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PETROLEUM AS A RAW MATERIAL.*

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Introduction.

It is common knowledge that petroleum contains innumerable compounds, both organic and inorganic; these varying in extent from traces of radioactive and other rare elements to the more preponderant paraffins, olefines, and cyclic compounds. Further, containing as it does the prolific elements carbon, hydrogen, oxygen, sulphur, and nitrogen, it is clear that the number of compounds and mixtures which are potentially possible to separate by physical and chemical methods and technique is beyond computation. Thus, limitations to the subject-matter to be covered by an address of this nature and duration have to be strictly confined to a small fraction of the possibilities.

It is proposed to treat the subject only in so far as pure chemical entities can be isolated or obtained from or through the intermediary of petroleum. Gasolines, kerosines, lubricants, oils of all grades and qualities are thus excluded. Again, in this view, only the peaks of the vast panorama can be singled out for a passing second, leaving the other interesting landmarks for more detailed study.

Perhaps it is not out of place to state that when dealing with the occurrence, isolation, or production of certain substances from petroleum, these substances may not actually occur as such in crude petroleum. To illustrate the point, it is probably true to say that olefines do not occur in undistilled crude; yet these reactive compounds are abundant in distillates of even narrow boiling ranges.

Under such limitations it appears convenient to adopt an arbitrary scheme, and consider the properties and applications of compounds under six separate headings: saturated, unsaturated, and oxygenated open-chain groups of hydrocarbons, cyclic compounds, sulphur compounds, and nitrogen compounds.

The Paraffins.

The normal paraffins occur in crude oil and its distillates, and all members up to C_{36} have been studied and their properties reported in the literature. Higher members very probably occur, but these have been isolated chiefly from the products of Kogasin synthesis, not from petroleum.

The importance of liquid propane and butane is increasing rapidly, particularly for domestic and industrial fuels. Propane has the advantage of low boiling point, high octane number, refrigeration qualities, and

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special value as a metal-cutting fuel. The two fuels have certain advantages over gasoline in internal-combustion engines, but they are still in no position to replace it. Mixtures of propane and hydrogen or butane and hydrogen to yield fuels of the density of air and of definitely controlled qualities are proposed for use in airships.

The use of pure branched paraffins as high-octane fuels is so well known that it needs only a passing mention. *iso*-Octane is, of course, the standard reference fuel.

Thermal Decomposition.

The exact mechanism of thermal decomposition of the normal paraffins is not understood in all cases—thus primary dissociation of methane to methylene radicles and hydrogen is proposed by one school, and to a methyl radicle and hydrogen by another, and even here the exact electronic constitution of the methyl or methylene radicle is not known. Still, by either mechanism thermal decomposition of methane yields hydrogen. In the presence of mercury or cadmium vapours methane may be converted into higher hydrocarbons by heat treatment between 400° and 1100° C. Ethylenic and acetylinic compounds are produced by the application of the glow-discharge method. Acetylene may be produced catalytically from methane alone, or methane and oxygen, or air under strict control.

When the higher members of the paraffins are subjected to pyrolysis under catalytic influences, higher members of olefines as well as ethylene are produced, together with aromatic and naphthenic hydrocarbons. The importance of these dehydrogenation processes lies in the fact that the olefines themselves may serve as the raw material for further chemical reactions. Thus an inert paraffinic hydrocarbon is converted into a most reactive compound. Similarly, catalytic cyclization of aliphatic hydrocarbons may be used as such (solvents, fuels, etc.), or as the raw material for nitration, sulphonation, in dyestuff and similar manufacture.

Reaction with Steam.

The reactions of the paraffin molecule with others are limited, but certain of these are important industrially. Thus one of the more important industrial methods of producing hydrogen is the partial oxidation of methane or the reaction of this gas with steam. It is to be noted that although the general result of interaction of steam and methane homologues is hydrogen and carbon monoxide or dioxide, in certain cases alcohols are produced. A 57 per cent. yield of methyl alcohol is, for instance, obtainable from methane and steam. Substituting steam by carbon dioxide still yields hydrogen in appreciable quantities.

Again, subjecting methane and ammonia in the presence of oxygen to high temperatures results in the production of hydrocyanic acid and nitrogen as by-product.

$$\begin{tikzcd} 2CH_4 + 2NH_3 \arrow[r] & 2HCN + 6H_2 \arrow[d, "3O_2"] \\ & 6H_2O \end{tikzcd}$$

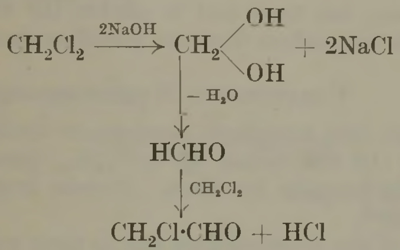
Reaction with Halogens.

By strictly controlling the reaction, methane may be chlorinated thermally, catalytically, or photochemically. Chloromethane may be the predominating product under selected conditions. Hydrolysis of monochloromethane produces methyl alcohol, whilst the interaction with carbon monoxide results in acetylchloride.

$$CH_3Cl \xrightarrow{NaOH} \underset{\text{methyl alcohol.}}{CH_3OH} + NaCl$$

$$CH_3Cl + CO \longrightarrow \underset{\text{acetyl chloride.}}{CH_3{\cdot}CO{\cdot}Cl}$$

Progressive halogenation yields dichloromethane, chloroform, and carbon tetrachloride. Formaldehyde and chloroacetaldehyde may be produced from the dichloromethane :



$$\begin{array}{l} CH_2Cl_2 \xrightarrow{2NaOH} CH_2\langle\begin{smallmatrix}OH\\OH\end{smallmatrix} + 2NaCl \\ \qquad\qquad\qquad \downarrow -H_2O \\ \qquad\qquad\qquad HCHO \\ \qquad\qquad\qquad \downarrow CH_2Cl_2 \\ \qquad\qquad\quad CH_2Cl{\cdot}CHO + HCl \end{array}$$

Further, $CH_2Cl_2 + CO \longrightarrow ClCH_2{\cdot}COCl$—*i.e.*, monochloroacetyl chloride, which is a potential source for monochloroacetic acid, is produced from the reaction with carbon monoxide. Thus methane, an inert saturated molecule, is transformed progressively to aldehydes and chlorobodies of great potentialities.

Chloroform is well known for its anæsthetical, solvent, and extraction properties. Carbon tetrachloride is characterized by the versatility of its uses, as can be seen readily from the following list :

Dewaxing or refining agent for lubricating oils;
Decarbonizing agent for I.C. engines and cleaning agent for metals;
Preparation of sand moulds;
Preparation of cosmetics;
Mixed with wax-like ketones, as polishing composition;
Preparation of die lubricants;
Production of chloral by interaction with formaldehyde;
Preparation of insecticidal sprays;
Preparations of dry-cleaning agents;
Preparations of fire extinguishers.

Further, it is used to produce chlorofluoromethanes, by interaction with antimony trifluoride, which mixed halides are useful as refrigerants because of their low boiling points, non-flammability, and low toxicity, or as solvents for cleaning operations.

Similarly, chlorinated paraffins of higher molecular weight are produced and used as solvents, refrigerants, in dry-cleaning, in insecticides, and in lacquers. As the number of isomers becomes greater with the higher mono- and dichloro-paraffins, so does the difficulty of controlling the reaction to yield a predominating amount of any one desired product.

A detailed discussion of the reactions of alkyl halides to yield olefines, acids, or condensation products with other hydrocarbons is beyond the scope of an address of this nature. Fortunately many of these reactions are well known in general organic chemistry. Reference to them is made here only to stress the importance of petroleum as a raw material.

Oxidation of Paraffins.

Further, by oxidation of the paraffins found in petroleum and its distillates large numbers of oxygen-containing derivatives have been produced or detected. Alcohols, aldehydes, ketones, and acids, together with aldehyde-acids, aldehyde-alcohols, keto-acids, and aldehyde-hydroxy-acids, have been found, as well as the esters of these acids. To produce such compounds involves many interesting and important pyrolytic-oxidation reactions.

Sufficient, however, has been said to sketch the vast number of substances it is possible to produce from the paraffins alone.

UNSATURATED HYDROCARBONS.

Olefinic, diolefinic, and acetylenic compounds occur in distillation and cracking products. Of the former up to $C_{18}H_{36}$ (octadecene) have been identified in certain kerosine fractions. Certain branched-chain olefines have also been studied.

The importance of the mono-olefines lies in their reactivity; thus they form chemical intermediates. Cracking of the lower paraffins is of special significance in this respect, for they are available in very large quantities, and constitute the most promising of raw materials. Acetylene and butadiene can be produced by cracking of the same raw materials under controlled conditions.

It is of interest to note that ethylene and propylene have a direct use as anæsthetics. The use of ethylene produces a deep surgical anæsthesia rapidly with very early analgesia. There appears to be no apprehension of asphyxia and very few symptoms of danger such as nausea and cyanosis. Danger of asphyxia is still smaller, if the gas is diluted with oxygen. The purity of gas has to be, of course, of a very high order.

Pyrolysis and Polymerization.

Pyrolysis of mono-olefines under controlled conditions results (1) in isomerization; (2) in dissociation into hydrocarbons of lower molecular weight and hydrogen; and (3) in polymerization to yield hydrocarbons of higher molecular weight.

$$CH_3{-}CH{=}CH_2 \longrightarrow CH_3{-}C{\equiv}CH + H_2$$

$$CH_3{\cdot}CH{=}CH_2 + CH_3{\cdot}CH{=}CH_2 \longrightarrow CH_2{=}CH_2 + CH_3{-}CH{=}CH{\cdot}CH_3$$

$$CH_3{\cdot}CH{=}CH_2 \longrightarrow CH_4 + CH{\equiv}CH$$

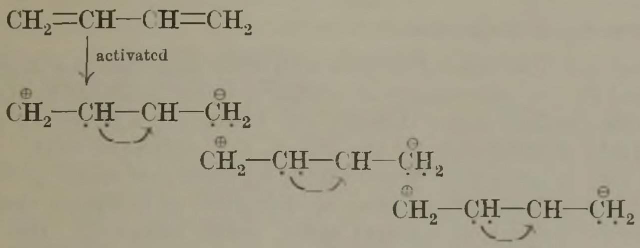
$$CH_3{\cdot}CH{=}CH_2 + CH_3{-}CH{=}CH_2 \longrightarrow CH_4 + \underset{\text{1 Methyl butadiene}}{CH_3{-}CH{=}CH{-}CH{=}CH_2}$$

$$CH_3{\cdot}CH{=}CH_2 + CH_3{\cdot}CH{=}CH_2 \longrightarrow C_6H_{12}$$

and so on.

Thus, even a simple molecule like propylene yields most complex results because of secondary reactions. A full study of the complete range of reactions involved is well-nigh impossible. This fact, however, need not be discouraging, for studies on simple lines have yielded valuable results. Pyrolysis of acetylene yields aromatics under suitable conditions.

Probably of greatest interest in this connection is the polymerization of olefines and diolefines. Polymer gasoline, synthetic lubricating oils, and rubber form such products of immense value. The butadiene used in synthetic-rubber manufacture is obtained either from ethyl alcohol or from petroleum cracking; but it is purer when obtained from alcohol. The diolefine is converted catalytically into a rubber-like composition, which, although it is harder to vulcanize, shows better vulcanization characteristics with sulphur than does natural rubber.



Growth ceases when a molecule of butadiene polarizes into

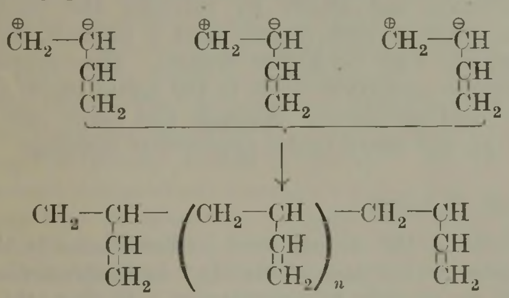
$$\overset{\ominus}{C}H{=}CH{-}CH{=}CH_2 + \overset{\oplus}{H}$$

and the two ions attach themselves to the ends of the chain giving

$$CH_2{=}CH{-}CH{=}CH{-}(CH_2{-}CH{=}CH{\cdot}CH_2)_x{-}CH_2{-}CH{=}CH{-}CH_3$$

which is the 1–4 addition.

The reaction may go on in another form, the 1–2 addition.



The reaction stopping either by an ionized molecule of butadiene or by a negative end of a polymer chain coming into juxtaposition with a positive end, and thus neutralizing each other. Various other complexes are possible, as, for instance, the branches of the 1–2 chain going into 1–4 chains themselves.

The synthetic material is already in use in tyres, rubber soles, and heels, ebonite goods, raincoat cloth, gasoline hose, and tyre tubes.

Higher polymers of *iso*butene appear to have potential use in safety glass, plywood, adhesive plaster, flypaper, greases, lubricating and insulating oils, chewing-gum, wax for sealing tree-wounds, decay preventative and cleansing compounds. Polymers of diolefines have particular value as dopes to increase viscosities and viscosity indices of oils, rubber substitutes, vulcanizable products, and coating and insulating materials.

This absorbing subject must be closed by mentioning the relatively recent new types of synthetic rubber made from the co-polymerizing of olefines with small amounts of diolefines to yield complexes less unsaturated than natural rubber, and thus superior in certain properties, such as stability, durability, freedom from impurities, taste, odour and colour, resistance to tear, abrasion and to mineral acids, and of remarkable electrical properties. This " butyl rubber " is a 100 per cent. petroleum product.

Hydration and Esterification.

Moving on to reactions of olefines with other materials, one is immediately impressed by the potentiality of adding a water molecule to the olefine to synthesize alcohols either directly by hydrating with steam in presence of catalysts or indirectly by the use of, say, sulphuric acid. Thus ethyl alcohol may be produced directly from ethylene and steam in the presence of organic catalysts like pyridine or quinoline, or inorganic catalysts such as diluted solutions of mineral acids, acidic salts—*e.g.*, the acid phosphates—or oxide catalysts, as alumina or clays. Similarly *iso*propanol is produced from propene and steam in presence of such catalysts. Phosphoric acid on pumice is a catalyst for normal butenes and milder catalysts such as dilute nitric acid for the *iso*butenes. The case of the higher alcohols from hydration of higher members of the olefines is not so well known.

The interaction of mineral acids, such as sulphuric acid and olefines, to give direct esterification is of interest both from the point of view of producing the alkyl esters and of using these as intermediates in the synthesis of alcohols and ethers by choosing the conditions. Direct esterification of ethylene with organic acid is difficult, but this reaction is easier to carry out with the higher olefines. Thus propene reacts fairly readily with organic carboxylic acids in the liquid phase and in presence of catalysts to yield the esters. Alcohols and esters and their uses will be discussed in greater detail under appropriate headings.

Reactions with the Halogens.

A characteristic of the unsaturated hydrocarbons is that they react with the halogens readily and additively; in contradistinction with the paraffins, which do so only by substitution. In fact, this characteristic is the basis for many methods of estimating the olefinic content of a substance by bromine and iodine numbers.

Ethylene dichloride, product of interaction of ethylene and chlorine, can be converted into chloroacetic acid in the presence of oxygen and ultra-violet light of short wave-length. It may be converted into ethylene glycol by hydrolysis with aqueous sodium carbonate, or to the glycol diacetate by heating with anhydrous salt of acetic acid. Interaction with ammonia yields, under certain conditions, ethylenediamine. All these compounds have their specific uses—the last, for instance, as a softening medium for the hydrolysis of cellulose acetate yarn or for increasing knock rating of motor fuels by the addition of 0·5 per cent. Further, they are intermediary compounds in the chemical industries.

Plastics may be produced from ethylene dichloride and alkaline-earth sulphides. As a solvent the dichloride has very desirable properties—high solvent power, low inflammability, and availability in large quantities. Many other uses of this compound are suggested and are being made, but it is sufficient to reflect that this compound is only one of many, such as the dibromides or di-iodides of ethylene, as well as the various dihalides of higher homologues of ethylene. Thus, to take an example at random, propene dichloride may be used as an insecticide; as a paint remover; or, since it forms azeotropic mixtures with water, to dehydrate acetic or propionic acids; or in the chemical preparation of a dinitrile, propene glycol, or propene diamine. In fact, the number of reactions possible with these dihalides is legion.

Again, the reaction of, say, ethylene and chlorine in water yields ethylene chlorohydrin, which is an excellent insecticide, and it has been suggested as a refining agent for rosin or to remove naphthalene compounds from petroleum. In chemical synthesis the chlorohydrins obtainable from petroleum have many an important place. To show only a few important instances, synthetic resins may be formed from ethylene chlorohydrin condensed with urea or methylurea. On the other hand, ethylchlorohydrin treated simultaneously with chlorine and an excess of ethylene yields β, β'-dichlorodiethyl ether—the basis of the "chlorex process."

Olefine Oxides.

Another class of products obtainable from the olefines is that of olefine oxides to be produced from the olefine halohydrins and alkalis or from the direct oxidation of the olefines. A typical member may serve. The principal application of ethylene oxide is that of a chemical intermediary in the manufacture of solvents such as glycol ethers. The compound itself, however, may be used as an insecticidal fumigant, particularly in such cases as fumigating ships and warehouses. Aliphatic nitrates in conjunction with acetone may be stabilized with ethylene oxide for treating leguminous vegetable materials to destroy their bitter components, and for reducing the nicotine content of tobacco. Ethylene oxide reacting with marine-animal oils produces emulsifying and dispersing agents.

A further step may be taken by changing the olefinic oxide (obtained from the chlorohydrin, which was in turn formed from the olefine) into olefinic alkylamines by treating it with ammonia. These compounds are of many uses, one of which, for instance, is that of making soaps to be used in dry-cleaning, or in cosmetics in conjunction with glycols, in products for glazing or finishing textile material, in separating wax from oils, or in oil-proofing porous fibrous materials.

The reactions of the olefines and the possibilities arising therefrom are far too numerous even to be listed in this short address. Additive reactions alone include, aside from those already discussed with the halogens, those with aromatic, paraffinic and naphthenic hydrocarbons, with phenols and acids, with acid halides and ammonia and amines, aside from other types of reactions with inorganic compounds such as oxides and halides of sulphur and nitrogen, and such important reactions as the condensation of the unsaturated hydrocarbon with aldehydes to yield synthetic resins.

It is to be noted that only one member of one type of the unsaturateds has been so lightly sketched—*i.e.*, the first of the mono-olefines—and with the exception of butadiene it has not been possible to mention anything regarding the other families of unsaturated hydrocarbons found in petroleum products or produced from them. The field is truly vast, and the greater the contemplation the farther back the horizon appears to recede.

OXYGEN-CONTAINING GROUPS.

The Alcohols.

The direct and indirect hydrations of olefines into alcohols have already been mentioned. Perhaps the most important of the monohydric alcohols is ethanol. This alcohol is produced from ethylene and steam, catalytically, or ethylene and sulphuric acid, giving an ester which, on hydrolysis, yields the alcohol. Ethyl chloride reacts with the alkaline hydroxides, oxides, and steam to yield ethyl alcohol too. Incidentally, the reactions of the alkyl halides may be made to yield primary, secondary, or tertiary alcohols from methanol upwards, in contradistinction from the hydration processes of olefines, which yield secondary and tertiary alcohols only, with the exception of ethanol and, of course, complete absence of methanol.

Ethyl alcohol is finding increasing use as motor fuel, solvent, and intermediary compound in chemical industries to produce a wide variety of organic compounds such as diethyl ether, ethyl esters, acetaldehyde, crotonaldehyde, normal butanol, acetic acid, or acetic anhydride, as well as a large number of ethylated bases such as ethyl aniline. These names alone suggest vast potential and actual values for petroleum as a raw material.

Overhead gas from stabilizer operations yields a propane–propene mixture, the latter component of which yields *iso*propyl alcohol on contact with sulphuric acid. The main industrial applications of this alcohol are connected with its solvent properties. It is used extensively in preparing perfumes and cosmetics, including shampoo, odorants, plant extracts, and medicinal products for external use. An important application is further found in preparing anti-freeze mixtures for car radiators, because on dilution with water a mixture of this alcohol and methanol does not attack metal parts, rubber, or varnishes. It is now possible to obtain, commercially, various derivatives of *iso*propyl alcohol. Acetone and *iso*propyl ether are the two most important of such products. The ether is not only a very valuable solvent, but is a blending compound for high-octane fuels—the blending is, in fact, reported to be better than that of technical *iso*-octane.

Aside from the unique case of *iso*propyl-ethylene, which gives only polymerization products with strong sulphuric acid, higher members of the olefines, such as the *n*-butene and *n*-pentene, yield secondary alcohols, or tertiary alcohols—for instance, trimethylethylene giving *tert.*-pentyl alcohol. The last group polymerize on contact with strong sulphuric acid.

Generally, the secondary alcohols find uses in the production of ethers, ketones, acids, and esters. For instance, the acetate ester of secondary butyl alcohol is finding widespread use as a lacquer solvent and thinner.

Tertiary alcohols, again, produce ethers and esters. The alcohols themselves may be used in solvent-refining processes to free oils from wax and asphalts, or mixed with propene chloride as a solvent for cellulose acetate.

Glycols and Glycerine.

Another important class of this nature is that of the glycols produced from products of petroleum. These glycols may be either those derived by the hydroxylation of olefines, where the hydroxyl groups are attached to adjacent carbon atoms, or those in which the hydroxyl groups are more remote from each other, as in trimethylene glycol. Both types may be produced from petroleum products.

The very large quantities of ethylene available in gases from cracking operations made this gas an attractive raw material for the synthesis of ethylene glycol. The methods used for glycol production may be either direct mild oxidation of the unsaturated hydrocarbon at its double bond or hydrolysis of derivatives of alcohols. Although the first operation may be used by utilizing potassium permanganate, or persulphuric acid, or even potassium chlorate, the oxidation being catalysed by osmium tetroxide, the hydrolysis method is more often employed.

Taking ethylene glycol as a typical (and the most commonly used) member, this dihydric alcohol may be prepared from the dihaloethanes, ethylene halohydrins, or from glycol esters. Ethylene dibromide and dichloride have been hydrolysed using alkaline carbonates to give ethylene glycol. This glycol has been used in many capacities, chief amongst which are the uses as anti-freezing complex, as a preservative, and in cosmetics. It is a good solvent for many organic substances, and is used in extracting vegetable matter from red rose petals, Brazil wood, carmine, buttercups, etc. It has also been proposed as a solvent for insecticidal compositions such as pyrethrins, and for gum-forming constituents in gasolines. The use of this glycol alone or with 10 per cent. ethanol has been suggested to prevent ice formation on propellers of airplanes. To illustrate its versatility it has been used to reduce the viscosity of nitrocellulose; employed in hydraulic brake fluids; added to solid carbon dioxide to reduce the size of the crystals and thereby improve its mechanical properties, and even as an electrolyte for batteries of certain characteristics, making them valuable for maintaining a grid-bias on a vacuum tube.

Glycol esters and ethers are of importance too, the first as plasticizers, particularly the lower members, and the latter as solvents and diluents; but a study of the derivatives of glycols is a major branch of chemistry in itself.

The synthesis of glycerine on a commercial scale has been the aim of many eminent scientists. Recently an increasing number of patents have been appearing in the literature pertaining to the synthesis of this important compound. Of the numerous methods possible, however, the most direct are those starting with the 3-carbon skeleton. This is particularly interesting to the petroleum industry, as unlimited quantities of propylene and propane are available from this source. Of the great number of possible syntheses, one line was recently chosen as promising the greatest degree of commercial success. The line of reactions starts with propylene and proceeds to allyl chloride. Allyl chloride is converted either to allyl alcohol or glycerine dichlorohydrin, either of which products is converted to glycerine. " Hot chlorination " of propylene is the key discovery in this process, *i.e.*,

$$2(CH_2 = CH\text{–}CH_3) \xrightarrow[+ Cl_2]{500^\circ C.} 2(CH_2 = CH\text{–}CH_2Cl).$$

The yield of allyl chloride is about 85 per cent.

The Aldehydes.

The study of the aldehydes obtainable from petroleum as a raw material may be illustrated by the first and the most important member of the series, formaldehyde. This compound is an oxidation product of methyl alcohol, and this process of obtaining the aldehyde is still the most common one, since it is simple, reasonably cheap, and the product is readily purified. Oxidation of the higher members of the primary alcohol family results in corresponding members of the aldehyde series. Dehydrogenation of the primary alcohols similarly results in the aldehydes, but the usual procedure is catalytic oxidation by air or oxygen. With the higher members there is a tendency towards degradation into lower members.

As large quantities of hydrocarbons are available in natural gases, and these at very low costs, direct catalytic oxidation of the hydrocarbons into the aldehydes has attracted attention, and this process is used industrially. Electro-catalytic processes are also proposed, utilizing the highly reactive oxygen produced from the decomposition of nitrogen oxides in the immediate region of an electric arc to oxidize methane or other hydrocarbons into the aldehyde.

The extremely high reactivity of the carbonyl group of the aldehydes places this class of compounds amongst the most important substances for purposes of synthesis. Thus, the reactions of this homologous series are multitudinous and of greatly varying types. Various higher oxidation products such as the carboxylic acids are obtainable from the aldehydes. Reactions of formaldehyde with the alcohols result in condensation products, certain of which are used to produce readily emulsified materials useful in treating textiles. The lower aldehydes can be made to yield higher members by using alcohol condensation as an intermediary step. However, probably one of the most important reactions of formaldehyde for industry is that of its condensation with such substances as phenols, urea, or casein to yield synthetic plastics. Other industrial utilizations of formaldehyde are there, such as its use to precipitate proteins in making water-proof glues, coating material or cements, etc.; but even in the absence of any other use, this property of forming plastics would rank formaldehyde amongst the more important compounds of the day. The plastic industry is, incidentally, the greatest consumer of this compound.

Ketones.

Although the ketones may be produced from unsaturated or saturated hydrocarbons, the more general method is still the oxidation of secondary alcohols in a similar manner to the production of aldehydes from the primary alcohols. The reaction is reversible and endothermic, and high temperatures therefore favour the production of the ketones. In the presence of air or oxygen, the reaction may, on the other hand, be made under exothermal conditions. Suggestions have been made to combine the types of reactions, and thus control the temperature.

Primary alcohols, aldehydes, ethers, and esters have been converted into ketones catalytically too; all obtainable from petroleum.

The two most typical of the ketones in the abundance and variation of utility are acetone and methyl ethyl ketone. To illustrate the value of this family of organic compounds obtainable from petroleum as a raw material, only acetone will be considered.

Acetone is one of the best known solvents for water, alcohol, ether and many esters, mineral and vegetable oils. It is used in the preparation of smokeless powder, for storing acetylene, as a fuel, and as a selective solvent for dewaxing oils. In dewaxing processes it may be used either alone or mixed with benzol, tetrahydronaphthalene, water-insoluble aliphatic alcohols, higher ketones, *ortho*-dichlorobenzene, monochlorobenzene, ethylene dichloride, *iso*propyl ether, or kerosine. This list illustrates its wide range of solvent power. Acetone has been recommended as a constituent of paint and varnish removers, and this process is widely used in decolorizing women's finger-nails in the eternal search after so-called beauty.

It is incorporated in a special lubricant recommended for chassis, which lubricant, when kept under pressure without air, is of high fluidity, but which assumes a heavy consistency when exposed to the atmosphere.

Again, acetone has been used in cleansing agents, as a solvent for wood preservers, as a pickling solution for steel when mixed with sulphuric acid, and in the preparation of gun-cotton and dopes for aircraft fabrics.

The chemical reactions of acetone, and the derivation of various compounds therefrom, are of great interest. The preparation of cyanohydrins, and amines, of alcohols, carboxylic acids, and halogen derivatives are general reactions for ketones. The production of such products as ketene and diketene are more specific to acetone, but are of equal importance. In the world of medicine, dihydroxyacetone is reported to be a good antidote for hydrocyanic acid poisoning.

Acids and Esters.

Carboxylic acids may be produced from petroleum hydrocarbons directly by either liquid or vapour-phase oxidation processes, using such agents as air or oxygen, nitrogen peroxide or ozone. High molecular-weight acids thus produced are incorporated in petroleum distillates to yield oils possessing marked penetrating qualities. The alkali salts of these monocarboxylic acids have been suggested for use as liquid dispersions for insecticidal purposes and fungicidal plant sprays. The water-insoluble, petroleum-soluble saturated monocarboxylic acids containing up to 12 carbon atoms, and prepared from petroleum hydrocarbons directly, are reported to act as activating materials for rubber vulcanization. Plastic compounds are produced from condensing these acids with formaldehyde or furfural. Similarly, polycarboxylic acids are condensed with polyhydric alcohols to produce synthetic resins.

Carboxylic acids are, of course, obtainable from the oxidation of the alcohols, glycols, aldehydes, and ketones. These acids may be esterified to yield the required esters. A simpler process, however, is to produce the esters by direct esterification of the olefines so abundant in petroleum products. Sulphuric esters, obtained by the absorption of the olefines in sulphuric acid, constitute important intermediary compounds widely used in commercial production of the corresponding alcohols. Again, alkyl esters may be obtained by a single-stage treatment of the appropriate olefin with the organic acid. Thus *sec.*-butyl acetate may be prepared in this way instead of the esterification of the alcohol.

A far greater number of oxygen-containing organic straight-chain compounds has been neglected than studied in this brief outline of the possible and actual value of petroleum crude as a raw material for this group of compounds. Yet the list is impressive even in its diminutive and curtailed form.

CYCLIC COMPOUNDS.

Aromatics.

Aromatic hydrocarbons occur in straight-run petroleum distillates to small and varying extents; however, large amounts of aromatics may be produced from the lower straight-chain fractions by thermal cracking and cyclization over a catalyst. The temperatures are usually around or exceeding 600° C. Because of the large quantities of the lower paraffin available at low costs, these straight-chain saturated hydrocarbons have been widely studied for aromatization purposes, with attendant successful results. The pyrolysis of the lower olefines at temperatures around or exceeding 700° C. yields aromatics more readily, or at least to a greater extent, than the paraffins of similar molecular weight. It was found that in the case of ethylene pyrolysis, raising the pressure did not increase the yield; but it allowed reduction of 100° C. in the required temperature for the same yield for an increase of 10 atmospheres. Benzene, alkylbenzenes, and xylenes are separated out from these pyrolytic reactions. Benzene itself may be subjected to further thermal reactions in order to condense two molecules of benzene into one of diphenyl, which is of technical importance, as it can be used in heat-exchange media.

Diphenyl, together with toluene, ethylbenzene, and many other hydrocarbons, have been isolated also from the reactions attendant upon treating benzene with aluminium chloride. Treating alkylbenzene with the metal halide usually results in re-arrangement and fission of the side-chain, although a certain amount of dehydrogenation and condensation takes place. Treating toluene with aluminium chloride at the boiling point of toluene yielded benzene, methyl*cyclo*hexane, *m*- and *p*-xylene, ditolyl and dimethylanthracene. Ethylbenzene yielded benzene, diethyl-benzene and triethylbenzene. Thus the possibilities of this type of reaction are numerous and varied.

