields, of which the Permian reserves are estimated to be 3,500,000,000 brl. The Upper Permian is still being actively explored at depths of 1500–5000 ft. The Yates sand is still being explored in the south, and the Capitan reef limestone pays west of the Central Basin Platform. The Grayburg shares production honours with the underlying San Andres, and during 1943 was found to be porous and oil-bearing well out in the deep Midland Black Shale Basin. Below the San Andres is the Holt horizon, which has not given prolific production. During 1942, the Fullerton pay of the Clearfork was opened in the Fullerton field of north-west Andrews County. This pay lies about 7000 ft. deep and has about 400 ft. of porous limestone pay section in three porous zones. This pay may occur in the north and east of the basin.

Pennsylvanian production was found in the Page area of Schleicher County in 1939, and in the Todd pool of Crockett County in 1940. Mississippian beds occur in parts of the basin, but so far they have not shown encouraging oil-shows. The Devonian shows oil in fractured chert, and it is likely that it will prove productive. Silurian production was found in south-eastern Ward County in 1940. In 1943 Silurian production was obtained at McCamey, and encouraging shows have been found elsewhere.

Since 1928 over a million barrels of oil has been obtained from each of 26 Ordovician wells at Big Lake, and in recent years more Ordovician discoveries have been made. Fifteen fields now produce from the Ordovician. Ordovician production is found at depths of 4000–10,500 ft. A Cambrian sand proved productive at Wentz in 1941.

Investigation prior to drilling in the Permian Basin is expensive, for the Permian structure is not a certain key to the underlying structure, and the area must be combed geophysically in search of deep complex folding. In the development of the deep Ordovician fields, the beds have been found to be sharply folded and faulted, while the fields tend to be smaller than those in the more gently folded Permian. In the pre-Permian beds the productive horizons may be missing over the top of "highs."

Lease costs have increased considerably in the Permian Basin, and drilling costs are high. Ordovician wells may cost $20–25 per foot overall, but Upper Permian wells cost less than $5 per foot. G. D. H.

842.* Persian Gulf Oil Furnishes Good Backlog for U.S. Reserves. H. L. Ickes. *Oil Wkly*, 6.3.44, **113** (1), 13.—It is widely accepted that the known U.S. oil reserves are 20,000,000,000 brl., equivalent to fourteen years' supply at the present rate of production, though not producible in that time. At present the rate of discovery is less than the rate of production. The military machine is being supplied with sufficient oil only by imposing restrictions on public consumption. These considerations constitute, with others, the background of the Petroleum Reserve Corporation's activities.

In Saudi Arabia the fields are held jointly by the Standard Oil Company of California and the Texas Company. There are 4,000,000,000 to 5,000,000,000 brls. of proved and indicated reserves, with current production 35,000 brl./day. The Kuwait fields have proved and indicated reserves of about 9,000,000,000 brls., but are now closed in. A British corporation holds this concession, and the Gulf Oil Corporation and the Anglo-Iranian each hold a 50% interest. The Iran fields produce 275,000 brl./day, and the Iraq fields 90,000 brl./day.

Standard of California, Texas, and Gulf have had serious problems, including inadequacy of transport and refining facilities, in their operations in this region.

P.R.C. has undertaken to construct the 1200-ml. pipe-line from Saudi Arabia and Kuwait to the eastern end of the Mediterranean, provided that the oil companies set aside 1,000,000,000 brl. of oil for the U.S. military services. The pipe-line will cost $130,000,000–$165,000,000, and this sum will be repaid to the Government by the companies within twenty-five years, with interest and a net profit, after which the Government will still own the pipe-line. The 1,000,000,000-brl. reserve will be available whenever requested at 25% below the market price either at the Persian Gulf or in the U.S.A., whichever is the lower. The companies agree not to sell any crude or products to any Government or person of whom the State Department disapproves. G. D. H.

843.* Finding World's Oil a Task for American Enterprise. W. A. Pratt. *Oil Wkly*, 6.3.44, **113** (1), 49.—Unless some new revolutionary form of energy is found, petroleum must continue to be one of America's paramount necessaries. It is of vital significance in a world of plastics, synthetics, machines, and the internal-combustion engine.

During the past three years the U.S. discoveries of new petroleum reserves have failed to balance the annual consumption. The proved reserves now total about 20,000,000,000 brl.

The causes of the decline in the rate of discoveries include Government restrictions, sub-normal prices for crude oil, and shortages of man-power and critical materials. It seems that with a price incentive and relief from war-time restrictions, twice as many wildcats would have been drilled as have been drilled, and this would surely have boosted the discovery rate.

Including the proved reserves, some 45,000,000,000 brl. of oil have been found in U.S.A. The proved gas reserves are equivalent to a further 17,000,000,000 brl. of oil. Under modern technique natural gas can be converted into liquid fuels at little more cost than for crude oil.

During the past thirty years Americans have discovered some 20,000,000,000 brl. of oil in other countries, and this also has large amounts of gas associated with it. Hence the total reserves remaining to be recovered from natural resources already discovered and developed by Americans at home and abroad are of the order of 60,000,000,000 brl., constituting a reserve more nearly commensurate with the nation's need.

In peace-time, U.S. oil consumption is 450 gal./annum/head. In the rest of the world the average is 15 gal./annum/head; in the United Kingdom 80 gal./annum/head, and in Russia 50 gal./annum/head. The U.S. oil output is equivalent, in terms of energy, to the work of 4,500,000,000 men working eight hour/day, six days/week, year in and year out.

It has been assumed that because much oil has been found in the U.S.A., that country must have been blessed with unusually rich oil-bearing rocks, but it seems likely that when the oil resources of the world have been fully explored, it will be found that less than 15% of these reserves are in U.S.A.

U.S.A. has been blessed with a native genius combined with political and social concepts which have enabled its citizens to search for petroleum more effectively and to discover it more rapidly than any other people. Risks have been taken. Tens of thousands of wells have been drilled in U.S.A. yearly for a generation. In other countries various conditions have seriously handicapped the search for petroleum.

The source of petroleum is the organic matter that has been buried along with muds on sea-floors. The present land surface of the earth is about 60,000,000 sq. ml. in area, and of this 22,000,000 sq. ml. has been covered by shallow seas and their deposits. Some 6,000,000 sq. ml. of the rocks offer first-class promise for petroleum; the remaining 16,000,000 sq. ml. shows less promise. Considering only the 6,000,000 sq. ml. of first-class promise, and allowing only 1 ml. depth of sediments, with 2·5% of organic matter (the average organic matter content of marine sediments), the organic matter will be ten times the weight of the known coal resources of the earth. If only 0·1% of this had been converted into petroleum and concentrated, the earth's oil reserves would be many times greater than the total known reserves. Thus it is not unreasonable to suspect that much oil remains to be discovered.

If abundant low-cost oil can be developed, standards of living can be raised materially throughout the world. American private enterprise is well qualified to undertake the development of the world's petroleum resources. The history of the oil industry shows that the finding and recovering of petroleum are enterprises which do not lend themselves to successful performance by the State; but Governments can assist in the development of the world's oil resources by facilitating the operation of free enterprise throughout the world. G. D. H.

844. Shell Wildcats in Colombia Below 9000 ft. Anon. *Oil Wkly*, 6.3.44, **113** (1), 60.—Shell's wildcat on the San Angel concession, Department of Magdalena, Colombia, is over 9000 ft. deep. Four Colombian wells have now exceeded 10,000 ft. in depth, and 9 have exceeded 9000 ft.

In January Brillianto 1 was testing at 10,250 ft., and on the Dificil concession another well was testing at 6120 ft. Retiro 1 of the Richmond Oil Company was drilling below 5000 ft. in Oligocene shale. G. D. H.

845.* Three Counties in Nova Scotia to Get Tests. Anon. *Oil Wkly*, 6.3.44, **113** (1), 60.—Lion Oil Refining Company has arranged to move drilling equipment to a location near Mabou, on the west side of Cape Breton Island, Nova Scotia. Sun Oil Company will put down one or more tests in Cumberland County, one near Spring Hill, north of the Cobequid Mountains. S. C. Nickle plans to drill a well in northern Hants County, south-west of Walton. G. D. H.

846.* New Structure Found in Tampico Area. Anon. *Oil Wkly*, 6.3.44, **113** (1), 60.—A large new structure has been found in the Panuco Arch district in the vicinity of Tampico. The structure is probably bounded by faults, according to geological and geophysical data. Plans have been made for exploratory drilling, and it is expected that rich pays will be found in the Upper Tamaulipas and Agua Nueva limestone zones. G. D. H.

847.* Russian Volga Area Fields are Active. Anon. *Oil Wkly*, 6.3.44, **113** (1), 60.—The Volga region fields are now reported to be second in production to those of the Baku area. In the region extending east of Kuibyshev, the oil production has been trebled during the war, and the output now exceeds that of the Emba district in Kazakhstan. G. D. H.

848.* Gulf Company Abandons Well in Nicaragua. Anon. *Oil Wkly*, 6.3.44, **113** (1), 60.—Late in February, the American International Fuel and Petroleum Company abandoned its stratigraphic information well drilled to 6700 ft. near Puerta Cabezas, Nicaragua. Geological and geophysical work will be continued in this area.

G. D. H.

849.* China's Production of 3000 brl. Daily Starts Nation Towards Self-Sufficiency. J. P. O'Donnell. *Oil Gas J.*, 9.3.44, **42** (44), 34.—900 ml. north-west of Chungking, the Kansu field has been developed with a production of 3000 brl./day. In 1940, China's crude output was about 30 brl./day.

Oil seepages occur along a 2000-ml. arc from Kashgar in western Sinkiang through Kansu into Shensi and Szechwan provinces. The arc follows the Trien mountains in Sinkiang and the Nan range in southern Kansu, parallel to depressions which were probably former inland seas. Production has been developed at two points along this arc, at Kansu and in Sinkiang. The Russians have production east and south of Samarkand in Turkestan, which may be an extension of the Szechwan–Sinkiang arc.

Before the war, China's oil consumption was less than 20,000 brl./day. Transportation of oil from Kansu presents difficulties. The construction of a refinery at Kansu is planned.

Fourteen wells are reported to have been drilled at Kansu, but the actual production is from 6 wells at depths of 1300–1400 ft. The first 7 wells drilled with cable-tool rigs found a small volume of oil at depths of 200–550 ft. G. D. H.

850.* Wildcat Completions and Discoveries. Anon. *Oil Gas J.*, 9.3.44, **42** (44), 95.—Sixty-eight wildcats were completed in U.S.A. in the week ended 4th March, 1944, and 13 produced oil and 3 gas. Three new Tensleep discoveries were made in Wyoming. A discovery in Rooks county, Kansas, gives promise of being an unusually good Arbuckle lime pool. On the Gulf Coast, a new pay was found on the south-west flank of the Placedo field, and the first Sparta production was developed on the north-west flank of the Pine Prairie field. A new Strawn sand pool was discovered 1 ml. east of Woodbine, Cooke County, Texas. A well in Big Horn County, Wyoming, swabbed 265 brl. of oil in fifteen hours.

A table summarizes the results of wildcat completions in U.S.A. in the week ended 4th March, 1944. G. D. H.

851. Mackenzie River Basin Best Opportunity for Oil in Canada. G. S. Hume. *Oil Wkly*, 13.3.44, **113** (2), 18.—The possible oil-bearing area in Western Canada includes 375,000 sq. ml. of the Prairie Provinces of Manitoba, Saskatchewan, and Alberta, 40,000 sq. ml. of north-eastern British Columbia, 150,000 sq. ml. of the Mackenzie Basin of the North-west Territories, and 10,000 sq. ml. at the head of the Peel River in the Wind River basin of the Yukon.

The structures of the plains of the Prairie Provinces are all gentle folds with dips rarely exceeding 1°. The possible oil-bearing rocks range from the Palæozoic to the Cretaceous, with non-marine Tertiary occupying the Alberta basin. In southern Alberta, the Red Coulee, Del Bonita, and Taber oil-fields, and the Bow Island, Foremost, and Medicine Hat gas-fields are on or at the edges of the Sweetgrass Arch. The oil accumulations are related to local structures or are in stratigraphic traps. The small production at Del Bonita is from the upper beds of the Palæozoic limestone, while the Red Coulee oil is in the lower sands of the Lower Cretaceous. The Taber oil comes from a lenticular sand, probably at the base of the Lower Cretaceous, A sand 350–400 ft. above the base of the Upper Cretaceous shales provides the gas at Bow Island and Foremost. The Medicine Hat gas comes from a sand 300 ft. below the top of the same shales.

In east central Alberta is the large Viking–Kinsella gas-field and the smaller gas-fields of Fabian, Vermilion, and Lloydminster. Small oil-fields occur at Wainwright, Vermilion, Lloydminster, and Dina. All the oil is from sands in the Lower Cretaceous. In Southern Alberta, the Lower Cretaceous is entirely non-marine; in the McMurray tar-sand area there are alternations of marine and non-marine beds, the cross-bedded basal McMurray sandstones suggesting deltaic conditions; between are the shore-lines of the Lower Cretaceous seas, and Vermilion and Wainwright are associated with these favourable shore-line conditions. South-west of Fort McMurray, drilling has shown oil in Lower Cretaceous beds. The oil in the tar-sands and the adjacent areas to the south-west and as far south as Wainwright probably has a common origin, and may be indigenous to the Lower Cretaceous. In east central Alberta, the Cretaceous rests directly on Devonian limestones, but to the south there are intervening Jurassic and Mississippian beds. Shows of oil have been found in the highly porous Devonian of east central Alberta, and the oil prospects are considered to be good.

Recent exploratory drilling has shown that in the Wheeler Island and Steepbank areas the tar-sands differ in quality and have a much lower bitumen content than near the Abasand plant.

Turner Valley, Canada's most important oil-field, is in the foothills of southern Alberta. It has produced 51,500,000 brl. of oil, and at present gives 23,000–24,000 brl./day. The peak production was 29,700 brl./day in February 1942. Wells are generally 6000–8500 ft. deep. The productive Palæozoic limestone is a westward-tilted fault block cut off by faults on both the east and west in the south and central parts of the field, while the block itself is broken by faults in the north. The limestone has dips of 15–20°, but surface dips are commonly much steeper. At the north end, a block seems to have been depressed by faulting subsequent to oil accumulation, and it has carried the oil down with it. The productive area is now fairly well defined except in the north. The closure within the oil zone may be 2100–2250 ft., and in the gas zone 2786 ft., giving a total of nearly 5000 ft.

Attempts have been made to develop other fields like Turner Valley, as in the Jumping Pound area, at Brazeau and Grease Creek. There are many favourable structures in north-eastern British Columbia, and the Lone Mountain anticline has a large gas-seep with 12% of ethane.

The first well at Norman Wells was drilled in 1920, and it found oil at a depth of 1025 ft. A few other wells were drilled, and in 1942 developments were speeded up under the Canol project. A major field is said to have been found. The oil comes from Middle Devonian limestones, although the original discovery well produced only from the overlying upper Devonian shales (Fort Creek formation). The Bosworth formation gives some seeps, and under adequate cover on favourable structures the Bosworth sands could be good reservoir rocks. In the area west of the Mackenzie river there are good prospects of finding oil under such conditions. South and south-west of the Great Slave Lake, the Middle Devonian has good cover and suitable structures, and so may provide oil, since it gives seeps where it outcrops to the north. To the north of Norman Wells is a large basin of Cretaceous rocks overlying the Devonian in the Peel river area extending westward into the Yukon. Oil-seeps have been reported, but little geological work has been done. G. D. H.

852. Undiscovered Oil Reserves in Illinois. M. M. Leighton. *Oil Wkly*, 13.3.44, **113** (2), 30.—The Illinois oil development shows two phases, one beginning in 1905, the other in 1937, and of the 1,022,000,000 brl. of oil produced, 566,000,000 brl. has been obtained from fields discovered since 1936.

Although no major pools have been discovered for several years, many small pools have been found, and continue to be found each month. In the past, major attention has been given to the finding of structural traps, and it may be that no large pools of the structural-trap type remain to be discovered. There is, however, good reason to believe that oil accumulations in stratigraphic traps exist in Illinois, and their discovery will require geological studies combined with large-scale systematic drilling programmes. It is also possible that oil awaits discovery in formations above and below those which are now productive. For several years following the new discoveries in 1937 most wells were drilled rapidly through the Pennsylvanian without adequate logging, and it is possible that pay-zones have been missed. Recently, efforts have been made to obtain more complete data on the Pennsylvanian strata, and structure maps and cross-sections have been compiled. Subsurface studies of pre-Pennsylvanian strata will be made in these areas.

4000 ft. of sediments below the St. Peter remain to be tested, and only a few wells have gone below the Kimmswick to test the St. Peter. The lithology and structure of the pre-St. Peter strata are therefore unknown. G. D. H.

853. Drilling Rate Much Higher Currently than for the Same Period in 1943. Anon. *Oil Wkly*, 13.3.44, **113** (2), 48.—In the first two months of 1944, wells were completed in U.S.A., at a weekly rate 13·8% higher than for the same months of 1943, and at the beginning of March 42% more wells were drilling or rigging than a year ago.

During February 1944, the weekly completion rate averaged 402 wells, against an average of 357 in January. Most States show greater drilling activity than last year.

Data on the well completions in February, and during the first two months of 1944, are tabulated by States, with comparative figures for January 1944 and February 1943. G. D. H.

854. Turner Valley Outpost is Canada's Deepest Producer. Anon. *Oil Wkly*, 13.3.44, **113** (2), 50.—Northend Petroleum Company's No. 1 is Canada's deepest producing well. It is 9612 ft. deep, penetrating the lime for 683 ft., and lies in the extreme north-eastern flank area of Turner Valley. The well is flowing 500 brl./day. G. D. H.

855.* Wildcat Completions and Discoveries. Anon. *Oil Gas J.*, 16.3.44, **42** (45), 125.—Among the 262 wildcats completed in U.S.A. during February 1944, 35 found oil, 4 distillate, and 11 gas. The discoveries were considerably more numerous than in January 1944, and almost reached the December 1943 total, in spite of 25% fewer wildcat completions.

Kansas, Oklahoma, West Texas, Texas Gulf Coast, and Mississippi were the areas showing the best comparative results, but recent developments in Wyoming give promise of more extensive search for Tensleep production in other areas.

Tables give by States and districts summaries of the wildcatting results in December 1943, January and February 1944, and in the week ended 11th March, 1944.
G. D. H.

856.* Prospective Oil Areas in South America. J. L. Rich. *Oil Gas J.*, 23.3.44, 42 (46), 90. (Annual Meeting of A.A.P.G. and affiliated Societies. 21st–23rd March, 1944.)—The most extensive area of promising oil territory in South America lies in a belt bordering the eastern base of the Andes running from Tierra del Fuego to Trinidad. The Sub-Andean belt produces in the Neuquen, Mendoza, and Salta regions of Argentina, in southern Bolivia, central Peru, and in Venezuela. Parts of Argentina are unfavourable, but otherwise for the whole length of the belt there are sedimentary formations likely to yield oil, together with folding adequate for trapping. However, in much of the belt, except locally close to the mountain base, the prospective oil-bearing rocks are at great depths, up to 15,000 ft. or more, and the structures are difficult to find because of the thick mantle of relatively recent sands, gravels, and silts, derived from the growing Andes, and resting unconformably on the older beds.

In eastern Patagonia a sedimentary basin developed in the late Cretaceous, and this gave the Comodoro Rivadavia field. To the south is a similar basin, with marine Tertiary and Cretaceous, which has not been adequately tested.

Tertiary subsidence and block-faulting developed a thick series of marine beds and suitable structural traps in northern Peru and western Ecuador. Some fields have been found in this area. Several troughs on the Caribbean slope offer promise in Colombia. Oil has been found in a relatively small down-faulted basin of Cretaceous rocks near Salvador, Brazil. Large areas of east-central Brazil have a relatively thin mantle of Palæozoic with oil-showings in places. One such area is a Palæozoic trough probably of moderate depth, with Silurian, Devonian, and Carboniferous beds. A large potential area of oil territory, not yet productive, is the Parana basin of south-western Brazil, Paraguay, and northern Uruguay. G. D. H.