The action of the halides themselves on benzene is either of the addition or substitution type; toluene and high homologues, however, give mostly substitution products, the halogen entering the side-chain or the aromatic nucleus, depending on the temperature, catalyst, and concentration of the reactants. Mono- and poly-chlorobenzenes are used industrially in the manufacture of sulphur-black dyes, phenols, *o*-dihydroxybenzenes, aromatic amines, diaryl ethers, and ketones. They have further uses as dielectrics and transformer oils, in the analysis of graphite greases, the dewaxing of hydrocarbon oils, the removal of carbon deposits from engine parts, the solution of paint and varnish, the preservation of wood, the destruction of insects, and the solution of refrigerants. Bromination and fluorination of benzene appear to proceed similarly to the chlorination of this hydrocarbon.

Chlorination of toluene yields benzyl chloride, together with other resultants. Benzyl chloride may be hydrolysed to yield phenolic compounds, as monochlorobenzene may be hydrolysed to yield phenol. Thus *o*- and *p*-cresol may be produced from heating monochlorotoluene in water to 300° C. with ammonia, cuprous oxide, and calcium hydroxide. Chlorocresols may be produced by reacting higher chlorotoluenes with alcoholic potassium hydroxide at 140–210° C. Benzyl acetate is produced from heating benzyl chloride with sodium acetate and acetic acid. Benzyl chloride may be mixed with a high-boiling distillate of coal tar to give a corrosion inhibitor for metals.

Further chlorination of benzyl chloride produces benzal chloride, the chlorination agent being nitrosyl chloride. Benzal chloride yields benzaldehyde on treatment with aqueous sodium sulphite. Again, by further chlorination, benzotrichloride is obtained, which may be used to give naphthalene sulphonyl chloride.

The aromatics which are so generally known for their uses as solvents, anti-knock fuels, and intermediary raw materials may be further studied with relation to oxidation processes. These studies are of interest both from an academic and a technical point of view. Thus, the oxidation of benzene appears to go in successive hydroxylations to yield phenol, hydroquinone, and finally quinone, after which step the ring appears to rupture. In the case of toluene and ethylbenzene the side-chain and the ring are oxidized simultaneously, giving in the case of toluene, dihydroxytoluene and benzyl alcohol simultaneously, the benzyl alcohol being further oxidized to benzaldehyde and benzoic acid; and in the case of ethylbenzene yielding dihydroxyethylbenzene and 1-phenylethanol simultaneously, the ethanol being further oxidized to acetophenone, benzaldehyde, and finally to benzoic acid.

Again, benzene may be oxidized to maleic acid catalytically, and this acid may be changed to the edible malic acid which is suggested as a substitute for tartaric acid. Maleic acid, on the other hand, may be reduced to succinic acid.

These are only brief glimpses of the vast number of aromatic compounds it is possible to generate from petroleum as a raw material.

cyclo*Paraffins.*

The proportion of *cyclo*paraffins occurring in many crudes is much less than that of aromatics or paraffins, and their isolation is very difficult. Consequently not so much is known about this class of hydrocarbons and their reactions as about the more abundant aromatics and non-cyclic compounds. However, enough is known about the characteristics of the lower members from *cyclo*propane to *cyclo*hexane to make their study both interesting and important.

The halogenation of the *cyclo*paraffins follows, more or less, similar lines of reactions as the halogenation of the paraffins, yielding the chloro- and bromo-derivatives. This similarity is particularly operative in the 5- and 6-membered rings: with the lower members of the series, such as *cyclo*propane and its homologues, halogenation not only gives a substitution reaction, but is accompanied with an addition reaction resulting in the rupture of the ring and the formation of halogenated straight-chain hydrocarbons. Thus, monochloro*cyclo*propane and 1 : 3-dichloropropane are produced when *cyclo*propane is chlorinated.

The most important member of this family is *cyclo*hexane, and thus with these preliminary remarks showing possible variations in the characteristics of individual members of the series, this compound will be studied as typical.

*cyclo*Hexane has been identified in certain crudes, and certain of its homologues have been found and isolated from distillation fractions of Russian, Eastern European, and American Mid-Continental crudes.

Catalytic dehydrogenation of *cyclo*hexane to benzene proceeds readily when nickel or palladium is used. The reaction, however, is not simple, and many by-products are produced simultaneously. In the purely thermal decomposition of *cyclo*hexane at atmospheric pressure and at temperatures of about 650° C. the main reaction products appear to be butadiene and ethylene, rather than benzene.

The action of aluminium chloride on this hydrocarbon is very interesting. In the reaction with acetylchloride in the presence of aluminium chloride the initial change appears to be one of dehydrogenation in which *cyclo*hexane behaves as a mixture of *cis*- and *trans*-isomers. The *cis*-form furnishes *cyclo*hexene, which is converted by acetyl chloride into tetrahydroacetophenone; and the *trans*-form is thought to proceed through a dicyclic system which would undergo fission to yield unsaturated radicles. Similarly, very interesting studies are afforded by the action of aluminium chloride on *cyclo*hexane in the presence of hydrogen chloride.

Chlorination of this hydrocarbon takes place when *cyclo*hexane and chlorine are exposed to diffused daylight, the chlorine displacing hydrogen in the ring. Mono-, di-, tri-, and tetra-chloro*cyclo*hexane have been prepared in this manner at low temperatures and without the use of catalysts. The chloro-derivatives then undergo reactions which are similar to those of the alkyl and aryl chlorides. Thus a Grignard compound may be obtained from the monochloro-derivative by treating it with magnesium in ether at 0° C. Similarly, bromo-derivatives may be formed into Grignard compounds with their important uses in organic chemistry. *cyclo*Hexane has been used as a reference compound in catalysis research and there is much data on its catalytic reactions.

The carboxylic derivatives of *cyclo*paraffins form the important group called " naphthenic acids," and these have found technical applications, particularly in the form of their alkali and heavy-metal salts. Naphthenic acids probably occur in all crude petroleums, the chief sources being Russian, Rumanian, and Polish oils. Although the content is usually between 0·1 and 2 per cent., it is estimated that even on the lower figure the potential world-annual production is 50,000 tons. They are usually extracted from petroleum by alkali wash; purification and production on a technical scale are, however, accomplished by various elaborate processes.

One of the uses suggested for these naphthenic acids is the breaking down of various types of oil emulsions, such as occur in the neutralization step following acid treatments of certain lubricating-oil distillates. On the other hand, emulsifying agents may be prepared from these very acids with sulphuric acid and its glycerol esters.

Artificial asphalts may be produced from heating these petroleum acids to 180° C. Insecticides and fungicides may be prepared by various methods from naphthenic acids. Again, esters of these acids have been recommended as plasticizers for cellulose esters.

Naphthenic or sulphonaphthenic acids are reported to increase the detersive power of soap solutions. The alkali soaps of the acids compare favourably with those of fatty acids with respect to foam-producing and emulsifying qualities, degrees of hydrolysis, and solubility in water. Due to disagreeable odours associated with them, however, their use as detergent materials has been limited. Deodorization of naphthenic acids is often very difficult. Emulsification properties as well as disinfectant and insecticidal qualities make these soaps very useful indeed.

The lead, cobalt, and manganese naphthenates are widely employed as driers in paints, and are reported to be more effective than the corresponding linoleates or resinates. Copper naphthenate is proposed as a component of priming coats intended as preservatives of wood. Metal salts of naphthenic acids have been used in the preparation of " extreme-pressure " lubricants. Many other uses of the metal salts of these petroleum acids exist, but sufficient has been said to indicate their variety and importance in modern life.

SULPHUR COMPOUNDS.

Sulphur compounds are found in all crude petroleums, Pennsylvanian and Rumanian oils having minimum quantities, 0·03 per cent. or less, whilst others, like Mexican and Iraq crudes, having larger quantities, approaching 5 and more per cent. Practically all types of sulphur derivatives have been isolated from various distillate fractions, the chief types being elemental sulphur, hydrogen sulphide, mercaptans, thioethers, disulphides, and thiophenes. It will only be possible to detail certain applications of some of these compounds, as their reactions and possibilities are far too many even to be listed exhaustively.

Hydrogen Sulphide.

Being abundant, hydrogen sulphide provides a cheap and economical raw material for the manufacture of sulphuric acid, with yields as high as 98 per cent. The gas is burned in excess air to the dioxide and further mixed with air or oxygen and converted into the trioxide of sulphur over vanadium, tin, or chromium oxides as catalysts. Absorption of the trioxide in water is all that is necessary to yield the vitally important sulphuric acid.

Other uses of hydrogen sulphide, or its alkali salts in particular, are of interest. The ripening of alkali-cellulose by air or gas containing oxygen is accelerated by the presence of an alkali-sulphide. Mild oxidation of the sulphides yields thiosulphates. Thus sodium hydrosulphide may be obtained from treating sodium sulphide with hydrogen sulphide at 300° C.

$$H_2S + Na_2S = 2NaHS.$$

Treating the hydrosulphide with air at 100–150° C. yields sodium thiosulphate.

$$2NaHS + 2O_2 \longrightarrow Na_2S_2O_3 + H_2O.$$

Various other methods exist for preparing this important compound from the sulphides. Again, an ore-flotation agent may be prepared from the interaction of rosin and hydrogen sulphide at 80° C. in the absence of oxidizing conditions.

Mercaptans and Others.

These sulphur compounds show certain acidic tendencies because they possess an –SH radicle. Their importance lies in the ability to react with many agents, such as with oxidizing agents like oxygen, sulphur, or halogens, to form disulphides; with aldehydes and ketones to form mercaptals and mercaptols respectively; and with acids to yield esters. Thus they are interesting intermediaries. Academically they offer valuable information on organic chemical reactions; their applications, however, are numerous as well.

Probably due to their great activity, they are used as oxidation inhibitors. Thus 1 per cent. of a mixture of amyl mercaptan and dibutyl amine can inhibit gum formation even in motor fuels obtained from cracked distillates. Insecticides and fungicides are prepared by incorporating mercaptans, admixed with phenols, with alkali polysulphides and an emulsifying agent; or simply by impregnating acid-treated fuller's earth or silica gel with mercaptans and disulphides. Disulphides or alkyl esters prepared from mercaptans may be used as accelerators in the vulcanization of rubber or flotation agents for ores. Sulphur bodies which possess detergent, wetting, and emulsifying properties may be prepared from mercaptans as a starting material. Further, softening agents for textiles may be produced from the combination of mercaptans and esters of chlorinated carboxylic acids.

Thioethers and polysulphides have been suggested as ingredients for fumigants and as solvents for rubber. Benzyl sulphide inhibits the corrosion of aluminium by hydrochloric acid. Derivatives of thioethers have been suggested for use as decolorizing agent for textile, as loosening agents for carbon deposits, and for the extraction of naphthenic hydrocarbons from mineral oils. Disulphides mixed with mercaptans or thioethers furnish flotation agents for copper ores; while tetrasulphides are said to accelerate ignition in diesel engines.

Sulphonic Acids.

As a result of sulphuric-acid treatment of petroleum products, a large group of compounds known as sulphonic acids is obtained. These products were formerly wasted as "acid sludge," but with increasing knowledge of their nature and usefulness an increasing number of individual products is now available for specific utility.

The mechanism of sulphonation is only known accurately in the case of the reaction of hydrocarbons of lower molecular weight. As it appears that the saturated hydrocarbons in the higher distillates of many oils are much more reactive towards chemical reagents, including sulphuric acid, than the lower-molecular-weight compounds, only inferences can be drawn regarding reactions which are of immediate interest to the petroleum chemist. Oleum or gaseous sulphur trioxide may be used to sulphonate oils; liquid sulphur dioxide extract layers from oils are found to be practically wholly composed of sulphonatable constituents. The sulphonic acids are removed, after sulphonation, either by selective solvent action of lower monobasic alcohols or by precipitating their salts by salting out.

Petroleum sulphonic acids are mildly detergent, being stable in hard water, acid, or alkaline solutions. The detergent action is enhanced by mixing the sulphonates from acid sludges with an alkali metal alkyl hydrogen sulphate of more than ten carbon atoms per molecule.

Sulphonic acids may also be used in making stable hydrocarbon emulsions, or, conversely, as constituents of emulsion-breaking mixtures. The emulsifying agents are useful in textile and leather work, whilst the emulsion-breakers are used in breaking the water-in-oil type of emulsion in petroleum production.

Further, a suggestion for using sulphonic acids from petroleum is their use as wetting agents for textiles in dyeing operations, particularly when dyeing from acid baths. Again, these sulphonates have been used as media for carrying protective lubricants for use on yarns.

The sulphonates of petroleum have several advantages as a wetting agent and vehicle for insecticides. Thus, for instance, they are more toxic when mixed with mineral oil than nicotine sulphate mixed with casein in hard water.

Of the miscellaneous uses of petroleum sulphonates, only a few need be mentioned to illustrate their wide scope and nature. They may be used in softening leather, as solvent activators to speed the mastication of rubber, or as a thermoplasticizing compound for use with rubber, in the manufacture of extreme pressure and other special lubricants, in the manufacture of polishing compounds, in making oil-soluble dyes from water-soluble dyes, in combination with fatty acids to prevent foaming in emulsions, in making fat-denaturants, in preparing medicinal products, in forming catalysts for esterification processes, in making resins applicable in varnishes and lacquers, and in making brushless shaving-creams. Many other varied uses could be mentioned, but full details of these operations and utilities can only be obtained from more comprehensive texts on the subject.

Nitrogen Compounds.

The nitrogen content of most petroleum oils is low, in the majority of cases not exceeding 0·1 per cent. However, considering the large quantities of oil produced, this figure is not a negligible quantity.

The nitrogen compounds existing in petroleum oils appear to be more complex than the pyridine homologues of the shale- and coal-oil nitrogenous substances. Petroleum products appear to be more of the hydro-aromatic types of molecules. Thus, the nitrogen-containing compounds derived from petroleum are called naphthenic bases. The structure of many of these nitrogen bodies is unknown, probably because they break down during ordinary distillation and refining operations. It is known, however, that they are complex and are probably closely related to the alkaloids.

Uses of petroleum bases are as pickling inhibitors, insecticides and germicidal preparations, and inhibitors in the autoxidation of lubricating oils.

Recent work on the direct nitration of the lower members of the paraffins has been of considerable interest, as these members were, and are still, considered as most inert bodies towards reagents. Direct nitration in the vapour phase of all the lower members, excepting methane, of the paraffins resulted in yet another group of nitrobodies from petroleum as a raw material in 1933.

Low-molecular-weight alkyl nitrates and nitrites are well known for their use as ignition promoters in diesel-engine fuels. Certain fuels have been nitrated directly, instead of being doped with these nitrobodies, and were found to improve in their quality as diesel fuels. Again, a mixture of nitromethane, benzol, and ethyl alcohol has been found effective in removing carbon deposits from I.C. engines. Nitropropanes and nitrobutanes have been found to be good solvents for lacquer. Nitrated petroleum fractions have also been used in producing resins, dyes, plasticizers, and intermediates in the production of motor fuels. Nitrating toluene obtained from petroleum results, of course, in the well-known T.N.T. explosive.

Conclusion.

This review reveals a vast field of human knowledge, experience, and needs, and also emphasizes the importance of the subject of chemistry in its broadest sense and its relation to the utilization of petroleum products.

We, as a nation, have not risen to the responsibilities of our civilization as we might have done, in the manner in which we have promoted and encouraged the development of scientific knowledge.

The neglect of science spells waste and industrial decay, and those industrial nations which not only do not keep abreast of modern thought and development in the world of science, but, what is more important, do not take the lead, must surely and rapidly decline in prosperity.

We have most certainly not led the world in synthesis in so far as those fields of study which find their raw material in petroleum are concerned, although a number of isolated problems are being nibbled at in various institutions, many of which are uninspired by anything beyond a desire for a University Mastership or Doctorate.

It is most essential for the prosperity of the British Petroleum Industry and this country that there should be organization, collaboration, and co-ordination of such research on the subject as subdivided in this paper, and equally essential that it should be controlled by those with specialized knowledge of the multitudinous possibilities before us. Although some of the investigations mentioned are of immediate concern, the majority are long-distance problems, but they should not be shelved longer than absolutely necessary because of this, despite the present emergency, if we, as a nation, are to reach the forefront of petroleum science.

After the last war, it was the hope of many that the vital dependence of our social and national prosperity on a knowledge and appreciation of the facts and principles of science, and on their application in industry, would be fully recognized, yet the scientific world has witnessed an appalling waste of natural resources since then.

It cannot be expected that one industrial organization, or even a group, should bear the responsibility, financial or otherwise, of developing comprehensive research on the lines indicated, however great the interest in such a scheme might be, particularly as we must beware of interpreting the usefulness of such work at the start, in the too narrow spirit of economic utility.

Although we have practically no indigenous source of supply of petroleum to speak of in Great Britain, and as an Empire we may lag behind other countries, through no fault of our own, as oil producers, nevertheless the amount of petroleum for which British capital is responsible is a very large proportion of the total available, and the scientific utilization of such a mineral and its many products can be said to be as important to us as that of coal.

We are spending anything up to £12 million a day to win the present war; could not a very small proportion of our war expenditure be allocated to experimental science, in order that we may also win the next peace, and so become the true benefactors to humanity by a more peaceful method, and one which would be less costly in its fullest meaning?

In other words, synthesis in its true understanding.

THE INSTITUTE OF PETROLEUM.

LUNCHEON.

THURSDAY, 1ST MAY, 1941.

A Luncheon of the Institute of Petroleum was held on Thursday, 1st May, 1941, at the Connaught Rooms, Great Queen Street, London W.C. 2. The PRESIDENT (PROFESSOR A. W. NASH) presided, and those present included :—

Mr. Geoffrey Lloyd, M.P. (Secretary for Petroleum), Sir Cecil H. Kisch, K.C.I.E., C.B., Sir Frank E. Smith, G.B.E., K.C.B., F.R.S., Sir Henry T. Tizard, K.C.B., F.R.S., Sir Alfred Faulkner, C.B., C.B.E., Dr. R. E. Priestley, M.A. (Vice-Chancellor, the University of Birmingham), Mr. F. C. Starling, Major G. P. Bulman, Mr. E. E. Soubry, Hon. M. R. Bridgeman, Mr. J. E. Montgomery, Mr. C. G. Burton, Mr. M. B. Donald, Dr. A. J. V. Underwood, Lt.-Col. S. J. M. Auld, O.B.E., Mr. T. Dewhurst, Dr. A. E. Dunstan, Mr. J. Kewley and Mr. T. Outen.

After the loyal Toast had been honoured, MR. T. DEWHURST (Past-President) proposed the Toast of

"HIS MAJESTY'S MINISTERS."

MR. T. DEWHURST (Past-President) said :

It is a great honour and privilege to be entrusted with this toast, for in these grave times His Majesty's Ministers represent all political parties and the whole nation, and offer the only hope for the deliverance and security of all enslaved and free peoples.

Two of the great speeches of recent times consisted of one sentence each. His Majesty the King visited a bombed area, when a spectator said to him, "You are a great King," and His Majesty replied, "And you are a great people." It is an axiom that a people gets the Government it deserves, and this great people and His Majesty's Ministers compliment each other.

The axiom casts a sinister light on the character of the German people. When one contemplates the Nazi leaders—those grotesque specimens of race purity—one is reminded of a recent dictum in regard to them. The dictum runs as follows: "It would require a special dispensation of Providence to raise them to the lowest level of human degradation." But whatever the German people may be, they certainly are not a race of Nordic supermen. They are about 40 per cent. Nordic and about 60 per cent. Alpine, whereas the people of the United Kingdom and Northern Ireland are about 75 per cent. Nordic and about 25 per cent. Mediterranean, so that even a Nazi ethnologist should be in no doubt as to which of these two peoples is the more fitted to survive in the present struggle for existence.

The late Lord Curzon said that in the last Great War "the Allies floated to victory on a sea of oil," and nothing could express so vividly the vital importance of petroleum products in modern warfare. When we contemplate the stupendous task of supplying petroleum products to the Navy on the seven seas, and to the Armies and Air Forces in this country, in the Mediterranean, in Libya, and Abyssinia, not to speak of the civil requirements of various countries, we realize how deeply indebted we and the whole nation are to the great Service Departments of State, to the Petroleum Board, and above all to the Petroleum Department and the Minister who is in charge of its activities. The victories of the Navy, notably that of the battle of Cape Matapan, the many victories of the Air Force, notably that of the Battle of Britain, the wonderful victories in Africa, and the gallant rearguard action in Greece—in all these engagements the adequate supply of petroleum products has been an indispensable condition of success, although in the case of the Italians we have doubtless been helped by their lack of " abdominal fortitude " !

In view of the vital importance of petroleum products in this war it is a fortunate circumstance that we have a perfect organization for the supply of these products to our armed forces in all the various theatres of war, and experience has amply confirmed the great wisdom of the Government in deciding to create the Petroleum Board. It is hoped that the time will come when the Nazi war machine will run down owing to a shortage of petroleum products, and many people believe that this will prove to be the weakest link in their chain of essential supplies. However, the Nazi Blitzkriegs on Poland, Norway, Holland, Belgium, France, Yugoslavia, and Greece were of brief duration and may not have caused serious depletion of their oil reserves, but perhaps we may hope that as a result of our unceasing attacks by air on tanks, refineries, coal-oil plants, and on vital links in their transport system, the Nazis in due course will be incapable of sustaining a prolonged period of total war. We would welcome enlightenment on this important subject, but our hopes of obtaining this from an authoritative source are somewhat dimmed by the political experience and discretion of our chief guest.

The Royal Society as such was formed in 1662, and throughout its existence has advised Governments on scientific matters. The geologists broke away in 1807, and were followed by others who formed their own scientific societies, yet none of these has been privileged to advise Government on its own special subject. A later development was the formation of professional and technical societies and institutions, covering subjects such as civil, mechanical, marine, electrical and chemical engineering, the chemical industry, iron and steel, mining and metallurgy, petroleum, etc. These scientific and technical bodies include many thousands of members who have had a thorough scientific training, reinforced by years of practical experience in their respective subjects. Yet so essentially conservative—I use the word in a metaphysical and not a political sense—is the English character that the Royal Society, which is the scientific analogue of the Bank of England, remains the sole unofficial scientific adviser to the Government and holds aloof from all other scientific societies and institutions. This subject was raised and debated in the House of Lords a few weeks ago, and the Government spokesman, Lord Hankey, made the following statement : " The Government were at present in close touch with the professional societies concerned with a view to the possible establishment of a separate organization working in the field of applied science and in close touch with the Scientific Advisory Committee and an announcement might be expected before long." An official announcement was made yesterday in regard to engineering, and this Institute would welcome wholeheartedly any further developments in this direction which would lead to greater use being made of the knowledge and experience that it represents.

The House of Lords debate doubtless originated with the Parliamentary and Scientific Committee, an unofficial liaison body between professional societies, including this Institute, and Parliament. It is one of the duties of this Committee to arrange for questions to be put to His Majesty's Ministers on scientific and technical matters, and therefore it is potentially able—may I say, Abel to raise Cain? Notwithstanding this position, the Secretary for Petroleum has not yet been asked a single question as a result of those activities, as we are too well aware of the scientific and technical perfection of the Department under his control.

One of the major tasks carried out by this Institute during its history was the initiation and foundation of the World Petroleum Congress. Congress activities are now in abeyance, but it is certain that they will revive. This great Congress could not have been established without the help of His Majesty's Ministers. Indeed, the first page of the *Proceedings* of the first Congress contains the following statement : " From the outset the Congress had the approval of His Majesty's Government. The Secretary of State for Foreign Affairs, the Secretary of State for the Colonies, the President of the Board of Trade and the Secretary for Mines signified their approval by accepting nomination as Honorary Presidents, while the Secretary of State for Scotland represented the Government at the Congress Banquet. The Foreign Office through its representatives invited the Governments of foreign countries to send delegations. The Government also entertained delegates at an official reception at Lanchester House and at an official luncheon at the Hyde Park Hotel. In addition the Congress Committee was strengthened by the inclusion of the Director of the Petroleum Department of the Board of Trade.'' This record alone demonstrates the great indebtedness of this Institute to His Majesty's Ministers, and we can only hope that the scientific and technical publications of the Institute have been of some slight service to the great Departments of State under their control.

It is a source of great pleasure to us to be able to couple this toast with the name of Mr. Geoffrey Lloyd. The early manifestation of Mr. Lloyd's qualities is proved by the fact that at the age of 27 he had been President of the Cambridge Union, Private Secretary to Sir Samuel Hoare, and was Private Secretary to Mr. Baldwin. As Private Secretary or Parliamentary Private Secretary to Mr. Baldwin for six years he must have been entrusted with many matters of high importance. Unfortunately, this experience deprives us of any hope that he will thrill us with any revelations which, however fascinating for us to hear, would be in the smallest degree impolitic for him to impart. While Parliamentary Under-Secretary to the Home Office he was responsible for the organization of the A.R.P. Services. During his tenure of office as Secretary of Mines he impressed the country by his frequent visits to the coal mines in search of information at first hand. It is unfortunate, therefore that we have not in this country about half a dozen big oilfields, particularly as truth is said to lie at the bottom of a well. Mr. Lloyd is the first Secretary for Petroleum in our history, and at a time when petroleum is recognized as a vital necessity for the survival of this country and Empire. We offer him our best wishes in his great task, and hope that a future historian will be able to say, again to quote Lord Curzon, that under his guidance this country once more floated to victory on a sea of oil. In view of Mr. Lloyd's heavy responsibilities and manifold duties at the present time, we deeply appreciate his presence here at the first function we have held since his appointment. I have pleasure in inviting you to rise and drink to the health of His Majesty's Ministers, coupled with the name of Mr. Geoffrey Lloyd. (*Applause.*)

MR. GEOFFREY LLOYD, M.P. (Secretary for Petroleum), in replying to the Toast, said :

It is a great honour to reply to this toast, but I am not going to be inveigled into any indiscretions. There are so many men in this room engaged so closely in secret work connected with armament and other vital industries in the war production of this country, that I doubt whether any other body of men that could be gathered together at this particular moment are aware of so many of the war secrets. There is therefore no need to talk about them at all. There will come a day when victory has been won and when we shall be able perhaps to exchange with each other some of the things we know.

We are all aware that oil is the motive force of modern war. It drives the ships of the navy, it drives the aeroplanes and the mechanized forces of the army, and in addition it provides the essential of power for a tremendous proportion of what is called the civilian war effort—an effort which, as we well know, is absolutely vital to the war effort as a whole. If the Government is entitled to credit in this matter, I think it is on the ground that it has had the sense to realize that in this country and the Empire we have an efficient oil industry and to take full advantage of the wealth of technical and business ability which is in that industry, also, from the point of view of supply, in making full use of the great organizations of the Petroleum Board. I am very glad to see Mr. Soubry, the representative of the Board, here to-day. I am not going to elaborate that point, but I think it was very fortunate and very wise that in handling our petroleum supply problems we have been able to arrange for the industry in this country to be unified, and so to be able to play its full part in a corporate capacity. So far every important and vital demand for oil for our war effort has been met, and in addition to the obvious thing that we all think of from the point of view of the armed forces, I would like to mention that, for example, the ploughing-up campaign of the Ministry of Agriculture has resulted in the largest demand for vaporizing oil for tractors ever known in this country. The industry has cooperated most efficiently with the Ministry in supplying these demands.

All these things have naturally required increased quantities of petroleum products. We are delighted that that should be so, that our military forces should have expanded so greatly as to require very much increased quantities of oil. The civilian private-car owner ever since the beginning of the war has made a great contribution by reducing his demand for the use of petrol in private cars, so that these other greatly increased needs might be met. Ever since the war began I have pleaded for economy in the use of petrol by the private-car owner, and the private motorist has made a very great response. But I do take this opportunity once again, as I do whenever I have the privilege of making a public speech, to re-affirm the need for economy by the private motorist in the use of petrol, and to remind those who have supplementary rations that those rations are only intended and allowed to be used for the essential purposes for which they were given. The Divisional Petroleum Officers have instructions to pay the strictest attention to that point.

I am not going to make a long speech to-day, and I merely wish to thank you very much for giving me the opportunity of meeting you and for the work that you are doing in connection with the war effort. I want you all to realize that those who are engaged in maintaining the oil supplies of this Empire and in perfecting the high quality of the petroleum products needed in the war effort are playing a great part in the battle as a whole. I hope that all our efforts will be as successful in the future as they have been in the past, and that the time may not be too distant when we shall be able to repeat the words which the last speaker quoted from Lord Curzon, that this country floats to victory on a sea of oil. (*Applause.*)

"The Institute of Petroleum."

Dr. R. E. Priestley (Vice-Chancellor, the University of Birmingham):

I have perhaps one or two qualifications which entitle me to propose the health of the Institute, not because I am a capable speaker, but because I have the honour of being Vice-Chancellor of the University which has one of the oldest Departments of Oil Technology and which in Lord Cadman and your President, Professor Nash, has had on its staff two of the greatest of British oil specialists. The second reason why I have some title to speak harks back to the distant past. Oil owes a tremendous lot to the geologist-explorer, and in my earlier days that is what I happened to be. It is true that most of my geology was done on the one continent where no oil has yet been found. I have a Cambridge friend who volunteered to drink all the oil that would be found in Britain. If he has attempted to fulfil his pledge, he must be suffering severely from indigestion to-day. I still feel, however, that I should be quite safe if I were rash enough to make a similar offer about Antarctica, where nearly all the country, except batches of the most recent volcanics, is covered by several thousands of feet of ice.

Scientific and technical associations are passing through difficult times to-day. Meetings of all sorts are not easy to arrange, travelling has to be cut to a minimum, and many of their members are not able to spare time from other work of national importance. It is one of the inescapable handicaps of democracy that it is not easy for these Institutes, which pride themselves first and foremost upon being free associations of individuals, to find their niche, as associations, in the national effort. This is bound to lead to a sense of frustration. Our societies have never been regimented or State-controlled. They have retained liberty of action and freedom of discussion, and above everything else they value the right of criticism. From time to time they have impressed upon reluctant Governments the claims of science, and it follows that they are not easily converted into Government Departments to play the rôle which similar associations play in the totalitarian States.

It is true that I am here as your guest, but also in a sense I am your war-time host, because the offices of the Institute have been housed at Edgbaston on the University site since September 1939. I do not know how far it is due to your presence that the University has recently received certain weighty presents from Hitler. You gentlemen have certainly made the world more interesting, though rather more uncomfortable in recent years. I give you my best wishes for the future. I bear in mind the fact that while the product with which you deal has greatly assisted men's powers of destruction it can equally, and in as great a measure, be applied to the reconstruction that must follow. With that in mind I have the greatest pleasure in proposing the health and continued prosperity of the Institute of Petroleum. (*Applause.*)

Professor A. W. Nash, in replying to the Toast, and in proposing that of "Our Guests," said :

It is with very great pleasure that I respond to this toast, particularly as it has been proposed by my Vice-Chancellor, because it gives me the opportunity of thanking him publicly, on your behalf, for his kindness in giving us office accommodation at the University of Birmingham, and this I do very sincerely. It is quite obvious, he being my Chief, that I cannot eulogize him to his face, but I am indeed very grateful to him for coming here to-day. I know he is such a busy man at the present time, having so many duties to perform in addition to his normal University duties of finding a common denominator for all the difficulties of his colleagues which are as diverse as the subjects which they profess.