857.* Regional, Subsurface Stratigraphy and Structure of Florida and South Georgia. P. and E. Applin. *Oil Gas J.*, 23.3.44, 42 (46), 92. (Annual Meeting of A.A.P.G. and affiliated Societies. 21st–23rd March, 1944.)—Sediments of Recent to Lower Cretaceous age overlie the crystalline basement rocks, and there may be buried pre-Cretaceous beds intercalated at depth. In the southern part of Florida the sediments are over 11,500 ft. thick.

From the top of the Oligocene to the base of the late Middle Eocene is a continuous sequence of limestones throughout the area, but in each formation between the top of the early Middle Eocene and beds of Austin age (Upper Cretaceous) two facies occur. In western Florida and southern Georgia there is a facies of sands and shales with some limestone and chalky marl; over most of the peninsula the sedimentary section is almost wholly limestone. The two facies grade into each other in the northern part of the peninsula.

The micro-faunas of the clastic facies resemble those of the western Gulf Coast, whereas those of similar age on the peninsula are more closely akin to those of Cuba and the West Indies, Mexico, and Europe. From the top beds of Taylor age onwards in the peninsula familiar Gulf Coast faunas again appear.

The structure of the Ocala limestone (Upper Eocene) shows two roughly parallel north-west-trending upwarps in the northern half of the peninsula, one along the east coast, and the other through the Ocala uplift. A north-easterly-trending trough extends from the Tallahassee area of Florida across southern Georgia.

A correlation table is given for the Oligocene–Lower Cretaceous beds of Florida and south-eastern Georgia. G. D. H.

858. Vermilion Field is Runner-Up in Alberta. Anon. *Oil Wkly*, 27.3.44, 113 (4), 40.—During 1943 the Vermilion field produced 93,258 brl. of oil from 36 wells, making it second to Turner Valley in output. Its cumulative production is 189,399 brl.
G. D. H.

859.* Orientated Hand Coring in Geological Field Works. K. Rohr. *J. Inst. Petrol.*, April 1944, 30 (244), 79–89. Early geological exploration in Trinidad, based on surface evidence, is reviewed. The use of auger holes in the early work is briefly described. The present coring equipment and technique is next discussed and illustrated. The accuracy of the orientation is stated to be satisfactory on the basis of field evidence. Advantages of the coring system over excavating test-pits are discussed. A. H. N.

860.* Wildcat Completions and Discoveries. Anon. *Oil Gas J.*, 6.4.44, 42 (48), 97.—The wildcat completion rate in U.S.A. in the week ended 1st April, 1944, was at about the same level as a year previously. There were 56 completions, 8 giving oil, 1 distillate, and 2 gas.

There is still a lack of first-class geophysical and geological prospects on which to drill. The demand for oil is causing a relaxation of standards for prospects, and some exploratory departments have been reminded that the size of the field found is not necessarily measured by the excellence of the geological prospects. There is a greater willingness to take more chances.

The results of wildcat completions in U.S.A. in the week ended 1st April, 1944, are tabulated, together with the cumulative totals for 1944. G. D. H.

Geophysics.

861.* Geophysics Looks Forward. R. D. Wyckoff. *Oil Gas. J.*, 23.3.44, 42 (46), 85. (Annual Meeting of A.A.P.G. and affiliated Societies. 21st–23rd March, 1944.)—While geophysical instrumentation may advance owing to war-time developments, no new geophysical principles will arise from them. Orthodox geophysical methods depend on one of two fundamental principles : (*a*) the observation at the surface of forces originating in subsurface anomalies ; (*b*) the probing of the subsurface so as to permit the mapping of the form of certain discontinuities which are stratigraphic markers or are related to such geologically significant markers. The first group makes use of gravitational and magnetic effects ; in the second elastic or electromagnetic wave energy is applied at the surface and propagated through the subsurface. The magnetic and gravimetric methods have been, and will continue to be, useful as reconnaissance tools. Their effectiveness has been increased in recent years through more enlightened methods of interpretation made possible by an increase in both the accuracy of the data and the amount of detail secured. Gravimeters are available now of a degree of accuracy which leaves no substantial justification for striving for increased instrumental sensitivity. More detail will help the interpreter, but this can best be obtained by improving the methods of topographical surveying, so as to reduce the over-all costs of topographical surveying.

There are improvements in view which can enhance the capabilities of the magnetometer. With modern interpretative technique applied to data of sufficient detail and accuracy, the magnetic method has definite usefulness as a reconnaissance tool.

Greater success than in the past may or may not attend the application of electrical methods of prospecting in the future, but it may be said with confidence that radiofrequency phenomena will not be applicable in oil-finding.

The seismic method appears more direct than the others, but the records include such complexities due to intervening strata that precise interpretations are impossible ; only a part of the information is used, and it may never be possible to make use of much of it. Geochemical methods have a theoretically sound basis, but only the future will show to what extent it is amenable to practical application.

The effectiveness of geophysical exploration should be improved substantially by better handling of equipment, of the data obtained, and of the geophysical talent available.

Since geophysical maps, especially seismograph data, are presented as subsurface contours, it has often been assumed that with the drawing of the map the geophysicist's job is done ; that the map is a unique and positive solution of the seismic data, and that an area may be condemned, or drilled, and often abandoned without adequate tests. Also the geophysicist and his tools are condemned, with the result that he becomes more conservative and unwilling to speculate beyond the most positive data visible on his records. The seismograph interpreter is practically alone in his understanding of the complexities due to possible distortions and complex travel paths. The location of stratigraphic traps is possible geophysically, but it can be accomplished only by frank acceptance of the risks that face the interpreter. The oil industry will have to accept and act upon seismograph data far less certain in character than has been acceptable in the past. The seismograph is not a machine which turns out maps. A large part of its effectiveness depends on the human factor, on the acuity and experience of the geophysicist. An imaginative and venturesome geophysicist is as necessary as his instruments. G. D. H.

862. Average Number of Geophysical Parties Shows Increase Despite Draft. E. A. Eckhardt. *Oil Wkly*, 27.3.44, **113** (4), 17.—During 1943, an average of 255 seismograph parties were operating in U.S.A. compared with 226 in 1942. During the first half of 1943 the average was 248; during the second half 263. It appears that as regards effectiveness in the performance of things over which the geophysicist has control, 1943 geophysical parties as a whole were below par.

Some geophysical organizations have lost half of their personnel to the armed services. As far as possible, women have been employed, but loss of man-power has prevented a much-needed and desired growth in the volume of operations. The peak demand for petroleum products will occur nearer the climax of the war than will the peak demand for other war materials.

Gravimeter parties grew more rapidly in number during 1943 than did seismograph parties. Seismograph activity was most concentrated in the areas giving most of the current production. G. D. H.

863. Preventing Power-Line Mishaps in Seismograph Shooting. W. O. Holmes. *Oil Wkly*, 27.3.44, **113** (4), 26.—In seismic work it is frequently necessary to shoot under or near power-lines, a procedure not without risk. This commonly arises in shooting along highways and roads to avoid the problems arising from crops and flocks, and to speed operations. Normally, when power-lines are met, the shot hole is drilled as far away on the opposite side of the road as fencing and terrain permit. At times the maximum distance may not exceed 50 ft., and often is not more than 100 ft.

Electric blasting caps are used in seismic shooting, and while the cap or lead wires can be anchored at the top of the hole, 50–150 ft. of wire extends down the hole, and this wire is usually blown into the air when the shot is fired. If the holes are deeper than the distance from the hole to the nearest power-line, the men in the shooting truck, and sometimes even in the recording truck, are subject to a serious hazard. Grids and deflectors placed over the holes before shooting have not proved entirely reliable, especially with heavy charges.

Recently lengths of patented detonating fuse have been substituted for parts of the wire in the hole. This fuse, like any other detonant, must be handled carefully, but it is relatively insensitive to shock, friction, and flame. Its rate of detonation is about 20,350 ft./sec., and it disintegrates completely on detonation.

Tests are described in which this detonating fuse was used, and the indications are that it can be applied successfully to minimize or eliminate the special hazards of seismic shooting in the vicinity of power-lines. The lag in the arrival times at the recording truck was found to agree with that estimated from the length of fuse and the velocity of detonation.

Cost considerations suggest that the length of fuse used should be the minimum which will give safety, and, since it is a powerful explosive, it should not be brought closer to the top of the hole than 10–15 ft., unless absolutely necessary. In some instances the up-hole geophone gave confused and inaccurate up-hole times. This generally occurred when the cap and the fuse were close to the top of the hole, but the confusion was usually satisfactorily reduced by placing the cap connection 15–20 ft. or more below the surface, and moving the up-hole geophone a few feet away from the hole. If heavy charges are used there is a possibility of fuse breakage in the hole, due to the fuse's fairly low tensile strength. The use of reinforced fuse is recommended for holes deeper than 150 ft., or where charges exceeding 20 lb. are used in shallower holes. It may also be necessary where the charge has to be worked to the bottom of a "tough" hole. The use of the fuse is not recommended in cased holes, especially if they are water-filled. G. D. H.

Drilling.

864. Positive Colloid Muds for Drilling Through Heaving Shale. D. C. Bond. *Petrol. Tech.*, January 1944, 7 (1), A.I.M.M.E. Tech. Pub. No. 1674, 1–10.—It is generally accepted that heaving shale contains large amounts of bentonite, a hydrophilic colloid that hydrates and swells very much when in contact with water.

The particles of an ordinary clay suspended in water carry negative charges, and these are surrounded by an electrically equivalent charge on positive ions, which are generally replaceable by other positive ions, so constituting the "replaceable base" of the clay. The properties of the clay vary widely with the amount and type of the replaceable base. Agents which reduce the charge on the clay particles have a flocculating effect, while the reverse is true of those which increase the charge. Generally, any electrolyte which deflocculates negative colloids will flocculate positive colloids, and vice versa, but large amounts of any electrolyte flocculate both types of colloid. Bentonite from which the replaceable base has been removed by dialysis does not swell when in contact with water. The swelling of the clay is due to the hydration of the exchangeable base, and thus may be reduced by the introduction of less hydrated bases.

Oil-base muds, various salt solutions, sodium silicate, and various processes have been used or proposed for drilling through heaving shales, but all are open to serious objections. It seems that a mud containing positively charged colloidal material should be satisfactory for drilling bentonitic shale, for the positive colloid should tend to flocculate the bentonite by neutralizing the negative charge. No naturally occurring positive colloids are available that are suitable for drilling muds, and so positive colloids for this purpose have been prepared by adding salts of polyvalent cations, acid gelatin and other proteins, or basic dyes such as methylene blue, to bentonite suspensions.

Experiment shows that heaving shale does not swell or disintegrate when placed in contact with a suspension of bentonite containing sufficient basic dye to render the bentonite positive. While fairly satisfactory drilling muds can be prepared from mixtures containing only bentonite and basic dye, the properties of such muds are improved by the addition of certain substances. A little diglycol laurate reduces the tendency to foam, and a small amount of wheat flower or starch improves the stability, gel strength, and filtration characteristics.

The results of tests on some representative methyl-violet bentonite muds are tabulated, and altogether they appear satisfactory. These muds have certain distinct advantages over sodium silicate muds, which have so far proved the most satisfactory for drilling through heaving shales. The clay particles in the sodium silicate muds are flocculated, and the high viscosity of the suspending medium prevents their settling rapidly. The wall-sealing ability of these muds also depends on the high viscosity of the suspending medium. Under high temperatures the viscosity of the sodium silicate muds is greatly decreased, and there is a considerable increase in the filtrate loss, while the positive colloid mud shows little increase in filtration loss. The electrical resistivities of typical sodium silicate muds are much less than the value which is favourable for electrical logging, but the resistivities of positive colloid muds are such as should yield accurate, undistorted electrical logs.

The initial cost of positive colloid muds, which have yet to be tested in the field, is about 25% higher than the cost of sodium silicate muds, but their superior properties and probable lower losses in drilling should more than offset this. G. D. H.

865.* Coastal Louisiana Blow-out Presents Numerous Capping Problems. J. F. Flint. *Oil Gas J.*, 10.2.44, 42 (40), 43.—The control of a well blow-out which required blasting to remove the debris over the flame-path before casing head could be set and drilling of a relief well for final control, is described in this paper, which is well illustrated with photographs. It was during routine drilling operations below 10,400 ft. that the Union Sulphur Co., Inc.'s 1 Gueno blew out and caught fire. This well, a rank wildcat located in the Branch area of Acadia Parish, Louisiana, was subsequently capped after twenty-seven days of burning and blowing, and is the discovery well for a new Coastal Louisiana field. Upon installing, the capping manifold gauged between 75,000,000 and 80,000,000 cu. ft. of gas through three 4-in. lines. These production figures would have been considerably increased were it not for the fact that the 3½-in.

o.d. drill pipe, with 4½-in. o.d. tool joints, remained inside the 7-in. o.d. production string. That the pressure gauges on the capping manifold registered 500 lb./sq. in. while the well flowed through three 4-in. flow-lines, is indicative of the extremely high pressures of the penetrated zones. Several shallower tests have been drilled on the Branch prospect in recent years, but without success. Nearest production is in the Bosco field, located approximately 6 miles due east of the new discovery well.

Shortly after Gueno 1 blew out, a spark of undetermined origin ignited the well-flow. The terrific heat quickly caused the derrick to buckle and settle down over the well, which, together with the drilling-control equipment and rotary table, deflected the flow of gas and oil and caused the flame to mushroom over a large area. Thus, the first objective in bringing the well under control was to remove this junk from the path of the flow, so that the flame would rise vertically and permit installing a special 6000-lb. test capping manifold.

Two attempts at blasting the junk resulted in clearing the path for the capping crew. The capping operation is fully described, together with the final control.

A. H. N.

866.* Application of Reverse Circulation. H. F. Simons. *Oil Gas J.*, 10.2.44, **42** (40), 54.—There are a number of cases in which reversing circulation is a distinct advantage. One of the simplest applications, and probably one of the earliest, is the unplugging of a bit by this method so that normal circulation can be established during a regular drilling operation. Another is simply reversing the circulation while washing in a well which has been perforated. The main application, however, lies in the completion and reconditioning of wells having pressures capable, or nearly capable, of flowing them. This latter class also includes reverse-circulation coring. Strictly, as a drilling tool, reverse circulation does not at present offer any particularly outstanding advantages. It has been suggested by Pigott as a better means of lifting cuttings than normal circulation, but at the same time Pigott points out that there are objections to this method, due to conditions other than lifting the cuttings. Principally, these objections are the compaction around the drill collars and the bit of any material which might slough into the hole, and the loss of the jet action of the fluid stream on the cutting surfaces of the bit. The use of reverse circulation in completion jobs is described in some detail. Reconditioning, recompletion, and cleaning out wells are discussed.

One of the outstanding facts arising from recent reverse-circulation work concerns the loss of fluid to the formation. Several years ago, reverse-circulation jobs would be stopped on a well whenever the fluid going into the formation became appreciable. At present, as long as the oil does not escape too rapidly, the work is continued until the desired results are obtained, as it has been found that the lost oil can be recovered quickly after the well is put back on production. If the loss of fluid is so high that circulation cannot be maintained, the formation must be plugged with fibre, mica, or some plastering material, such as an oil-base mud or a water-bentonite mixture. When all the drilling and cleaning out after the shot has been accomplished, the hole can then be washed with oil, providing a pump of sufficiently high volume is available. A. H. N.

867.* Well Pressure Affects Workover Procedure. H. F. Simons. *Oil Gas J.*, 23.3.44, **42** (46), 116.—Loss of fluid to the formation is always of interest in a cleaning-out job by the rotary method with either normal or reverse circulation, and it occasionally becomes of interest when working on a well with cable tools. Frequently, this factor will control the choice of method to be used and the procedure to be followed. If return of the fluid to the surface cannot be obtained, the rotary method cannot be used, or at least the effectiveness and efficiency of the method are reduced. The rate at which the well takes fluid can be determined by actual test, and can often be estimated from the history of the well. The production and bottom-hole-pressure histories of the well give a good indication of the amount of oil which will be lost to the formation/day under the conditions at the time the work is performed. If the well produced 300 brl./day at a differential of 300 lb./sq. in., it is reasonable to expect that losses to the formation will approach that amount after the well has been cleaned and shot and a similar pressure is acting in the opposite direction—*i.e.*, from the well to the sand. Generally, the rate at which the formation takes fluid at any differential pressure is also an indication of the rate at which oil will come into the well when the conditions are reversed.

The pressure drop in the tubing can be calculated from

$$P = \frac{0{\cdot}000108\,flrv^2}{d}$$

where P = pressure drop, lbs./sq. in.; f = friction factor; l = length of tubing, ft.; r = density of mud, lb./cu. ft.; v = velocity, ft./sec. and d = inner diameter of tubing, ft. A. H. N.

868.* Mud Conditioning in West Edmond Field Involves Special Treating Problems. N. Williams. *Oil Gas J.*, 23.3.44, 42 (46), 135.—The chief troubles encountered in this field are described. Since there are no high pressures down to the producing horizon to be controlled, high mud weights are not required. From a pressure-control standpoint there is no occasion to carry a weight of 9·5–10 lb./gallon. In view of this, the principal concern in weight control is to lighten the mud to such a range that excessive returns will not be lost in the porous formations. The greatest trouble with loss of returns is most likely to occur in the Oswego lime, just below the shale section around 5500 ft. Many of the stuck-drill-pipe cases and twist-offs experienced in the field have occurred while drilling at this depth. Down to the Oswego lime, mud weight is not closely controlled. In drilling the upper formation, it largely takes care of itself, by reason of the large volume of water circulated to dilute the chlorides. However, with the addition of muds and building up viscosity, it has a tendency to build up when drilling the shales, and sufficient make-up water has to be added to the system to lighten it. General practice is to hold the weight to a top range to 10·1–10·2 lb. while drilling through and particularly below the shales. It has been found that when the mud weight is allowed to exceed that range, excessive loss of returns is likely to occur in the Oswego and give trouble, while with lower weights the loss of returns can be readily controlled, especially with the addition of wall-sealing material to the mud. Preparatory to starting mud conditioning for entering the shale section, the pits are thoroughly cleaned, a shale shaker is put on the return discharge, and circulation is switched from the reserve pit to the regular pits. The next step is to get the system in condition to receive the new mud. This generally consists of adding soda ash and tannic acid in the ratio of 1 : 1 to the make-up water and circulating at least sixteen hours before adding and treating new mud.

By the somewhat drastic initial chemical treatment resorted to, water loss of the drilling fluid in the system is decreased from about 70 c.c. as carried in drilling the upper part of the hole, to within a range of 35–40 c.c. before the addition of any new mud. Moderate use of chemicals is made later as make-up water is added, with consequent further reductions in water loss. Usually the water loss of the mud is decreased to about 25 c.c. by the time a depth of 6000 ft. is reached, and to as low as 16–18 c.c. for the drilling of the remainder of the hole. Following the initial treating and conditioning of the system while circulating for about sixteen hours, bentonite, clays, and gels are added to build up viscosity and other mud properties. The amount added initially depends largely on the volume of old mud taken from the pits during the initial cleaning. Usually, from 30 to 60 sacks are required. Through the effect of the soda ash and tannic acid treatment, the initial gel is held down to a range low enough so that drilling progress is now slowed by the increase in viscosity. Treated make-up water is added as needed to maintain volume and lighten the mud. A. H. N.

869.* Drilling. M. C. Seamark. *J. Inst. Petrol.*, May 1944, **30** (245), 134–149.—The paper deals with the elements of drilling practices, and is written for those not specialists in drilling. Such processes as cementing, pressure control, verticality of wells, coring and formation testing, shooting and acid treating formations are described, besides the main problem of actual drilling of the well. A. H. N.

Production.

870. A Method of Evaluating Pressure Maintenance. N. van Wingen. *Petrol. Tech.*, January 1944, 7 (1), A.I.M.M.E. Tech. Pub. No. 1665, 1.—A consideration of optimum economic returns is one of the most important factors involved in the selection of a method or scheme of operation for any given reservoir.

Benefits from maintaining the reservoir pressure or from arresting its decline in reservoirs of low-gas–oil ratio may accrue from decrease in lifting costs by extension of flowing life, and reductions in shrinkage of the non-recoverable oil, and production at economic rates to lower residual oil saturations due to lower viscosities and interfacial tensions at the higher pressures, thus permitting the attainment of a higher ultimate recovery. In the present analysis benefits due to the decreased development costs and greater control of the gas cap are ignored.

It is assumed that the initial development of the reservoir has proceeded in such a manner that by the drilling of a relatively small number of widely-spaced wells the reservoir's characteristics, and hence the total volume of oil in place, have been established. The factor to be applied to find the proportion of the oil which will be recoverable under normal depletion methods of operation was found from the results of laboratory studies, and checked by comparison with actual fields of similar characteristics, but which have reached advanced stages of depletion. The additional recoveries obtainable when operating under various degrees of pressure maintenance can be established, in the absence of comparable field data, on the basis of the results of laboratory model studies, or analytically.

On the above basis the following curves were deduced for natural depletion, two degrees of partial pressure maintenance, and complete pressure maintenance : (1) the pressure decline, (2) the average behaviour of the well productivity index, (3) the average well-potential, and (4) the field production rate. All the curves were plotted against time, using a twenty-five-year life for natural depletion and the lowest degree of pressure maintenance, and thirty years for the other two cases. In each case gas injection is stopped five years before the end of the reservoir's producing life.

On making an economic analysis of the four modes of operation, assuming that the price of oil and gas are constant throughout the field's life, it is found that the net profits increase in nearly direct proportion with the amount of gas returned to the reservoir, to an extent that the purchase of "make-up" gas, which is necessary in order to achieve the higher degrees of pressure control, appears to be profitable. The profit increase is particularly rapid between natural depletion and the re-cycling operation which involves the return of 50% of the solution gas produced. After this point the rate of additional profit increase is more moderate. Thus it seems that a return of at least 50% of the solution gas produced is a minimum requirement for optimum economic returns. The increased revenues obtainable as gas-injection volumes increase arise from the correspondingly greater oil recoveries estimated.

On the basis that the oil recovery is unchanged by re-cycling, with corresponding adjustment of the productive life and production costs, the net profit is estimated to be essentially the same irrespective of the manner in which the field is to be produced—*i.e.*, increased costs due to the return of gas to the reservoir, loss in gas revenue due to larger volumes being lost as plant fuel and shrinkage, and, in two of the cases, the cost of purchasing gas for injection, are offset by increased gasoline revenues and a reduction in lifting costs. Hence, any increased oil recoveries obtainable under pressure maintenance essentially represent merely a proportional amount of additional income. G. D. H.

871.* Paraffin Removal from Oil-Wells. C. C. Pryor. *Petrol. Engr*, February 1944, **15** (5), 122.—As the temperature of a crude oil containing amorphous wax (paraffin) approaches the melting point of the paraffin, the paraffin becomes completely soluble in the oil. Lowering the temperature of the crude oil results in its becoming more viscous, due to the gradual forming of wax crystals. Thus, wax of high melting point has low solubility in the crude oil at a temperature below its melting point. Deposition of paraffin in the tubing of flowing, pumping, and gas-lift wells will restrict the flow, and if permitted to accumulate will, in time, plug the well. Paraffin usually begins to deposit in the flow-string of a well at the point where the earth temperature approaches the wax saturation temperature of the oil. Variations from this point of deposition depend on the temperature of the oil leaving the formation, wax content of the oil, and the volume of lighter hydrocarbons and gas present in solution. Deposition of wax may extend from this initial point to surface connections of the well, through flow lines, separators, and storage tanks. The paper deals systematically with paraffin deposition in flowing wells, pumping wells, and in wells on gas-lift. Among the methods used in removing paraffin accumulation in flowing, pumping, and gas-lift wells is one now in extensive use in the East Texas field. The basis of this method is the use of heated crude oil, and its manner of application to the well is given. It consists in forcing hot oil under pressure down the tubing at sufficient temperature to melt the wax. Equipment consists of a small steam generator, heat exchanger, and high-pressure pump mounted on a truck. A wire line reel, heat retainer piston, and a hot oil line complete the set-up.

The use of the method in naturally flowing wells and in wells on artificial lift is described. A. H. N.

872.* Added Load Factors Involved in Pumping Multiple Wells. J. Zaba. *Oil Gas J.*, 10.2.44, **42** (40), 62.—As in the case of unit sucker-rod, calculations relating to the multiple pumping installations must have as their starting-point the bottom of the well, the size of the plunger determining the loads involved. To the well loads, however, there must be added loads resulting from operation of rod lines, which represent the medium of transmission of forces from the central power plant to the individual wells. In order to evaluate the resulting loads at the knock-off post of the power, it is customary to combine all the loads involved in the so-called rod-line pull. This concept offers a convenient medium for calculation of loads, torques, and power requirements. The load on the rod line at knock-off post of the power plant consists of the following component parts: (1) Well load, (2) rod-line friction, (3) rod-line inertia. These three items are discussed separately and then combined. The influence of auxiliary equipment—*e.g.*, swings, hold-overs, hold-ups and hold-downs, multipliers and reducers, and counterbalancing dummies—is briefly indicated. A. H. N.

873.* Wartime Use of Abandoned Wells as Induction Centres. F. R. Cozzens. *Oil Wkly*, 20.3.44, **113** (3), 16.—The basic requirement for making an abandoned well an effective part of a recovery pattern is that the well must not have been previously used as an input. Best results are obtained on wells which have been salvaged and plugged before present recovery measures were started. Generally, the operator has at least a partial log record as to the location and depth of all wells abandoned on his property, and from these data he selects those wells within radius or influence of present producers. Many of the old wells still contain the original drive-pipe, extending above ground. Most of them are bridged at the top and at intervals along the walls with debris or trash which is easily drilled out. Once the hole diameter (at the top) has been ascertained, the procedure is to rig a spudding outfit or light string of tools over the site, using in most cases bits of the same dimensions as the original bore. Cleaning out is accomplished most efficiently by drilling with a taut cable and using as little outside water as possible. If the side-walls are fairly dry, as will probably be the case in the upper stretches of hole, very little cavings are encountered, and the original casing point can usually be reached before any pipe is needed. If water is encountered, the operator starts his pipe and allows it to follow the tools, especially through areas of soft formations. First-grade casing is rarely used, and it is seldom necessary to seat the pipe in cement. Some of these old wells, especially in the lower stretches of hole, contain one or more sections of casing which were broken off when the original pipe was pulled. When this obstacle is met, it is necessary to change to a smaller bit, to avoid sticking. By proceeding with caution, the old casing is generally made an aid in holding back the wall cavings while cleaning continues, and, unless badly damaged, no time need be taken to remove it.

Cleaning the hole and setting packer, etc., are detailed. The pressure is put slowly on the well until it reaches the standard of the field. A. H. N.

874.* Determining Saturations by an Extraction Distillation Method. S. T. Yuster. *Oil Wkly*, 20.3.44, **113** (3), 20. The apparatus used is a distillation extractor using porous thimbles. Two types are described: a large flask apparatus, and a small sample apparatus. In determining the saturation, oil, and water, the core is removed from its sealed container and rapidly broken into a size convenient for filling the thimbles. After filling the thimbles to about 0·5 in. from the top, they are weighed to the nearest 0·01 g. This process should be conducted as rapidly as possible, in order to minimize the evaporation of water and the lighter ends of the oil. In certain cases it may be desirable to use weighing bottles for holding the smaller thimbles. If the core is friable and contains loose pieces of sand, it is advisable to use a loose plug of cotton on the top of the filled thimble. This plug of cotton must be weighed with the clean, dry thimble prior to filling with the core sample.

After the thimble has been weighed, the solvent is placed in the flasks, and the apparatus assembled. No stopcock lubricant must be used in any circumstances on the ground-glass joints, or errors will result. The standard taper joints fit sufficiently close to give an adequate seal. The solvent in the small sample extractor flasks should come to about three-quarters of an inch from the bottom of the suspended thimble. The large sample extraction flasks should have the bulb about half filled with solvent. The top of the condenser tube should be covered with a fairly snug-fitting vial or a loose plug of cotton, to prevent atmospheric moisture from collecting in the condenser. Hints on correct manipulation and common errors are given. The formulæ to be used are given in full. The solvent used was a special naphtha cut called Amsco heptanes, obtained from the American Mineral Spirits Company of Carteret, New Jersey. The boiling range was 199–212° F. Other solvents could be used, but it is considered that they must be immiscible with water; miscible with the oil; have a boiling point near that of water; be inert towards formation samples; non-toxic, and low in cost. A. H. N.

875.* Methods of Torque Analysis in Central-Power Operation. J. Zaba. *Oil Gas J.*, 23.3.44, 42 (46), 119.—A graphical method is presented. All forces acting on a power resolve themselves into two components. The one vertical to the crank causes the torque on the power, the torque equalling the vertical component times the crank throw. The other component, acting along the arm of the crank, tends to overturn the power. Of the two components, the one causing the torque is of primary importance, since even distribution of torques is a condition on which the satisfactory and smooth operation of the central power is based. The other component, representing direct pull on the power along the rod lines, is usually not considered in an ordinary analysis. It is being generally assumed that power itself and the foundation have been designed in such a manner as to take care of the ordinarily expected overload conditions resulting from the component acting along the arm of the crank. On this basis, a graphical method is outlined for torque analysis of central-powers.

A. H. N.

876. Patents on Drilling and Production. C. W. Breukelman. U.S.P. 2,340,861, 8.2.44. Appl. 2.8.40. Orientating device.

G. F. Downs. U.S.P. 2,340,943, 8.2.44. Appl. 26.5.41. Oil-well pump.

P. H. Harth. U.S.P. 2,340,959, 8.2.44. Appl. 3.8.40. Recovery of pipe.

W. L. Kitsman. U.S.P. 2,340,966, 8.2.44. Appl. 7.3.41. Perforating method and apparatus.

F. T. Robidoux. U.S.P. 2,340,987, 8.2.44. Appl. 14.11.41. Electrical well caliper.

A. L. Smith. U.S.P. 2,340,993, 8.2.44. Appl. 24.11.39. Method of testing wells.

R. W. Wilson, A. Long, Jr., and M. T. Randolph. U.S.P. 2,341,169, 8.2.44. Appl. 30.12.40. Method and apparatus for detecting gas in well drilling fluids.

E. E. Moore. U.S.P. 2,341,228, 8.2.44. Appl. 30.1.42. Straight-hole device.

K. D. Detling. U.S.P. 2,341,500, 8.2.44. Appl. 10.1.42. Process of recovering oil from oil-sands.

M. De Groote. U.S.P. 2,342,648, 29.2.44. Appl. 8.9.41. Process for breaking petroleum emulsions.

M. De Groote. U.S.P. 2,342,649, 29.2.44. Appl. 8.9.41. Process for breaking petroleum emulsions.

M. De Groote. U.S.P. 2,342,650, 29.2.44. Appl. 8.9.41. Process for breaking petroleum emulsions.

A. L. Frye and W. M. Dobson. U.S.P. 2,342,656, 29.2.44. Appl. 1.10.41. Well-treating fluid.

A. L. Ackers. U.S.P. 2,342,827, 29.2.44. Appl. 28.6.40. Apparatus for well logging.

W. E. Green. U.S.P. 2,342,855, 29.2.44. Appl. 18.4.41. Gas-operated pump for oil-wells and the like.

T. V. Moore. U.S.P. 2,342,884, 29.2.44. Appl. 22.7.41. Hydraulic packer.

H. O. Williams and A. A. Jens. U.S.P. 2,342,913, 29.2.44. Appl. 15.4.40. Deep well screen.

H. O. Williams and A. A. Jens. U.S.P. 2,342,914, 29.2.44. Appl. 15.4.40. Deep well screen.

J. C. Fortune. U.S.P. 2,342,930, 29.2.44. Appl. 1.12.41. Well-liner setting apparatus.

J. C. Fortune. U.S.P. 2,342,931, 29.2.44. Appl. 13.7.42. Drag-bit.

J. C. Stokes. U.S.P. 2,343,032, 29.2.44. Appl. 11.5.42. Pressure coring apparatus.

H. C. Otis. U.S.P. 2,343,075, 29.2.44. Appl. 12.11.40. Locking mechanism for well-tools.

H. C. Otis. U.S.P. 2,343,076, 29.2.44. Appl. 13.2.41. Well apparatus.

M. Schlumberger. U.S.P. 2,343,087, 29.2.44. Appl. 23.1.40. Switching mechanism for borehole apparatus.

P. H. Jones. U.S.P. 2,343,113, 29.2.44. Appl. 14.2.39. Treating drilling muds.

W. M. Dobson and A. L. Frye. U.S.P. 2,343,136, 29.2.44. Appl. 2.8.41. Well completion fluid.

E. L. Alexander and A. W. Braithwaite. U.S.P. 2,343,517, 7.3.44. Appl. 28.2.41. Drilling rig.

B. W. Sewell. U.S.P. 2,343,805, 7.3.44. Appl. 15.11.41. Pressure core barrel.

R. C. Baker. U.S.P. 2,344,120, 14.3.44. Appl. 21.4.41. Method and apparatus for cementing wells.

R. Bassinger. U.S.P. 2,344,121, 14.3.44. Appl. 23.9.40. Releasable setting tool and by-pass.

H. H. Greene. U.S.P. 2,344,297, 14.3.44. Appl. 3.8.40. Deep-well firing mechanism.

E. L. Alexander and A. W. Braithwaite. U.S.P. 2,344,383, 14.3.44. Appl. 9.1.41. Shoring for portable drilling rigs.

W. L. Church. U.S.P. 2,344,598, 21.3.44. Appl. 6.1.42. Wall scraper and well-logging tool.

R. E. Deschner. U.S.P. 2,344,681, 21.3.44. Appl. 10.5.41. Draw works.

C. A. Fischer and D. T. Harbison. U.S.P. 2,344,687, 21.3.44. Appl. 30.10.39. Pump plunger.

J. T. Phipps. U.S.P. 2,344,725, 21.3.44. Appl. 29.7.40. Jar.

E. D. Smyser. U.S.P. 2,344,744, 21.3.44. Appl. 15.8.42. Gas-lift pump.

E. P. Halliburton. U.S.P. 2,344,771, 21.3.44. Appl. 21.5.43. Method of determining the volume of the annular space between the casing and wall of boreholes.

C. H. Keplinger. U.S.P. 2,344,778, 21.3.44. Appl. 9.2.43. Gun perforator device.

E. W. Patterson and W. L. Patterson. U.S.P. 2,344,786, 21.3.44. Appl. 24.3.42. Antipound pump pressure equalizer.

E. W. Patterson and W. L. Patterson. U.S.P. 2,344,787, 21.3.44. Appl. 10.5.43. Antipound pump pressure equalizer.

H. O. Williams and A. A. Jens. U.S.P. 2,344,909, 21.3.44. Appl. 15.4.40. Deep well screen.

M. De Groote and B. Keiser. U.S.P. 2,344,976, 28.3.44. Appl. 27.12.41. Process for breaking petroleum emulsions.

M. De Groote and B. Keiser. U.S.P. 2,344,977, 28.3.44. Appl. 27.12.41. Process for breaking petroleum emulsions.

M. De Groote and B. Keiser. U.S.P. 2,344,978, 28.3.44. Appl. 25.5.42. Process for breaking petroleum emulsions.

M. De Groote and B. Keiser. U.S.P. 2,344,979, 28.3.44. Appl. 25.5.42. Process for breaking petroleum emulsions.

M. De Groote and B. Keiser. U.S.P. 2,344,980, 28.3.44. Appl. 15.6.42. Process for breaking petroleum emulsions.

W. G. Bradford. U.S.P. 2,345,027, 28.3.44. Appl. 19.3.41. Perforation cleaner for pipe.

D. G. C. Hare. U.S.P. 2,345,119, 28.3.44. Appl. 26.6.40. Subsurface prospecting.

F. A. Funk. U.S.P. 2,345,253, 28.3.44. Appl. 28.12.40. Portable derrick.

J. P. Whann and J. Zumeta. U.S.P. 2,345,370, 28.3.44. Appl. 11.5.42. Replaceable liner construction for mud pumps.

W. L. Horner. U.S.P. 2,345,535, 28.3.44. Appl. 3.1.38. Method of determining porosity.

W. B. Lerch, C. H. Mathis and E. J. Gatchell. U.S.P. 2,345,611, 4.4.44. Appl. 7.4.38. Process for plugging formations.

J. M. Camp. U.S.P. 2,345,699, 4.4.44. Appl. 20.4.42. Retractable core-head.

B. H. Lybyer. U.S.P. 2,345,710, 4.4.44. Appl. 21.12.42. Well-pumping equipment.

T. V. Moore and G. E. Cannon. U.S.P. 2,345,713, 4.4.44. Appl. 28.8.37. Method for improving oil-wells.

G. H. Fisher. U.S.P. 2,345 739, 4.4.44. Appl. 1.4.41. Coring apparatus.

L. C. Miller. U.S.P. 2,345,766, 4.4.44. Appl. 2.12.40. Deflecting tool.

S. Park. U.S.P. 2,345,770, 4.4.44. Appl. 5.10.40. Means for surveying well-bores.

B. A. Harroun. U.S.P. 2,345,815, 4.4.44. Appl. 1.5.41. Oil saver and rod stripper.

R. R. Hays. U.S.P. 2,345,816, 4.4.44. Appl. 24.12.40. Hydraulic drilling apparatus.

J. F. Shaw. U.S.P. 2,345,836, 4.4.44. Appl. 24.7.42. Trip tube.

A. Boynton. U.S.P. 2,345,865, 4.4.44. Appl. 8.12.39. Differential stage lift-flow device.

M. L. Hart. U.S.P. 2,345,872, 4.4.44. Appl. 10.1.41. Bridging plug device.

M. L. Hart. U.S.P. 2,345,873, 4.4.44. Appl. 10.1.41. Bridging plug.

B. H. Scott. U.S.P. 2,345,888, 4.4.44. Appl. 29.12.41. Liner hanger.

G. L. Hassler. U.S.P. 2,345,935, 4.4.44. Appl. 6.4.42. Method and apparatus for permeability measurements.

R. A. Henricks. U.S.P. 2,346,026, 4.4.44. Appl. 4.5.43. Deep-well pump-jack.

C. A. Yeatman. U.S.P. 2,346,060, 4.4.44. Appl. 18.3.41. Method and apparatus for setting well-casing. A. H. N.

Transport and Storage.

877. Methods used by Magnolia Pipeline to Combat Internal Corrosion. H. M. Stevenson. *Oil Gas J.*, 18.11.43, 42 (28), 46. (A.P.I. Chicago 1943 paper.)—The system went into operation in July 1936 and continuously transports mixtures of light hydrocarbons from a number of plants in E. Texas to the Baytown refinery. The main line is 8 in. in size, and 98 of the 283 miles had previously been in oil service. The design was based on data showing that the material to be handled would be of 80–85° A.P.I. gravity at 60° F. and approximately 26 lb. Reid vapour pressure at 100° F. However, within two years material of 100–110° A.P.I. gravity and 55–60 lb. Reid was being satisfactorily transported. There has been little evidence of internal corrosion during the seven years' operation, there having been no appreciable increase in pressure drop or decrease in capacity, whilst the amount of scale caught by the strainers has been small. No preventive measures such as chemical corrosion inhibitors have been necessary. Settling tanks are used to remove water from the gasoline before it enters the system. No regular cleaning or scraping has been required, and when scrapers were run through all lines in 1939 only a small amount of scale was removed. Some scraping done this year with scrapers, equipped with neoprene discs and knives, again removed little scale. It is believed that the material pumped is practically free from corrosive elements. The stabilizing plants are also believed to remove water and oxygen from the gasoline. As there has been so little trouble through corrosion, operating procedures have not had to be changed because of it, but felt or cloth filters were installed a few years ago to protect meters from a small amount of fine scale. J. C.