I am sorry that His Excellency the Prime Minister of the Netherlands was prevented from attending, as so many of us have such happy recollections of business trips, as well as pleasure trips, paid to his country and to friendships formed with many of his fellow-countrymen. I sincerely hope it will not be very long before we are visiting our friends in Holland once again.

I am also sorry that Mr. C. S. Wright, the Director of Scientific Research and Experiment at the Admiralty, could not be present, as he would have had much in common with Dr. Priestley, both having been explorers—indeed, I believe they were shipmates on one expedition—but more particularly because I wanted to tell him a story which he could have taken back to his Service colleagues at the Admiralty.

The story was told to me by one of my students who joined the Royal Navy just after the outbreak of this war and, after some training, was sent as a seaman wireless operator, to a trawler which had been taken over by the Admiralty. This trawler was one of a fleet of five which had belonged to a certain company, all of which had been built in a small German shipyard. The engines had been giving trouble, and so the skipper, who had been in the ship since she was built, and, for that matter, so had the crew, wrote a report to the Commanding Officer of the fleet, aided, incidentally, by the rest of the crew, particularly in regard to the spelling in the report.

The Commanding Officer was a young Sub-Lieutenant, R.N., with no knowledge of the history of the vessels under his command, and the report he received, after explaining the repairs necessary, finished up with, "I have the honour to submit therefore that this vessel be returned to her original builders for a complete overhaul."

In due course a reply came from the Sub-Lieutenant to the effect that the Admiralty had looked up the records of the trawler, and as she was built in a German shipyard, the skipper would proceed to such and such a yard on the East Coast for repairs and refit.

Attached to the official letter was a private note from the "one ringer," which read: "If you think this is damned funny, I don't, and neither did My Lords of the Admiralty." (Laughter.)

I will not weary you with a long account of the Institute's proceedings over the last year. I always think such a procedure is most boring to the guests, who are not interested in our domestic affairs, and should not be necessary for the members if they have attended the meetings and read their journals regularly. We are still working under a considerable handicap, and our difficulties have not been lightened during this last year, due to reasons entirely beyond our control.

I feel I must pay tribute to the loyalty of our staff in this respect. They have worked splendidly. It is no easy matter these days, in an organization depleted of staff and the facilities which have previously been available, to keep the wheels running at all, but I can assure you, gentlemen, the wheels have been running much more smoothly than I ever expected.

Particularly would I mention our Secretary, Mr. Astbury, and the Assistant Secretary, Miss Tripp, and I would here say that this lady is also engaged in work of some importance in the Headquarters of one of our Civil Defence Services, in addition to her professional work.

As I have to address you again later, I will not make any further reference to the Institute's affairs at this stage, other than to say how very sorry we are not to have with us on this occasion one of our most distinguished Past-Presidents, Lord Cadman, who is, unfortunately, indisposed. I am sure you will all join with me in wishing his Lordship a speedy recovery, and I propose, with your agreement, to despatch a telegram expressing these sentiments. (*Applause.*)

Gentlemen, we have with us today a number of distinguished guests, and as they are all engaged on work of the greatest national importance, and will be anxious to return to their duties with as little delay as possible, your Council decided to cut the number of speeches to a minimum, hence the reason why I am responding to, and proposing, a toast at one and the same time.

We have important representatives of the Industry and of the Institution of Chemical Engineers, whom we are very pleased to see here today. Perhaps I may take this opportunity of thanking the President and Council of that body for their kindness in giving us the use of their Council Chamber for our Council Meetings in London.

I am also pleased to be able to welcome here today Mr. Soubry, who has succeeded my old friend Mr. Wolfe with the Anglo-American Oil Company.

Of the Minister for Petroleum you have heard already from one of our Past-Presidents, Mr. Dewhurst, so, beyond extending to him a hearty welcome, I will content myself with asking that he will do me the honour of reading the conclusions to the second Presidential Address which I am to give this afternoon, a copy of which I have handed to him. I would assure the Minister that this has been passed by the Censor.

The Petroleum Department, which, I think you will agree with me, is entrusted with one of the most important tasks associated with the war effort, is well represented, in that not only have we the honour of the presence of the Minister, but also Sir Cecil Kisch, the Director-General of the Department, who gave us such an excellent speech last year. We have also from the same Department Sir Alfred Faulkner, one time Director of Sea Transport, who has, consequently, a considerable knowledge of shipping, including oil tankers, and who is now Under-Secretary for Petroleum and Chairman of the Executive Committee responsible for investigating all oil questions.

The Hon. Maurice Bridgeman and Mr. F. C. Starling are so well known to us that I am sure they will forgive me if I cull an expression from the recent broadcast speech of Lord Beaverbrook, and describe them as two of the more senior " boys," but very important " boys," in the back rooms of the Petroleum Department.

When I come to Sir Frank Smith, I have to pause. I think everyone pauses when they come to Sir Frank. To give you a cavalcade of his scientific career would be an education in itself, for he is one of the most versatile scientists we have at the present time. From the Electrical Department of the N.P.L. he passed to the Admiralty as Director of Research, then transferred to the Department of Scientific and Industrial Research as its Secretary, during which time he was also the Secretary of the Royal Society.

I regret that at this stage I must disappoint you. It is said that the higher you climb the farther you have to fall, and Sir Frank then fell from grace with a bump. He entered the Petroleum Industry ! However, he is now staging a " come-back," as since the war he has been appointed Director of Instruments. For myself, my greatest admiration for him lies in the fact that he chose the city of my adoption, Birmingham, as his birthplace. In addition, Sir Frank Smith represents the Ministry of Supply, which body is housed in a certain building somewhere in England, the whereabouts of which I regret I must keep you in complete ignorance because of the Censorship.

One of the greatest difficulties with which, I should imagine, the scientists in the various Ministries have to contend, is to watch that square pegs are not fitted into round holes. Perhaps I may be forgiven if I remind them that there are still many pegs, both round as well as square, in the world of Science which have not yet been fitted into *any* holes—a state of affairs I find it difficult to believe could exist in any other belligerent country.

I now come to the gentleman who plays one of the original characters of " the boys in the back room " at the Ministry of Aircraft Production in that Machiavellian fantasia " Bigger and More Beautiful Bombs " written and produced by Lord Beaverbrook, a description of which was given over the wireless recently. If we knew Major Bulman better, we should probably find his hobby is butterfly collecting or piscatology. Anyhow, may their bombs never grow less, and Major Bulman's engines never stall. Perhaps I may add that we do not mind which room Lord Beaverbrook puts them in, but Major Bulman and his colleagues in the various departments of that very live Ministry certainly come out of the top drawer so far as we are concerned. (*Applause.*)

By this time you will be saying to each other, " By Jove, what a covey ! " But that is not all, gentlemen.

I have left Sir Henry Tizard till the last, only because he is to respond to this toast.

Sir Henry has attended many of our functions in the past, he is an Honorary Member of the Institute, and, as you all know, I was associated with him for some few years on a publication which some reviewers did us the honour of describing as a monumental work.

As many of you know, Sir Henry has been interested in aeronautics all his life, for he was in the Royal Flying Corps in the early part of the last war, when he received the Air Force Cross—that was before flying men were provided with "umbrellas"—and later became Assistant Controller of Experiments and Research in the Royal Air Force. Although he has since been Secretary of the Department of Scientific and Industrial Research, and subsequently Rector of the Imperial College of Science, he has always played an important part in the scientific development of aeronautics. In fact, he has been Chairman of the Aeronautical Research Committee for some years now. It was but natural that he should be called upon by the Air Ministry to serve the country at the outbreak of war—indeed, it would have been a calamity had it been otherwise—since when he has transferred to the Ministry of Aircraft Production.

I have already referred to Lord Beaverbrook in theatrical language as the Author and Producer of the Play. Perhaps Sir Henry will forgive me if I describe him, in the language of the silver screen, as the Director of Technical Effects. That he is a wise administrator, an indefatigable worker, and a forceful but tactful leader, I have very good cause to know, and it is only to be expected that one of our most virile services should now claim him.

I believe I am right in saying that our fighting services encourage their scientific staffs to co-operate and collaborate to the fullest extent with their operational staffs. About a month back, Viscount Samuel raised in the House of Lords the question as to whether some of the Government Departments had not taken too narrow a view of the word "scientist," and suggested that with some of the appointments there was not a sufficiency of direct contact with the operational side of the subject, whether military, industrial, or agricultural.

Lord Hankey, in a most interesting review of the situation in reply, made it quite clear that the Government had spared no pains in forming a large number of committees, many of the members of which by now, I am afraid, will have forgotten they were working men of science and have become officials, but I was more perturbed to read that after this country has been at war for one year and eight months, the Government was only now getting in touch with the professional societies concerned, with a view to the possible establishment of a separate organization working in the field of applied science, and in close touch with the Scientific Advisory Committee.

Anyone with any knowledge of industrial conditions knows that the procedure adopted by successful industrial leaders has been to employ industrial scientists who are familiar with processes and their problems, and who, having recognized those problems as being such as to require research of a fundamental character, as distinct from industrial experimentation, invariably call in the pure scientist to help. The Government's policy in regard to many committees appears to be, under our present system of nationalization, a reversal of a policy which has hitherto worked so well under many successful systems of rationalization in the past.

Since I prepared these notes—in fact, only yesterday—information has been published in the Press to the effect that a new Government Committee to advise on engineering problems has been formed under the Chairmanship of Lord Hankey. As this is an engineers' war, the advisability of such a step is without question, and I am sure we are all pleased to see that this Committee is to have the benefit of the knowledge, experience, and advice of Sir Henry Tizard and Mr. H. R. Ricardo.

Perhaps I may conclude by telling you of a conversation I had with the Chairman of a certain committee which was formed about a year ago to investigate a subject of which I think I may claim to have some little knowledge. When he asked me what I thought of his committee, I replied that I thought it would have functioned much better if the members had a greater knowledge of their subject. To this the Chairman replied, "Yes, but look at the list of names on the Committee!"

Well, gentlemen, the guests I have introduced to you today, have been called to their important posts not because of their names, but because of their reputations, and I think we are very fortunate in having such men at the head of affairs at the present time.

I now give you the toast of "Our Guests," coupled with the name of Sir Henry Tizard. (*Applause.*)

Sir Henry Tizard, replying to the Toast, said :

I am the last speaker on your list, and my idea was to wait and pick up some gems in the rough that had been dropped by previous speakers, and see whether I could do anything in the way of polishing them. But the gems have been so well polished on this occasion that I am rather at a loss. I did, however, notice one gem a little in the rough which was dropped by Mr. Dewhurst. I understood him to say that His Majesty's Ministers offered the only hope of victory for democracy. No one, except possibly His Majesty's Ministers themselves, has a higher respect for them than I have, but that reminds me of the other old story of the man who was very ill and whose wife asked the doctor whether there was any hope. The doctor replied, "I have done everything I can; all we can do now is to trust in Providence," whereupon the wife said, "Is it as bad as that, doctor?" (Laughter.) If I were one of His Majesty's Ministers it would horrify me to be told that the only hope of victory rested on me and my colleagues. The hope of victory lies in the courage of the people of this country and in this country's scientific and technical resources. Is it not significant that we have a Prime Minister who never tells us to be courageous, but always assumes that we are?

Everybody knows the tremendous importance of petroleum in this war. The fact is that this is a war of mechanical power, and the great technical problem is to know what types of engines are made and to use them in the right way, and the using of them in the right way is not the simplest part of the problem. The last war, from a scientific point of view, was a chemist's war, and this might be called a radio war. There is more demand for radio scientists in this war in proportion to the number available in peace-time than in any other branch of science.

I went to America last September, and I should like to tell you something about that. We have got a lot to face now, and we are going to have a lot to face in the future, but it is of interest to realize some things that have happened, and especially the tremendous prestige which this country has gained for its courage—the courage of the ordinary common man and woman. But what is not quite so well realized is the tremendous technical prestige we have now. I have not a grasp of everything that has happened on all sides of the war effort, but I do know something about my own particular branch, and, with possibly one exception, I do not know of any single field of which we can say that another country has surpassed us in scientific and technical merit. (*Applause.*)

The proceedings then terminated.

VISCOSITIES OF HOMOLOGOUS SERIES AT EQUAL TEMPERATURES.*

By A. H. Nissan, Ph.D., and A. E. Dunstan, D.Sc.

Viscosity is a strongly constitutive property, but it was early found that the logarithmic function of viscosity was additive in many hydrocarbons over a certain range of molecular weight. Thus, at a constant temperature,

$$\log \mu = A \text{ (molecular weight)} + B,$$

for an homologous series.

However, even in the very early stages of these studies (1914), it was reported that " The tendency of the members of highest molecular weight to depart from linearity . . . shows that not only must the gross effect of each CH_2 be considered, but also, perhaps, its percentage effect, which, of course, will become less as the molecular weight increases." In other words, notwithstanding the remarkable similarity in the values of $\Delta \log \mu$ for the increment of molecular weight of CH_2 as calculated from various series, such as normal paraffins, alkyl iodides, ethers, esters, ketones, etc., yet in any one series if the range of molecular weight of the members be extended indefinitely upwards the value of $\Delta \log \mu$ appears to decrease.

Recently an attempt was made to derive this additive law from semi-empirical considerations,[1] and it was found that in certain cases this deviation with higher molecular weights could be reduced if the law is rendered

$$\log \mu = A \log \text{ (molecular weight)} + B.$$

This improvement could not be attained in all series, and can therefore be taken to be only fortuitous. To illustrate both the constancy of $\Delta \log \mu$ over limited ranges of molecular weight and its variation over a wide range, Table I is given for the normal paraffins from C_4 in the molecule up to C_{18}.

Table I.

Number of C in molecule.	Log μ in millipoises at 20° C.	$\Delta \log \mu$ for CH_2.	Average for $\Delta \log \mu$.
C_4	0·236		
C_5	0·364	0·128	
C_6	0·504	0·140	
C_7	0·614	0·110	
C_8	0·732	0·118	
C_9	0·851	0·119	
C_{10}	0·958	0·107	0·101
C_{12}	1·166	0·104	
C_{14}	1·337	0·085	
C_{16}	1·546	0·054	
C_{18}	1·656	0·055	

Table II gives the same results for the case of n-alkylbenzenes. The

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* Paper received 6th February, 1941.

first members were omitted, as molecular shape factors enter into the results and complicate the analysis.[2]

TABLE II.

Number of C in side chain.	Log μ in millipoises at 20° C.	Δ log μ for CH_2.	Average for Δ log μ.
C_3	0·934		
C_4	1·021	0·087	
C_5	1·134	0·113	
C_6	1·239	0·105	
C_7	1·329	0·090	0·091
C_9	1·508	0·089	
C_{12}	1·748	0·080	
C_{14}	1·898	0·075	

To understand both the regularities and the anomalies exhibited, the significance of $\Delta \log \mu$ should be appreciated. The most useful and frequently attested formula connecting viscosity and temperature for liquids is:

$$\mu = A'e^{B/T} = A'e^{Q/RT},$$

where μ = absolute viscosity,
Q = energy of activation of viscosity,
T = absolute temperature,
and A', B, and R = constants.

Q is assumed to be a constant, when actually it varies with temperature. Its variation over, say, 100° C. for unassociated liquids is, however, negligible. Thus:

$$\log_e \mu = A + \frac{Q}{RT}.$$

For two liquids, being successive members of an homologous series, then at equal temperatures T,

$$\log_e \mu_2 - \log_e \mu_1 = \left(A_2 + \frac{Q_2}{RT}\right) - \left(A_1 + \frac{Q_1}{RT}\right)$$

$$= \left(\frac{Q_2 - Q_1}{RT}\right) + (A_2 - A_1)$$

Thus $$\Delta \log \mu = a(\Delta Q) + b(\Delta A)$$

ΔQ represents the excess energy required to drive the larger molecule through a hole in the liquid and is connected with molecular volume. The constant A was derived approximately by Eyring and his collaborators [3] and was found to be proportional to

$$\left(\frac{M^{\frac{1}{2}}T^{\frac{3}{2}}}{V^{\frac{1}{3}}Q}\right)$$

where M = molecular weight,
V = molecular volume.

As T is constant, and $Q = f(V)$, it is seen that (ΔA) is connected with molecular volume to a greater extent than with molecular weight. Thus, it may be concluded that an approximate equation for $\Delta \log \mu$ would be:

$$\Delta \log \mu = f(V).$$

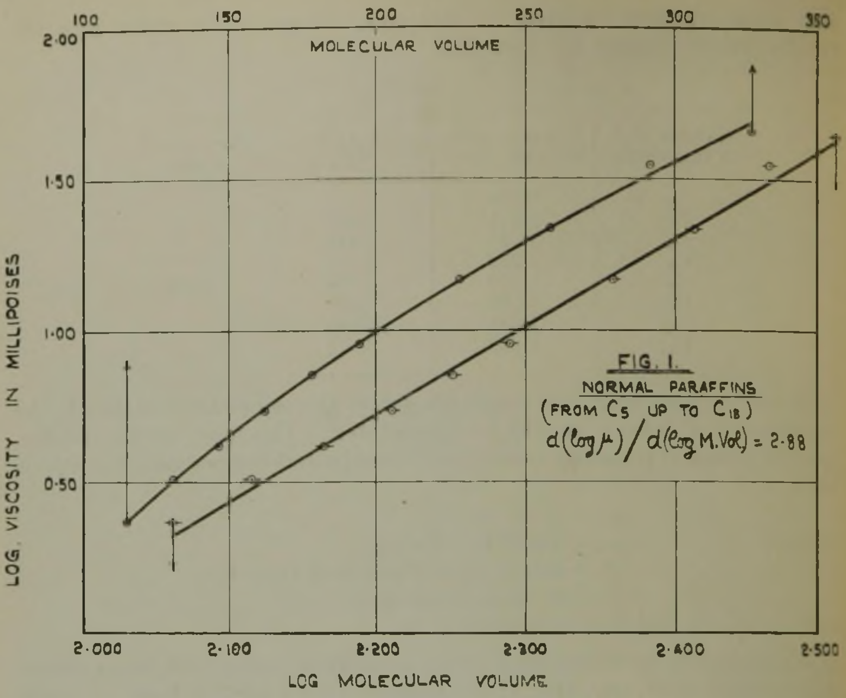
100
150
200
250
300
350
MOLECULAR VOLUME
2·00
1·50
1·00
0·50
LOG. VISCOSITY IN MILLIPOISES
FIG. I.
NORMAL PARAFFINS
(FROM C5 UP TO C18)
d(log μ) / d(log M.Vol) = 2·88
2·000
2·100
2·200
2·300
2·400
2·500
LOG MOLECULAR VOLUME

Fig. 1.

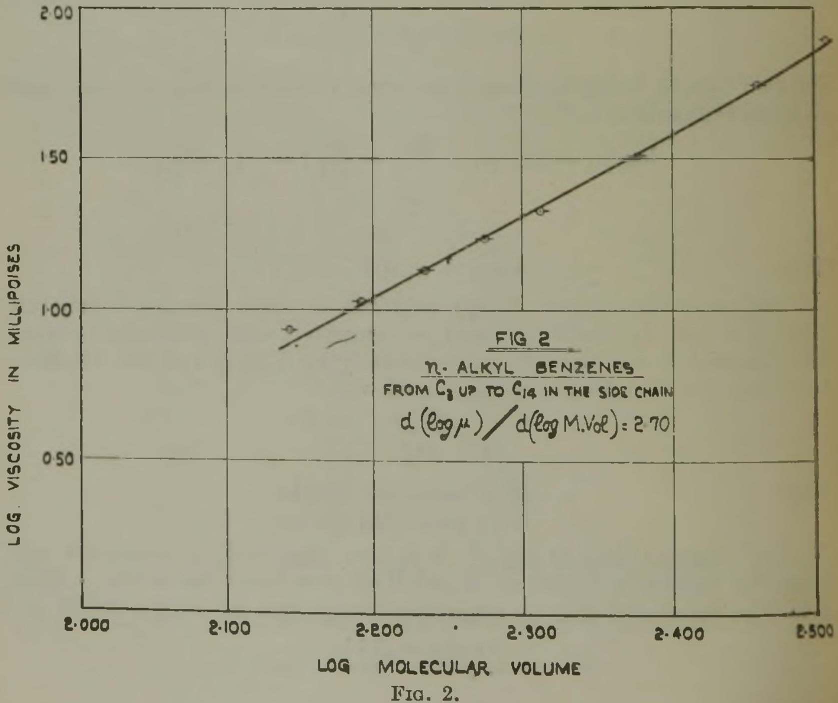
2·00
1·50
1·00
0·50
LOG. VISCOSITY IN MILLIPOISES
FIG 2
n- ALKYL BENZENES
FROM C3 UP TO C14 IN THE SIDE CHAIN
d (log μ) / d(log M.Vol) = 2·70
2·000
2·100
2·200
2·300
2·400
2·500
LOG MOLECULAR VOLUME

Fig. 2.

This equation suggests that a better relationship will probably result when $\Delta \log \mu$ is studied in conjunction with V than with M. To test this theory Table III was prepared and Figs. 1 and 2 plotted.

TABLE III.

Hydrocarbon.	V at 20° C.	Log V.	Log μ in millipoises at 20° C.
n-C_5H_{12}	114·9	2·0605	0·364
n-C_6H_{14}	130·4	2·1153	0·504
n-C_7H_{16}	146·2	2·1651	0·614
n-C_8H_{18}	162·2	2·2101	0·732
n-C_9H_{20}	178·3	2·2512	0·851
n-$C_{10}H_{22}$	194·4	2·2889	0·958
n-$C_{12}H_{26}$	228·0	2·3580	1·166
n-$C_{14}H_{30}$	258·9	2·4130	1·337
n-$C_{16}H_{34}$	291·6	2·4647	1·546
n-$C_{18}H_{38}$	326·9	2·5144	1·656
$C_6H_5{\cdot}C_3H_7$	139·2	2·1437	0·934
$C_6H_5{\cdot}C_4H_9$	155·4	2·1916	1·021
$C_6H_5{\cdot}C_5H_{11}$	171·7	2·2348	1·134
$C_6H_5{\cdot}C_6H_{13}$	188·4	2·2750	1·239
$C_6H_5{\cdot}C_7H_{15}$	204·8	2·3115	1·329
$C_6H_5{\cdot}C_9H_{19}$	237·8	2·3761	1·508
$C_6H_5{\cdot}C_{12}H_{25}$	287·0	2·4579	1·748
$C_6H_5{\cdot}C_{14}H_{29}$	319·8	2·5048	1·898

It will be seen from Figs. 1 and 2 that a straight line represents fairly the plots of $\log \mu$ against $\log V$, but, as expected from the analysis, a certain amount of curvature is evident due to the complex nature of $f(V)$ and to the effects of molecular weight and molecular shape. Again, the slope of the line for the n-paraffins is 2·88, as against 2·70 for the n-alkylbenzenes. Considering the wide range in molecular weight and the great difficulties in isolating pure normal paraffins of high molecular weights, the agreement appears to be as good as could be expected.

CONCLUSION.

It appears that $\log \mu$ is connected more directly with molecular volume than with weight. The formula :

$$\log \mu = A \log (\text{molecular volume}) + B$$

applies to a greater extent than the original

$$\log \mu = A\ (\text{molecular weight}) + B,$$

when a wide range of members of homologous series is considered. The molecular volume formula, however, is still far from being comprehensive.

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References.

[1] Nissan, A. H., " Dunstan's Law," *Nature*, 1939, **144**, 383.
[2] Nissan, A. H., Clark, L. V. W., and Nash, A. W., *J. Inst. Petrol.*, 1940, **26**, 154–222.
[3] Eyring, H., *J. Chem. Phys.*, 1936, **4**, 283.

REVISED STANDARD METHOD OF TEST FOR DISTILLATION OF LIQUID ASPHALTIC BITUMEN (TENTATIVE).*

(CUT-BACK ASPHALTIC BITUMEN AND ROAD OILS.)

I.P.T. Serial Designation—C.B. 3–1941 (T).

A.S.T.M. Serial Designation—D. 402–36 (*modified*).

APPARATUS.

Flask.—The distillation flask, Fig. 1, shall be a side-neck glass distilling flask and shall have the following dimensions :

Capacity of bulb to base of neck	455 ml. ± 12 ml.
Diameter of neck, inside	25 mm. ± 1·2 mm.
Diameter of tubulature, inside	10 ,, ± 0·5 ,,
Height of flask, outside	135 ± 5·0 ,,
Vertical distance bottom of bulb, outside to horizontal tangent at tubulature, inside	105 ,, ± 3·0 ,,
Length of tubulature	220 ,, ± 5·0 ,,
Angle of tubulature	75 deg. ± 3 deg.
Thickness of tubulature wall	1·0 to 1·5 mm.

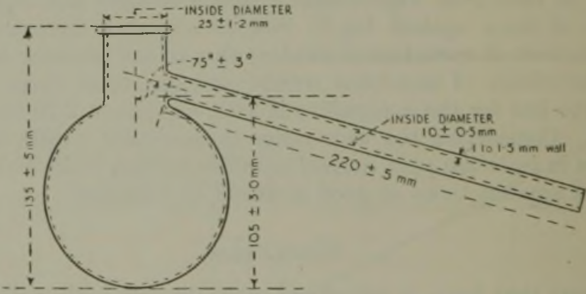

FIG. 1.

DISTILLATION FLASK FOR LIQUID ASPHALTIC BITUMEN.

Condenser.—This shall be a Liebig-type condenser having a water jacket 200 to 220 mm. long.† The actual condenser tube shall be a suitable form of tapered glass tubing of the following dimensions :

Outside diameter of small end	12·5 mm. ± 1·5 mm.
Outside diameter of large end	28·5 ,, ± 3·0 ,,
Length	360·0 ,, ± 4·0 ,,
Length of tapered portion	100·0 ,, ± 5·0 ,,
Thickness of walls	1·0 to 1·5 mm.

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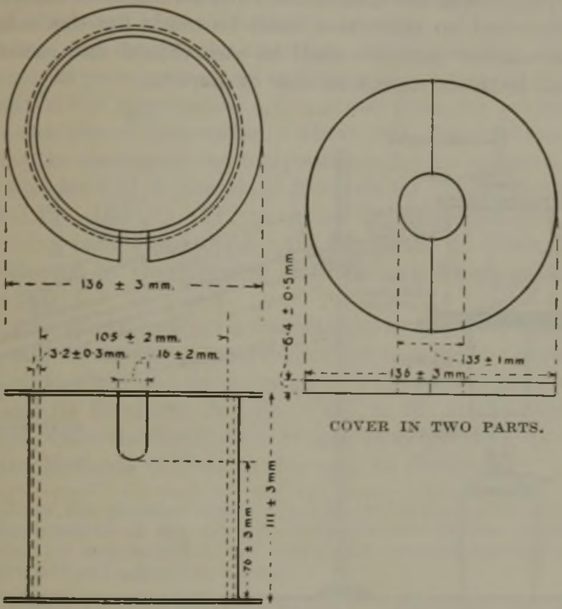
* Revised March 1941.

† If preferred an air condenser of the same liquid tube dimensions as the standard water condenser may be used, provided that the operator is satisfied that no vapour loss will result.

Shield.—A galvanized iron shield, lined with $\frac{1}{8}$-in. asbestos, of the form and dimensions shown in Fig. 2 shall be used to protect the flask from air currents and to prevent radiation. The cover (top) may be of fibre board made in two parts, or it may be of galvanized iron lined with $\frac{1}{8}$-in. asbestos.



COVER IN TWO PARTS.

FIG. 2.
SHIELD.

Graduated Receiver.—The distillate shall be collected in a Crow Receiver, conforming to the British Standard Specification No. 605.

Thermometer.—The thermometer shall be the "I.P.T. High Distillation," and shall conform to the specification as laid down on p. 192 of Standard Methods for Testing Petroleum and its Products, 3rd Ed., 1935.

PREPARATION OF SAMPLE.

The sample, as received, shall be thoroughly stirred and agitated, warming, if necessary, to ensure a complete mixture before the portion for analysis is removed.

The material may be tested for distillation without dehydration if the amount of water present permits this. If water is present to such an extent that distillation is not practicable, the sample shall be dehydrated before distillation.*

METHOD.

The flask shall be supported on a tripod or rings over two sheets of 20-

---

* The dehydration may be effected by distilling the water from an amount of not less than 250 ml. of the material. Any light oils which appear in the distillate must then be separated and poured back into the flask when the bituminous material is sufficiently cooled. After thorough mixing, the amount required for the distillation test is taken, the results being recorded as for the dehydrated sample.

mesh gauze, 150 mm. square, as shown in Fig. 3. It shall be connected to the condenser tube by a tight cork joint. The thermometer shall be inserted through a cork in the neck and immersed in the sample with the bottom of the bulb 6·5 mm. (¼ in.) above the bottom of the flask.

During the progress of the distillation the thermometer shall remain in its original position and no correction shall be made for the emergent stem. The actual barometric pressure shall be ascertained and recorded, but no correction shall be made except in case of dispute.

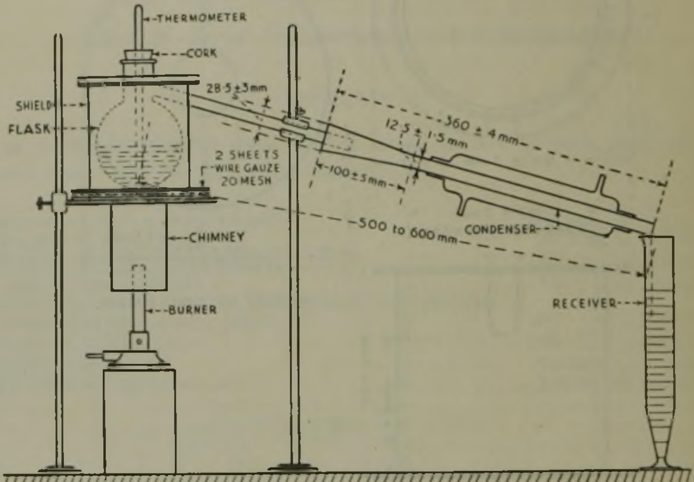


FIG. 3.

DISTILLATION APPARATUS ASSEMBLY.

The axis of the flask through the neck shall be vertical.

The distance from the thermometer to the outlet end of the condenser tube shall be not more than 600 nor less than 500 mm.

The burner shall be protected from draughts by a suitable shield or chimney (see Fig. 3).

The quantity of the sample to be used shall be 200 ml., and this amount shall be obtained by weighing the requisite quantity into the distilling flask, the weight being calculated from the specific gravity of the material at 60° F. When this amount has been introduced into the flask, the apparatus shall be assembled and heat applied, so that the first drop comes over in from 5 to 15 minutes. The distillation shall be conducted at the rate of between 50 and 70 drops per minute and the distillate collected.

The fractions to be reported shall be recorded in percentages by volume as follows :

Total distillate to	175° C.
” ”	200° C.
” ”	225° C.
” ”	250° C.
” ”	275° C.
” ”	300° C.
” ”	325° C.
” ”	360° C.

When the temperature of 360° C. is reached the flame shall be removed and the residue allowed to cool to 300° C. without disconnecting the flask from the condenser. The residue shall then be poured into a tin $2\frac{1}{2}$ in. in diameter by 3 in. deep, and shall be allowed to cool in a position free from draughts and without covering, to a temperature that is below its fuming point and at the same time suitable for pouring. It shall then be stirred and poured into the receptacles that have been specified when testing for properties such as penetration and softening point, the procedure employed following that of the appropriate I.P. method from the pouring stage.*

If the penetration of the residue is above 500, then the viscosity shall be determined at the recommended temperatures by the apparatus and method as laid down under L.O. 8 (Standard Methods for Testing Petroleum and its Products, 3rd Ed., 1935, p. 161) using the No. II instrument.

After allowing sufficient time for the condenser to drain, the volume of distillate collected in the receiver shall be noted and recorded as Total Distillate to 360° C.

If desired, the fractions from a distillation, or the distillates from parallel operations, may be combined and submitted to a further distillation by the apparatus and method laid down under G. 3 (Standard Methods for Testing Petroleum and its Products, 3rd Ed., 1935, p. 66) in the case of petroleum compounds or, when the distillate is of coal-tar origin, by C.O. 3 as laid down in "Standard Methods of Testing Tar and its Products."

---

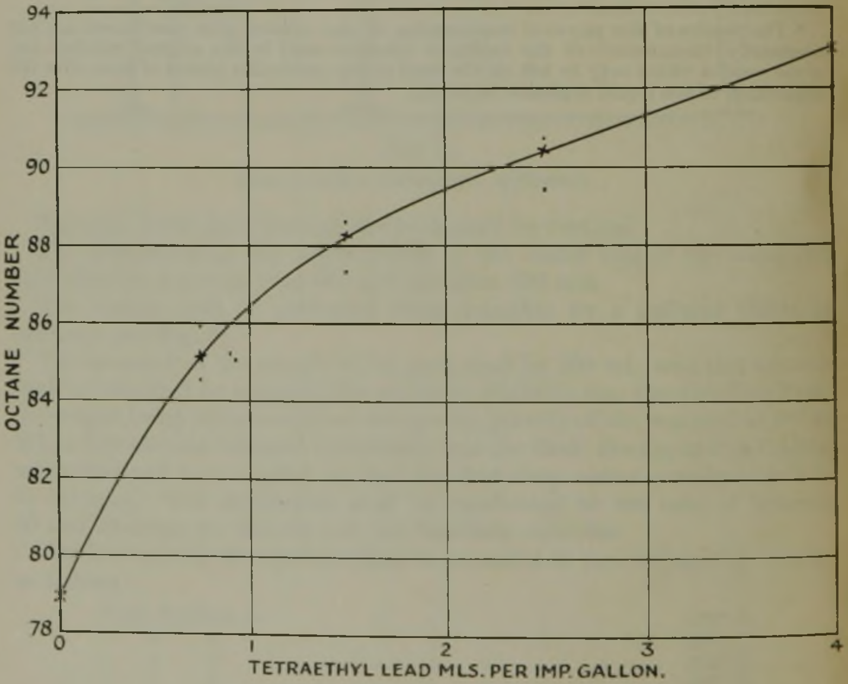
* The results of the physical examination of the residue after distillation are not necessarily characteristic of the asphaltic bitumen used in the original mixture nor of the residue which may be left on the road at any particular period of time after the application of the liquid asphaltic bitumen.

CALIBRATION OF TETRAETHYL LEAD IN STANDARD REFERENCE FUEL C.12 BY C.F.R. MOTOR METHOD.

REPORT OF THE INSTITUTE OF PETROLEUM KNOCK RATING OF AIRCRAFT FUELS PANEL SUB-COMMITTEE.

AT a meeting of the above Panel it was decided to prepare a calibration for T.E.L. in C.12 reference fuel. It was also agreed that primary reference fuels should not be employed in this instance, as two accepted sub-reference fuel calibrations were available for providing cross checks—namely, T.E.L. in C.11 and F.3 in C.12. Four concentrations of T.E.L. in C.12 were rated in twelve C.F.R. engines, owned by seven laboratories, thus providing twenty-four ratings for each point.

The test data are given in Appendix A, from which it will be seen that the maximum spread obtained on any point was 1·8 O.N. The average points have been plotted in the figure and a calibration table for laboratory use has been prepared.



CALIBRATION CURVE FOR C.F.R. MOTOR METHOD.

T.E.L. in C.12.

Prepared by the Institute of Petroleum, March, 1941.

REMARKS.

The calibration curve is almost coincident with that of T.E.L. in C.11, varying by not more than 0·2 O.N. The disagreement with the C.12 calibration table prepared in America varies up to a maximum of 1·1 O.N. in the region of 86 O.N.—that is in the region of 1 ml. T.E.L./Imp. gall. concentration.

Octane Number Calibration Tables for Motor Method.
C.12 + T.E.L. (mls. per Imp. gall.).

T.E.L.	Oct. No.	T.E.L.	Oct. No.	T.E.L.	Oct. No.
0·00	78·9	1·20	87·2	2·40	90·2
0·05	79·4	1·25	87·4	2·45	90·3
0·10	79·9	1·30	87·6	2·50	90·4
0·15	80·4	1·35	87·7	2·55	90·5
0·20	80·8	1·40	87·9	2·60	90·6
0·25	81·3	1·45	88·0	2·65	90·7
0·30	81·8	1·50	88·2	2·70	90·8
0·35	82·2	1·55	88·3	2·75	90·9
0·40	82·7	1·60	88·5	2·80	91·0
0·45	83·1	1·65	88·6	2·85	91·0
0·50	83·5	1·70	88·7	2·90	91·1
0·55	83·8	1·75	88·9	2·95	91·2
0·60	84·2	1·80	89·0	3·00	91·3
0·65	84·5	1·85	89·1	3·10	91·5
0·70	84·8	1·90	89·2	3·20	91·6
0·75	85·1	1·95	89·3	3·30	91·8
0·80	85·4	2·00	89·4	3·40	92·0
0·85	85·7	2·05	89·5	3·50	92·2
0·90	85·9	2·10	89·6	3·60	92·3
0·95	86·2	2·15	89·7	3·70	92·5
1·00	86·4	2·20	89·8	3·80	92·7
1·05	86·6	2·25	89·9	3·90	92·8
1·10	86·8	2·30	90·0	4·00	93·0
1·15	87·0	2·35	90·1		

APPENDIX A.

Calibration C.12 + T.E.L.

Mls. T.E.L./Imp. gall.:	0·75.	1·5.	2·5.	4.
Engine A	85·0	88·5	90·6	—
	84·7	88·6	90·5	93·4
B	84·9	88·1	90·7	—
	85·1	88·6	90·3	93·2
C	85·1	88·2	90·4	—
	84·8	87·9	90·0	93·0
D	85·2	88·3	90·5	93·1
	84·9	88·1	90·0	92·8
E	85·5	88·3	90·6	93·8
	85·9	88·6	90·6	93·6
F	85·3	88·3	90·5	93·5
	85·4	88·5	90·2	93·3
G	85·4	88·4	90·5	93·1
	85·3	88·4	90·5	93·0
H	85·4	88·4	90·3	92·7
	85·4	88·2	90·3	92·8
I	84·9	88·2	90·4	92·8
	85·0	88·2	90·2	92·8
J	85·3	88·4	90·5	92·4
	85·1	88·1	90·2	92·5
K	85·0	87·9	90·6	93·2
	84·5	87·3	89·4	92·0
L	85·3	88·4	90·7	93·0
	85·2	88·0	90·3	92·5
Average octane number	85·1	88·2	90·4	93·0
Spread	1·4	1·3	1·3	1·8

Note.—The first rating on each engine was using C.11/T.E.L.; the second was using F.3/C.12.

TWENTY-SEVENTH ANNUAL REPORT.

1940.

The Twenty-Seventh Annual Report of the Council covering the activities of the Institute during 1940 is presented for the information of the members.

MEMBERSHIP.

The changes in membership which occurred during 1940, and the total membership of all classes on 31st December, 1940, are summarized in the Table below :—

	Total Dec. 31, 1939.	CHANGES DURING 1940.							Total Dec. 31, 1940.
		New.	Trans-ferred to.	De-ceased.	Re-signed.	Trans-ferred from.	Re-moved.	+ or —.	
Hon. Members .	19	—	—	2	—	—	—	— 2	17
Fellows . .	406	11	2	5	2	—	2	+ 4	410
Members .	516	23	5	7	16	—	19	—14	502
Assoc. Mems. .	546	25	4	1	10	7	20	— 9	537
Students .	130	17	—	—	2	4	5	+ 6	136
Totals .	1617	76	11	15	30	11	46	—15	1602

The number of new entrants is considerably less than in recent years, but the main reason for the decrease in membership is the removal of 46 names. At the end of 1939 no names were removed from the Institute's register for reason of non-payment of subscriptions, but it has now been considered advisable to remove certain names in order to avoid giving a false impression of the growth of membership. It is confidently expected that many names now removed will be reinstated after the war.

The Council has to record with deep regret the decease of the following members during 1940 :—

	Date elected.	Class of membership.
ANFILOGOFF, N. A.	1913	Fellow
BLAKE, D. M.	1935	Associate
CAMBI, V.	1933	Member
COSTE, E.	1917	Member
EDMED, F. G.	1932	Hon. Member
FRANCIS, C. K.	1927	Fellow
GROUNDWATER, W.	1920	Member
HADFIELD, SIR ROBERT A.	1929	Hon. Member
HENDERSON, J. A. L.	1913	Member
HENNY, V.	1924	Fellow
HILLMAN, E. S.	1931	Member
KEITH, H.	1932	Member
LEA, F. B.	1919	Fellow
†RHYS-PRYCE, M. A.ap.	1934	Fellow
STRINGER, R. J.	1921	Member

† Killed on active service with the R.A.F. in France, June 1940.

Honours.

Mr. William Sigsworth (Associate Member) was among the first recipients of the award of the George Medal for conspicuous gallantry.

It is estimated that about fifty members of the Institute are serving with the Imperial Forces.

Representation on Other Bodies.

The Institute has been officially represented on the following bodies :—

The American Society for Testing Materials : Lt.-Col. S. J. M. Auld, O.B.E., M.C., Dr. A. E. Dunstan, Dr. F. H. Garner, and Mr. J. Kewley (Honorary Members of Committee D-2 on Petroleum Products and Lubricants).
The Parliamentary and Scientific Committee : Executive Committee : The President and Lt.-Col. S. J. M. Auld, O.B.E., M.C. General Committee : The President, Lt.-Col. S. J. M. Auld, Mr. T. Dewhurst, and Dr. E. R. Redgrove.
The British National Committee of the World Power Conference : Dr. A. E. Dunstan.
The British Standards Institution, Petroleum Industry Committee : Lt.-Col. S. J. M. Auld, O.B.E., M.C., Prof. J. S. S. Brame, C.B.E., Dr. A. E. Dunstan, Mr. B. J. Ellis, Dr. F. H. Garner, Mr. J. Kewley, and the Secretary.
Diesel Engine Users Association : Mr. L. J. Le Mesurier and Mr. N. Mitchell.

The Institute has also been represented on numerous sub-committees of the British Standards Institution. Various matters relating to new or revised specifications have been referred by the B.S.I. to sub-committees of the Institute's Chemical Standardization Committee.

Benevolent Fund.

The audited statement of Receipts and Payments of the Benevolent Fund during 1940 is submitted below. The receipts from all sources were £121 1*s.* 8*d.* as compared with £76 6*s.* 5*d.* in 1939.

Contributions to the Fund during 1940 were received from the following members, to all of whom the Council expresses its grateful thanks :—

Adams, A. C.
Auld, S. J. M.
Bailey, E. M.
Barrett, J.
Bell, O. A.
Blakiston, J. H.
Bolton, R. P.
Bressey, R. J.
Brodie, N. M.
Brown, C. B.
Brown, R. G.
Bushe, L. A.
Cameron, I.
Carter, A.
Castle, A. F.
Chadwick, A. (decd.).
Charlton, H. E.
Chrisman, A. E.
Clement, L.
Clifford, G.
Cohn, T.
Cole, F. A. J.
Connor, W. W.
Cox, A. W.
Coxon, G. H.
Crichton, R.
Cuthill, J.
Dalley, C.
Darley, H. C. H.
Dick, A. E.
Dodds, E.
Downs, W. W.
Dunkley, G. W.
Dunstan, A. E.
Edeleanu, I.
Egloff, G.
Elliman, S.
Evans, E. B.
Everist, G. E.
Fay, E.
Fletcher, H. D.
Garner, F. H.
Gascoigne, G. N.
Godfrey, R.
Greenwood, W. A.
Griffiths, P. M.
Hartley, A. C.
Heath-Eves, H. B.
Henson, F. R. S.
Hirst, W. P.
Hotham, E.
Howard, G.
Jackson, J. S.
Jameson, J.
Jennings, J. C.
Kamen-Kaye, M.
Kenyon, H. F.
Kewley, J.
Knights, J. W.
Kugler, H. G.
Lavington, H. V.
Le Mesurier, L. J.
McCreath, T. T.
Mackilligan, R. S.
Macniven, H.
Masters, J. S. S.
Mayo, H. T.
Moon, C. A.
Nash, A. W.
Owen, A. G.
Owen, R. M. S.
Perks, A. J.
Porter, P. N. D.
Pracey, H. E. F.
Purves, A. R.
Redgrove, E. R.
Reid, H. W.
Richard, A. H.
Richards, G. A.
Robathan, T.
Roger, A.
Ruthven-Murray, A. J.
Sams, C. E. R.
Schlumberger, M.
Scott, G. H.
Smallwood, W.
Southwell, C. A. P.
Spielmann, P. E.
Stevens, L. C.
Strickland, A. F.
Taitt, G. S.
Tullett, G. V.
Tweed, R. R.
Underwood, A. J. V.
Walsh, D. M.
Walter, G.
Watling, R. A.
Westbury, J.
Wood, C. W.
Wood, N. E.
Young, J. H. M.
Oil Industries Club.
Shell Marketing Co., Central Laboratories.

The number of members (101) who supported the Fund during 1940 shows a very gratifying increase over previous years.

The Benevolent Fund Committee has been able to deal promptly with all cases requiring financial assistance which have arisen during the year. Important aid has been given to the widow and children of a former member of the Institute.

FINANCE.

The audited Revenue Account for the year and the Balance Sheet as at 31st December, 1940, are given below. The excess of income over expenditure for the year was £1370 14*s.* 4*d.* This surplus is ascribed to the enforced curtailment of meetings and other activities, a reduction in the *Journal*, and administration economies. It has been considered advisable to create a reserve for war contingencies. Accordingly the sum of £1250 has been transferred from the surplus to a War Contingencies Reserve, leaving a net surplus of £120 14*s.* 4*d.* to be transferred to the Balance Sheet. A donation of £105 has subsequently been made by the Council to the R.A.F. Benevolent Fund.

Compensation from H.M. Office of Works in respect of the requisitioned offices at the Adelphi has been received to the extent of £942 10*s.* This sum has been paid over to the owners of the Adelphi. In addition, a sum of £457 10*s.* has been received from H.M. Office of Works as compensation for requisitioned furniture. This is represented on the Balance Sheet by an investment of £500 in 3% Defence Bonds.

The Council expresses its thanks to the University of Birmingham and the Department of Oil Engineering and Refining for the continuance of office facilities at Birmingham. It is a very fortunate circumstance that close and continuous contact between the President and the executive staff should be possible at the present time.

The Council regrets to report that furniture from the Adelphi, which had been placed in store in London, was completely destroyed by fire in November, 1940, as the result of enemy action.

MEETINGS OF THE INSTITUTE.

Two Ordinary Meetings of the Institute and the Annual General Meeting were held in London during 1940. The Asphaltic Bitumen Group organized two meetings and the Lubrication Group one meeting. A notification of these Group meetings was given to all members in the London and Home Counties area. Particulars of the Papers read are given in the following Table :—

Date, 1940.	Subject.	Authors.
26th Jan.	Presidential Address : "The Development of Petroleum Refining."	A. W. Nash.
14th March.	"Viscosity and Constitution."	A. H. Nissan.
16th May.	Annual General Meeting : "Control of Oil Fires."	A. F. Dabell.
	Asphaltic Bitumen Group.	
16th Jan.	"Bitumen Emulsions in Soil Stabilization."	A. E. Lawrence.
	"Soil Mechanics in Foundation Engineering."	R. L. James.
16th April.	"Manufacture of Roofing Felts."	D. M. Wilson.
	Lubrication Group.	
22nd Feb.	"Testing of Greases."	M. W. Webber.

The programme of Papers arranged for the latter half of the year had to be cancelled owing to the inability of authors to devote the necessary time to the preparation of Papers, all of them being otherwise engaged on work of national importance.

Institute Luncheon.

By courtesy of the Council of the Royal Empire Society a Luncheon was held on 26th January, 1940, at the rooms of the Royal Empire Society. The Institute had the pleasure of welcoming the members of the Permanent Anglo-French Executive Committee for Oil.

The President presided over a gathering of about 180 members and guests. Among those present were the Rt. Hon. Lord Cadman, G.C.M.G., Col. L. Pineau, Sir Cecil Kisch, K.C.I.E., C.B., the Rt. Hon. Sir Ronald Graham, P.C., G.C.B., G.C.M.G., M. J. Filhol, and Sir Andrew Agnew, C.B.E.

Publications.

The Journal.

The monthly publication of Volume 26 of the *Journal* continued throughout 1940 in spite of some scarcity of Papers and the war-time rationing of paper supplies. A comparison with previous years is given in the following Table :—

	Journal of the Institute of Petroleum.		
	1938.	1939.	1940.
Papers published :—			
Read at Institute meetings in England	8	35 *	2
Read at meetings of Branches or Groups	3	5	10
Contributed Papers	33	20	21
	44	60	33
No. of Abstracts published	1469	1406	1621
No. of pages	1253	1304	1133

* Includes Papers of two special conferences.

The Table shows a gratifying increase in the number of Papers previously presented to one of the Branches or Groups of the Institute. In view of the difficulties of obtaining Papers from Great Britain, when so many members are engaged on work of urgent national importance, the Honorary Editor appealed to members in U.S.A., through Dr. G. Egloff, Chairman of the American members' Branch, to forward Papers for publication in the *Journal.* This appeal met with an immediate response, and several Papers have been promised from U.S.A. for publication during 1941.

The Council regards the *Journal* as of the greatest importance at the present time. It is the principal means available for carrying on the work of the Institute, and its publication will be maintained as long as possible.

All publications of the Institute are voluntarily submitted to and approved by the Ministry of Information, Trade and Technical Press Censorship Division, before they are issued. This arrangement has worked satisfactorily and expeditiously.

Despatch of the *Journal* to certain countries is made under the Defence

Regulations through the Postal Censorship. There are consequent delays in the receipt of the *Journal* by members abroad, but these are unavoidable. In cases where members' copies of the *Journal* have been lost in transmission by enemy action, the Institute will endeavour to replace these free of charge.

Petroleum Technology, Vol. V.

It was also possible to publish in September 1940 Volume V in the series of annual reviews of petroleum technology. This volume was as comprehensive as its predecessors. The Council records its appreciation of the collaboration of many scientists in the United States, without whose assistance such a complete survey of developments would not have been possible in present circumstances.

List of Members.

A re-issue of the List of Members (last published in 1936) was in preparation at the end of 1939, but has had to be postponed. Owing to frequent changes in address and the uncertainty of the whereabouts of many members, it is not considered advisable to re-issue the List of Members at present.

CHEMICAL STANDARDIZATION.

The following is a short account of the work of the Sub-Committees and Panels of the Chemical Standardization Committee which were active during 1940.

Kerosine. (Chairman : J. S. Jackson, Shell Marketing Co., Ltd.) A revised Burning Test for kerosine, K 35(T) 1940, was published in February 1940 (*J. Inst. Pet.*, **26**, 91–95). The revision extended the experimental details given in the Tentative Method of 1935 ("Standard Methods for Testing Petroleum," 3rd ed.), and included a closer specification for the wick, burner, and chimney.

Gum in Gasoline. (Chairman : W. H. Hoffert, National Benzole Co.) Investigations have been carried out by members of the panel with different bomb tests to determine the stability of gasoline. The object of these investigations is to make a recommendation as to the adoption or otherwise of the A.S.T.M. bomb test (D 525–40 T). This work is still in progress.

Knock-Rating of Aviation Fuels. (Chairman : W. L. Tweedie, Air Ministry.) Two meetings of the main committee and numerous meetings of its sub-committee were held during 1940. In April the Institute took over the correlation scheme for checking knock-ratings inaugurated by the Asiatic Petroleum Company. This scheme is now operated by the sub-committee.

Calibration curves for leaded secondary reference fuels C 12 and F 3 have been prepared. Calibration curves are also prepared for all new reference fuels as they become available in England, when such curves are not supplied from U.S.A. A tentative method for the knock-rating of experimental aviation fuels has been prepared and has also been published in the *Journal* (May 1941, **27**, 211, pp. 191–194).

There is a regular exchange of Minutes and Reports between this Committee and the C.F.R. Committee of America. Membership of the Institute's Knock-Rating of Aviation Fuels Committee includes representatives of the Air Ministry, the Ministry of Aircraft Production, aero-engine manufacturers, and the petroleum companies supplying aviation fuels.

Grease (Chairman : E. A. Evans, C. C. Wakefield & Co., Ltd.) The Grease panel has had before it the task of considering the whole question of the standardization of methods of testing greases. Members of the panel have carried out work on melting point tests, water estimation, and consistency. The panel hopes to be able to make some definite recommendations in the near future.

Measurement of Oil in Bulk. (Chairman : J. Kewley.) Work has been carried out on the preparation of tables of coefficients of expansion and gravity correction factors. In September 1939 this Committee was collaborating with the A.S.T.M. Committee on Sampling and Gauging, with the object of preparing a joint publication on the measurement of oil. This aspect of the Committee's work is temporarily suspended.

Asphaltic Bitumen and Cut-backs. (Chairman : P. E. Spielmann.) These two sub-committees have revised the I.P.T. Test C.B. 3 for the distillation of cut-back asphaltic bitumens. The revision is concerned with the procedure adopted at the termination of the distillation and during the pouring of the residue. The revised method is published in this *Journal* (pp. 226–229).

The secretarial work of all the above sub-committees has been ably carried out by Miss B. M. H. Tripp, and the Council records its appreciation of her valuable assistance.

AWARDS.

Two scholarships of £40 each, tenable by Students of the Institute at the Universities of London and Birmingham for the year 1940–41, were awarded to G. J. Clarke (Royal School of Mines) and A. H. Baldwin (Department of Oil Engineering and Refining, Birmingham University) respectively.

T. Y. Ju, Stud.Inst.Pet. (Birmingham University), was awarded the Students Medal and Prize for an essay on " The Behaviour of Fuels in C.I. Engines." A special prize was also awarded to D. G. Brunner, Stud.Inst.Pet. (Birmingham University), for an essay on " Mud Fluids for Drilling."

B. A. Murphy (Melbourne) and P. G. Owen (Birmingham) were highly commended for their essays.

No award of the Redwood Medal or the Burgess Prize was made in 1940.

BRANCHES AND GROUPS.

Stanlow Branch. A new Branch of the Institute was inaugurated on 13th March, 1940, at Stanlow, Cheshire. Mr. J. S. Parker was elected Chairman and Mr. J. C. Wood-Mallock Honorary Secretary. Addresses were given to the Branch by Dr. A. E. Dunstan (May 1940) and Prof.

A. W. Nash (January 1941). A regular monthly meeting has been held since October 1940.

Northern Branch. The ordinary meetings of the Northern Branch were suspended during 1940. A Luncheon Meeting was held in Manchester on 25th January, and was addressed by Prof. A. W. Nash on " Aviation Fuels and Lubricants." Mr. J. Cuthill has been elected Chairman of this Branch and Mr. E. J. Dunstan, Honorary Secretary.

U.S.A. Branch. The sixth annual meeting of members of the Institute in U.S.A. was held at the Stevens Hotel, Chicago, on 13th November, 1940. Addresses were given by Mr. T. A. Boyd and Dr. G. Egloff.

Scottish and S. Wales Branches. The meetings of the Scottish and S. Wales Branches were suspended during 1940.

Trinidad Branch. The annual report of the Trinidad Branch is printed on pp. 247.

Asphaltic Bitumen Group. Two meetings of the Asphaltic Bitumen Group were held in London during 1940. Particulars of the papers read are given above in the paragraph " Meetings of the Institute."

RESEARCH.

A grant of £15 was made to the British Electrical and Allied Industries Research Association in aid of investigations on the creep and corrosion of steels at high temperatures.

COUNCIL AND OFFICERS.

Professor A. W. Nash, M.Sc., M.I.Mech.E., was re-elected President of the Institute at the Annual General Meeting on 16th May, 1940. Professor Nash has also been nominated by the Council for a third term of office as President for the year 1941–42.

Mr. Ashley Carter, Mr. C. Dalley, Dr. F. H. Garner, Mr. J. McConnell Sanders, and Dr. F. B. Thole have been nominated Vice-Presidents for the year 1941–42.

The following were elected members of Council at the Annual General Meeting on 16th May, 1940: Mr. E. A. Evans, Mr. W. E. Gooday, Mr. J. A. Oriel, Mr. C. A. P. Southwell, Mr. A. Beeby Thompson, and Mr. C. W. Wood.

Five meetings of the Council and fifteen meetings of Committees of Council were held in London during 1940. At the May Council Meeting the number of committees of the Council was reduced to six, viz :—

Chemical Standardization .	Chairman :	Dr. F. H. Garner.
Election	,, :	Mr. J. McConnell Sanders.
Engineering Standardization .	,, :	Mr. A. C. Hartley.
Finance	,, :	Mr. C. Dalley.
Publication . . .	,, :	Dr. A. E. Dunstan.
Benevolent Fund . .	,, :	Dr. A. E. Dunstan.

Business previously dealt with by the Awards, Branch, House, Library, and Research Committees is now dealt with directly by the Council.

ACKNOWLEDGMENTS.

The Council records its appreciation of the services to the Institute of the Rt. Hon. Lord Plender, G.B.E., Honorary Treasurer; Messrs. Price Waterhouse & Co., Auditors; Messrs. Ashurst, Morris, Crisp & Co., Solicitors; and the members of the Staff.

The Council also desires to thank the Council of the Institution of Chemical Engineers for permission to hold Council and Committee Meetings at 56 Victoria Street; the Councils of the Institution of Mechanical Engineers and the Royal Society of Arts for the use of their lecture halls; and the Midland Bank Ltd., Selly Oak, Birmingham, for banking facilities.

Approved for publication on behalf of the Council of the Institute.

ALFRED W. NASH, President.
ARTHUR W. EASTLAKE, Honorary Secretary.
S. J. ASTBURY, Secretary.

21*st April*, 1941.

THE INSTITUTE OF PETROLEUM

BALANCE SHEET AND ACCOUNTS FOR THE YEAR ENDING 31st DECEMBER, 1940

THE INSTITUTE

REVENUE ACCOUNT FOR THE

	£	s.	d.	£	s.	d.	1939 £
To Administrative Expenses :—							
Staff Salaries	1514	17	5				*1686*
Printing and Stationery	182	6	2				*294*
General Postages	165	5	0				*203*
Telephone, Cables and Telegrams	6	0	0				*20*
				1868	8	7	
,, Establishment Charges :—							
Rent, Rates, etc.	530	5	11				*809*
Cleaning and Lighting	33	2	2				*17*
Repairs and Renewals	6	12	6				*141*
				570	0	7	
,, Publications :—							
Journal Expenses	1416	8	11				*1635*
Abstractors' Fees	246	1	7				*221*
Postage on Journals	189	17	8				*217*
Cost of other Publications	453	19	7				*485*
				2306	7	9	
,, Meetings :—							
Hire of Hall, Preprints, Reporting	118	19	4				*283*
Birmingham Meeting Expenses		—					*125*
				118	19	4	
,, Professional Fees :—							
Legal Expenses	50	0	0				*37*
Auditors' Fee	42	0	0				*42*
				92	0	0	
,, Students' Scholarships and Prizes				88	14	5	*88*
,, Library Expenditure				45	0	7	*40*
,, Branches and Sections :—							
Students' Section	10	0	0				*18*
Trinidad Branch	40	0	0				*40*
Northern Branch	5	0	0				*35*
Scottish Branch		—					*5*
South Wales Branch		—					*10*
Roumanian Branch		—					*3*
Branch Lectures		—					*49*
				55	0	0	
,, Sundry Expenses				149	10	7	*184*
,, Depreciation of Office and Library Furniture				149	0	0	*50*
,, Removal and other Expenses re requisitioning of the Adelphi					—		*36*
,, Transfer to War Contingencies Reserve				1250	0	0	—
,, Balance, being Surplus for year, carried to Balance Sheet				120	14	4	*155*
				£6813	16	2	*£7123*

RESEARCH FUND INCOME AND EXPENDITURE

	£	s.	d.
To Grant Made During Year :—			
British Electrical and Allied Industries Research Association	15	0	0
,, Balance as at 31st December, 1940	142	16	1
	£157	16	1

OF PETROLEUM
YEAR ENDED 31 DECEMBER, 1940

	£	s.	d.	£	s.	d.	1939 £
By Subscriptions for 1940 received				3583	9	1	*3894*
,, Special Subscription				20	0	0	*20*
,, Subscriptions in Arrear received during Year				72	8	6	*94*
,, Publications				2400	3	2	*2891*
,, Interest and Dividends (Gross)				237	15	5	*224*
,, Grant in aid of Rent				500	0	0	—
,, Compensation Received from H.M. Office of Works	942	10	0				
Less Paid to the Adelphi	942	10	0		—		—
				£6813	16	2	*£7123*

ACCOUNT FOR THE YEAR ENDED 31ST DECEMBER, 1940.

	£	s.	d.
By Balance as at 31st December, 1939	147	14	4
,, Interest Received During Year	10	1	9
	£157	16	1

THE INSTITUTE

(A Company limited by Guarantee

BALANCE SHEET AS

				£	s.	d.	£	s.	d
Capital of the Institute under Bye-Law, Section 6, Paragraphs 14 and 15 :—									
Life Membership Fund,	£	s.	d.						
As at 31st December, 1939	811	7	0						
Additions during year	6	7	0						
				817	14	0			
Entrance and Transfer Fees—									
As at 31st December, 1939	3538	2	9						
Additions during year—									
Entrance fees	97	3	0						
Transfer fees	7	7	0						
				3642	12	9			
Profit on Sale of Investments—									
As at 31st December, 1939				351	10	11			
Donations—									
As at 31st December, 1939				326	5	0			
							5138	2	8
Research Fund							142	16	1
T. C. G. Burgess Prize Fund							10	0	0
War Contingencies Reserve							1250	0	0
Members' Subscriptions received in advance							78	19	0
Journal Subscriptions received in advance							148	13	3
Sundry Creditors—General Account							436	18	1
World Petroleum Congress							212	15	3
Revenue Account :—									
Balance as at 31st December, 1939				1946	4	9			
Add Surplus for year as per separate statement				120	14	4			
Add Compensation received from H.M. Office of Works for Furniture Requisitioned				457	10	0			
							2524	9	1
							£9942	13	5

ALFRED W. NASH, President.
C. DALLEY, Chairman, Finance Committee.

AUDITORS'

We report to the Members of THE INSTITUTE OF PETROLEUM that we have obtained all the information and explanations we have required. We are of the correct view of the state of the Institute's affairs as at 31st December, 1940, according the books of the Institute.