878. **Shipment of Packed Petroleum. Part 1. Handling and Storage.** Anon. *Petroleum*, April 1944, 7 (4), 52.—In normal times, shipment of packed petroleum products, was made in 4-gallon non-returnable cans packed in strong wooden cases. Shipment was made from ports with adequate facilities for dunnage and stowage. The demands of war operations have greatly altered this situation.

The maintenance of ample operating reserves and the rapid delivery of supplies to vehicles and aircraft in advanced fighting areas have necessitated the shipment of huge quantities of packed petroleum products, often from ports which lacked the facilities and the trained personnel which had been regarded as essential to this type of work.

In the first place, wooden cases gave way to cartons to cope with large-scale operations, but in the light of experience gained, attention was given to the development of new and stronger containers, improved methods of allocating shipping space, and more effective safety measures.

Returnable containers have now largely replaced cans, the principal types being the 4-gallon drum, the 4½-gallon jerrican, and the 40–50 gallon drum.

A School of Instruction for Sea Transport Officers and Stevedores was set up for training the personnel engaged in this work, the course including lectures, films, and practical instruction.

Numerous illustrations are shown from the official film "Wartime Shipment of Packed Petroleum." C. G. G.

Cracking.

879. **Fluid Catalyst Cracking for Premium Fuels.** E. V. Murphree, H. G. M. Fischer, E. J. Gohr, W. J. Sweeney, and C. L Brown. *Oil Gas J.*, 18.11.43, 42 (28), 37. (A.P.I. Chicago 1943 paper.)—Fluid catalytic cracking plants, by virtue of their new technique, wherein solids are handled as "fluids," have the advantages of simplification in design and flexibility in operation over conventional fixed-bed processes.

A fluid plant consists essentially of cracking, regeneration, and fractionation sections, and the spent catalyst is removed (and replaced) continuously; thus the characteristic features of fixed-bed design, involving intermittent shifting of reactors through cracking, purging, and regeneration cycles, are eliminated. Regenerated catalyst flows by gravity from a storage hopper through the reactor at low velocity, and cracking of the oil vapours occurs with deposition of carbon on the catalyst. The solid/gas mixture in the reactor is turbulent, and resembles a boiling liquid in many respects. The spent catalyst/cracked products mixture from the cracking zone is separated in dust-recovery equipment. The cracked products go to fractionators, whilst the carbon is burnt off the spent catalyst in the regenerator, the heat of combustion being used to preheat the fresh feed.

Operation of the plant is virtually automatic; reaction and regeneration temperatures can be varied, and liquid or vapour stocks can be processed with equal case. In commercial operation, reaction temperatures are normally 800–1000° F. and regeneration temperatures 1000–1200° F.

The general construction of plants does not differ a great deal from that of conventional low-pressure refinery equipment. The latest plants are of a new and simplified design, and more than 30 such plants are being brought to completion. The basic soundness of the process has been amply demonstrated and continuous runs of five months have been achieved. Catalyst recovery has usually been satisfactory, erosion is low, and maintenance requirements are of the order of 5–6% per year of capital investment.

For motor gasoline, production is normally carried out by contacting light and heavy fractions with catalysts of moderate temperature in single pass operations. Unleaded product from a paraffinic gas oil has a C.F.R. Research O.N. of approximately 92. Higher temperature results in an even better quality product. Other properties of the gasoline are also good, and choice of temperature and depth of cracking is governed by economic factors.

Catalytically cracked gas oils are refractory towards further cracking but can be treated by a combination of hydrogenation and catalytic cracking.

Commercial plants are now all producing war products, *e.g.* aviation gasoline, the fundamental change being in the nature of the catalyst used, which is now a synthetic product. As with many other types of catalyst, product distribution and naphtha composition are affected by type of feed stock, temperature and depth of cracking. Aviation gasolines produced at low temperatures are high in saturated *iso*paraffins but low in aromatics, whereas high temperature gives more unsaturated and more aromatic fuels. Greater depth of cracking gives more saturated and more aromatic fuels. Naphthenic stocks give a higher quality product than do paraffinic and using the same type of stock the lighter, more refractory, fractions give the more saturated products. The optimum type of operations is generally determined by consideration of the combined refinery effort, *e.g.* the production of raw materials for alkylation may be of primary importance. High temperature of cracking gives an aviation fuel of comparatively poor AFD–1C anti-knock quality due to the highly olefinic nature of the product. The olefins are concentrated in the fraction boiling up to 225° F. and this may be removed and discarded to motor fuel. Other methods of treatment are hydrogenation or severe acid treating for which spent alkylation acid is suitable.

With fluid catalytic cracking as one part of integrated refinery operations, very high yields of aviation gasoline can be obtained, *e.g.* 78 bbl. of 100 O.N. fuel from 100 bbl. of heavy paraffinic gas-oil charge.

A number of diagrams, tables, etc., are given showing, *inter alia*, product quality resulting from a variety of stocks cracked under various conditions. J. C.

880. Study of the Effect of Catalytic Cracking on the Post-War Supply of Motor Gasolines, Distillates, and Residual Fuels. Anon. *Refiner*, March 1944, **23** (3), 111–112.—Indications of the influence of catalytic cracking on motor fuel were given in the study of what has taken place in two areas, as outlined by W. G. Moore, Gulf Oil Corporation, and T. G. Elder, National Refining Company, before the annual meeting of the American Institute of Mining and Metallurgical Engineers, New York, on 24th February. Their comparisons are between actual operations in 1940 and projected operations with catalytic processes available. Higher yields of gasoline, furnace oil, and fuel gas are the general changes indicated, with consequent reductions in amounts of residual fuel oil. Tables show projected results. For the " Study of the Effect of Catalytic Cracking on the Post-war Supply of Motor Gasolines and Distillate and Residual Fuels," the authors took the Eastern Seaboard and Gulf Coast refining centres as a group, since these have had substantial additions of catalytic capacity, while the Mid-Continent has drawn limited catalytic cracking capacity.

The present paper is in the form of comments on the tabulated and other data, and on conclusions reached by Moore and Elder. A. H. N.

881. Patents on Cracking. Standard Oil Development Co. E.P. 556,711, 19.10.43. Appl. 13.2.41. A catalyst for cracking hydrocarbon oils is composed of an adsorbent mass, chiefly silica and magnesia. The catalyst is formed by intimately mixing a hydrous oxide of silica with a compound of magnesium of the class consisting of magnesium oxide, hydroxide, carbonate, and bicarbonate.

J. C. Munday. U.S.P. 2,326,553, 10.8.43. Appl. 26.8.39. In the catalytic cracking of hydrocarbon oil, the amount of cracking can be controlled by combining with the oil vapour before passing it to the reaction zone, a diluent gas in amount sufficient to maintain the degree of cracking at a predetermined maximum at the start of the operation. Afterwards, the volume of diluent gas is reduced to maintain the degree of cracking at the predetermined maximum. H. B. M.

Polymerization and Alkylation.

882. Patent on Polymerization and Alkylation. Standard Oil Development Co. E.P. 556,712, 19.10.43. Appl. 26.9.41. A process is described for reacting *iso*paraffins with olefins to produce saturated normally liquid, branched-chain hydrocarbons. The reaction is carried out at a temperature between 375° and 950° F. under pressures of at least 500 lb./sq. in., in contact with at least one catalyst selected from the group consisting of oxides and sulphides of metals of Groups 5, 6, and 7 of the Periodic System. The catalyst has added to it a small amount of at least one compound having the formula H_2X, where X is a member of the group consisting of oxygen and sulphur. H. B. M.

Refining and Refinery Plant.

883.* Economic Selection of Exchanger Sizes. H. T. Broeck. *Industr. Engng Chem.*, 1944, **36** (1), 64.—A method is given which enables an economic selection to be made of the sizes of individual heat exchangers in a battery operating as a series stream. The derivation of the equations is given in full, and a nomograph is presented to enable the requisite functions to be evaluated in countercurrent and multipass exchangers. J. W. H.

884.* Pipe Still Processes More than Ten Million Barrels in Single Run. J. P. O'Donnell. *Oil Gas J.*, 23.1.44, **42** (46), 111–115.—A crude pipe-still at Bayway refinery recently completed a run of 6366 hrs. processing a total of 10,285,561 brl. of oil. The still was designed to run E. Texas crude to 20% bottoms (28,000 brl. a day) or W. Texas crude to 30% bottoms (32,000 brl. a day), but averaged 38,800 brl. a day running approx. 2 parts sweet to 1 part sour crude.

Unusual design features contributing to this extended run are: (1) The use of flash drums ahead of the furnace, after partial heat exchange, whilst crude is under sufficient pressure to prevent water vaporization. Corrosive wet vapours are disengaged at the drum and returned to the charge stream near the furnace outlet, thus by-passing subsequent exchangers and most of the furnace tubes. (2) Introduction of intermediate reflux systems. Without appreciable loss in fractionation, these systems lowered the heat load in the upper section of the tower, thereby enabling a reduction in size of that section and provided preheating at a higher temperature for the incoming crude. (3) Combining the side-stream strippers into one column, thus reducing construction costs and heat requirements. A description of the plant, a flow-sheet, and illustration are provided. R. A. E.

885. Bauxite as a Drying Adsorbent. W. A. La Lande, W. S. W. McCarter, and J. B. Sanborn. *Industr. Engng Chem.*, 1944, **36** (2), 99.—Three bauxites of different types have been used to investigate the effect of activation temperature on the efficiency of bauxite as a drying adsorbent for gases and liquids. The investigation covered the mechanism of the thermal decomposition of bauxite, which is discussed in terms of differential thermal and X-ray diffraction analyses. Data are given to show the relationship between activation temperature, residual volatile content, surface area, dry-gas capacity, and equilibrium capacity. The maximum dry-gas capacity is obtained by activation at 700–750° F., and the bauxite may be regenerated repeatedly by heating at 300–500° F. Liquid phase drying is illustrated by the dehydration of a light naphtha with bauxite activated at 700° F. and 1100° F., the former temperature giving the greater quantity of water adsorbed before the break point in the water content of the effluent stream. J. W. H.

886.* Improved Refining of Sour Crudes by New Tannin Solutizer Process. H. N. la Croix. *Oil Gas J.*, 10.2.44, **42** (40), 50.—Extraction of mercaptans from gasoline by the Solutizer process has been improved by the inclusion of a Tannin catalyst promoter, and by a considerable simplification of the regeneration step. Processing is similar to that in the original process, but plant cost is reduced by 15%, and less critical materials are involved, no special alloys being required. Doctor sweetening plants can be utilized by the addition of regeneration equipment and modification of the treating section. Operating costs are reduced by two-thirds, the original Solutizer process costing 1¼–1½ cents per brl. to treat gasoline of 0·09% mercaptan content, while the new costs 0·4–0·5 cents per brl. The sulphur oil is recovered in an easily handled and profitable form. The process will be of great advantage to refiners now faced with the necessity of handling sour crudes, and, in view of its low cost, may also be used for treating butane–butylene feed-stocks. Two plants employing this process are now being built for a combined capacity of 44,500 brl. per day, operating on Mid-Continent and West Texas gasolines. C. L. G.

887.* Distillate Production Corp. of Houston Completes its New Cycling Plant Designed for Obtaining High Percentage of Propane and Butane. E. H. Short. *Oil Gas J.*, 16.3.44, 42 (45), 67–74.—Under a unitization and recycling agreement, all natural gas from the various leases in the North Houston field, Texas, is passed to a recycling plant operated by the Distillate Production Corporation for processing. At present there are six producing gas-wells and three gas-injection wells. The plant is now processing 53–58 million cu. ft. of gas per day, of the following average composition, expressed in vol.-% : methane, 89·81 ; ethane, 5·16 ; propane, 2·02 ; *iso*butane, 0·52 ; *n*-butane, 0·53 ; *iso*pentane, 0·22 ; *n*-pentane, 0·20 ; hexanes, 0·34 ; heavier, 1·20. The plant was designed to extract 80% of the butanes in the gas, and during a recent test actually extracted 93% of the butanes and substantially all heavier hydrocarbons. The residue gas contained only 0·15 vol.-% of butanes and heavier.

Gas from the gathering system passes, via atmospheric-type coolers and a pressure reducing valve, to the H.P. absorber, entering at a temperature of about 80° F. and a pressure of 1700 p.s.i. Condensate is removed at an inlet scrubber and, after reduction in pressure, passes to the raw-product feed tank. Rich oil from the H.P. absorber is reduced in pressure in two stages. Vapour from each stage of separation of condensate and rich oil pass to reabsorbers operating at appropriate pressures. The combined rich oils are then stripped, and the stripped oil passes via heat exchangers, pumps, and high-pressure coolers back to absorbers and reabsorbers. The overhead distillate from the strippers is combined with condensate, and then passed to the fractionation section, which is designed to produce the lighter hydrocarbons in a high state of purity, and also to produce finished aviation gasoline and other products in conformity with specifications. Details and illustrations of the fractionating system and auxiliary equipment are provided. The daily yield of products obtained is given as liquid propane, 10,000 gals. ; *iso*butane, 7500 gals. ; *n*-butane, 8700 gals. ; finished aviation gasoline, 45,000 gals. ; kerosine, 11,000 gals. ; mineral seal and gas oil, 3000 gals.

The propane is utilized in synthetic rubber manufacture, *n*-butane is isomerized, and the *iso*butane utilized in the manufacture of 100 octane aviation gasoline.
R. A. E.

888.* Refineries Operating in the U.S., Canada, and Mexico. Anon. *Oil Gas J.*, 13.4.44. Refinery Issue, Section 2. B. 107–111.—Lists are given showing the location, operating company, crude oil capacity, cracked gasoline capacity, and type of the refineries operating in the U.S., Canada, and Mexico.

Similar information is given concerning the shut-down plants in the U.S.
C. L. G.

889. Patents on Refining and Refinery Plant. The Atlantic Refining Co. E.P. 556,606, 13.10.43. Appl. 26.2.42. To remove acidic organic compounds from hydrocarbon oil, the oil is passed into a counter-current contact, first with an aqueous solution of an alkaline reagent containing an organic solvent more soluble in the solution than in the oil, and afterwards with an aqueous solution of an alkaline reagent.

W. P. Gee. U.S. 2,326,294, 10.8.43. Appl. 26.9.39. A continuous process is described for decolorizing lubricating oil by contact with clay. The used clay is afterwards reconditioned and subjected to decolorizing contact with additional raw oil.

W. H. Perdew. U.S.P. 2,326,882, 17.8.43. Appl. 5.4.40. During desalting and demulsification an aqueous solution is mixed with an oil and heated. The heated mixture is then introduced under the surface of an unobstructed vertical column of water. The oil thus rises vertically in a substantially straight path to the surface. The column of water is sufficiently high to effect substantially complete washing of the oil passing through it. The aqueous solution has an electrolyte dissolved in it selected from the group consisting of the acid reacting and the alkaline reacting materials.

E. S. Hill. U.S.P. 2,327,187, 17.8.43. Appl. 31.8.39. Distillate hydrocarbons are obtained from a high-pressure well fluid by contacting the fluid in a contacting zone with a liquid absorption medium substantially less volatile than and miscible with the distillate hydrocarbons. The absorption medium has an initial boiling point sufficiently high to allow recovery of the hydrocarbons by distillation.

E. A. Nill. U.S.P. 2,327,445, 24.8.43. Appl. 27.4.40. To facilitate the separation of wax from lubricating oil, a hydrogenated solid fatty acid glyceride is added to the wax-oil mixture before chilling, and in the presence of a solvent which is liquid at atmospheric temperatures.

C. A. Cohen. U.S.P. 2,327,504, 24.8.43. Appl. 26.12.40. To improve the colour and reduce the corrosiveness of acid-treated petroleum hydrocarbons, they are first treated in the neutral state with an alkali metal hydroxide at a temperature between 100° and 150° C. After cooling to 20–100° C., a finely divided filter aid is added.

H. C. Paulsen. .U.S.P. 2,327,547, 24.8.43. Appl. 30.12.41. In the sweetening of hydrocarbon distillate oil containing mercaptans, after dispersion of finely divided metal sulphides in the distillate product they are separated from the oil with an aqueous solution containing a small concentration of mercapto-aryl thiazole salt of a substance selected from the group consisting of alkali metals, alkaline-earth metals, and the ammonium radical, which is substantially insoluble in the hydrocarbon oil.

R. E. Burk and E. C. Hughes. U.S.P. 2,328,190, 31.8.43. Appl. 29.11.40. A petroleum cut is stabilized against oxidation by the addition of diphenylthiocarbazide.

H. H. Walker. U.S.P. 2,328,760, 7.9.43. Appl. 12.7.41. During the process of sweetening a petroleum oil by treating with an alkaline solution of a lead compound, an oil is produced which is substantially free from odoriferous sulphur, but which contains suspended lead sulphide. It is effective if steam is injected into a confined flowing stream of the oil to increase the tendency of the suspended lead to precipitate. Afterwards the oil is allowed to settle and precipitated lead sulphide is separated from the oil.

C. O. Hoover. U.S.P. 2,329,615, 14.9.43. Appl. 10.4.42. An improved method is described for sweetening hydrocarbon oil by contacting with a solid alkali metal hydroxide under conditions which result in the formation of an alkali metal monosulphide. The contact is performed while the oil is in the liquid phase and in the presence of added, extraneous, uncombined oxygen and a salt of a metal which forms water-soluble sulphides.

C. O. Hoover. U.S.P. 2,329,616, 14.9.43. Appl. 10.4.42. Mercaptans in hydrocarbon oils are converted into sulphides not higher in sulphur content than disulphides by contacting the oil in liquid phase, in the presence of added extraneous gaseous oxygen and a salt of a metal which forms water-soluble sulphides, with a solution containing an alkali metal hydroxide.

H. C. Paulson. U.S.P. 2,330,735, 28.9.43. Appl. 24.1.42. During the treatment of petroleum hydrocarbons containing mercaptans and corrosive sulphur, the hydrocarbons are mixed with an aqueous solution containing a caustic alkali, a small amount of cupric hydroxide, and a small amount of a sulphide of a multivalent heavy metal in suspension. H. B. M.

Chemistry and Physics of Hydrocarbons.

890.* Tie Lines in Quaternary Liquid Systems. J. C. Smith. *Industr. Engng Chem.*, 1944, **36** (1), 68.—Plane graphs are used to represent phase equilibria in quaternary liquid systems which permit the rapid solution of problems in mixed solvent extraction. The method of constructing these graphs is described by reference to the system chloroform–acetone–acetic acid–water, a knowledge of the phase equilibria in the two ternary systems being essential. A typical problem in mixed solvent extraction is worked out in detail. J. W. H.

891. Phase Equilibria in the Gaseous Region in the System Methane–Carbon Dioxide. H. H. Reamer, R. H. Olds, B. H. Sage, and W. M. Lacey. *Industr. Engng Chem.*, 1944, **36** (1), 88.—The volumetric behaviour of the above system has been studied over the temperature range 100–460° F. and at pressures between 100 and 10,000 p.s.i. The data are presented in the form of compressibility factors and in terms of residual specific volumes against pressure. J. W. H.

892.* Line Co-ordinate Representation of Solubility Curves. F. E. E. Germann and R. P. Germann. *Industr. Engng Chem.*, 1944, **36** (1), 93.—The solubility of 143 solids in 17 liquids at various temperatures has been correlated in the form of a solubility chart which is based on Mortimer's form of the Le Chatelier solubility equation. A number of the substances shown on the chart are hydrocarbons and selective solvents used in refining operations. J. W. H.

893. Application of Unit Operations to Fractionation and Other Vaporization Processes. R. L. Huntington. *Refiner*, March 1944, **23** (3), 107–110. The use of the phase rule in analysing equilibria in simple systems was discussed in a previous paper in this series. The Gibbs phase rule can also serve as a useful tool in the study of equilibria between hydrocarbon vapours and liquids, a sound understanding of which is needed in the solution of problems pertaining to the design of absorption, distillation, and fractionation equipment. The rule may be stated mathematically as follows:

$$F + P = C + 2.$$

where F = the number of degrees of freedom or variance, such as a temperature, pressure, and composition; P = the number of phases; C = the number of components or chemical compounds which go to make up the system.