3, FREDERICK'S PLACE,
OLD JEWRY, LONDON, E.C.2.
7th April, 1941.

OF PETROLEUM.

and not having a Share Capital.)

AT 31ST DECEMBER, 1940.

	£	s.	d.	£	s.	d.
Investments :—						
On Account of Capital, at cost—						
£461 12 0 3% Conversion Stock (1948/53)	491	12	6			
664 6 6 3% London County Consolidated Stock, 1920	481	10	6			
806 8 3 3% Manchester Corporation Redeemable Consolidated Stock, 1958	845	17	7			
867 8 6 2¾% Bristol Corporation Redeemable Stock, 1955/65	845	17	7			
150 0 0 5% Wandsworth and District Gas Co. Debenture Stock	154	8	6			
400 0 0 3% Metropolitan Water Board "A" Stock, 1963	346	10	7			
125 0 0 5% Great Western Railway Co. Consolidated Preference Stock	105	4	9			
150 0 0 3% Luton Corporation Redeemable Stock, 1958	151	6	7			
150 0 0 3% Smethwick Corporation Redeemable Stock, 1956/58	151	4	9			
600 0 0 3% Bristol Corporation Redeemable Stock, 1958/63	597	7	3			
	4171	0	7			
(Market Value at 31st December, 1940, £4,047 16*s*. 4*d*.)						
Cash awaiting Investment on Deposit with Post Office Savings Bank	967	2	1			
				5138	2	8
On Account of Revenue, at cost—						
£790 8 3 3% Conversion Stock	842	8	0			
£500 0 0 3% Defence Bonds	500	0	0			
	1342	8	0			
On Account of Research Fund, at cost—						
£336 5 10 3% Conversion Stock	357	14	8			
				1700	2	8
(Market Value at 31st December, 1940, £1660 9*s*. 6*d*.)						
Office and Library Furniture (excluding Presentations) :—						
As at 31st December, 1939	150	0	0			
Less Depreciation	149	0	0			
				1	0	0
Library Books (excluding Presentations) :—						
As at 31st December, 1939.					—	
Subscriptions in Arrear :—						
Not valued.					—	
Sundry Debtors, less Reserve for Doubtful Debts				355	0	3
Cash at Bank on Current Account				868	1	7
Cash on Deposit :—						
Post Office Savings Bank	1667	11	0			
World Petroleum Congress Account	212	15	3	1880	6	3
				£9942	13	5

REPORT.

examined the above Balance Sheet with the books of the Institute and have opinion that such Balance Sheet is properly drawn up so as to exhibit a true and to the best of our information and the explanations given to us, and as shown by

PRICE, WATERHOUSE & Co.

BENEVOLENT FUND.

RECEIPTS AND PAYMENTS ACCOUNT FOR YEAR ENDED 31ST DECEMBER, 1940.

RECEIPTS.

	£	s.	d.	£	s.	d.
Balance on Current and Deposit Accounts on 1st January, 1940 :—						
Benevolent Fund Account . . .				763	2	0
Receipts during 1940 :—						
Subscriptions	45	19	6			
Donations	55	6	6			
Interest	12	8	8			
Income Tax recovered	7	7	0			
				121	1	8
				£884	3	8

PAYMENTS.

	£	s.	d.
Benevolent Fund :—			
Grants in aid	68	18	6
Balance on 31st December, 1940 :—			
Benevolent Fund	815	5	2*
	£884	3	8

* The Balance on Current Account and invested on 31st December, 1940, was made up as follows :—

	£	s.	d.
Cash on Current Account	86	8	2
3% Local Loans at cost	528	17	0
3% Defence Bonds	200	0	0
	£815	5	2

A. E. DUNSTAN, Chairman, Benevolent
Fund Committee.
ALFRED W. NASH, President.

We have examined the above Receipts and Payments Account with the books and vouchers of the Fund and find it to be in accordance therewith. We have verified the Investments and Balances with Bankers comprising the Balance on 31st December, 1940: £815 5 2.

3, FREDERICK'S PLACE,
OLD JEWRY, LONDON, E.C.2.
7th April, 1941.

PRICE, WATERHOUSE & CO.

TRINIDAD BRANCH.

REPORT OF THE COMMITTEE ON THE WORKING OF THE BRANCH DURING THE SESSION 1939–1940.

Four meetings were held during the session, at which the following papers were read :—

January 10th, 1940.	12th Annual General Meeting : "Some Aspects of Industrial Relations," by R. Gavin.
February 28th, 1940.	61st General Meeting : "Errors in Acid Bottle Readings," by G. H. Scott. "Evaluation of Rotary Drilling Lines," by H. C. H. Darley.
May 1st, 1940.	62nd General Meeting : "Control of Drilling Mud in the Field," by H. C. H. Darley.
June 26th, 1940.	63rd General Meeting : "The Effects of Crooked Hole on Exploitation," by H. C. H. Thomas.

The average attendance of members and guests at meetings was 25.

There were 73 members on the roll at the end of the year.

Mr. L. A. Bushe was elected Chairman.

Mr. A. F. Castle was deputed to act for Mr. C. C. Wilson, who had been elected Hon. Secretary and Treasurer, and who was incapacitated by illness.

The Annual Dinner was not held on account of the war.

The Accounts for the year ended 31st October, 1940, are printed on the following page.

Signed A. F. Castle, *Hon. Secretary.*
,, L. A. Bushe, *Chairman.*

20*th January*, 1941.

THIRTEENTH ANNUAL GENERAL MEETING OF TRINIDAD BRANCH.

29th January, 1941.

The thirteenth Annual General Meeting of the Trinidad Branch was held at the Apex Clubhouse on 29th January, 1941. Mr. L. A. Bushe occupied the Chair.

On the proposition of Mr. A. H. Richard, seconded by Mr. J. D. Fullerton, the Committee's Report on the year's working of the Branch, together with the Accounts for the Session ended 31st October, 1940, were unanimously adopted.

The Chairman observed that contributions from the Trinidad Branch to the Benevolent Fund of the Institute totalled $140.80 in two years 1939 and 1940. This was the equivalent of $1.00 per head of the members in Trinidad, as compared with 8*d*. per head over the whole membership of the Institute. It seemed likely that the Branch would be sending $70 to $80 per annum.

The accounts were very satisfactory, although the surplus was partly due to the fact that the usual Annual Dinner had not been held.

As a result of a ballot, the following were elected officers and members of Committee for the ensuing Session ; Messrs. L. A. Bushe (Chairman),

A. F. Castle (Hon. Secretary), H. W. Reid, G. S. Taitt, H. C. H. Thomas, F. H. L. Tindall and C. Wilson.

A vote of thanks was unanimously accorded to the auditors, Messrs. H. A. Harris and F. E. Hunter.

At the conclusion of the Annual General Meeting Mr. G. Stewart Taitt read a Paper on " A Note on the Sealing Effect of Fault Surfaces."

TRINIDAD BRANCH.

BALANCE SHEET AS AT 31ST OCTOBER, 1940.

LIABILITIES.			ASSETS.	
Subscriptions to Benevolent Fund to be remitted to London		$140.80	Cash at Bank	$577.67
Income and Expenditure Account :			Cash in Hand	3.05
As at 31st October, 1939	$295.61			
Excess Income over Expenditure for year ended 31st October, 1940	144.31			
As at 31st October, 1940		439.92		
		$580.72		$580.72

INCOME AND EXPENDITURE FOR YEAR ENDED 31ST OCTOBER, 1940.

EXPENDITURE.			INCOME.	
Stationery, Printing and Postage	$28.62		Grants from Institute of Petroleum, London	$192.00
Clerical Assistance	18.08			
Telephone	.99			
		$47.69		
Excess Income over Expenditure		144.31		
		$192.00		$192.00

(*Signed*) L. A. BUSHE,
Chairman.

A. F. CASTLE,
Hon. Secretary and Treasurer.

F. E. HUNTER
H. A. HARRIS } *Auditors.*

ANNUAL GENERAL MEETING.

1st May, 1941.

The Twenty-Eighth Annual General Meeting of the Institute was held at the Connaught Rooms, London, W.C. 2, on Thursday, 1st May, 1941, at 3.30 p.m. The Chair was taken by the President, Professor A. W. Nash.

The Secretary (Mr. S. J. Astbury) read the Reports of the Auditors.

The Minutes of the Twenty-Seventh Annual General Meeting were read, confirmed and signed.

NEW MEMBERS.

It was agreed that the list of Fellows, Members, Associate Members, and Students elected and transferred during 1940 should be laid on the table.

ELECTION OF MEMBERS OF COUNCIL.

The Secretary announced that, in accordance with the Articles of the Institute, the following members of Council retired at the Annual General Meeting but offered themselves for re-election : Messrs. A. F. Dabell, V. C. Illing, E. R. Redgrove, and W. J. Wilson. One new nomination had been received, on behalf of Mr. Robert Crichton, J.P., General Manager, Scottish Oils, Ltd. The Council decided that, in view of the present circumstances, a postal ballot should not be held, and the names of the above five candidates were therefore submitted to the Meeting to fill five vacancies on the Council.

On the motion of the President, the names of these five candidates were put to the Meeting and unanimously elected Members of Council.

The President then moved :—

> "That the Annual Report of the Council for the year 1940, together with the Accounts and Balance Sheet as at 31st December, 1940, be and are hereby adopted."

In doing so, he said that the Report had been circulated to all the members, and he would therefore be glad if, for the purpose of the meeting, it might be taken as read. (*Agreed.*)

The work of the Institute had naturally been considerably handicapped during the past year. They had not been able to enjoy their usual programme of meetings for several reasons—shortage of papers, difficulties of travelling, the black-out, and air raids. The work of the technical committees dealing with the standardization of methods of test had also been slowed down. Some of the members of these committees had had to transfer their attention to work of more immediate national importance.

The *Journal* had continued throughout the year, although its pages were somewhat fewer than usual. This was due to a shortage of papers. The Honorary Editor, Dr. Dunstan, had appealed to their American colleagues for support, and Dr. Egloff and others had immediately responded with offers of papers, one of which was presented to a meeting of the Institute in March. There were signs, however, that this source of contribution would soon become dried up. The Americans, like ourselves, were becoming more and more engrossed in the tasks of national defence. Only the other day a cable was received from Dr. Mackenzie regretting his inability and that of his colleagues in the Texas Company to write their usual article for the Annual Reviews.

The Council had decided, however, to turn the normal winter session into a summer session as far as circumstances and papers would permit, and monthly meetings would be held in London up to September. They would be sorry to hear that the Royal Society of Arts, where these meetings would have been held, had suffered badly in a recent raid. Their sympathies would go out to that old-established Society, which had been a good host to the Institute on so many occasions. It was second only to the Royal Society in date of foundation. The glass in some of the windows of the building in John Adam Street, recently devastated by German bombs, had been in position since 1780. The same raid caused some damage to the Institute's old offices at the Adelphi, but he was pleased to say that the library had so far escaped intact.

Members would welcome the formation during 1940 of a new branch of the Institute at Stanlow. This Branch was in a very flourishing condition under the chairmanship of Mr. J. S. Parker, and with the collaboration of Mr. Oriel, a member of Council, had had an active session.

In conclusion he wished to thank his colleagues on the Council for their whole-hearted support during his second year of office as President. They had honoured him by asking him to take office for a third year, and he had accepted the invitation, although the Bye-laws and normal practice required him to relinquish his office at the end of the second. But he would be very glad to do what he could for the members and the Institute for a further term. The war period was inevitably a period of marking time. They had to defer their schemes for the development of the Institute and to maintain as good a service as possible for their members through the *Journal* and such meetings as they could arrange. (*Applause.*)

Mr. **Ashley Carter** (Deputy-Chairman, Finance Committee) seconded the adoption of the Annual Report and Accounts. Mr. Carter regretted the unavoidable absence of Mr. Christopher Dalley, Chairman of the Finance Committee, and referred to the remarks which Mr. Dalley would have made if he had been able to be present. Mr. Dalley's observations on the Annual Accounts are given below :—

"Members would see from the printed statements of accounts that there was a surplus of income over expenditure in 1940 of £1370. To a great extent economies had been forced upon them, by a reduction in the number of meetings, in the size of the *Journal* and the numbers printed month by month. The Finance Committee and Council had thought it prudent to transfer £1250 of this surplus to a War Contingencies Reserve, and he was sure every member would agree that this was a wise precaution at the present time. They could not foresee what reduction in income would take place in the next few years. The Council had decided to adopt a policy of conserving the resources of the Institute, so that they could maintain the *Journal* and essential activities as long as possible.

"The *Journal* was bringing in to the country a small but appreciable amount of dollar exchange. It was estimated that £2500 of the total income during 1940 was remitted from dollar countries. Such remittances would ultimately find their way back to the United States, via the Treasury, to be spent on essential armaments.

"Members would note from the Balance Sheet that all their assets were in a liquid form, either existing as investments, as cash in the Post Office Savings Bank or as cash on current account. During the year £500 had been invested in 3 per cent. Defence Bonds. A further £500 had been invested in the previous week. Members could rest assured that cash surplus to immediate requirements would be lent to H.M. Government as early as it became available.

"On the question of the Adelphi, the position was fully explained by the entries on the Revenue Account. Whatever compensation they had received from H.M. Office of Works had been immediately paid over to the owners of the Adelphi building. The Council had repeatedly affirmed that it had no desire to make any profit out of compensation received for the requisitioning of its offices. With the full approval of the Institute's solicitors it had agreed to pass over whatever monies it received by way of compensation."

The motion to adopt the Annual Report and Accounts was carried unanimously.

In reply to a question by a member, the Secretary stated that periodicals formerly received at the Adelphi, except those from European countries, were still being received and bound. The bound volumes for 1939 and 1940 were at Birmingham, and available on loan to members. As regards new books, there were not so many published nowadays. Such new books as related to petroleum and allied subjects were either received for review or obtained by purchase and added to the library. They were noted in the *Journal* either as a " Book Review " or " Book Received," and any book referred to therein could be borrowed through the post by members. Last year about twenty-five or thirty new books (as distinct from pamphlets and periodicals) had been added to the library.

ELECTION OF AUDITORS.

On the proposition of Capt. W. H. **Cadman**, seconded by Mr. J. T. **Ward**, Messrs. Price Waterhouse & Co. were re-elected auditors for the ensuing year.

The proceedings of the Annual General Meeting then terminated, and the President declared the meeting closed.

PRESIDENTIAL ADDRESS.

Following the Annual General Meeting, the President delivered an Address on " Petroleum as a Raw Material " printed on pages 195 to 213 of this issue of the *Journal*.

VOTE OF THANKS TO THE PRESIDENT.

Mr. J. **Kewley** proposed a hearty vote of thanks to Professor Nash. He said that it was typical of Professor Nash that he had chosen to deal with the most modern developments in the petroleum industry. The members present had had two good meals that afternoon—one physical and the other intellectual. This second one, in the shape of the Address, was perhaps somewhat difficult of digestion. But the President had only given them a *résumé* of his Address, and had left them to complete the digestive process at their leisure.

During past years, at the University of Birmingham, Professor Nash had carried out some pioneering work, and his Address itself was significant as a spear-point of petroleum development. The proposer's function was simply to say grace after this intellectual meal, and to ask the members to thank Professor Nash for his excellent Address.

Mr. T. **Dewhurst** seconded the vote of thanks, and said that, apart from the Address, which had a special value, they were deeply indebted to the President for his control of the interests of the Institute in these very troublous times, and for presiding for an exceptionally long and difficult period. Those who were on the Council had special opportunities of appreciating the application and wisdom which he devoted to the affairs of the Institute.

The vote of thanks was put to the meeting by the Seconder and carried with applause, and the President briefly acknowledged the compliment.

The meeting then terminated.

OBITUARY.

WILLIAM HENRY HOWE.

By the death of William Henry Howe, the lubricating oil trade in general and the smaller distributors in particular have lost a very good friend—a friend who during the past twenty years devoted a great deal of time and energy to a determined effort to bring about a spirit of trust and understanding between all firms engaged in the lubricating-oil trade.

Mr. Howe was a happy combination of commercial and technical ability, and realized that the user of lubricants is entitled to expect advice on the selection and application of the product on which depends the efficiency of his machinery. Feeling that he himself could not know too much about his subject, Mr. Howe joined the Institute as an Associate Member in 1928, and was elected a Fellow under the revised constitution in 1939. He regularly attended the Institute meetings and kept in close touch with American progress. The National Lubricating Oil & Grease Federation owe a great deal to his staunch support, and he twice filled the office of President (1928–9 and 1931–2)

All those who had the privilege of knowing him will greatly miss his cheerful personality and will deeply regret his passing.

E. R. Redgrove.

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.

530.* South Texas Still an Oil-producer of the Future. E. S. Post. *Oil Wkly*, 10.3.41, **101** (1), 33. The sixty counties of South-west Texas have been yielding new fields and new sands at the rate of 100 per year, and much development took place in 1940. On 1st January the unproduced but developed reserves stood at 1,458,515,899 brl., with production from 338 separate oil and distillate fields. This amounts to 7·8% of the U.S. reserve. Attempts have been made to assess deep possibilities, and on 1st March the chief play was on the Wilcox trend. Six fields have been found and dozens of geophysical prospects shot, and it is a case of deep exploration on an established trend, for previously most tests here stopped at the Yegua. The new work has led to exploration of the Cook Mt., Mt. Selman, and Carrizo levels, as well as the projected Wilcox, and sands have been opened in these zones. There has been exploration down to latest Ordovician, and virtually every zone has given production, leading to high hopes for deep development generally.

South Texas represents about a quarter of the Texas activity. A table shows that in the 5-year period to 1st January, 1941, South Texas reserves had improved from 2·6 to 7·8% of the U.S. reserves, and Texas reserves from 42·2 to 53·1%. 22·88% of all discoveries in U.S. in the above period were in South Texas. In 1940 Wilcox production was found in La Salle, Colorado, De Witt, and Live Oak counties, and in 1941 in Lavaca and Colorado counties ; Mt. Selman production was found in Bee county.

Tables give the number of wells drilled, the footage and average depth, for U.S., Texas, South Texas and the Corpus Christi, Laredo and San Antonio districts of South Texas, for the years 1935–1940 inclusive. The reserves for South Texas are given for the Miocene–Oligocene, Jackson–Yegua–Cook Mt., Mt. Selman–Wilcox, Serpentine–Dale lime, Navarro–Taylor, Austin Chalk–Edwards, Glenrose–Ordovician for 1st January, 1935, 1st January, 1939, and 1st January, 1941, with the developed acres, expected yield/acre, estimated ultimate yield, cumulative recovery, remaining reserve, and the percentage of the South Texas reserves. G. D. H.

531.* South-west Texas Development, Production, and Reserve Data. Anon. *Oil Wkly*, 10.3.41, **101** (1), 36.—The data, given by counties and fields, include the following: discovery date, range of producing depths, producing formations, amount of acreage proved for oil and gas and that developed in oil, number of producing wells (those flowing and on artificial lift), daily output allowed, the cumulative production in barrels for the field and per acre, the 1940 production, estimated ultimate production for the field and per acre, the remaining reserve, greatest depth and the formation reached, the range of gravity, and the number of rigs running.

A map shows the locations of the 1940 discoveries—new fields, new sands, and extensions. G. D. H.

532.* Detailed Exploration Finds New Fields in Oklahoma. F. Taylor, *Oil Wkly*, 17.3.41, **101** (2), 26.—Early last year exploratory work was undertaken in Creek, West Okmulgee, North Hughes, East Seminole, and Okfuskee counties, and seventeen new fields have been found, despite the fact that the areas had been previously explored by the drill. Other areas in Oklahoma appear to merit re-examination.

The logs of old wells are being examined and their indications tested by the reflection seismograph, using twelve geophone locations between shot-points ¼ mile apart, a method which has given a high percentage of discoveries in Central Oklahoma in the past few years. The Viola lime and the Wapanucka–Cromwell zone are probably the most generally used reflecting horizons.

The entire province throughout this part of Oklahoma is a monocline rising to the east and north, but interrupted by faults and anticlines and some unconformities and lenses. From the surface down to 5500 ft. the following possible producing horizons occur: Oswego lime, Prue, Calvin, Senora, Earlsboro, Booch and Gilcrease sands, Wapanucka lime, Cromwell and Misener sands, Hunton and Viola limes, Simpson dolomite, and Wilcox sand. Drilling is not very expensive in this region because of the moderate depths and comparatively favourable lithology, but there is a little trouble with high-pressure gas. Gas-injection is being practised at one point.

In Central Oklahoma some 6,704,000 brl. of reserves have been added since 1st January, 1940, by new fields, and 4,286,000 brl. by new horizons and extensions in old fields. 220 wells were completed in 1940. The oil is sulphur-free and paraffin base. There are some distillate fields in the Hunton lime. G. D. H.

533.* Venezuela : Pantepec and Standard have Production at Roble 4. Anon. *Oil Wkly*, 7.4.41, **101** (5), 63.—Roble 4 in the El Roble field has given 40·5° oil at the rate of 1078 brl./day on a ⅜-inch choke from two sands at 9960–9990 ft. and 10,008–10,018 ft. Two upper levels at 9637–9677 ft. and 9735–9745 ft. have given oil at the rate of 1243 brl./day on the same choke. The gas/oil ratio was probably about 3000. Other wells have been located at El Roble.

Rincon Largo 1 on the Santa Ana structure is at 9124 ft., and Mercedes 1 in Guarico is at a depth of 5366 ft. G. D. H.

534.* New Well Indicated South of San Joaquin Area. Anon. *Oil Wkly*, 14.4.41, **101** (6), 59.—Santa Ana 3, 12 km. south-west of the San Joaquin area, has given 33·8-gravity oil at rates of 666, 1236, and 1722 brl./day through ¼-, ⅜-, and ½-in. chokes, respectively, in 4-hour tests. In each case the gas–oil ratio was under 900. The production is from the Periquito sand at 8320–8335 ft.

In Rincon Largo 1, on the Santa Ana structure, perforating at 8695–8985 ft. was unsuccessful, and perforations are to be made higher. Anaco 1 is at 8901 ft., after topping a thin oil sand at 8560 ft. G. D. H.

535.* Venezuela—Two Lower Pay Sections Tested in New Roble Well. Anon. *Oil Gas J.*, 6.3.41, **39** (43), 26.—3 Roble, ¾ ml. east of 1 Roble, has given 1291 brl. of 42° A.P.I. gravity oil through a ¾-in. choke from sands at 9627–9650 ft., and 936 brl. of the same gravity oil from three sands in the interval 9450–9530 ft. Both these pay sections are said to be lower than in the other two producing wells.

The Roble field is in Anzoategui, about 50 ml. north and a little west of Oficina. It gave 3000 brl./day during December and January, and is connected to the Oficina pipe-line. 4 Roble is at 9170 ft. and two other locations have been made.

G. D. H.

536.* Kansas Activity Curve Upward as New Markets Open. R. Ingram. *Oil Gas J.*, 13.3.41. **39** (44), 12.—Exploration in Kansas has followed, with success, the general north-west trend of the Barton Arch (Central Kansas Uplift), and the cross-trends on the flanks. Fields have been found recently on both the north-east and south-west flanks, and the northernmost production at Ray has focussed attention on the Nebraska border region. Ray produces from the Reagan sand. Some wells have been sunk in South-west Nebraska.

Four new fields have been found and extensions made to producing areas since 1st January. The gain in activity has increased prorated wells from 5611 on 1st February, 1940 to 6713 on the same date this year. There was only a slight increase in the number of unprorated wells. Apparently the State's producing capacity has gone up 10–20% in the past year, and a commission has estimated it at 7,097,209 brl. There has been a continuous rise since the low of 148,000 brl./day at the beginning of May 1940. Since the middle of September 1940 it has hovered about 190,000 brl./day, with a peak of 207,000 brl./day at the end of February.

The use of 20-acre spacing is becoming general.

A map shows the geology of the Barton Arch roughly, and gives the sites of the fields. G. D. H.

537.* Leasing in Western Nebraska Developing into Major Play. W. V. Howard. *Oil Gas J.*, 20.3.41, **39** (45), 25.—Between 4,500,000 and 5,000,000 acres have been leased in Western Nebraska during the past months. Commencing in 1935 blocks were leased in Nebraska and the adjacent parts of Kansas, and small pools were opened. In 1940 the Ray pool was discovered in Kansas, Phillips County, and this revived interest. The oil was in a basal sand directly above the granite. Oil was also reported in the granite wash and showings in the Arbuckle. The leasing has been on the eastern and western sides of the Cambridge Arch, a probable continuation of the Barton Arch.

Following the discovery of oil shows in the Topeka series of Thomas County, Kansas, there has been leasing in Rawlins, Sheridan, and Decatur counties. A number of wells have been drilled or are under way, and data are given concerning these. The possible producing horizons are the Arbuckle, Chat, Kansas City-Lansing, etc., which are found bevelled off by erosion on the flanks of the arch, and the basal sandstone over the granite. Only the Upper Pennsylvanian or Permian beds cross the arch. The Morrison and Sundance wedge out on the west flank, and the latter, which produces in Wyoming, is viewed as a possible producer in this region. The Jurassic and Cretaceous beds rest unconformably on the older beds, thus masking the structures, and they themselves are often blanketed by Tertiary and Pleistocene beds. G. D. H.

538.* Hoodville Field Holds Attention of Illinois Operators. H. F. Simons. *Oil Gas J.*, 20.3.41, **39** (45), 34.—The Hoodville pool is now giving 12,000 brl. of oil/day and its production is rising. This pool lies 3 ml. south of McLeansboro. Ninety wells have been completed and twenty-one are drilling. Hoodville is one of a line of fields running south-east from the Salem field. It yields oil from the Benoist and Aux Vases sands. Its discovery well was completed in the McClosky lime at 3189–3200 ft., from which it flowed oil for only a few hours. A Fredonia test at 3154 ft. was similar, but the Benoist gave 353 brl. of oil in 24 hr. from 2947–2978 ft., after acidizing. All other attempts to get McGlosky production in this field have failed.

The Aux Vases sand ranges 3030 ft. to 3050 ft. in depth, and the Benoist 2931–2983 ft. The former sand gives wells averaging 250 brl. of oil/day; the latter gives wells averaging 200 brl./day. The former sand averages 15 ft. in thickness and the latter 18 ft. In some wells both horizons are produced at the same time. The structure may be large, and its eastern and southern limits have probably been partly defined by a number of dry wells. G. D. H.

539.* North Texas Drilling Most Active in State. D. H. Storment. *Oil Gas J.*, 6.3.41, **39** (43), 16.—In North Texas thirty-two new fields or producing horizons in old fields were added last year as a result of widespread exploratory work. The Fort Worth basin was the scene of the main activity, and yielded ten new fields or horizons in the lower Strawn and Bend series, but recently there has been a slackening of work as a result of failures. There are possibilities of widespread Ellenburger lime production in the south-west part of the K.M.A. field. This Ordovician production was discovered in April 1940. The horizon is a little over 4000 ft. deep, and an area of 1000 acres seems to have been proved productive.

The Hull-Silk field has ten horizons from the Canyon to the lower Strawn at 4650 ft. There are six horizons at Fargo down to the Ellenburger at 6717 ft., although, for economic reasons, most attention has been given to the 3250- and 3900-ft. pays. At Walnut Bend Strawn pays have been found at 4100 and 4700 ft., although earlier work was in two deeper Strawn pays and the deep Simpson and Ellenburger limes. Bonita seems to be the best 1940 discovery in the Fort Worth basin. It has twenty-one producers in either the 5200-ft. Bend conglomerate or the 5400-ft. Bend arkosic pay. Ringgold has Bend pays at 5693 and 5789 ft.

Although deep production was the main interest in 1940, the average well-completion depth was only 2650 ft., 350 ft. deeper than in 1939. The low allowables for deep wells and the lack of capital amongst the independent operators will restrict the number of 5000–6000 ft. wells, and the chief attention is still likely to be paid to the shallow sands. The shallow activity is largely confined to the trend of the Muenster arch in Cooke and Montague counties, and the axis of the Electra arch and the Bend flexure. It is mainly near the old fields. New pools, although small, are constantly being added. At Voth twenty wells have been drilled this year to the 1200- and 1600-ft. pays; near

Olney the 870-ft. sand is being sought by twelve rigs, and at Petrolia-Thornberry twenty-five rigs are drilling to the 1050-ft. Thomas pay and the 1250-ft. Gunsight pay.
G. D. H.

540.* Eastern Kentucky Active as Markets Expand. R. Sheldon. *Oil Gas J.*, 10.4.41, **39** (48), 8.—Eastern Kentucky gas-fields are supplying at least 30,000,000,000 cu. ft. of gas per year, and at present seventy-three wells are being drilled for gas in this area. The gas supply in West Virginia is diminishing rapidly, and its Oriskany sands are deeper (4500–5000 ft.) than the gas-bearing Devonian (2500–3000 ft.) of Eastern Kentucky. Gas has been developed in Pike, Martin, Floyd, and Knott counties (Eastern Kentucky), and development is expected in Letcher, Leslie, Bell, Knox, Jackson, and Clay counties.

In 1940 109 gas-wells, five oil-wells, and nine dry holes were completed in Eastern Kentucky. The oil comes from shallow sands, and from 6500 wells only 5500 brl./day are obtained.

Over 500,000 acres have been leased in Eastern Kentucky following the recent successes in deeper horizons in Illinois. Along the Paint Creek uplift are the Laurel, Mine Fork, Win, and Ivyton domes, all features of interest. Next in size comes the Rockcastle uplift. The Corniferous (Dev.), Clinton (Sil.), Trenton, and St. Peter (Ord.) and Knox dolomite are the horizons sought. In Leslie County oil-shows have been found in the Devonian, Silurian and Ordovician (Trenton). In a deep test on the Burke Dome (Elliott county) the St. Peter was at a depth of 3929 ft. Other deep tests are on the Paint Creek uplift near Oil Springs and on the Sinking Creek dome, Laurel County.
G. D. H.

541.* Year Looms as One of Best in History of Gulf Coast. N. Williams and F. L. Singleton. *Oil Gas J.*, 17.4.41, **39** (49), 40–41.—Sixteen new fields have been opened and new sands have been discovered in old fields on the Gulf Coast this year, and altogether this looks like being one of the best years in its history. There is concentrated wildcatting round the flanks of known salt domes, mainly on the Louisiana coast, search for deep-seated salt domes in the delta district of Louisiana, a wildcatting revival on the Wilcox trend and moderately extensive wildcatting round the flanks of the Agua Dulce and Stratton fields of Texas. Three of the year's discoveries were on the Lower Gulf Coast, eight on the Upper Texas Gulf Coast, and five on the Louisiana Gulf Coast. In the flank-drilling campaign distillate production has been found recently on the east flank of the Belle Isle dome. The Louisiana Gulf Coast still leads in deep drilling with 125 wells below 11,000 ft. and nine fields producing below that level. Many of the fifty-five fields discovered in the past three years are still in the early stages of development.

The Upper Texas Gulf Coast fields include Navidad, Maurbro, Vienna, West Garwood, West Hamman, Sabine Pass, Lakeview, and Chenango. They are mainly distillate fields. Five new fields have been opened in the inland bays adjoining the coastline. Many prospects have been leased on this coastal area, and they are expected to be tested soon.