The application of this rule to systems of immiscible liquids is illustrated by considering water–hydrocarbon systems. An exception to the rule is pointed out. In the fractionation of propane a small amount of dissolved water is often found to be present. The removal of this water from the propane is required before it can be sold as domestic fuel, as the presence of water is apt to cause freezing in the gas-reducing regulators. Drying agents such as silica gel have been used for the dehydration of propane, but the most satisfactory method of water removal has been effected through fractionation. Although propane has almost 200 times the vapour pressure of water, dissolved water in propane does not behave according to Raoult's law, but, on the contrary, the dissolved water proves to be more volatile than the propane. As a result, the water is taken out overhead from the fractionating column. A. H. N.

893*a*. Patents on Chemistry and Physics of Hydrocarbons. G. B. Hanson. U.S.P. 2,325,850, 3.8.43. Appl. 27.12.38. A method is described for effecting the electrical resolution of an oil continuous emulsion, in which the continuous phase comprises a mineral oil and the dispersed phase comprises droplets of added water. The emulsion also contains water-soluble alkaline-earth compounds and an added alkaline agent. During electrical resolution an inhibitor is added, selected from the group consisting of alkali metal hexametaphosphates and pyrophosphates to retard precipitation of insoluble alkaline-earth compounds. H. B. M.

Analysis and Testing.

894.* Redwood as an Auxiliary Absolute Viscometer. A. L. Read. *Petroleum,* 1944, 7 (3), 37.—The Redwood viscometer does not measure absolute viscosity, and from the theoretical standpoint it has inherent defects common to all short-capillary efflux viscometers. It is nevertheless open to question whether better use might not be made of the apparatus both for observations in Redwood seconds and as a complementary method to the absolute methods. In the author's experience, a much higher standard of repeatability is possible than is usually assumed or officially recognized.

By calibrating a Redwood viscometer in terms of centistokes direct, against a U-tube standard, the Redwood instrument could be made a useful auxiliary where facilities for absolute measurement are limited. It is claimed that the measurement of kinematic units from observed Redwood times may be made with an accuracy equal to that quoted for the reverse conversion by the I.P. conversion table. If the Redwood instrument were to be employed for V.I. work, then it would be preferable to modify the existing method for calculating V.I., and base the calculation upon reference temperatures of 100° and 200° F., since the Redwood viscometer is not very suitable for use at 210° F.

Until all viscosity measurements can be based on a common standard, specifications should state not only the units in which viscosity is to be expressed, but also the exact procedure to be followed. C. G. G.

895.* The Constitution of Petroleum Oils. Part 1—Group Analysis. A. V. Brancker. *Petroleum,* April 1944, 7 (4), 56.—At present, work on the constitution of petroleum oils is confined mainly to the determination of hydrocarbon types or groups rather than to the individual hydrocarbons. Petroleum oils are composed mainly of paraffinic, naphthenic, and aromatic hydrocarbons.

The present paper is a survey of published methods for the determination of the relative proportions of these constituents, with 17 references. C. G. G.

Synthetic Products.

896. Carbon Disulphide Production. C. M. Thacker and E. Miller. *Industr. Engng Chem.,* 1944, 36 (2), 182.—The effect of catalysts on the reaction of methane with sulphur to produce carbon disulphide has been investigated. It is shown that under the conditions described the reaction proceeds without appreciable side reactions according to the equation $CH_4 + 4S = CS_2 + 2H_2S$. The compositions of the 18 catalysts used in the investigation are given, and the effect of temperature on the reaction has been studied. High yields can be obtained at 700° C. in the presence of catalysts of the activated clay types, which give better yields than metallic compounds. Activated alumina containing small amounts of chromium oxide gives a 90% conversion of the methane charged at a temperature below 700° C. At the higher temperatures considerable corrosion of 18-8 reactors occur, but a 25–20 alloy withstood the corrosive gases much better. J. W. H.

897. Patent on Synthetic Products. G. Egloff and V. Komarewsky. U.S.P. 2,326,627, 10.8.43. Appl. 30.9.40. In a process for converting hydrocarbon oil into more valuable products, the oil is mixed with aluminium chloride to form a slurry, and then heated to conversion temperature. The heated slurry is introduced into one end of a reaction zone, and the oil is thus converted in the absence of any external application of heat. Conversion products are withdrawn from the other end of the zone at a rate designed to prevent substantial accumulation of liquid. Simultaneously, in a second heating process a mixture of hydrogen and hydrogen chloride is raised to a temperature above the conversion temperature. This heated mixture is then passed to the reaction zone to supply heat and promote the desired reaction.

H. B. M.

Motor Fuels.

898. Patents on Motor Fuels. Anglo-Iranian Oil Co. E.P. 556,399, 4.10.43. Appl. 28.3.42. In the production of branched-chain aliphatic hydrocarbons, a normal hydrocarbon feedstock is contacted with an anhydrous metallic halide at a temperature between 50° C. and 150° C. In this way the highly reactive compounds of the feedstock react with the metallic halide and cause a tarry residue to be deposited on it. Having been freed of these highly reactive compounds, the hydrocarbon feedstock is treated with a metallic halide catalyst to convert normal into branched-chain hydrocarbons.

Anglo-Iranian Oil Co. E.P. 556,481, 6.10.43. Appl. 14.4.42. In a process for converting into branched-chain hydrocarbons normal aliphatic hydrocarbons, alone or in admixture with other hydrocarbons, the feedstock is contacted at a high temperature with a hydrocarbon-metallic halide catalyst. The catalyst is prepared by contacting normal or branched-chain hydrocarbons containing more than five carbon atoms per molecule with an anhydrous metallic halide at a temperature between 100° C. and 250° C.

Anglo-Iranian Oil Co. E P. 556,577, 12.10.43. Appl. 19.11.40. *iso*Octane is produced by the catalytic conversion of a mixture of di*iso*butylene and tri*iso*butylene by hydrogenation of the di*iso*butylene and simultaneous depolymerization and hydrogenation of the tri*iso*butylene. To achieve this the mixture is contacted with a hydrogenation catalyst consisting of tungsten and nickel sulphides at a temperature between 300° and 600° F. and under a pressure of 10–100 atmospheres, in the presence of hydrogen and with a throughput of the order of 1·4 volumes per volume of catalyst per hour.

D. G. Brandt. U.S.P. 2,325,588, 3.8.43. Appl. 27.12.40. A method is described for recovering desirable hydrocarbon constituents from mixtures of hydrocarbons containing hydrocarbons normally within the gasoline range and higher-boiling constituents and constituents of lower molecular weight, such as C_3 and C_2 hydrocarbons.

du B. Eastman and L. P. Scoville. U.S.P. 2,325,839, 3.8.43. Appl. 7.1.41. Gasoline is rectified by treating in a rectifying zone under superatmospheric pressure. Afterwards it is transferred to a reboiling zone and the steam is passed under a lower pressure than that obtaining in the reboiling zone, in indirect heat exchange with liquid gasoline. In this way vaporization of lighter hydrocarbons is effected and a portion of the steam is condensed. Resultant hot water is separated from uncondensed steam and subsequently is passed into direct contact with gasoline in the reboiling zone. Lighter hydrocarbons and steam from the reboiling zone are directed to the rectifying zone and subjected to reflux condensation.

M. Pier and G. Free. U.S.P. 2,326,166, 10.8.43. Appl. 26.7.39. An anti-knock motor fuel is obtained by passing a hydrocarbon fluid boiling above 250° C. at a cracking temperature through two reaction zones in succession. A superatmospheric pressure of about 10 atms. is maintained in the first zone to effect substantial cracking of the fluid. Pressure is reduced by at least 5 atms. before the fluid is passed to the second reaction zone, which contains a cracking catalyst.

G. Egloff. U.S.P. 2,326,628, 10.8.43. Appl. 31.3.41. To produce gasoline from naphthenic and paraffinic oils, the naphthenic charging oil is first subjected to catalytic dehydrogenation to convert naphthenes into aromatics. The paraffinic charging oil is mixed with the heated products of the dehydrogenation, and the resultant mixture is contacted with a cracking catalyst. Conversion products are fractionated to form gasoline distillate and a reflux condensate. Some of the reflux condensate is heated to a temperature between 900° F. and 1100° F. and passed to the cracking zone.

E. J. Houdry. U.S.P. 2,326,779, 17.8.43. Appl. 1.2.40. A high-grade motor fuel is prepared from naphthas in the boiling range 200–420° F. by subjecting them in vapour phase to the action of a splitting catalyst of high activity within a reaction zone. After withdrawal from the reaction zone, the products are subjected at reaction temperature to a dehydrogenating catalyst in a second reaction zone. Both zones are maintained at substantially the same pressure up to 300 lb./sq. in. and the feed rate to each zone is maintained in excess of 1 : 1. By keeping the feed rate to the first zone higher than to the second, at least 10 points octane increase is obtained in the products from the first zone with practically no gas or liquid loss. Also, the initial boiling point is substantially lowered, and a further increase in octane is obtained in the second zone without any marked change in the boiling range of the products.

du B. Eastman. U.S.P. 2,327,099, 17.8.43. Appl. 9.11.40. In the manufacture of high anti-knock gasoline, the raw charging stock is passed through a heating coil in which the oil is vaporized and heated to cracking temperature. The heated vapours are directed through a catalyst chamber in which the oil is subjected to cracking temperature in the presence of a catalyst designed to effect conversion into lower-boiling hydrocarbons of the gasoline range. The cracked products are passed to a thermal cracking zone. Cycle condensate is heated to cracking temperature in a heating zone, and then delivered to the thermal cracking zone in which the admixed products are maintained at a cracking temperature between 850° F. and 925° F. and subjected to conversion. Products of conversion are separated into vapours and residue, and the former are fractionated to obtain a reflux condensate from lighter products. Finally, the reflux condensate is directed to the heating zone as the cycle condensate.

F. E. Frey. U.S.P. 2,327,633, 24.8.43. Appl. 2.10.39. In a process for reacting a low-boiling *iso*paraffin with low-boiling olefins and olefin polymers, a stream, comprising an intimate liquid mixture of a sulphuric acid catalyst and a low-boiling *iso*paraffin and normally liquid olefin polymers, is passed through an elongated reaction zone under alkylating conditions to produce *iso*paraffins in the motor fuel range. A normally gaseous olefin is added to supply additional olefin reactant and in amounts only sufficient to maintain a relatively low olefin concentration in the zone. From the effluent from the reaction zone is recovered a fraction containing *iso*paraffins boiling in the motor fuel range.

W. A. Herbst. U.S.P. 2,327,708, 24.8.43. Appl. 31.12.40. The inflammability of motor fuels for high-compression spark-ignition engines is controlled by blending with them 0·5–5·0% by volume of a non-inflammable organic halide boiling below 60° C. (140° F.).

C. L. Thomas. U.S.P. 2,328,754, 7.9.43. Appl. 30.6.39. Motor fuels of high anti-knock value are manufactured from olefin-containing gasoline distillates by contacting the latter at cracking temperature and at a liquid space velocity of 0·5–5·0 with a composition consisting essentially of a major portion of precipitated silica and a small amount of a compound selected from the group consisting of precipitated alumina, zirconia, and alumina-zirconia.

W. L. Benedict. U.S.P. 2,328,773, 7.9.43. Appl. 8.1.40. Hydrocarbon oil is converted into substantial yields of valuable products, including anti-knock gasoline, by contacting it in vaporous form with a granular catalyst. Afterwards the reaction products are fractionated into gas, gasoline, and insufficiently converted oil. The insufficiently converted oil is mixed with a portion of the gasoline and heated to a temperature between 500° F. and 900° F. A heated powdered catalyst is incorporated and the mixture is treated in a reaction zone under conditions designed to effect substantial conversion into olefin-free gasoline. The reaction products are fractionated into gas, gasoline, and insufficiently converted oil containing catalytic agent in suspension. The insufficiently converted oil is combined with the hydrocarbon oil and heated to a temperature between 900° F. and 1200° F. The heated mixture is passed to a flashing zone, and residual oil is removed. The vaporous portion is then passed into contact with the granular cracking catalyst.

E. C. Pitzer. U.S.P. 2,328,846, 7.9.43. Appl. 17.8.42. In a process for converting hydrocarbons into high anti-knock rating gasoline by the action of a catalyst, an olefin hydrocarbon gas is contacted at polymerization temperature with a catalyst consisting essentially of aluminium oxide. The catalyst is prepared by gelling an aluminium sol with hydrofluoric acid, drying, and igniting the resultant aluminium gel.

J. A. Chenicek. U.S.P. 2,329,251, 14.9.43. Appl. 21.1.41. The stability of a hydrocarbon distillate with respect to gum formation is improved by the addition of a gum inhibitor, together with an alkylene polyamine salt of an organic acid. The salt contains at least three amino radicals.

H. L. Hays. U.S.P. 2,329,834, 21.9.43. Appl. 2.9.41. High-octane-number hydrocarbons are produced from low-octane-number hydrocarbons by subjecting them to catalytic desulphurization. The product of this reaction is separated to recover a fraction in the aviation fuel range and a heavier fraction. The light fraction is catalytically isomerized, and the product is separated to recover a fracti suitable for use as aviation gasoline and a heavier fraction. The two heavier fractio are combined and catalytically dehydrogenated. A high-octane-number motor fu is recovered from the dehydrogenated product.

E. T. Marshall. U.S.P. 2,330,069, 21.9.43. Appl. 28.10.39. To prepare internal-combustion fuel of high octane number, low acid heat, and low gum conten a mixture of gas rich in free hydrogen and a vaporized hydrocarbon oil are introduce into a reaction zone containing a rigidly arranged catalyst which promotes reformin and is capable of regeneration. The whole reaction zone is maintained under pressure between 50 and 300 lbs./sq. in., that portion of the reaction zone which nearest the point of introduction of the oil is maintained at a temperature betwee 900° F. and 1000° F. and under a partial pressure of hydrogen in the lower range partial pressures; the remaining portion of the zone is maintained at a temperatur between 600° F. and 850° F. and at a partial pressure of hydrogen in the upper range o partial pressures. The portion of the zone maintained at the higher temperature progressively increased as the reaction cycle proceeds by moving the point at whic the cold gas containing hydrogen is introduced nearer to the exit end of the zone Reaction products are removed from the zone, and a fraction boiling within th motor fuel range is obtained from them.

C. L. Thomas and H. S. Bloch. U.S.P. 2,330,090, 21.9.43. Appl. 29.4.39. Th anti-knock value of low-boiling hydrocarbons in the motor fuel range is increased by subjecting them at conversion temperature to contact with particles of synthetic alkali metal ion-free catalytic mass comprising essentially a calcined mixture of a precipitated hydrated silica gel and a precipitated hydrous oxide of a heavy metal selected from the group consisting of vanadium, tin, chromium, zinc, molybdenum, and thallium.

J. H. James. U.S.P. 2,331,121, 5.10.43. Appl. 5.6.41. During the manufacture of motor fuel from mineral oil, part of the oil is cracked to convert some of it into gasoline-type motor fuel. The product is fractionated to separate the lighter gasoline portion. Afterwards a heavier fraction is partly oxidized under conditions designed to form a material percentage of oxygen derivatives of hydrocarbons in the range from alcohols to oxy-acids. This heavier fraction is finally recracked to produce further amounts of motor fuel.

E. Arundale and L. A. Mikeska. U.S.P. 2,331,158, 5.10.43. Appl. 27.7.40. A gasoline motor fuel consists of a hydrocarbon distillate boiling between 65° C. and 205° C. and a *meta*-dioxane within the gasoline boiling range and chosen from the group consisting of *meta*-dioxane, *meta*-dioxanes bearing hydrocarbon substituents, *meta*-dioxanes bearing oxygen-containing substituents, and *meta*-dioxanes bearing nitrogen-containing substituents. H. B. M.

Gas, Diesel and Fuel Oils.

899. Patents on Gas, Diesel and Fuel Oils. E. M. Nygaard, J. H. McCracken, and F. M. Seger. U.S.P. 2,326,102, 3.8.43. Appl. 24.4.41. A diesel fuel is composed of a hydrocarbon fuel oil and a small proportion of the oil-miscible product obtained by reacting perchloromethylmercaptan with a compound of the general formula $R(XH)n$ and $R(XM)n$. R is selected from the group consisting of alkyl, aryl, alkaryl, and aralkyl radicals, X is selected from the group consisting of oxygen and sulphur, M is a metal, and n is a whole number. The oil-miscible reaction product is separated from the unreacted and oil-miscible components of the reaction mixture.

G. H. Cloud and W. J. Sparks. U.S.P. 2,326,522, 10.8.43. Appl. 18.10.40. A diesel fuel is prepared from a hydrocarbon oil and a minor proportion of an organic hypochlorite.

F. M. Seger and E. M. Nygaard. U.S.P. 2,329,489, 14.9.43. Appl. 25.4.41. A diesel fuel consists of a hydrocarbon fuel oil and a small amount of the non-volatile, oil-soluble product obtained by reacting perchloromethylmercaptan with elementary sulphur. The reaction product contains only carbon in chemical combination with substantial proportions of chlorine and sulphur. H. B. M.

Lubricants and Lubrication.

900.* The Contamination, Deterioration, and Decomposition of Lubricating Oils in Service. R. G. Pomeroy. *J. Inst. Petrol.*, May 1944, **30** (245), 95–133. Reprinted from the *Journal of the Institution of Certificated Engineers*, South Africa.—The paper deals with the subject from the user's viewpoint. After a brief study of the elementary chemistry of lubricants, and of the causes of deterioration of oils, different plants—*e.g.*, compressors, gear boxes, etc.—are studied individually. Reclamation of oil is briefly studied. The paper is followed by a discussion. A. H. N.

901.* Lubricants for Press Tools and Wire Drawing. A. H. Stuart. *Petroleum*, 1944, 7 (4), 67.—Lubricants for press tools and for wire-drawing dies must be capable of withstanding high temperature, since local temperatures of a high order occur even in the "cold" pressing and drawing processes. In addition, great film strength is necessary to ensure that the lubricant remains between the metal surfaces under the pressures encountered. Ease of application, which implies good wetting characteristics, and ease of removal, especially if the surface is to be further treated, are imperative.

Those requirements have led to the widespread adoption of fatty oils in the form of soaps, together with a fine powder such as chalk or graphite, which gives increased resistance to film rupture. Chlorinated and sulphurized oils are sometimes used to augment film strength.

Graphite may be strongly adsorbed on metal surfaces, and hence be extremely difficult to remove. It has been shown that so long as mineral oil is absent, this graphite film is not disadvantageous if the further treatment of the surface consists in painting or electroplating, but that it prevents satisfactory galvanization in a molten zinc bath. The graphite may be removed from iron in a nitric acid bath.

Graphite alone is used as die lubricant for drawing tungsten wire at 600° C.

C. G. G.

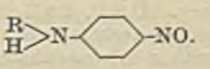
902. Patents on Lubricants and Lubrication. B. B. Farrington, J. O. Clayton, and J. T. Rutherford. U.S.P. 2,325,597, 3.8.43. Appl. 13.1.41. A lubricating composition has incorporated in it a metal salt of an acid of phosphorus having a halogenated organic substituent.

F. C. Gzemski. U.S.P. 2,326,140, 10.8.43. Appl. 20.2.40. A lubricant is prepared from a refined hydrocarbon oil normally tending to deteriorate by oxidation, and a small quantity of an oil-soluble, water-insoluble reaction product of an ester of phosphorus acid and a relatively high boiling aliphatic alcohol. The reaction product contains at least one, and not more than two, aliphatic radicals corresponding to the high-boiling alcohol and is effective in preventing oxidation of the hydrocarbon oil.

R. C. Moran. U.S.P. 2,326,483, 10.8.43. Appl. 20.7.40. A viscous mineral-oil fraction has incorporated with it a small amount of a compound of the general formula *RS–Z–SR*. *R* represents a hydrocarbon radical and *Z* represents an alkyl ether group having at least one ether linkage. The compound is added in sufficient amount to inhibit deleterious effects of oxidation on the oil.

J. C. Zimmer and A. J. Morway. U.S.P. 2,326,596, 10.8.43. Appl. 29.12.39. A lubricant consists of a minor proportion of a soap selected from the group consisting of alkaline-earth metals and aluminium soaps of fatty acids and naphthenic acids, and a major proportion of a mineral lubricating oil having a viscosity index substantially below zero. The mineral oil consists essentially of aromatic and unsaturated aliphatic hydrocarbons, extracted from a petroleum lubricating stock by a solvent having a selective solvent action on aromatic and unsaturated hydrocarbons.

E. W. Fuller and L. A. Hamilton. U.S.P. 2,326,938, 17.8.43. Appl. 31.7.40. A viscous mineral-oil fraction has incorporated with it a small proportion of a compound of the general formula :



R is a radical of the class consisting of alkyl and aralkyl radicals. The compound is added in sufficient quantity to inhibit deleterious effects of oxidation on the oil.

G. H. von Fuchs and H. Diamond. U.S.P. 2,327,158, 17.8.43. Appl. 3.3.41. In the manufacture of lubricating oils, at least one low-resin-content mineral oil and a petroleum resin concentrate are produced. The petroleum resin concentrate is purified without materially altering the resin content. The two ingredients are then blended to produce a composition containing between 3% and 7% resin and having maximum oxidation stability.

E. Lieber and H. T. Rice. U.S.P. 2,327,535, 24.8.43. Appl. 27.12.40. A lubricant consists of a major proportion of a waxy hydrocarbon oil and a small amount of an auto-condensation product of a chlorine-containing paraffinic hydrocarbon substance having less than 7 carbon atoms and containing 1–2 chlorine atoms. The auto-condensation product is substantially non-volatile at temperatures below 600° F.

P. K. Frolich and H. B. Kellog. U.S.P. 2,327,705, 24.8.43. Appl. 6.7.40. A lubricant is prepared from a mineral lubricating oil and an interpolymer in solution having a molecular weight above 2000. The interpolymer is formed by the copolymerization of ethylene and another olefin at a pressure of at least 500 atms. and a temperature between 100° C. and 400° C. It is added in sufficient amount to modify the viscosity index properties of the oil.

H. G. Berger and F. M. Seger. U.S.P. 2,329,324, 14.9.43. Appl. 22.5.41. A lubricant consists of a hydrocarbon oil and a small amount of the product obtained by refluxing 2–6 parts of perchloromethyl mercaptan with 1 part of sulphur at a temperature between 145° C. and 170° C.

A. Lazar, P. M. Ruedrich, and R. Le Roy Frazier. U.S.P. 2,329,474, 14.9.43. Appl. 5.1.37. A lubricant suitable for severe service internal-combustion engines consists of a naphthenic base mineral lubricating oil containing about 1% of an oil-soluble soap of abietic acid. The soap controls ring sticking, and does not substantially increase the viscosity of the base oil.

P. G. Waldo, P. M. Goodloe, and H. G. Berger. U.S.P. 2,330,163, 21.9.43. Appl. 8.3.40. Petroleum sulphonic acid bodies and a stable lubricating oil are produced simultaneously by subjecting the solvent extract of a distillate lubricating stock to sulphonation treatment with strong sulphuric acid. In this way a substantial amount of unsulphonated oil containing petroleum sulphonic acids is obtained. The sulphonated sulphonic bodies are separated from the oil, which is afterwards refined to produce a stable lubricating oil.

C. F. Prutton. U.S.P. 2,330,238, 28.9.43. Appl. 1.3.39. A lubricant is prepared from refined mineral lubricating oil and 0·1–20% of both an oil-soluble halogen-bearing hydrocarbon and an oil-soluble oxygen compound. The addition agents are designed to improve the gum-solvent properties of the oil.

C. F. Prutton. U.S.P. 2,330,239, 28.9.43. Appl. 25.11.40. A lubricant is composed of a major proportion of mineral lubricating oil and an oil-soluble salt of an aromatic acid in an effective amount, but insufficient substantially to change the viscosity of the composition.

J. C. Zimmer and A. G. Morway. U.S.P. 2,330,773, 28.9.43. Appl. 12.9.41. A steam cylinder lubricant consists of a major proportion of mineral oil and 0·1–2·0% of polymerized ester of an acrylic acid, also 1–15% of acidless tallow. H. B. M.

Asphalt and Bitumen.

903. Patents on Asphalt and Bitumen. J. N. Borglin. U.S.P. 2,326,610, 10.8.43. Appl. 26.3.41. A bituminous emulsion of the oil-in-water type consists of 1–70% by weight of water-insoluble phase comprising a bituminous material and free polymerized rosin, 1–40% of an emulsifying agent capable of yielding an oil-in-water type emulsion, and 30–98% of an aqueous phase.

D. E. Carr and H. W. Ritchey. U.S.P. 2,327,247, 17.8.43. Appl. 16.6.39. To produce relatively non-photosensitive asphalt from relatively photosensitive asphalt, the original material is mixed with a solvent which is capable of dissolving oil but incapable of dissolving asphaltenes at the temperature employed. A solution of the oil and solvent is separated from the asphaltenes and treated with a solvent capable of dissolving relatively non-paraffinic fractions but not relatively paraffinic fractions. The non-paraffinic fractions are separated from the paraffinic fractions which are then distilled to remove light and medium lubricating oils. The remaining heavier paraffinic oil fractions are mixed with the separated asphaltenes to produce a relatively non-photosensitive asphalt.

L. G. Gabriel and J. A. Rawlinson. U.S.P. 2,327,882, 24.8.43. Appl. 16.8.40. In a process for the preparation of stable bituminous base dispersions for use in the production of coloured bitumen dispersions of low viscosity, a substance selected from the group consisting of bitumen and aqueous bitumen dispersions is mixed with an aqueous dispersion of a bentonite. The total amount of water present in the two components is such that the resultant dispersion contains not more than 25% by weight of bitumen, excluding the weight of the bentonite.

E. A. Mayfield. U.S.P. 2,328,481, 31.8.43. Appl. 31.7.41. A bituminous emulsion of high stability is prepared by emulsifying a bitumen in water containing a sulphonation product of a substantially petroleum hydrocarbon-insoluble pinewood resin. The amount of the sulphonation product is not more than 3% by weight of the emulsion.

H. G. Williams. U.S.P. 2,330,100, 21.9.43. Appl. 12.4.40. A stable bituminous compound which readily forms a surface coating when applied to a mineral aggregate, is prepared by emulsifying bitumen with an aqueous solution containing 0·25–0·5% of water-soluble soap and 0·1–0·2% of alkali metallate, selected from the group consisting of aluminium, tin, zinc, chromium, boron, molybdenum and vanadium, and caustic alkali. To effect shortening of the time before breakdown, the amount of caustic alkali added is not more than 0·02% by weight of the finished emulsion.

H. B. M.

Special Products.

904. Precautions in the Use of Chlorinated Naphthalenes and Diphenyls. L. Greenburg. *Chemical Industries*, Jan. 1944, **54** (1), 68.—A review is given of an investigation carried out by the Division of Industrial Hygiene, New York State Dept. of Labour, on the hazards entailed and the precautions necessary in the use of chlorinated naphthalenes and diphenyls in cable plants. Use of the products in the heated state for impregnation of cables gave rise to a much higher incidence of acneform dermatitis than use in solution, while all cases of liver disease were associated with exposure to vapour or fumes from the hot process. It was recommended that all new installations should operate by the cold solvent process, and that systematic hygiene measures should be adopted.

C. L. G.

905. Synthetic Waxes in Cable Making. Anon. *Chem. Tr. J.*, 5.5.44, **114** (2972), 480.—See Abs. No. 904.

C. L. G.

906.* Stability of Butadiene. R. F. Robey, H. K. Wiese and C. Morrell. *Industr. Engng Chem.*, 1944, **36** (1), 3.—The reactions which butadiene undergoes during storage and processing have been studied. It is shown that, in the absence of peroxides, dimerization is the most prominent polymerization. The reaction is not catalyzed by peroxides or steel surfaces. In the presence of appreciable amounts of peroxides, formation of high-molecular-weight polymers become prominent, but the reaction can be inhibited by the addition of a suitable anti-oxidant, this polymerization reaction being directly proportional to the peroxide concentration. The peroxides are not readily volatile, and hence, unless a peroxide destroying substance is added before distillation, an unstable residue may be formed which decomposes with explosive violence on heating.

J. W. H.

907.* Conductivity of Natural and Synthetic Rubbers. L. H. Cohan and M. Steinburg. *Indust. Engng Chem.*, 1944, **36** (1), 7.—To dissipate hazardous accumulations of static electricity, semi-conducting rubber is employed. Natural and synthetic rubbers are made electrically conducting by incorporating powdered graphite or other carbon pigments in the rubber mix. To obtain conductivity without sacrificing other desirable physical properties, acetylene black is usually employed, but owing to the present shortage of this material, it has been necessary to use other types of carbon black for this purpose, and the present investigation describes the effect of these blacks on the resistivity, cure, and physical properties. J. W. H.

908.* Structure of Copolymers of *iso*Butylene and *iso*Prene. J. Rehner. *Industr. Engng Chem.*, 1944, **36** (1), 46.—The structure of *iso*butylene–*iso*prene copolymers of various degrees of unsaturation has been investigated by ozone degradation. It is shown that *iso*prene unites exclusively in the 1, 4 position in copolymers, as in the case of natural rubber. It is also shown that there is no tendency for the diolefin units to occur in sequences, the diolefin entering the polymer chain at random.

J. W. H.

909. Polyvinyl Alcohol—Its Chemistry and Applications. Anon. *Brit. Plastics*, Dec. 1943, **16** (175), 380–384, Feb. 1944, **16** (177), 77–83, and March 1944, **16** (178), 122–128.—A detailed review is given of the chemical reactions of polyvinyl alcohol and of methods of manufacture, properties, and applications of polyvinyl alcohol plastics. It is prepared by hydrolysis of polyvinyl esters—usually the acetate—and not directly from the monomer, by treatment in alcoholic solution with dilute acids or alkalis. The precipitated P.V.A. is dissolved in water, the alkali salts removed by dialysis, and the polymer recovered by precipitation in alcohol or acetone.

The product normally marketed contains varying percentages of unhydrolyzed acetate groups. P.V.A. is soluble in water, and on evaporation from solutions gives films which are transparent, colourless, tough, flexible, and resistant to abrasion and solvents.

The reactivity of polyvinyl alcohol has led to the production of a number of derivatives of commercial importance, of which the acetals are the best known (condensations of polyvinyl alcohol with aldehydes or ketones). These are available in a wide variety of properties for use in insulating enamels, bonding agents, coatings, safety-glass interlayers.

The water solubility of polyvinyl alcohol can be overcome by treatment with formaldehyde, formation of insoluble complexes with inorganic compounds such as boric acid, borax, chromium salts, cuprammonium hydroxide, etc., or with esters such as diethyl oxalate with which ester exchange takes place giving cross-linkage, or with polycarboxylic acids or polyhalogenated compounds or dialdehydes, or with water-soluble thermosetting resins such as dimethylol urea and the methylol derivatives of melamine. However, even the insoluble cross-linked products show varying degrees of water susceptibility.

The P.V.A. resin when heated gives hard, tough products, but when suitably plasticized any degree of softness can be obtained. "Solvent" plasticizers tend to cause hygroscopicity and dimensional instability, but "mechanical" (*i.e.*, incompatible) plasticizers give products of superior plasticity and improved performance. The latter class includes mineral and vegetable oils, higher fatty acids and esters, etc. The incorporation of halides reduces temperature susceptibility. Polyvinyl alcohol plastics are characterized by elasticity, flexibility, toughness, and resistance to heat and a wide variety of oils and industrial solvents, though they are affected by water and alcohols. The major application is as rubber substitute in hoses, industrial gloves and aprons, gaskets, vessel linings, etc.

They are also used to increase the wet strength and for the grease-proofing of paper, as an ingredient of adhesives, leather dressings, inks, paints, and in the form of films as protective wrappings and coatings. The emulsification properties are of value in creams, and they form useful textile sizing and bonding agents as well as being capable of forming threads suitable for surgical use, etc. C. L. G.

910. The Vulcanization of Aromatic Petroleum Residues. E. Melling. *Paint Techn.*, March 1944, **9** (99), 49.—Experimental work has been carried out on the vulcanization of aromatic petroleum residues with a view to shortening the drying time. Finely powdered sulphur was found preferable to sulphur dichloride, which gave uncontrollable local reactions. The sulphur was mixed with the A.P.R. (Pool Group I of viscosity 650 secs. R.I. at 140° F. and twenty to twenty-four hours' surface drying time) and heated, reaction commencing at 400° F. accompanied by evolution of H_2S_1 heavy frothing. On completion of the reaction a solid, brittle pitch was given, which was incompatible with coal-tar pitch, insoluble in Pool white spirit, but soluble in coal-tar naphtha to give solutions from which highly glossy films possessing great adhesion was obtained. The melting points increased with the percentage of sulphur used, being over 80° C. with 40% of sulphur in the case of Group I and between 70° and 80° C. with 20% of sulphur in the case of Group 2 A.P.R. It was not found possible to liquefy the pitch by adding further A.P.R. unless very large quantities were used, but linseed oil satisfactorily plasticized the product. The pitch could be blended with filling agents, such as slate powder for battery-filling materials. It is suggested that further work should be carried out on this subject—*e.g.*, the removal of the odour of sulphur from the product by air blowing or other methods, the possibility of improving resilience by vulcanization in the presence of linseed or fish oil and using such a product for roof mastics and the use of emulsified pitches fluxed to about 200 pen. as road dressings and of naphtha solutions of the softer pitches for high-gloss non-oxidizing coatings for exterior ironwork. C. L. G.

911. Styrene, Buna Rubber, and Polystyrene. W. C. Goggin. *Refiner*, March 1944' 23 (3), 87–92.—The historical development of polystyrene polymerization is given briefly. The basic chemistry of styrene production by the process is relatively simple. It involves: (1) the alkylation of benzene with ethylene to form ethyl benzene; (2) the dehydrogenation of purified ethyl benzene to give styrene. Ethylene gas and benzene enter a tower operating at essentially atmospheric pressure, using aluminium chloride as catalyst. Here alkylation takes place to form ethyl benzene, diethyl benzene, and polyethyl benzenes. The crude ethyl benzene so formed is then sweetened and distilled to give pure ethyl benzene. Other products separated in this step are benzene, which is recycled, and the polyethyl benzenes, which are returned for de-alkylation to ethyl benzene. The ethyl benzene is then dehydrogenated over a fixed catalyst in the presence of steam to give styrene and small amounts of benzene, toluene, and tar. In the distillation step these components are separated at reduced pressure to give benzene for recycling, ethyl benzene for recycling, toluene as a by-product, and styrene at 99·5% or higher purity is produced. The fractionation step is a delicate one, due to 9° F. difference in the boiling points of ethyl benzene and styrene. In addition, styrene, under these conditions, has a strong tendency to polymerize. The proper combination of high-vacuum-distillation technique plus suitable inhibitors has made a routine operation out of an extremely difficult problem. Before storage or shipment, styrene is cooled to 60° F., and a few parts per million of a polymerization inhibitor are added. A. H. N.

912. Carbon Black. J. F. Gallie. *Refiner*, March 1944, 23 (3), 93–104.—The use of carbonaceous pigments through history is reviewed. The early Chinese obtained high-grade lampblack by impinging the flame from oil-burners on ceramic cones. Present-day methods are described in some detail, and a table lists 10 of the more important ones. Tables also give the properties and a long list of uses of blacks, and these are discussed in some detail. The use of blacks in natural rubber is discussed, followed by its use in synthetic rubber. The main differences now existing between synthetic and natural rubber are those of processing, reinforcement, resiliency, and heat generation. Buna S, the most important of the synthetic rubbers, is relatively harder to process than natural rubber; it lacks reinforcement by itself; it is not as resilient, and it heats up excessively when subjected to heavy loads and high speeds. From the first of these differences, it is obvious that an easy-processing black is desirable in synthetic-rubber compounding; from the second, that a black is required which will build up modulus and tensile strength; from the third, that resiliency should be abetted, or at least left relatively unharmed, by the black used; and from the fourth, that a black must be used which will keep heat generation to a minimum.

In the early days of the industry, the carbon-black manufacturer had developed contact black, which possessed excellent abrasive and tear resistance, as well as high modulus and tensile strength, but which generated excessive heat, markedly decreased resilience, and was hard on processing. At the other extreme he had developed, primarily in an attempt to increase his yield, thermal black, which, conversely, offered little resistance to abrasion and tear, had low-stress-strain properties, was low in heat generation, did not greatly alter resilience, and, moreover, was an extremely easy processing black. He subsequently developed a semi-reinforcing, medium-loading furnace black, which possessed somewhat intermediate properties; and a high-loading, semi-reinforcing, fine-particle thermal black with properties largely intermediate to thermal and semi-reinforcing furnace blacks, but with balance between reinforcement and heat build-up better than either—better at high loadings, in fact, than the contact blacks. A. H. N.

913. Chlorinated Paraffin Wax. Anon. *Chem. Tr. J.*, 5.5.44, **114** (2972), 469.—A review is given of an article in *Chemical Industries* of February 1944 on the properties and use of a range of products given by controlled chlorination of paraffin wax. The most important grades are produced by chlorinating 125–130° C. melting-point paraffin wax, and comprise (1) a non-volatile liquid with about 43% combined chlorine, (2) a soft resin melting at 50° C. with about 60% chlorine, and (3) a hard, brittle resin melting at 80–100° C. with about 70% chlorine. They are insoluble in water, but soluble in organic solvents, the higher chlorine content grades requiring high aromatic solvents. They are thermoplastic and resistant to ageing and are emulsifiable. Traces of by-product hydrochloric acid must be removed, by blowing air or CO_2 through the mixture, in order to prevent decomposition. A stabilizer is also usually added.

The chlorinated paraffin waxes are used widely in the flame-proofing of fabrics—generally in a naphtha or water suspension containing film-forming resin, antimony oxide, calcium carbonate, mildew inhibitor, pigment, and fillers. They are also added to synthetic rubbers to improve the oil resistance and to chlorinated rubber for the production of linings for food containers, and of corrosion-resisting paints. Their use in special fireproof paints is a post-war possibility. Large quantities are also used as extreme pressure additives to lubricating oils and for the manufacture of Paraflow—a pour-point reducing compound. Chlorinated paraffins have been proposed as components of chewing-gum and of citrus fruit protective coatings and, when mixed with terpenes, as insecticides. Chlorinated kerosine is an interesting raw material for the manufacture of synthetic detergents and wetting agents. A plant at Parlin, planned to produce 4 million lb. of chlorinated rubber per annum, has been changed over to produce chlorinated paraffin wax. C. L. G.

914. Carbon Blacks Research. Part I. Anon. *Chem. Tr. J.*, 12.5.44, **114**, 493.—A summary is given of an article by W. B. Wiegand in *Canadian Chemistry and Process Industries* for March 1944, which reviews recent research into the production of new types of carbon black suitable for incorporation in synthetic rubber and into the structure of carbon blacks.

While most of the black is still produced by the Channel process, there has been much progress in the furnace methods. The Thermatomic process, involving direct cracking of methane, and collection of the carbon black in bags, produces Medium Thermal Carbon (Thermax), which presents an inert surface condition with a surface area of 1 acre per lb., or a finer grade (Fine Thermal Carbon P.33) of surface area 3 acres per lb. Both are used where high loading capacity or low modulus is required. In the S.R.F. process (Semi-reinforcing Furnace Carbons), natural gas is burnt in multiple free flames with restricted air, and the soot collected in electric precipitators, followed by cyclones. The process is versatile and susceptible of precise control, and more efficient than the channel black process, though the quality of the product is not as good. Fully reinforcing furnace carbons, which may replace channel black in most of its applications, are now being produced (Statex B and Statex 93) of high surface area—8 and 6 acres per lb. respectively. It has been established that a carbon black of low *p*H value in water retards the vulcanization of rubber, while a high *p*H value accelerates the cure, although in the case of GR–S rubber the specific surface of the carbon appears to be a predominant factor. C. L. G.