Oil has been found on the flanks of the Agua Dulce–Stratton fields which were classed as gas-distillate structures.

The presence of deeper sands in the basal Frio has been established recently in the Luby field, whilst the discovery of the first commercial production in Willacy county has attracted wide attention to the Rio Grande embayment area. Geophysical work is said to have uncovered several promising prospects in that area.

At the end of March there were 15,220 producing wells in the three districts of the Gulf Coast giving 606,797 brl. of oil/day.
G. D. H.

542.* History of Gulf Coast: 40 Years of Brilliant Achievement. C. A. Warner. *Oil Gas J.*, 17.4.41, **39** (49), 64.—The Gulf Coast area of Texas and Louisiana has given about 9% of the U.S.A. production and its proven reserves are now estimated as 22% of the nation's total. Up to the end of 1940 545,926,000 brl. of oil had come from Louisiana, 1,318,703,000 brl. from the Upper Gulf Coast of Texas, and 269,102,000 brl. from the Lower Gulf Coast of Texas.

The beds dip generally coastwards, the dip increasing with depth due to thickening and the incoming of other beds in that direction. The bulk of the production comes from true salt-dome fields or fields believed to overlie deeply buried salt masses. The rest comes from fold, fault, lens, and wedge-edge fields. Pliocene to Eocene sands and sandy shales give oil at depths from 190 ft. to more than 13,000 ft., twenty-three fields are producing at less than 1000 ft. and thirty-two at over 10,000 ft.

Oil from seeps was used as early as 1543, and there are numerous references to oil and the oil possibilities of this region prior to 1900. Various attempts were made to obtain production before 1900, and these are briefly described. The Spindletop discovery initiated a vigorous campaign of searching for oil on other similar surface features, leading to the finding of Saratoga, Sour Lake, and Jennings. In 1902 the overhang at Anse la Butte was drilled through to give oil beneath 500 ft. of salt. In 1903 Batson and Welsh came in, and in 1904 Big Hill and Kiser Hill. All the fourteen discoveries of the first decade of Gulf Coast production were the direct result of surface indications, and the same is true of the ten discoveries of the second decade. The history of some of these fields is outlined briefly, whilst the surface features are listed for all twenty-four.

Forty-four fields were discovered in the period 1921–1930. Surface geology had not given very satisfactory results, and most prospecting was therefore based on the various surface indications until geophysics entered the picture in 1922. The improved ability to find fields is shown by the discovery of 248 oil-fields in the period 1931–1940.

Amongst the important features of recent years are the increased depth of production, condensate fields, and the introduction of recycling and repressuring. The development of production has been supplemented by the construction of adequate pipe-line facilities and efficient refineries with a throughput capacity of over 1,000,000 brl. of oil/day. G. D. H.

543.* Producing Horizons of Coastal Sector of South Texas. J. C. Poole. *Oil Gas J.*, 17.4.41, **39** (49), 66.—Commercial gas was discovered in the coastal sector of South Texas in 1916, but the first oil well was not completed until 1925. The oil is obtained from sands of Oligocene and younger age. As a consequence of the many electrical logs available it is possible to divide the producing horizons into major divisions of sand series and groups which do not coincide with geological time divisions. At the base is the " Refugio sand series," variously named Frio, Vicksburg, Frio. Vicksburg, etc., according to the area. The " Sinton sand group " includes sands referred to as Frio, Upper Frio, and " so-called Frio." It wedges out up-dip, but down-dip there is a great thickness of sand bodies.

The " Greta sand series " was laid down by a transgressing sea. It is non-marine mainly and generally considered as Frio in age. The " Catahoula sand series " is mainly Miocene, but up-dip some of it is Middle Oligocene. It was deposited by a receding sea. The " Oakville sand series " produces gas chiefly and but little oil. It is of Miocene–Pliocene age.

A table lists the important fields producing from the Oligocene or younger beds in this area and the various sand series or groups which give oil in them, whilst the five main sand series are shown on a cross-section embodying electrical logs. A map is included. G. H. D.

544.* Bright Future in Prospect for Louisiana Development. J. Hunor. *Oil Gas J.*, 17.4.41, **39** (49), 69.—Louisiana's oil production began in 1902 at Jennings, and to the end of 1940 it had amounted to 1,065,173,731 brl., with 103,065,698 brl. in 1940, placing it as sixth State for that year. On 1st July, 1940, the reserves were estimated at 1,210,895,921 brl., a rise of 425,183,788 brl. in six months. Twenty-one new fields were found in 1940.

Most of Louisiana's fields have a number of separate and distinct reservoirs. Thus Golden Meadow gives oil from nineteen sands. Many areas will be developed when accessibility is improved—*e.g.* the Atchafayala Basin.

Up to the end of 1940 536,088,575 brl. of oil had been recovered from the Miocene and Pliocene. In general, salt-dome cap-rock production is of relatively minor importance in Louisiana. The Pliocene sediments cover 11,000,000 acres and average 2000 ft. in thickness. Fifteen fields now produce from the Pliocene, the potential reserves of which are large and which has 219 prospects where the geological and structural conditions are such that the expectation of Pliocene production is reasonable. In many instances there is already Miocene production below the Pliocene.

Most of Louisiana's production comes from the Miocene, in which there are now 120 fields. The Miocene is 15,000–18,000 ft. thick. The sands of the Upper Miocene, although numerous and thick, are not persistent. Few fields produce from only one sand. The sands are of high porosity and permeability. 220 sands of the Upper Miocene seem to have possibilities, and there are 209 prospects, some of which now produce from the Pliocene or Lower Miocene.

Thirty-four fields give oil at present from the Lower Miocene, where the sands range from 4 to 100 ft. in thickness and have a high porosity and permeability. There are 177 prospects, many now producing from the Upper Miocene.

The Cockfield, Sparta, and Wilcox reserves were estimated at 165,186,667 brl. on 1st July, 1940. The Cockfield has only three fields, all of which produce from the upper 100 ft., although there are shows in other sands. The Cockfield sands are continental and lenticular at outcrop, but become marine and extensive down-dip. There are 112 prospects.

The Sparta sand has provided only one field and some shows along the Sparta–Wilcox trend, but this may be due to inadequate testing. It resembles the Cockfield and Wilcox. Little interest was shown in the Wilcox until the discovery of the Eola field in 1939, and it has now eight fields. Production comes from at least two zones, and there appear to be deeper shows, whilst fifty-six prospects are known along the trend. Down-dip development has not been extensive, but the various marine stringers now apparent lead to the belief that a number of deeper Wilcox producing zones will be found. G. D. H.

545.* The Eocene Wilcox, with Special Reference to the Upper Gulf Coast of Texas. S. R. Casey. *Oil Gas J.*, 17.4.41, 39 (49), 74.—Many have sought the Wilcox section because it is largely composed of sand, and since the discovery of the Eola field, adding 75,000,000–80,000,000 barrels of oil to the reserves, the Wilcox trend has been "worked" with every available method of subsurface exploration. Before the beginning of 1940 there was Wilcox production in at least six Texas fields and three Louisiana fields. The first in Texas was the Clay Creek salt dome, yielding oil from the Middle and Upper Wilcox, and subsequently Kittrell, Joes Lake, Cleveland, Segno, and Ace added 100,000,000 brl. of recoverable oil to the reserves. In Louisiana Urania was probably the first Wilcox producer, followed by Ville Platte and Eola.

The Wilcox trend overlaps a part of the old "Conroe" or Cockfield trend, which was tested in 1934–1936, and in 1940 the Yegua data were extrapolated to the Wilcox. In the Texas coastal area thirty-five to forty wildcats were drilled, giving the Washburn, Thomaston, Sheridan, Cold Springs, and Lake Creek fields, and Providence City in 1941. Three Wilcox fields, Neal, Olla, and Jena were found in Louisiana.

New fields along the Wilcox trend are opening new types of oil- and gas-traps which have long been known as possibilities. Disconformities, nonconformities, sand anticlines, sand wedging, and strandline sands are being sought by the subsurface geologist.

The high producing qualities of the Wilcox make it an ideal objective for exploration. The trend covers parts of Texas, Louisiana, Mississippi, and Alabama, with oil production ranging from 1800 to over 10,000 ft. in depth. The Wilcox is generally assumed to be of deltaic or near-shore origin. Its sand sections are very irregular and difficult to correlate.

The production control in the new fields seems to include stratigraphic trapping with faulting (Neal, Eola, Joes Lake, Segno, and Sheridan), stratigraphic trapping (Urania, Olla, and Jena), and closure on the down-thrown side of a major fault (Magnolia). In the main the structural relief is small in these Wilcox fields.

A list gives some of the interesting Texas Wilcox wells in 1940, with the depths and dates of completions. G. D. H.

546.* Predict Discovery of Much Oil from Known Domes. C. Hagen. *Oil Gas J.*, 17.4.41, 39 (49), 82.—The period 1901–1923 covered the time from the discovery of oil on a Gulf-Coast salt dome to the introduction of geophysics. The early development depended on the interpretation of oil, gas and water seeps, topographical forms, etc. Drilling alone delineated the salt domes on discovery, and many dry holes were put down in the search for salt domes. However, thirty salt domes were discovered from surface indications. Most of the oil was from Miocene and Pliocene sands, with the first flank production at Vinton in 1911. The drilling and testing methods were not good. Several salt domes discovered during this period have given over 20,000,000 brl. of oil to date—Spindletop, Humble, Batson, Saratoga, Barbers Hill, Hull, Sour Lake, West Columbia, Orange, Goose Creek, Jennings, New Iberia, and Vinton.

The introduction of geophysics in the 1923–1934 period led to the discovery of many salt domes. The reflection seismograph permitted the detailing of the structures, and overhangs were determinable by the refraction method. Flank production came to the fore, well samples were handled more ably, and drilling and production practices were improved. Considerable amounts of Oligocene oil were discovered and some development of Eocene sands took place. Spindletop (deep), Humble (deep), Sugarland, East Hackberry, Lake Barre, Caillou Island, Leeville, and Cameron Meadows were the fields found which are expected to have ultimate recoveries exceeding 20,000,000 brl.

From 1934 to date the vast potentialities of salt domes haye been recognized, and these include stratigraphic traps and the features associated with non-piercement domes. Electrical logging and directional drilling have made salt-dome development less treacherous and less hazardous. Improved drilling and production practices, particularly better control of heaving shale, have made 10,000 ft. holes common.

With the declining rate of discovery of new and less obvious geophysically determinable structures on the Gulf Coast, the exploration and development of known piercement type salt domes will be carried on in future with increased intensity. Refined seismograph profiling on the flanks will provide better knowledge of dips, faults, and structural conditions. Many faults can be traced or found in shallow holes. The prime importance of good well records is already recognized. The residual " highs " between rim synclines will probably be sought, and no doubt much new oil will be obtained from known salt domes. G. D. H.

547.* Maritime Development Certain to Assume More Importance. F. L. Singleton. *Oil Gas J.*, 17.4.41, **39** (49), 96.—Recently a second oil-field in the Gulf of Mexico was discovered offshore from Jefferson county, Texas. For several years marine development has largely been confined to the development of structures in marshlands and inland bays along the Louisiana Gulf Coast. The new field lies nearly 2 ml. offshore and gives Miocene production from 4982 to 4992 ft. at the rate of 5 brl./hr., the oil being of 26·7° gravity. This structure was worked over geophysically, and three wells have been drilled. The other field is 1 ml. offshore from Cameron parish, Louisiana. Drilling is expected to be resumed on a salt dome at McFaddin Beach, offshore from Jefferson County, where there have been several failures, the deepest having been abandoned at 7600 ft. In Galveston Bay are several structures, of which three have proved productive. Cedar Point gives oil from the Frio at 4400 ft. and 5900–6000 ft. On the Red Reef prospect, 6 ml. to the south-east, gas-distillate production was discovered in the basal Frio at 8814–8815 ft., and oil wells have also been completed. The structure is extremely faulted, with a number of producing sands between 8800 and 10,300 ft. The Fisher's Reef prospect, 9 ml. to the north, found oil at 8961–8963 ft. in the Frio, but testing is suspended. Preparations have been made to drill 1½ ml. offshore from the Bay Marchand area, Louisiana, and at points 10 ml. south-east and 8 ml. south of Seadrift. Oil showings were found on the Mud Island prospect in Aransas bay. Gas and a little distillate were found at 7840–7850 ft. in a St. Charles Bay test.

Nine discoveries have been recorded in marine development in the Gulf of Mexico, and they include Caplen, Bird Island, and Baffins Bay, East Flour Bluff, and the Corpus Christi gas-field. G. D. H.

548.* Complete Report of Gulf-Coast Operations by Fields. Anon. *Oil Gas J.*, 17.4.41, **39** (49), 114.—Under the district headings of Laredo, Lower Gulf Coast, Upper Gulf Coast, Western Louisiana Gulf Coast, and Eastern Louisiana Gulf Coast the fields are listed alphabetically with the following information: discovery month and year; number of producing wells at the beginning of February 1941, and daily average production on that date; cumulative production to the end of 1940; number of active operations; producing depth and formation; gravity of oil and pipe-line outlet.

Maps are given of the various districts. G. D. H.

549.* Hawkins Field Valuable Addition to Nation's Reserves. M. T. Halbouty. *World Petrol.*, Feb. 1941, **12** (2), 24.—The Hawkins field lies about 12 ml. west of the Gladewater district of the East Texas field. It was located geophysically, and three producers have now been completed. The closure is about 800 ft., with the upper 100 ft. containing gas and the next 400 ft. oil. Production is from the Woodbine at a depth of 4390–4790 ft., the total thickness of sand in the section aggregating about 145 ft. It appears to be under water drive, and has a bottom-hole pressure of 2026 lb./in^2. The recoverable oil, of 28–29° gravity, is estimated at 750 brl./acre-ft., and the area of the field may be 7500–8000 acres. A spacing of 20 acres per well has been fixed. Sands down to 1400 ft. carry fresh water, whilst the Nacatoch and Blossom sands have salt water.

The reserve at Hawkins is estimated to be 562,500,000 brl., as compared with 5,000,000,000 brl. at East Texas initially. East Texas has a maximum effective sand thickness of over 100 ft., and an area of 150,000 acres, on which 26,000 wells have been drilled.
G. D. H.

550. The New Oil Region between the Volga and the Urals. N. Polutoff. *Oel u. Kohle*, 1940, **36** (13), 113–117; **36** (15), 137–140.—During the past ten years a series of important oilfields has been discovered between the Ural Mts. and the Volga, and so far they have yielded more than 4,000,000 tons of oil. The number of prospective structures exceeds 100, and the discovery of new gas- and oil-fields continues.

The new oil province occupies the eastern edge of the East Russian Depression which lies immediately to the west of the Urals. Geological work there is hampered by the fact that the revision of the old divisions of the Carboniferous and the Permian is not yet completed, and so correlation between various deposits is not always possible. The tectonics of the region are characterized by north to south uplifts, which can be traced from the Vyatka river in the north to the Donets river in the south. Oil-shows in the form of asphalt and asphaltic limestone have long been known.

The most important fields occur in the Bashkirian Republic, the largest producers in the whole of the Volga–Ural oil province being found in the Ishimbaevo area. Production comes from Upper Carboniferous–Lower Permian limestones, which form buried hills the origin of which is attributed by some to reef formation and by others to tectonic forces. Six of these structures have been discovered, five being exploited. Geological conditions suggest that they extend all along the west slopes of the Urals, from Ishimbaevo to Chussovskie Gorodkie, with the exception of the area covered by the Ufa Plateau. Particulars of the various oil-fields and occurrences are given, as well as some details of the developments in the Tuimasy area, some 150 km. west of Ufa.

The oldest field in the Perm district is Chussovskie Gorodkie, 70 km. north-east of Perm. The oil comes from limestones which are similar in age and structure to those in the Ishimbaevo area. Exploration there has been abandoned since 1934. A new field, located on the south-west end of a large structure, the Krasnokamsk-Polasna anticlinale, was discovered in 1934 at Krasnokamsk, 40 km. west of Perm. A number of other fields have been developed on subsidiary structures. To the north of Perm oil-shows have been found in many borings in the Cherdyn and Solikamsk district, the oil at Solikamsk possibly being associated with salt-stocks.

The oil deposits of the Kuibyshev region lie within the area of the Samarskaja Luka, a sharp bend in the Volga between Stavropol, Kuibyshev, and Syzran. The two main pools are at Syzran and Stavropol, and both produce from the Carboniferous. There are other structures in the area related to the same tectonic feature.

In the Chkalowsk region there are occurrences at Buguruslan and Novostepanovka, both of which are being developed and both of which produce from the Permian. The situation of the Buguruslan occurrence, between Tuimasy and Samarskaja Luka, suggests that Carboniferous oil must occur there also.

No exploitable occurrences of oil are yet known in the Tartar Republic, although shows are numerous. This is also true of the Saratov and Kirov regions, but suitable structures have been mapped, and exploratory drilling is being carried out.

Apart from the Ishimbaevo area, where the oil is at shallow depths and the wells very productive, most of the fields produce from 800 to 1200 m. The individual production of the wells is smaller than at Ishimbaevo, but the fields are much more extensive. In deposits of the Buguruslan type considerable quantities of oil are obtained from depths of 200–300 m., and in spite of low production per well, the exploitation of these deposits is profitable.

According to the 5-year plan, the Volga-Ural oil province is to produce 7,000,000 tons in 1942. S. E. C.

Geophysics and Geochemistry.

551. Seismic Investigations at the Geophysical Institute, Göttingen. XXXIX. Derivation of Absorption Coefficients Independent of Frequency from Engine Vibrations. O. Förtsch. *Z. Geophys.*, 1940, **16** (1/2), 57–84.—In previously published work the absorption coefficient has been calculated from the formula for propagation of earth vibrations of sine-wave form, the distances being measured in metres. The coefficients so obtained are strongly influenced by the frequency and velocity of propagation of the vibrations. This influence disappears, however, if one substitutes wave-length as a measure of distance, and the absorption then becomes solely a characteristic of the earth through which the vibration travels. Theoretical considerations and practical work which was carried out around Gottingen are discussed. From an analysis of the measurements made the following additional facts emerge. Machine-made vibrations are plane-propagated. The absorption coefficient is determined not only by the stratum carrying the vibration, but by the whole vibrating subsurface. If the waves are propagated simultaneously in two strata, the same absorption coefficient is valid for both. Earth vibrations which have a frequency close to the natural frequency of the rock are considerably less absorbed than others. S. E. C.

552. Seismic Investigations at the Geophysical Institute, Göttingen. XXXVIII. Investigations of the Elastic Properties of Rock Prisms. W. Regula. *Z. Geophys.*, 1940, **16** (1/2), 40–56.—Prisms of brass, marble, slate, and granite, 20 cms. long and 1 cm. square in cross-section, were cemented to a depth of 4 cms. in the concrete floor of the " Erdbebenhaus " at Gottingen. In order to give these short prisms a reasonable frequency, they were loaded with lead. Both static and dynamic measurements of the moduli were made, and it was found there were considerable variations between the two sets. The main cause of this was stretch, and the influence of stretch and of cross-sectional deformation in prisms of square cross-section were investigated. The results of the measurements are tabulated. The Poisson Constant was calculated from the elasticity and shearing moduli. Hysteresis, both in the case of bending and of torsion, was also investigated. The results show that, if we except the case of torsional hysteresis, even small samples of rock may be treated as isotropic from the point of view of elasticity. S. E. C.

553.* New Advances Broaden Use of Geochemical Prospecting. Anon. *Oil Wkly*, 14.4.41, **101** (6), 34.—Geochemical prospecting is expected to play an important part in future oil and gas discovery, especially in the search for marginally low-relief structures and stratigraphic traps which will be sought more and more as structural prospects are drilled.

There are two broad classes of geochemical manifestations of a petroleum accumulation—near surface effects, and near deposit effects. The former fall in the province of soil analysis and give data regarding the position and areal extent of the accumulation, but no depth data; the latter—geochemical well-log data—give information of the nearness of the accumulation.

The possibility of accumulation can now be estimated for 500–1000 ft. of undrilled sediment beneath the bit, and there are also lateral indications. Well-cuttings are used, taken at 30 ft. intervals. After determining the water content of a small sample, sufficient to give 100 gm. of dry cuttings is extracted. The extracted gases are analysed by a combination of low-pressure, low-temperature fractionation and combustion methods. Three gas fractions are separated: (1) that not condensable at − 190° C. (air, methane, and hydrogen); (2) that boiling between − 190° and − 145° C. (ethane, propane, butane); (3) pentane and higher. Hydrogen seems to have maxima some distance above the oil-sand. The hydrocarbons have maxima at the sands, and non-producing wells have very low hydrocarbon concentrations. The best data are obtained from the less permeable formations rather than the potential reservoir rocks.

Two geochemical logs are given. There seems to be a straight-line relationship between the gravity of the oil and the distance above the deposit at which the first strong indication is encountered.

In soil analysis it is believed that absolutely impervious strata are probably non-existent. Usually hydrogen, methane, ethane, butane, propane, and the heavier saturated hydrocarbons are separated and identified quantitatively, in addition to certain inorganic materials and hydrocarbon polymers. There is debate as to whether the magnitude of the surface geochemical anomaly is a measure of the depth of the oil accumulation. G. D. H.

Drilling.

554.* Choice of Drilling Equipment. V. J. Beissinger. *Oil Wkly*, 24.3.41, **101** (3), 21. *Paper presented before American Petroleum Institute.*—The mechanics and economy of drilling operations are affected by such factors as programme, power, and cost. Fundamentally, cost relationships and effects are truly realistic, and the most advantageous choice of drilling equipment may be substantiated by the cost of its ultimate performance. In order to obtain conclusive regional expression for the most basic cost determinations, the writer suggests the pooling of individual company drilling-experience records. By such co-ordinated effort full information in the light of full perspective could be obtained. While this paper stipulates the nature and importance of the factors which influence the choice of drilling equipment, the relative weight of these criteria must be determined by much more detailed investigations.

By pooling of drilling-performance information, regional as well as local drilling factors could be set up for general industry use, so that the consideration of drilling equipment would be on a basis similar in scope to the design of casing strings and the application of areal production formulæ. Variations in drilling programmes, as well as differences in power-plant and equipment power-consumption economics, could be catalogued on the basis of oil-industry experience to the extent that the choice of drilling equipment would be facilitated by an inspection of correlated reliable facts and figures. Because the cost of drilling equipment is the ultimate measure of its utility value, the most direct approach to the proposition of selection is along some line of comparable standards of value. A measure of useful life in terms analogous to the work performed has been suggested. Until the industry accepts some such standards as indicative factors of use and performance, there will not be a sufficiently common reference base for any practical consideration of useful selection. A. H. N.

555.* Crown and Travelling Block Design Meets Deep Hole Need. E. Sterrett. *Oil Wkly*, 7.4.47. **101** (5), 15–26.—Crown and travelling blocks, rigidly held to fixed overall size by existing derrick conditions, meet deep-drilling demands by using high-tensile materials, ingenious sheave and bearing arrangement, and with stepped-up units to distribute concentrated bearing and running loads over precision-formed areas capable of meeting maximum stresses through long operating life.

The fleet angles formed by reeved lines, as distinct from that of the live line, are more serious from the point of sheave and line wear than the one which continually changes—that between the blocks varying in value, but always forming in the same direction, and affecting in each phase the same short section of the wire line.

Reduction of this transitory fleet angle is secured in modern blocks by holding sheave thickness to a minimum, by ranking them in two decks in the crown block and placing them in tandem rows in the travelling block, and by setting two of the crown-block sheaves with their axes at right angles to the others in the block, thus equipping the two sheaves to serve as cross-over units and permitting the lines to be brought back or set so that the resultant fleet angles are opposed.

Capsizing effect, as well as the fleet angle between corresponding sheaves of the two blocks, are both inherent in the commonly used " spiral " reeving used in either left- or right-hand string-ups when five- or six-sheave blocks are loaded to capacity. Both these load-distribution factors are anticipated and well covered in newer designs by additions to usual safety factors and the provision of greater bearing capacities.

Relatively soft sheaves, with consequent corrugated grooves to amplify rope wear, have been entirely superseded in the heavier types with special alloy steels, susceptible of hardening through heat treatment until the contacting surfaces of sheave and wire rope resist equally the abrading effects of service, wind-borne grit, and tangential chafing due to fleet angle misalignment. Fully heat-treated sheaves, of special alloy steel to develop desired toughness under heating and quenching, fitted to accurately machined and ground bearing races, permit a high-quality groove finish. These sheaves, balanced both statically and dynamically, deliver a service life many times that secured from earlier designs under much lighter load ratings.

Fluid lubrication of sheave bearings in the heavier units has been almost superseded by pressure-gun-grease systems. Each bearing, being self-contained and enclosed with grease retainers, is fed from a separate fitting in the end of the drum or shaft on which the bearings are carried. Where solid pins are employed, these grease-lines are bored within the metal, with laterals at right angles to the bearing sites. On the larger units, where a hollow drum provides adequate support for the bearing races, an end-plate carries the grease nipples, with flexible conduits to the individual bearings. The use of small pipe formerly employed for this purpose, has been practically discontinued, due to its tendency to work apart under vibration, and to divert needed lubricant from the bearings to the interior of the drum.

Trend of block design is towards simplification; more complete unitization of each sheave and all its bearing components, in which more widespread use of pressed-in outer races, instead of employing the inner face of the hub for this service, is indicated; and specification of materials susceptible of having incorporated in them, through heat treatment and flame hardening, lasting wearing surfaces which will eliminate re-working until the service life of the unit involved has been exhausted.

This extensive paper is illustrated with photographs of representative blocks, each of which is described in detail. A. H. N.

556.* Recover over Mile of Drill Pipe against Difficult Odds. N. X. Lyon. *Oil Wkly*, 7.4.41, **101** (5), 28.—A combination of sulphur gas, brine, and high pressures constituted one of the major troubles in drill-pipe recovery work. In going in and coming out of the hole brine flowed in torrents, and the sulphur gas rendered necessary periodic shut-downs for fresh air. A pair of rubber gloves ordinarily became worthless during one operation of pulling out or going into the hole, due to reaction of the salt and sulphur.

To add to the difficulties, badly fractured drill stem boxes, and in some cases completely parted pipe, were found. This is believed to have been due to the combination of sulphur gas, brine, and pressures, which set up a crystallization action that split the boxes, causing fractures the width of an ordinary pencil and complete parting of the pipe at the boxes in some instances.

The break-up of the pipe at the boxes probably prevented full recovery of the pipe-string. That recovery to 6400 ft. was obtained under conditions experienced is regarded as exceptional, for the pipe recovered had forty-seven splits. Bridges both inside and outside the drill pipe baulked attempts to circulate mud, so the entire fishing operation had to be carried on without benefit of even partial control with mud. Approximately 1344 ft. of pipe remains in the hole. It is believed to be completely trapped by bridging and to be unrecoverable due to the countless splits and fractures in the pipe-boxes.

Details of the recovery operations are given. After recovering many sections, side-tracking was used. Mud troubles are described with the methods used to overcome them.

This well—Bateson 1—is the first attempted deep well in the Michigan basin, and on its completion are hinged in no small measure the starting of two or more other deep wells this year. Without question the gas-distillate pay at 7776 ft. offers encouragement for deeper beds in Michigan, but it is not entirely adequate proof. Production is from an unclassified bed of the predominately salt zones of the Salina. Many geologists believe that the high pressures and low volume of gas are indicative of salt production. A. H. N.

557.* Relationship of Drilling Contractor to Oil Operator. A. Rowan. *Oil Wkly*, 7.4.41. **101** (5), 36. *Paper presented before American Petroleum Institute.*—The relationship of the drilling contractor to the operator is substantially that of the employee to the employer. Practically all drilling contracts are made on the basis of what is known as a footage contract. The contractor makes the hole and performs the labour necessary to set the pipe and complete the well, and the operator furnishes the materials and special services, such as cementing, electrical logging, etc.

In considering the price to be paid a contractor for his work, it should be borne in mind that the contractor has no control over the price he pays for supplies, such as wire lines, drill pipe, drilling bits, and other necessary repairs to his equipment. His only control over cost is in the wages which he pays his employees, and the efficiency of these employees in the conduct of their work, so as not to abuse his equipment, but instead to operate them in the most economical way possible. The care and selection of these employees are of the utmost importance, not only to the operator, but also to the contractor. These employees, including the tool-pusher, are really the employees of the operator, since they are taking orders from him—possibly not directly but through the contractor—and the efficient execution of their work is of prime importance to the operator.

In the operation of drilling rigs, if a contractor can operate his drilling rigs in a given field on a continuous basis—*i.e.*, locations waiting before the completion of the well on which he is then working—his costs will be materially less than if each well is finished and a period of time then elapses before the commencement of another. Likewise, if a contractor can operate two or more rigs in a given field, his operating costs are lessened. In both these instances the contractor passes, or should pass, these savings on to the operator by reducing the contract price per foot.

The function of the contractor is to perform the work required by the operator in a first-class, workman-like manner, and at a cost comparable with that of the operator if he ran his own tools, taking into consideration, of course, all elements of such cost. These should include proper charges for depreciation, obsolescence, overhead, and supervision, and also camp facilities for his employees, annuities, insurance, etc., together with any other benefits given to his employees, and hazard. With the proper co-operation between contractor and operator this can be done, the resulting advantage to the operator being the elimination of invested capital and decrease in number of employees and possible labour troubles. The contractor, being a small organization, can probably run his organization with less likelihood of labour trouble than the operator, because of the personal contact with his men.

Other items are discussed. A. H. N.

558.* Wells Slightly Deeper in 1941 and Footage Relatively Large. Anon. *Oil Wkly*, 21.4.41, **101** (7), 22.—Wells drilled in the first three months of 1941 were slightly deeper, on the average, than those completed in the corresponding months of 1940. Consequently, total footage drilled has continued relatively large, having fallen short of that for last year only by about the same small proportion as completions have lagged.

Comparative data for the interval 1925–1941 are presented for number of wells completed, total footage drilled, and average depth/well for each year. A. H. N.

559.* New Methods and Equipment Lower Drilling Costs. A. F. Lager. *Oil Wkly*, 21.4.41, **101** (7), 26. *Paper presented before American Petroleum Institute.*—The paper deals in particular with practices in the Illinois Basin, and, because the rotary is the main system used, the discussion is entirely confined to this type of rig. In general, the Illinois Basin has offered many opportunities for detailed bit studies, and it can be pointed out that the result of the combined efforts of operators and manufacturers alike has been to reduce bit costs as much as 50%. In reducing such costs the penetration rate/bit has been materially increased, all of which have combined to place Illinois rotary drilling on a cost basis comparable to other areas.

As might be expected, the abrasive nature of the formations causes severe erosion action on the body of the drill-pipe and tool-joints. Ordinarily the life of drill-pipe and tool-joints is about the same, and a commonly accepted figure in the Mid-Continent is from 75,000 to 100,000 ft. However, in the Illinois field it was found during the early drilling that it was necessary to replace tool-joints at from 15,000 to 20,000 ft. and to retire the drill-pipe at 40,000–50,000 ft. Therefore the drill-pipe usually consumed three to four sets of tool-joints. In an endeavour to correct this condition several steps have been taken with beneficial results. Surface rebuilding of tool-joints employing ribbons of steel or welded sleeves are being used, which greatly reduces the cost of repairs.

One of the most important contributions to rotary drilling in Illinois has been the development of field-applied tool-joints. In the past it has always been necessary to haul drill-pipe to a machine shop for bucking off and bucking on new tool-joints. New shrink grip-joints have been developed which can be applied to drill-pipe on location without the necessity of machine-shop labour and equipment. Although no actual data are available, it is believed that better costs can be attained through the use of replaceable joints than by rebuilding or hard facing worn joints.

The development of hydraulic torque converters for use in driving rotaries is a notable advance made during the last two years, and is finding favour among operators. Through its use an infinite number of speeds are obtainable, with instant application of maximum power when needed.

The problem of lost circulation is being more efficiently handled through the use of a newly developed instrument for finding fluid levels in the holes after circulation has been lost, and in checking the placement of cement so that some of the slurry is left in the hole and the rest placed immediately around the well-bore.

A pressure core-barrel is being used experimentally in the area at the present time. The purpose of this type of barrel is to recover a core which is as nearly as possible in its original condition. A. H. N.

560.* California Operators set Fast Drilling Time. L. P. Stockman. *Oil Gas J.*, 13.3.41, **39** (44), 37.—Various records are described for fast drilling and completion. For instance, in the Ten Section field, Shell Oil Co. showed an average of 412 ft./day total elapsed time in Kern County Land, which was finished at 8235 ft., but it must be remembered that in this total time the company landed surface pipe, a combination oil string and 2-in. tubing and had the well on production in twenty days. The actual footage average was about 451 ft. daily, exclusive of time spent in cementing.

The fastest drilling time on record was made in the Wilmington field of Los Angeles Basin by the Kern Drilling Co., which on a night tour made 1595 ft. in 8 hrs. for an average of 199·3 ft./hr. A depth of 2713 ft. was reached in 40 hrs., and this included an electrical survey, directional survey, mud conditioning, and running casing which consumed 14 hrs. The 40 hrs. drilling time to 2713 ft. also included the landing of 8⅝-in. casing as a water string at 2710 ft. Actual time on bottom of the hole approximated 25 hrs. as far as actual drilling is concerned.

Other interesting data are included for different fields of California. A. H. N.

561.* Maintenance and Operation of Rotary Drilling Lines. H. F. Simons. *Oil Gas J.*, 13.3.41, **39** (44), 39.—The fact that no money is being made by a rotary drilling rig when the bit is off bottom has led drillers to operate the hoist at maximum speed while making a trip. The later-type rigs are capable of high drum speeds and have a capacity for over 6000 ft./min.

Such speeds frequently lead to many complications which affect the efficiency and service of the wire rope. About 4000 ft./min. is the maximum speed at which the line will spool smoothly and evenly; when this rate is exceeded there is danger of balling up and overlapping on the drum, particularly if the blocks are not loaded.

Running long strings of pipe in the hole at high speeds is also dangerous, for if the bit strikes a shelf or tight place in the hole, the line will continue to unreel until the drum rotation is stopped by the driller applying the brake. If the pipe then becomes free it will drop until the slack is taken out of the line. The momentum of the drop may exceed the breaking strength of the line if too much slack was run off the drum. A preformed line has greater flexibility and less tendency to twist under light loads and high speeds.

Many operating hints are given. For instance, in cutting a new line an even number of coils or half-coils should never be removed. Rather the amount of the line cut off the drum should be so many coils and a fraction of a coil, one-fourth and three-fourths being the best. This changes the portion of the line at the major and minor cross-over of each coil. Cutting on the even or the half-coil will not change the cross-over points, and part of the purpose of changing the position of the line will be defeated. The periodic and systematic changing of the position of the wire rope on the drum is the most important means open to the drilling contractor of lengthening the life of the drilling line.

When a new wire rope is being placed on a drum, or the ends of line already in service are being interchanged, the new rope or section should be loaded gradually and should see as much mild service as possible before it is subjected to heavy loads. This practice is to pull all but ten or twelve stands of pipe (manufacturers recommend the former, while drillers generally use the latter) from the hole and then perform the change-over. The wire rope thus has ample time to adjust itself before it is heavily loaded.

Because of the risk to human life and property involved, it is considered dangerous to run a rope having a safety factor less than 3·75. This represents 75% of the strength of a wire rope having a safety factor of 5 when installed. Some wire ropes when new have a greater safety factor than this, and can consequently be used with a smaller percentage of the remaining strength.

The simplest way to obtain all the necessary information for estimating the remaining strength is to count and list the broken wires by strands. Wire Engineering presents several re-roping charts for different types of ropes for use in other industries. These may be used for the construction of charts for wire ropes used in drilling service.

A. H. N.

562.* Repair of Surface Casing on Rotary Drilling Wells. H. F. Simons. *Oil Gas J.*, 20.3.41, **39** (45), 54.—Various reasons for failure in surface pipes are discussed, ranging from improper installation and operation to accidental causes. Generally failure in the surface pipe occurs suddenly and without warning. If the break is in the upper portion, the first sign will be a reduction in the mud in the flow-line, whilst the cellar will begin to fill up and mud will start flowing around under the derrick floor. Breaks in the lower portion of the pipe will cause a binding of the drill-stem, or may not be noticed until the bit fouls on the broken-off portion as the drill-pipe is being pulled from the hole.

Repair of an upper break is rather simple, the top portion of the pipe being pulled from the hole and a die collar or nipple installed on it. The top portion can then be screwed into the lower and cement pumped down around the outside of the casing to reinforce it. If the top portion cannot be pulled from the hole, a bridge can be placed in the lower section and cement squeezed through the break. The pipe should be centred to insure a good job.

If the bottom section has not fallen down the hole, it can be re-centred and then cemented in place. For centring the pipe a long spear can be made from a tree or timber, with a groove cut down one side to permit passage of the cement. This may be run on the bottom of the drill-pipe or below a pack-off tool, which will force the cement downward and around the loose section of pipe. The same method can be used to cement in place a section of surface casing which has fallen a considerable distance.

A new method of repairing such breaks was introduced during the past year. It was originally designed to repair producing string or casing, the bottom portion of the string having fallen down the hole while a window was being cut opposite an upper producing section. It has since been used to repair several surface-casing breaks.

The objective is the return of fallen suction-pipe to its original position, centring it in the hole and then cementing it in place. A cement retainer is modified so that it becomes a casing spear in addition to a means of forcing drilling fluid and cement slurry around the pipe. A. H. N.

563.* Refrigerated Mud Proposed for Overcoming Heaving Shale. C. P. Bowie and R. V. Higgins. *Oil Gas J.*, 20.3.41, **39** (45), 60.—The use of oil as a drilling fluid in heaving shale localities is discussed. The authors believe that a more satisfactory and less expensive drilling fluid would be a " water-in-oil " emulsion in which the water phase is a refrigerant, such as calcium chloride. This could be a " loose " emulsion containing a small quantity of oil and wall-building material and a large quantity of refrigerant, as the two fluids would be agitated during drilling operations and would therefore not separate. It may not be necessary to use an emulsion, as a mixture of oil and water does not flow nearly as readily through porous mediums—the formation or the mud cake on the wall—as do single-phase liquids.

Experiments by the authors indicate that it should be possible to prepare a satisfactory fluid without the use of oil. One such fluid consisted of 25 parts by weight of calcium chloride, 75 of water, and 29 of a good wall-building commercial clay. The

Stormer viscosity of the fluid was 23·6 centipoises and the weight 11 lb./gall. A Union Oil type of filter press, 3 in. in diameter, was used. It was surrounded by a cold kerosene bath. Under a differential air pressure of 100 lb./sq. in., 12 c.c. of calcium chloride solution came through the press in the first 20 mins. when the temperature was — 5·0° F. This amount of fluid is smaller than normally flows from the average field mud when tested in such a press at room temperature, notwithstanding the fact that calcium chloride would flocculate the colloidal content of the mud. The thickness of the mud cake was about 1/16 in.

It is noted that the wall-building properties of clays rich in colloids are enhanced as the temperature of the drilling fluid is reduced. This becomes particularly apparent when the temperature approaches the freezing point of water.

The cost of a portable refrigerating plant suitable for refrigerating the drilling fluid is estimated to be $55,000. Such a plant could be moved from place to place and used again and again.

In introducing this system of drilling some changes will be necessary in the usual drilling technique. These changes are discussed in this paper. None of them seems to offer any particular difficulty.

Manufacturers of refrigerating equipment and operators of refrigerating plants, who have been consulted, are agreed that the application of refrigeration to drilling such formations, from their viewpoint, presents no unusual problem. A. H. N.

564.* Current Practices in Maritime and Water-Bed Drilling. P. Oldenburg. *Oil Gas J.*, 17.4.41, **30** (49), 72.—The use of a submersible drilling barge is ideal in open yet protected-water locations where the depth of the water ranges from 5 to 10 ft. In such places the barge is easily moved about and no excavation of channels is necessary, and yet it is protected from high seas. If a field has once been established in a marshy section by using piling for foundation for the first few wells, a great deal of saving can be accomplished by establishing a series of canals and moving a drilling barge into the locality to complete the drilling programme. It may be roughly estimated that the cost of a drilling barge and power barge is equivalent to the cost of seven to eight piling foundations, drilling equipment excluded in both cases. While there is very little saving to a piling foundation the drilling barge is moved intact from place to place.

The development of diesel, and especially diesel-electric power has proved of great value to marine drilling. It puts much less demand on supply of fuel and water. An ordinary diesel-electric power plant with adequate storage facilities will require only one or two monthly replenishments of fuel oil. Fresh water used in the cooling system is cooled by sea-water in heat exchangers. Since marine drilling must necessarily depend on water transportation for its supplies, any method which will reduce this to a minimum will raise the efficiency of the entire undertaking. Direct current is generated by the diesel-electric power plant, which is utilized through cable transmission on the drilling barge to operate the electrically driven pumps, draw-works, and rotary table. Through a switchboard any combination of power may be had if desired to concentrate or divide this power, thus giving the entire system much flexibility. Once the drilling is actually under way it does not differ greatly from any other type of rotary operation on a land location.

In marine drilling safety precautions assume even greater importance than in land drilling; blow-outs and fires are much more serious. Safety methods are described.
A. H. N.

565.* Marked Improvement Shown in Deep-Drilling Technique. N. Williams. *Oil Gas J.*, 17.4.41, **39** (49), 88.—The paper deals particularly with Gulf Coast practices. Contributing to the increased problems and difficulties of deeper drilling are such conditions as greater gas pressures, high-pressure salt-water flows, excessive temperatures, and heaving shale. These not only create complications in direct control of wells during drilling and completion, but accentuate the hazards involved in such normal mechanical requirements as coring, directional surveys, and drill-stem tests. This is particularly true in attempting to reach an objective below 10,000 ft. with only surface casing in the hole or with small-diameter pipe as a secondary or protection string. So far as heaving shale is concerned, operators for the most part are inclined to discourage attempting to drill deep wells in known heaving-shale zones.

In this extensive paper the author deals with many of the usual hazards during drilling, cementing, and completion of deep wells. Improvements of equipment and a greater knowledge of its application and fuller realization of the importance of conditioning and controlling the mud flush have been major factors in the progress made on the Gulf Coast in meeting the problems and minimizing the hazards of deeper drilling. Improvements in equipment, both in size and adequacy and in quality of materials, have made possible more effective and efficient operation and have lessened the chances of mechanical failures and break-downs at critical times. Better mud conditioning has provided more effective control of formational conditions at the point of inception of trouble. A. H. N.

566.* Methods to Recover Stuck Drill-Pipe. Anon. *Oil Gas J.*, 17.4.41, **39** (49), 149.—Dependent on conditions, three methods of recovering stuck drill-pipe may be resorted to—viz., spotting or circulating oil, inside cutting, and washing over together with outside cutting.

Drill-pipe may freeze while attempting to control an active well when movement of the pipe is limited. Again, the pipe may stick while pulling out, due to an unknown groove in the wall or the balling up of reamers used prior to running casing. In such cases, particularly the latter two, circulation may be established.

Where it is definitely known that the pipe is stuck at or near the bottom of the string, the inside cutting method usually saves considerable time and expense in completing the operation. The cutting tool is run on 1¼-in. or 2⅜-in. flush drill-pipe, and will cut 3½-in. internal flush, 4½-in. and larger drill-pipe. In cutting the 4½-in. size the tool-joints must be the full-hole type, to permit passage of the cutter. Extreme care must be exercised in operation because of the fragile nature of the cutters in small tools.

In the majority of cases where drill-pipe freezes or sticks, the method of washing over and outside cutting is generally preferred, and meets with a greater percentage of success than the other two methods. Various factors are responsible for this preference, chief of which is that the drill-pipe sticks more often when combating an active well and surface casing is the only protective string.

With modern types of casing and outside cutters in use, this method of recovery in a normal-size hole is successful. Cuts as long as 900 ft. have been made by some operators, although generally it is considered preferable not to take cuts longer than 600 ft., due to the possibility of dropping the fish while pulling out, and thus complicating an undesirable situation.

Side-tracking and milling from bottom up are also described. A. H. N.

567.* Drilling Shallow Wells Profitably in the North Texas Area. H. L. Flood, *Petrol. Engr*, April 1941, **12** (7), 80.—The paper deals in particular with the problems of the "small" drilling contractor, and describes a one-engine portable rig which is being used to solve the financial side of these problems. The unique feature of the entire assembly is the single 165-h.p. engine used to supply power for the entire operation. It is also interesting to note that only one mud-pump is available in drilling with this rig. The entire assembly, including a 65-ft. telescoping mast, is mounted on a single skid that permits the rig to be moved as a unit on a heavy-duty truck. The units are fixed in place, and thus are always in perfect alignment, and no time is lost in lining-up after a move is made. Total weight of the rig is 47,000 lb. When highway requirements prohibit this weight or special permits cannot be obtained, or when the going is soft underfoot, the engine and pump can be moved separately on their respective skids.

Various modifications in the conventional type of rig have been used. As an example of ingenuity, the owners of this rig, adjusting their methods to the local field conditions, have eliminated the drilling of a rat-hole to receive the kelly, and are laying the kelly down while a trip is made. This innovation is justifiable in this instance because the top 50 or 60 ft. of drilling in the field is hard rock digging. Offset operators, adhering to the practice of drilling a rat-hole, consume 18–24 hrs. for the operation, the time required to drill 25–30% of the rotary hole.

The single mud pump used on the rig is of the modern outside-crank type with heavy-duty tapered roller bearings on the crankshaft and crank-pins. The maximum liner size is 6 in. and the stroke is 12 in. The fluid chamber is recommended for a maximum discharge working pressure of 1800 lb./sq. in. tested to 3000 lb./sq. in hydrostatic pressure. At maximum operating speed of 65 r.p.m., when equipped with full-size liners, theoretical displacement of the pump is 364 gal./min. and recommended maximum brake horse-power input is 129. The one-piece semi-steel fluid end of the pump is of the direct-flow type with no internal walls subject to internal pressures.

A. H. N.

568.* California Practice in Casing Deep Wells. W. A. Sawdon. *Petrol. Engr*, April 1941, **12** (7), 86.—Many of the long strings now being run are " tailor-made " to fit the specific well conditions. Many of these strings are made up with a bottom section of N-80 pipe, a middle section of J-55 pipe, and a top section of N-80. No definite ratio of N-80 and J-55 pipe can be stated, but the average will probably be about 50% of each, whether the J-55 is on top or in the middle. By placing the N-80 on the bottom of the string the greater strength is used against collapse ; by placing the N-80 on top the greatest tensile strength is obtained where most needed. Examples are given in detail.

A considerable amount of special casing is being used for long strings in California. The chief features of many of these makes of special casing are in the joint design or in the strength of the coupling material. The use of high-tensile-strength couplings allows a reduced O.D. with more clearance at the joint. The pipe itself is frequently made of a special alloy steel that may exceed A.P.I. specifications.

In determining the stretch to allow, consideration must be given to the fact that the string will weigh less in a hole full of mud, even with the inside full, and that after the string has been cemented the entire string is not hanging. Moreover, under some formation conditions the casing may not be free for some distance above the top of the cement, and this will further shorten the distance over which the stretch is effective. One suggestion has been made that the weight of the string before cementing, as read on the weight indicator, be noted, and that this weight-reading be used when setting the casing in the slips after the cement job is completed.

If too much tension is taken on the pipe the string will be too taut and the whipping of the drill-pipe may cause it to break. Subsequent cooling may also cause additional stretch to such a degree that the metal will fail. In one well, for example, a heavier gas-flow than expected was encountered when drilling-in, and after the production of the well declined the cooling effect from the expansion of the gas caused the pipe to part at the top joint. The stress at the point of highest tension should not be allowed to exceed two-thirds of the yield point of the pipe.

When the string is landed with insufficient stretch the casing will hang too loosely in the hole, and may wobble during subsequent operations. There is then the hazard of the pipe breaking near the top of the string. The A.P.I. round threads now generally used withstand wobble, but when the wobble is excessive they will not prevent breaking at the coupling.

Cementing problems are also discussed. A. H. N.

569.* Current Drilling Practice in the Texas Panhandle. H. L. Flood, *Petrol. Engr*, April 1941, **12** (7), 92.—It has been, and probably will continue to be, standard practice in the Panhandle to complete the wells with cable tools, whether rotary or cable tools have been used to drill from the surface to set casing.

One company has had fair success drilling into the dolomite with rotary, using the lightest weight mud possible and getting " in and out " of the formation as quickly as possible. Difficulty is usually encountered, however, after the formation is shot with explosives to open up the relatively dense oolitic rock. If the hole can be completely bailed-out prior to the shot, removing all mud and water, and the shot tamped satisfactorily, it is believed the use of rotary may increase for drilling dolomite wells.

Another company has recently drilled a number of gas wells using rotary all the way and employing gas as the circulating medium to remove cuttings from the hole. This method is apparently satisfactory, and may be adopted more widely in drilling gas wells, despite the many objections to the method now being expressed. It is not believed, however, that gas circulation can be made to apply in drilling oil wells.

Thus far there is apparently no method whereby rotary can be used to complete oil wells, particularly in the Granite wash. It is possible that the present developments in California and elsewhere, involving the use of chemicals to reduce surface tension and to dissolve mud and other plugging materials, may eventually be effective as a solution for this problem of flooding the formation with mud and water.

An analysis of the cost of operating a light rotary rig of the portable rig, employing a three-man crew, indicates a monthly cost of $10,312, including a depreciation charge of 3½%/month on the rig. In the Pampa area, drilling three 3100-ft. wells/month, the unit cost of drilling is therefore $1.11/ft. This compares favourably as an average with the $1.05/ft. cost of one of the leading slim-hole operators in the Panhandle.

It is a coincidence in the Texas Panhandle that the water level in each porous formation occurs at or close to sea-level. Above the water-level a zone of oil occurs, and the upper portions of the anticlinal folds contain gas only. Consequently, it is only necessary for the porous horizon in a well to be encountered above sea-level to be productive of oil or gas. The amount of production then depends solely on the local porosity.

The rock pressure is uniform in the Panhandle, but is sub-normal, being less than half the normal hydrostatic head. The controlling factor determining this pressure anomaly is not definitely known. The decline in pressure from the initial rock pressure of 430 lb./sq. in for the field as a whole has been greatest in the areas developed for oil.

A. H. N.

570. Directional Drilling. Anon. *Mining & Geol. Mag.*, March 1941, 2, (4), 250—251. —A brief review of the development of the Eastman directional drilling method and illustrations of its employment in controlling large well-fires. B. M. H. T.

571. Patents on Drilling. C. E. Reed. U.S.P. 2,234,197 and 2,234,198, 11.3.41. Appl. 13.12.38 and 24.3.39, respectively. Earth-boring apparatus, each being a rotary drill-bit utilizing a special cutter mounted in a specific manner.

D. D. Anderson. U.S.P. 2,234,219, 11.3.41. Appl. 1.2.40. Reamer consisting of a body with a recess in its side in which a cylindrical cutter is mounted.

C. E. Lang. U.S.P. 2,234,264, 11.3.41. Appl. 21.11.38. Core-drill with a core-barrel which is movable in a vertical direction.

J. V. Pennington. U.S.P. 2,234,273, 11.3.41. Appl. 19.2.40. Rock-bit cutter with laminated relatively soft tough material and hard laminæ to form the cutter teeth.

J. C. Stokes. U.S.P. 2,234,286, 11.3.41. Appl. 29.2.40. Core-catcher with a plurality of flexible arms.

J. A. Muller. U.S.P. 2,234,350, 11.3.41. Appl. 15.7.39. Hose and coupling structure.

G. L. Kothny. U.S.P. 2,234,438, 11.3.41. Appl. 18.4.40. Tool-removing device to remove whipstocks from bore-holes.

H. F. Richter. U.S.P. 2,234,454, 11.3.41. Appl. 20.5.40. Apparatus for drilling wells consisting of squared-section drill-pipes with passages for intake and outtake of fluid.

S. W. Craig. U.S.P. 2,234,798, 11.3.41. Appl. 29.1.40. Mud-line pressure-control valve.

B. B. Smith. U.S.P. 2,234,811, 11.3.41. Appl. 9.7.37. Cathead drum.

A. Boynton. U.S.P. 2,234,957, 18.3.41. Appl. 28.10.38. Thread locking means in a tool-joint.

J. S. Morgan, Jr. U.S.P. 2,235,080, 18.3.41. Appl. 21.12.35. Draw-work.

J. D. Spalding. U.S.P. 2,235,088. 18.3.41. Appl. 12.2.40. Draw-work.

T. S. Bunker. U.S.P. 2,235,279, 18.3.41. Appl. 21.11.29. Weight indicator for deep-well drilling-rigs.

E. P. Halliburton. U.S.A. 2,235,318, 18.3.41. Appl. 6.6.40. Apparatus for cementing wells, including packers and non-return valves.

J. F. Bozeman. U.S.P. 2,235,548, 18.3.41. Appl. 1.4.40. Bit for drilling well-bores by the rotary system.

F. I. McConnell. U.S.P. 2,235,770, 18.3.41. Appl. 16.8.37. Method of determining the volume of a lower uncased portion of a well provided with the usual casing and tubing, by means of forcing the well liquids into the formation, putting in well a light non-penetrating liquid, and allowing well-liquid to return from formation, and then withdrawing excess of non-penetrating liquid.

W. J. Crites and P. C. Murphy. U.S.P. 2,237,387, 8.4.41. Appl. 28.6.39. Drilling barge fitted with piling members which are anchored by pumping water in them.

J. F. Smith. U.S.P. 2,237,394, 8.4.41. Appl. 27.2.39. Oil-well rig-power transmission apparatus, adapted for use under conditions wherein the relation between the load torque and the input torque is subject to sudden changes.

H. E. Grau. U.S.P. 2,237,427, 8.4.41. Appl. 1.7.40. Pipe-tong support.

J. A. Zublin. U.S.P. 2,237,538, 8.4.41. Appl. 25.2.39. Swedge adapted to be lowered to a point remote from the surface in a casing set in a well.

B. S. Minor. U.S.P. 2,237,683, 8.4.41. Appl. 24.4.39. Method and apparatus for suspending well-casing.

R. Parr. U.S.P. 2,237,686, 8.4.41. Appl. 23.6.39. Bailer of the suction type.

E. O. Lowe. U.S.P. 2,237,709, 8.4.41. Appl. 5.2.40. Blow-out preventer.

W. A. Shaw, and A. O. A. Hodge. U.S.P. 2,237,715, 8.4.41. Appl. 18.12.39. Rotary swivel.

A. Kendrick. U.S.P. 2,237,965, 8.4.41. Appl. 19.3.38. Structural steel tower to be used as a derrick.

J. J. Whalen. U.S.P. 2,238,199, 15.4.41. Appl. 2.1.40. Rotary drill-bit with a magazine of cutter teeth which feeds the teeth into a holder only when previously fed teeth are worn out and useless.

E. S. Strang. U.S.P. 2,238,377, 15.4.41. Appl. 9.9.39. Under-cutter adapted to be mounted on a drill pipe.

J. E. Reed. U.S.P. 2,238,398, 15.4.41. Appl. 22.5.37. Line-spoole which is a guide for damping vibrations in a long span of travelling cable.

B. W. Sewell. U.S.P. 2,238,609, 15.4.41. Appl. 21.4.39. Pressure core barrel for rotary coring systems.

A. R. Maier. U.S.P. 2,238,654, 15.4.41. Appl. 27.2.40. Swivel for rotary drilling.

R. L. Ohls. U.S.P. 2,238,706, 15.4.41. Appl. 12.10.39. Tool-joint with the male and female portions fitting by a non-rotary motion. A. H. N.

Production.

572.* Pressure Maintenance Yielding Beneficial Results at Kermit. D. H. Stormont. *Oil Gas J.*, 13.3.41. **39** (44), 32–34.—In a low-pressure area in the Kermit field of West Texas highly satisfactory results are being obtained from a pressure-maintenance project—the first undertaken in West Texas. To date over 4,719,314,000 cu. ft. of gas has been returned to the producing formation, with the result that a number of wells previously not capable of making their allowables are now doing so, and wells that were on artificial lift are now flowing their production. Other favourable results obtained include a check in the decline of bottom-hole pressures, a rise in the fluid level, and decrease in gas–oil ratios of some wells, and the checking of water encroachment in at least one well.

The Magnolia project differs from usual pressure-maintenance and repressuring operations in that the pay-zone into which the gas is being returned is composed of lenticular sands, some producing oil and gas and others producing only gas. To make the project even more difficult, practically all wells involved had been given heavy shots of nitroglycerin on completion. This makes it impossible to run liners and shut off the gas-bearing sands, or use of other mechanical methods that will permit gas injection into only the desired oil-producing sands. Thus control of the gas-drive, on the whole, must be accomplished solely from the surface through proper selection of gas-injection wells and constant control of the gas-injection volumes.

Each of the seven injection wells is equipped with a pressure-reducer regulator, a volume-flow controller, and a recording thermometer. The pressure regulator, of course, reduces the line pressure of the gas to the desired injection pressure. In the event of the flow controllers on some input wells freezing, the regulators were installed to prevent one well from " hogging " all gas.

All injection wells were thoroughly cleansed before gas was started into them. All cavings were removed from the hole and any paraffin accumulation removed from the face of the pay. The latter was necessary to avoid possibility of the high-pressure gas forcing the paraffin into the pay-sands and thereby interfering with gas-flow into the producing sands.

In conclusion it is stated that sufficient time has not yet elapsed for a complete study of the field. A. H. N.

573.* Pressure-Maintenance Projects under way in Permian Basin. D. H. Stormont. *Oil Gas J.*, 13.3.41, **39** (44), 34.—This short paper deals with four of the five projects in the Permian Basin. As an example, gas is being returned to the Yates sand-pay at 2032–2100 ft. through three input wells at the rate of 150,000–300,000 cu. ft./well. Gas is taken at 15–20 lb. from the field separators, compressed to 150 lb. in the first stage of two 165-h.p. units, and discharged at 1000 lb. on the high side. Injection pressures vary from 425 to 1000 lb.

Gas return has not been carried on sufficiently long to show maximum results, but the leases have shown favourable response to the operations. Bottom-hole-pressure surveys in April and September 1940 showed drops of from 15 to 40 lb. during the period, as compared with declines of 150–200 lb. in surrounding leases. One key well in a low-pressure area of the lease on a recent test showed a bottom-hole pressure of 325 lb., whilst an offsetting producer on another property tested only 175 lb. In several wells production has been increased, with resulting lower gas–oil ratios. Some of the high-pressure gas is being used for gas intermitting in seven lift wells. The remainder of the seventeen wells are flowing, the only ones in the field.

Data for the other projects are also included. A. H. N.

574.* Salt-Water Injection in East Texas at Important Stage. G. Weber. *Oil Gas J.*, 13.3.41, **39** (44), 36.—A review is given of experiments and studies in brine disposal into the Woodbine sand to solve problems both of disposal and of flooding. Tests employing wells on the south edge of the field, either former producers or specially drilled wells, were made. Some experimenting was done in injecting salt water to the lower section of the sand, in a well which was kept on production through the annular space, employing a packer below the oil section.

Out of this diversified investigation, the open system of handling salt water at the surface, and injection into re-worked, specially equipped input wells has evolved as the most generally accepted method at the present time. Salt water is gathered and passed through stepped-trough sections, accomplishing sufficient aeration to cause precipitation of iron oxides. Settling-tanks are provided to remove much of the solids, and filtration after settling renders the salt water sufficiently free of solids to prevent clogging in the sand.

Of the thirty-four injection wells in use during January, most were taking water at a vacuum, with no well-head pressure required to force the salt water into the formation. In some cases, however, pressure is required, sometimes temporarily to " break down " the formation, after which lower pressure or gravity is required for flow. Building up of back pressure has been combated in several cases simply by back-washing and

flushing or swabbing the wells to remove what is believed to be filter-cake on the face of the sand. This is apparently caused by bacterial action, or in some cases possibly by lack of sufficient settling time at the surface. Longer settling time has improved operations and treating in others. Treating is restricted mainly to the use of chlorine, alum, or lime for bacterial control, and has not been found necessary in all cases.
A. H. N.

575.* Flowing Practices in Flooding at Nowata. P. Reed. *Oil Gas J.*, 13.3.41, **39** (44), 48.—A distinctive feature of producing oil by the water-flood method in the Nowata, Oklahoma, field is the practice of lifting oil in producing wells by flowing. Up to the time the water-flood boom started in Nowata in 1936 it had been common practice to pump water-flooded production.

With present flowing methods, principal operating expense for the property in the latter stages of the flood's life is the cost of power for pumping water into injection wells. There is no expense for treating and filtering, because the water used for injection is brine-produced with oil on nearby properties. This brine is injected without treating and filtering, under the same pressure used on freshwater-injection lines on adjacent portions of the flood. Because of the manner in which it is operated, this property is commonly referred to in the area as a salt-water-disposal project.

With the rapid-depletion method of operating water-flood projects it is possible to return the original investment in the shortest time and to maintain a higher yearly income.

A longer period of water-flood operation is advocated by a number of independent operators. It is believed that with the longer period of flooding the ultimate recovery will be greater although the yearly recovery may be less. These operators prefer to exploit as effectively as possible. Properties offering the most favourable conditions for water-flooding are not readily acquired.

While there has been a growing practice in Nowata towards flowing producing wells, flowing is far from being the universal method for bringing oil to the surface in the area; since a substantial part of it is lifted by wells pumped by central powers and electric motor-driven jacks.
A. H. N.

576.* Injection of Gas in Lime. P. Reed. *Oil Gas J.*, 20.3.41, **39** (45), 48.—A report of the unusual practice of injecting gas into a small oil-producing lime formation is presented. Gas is injected, mostly from one well, by a small compressor driven by a 25-h.p. gas-engine of a type commonly used for pumping powers. This equipment is operated at capacity all the time, and injects gas at a pressure of 280 lb. This pressure has been maintained for the past two years. Before that the pressure maintained was between 340 and 350 lb.

As a result of gas injection, the decline of production has been checked sufficiently to justify the application of gas injection on the property. The oil has a gravity of 32° A.P.I. Complete data regarding the amounts of oil produced and of gas injected have not been made available for publication. For the last two years production has been maintained at approximately 25 brls./day from the wells on the property. In reviewing what has been accomplished by this experiment, it has been found that the decline of production in the last 5 years has been sufficiently checked to make it possible to operate profitably a property which could not have been paid out under normal conditions.
A. H. N.