915. Activation of Pyrethrins in Fly Sprays. W. A. L. David and P. Bracey. *Nature*, 13.5.44, **153** (3889), 594–595).—The effect of non-toxic adjuvants to pyrethrum sprays from odourless distillate has been studied from the point of view of particle size and control of *aedes aegypti*. It is shown that the addition of *iso*butyl undecyleneamide delays the knockdown, and so prolongs the period of flight through

the mist, giving a higher kill. The importance of impact with spray droplets during flight is shown by the low kills found on wingless insects, and the high kills given by increasing the rate of flow of spray mist over motionless insects. However, activators do increase the kill on wingless insects, so that prolongation of flight is not the only factor. The effect of activators on particle size and persistence has been studied, it being shown that these materials, being non-volatile, persist when the carrier has evaporated, leaving a mist of particle size 1–10μ. While this effect is noticed with products such as olive oil, oleic acid, lubricating oil, and desesaminized sesame oil which give increased kills, it has previously been noticed that some allied products have no adjuvant effect on pyrethrum against house-flies, so that increased persistence is not the only factor. Similarly, in the case of sesame oil, the reduction of penetration caused by the presence of the non-volatile matter is probably not the explanation of the delayed knockdown. The particle size of the spray is of importance, since if too large the toxic principle is rapidly lost by sedimentation, and if too small impact with the insect will be reduced. There is some evidence that activation becomes more apparent as the degree of atomization produced by the gun increases.
C. L. G.

916. Sugar Cane Wax. Anon. *Chem. Tr. J.*, 9.6.44, **114** (2977), 602.—The January–March 1944 *Bulletin of the Imperial Institute* reports on pilot-plant tests carried out in South Africa on the extraction of sugar-cane wax. The wet filter press cake from the raw juice is made into a slurry with water and screened with continuous water circulation through a 60-mesh sieve into a settling tank to remove low-wax-content material. After settling the 60-mesh wax particles are filtered and extruded through $\frac{1}{8}$-in. apertures into rods and dried. The rods are compact, and dry easily, and are extracted with 250% of benzol at 70° C., giving a 95% yield of a dark, somewhat soft wax, from which pale and dark fractions can be separated by heating with bone char and fractionating in a 90 : 10 alcohol-benzol mixture. C. L. G.

917. Substituted Phenols Production. Anon. *Chem. Tr. J.*, 9.6.44, **114**, 607.—E.P. 560,908 of 1942 granted to Bakelite, Ltd., describes the production of nuclear-substituted phenols by the catalytic alkylation of phenols with unsaturated materials, which may be pure hydrocarbons, natural resins, or drying oils, producing oil-soluble paint and varnish media.

The method is claimed to be economic and rapid and to give high yields of easily purified products. The catalyst composition comprises an oxy-compound of boron or an alkyl, alkenyl or aryl borate, together with an organic compound of the formula $ROOC–COOR^1$, in which R or R^1 or both of them are hydrogen or an alkyl, alkenyl, or aryl radical. An example is given of the treatment of phenol, in which boric acid and oxalic acid are dispersed by heating at 130° C. for twenty minutes, with 1 mol. of *iso*butylene at 45° C., yielding after neutralization of the catalyst with Na_2CO_3 and fractional distillation, 25% of *ortho*-butylphenol. By carrying out the reaction at 140° C. the *para*-butylphenol would be formed. Treatment of wood rosin with phenol at 140° C. with the catalyst yields an oil-soluble resin of melting point 50° F. higher than that of the original, and which produces varnishes of superior durability and quality. C. L. G.

918. Patent on Special Products. H. G. Berger, L. A. Hamilton, and E. W. Fuller. U.S.P. 2,326,324, 10.8.43. Appl. 24.5.40.—An oil for use in dielectric structures consists of a mineral oil, aromatic hydrocarbon material capable of accepting added hydrogen, and catalyst material capable of promoting hydrogenation. H. B. M.

Coal and Shale.

919.* Coal and Oil as Basic Materials for the Chemical Industry. W. D. Spencer. *Petroleum*, 1944, **7** (4), 60.—Coal reserves in the U.K. probably amount to some 150,000 million tons. The economic development of the country has inevitably been bound up with coal output and utilization.

The sections of chemical industry in which coal products are of greatest significance include fuels, dyestuffs, nitrogen fixation, solvents, synthetic oils, synthetic rubber, plastics, and pharmaceutical chemicals.

In 1936–37 the world consumption of nitrogen compounds was 2·7 million tons, of which 91% was synthetic, including $(NH_4)_2SO_4$, cyanamide, and $Ca(NO_3)_2$.

Production of methanol in the U.S.A. in 1940 was about 150,000 tons, of which 90% was synthetic material from water-gas. World production was about 300,000 tons made in some 25 plants, 1 plant only being in Great Britain.

German production of oil products by the Fischer–Tropsch process is estimated to be about 1 million tons annually (1942). Several million tons are obtained by hydrogenation of coal and coal products.

Diagrams are shown indicating the varieties of synthetic rubbers, plastics, and sulphonamide dervatives which may be obtained from coal products. It is claimed that calcium carbide would be a satisfactory starting material for synthetic rubber manufacture in the U.K.

A brief reference is made to isomerization, alkylation, hydroforming, and catalytic cracking processes in the petroleum industry. C. G. G.

Economics and Statistics.

920. Resumé of Oil Field Operations in 1942. R. D. Bush. *Calif. Oil Fields*, July–December 1942, 28 (2), 34.—Statistics indicate that a total of 133,391,545 brl. of oil were produced in the State of California during the last six months of 1942, making an aggregate for the year of 247,474,101 brl., or an increase of 17,809,322 brl. as compared with the figure for 1941. Production in the second half of 1942 was 19,308,989 brl. more than in the first half.

Tables included in this report give production figures by districts over the six-months period ended 31st December, 1942; segregated data of production of clean oil and water in various fields in the State; average daily oil production by fields, monthly; and estimates of known gas reserves of the State as at 1st July, 1942.

During the year 1942 there were no major discoveries in California, but one comparatively small field, Antelope Hills, Kern County, and two productive areas, East Strand in Kern County and Buena Park in Orange County, were discovered. The productive limits of several oil-fields were also extended. H. B. M.

921. Estimated Consumption of Petroleum Products in the United States after the War. Anon. *Refiner*, March 1944, 23 (3), 105–106.—C. L. Burrill makes estimates of petroleum needs after the war, based on certain assumptions; one of which is that the business activity index for the United States will be higher for the period after the war than for a similar period previously. In consequence of this, he anticipates a higher consumption of gasoline/automobile, rising to 777 gal./car in 1947 and 1948. Plenty of gasoline and ample funds are anticipated. His calculations as to the number of automobiles involve some production for civilians in 1945, with peak manufacture to come in 1947, when 6,000,000 new automobiles will be made, after which manufacture will drop to 3,000,000 by 1950, when he estimates that the nation will have 31,800,000 automobiles. Some of his other assumptions are: (1) The war will be over in Europe in 1944 and in the Far East by the end of 1945. (2) A substantial amount of reconversion of facilities to the production of civilian goods will take place in 1945, and some passenger cars for civilian use will be manufactured. (3) Restrictions on the consumption of petroleum products will be partly removed during 1945, and will be entirely removed by the end of that year. (4) Government control over the prices and qualities of petroleum products and over tanker rates will be removed by the end of 1945. (5) Consumption of gasoline by passenger cars will not be seriously limited by the availability or quality of tyres after 1st January, 1945. (6) Consumption of gasoline by trucks and buses will not be limited by the availability of tyres after 1st July, 1946. On these assumptions, various needs are studied. The estimates of total demand for all gasolines indicate a figure of 649,500,000 brl. in 1946, which is only 6·5% less than the pre-war peak demand reached in 1941. A sharp increase, almost entirely attributable to passenger-car consumption, is indicated for 1947, and by the end of the period total demand is estimated at 862,500,000 brl., which is 24% greater than it was in 1941. A. H. N.

BOOK REVIEWS.

Varnish Constituents. By H. W. Chatfield. Pp. xvi + 496. Leonard Hill, Ltd., London, 1944. Price 35*s*.

The rapid growth in the number of raw materials available to the varnish-maker has led the author to prepare a digest of the literature on the properties and uses of these products, broadly reviewing the developments of recent years. So often a book of this type turns out to be a disorderly collection of abstracts, but in this case an abundance of detailed information with copious references (over 1500) is blended into a readable, well-connected whole. The author has wisely, in a book of this type, made little attempt to deal with theories of the mechanism of drying, resin formation, etc., but quotes references from which the subjects can be further studied. The wide scope of the book can be gathered from the chapter headings, viz. :—

> Varnish Oils, Acids, Monoglycerides, Natural Oil Varnish Resins, Natural Spirit Varnish Resins, Modified Natural Resins, Synthetic Resins, Solvents and Diluents, Plasticizers, Driers and Other Metallic Soaps, Antioxidants, Asphaltums and Pitches, Waxes, Rubber, and Chlorinated Rubber.

While the book is of primary interest to varnish manufacturers and technologists, there is much in it of direct value to the petroleum industry as producers of chemical and hydrocarbon solvents, naphthenic acids, asphaltic bitumens, etc., and the author's statement that " except for the very volatile constituents, every fraction of crude petroleum has some use in varnish manufacture," is, rather surprisingly, shown to be but slightly exaggerated.

In general, the information on petroleum products is accurate and up to date, although the terminology used occasionally lapses from that preferred by the petroleum industry (*e.g.*, " paraffin " is used for " kerosine," while asphaltic bitumen is included under " pitches ").

Chapter 8, on Solvents and Diluents, gives useful information on the analyses and properties of these products and their value in varnish formulation, with an extensive tabulation showing chemical and trade names, etc. Exception might be taken to the identification of " petroleum hydrocarbons " with " aliphatic hydrocarbons " (pp. 274 and 285), as this does scant justice to the high aromatic content of many petroleum solvents.

Chapter 10, on Driers and other Metallic Soaps, includes practically everything there is to be said on naphthenate driers, though there is no reference to the classic work of von Braun on the constitution of the acids, while many of the methods of production from petroleum are of academic interest only.

Chapter 12, on Asphaltums and Pitches, includes information on the use of asphaltic bitumen, etc., in varnishes which it would be difficult to find elsewhere. Methods of test are briefly described, and it would have been of value to refer to books of standard methods, such as those of the Institute of Petroleum or American Society for Testing Materials, for further details. The methods described on page 408 for the production of petroleum resins do not include the common one of distillation of lubricating-oil extracts, while the reference to their production by propane extraction of selected lubricating-oil fractions is inaccurate. A brief but adequate review is given of the potentialities of petroleum linseed-oil substitutes, based on the properties of certain proprietory grades, though it should be pointed out that the products referred to are now marketed by the Petroleum Board, and are designated Aromatic Petroleum Extracts.

Chapter 13, on Waxes, includes data on paraffin waxes, mineral jelly, and petroleum ceresin, and mentions a surprisingly large variety of uses in the paint industry.

The book is well printed and bound, adequately indexed, and reasonably free from printer's errors (apart from an unfortunate error in the caption to the photograph opposite page 406). Useful photographs are included, though they are not very well set out.

The price is rather high (35*s*.), but the book will be invaluable to a wide circle of technologists, and is to be heartily recommended. C. L. Gilbert.

Beitrag zur Kenntnis der Schmierole und Treibstoffe für Diselmotoren (Part 3). By H. Stager and H. Kunzler.

The experimental work discussed in this third paper is a continuation of that previously reported in Parts 1 and 2 and is concerned chiefly with the effect of temperature on the form and composition of deposits left by lubricating oils in diesel cylinders.

Experiments, using the apparatus already described, were carried out at 150° C., 180° C., and 245° C. A critical discussion of recent work on the influence of temperature on deposit formation is followed by a description of this work and analysis of the results obtained. A pure "methane" oil composed of paraffin hydrocarbons and a pure "naphthene" oil composed of naphthene hydrocarbons were used, each being pumped through the experimental installation as long as possible at the temperature in question.

The used oils and the deposits were then examined chemically and physically. The "selective solution" method, using consecutively boiling ethyl alcohol, petroleum ether, benzene, and chloroform, was employed as detailed in previous papers.

As a general conclusion it is indicated that oxidation products are the principal cylinder deposits in engines working at normal operational temperatures. The authors found that coke or soot-like deposits and cracking products did not occur at the temperatures employed.

The actual form of the deposits was found to depend on the hydrocarbon groups present in the lubricating oil, and also the dispersion ratio between insoluble oxidation products and unoxidized or only slightly oxidized mineral oil. Here reference is made to recent theories of bitumen formation. The analysis of actual diesel-engine deposits is also discussed, and compared with that of those experimentally produced.

A statistical treatment of the figures obtained by chemical analysis (per cent. of carbon, hydrogen, and oxygen) of the individual groups of reaction products, separated by the selective solvent treatment, shows that a fairly sharp segregation is possible. W. H. Thomas.

BOOKS RECEIVED.

A National Oil Policy for the United States. A Preliminary Report of the National Oil Policy Committee of the Petroleum Industry War Council. Pp. 8. Petroleum Industry War Council, 1625, K Street, N.W., Washington 6, D.C.

British Standard No. 1162 : 1944.—Mastic Asphalt for Roofing. Natural Rock with High Bitumen Content (6–10 per cent.). Pp. 11. British Standards Institution, 28, Victoria Street, London, S.W.1. Price 2*s*. net.

Proceedings of the Institution of Mechanical Engineers. Vol. 150, July–December 1943. Pp. 216. Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1.

Among the papers published in this volume the following may be mentioned as being of interest to the petroleum industry :—

A Survey of Modern Centrifugal Pump Practice for Oilfield and Oil Refinery Services. (N. Tetlow.)

INSTITUTE NOTES.

JULY, 1944.

NEW MEMBERS.

The following elections have been made by the Council in accordance with the By-Laws, Sect. IV. para. 7.

Elections are subject to confirmation in accordance with the By-Laws, Sect. IV, Paras. 9 and 10.

Transferred to Fellows.

MITCHELL, James.
WAITE, Stephen Temple.

As Members.

BONWITT, Ernest.
EVANGOULOFF, George Leon.
MAYERS, Wallace.
SHARPE, John William N.

As Associate Members.

FERGUSON, William Grossart.
LABRUM, Eric John.
TRUEMAN, Fred Norman.
TURNER, John Kenneth.

Transfer to Associate Member.

KYLE, William Galloway.

APPLICATIONS FOR MEMBERSHIP.

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.

ASCHER, Richard, Research Chemist, Middlesex Oil & Chemical Works, Ltd. (*F. Frank ; E. Steinitz*).

CLUER, Abraham, Process Chemist, Lobitos Oilfields Ltd., (*J. C. Wood-Mallock ; J. S. Parker*).

ELLIOTT, John Lanyon, Technical Officer, Ministry of Fuel & Power. (*G. W. Lepper ; J. Mulhern*).

FERGUSON, William Grossart, Analytical Chemist, Percy & Holden, Ltd. (*W. M. Cumming.*)

Gill, Thomas Edmund, Engineering Assistant, Beckenham Borough Council (*J. S. Jackson ; J. Kewley.*)

Kennedy, Thomas, Research Chemist, Anglo-Iranian Oil Col, Ltd. (*M. F. Sawyer ; S. J. Green.*)

Newman, Jocelyn Eric, District Representative, Sternol Ltd. (*C. H. Hudson ; A. L. Read.*)

Smith, James Alfred, Company Secretary and Manager, British Bitumen Refineries Ltd. (*I. Cameron ; A. E. W. Baines.*)

Stamford, Derek Hanchett-, Marketing Assistant, Trinidad Leaseholds Ltd. (*H. C. W. Johnston ; P. H. B. Trasler.*)

Thomson, Alan John, Plant Control Engineer, Iraq Petroleum Co., Ltd. (*D. Glynn Jones ; F. R. S. Henson.*)

ROLL OF HONOUR.

The death is announced with much regret of :—

F/O. P. D. Bruce (Student)

as the result of a flying accident.

BIRTHDAY HONOURS.

Among the Birthday Honours conferred by H.M. the King are the following :—

C.M.G.

Robert Springett Mackilligan, O.B.E., M.C. (Fellow).

C.B.E.

Major Kenneth Gordon, M.C. (Fellow).

Arthur Clifford Hartley, O.B.E., M.Inst.C.E., M.Inst.Mech.E. (Fellow).

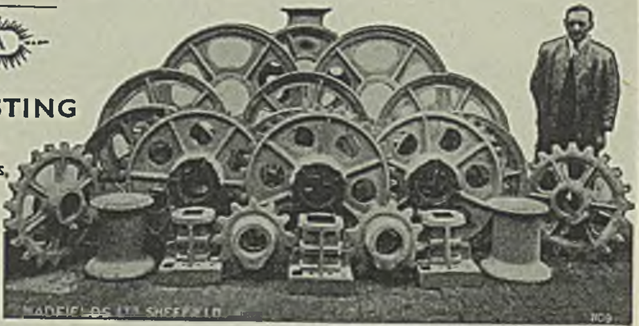
PERSONAL NOTES.

Dr. A. J. V. Underwood has resigned from the position of Joint Honorary Secretary of the Institution of Chemical Engineers which he has held for the last eight years.

JUNE JOURNAL—A CORRECTION.

The name of Colonel D. S. Paul should be inserted in the Report of the Annual General Meeting (p. 171) as having been nominated for election to Council.

ARTHUR W. EASTLAKE,
ASHLEY CARTER,
Joint Honorary Secretaries.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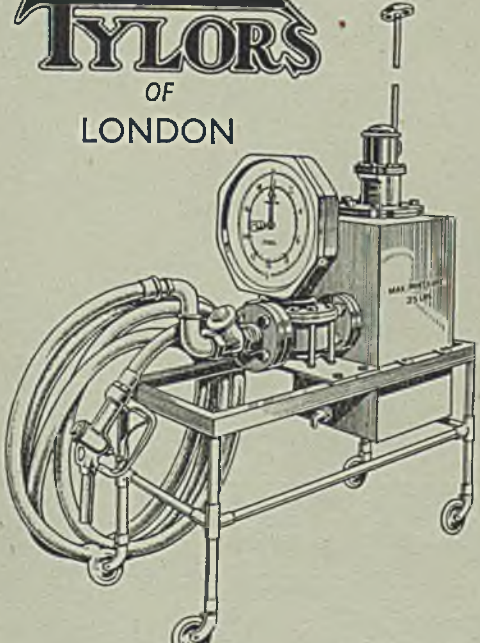
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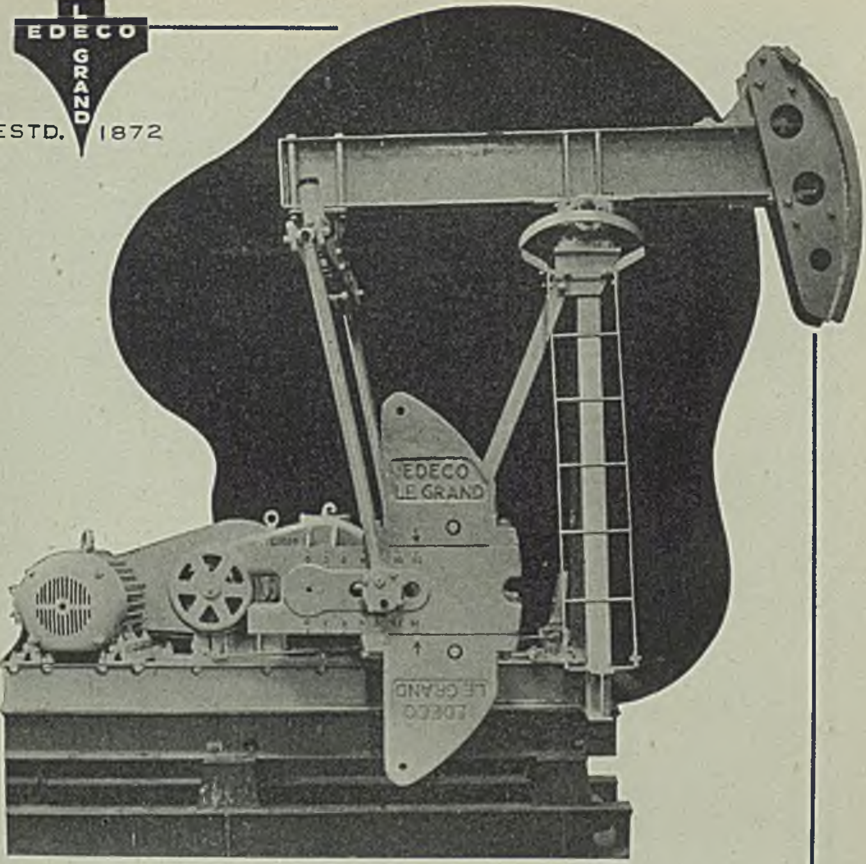

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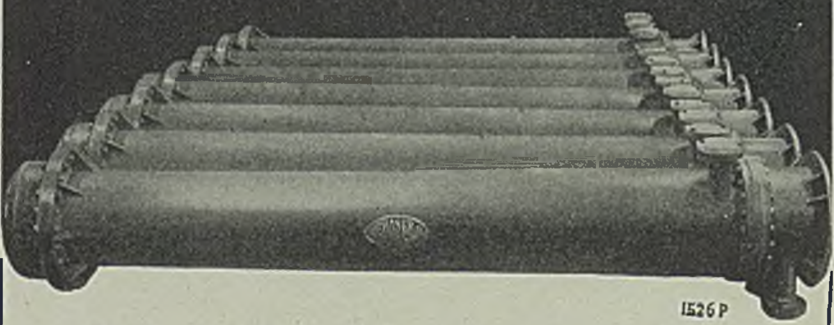
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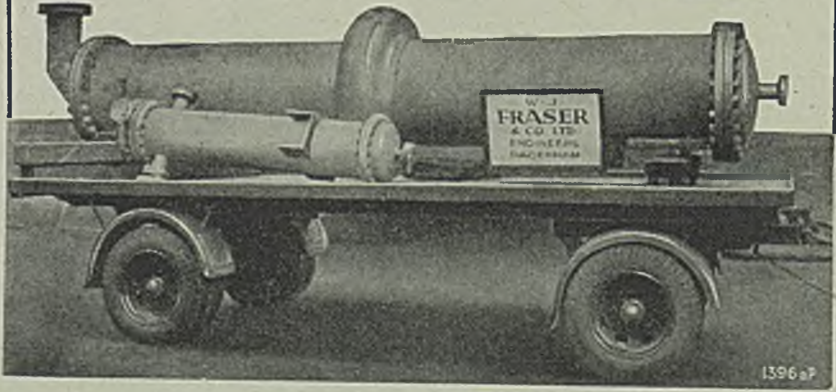
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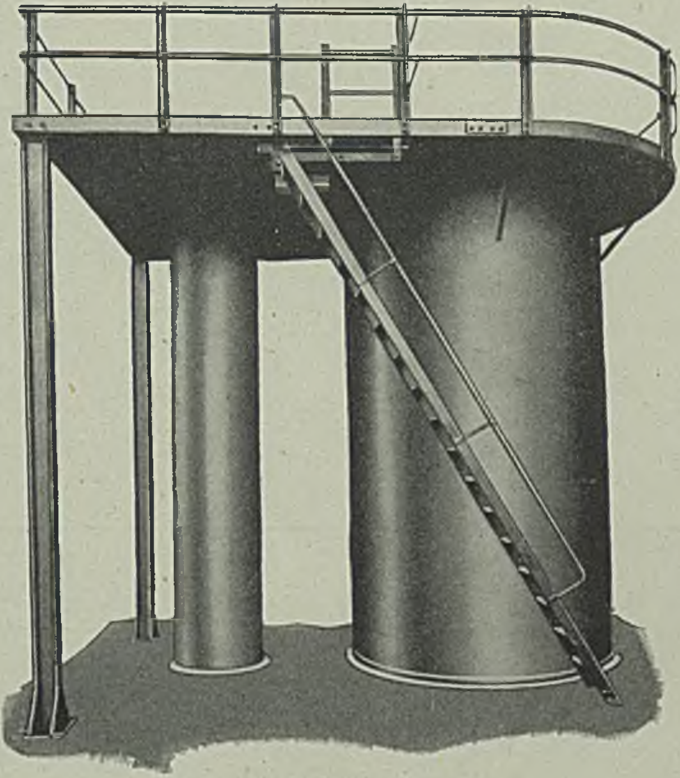

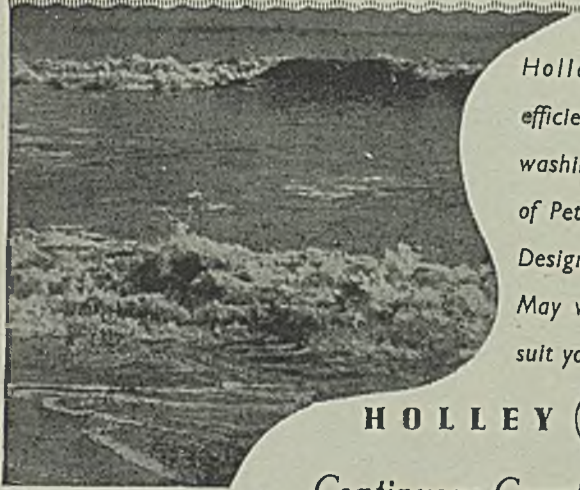

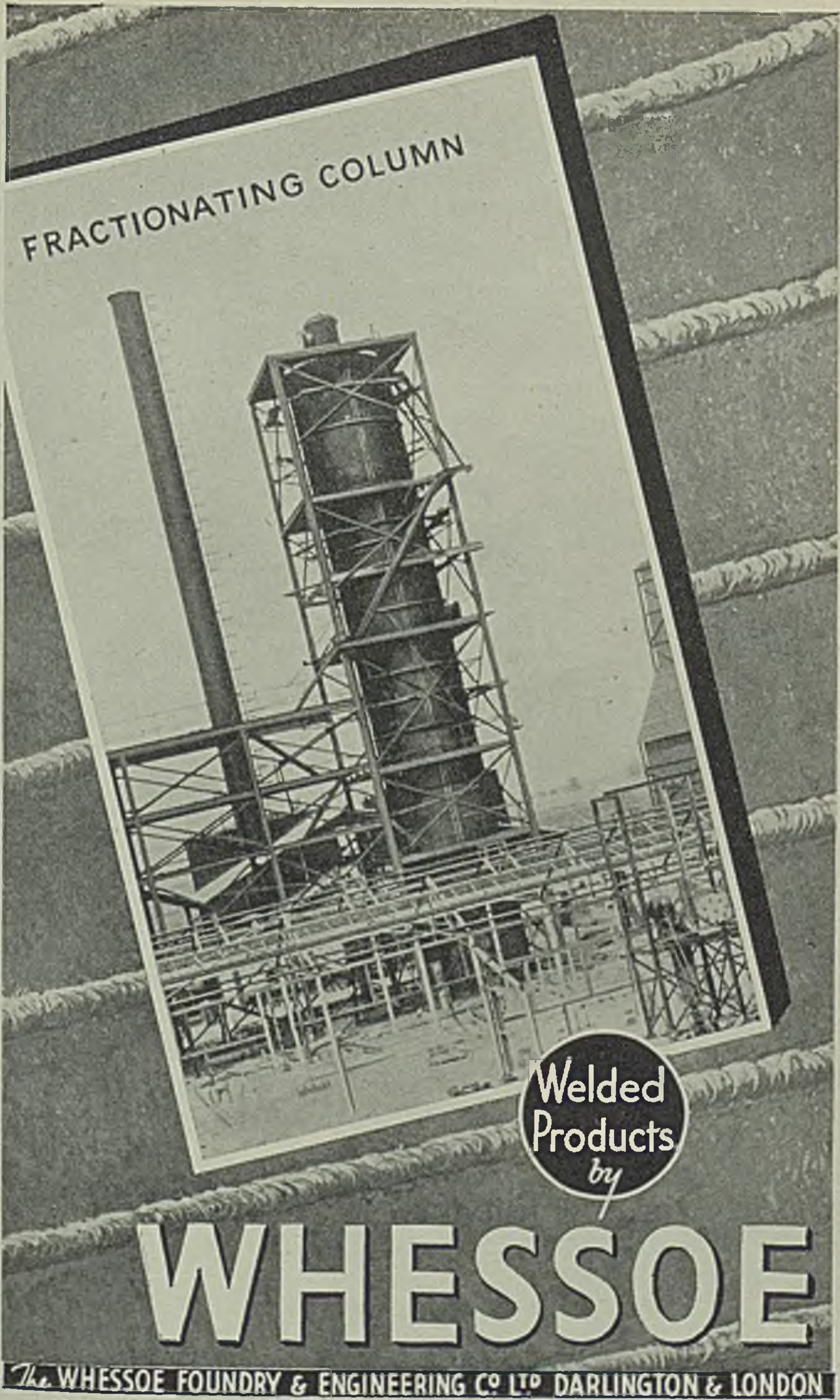

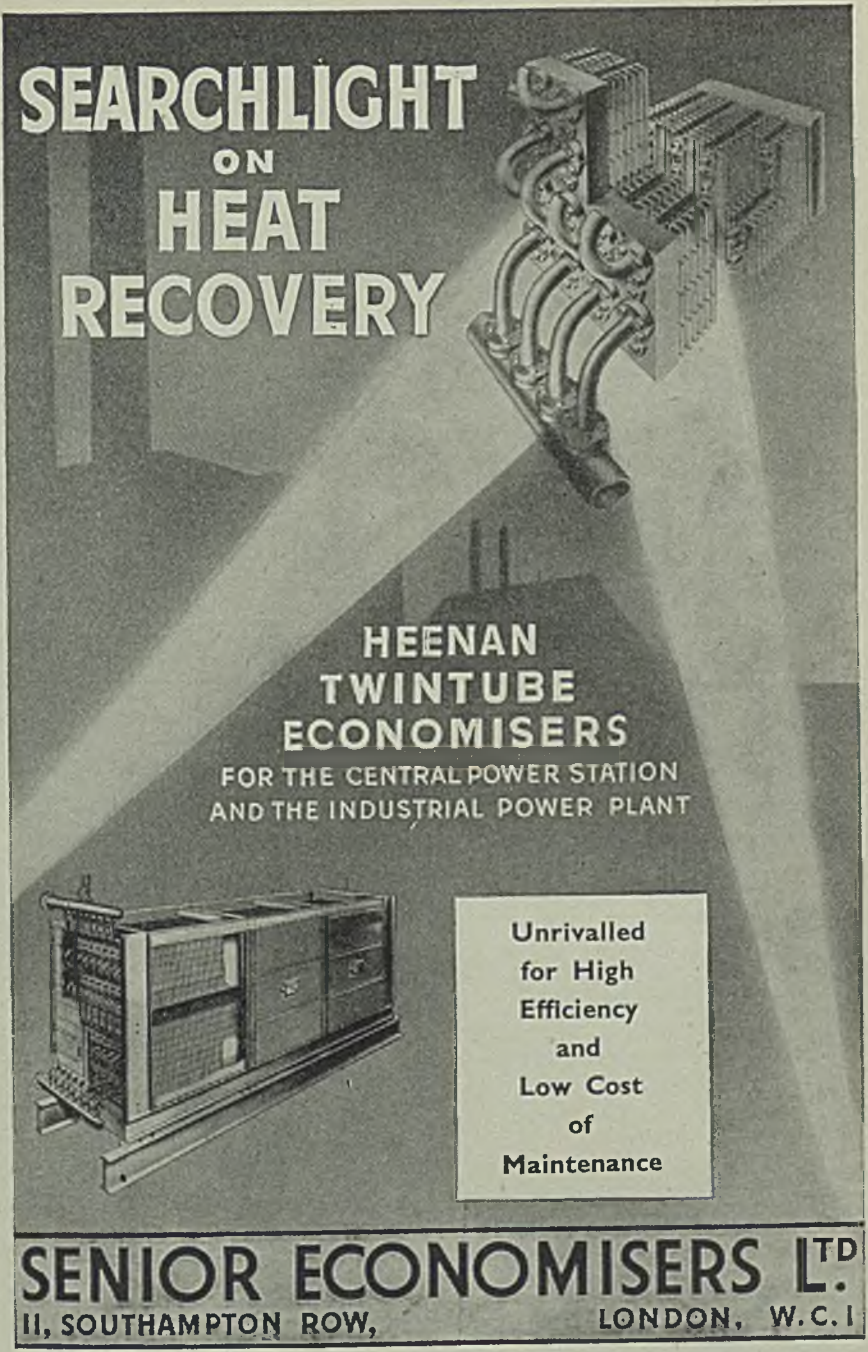

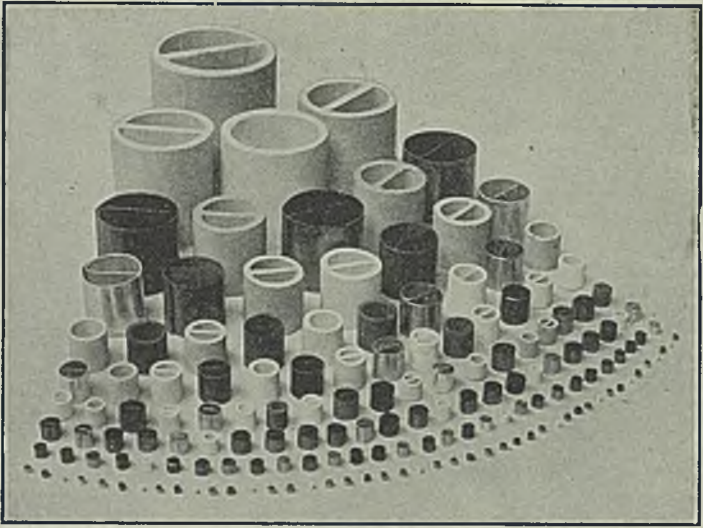

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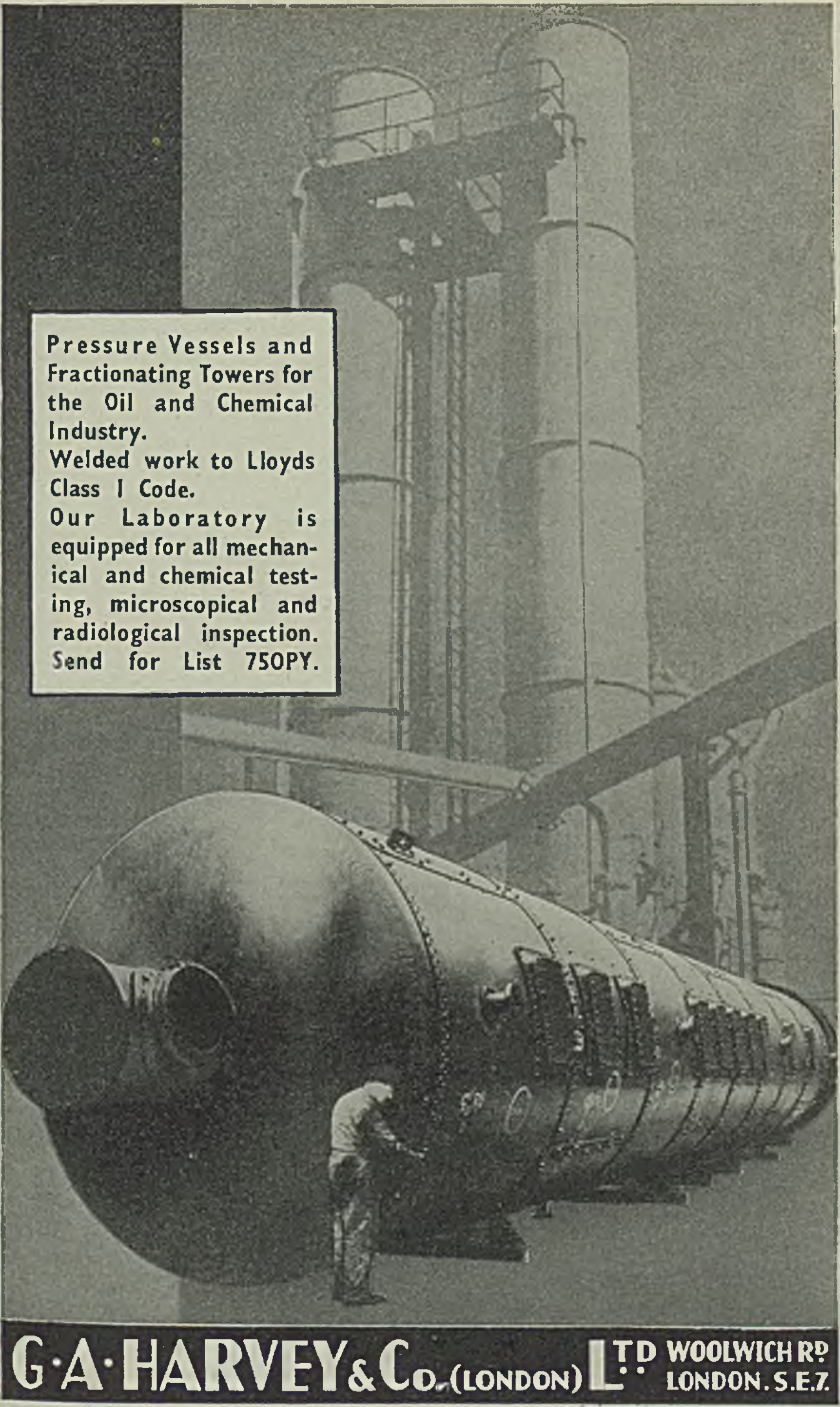

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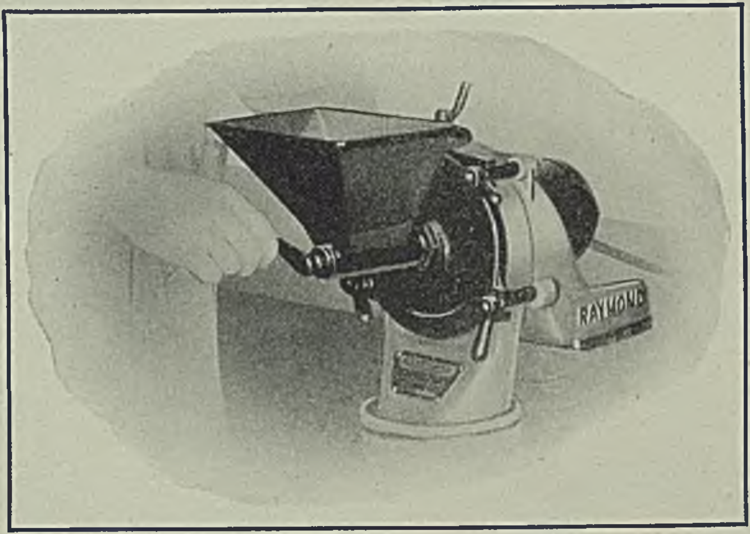
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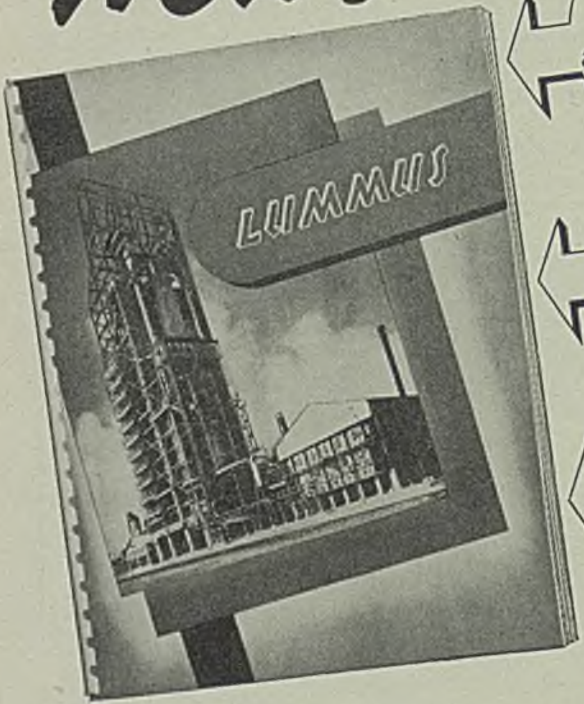
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