577.* Inspection of Tubular Goods and Sucker-Rods. H. M. Henderson. *Oil Gas J.*, 20.3.41, **39** (45), 50. *Paper presented before American Petroleum Institute.*—A diagram shows an arrangement of an instrument in a section of a tubing and the manner in which it operates to detect the worn spots and the extent of the reduction of wall thickness. The instrument is set, before running into the tubing, to indicate when the remaining wall thickness is less than a given amount. For example, if it is set to indicate a remaining wall thickness of less than $\frac{1}{8}$ in., no electrical contact is made unless the remaining wall at any point throughout the length measured is less than this amount. The actual wall thickness may be any amount between $\frac{1}{8}$ in. and the full thickness of new pipe if no electrical contact is made. In other words, the instrument only indicates if the remaining wall is less than the amount for which the instrument is set.

By resetting the instrument to indicate other remaining wall thicknesses, tubing may be segregated into different classes and utilized to the most economical advantage.

The instrument does not measure the actual wall thickness of the pipe, but indicates the inside diameter opposite each one of the fingers. The remaining wall thickness is determined by comparison of this diameter with the normal o.d. of the pipe. Commonly used settings of the instrument are for $\frac{3}{16}$, $\frac{3}{32}$, and $\frac{1}{8}$ in. remaining wall in order that tubing may be classified sufficiently for proper segregation.

When surveying tubing on the rack, an "electrical buzzer" indicates the existence of a worn area, whilst a strip recorder with pen records the length and depth of worn area in the tubing when a survey is conducted in a well. To determine the length of the worn area in tubing surveyed on the rack, the operator notes the distance the instrument is moved while the buzzer is buzzing.

In order that the entire circumference of the tubing be surveyed without the necessity of rotating the instrument, contact fingers are spaced at $\frac{3}{8}$-in. intervals around the circumference of the tool, and these will detect a worn spot as small as $\frac{3}{8}$ in. in width.

For inspecting sucker-rods an instrument is described which classifies rods on removal from the well so as to eliminate potentially dangerous sections. The operation of the instrument depends on the magnetic properties of the material in the sucker-rod. The sucker-rods are drawn through the instrument as they are raised from the well. This assembly contains a group of primary coils which surround the rod and are energized by an electric current drawn from an A.C. motor generator set mounted on the truck, which also carries the recording instruments. A set of pick-up coils which surround the rod are also carried in the well-head assembly. A voltage is generated in the pick-up coils by the magnetic field which is induced in the sucker-rod by the energized primary coils, and it is the variation in this voltage which is indicated by the recording instrument.

Similarly, a telescopic instrument for inspecting the internal surface of drill-pipe is described. A. H. N.

578.* Multiple Hydraulic Pumping in Illinois Oil-Fields. H. F. Simons. *Oil Gas J.*, 10.4.41, **39** (48), 30–31.—While most of the pumping in Illinois is by the beam method, in recent months there have been several leases equipped with fluid-driven bottom-hole pumps. This type pump has been used for a number of years in deeper production and in fields where large volumes of fluid needed to be handled. The method in Illinois consists of installing a central power plant and then running power-oil lines to the individual wells. In this manner one power unit is used for lifting the oil from as many as twelve wells and as few as two wells.

Essentials of the system include a surface pump which supplies power oil through a macaroni string to a reciprocating pump at the bottom of the well. The exhaust from the power cylinder is into the tubing, and the used power oil is brought to the surface with the production.

The pumps are run inside the tubing on the macaroni string in the same way as an ordinary insert pump is run in on a rod-string. The pump is retrieved from the bottom by pulling the power-string. A seat in the bottom of the tubing receives the pump. The proximity of the pump to bottom is determined by the type of gas-anchor needed for the particular well. In the Salem field the gas-anchor used allows the pump to be located about 10 ft. from bottom; by remodelling the assembly the pump could be located on bottom.

Other details are given and illustrated. A. H. N.

579.* Schuler Unitized Repressuring Project is First in Arkansas. G. Weber. *Oil Gas J.*, 10.4.41, **39** (48), 32.—The undivided interest in the production of oil and gas and the share which each party to the agreement carries in the cost of the project are set in a tabulation of participation in the unit. The basis for participation in the unit is not producing acreage alone, as is generally the case in unitization agreements. Instead, each tract in the unit area is assigned a value in proportion to the value of all such drilling units, in the same ratio thereto as the number of barrels of oil which the drilling unit was allowed to produce each 24-hour day from the Jones sand under the allowable schedule of 1st August 1940 bears to the total daily pool allowable for the Jones sand, fixed by the Commission as a basis of said allowable schedule.

The allowable schedule for Schuler at the time designated was fixed on an acre-pound basis. Each well's allotted acreage was multiplied by its bottom-hole pressure, either directly measured as in key wells, or interpolated from the monthly pressure map of the field. The total of all per-well acre-pound products was divided into the total daily crude allowable allotted the Jones sand, obtaining the factor, " brls./acre-pound." This in turn was applied to each well by multiplying by its acre-pound factor, and the well's daily allowable in barrels was thus determined. Hence, interest in the unit is placed on an acre-pound basis, instead of the straight acreage factor usually used in determining participation.

Primary data on the pool are presented. A. H. N.

580.* Intermittent Repressuring of Pennsylvania Oil-Sands. P. A. Dickey. *Oil Gas J.*, 10.4.41, **39** (48), 35.—One of the chief troubles in repressuring programmes is due to by-passing. The fact that intermittent injection of gas inhibits by-passing indicates that during the time when the gas is not being injected the liquids redistribute themselves in such a manner as to decrease the permeability of the by-passing channel. Therefore, when gas is again applied, more resistance is encountered. The gas is thus able to move out the oil that collected in the channel, and since a higher pressure is developed, it also affects the less permeable parts of the sand.

When gas is no longer injected, the pressure in the permeable channel will quickly drop nearly to atmospheric, and a sizable pressure drop will exist between the channel and the less permeable places. This will tend to force the oil and water towards the channel. Their presence there materially reduces the effective permeability of the channel, and they are, besides, easily forced towards the producing well. The gas entering the less permeable places will, of course, tend to force the liquids away from the channel, but it will enter more slowly than it will leave. Thus, it is more effective escaping than entering.

This action is probably more effective with natural gas than with air, because gas is more soluble in oil. Natural gas under pressure would go into solution, and on release of pressure would form bubbles in the oil as it came out. These would tend to block the pore openings and make it possible for the gas to push the oil instead of simply passing by it. As an example of the effectiveness of this action, the oil saturation of a sand was experimentally reduced 60% by the escape of gas contained in it at a pressure of 900 lb./sq. in.

If the foregoing is a correct explanation of the mechanism of intermittent air-drive, it would seem that higher pressures, and longer opportunity for the pressures to redistribute themselves, might result in more efficient recovery. Certain field experiments tend to substantiate this theory. A. H. N.

581.* Subsurface Flow Control. J. H. Rambin. *Oil Gas J.*, 17.4.41, **39** (49), 78.—The paper deals with marine localities in the Gulf Coast. During squalls, fogs, and other undesirable barging and boating conditions that are often present along the Gulf Coast, the complete control of floating marine equipment is not always possible. As an additional safety measure a positive shut-off for the well itself, to act in case any surface connections were broken off, was devised. It was necessary to obtain a shut-off for both the casing and the tubing below the ground level, since in conventional completions both have pressure and are subject to flowing oil and gas if the surface casing or tubing connections are opened.

After many experiments, some of which are described, subsurface control under all conditions was finally attained, through experiments with various types of automatic shut-off valves for the tubing. This eventually resulted in the use of an automatic valve, which depended entirely on the velocity of flow for its operation. Through the combined use, then, of the double packer and the automatic shut-of valve, it became possible to produce a well with the assurance that if for any reason the flow through the tubing exceeded a predetermined amount, the valve would immediately shut the well in until such time as it was desired to reopen it.

The principle of operation of the storm-choke assembly depends on the fact that when the fluid velocity of the oil and gas through the choke reaches a certain point, the valve automatically shuts in the well until steps are taken to release it. The releasing process is accomplished by equalizing the pressure above and below the choke, after which the valve remains open until the velocity again exceeds the limitations of the choke adjustment. Thus, the choke assembly need never be removed from the hole unless it is desired to change its adjustment to correspond to some change in production.

The choke may be adjusted to shut off at any desired rate of flow, and experience and knowledge of each individual well, together with the quantity of production desired, are the only guides in making the adjustment. The setting depth for storm-chokes is governed by the paraffin accumulations, and it has been found to be better practice to set the choke below the normal paraffin level, which seldom exceeds 2000 ft. and is normally about 1000 ft. in this area.

Diagrams illustrate the assembly. A. H. N.

582.* Surface-Control Equipment and its Maintenance. R. N. Bean. *Oil Gas J.*, 17.4.41, **39** (49), 142.—The trend of development in surface-controls and flow-chokes points towards the use of a smaller size of master tubing valve and wing-valves and positive chokes that can be quickly and easily changed without leaks and galled threads. In localities where pressures are low the adjustable beans are used to flow wells the producing stratum of which does not contaminate the oil with sand or other abrasives. On high-pressure wells adjustable beans are used to arrive at an indication of size of positive choke to use; the flow is then switched back to the positive choke for permanent flowing of the well.

A review of development in chokes used for surface control is given, detailing refinements as well pressures became increasingly high. With the coming of surface-flowing pressures ranging from 2000 to 3000 lb., further refinements were made to give a better seal between the cage-nipple and the choke. Closer tolerances of the machined parts and proper selections of steel to meet choke requirements resulted in a better product. However, the present design remains substantially the same in principle as it was when first introduced, inasmuch as the chokes are still screwed into the cage-nipples. One of the chief difficulties experienced with this method in controlling high pressures has been the leaks and cutting out of the threads between cage-nipple and choke. Galled threads frequently gave operators trouble, resulting in costly replacements. To remedy this condition, numerous designs of seals, gaskets, and quick-change unions have been developed. Within the last five or six years new inventions and devices have appeared on the market to meet the need of the present high-flowing pressures that run from 4000 to 6000 lb. and in a few instances even higher.

Typical surface installations are illustrated and described. A. H. N.

583.* East Alice Field Gas-Recycling Project placed in Operation. N. Williams. *Oil Gas J.*, 17.4.41, **39** (49), 145.—After describing the property and its history, the recycling plant is studied. High-pressure absorption is embraced in the primary-recovery phase of the plant operation. There are three high-pressure absorbers, to which the high-pressure gas from the field-gathering system is directly charged without prior separation of any fluids. Meters and regulators ahead of the absorbers control the volume of gas and the pressure drop to each of the absorbers. The absorbers operate at pressures up to 1500 lb., as against a gas-delivery pressure to the plant of approximately 1650 lb. This entails a pressure drop of approximately 150 lb. to the absorbers. Inlet-gas temperature is approximately 100° F.

Four 600-h.p. compressors, taking suction through scrubbers from the overhead stripped gas from the three high-pressure absorbers, return the dry gas to the sand. These boost the pressure of the gas from 1500 lb. to approximately 2150 lb., which is slightly above the bottom-hole pressure of the sand. There are two input wells, both of which are located on opposite sides of the structure.

In the secondary-recovery phase of the plant operation, retention in the system of all the light, valuable constituents is effected by efficient reabsorption of volatile light fractions flashed in reduction of pressures of the rich-oil stream from the high-pressure absorbers. By careful selection of optimum temperatures and pressures for rich-oil venting, a maximum amount of gas containing a minimum amount of valuable constituents is further processed in reabsorbers.

Steam is used exclusively throughout the plant, both for processing pumps and distillation heat. Because only high-gravity material is involved, no direct-fired furnaces are needed. Facilities include a complete closed condensate system for condensing all exhaust steam. Tube sections are provided in the cooling-tower for that purpose. Boiler feed-water make-up requirements are confined to replacement of only that steam used in distillation. Generating the steam are three 397-h.p., 250-lb. working-pressure water-tube boilers. A. H. N.

584.* Use of Extraneous Gas Prolongs Lifting Energy in Saxet Field. Anon. *Oil Gas J.*, 17.4.41, **39** (49), 172.—The high-pressure gas injected into the wells performs a double function, not only of providing the lifting medium for the oil production, but also the gas is returned to the surface to be recovered as vent gas from the separators, thus greatly augmenting the supply that would normally be produced with the oil. Under proration regulations, wells being produced under these conditions with high water yields are permitted a gas–oil ratio of 10,000 cu. ft. of gas/brl. in addition to the regular allowance of 3000 cu. ft./brl. granted flowing wells. Although dry when injected, the high-pressure gas normally picks up a certain amount of additional light-ends to be recovered in the gasoline-plant processing.

The plant has a total low-pressure absorption capacity of 70,000,000 cu. ft. of gas daily, although runs now are down to approximately 40,000,000 cu. ft. daily, due to decline of production in the oil-sands supplying the vented gas. At capacity, the plant was recovering approximately 40,000 gal. of gasoline daily, or at the rate of 0·571 gal./1000 cu. ft. of gas. With present runs, approximately 25,000 gal. (0·625 gal./1000 cu. ft.) are being produced.

Originally, a capacity of only 20,000,000 cu. ft. of gas daily was provided. Then the plant was designed to handle only the vent-gas produced with the oil from the 5800-ft. sand, which at that time was in its early stages of development. With that capacity the plant produced approximately 10,000 gal. ($\frac{1}{2}$ gal./1000 cu. ft.) daily.

Other details of the plant are given. A. H. N.

585.* Drilling Cost Primary Factor in Secondary Recovery. F. B. Taylor. *Oil Wkly*, 24.3.41, **101** (3), 14–16.—Certain budget factors have as much bearing on the financial success of secondary oil-recovery projects as probable production and revenue returns, and should be carefully considered by operators planning such operations. With narrow profit margins it is not enough to accept extremely rough estimates of costs and plot these against indicated revenues. Mid-Continent experience during the past several years, a period of vastly increased application of secondary-recovery programmes, has shown the largest single expense item involved is the cost of drilling new wells. Yet greater error has been made in calculating this figure than in any other factor.

Depth variations from 100 ft. to 1000 ft. do not effect a material difference in drilling costs. A well that can be drilled to 650 ft. for 80 cents/ft. cannot be drilled to 300 ft. on the same location for much less than 70 cents/ft. At about 900 ft. the per-foot cost does begin to indicate an increase, but to 1000 ft. this increase is not critical. Contractors and operators developing recovery projects point out that actual drilling time is more or less proportional to depth, but moving, shooting, cementing, and cleaning-out time is independent of depth.

Taking three specific areas, costs have been determined on a per-foot basis in North-east Oklahoma as averaging 61 cents on one project and 76 cents on another, with the latter figure including some minor equipment expense. In Kansas projects are being drilled from 85 to 92½ cents/ft. to a depth of 800 ft. In this area, in addition to a slight increase in the per-foot cost as a result of increased depth, there is more lime in the section, and consequently hole is a little slower to make. In North Texas, where conditions probably vary more than in any other comparable area, shallow drilling costs range from 55 cents to as high as 95 cents/ft.

Analyses of drilling costs on other projects have shown per-foot rates as low as 44 cents. The method of keeping cost accounts has much to do with per-well expense figures, and variations in formation result in minor changes from well to well. If equipment is added to the drilling cost, it should be part of the drilling function, not part of production equipment cost. A. H. N.

586.* Gas-Well Acidizing. G. L. Leach. *Oil Wkly*, 24.3.41, **101** (3), 17–20. *Paper presented before American Petroleum Institute.*—Special difficulties are encountered in the acidizing of Texas Panhandle wells because instead of pure limestone, dolomite, and dolomitic limestone, mixtures are generally encountered. These respond in an entirely different manner from regular acid. Being comprised of complex magnesium–

calcium carbonates with varying amounts of silicates, sand, granite, chert, shale, iron, and alumina, and frequently with large quantities of gypsum, anhydrite, and selenite, they react much more slowly. Many iron and aluminium compounds will dissolve in hydrochloric acid, but as the acidity of the treating solution decreases these compounds reprecipitate out of solution as highly flocculent, gelatinous hydroxides. Such precipitates occupy at least forty times the space of the original oxides and may contribute to the damming or plugging of the drainage pores.

Laboratory and field research has resulted in new acidizing methods which overcome many of the difficulties encountered. Some of the more important improvements involving addition agents for acid having particular application to Panhandle acidizing are: (1) intensifier to increase the rate of reaction of acid on slowly soluble dolomites; (2) retarding agents to slow down the rate of reaction and allow for further penetration away from the well-bore; (3) low surface tension and wetting agents to decrease the resistance to flow of both fresh acid and spent acid solution; (4) stabilizers to reduce secondary precipitation of iron and aluminium; (5) inhibitors to eliminate corrosion of the casing and tubing.

Except in unusual conditions, gas-well treatments are made down the casing. As a first step, the well is blown to the air until clean of fluid and shut in. After suitable well-head connections have been made and the hole measured up to check that it is open to bottom, the first stage is ready to begin. Usually in the first stage 1000 gals. of acid are pumped in the casing and the compressor is immediately started. From the commencement of the treatment until its completion casing pressures are recorded at frequent intervals. Fluid levels as determined with a float on the measuring line are included in the records.

Displacement of the fluid is continued until first, a pressure break is experienced; and second, the fluid level, as measured with the float, remains constant. This indicates that gas is entering the formation at that point, and that no more fluid can be displaced from the well-bore.

After 1 hour or less, depending on the type of acid and auxiliary chemicals used and the character of the formation, the well is opened and allowed to blow to the air until clean of fluid. The first stage serves mainly to clean the pore-space in the immediate vicinity of the hole preparatory to the treatment proper. This treatment is usually a repetition of the same procedure but utilizing larger quantities of acid.

Other details and methods are described. A. H. N.

587.* Economics of Chemical Treating Crude Oil Emulsions. C. Hetherington, L. Battle, P. Haskett, and R. L. Huntington. *Oil Wkly*, 24.3.41, **101** (3), 33–34.—An item of considerable expense on some leases is that of treating water-cut oil production. When using chemical or soap treatment for this purpose, the desired improvement in relationship between operating expenditures and income may be accomplished by balancing chemical or soap cost against vapour losses caused by high treating temperatures. In this article the economics of a specific case are analysed, both graphically and mathematically, in order to determine the optimum operating conditions. It is thought that this example may show producers how costs on this phase may be lowered. The solutions use a balance between heating cost, soap cost, and loss in price of oil due to evaporation under high temperatures. A. H. N.

588.* Automatic Crude-Treating Plant Operates Continuously Without Attendance. Anon. *Oil Wkly*, 14.4.41, **101** (6), 20–22.—The plant, besides auxiliary equipment, contains: two electrically operated dehydrating vessels, for removing the water from the oil; two oil and gas separators, one of which removes the free gas and the other the vapours produced by heating of the oil; a double setting of oil heaters and coolers, one section operating on a cold-and-hot oil exchange and the other on an oil-and-steam exchange; one common oil-field-type boiler equipped to operate at a maximum pressure of 15 lb.; two stock-tanks, one to receive the oil from the treater while the other is being emptied into the pipe-line.

Water separated from the fluid is re-circulated by a small motor-driven centrifugal pump. This holds the emulsion-cake layer, which invariably lies between the water and the partly treated oil, to a minimum, and permits the electrodes in the electrified zone to remain clean. It has been found that re-circulation of the hot water through the vessel helps to provide effective treating. The quantity of water separated averages 7½ brls./hr.

The steam line between the exchanger and boiler dome runs overhead on an " A " frame fabricated from pipe. In this line, near the exchanger inlets, is a control valve that regulates the volume of steam passed from the boiler to the heaters, thus providing a means of having a constant predetermined temperature. This steam-control valve is actuated by an adjustable recorder-controller, located on a small panel at the control end of the steam exchangers. The steam-control valve is protected from the weather by a hooded cover, in which is a receptacle for unused charts.

Details of the plant are illustrated by photographs and diagrams and discussed at some length. A. H. N.

589.* Hydraulic Pumps used to Produce Prorated Wells. J. N. Miles. *Oil Wkly*, 21.4.41, **101** (7), 11–14.—In order to obtain the most attractive investment, operating, and maintenance picture possible, the producing equipment installed at the well must be an economical investment from the first cost to and through a long life of efficient operation, with low supervision and operating expense.

Some of the requirements pumping equipment must meet in order to satisfy the above financial and operating problems are : (1) Low investment cost. (2) Low operating expense. (3) Capacity to produce 15 brls./hr. over short periods for the determination of potentials. (4) Capable of producing at low rates for slow withdrawal purposes. (5) Capable of being used on as many types of wells as possible. (6) High operating efficiency at all rates of production. (7) Simplicity of operation to permit a minimum of direct labour and supervision charges. To meet these requirements twenty-five hydraulic pumps are used, drawing power from five central power-plants.

One central power-plant furnishes power-oil to actuate eight 2½-in. hydraulic bottom-hole pumps, each having maximum production capacity of 500 brls./day. The other four plants do not have a complete number of wells connected. They are equipped with 5000 lb. maximum pressure, 400-brls./day-capacity triplex pumps, being driven by 217-cu.-in. multi-cylinder gas-engines and one by a 202-cu.-in. multi-cylinder gas-engine.

It was first thought necessary to install the 2½-in. production unit in order to have a pump capable of producing 15 brls./hr. during the modified potential tests now used in Kansas, but by the use of higher operating pressure it was found that the 2-in. production unit was capable of producing 15 or more brls./hr. for the short period necessary to establish a potential test. This reduction in size of pump allowed a reduction in tubing sizes and an overall decrease in per-well costs.

All bottom-hole hydraulic pumps connected to the small high-pressure triplex power units are of the 2-in. size. It was necessary to use a high-pressure surface pump on the last four installations in order to pump 15 brls./hr. with the 2-in. bottom-hole pumps which are normally rated at 11·25 brls./hr.

Costs are discussed and found favourable.

Methods of paraffin removal are outlined. A study of the removal and prevention of paraffin accumulation is being continued, and more information should be available at a later date.

The hydraulic pump being used on these leases can operate in wells with a fluid-lift of 6000 ft. by the application of high pressure to the power oil, or it will operate in wells with a shallow lift. This adaptability to wells of wide variation in depth and its flexibility in production capacity allow this one-size pump to be used in many different areas. A. H. N.

590.* Mud Removal During Completion Increases Well Initial. Anon. *Oil Wkly*, 21.4.41, **101** (7), 15.—A review is given of difficulties which finally resulted in the development of the relatively new completion technique, which provides improved washing methods for cleaning the walls of the hole. The new practice features the principle that mud removal from the wall of the hole is necessary, and accomplishes this by a combination of abrasion and circulation.

The procedure, used for both new completions and work-overs at Wilmington in twenty-five cases, has been to mount wall-cleaning guides at spaced intervals on the outside of the liner or screen throughout its entire length. These wall-cleaning guides are collars on which oil-tempered spring-steel wires or abrading members are mounted.

Circulation is confined to the space between the liner or screen and the wall by installing a wash-pipe assembly. The entire assembly of perforated or gravel-packed liner, together with the washing unit, is run in on the drill-pipe or tubing.

After reaching bottom, circulation is first established and continued as the liner is alternately raised and lowered in increasing amounts until the travel is slightly greater than the spacing between the wall-cleaning guides. Repeated movements abrade the wall, and circulation with oil or clear water removes the mud and bit cuttings which make up the filter-cake formed during drilling operations.

Return circulation from bottom shows large amounts of this material removed from the walls by the scratching action of the spring-steel wires. The character, particle size, and amount removed explain the satisfactory completions obtained by the procedure.

A report on a work-over job in the extreme south-western corner of the Wilmington field—an area which yields heavy oil—shows an increase in production from 18 brls. to 145 brls. daily through gravel-packed liner. Farther to the north-west a work-over job resulted in a 200-brl. well, in contrast with the well's original output of 125 brls. daily a year earlier. A. H. N.

591.* Repressuring Profitable in Kansas Shoestring Sands. L. L. McWilliams. *Oil Wkly*, 21.4.41. **101** (7), 17–20. *Paper Presented before American Petroleum Institute.*—The oil in the pool is a dark-green colour, of paraffinic base, and sweet, and quite desirable at refineries, having about a 35% gasoline cut and good lubricating qualities. The viscosity is believed to be about 5 centipoises, which is considered excellent for repressure purposes. The original gravity was about 40–42° A.P.I. It has been reported in some instances, however, where repressuring has raised the gravity, that little use is made of such information. These pools were developed before the advent of bottom-hole sampling, consequently it is not known whether the oil was saturated at the original bottom-hole pressure.

Although the spacing patterns are not consistent, the average ratio of input to producing wells will vary from a minimum of 1 to 3 and a maximum of 1 to 7.

The media for injection into the input wells is air, recycle, and purchased gas; however, gas is the more desirable and the most widely used. The policy of the operators varies as to the media injected. The majority of operators feel that the purchase of outside gas to supplement the recycle gas is justified. In two projects the operator supplements the recycle gas with as much as 25% air and reports no apparent detrimental effects. There are several sources of purchased gas in these areas; however, most of the pools are supplied by one major gas company which has lines in the area.

The injection pressures and volumes vary considerably in individual pools. On projects where data are available the injection pressures are observed to vary from 20 to 550 lb. The higher pressures are noted to be in the poorer pools or in the poorer parts of the individual pools. The input volumes are observed to vary from 10 to 300 M.C.F./well/day, and the average volume/well is observed to vary greatly between some pools. The variance in input volumes for the individual pools is primarily attributed to the difference in opinion of the operators.

A very important development during the last few years has been the unitization of properties within the individual pools. The operators are usually quite agreeable to unitizing their properties and on some basis such as past production, producing wells, and current oil production. Unitization has many advantages from the standpoint of operation and repressuring. Naturally, with unitized operation, well-operating costs can be reduced. Unitization offers the cheapest repressure costs to the operators, in addition to the most flexible programme for input-well spacing and input volumes. In several of the major projects it is doubtful if widespread repressuring could have been effected without unitization.

An interesting development which is increasing in application is the injection of small volumes of water together with the input gas. The essential idea is to reduce the movement of gas through the more permeable streaks of sand. Although this practice is still in the experimental stage, it is known that in one instance the gas/oil ratio of wells off-setting the input wells was reduced and in another instance the oil production on off-set producing wells is reported as increased. A. H. N.

592.* Breaking Oil-Water Emulsions in the Storm Field, Illinois. J. C. Albright. *Petrol. Engr,* April 1941, **12** (7), 25.—Because of the peculiarity of the emulsion, settling at atmospheric temperature was not successful, and it was observed that the cut oil should be heated to a high temperature, and chemicals added to obtain a satisfactory break. In some instances heating with the addition of chemicals was not sufficient to reduce the oil to pipe-line grade on a once-through pass from the separators to stock tanks, requiring re-circulation by means of pumps. On most leases, however, the once-through application of heat and chemicals reduces the cut oil to a satisfactory pipe-line grade.

The type of equipment most commonly employed at Storms for treating emulsified oil consists of the usual stock-tank battery, a treating-tank with a down-comer or flume, which places the heated oil and emulsion on the floor of the vessel, so that when the oil being treated begins to rise it is forced through a body of warm water to the outlet at the top. Oil then passes to a second tank for siphoning-off the water released at this point.

The wells are usually single-trapped to separate the oil from the gas, with the flow-line running to the battery and water-separator. But to heat this oil, and successfully treat it, there is placed in the flow-line a tubular-type furnace with automatic equipment for maintaining the required conditions while the well, or wells, flow through the apparatus. A. H. N.

593.* Machine-Design Problems Encountered in the Petroleum Industry. M. L. Begeman and V. L. Doughtie, *Petrol. Engr,* April 1941, **12** (7), 29–32.—All the following factors should be at least considered in a properly designed member: strength, rigidity, fatigue, corrosion, wear-resisting qualities, safe operation, and economical operation. Some thought should be given to general appearance, but in equipment of this type it is not of primary importance. Accessibility, ease of repair, and lubrication are to be expected in any good design.

One of the most difficult items to determine in machine design is the allowable or design stress. This stress is defined as the ultimate strength of a material divided by the factor of safety. Usually the ultimate tensile stress and yield-point in tension are known, but information regarding shear, compression, and endurance limits is frequently not available.

To determine the factor of safety, first the type of loading—*i.e.*, whether the load is static or dynamic—should be ascertained. With static loads the real carrying strength of a material is the yield-point. Under such conditions the apparent factor of safety is the product of two factors, one to reduce the strength of the material from the ultimate to the yield-point, and the other—called the real factor of safety—is to care for emergencies and unknowns. The first factor is from 1½ to 2, and the second is 1½ to 2 for steel, 2 to 3 for cast iron, and 3 to 4 for wood.

The real carrying strength for live loads depends not on the yield-point, but on the endurance limit of the material. If the endurance limit for the type of load applied is known, therefore, the design stress would be determined by dividing the endurance limit by a real factor of safety. The endurance limit will depend on the type of loading—*i.e.*, whether the load is reversed in one direction or completely reversed—on the number of repetitions of stress, and whether gradually applied or impact. Thus the apparent factor of safety is the product of four factors which are defined and discussed.

A general study is made of designing bearings and bolts and of material selection for different jobs. A. H. N.

594.* Gas-Lift in Combination with Other Production Methods. S. F. Shaw. *Petrol. Engr,* April 1941, **12** (7), 56.—Three types of combination gas-lift are discussed: (1) gas-lift with beam pump or other plunger-pump equipment; (2) gas-lift with electrical submersible centrifugal pump; (3) gas-lift with hydraulic pump.

A typical example of the first type is the Jackson pump, which was tried in a few wells in the Oklahoma City field, and gave some promise of success, and in a few wells seemed to operate fairly successfully for a short period. This combination method consisted of a plunger pump run on a tubing string to the bottom of the well. A packer was run on the tubing to seal-off the annular space between the tubing and the casing, at a short distance above the pump. Compressed gas was introduced through the casing and used to operate the pump. The oil lifted by the pump, together with the exhaust gas that had been employed to drive the pump, were lifted to the surface through the gas-lift column by means of the gas-lift action of the expanding gas.

The centrifugal-pump combination method operated to best advantage in wells that had been completed with the casings of larger diameters, which in this field were as large as 9⅝-in. O.D., and in many of these wells with this larger diameter of casing the tubing was of 3-in. diameter, thus reducing the friction loss due to the passage of the gas from the surface to the point where the tubing is perforated above the packer.

The oil picked up by the centrifugal pump was lifted to a point above the packer where the tubing was perforated, thus allowing the oil to pass into the casing at that point. The compressed gas was pumped down the tubing to these perforations and passed out into the casing, mixing with the oil and lifting it to the surface.

A few installations of hydraulic pumps in combination with gas-lift have been made in the Oklahoma City field. In this method the hydraulic pump is run on the lower end of a string of 5-in. casing, with a packer set at about 500 ft. above the pump, and the oil passing through the pump was lifted through this larger pipe to perforations in the pipe above the packer, and then passed into the casing. The oil-producing pump is driven by power-oil pumped by a triplex pump on the surface through a string of 1¼-in. tubing, which is run inside the 3-in. tubing. The gas employed for lifting the oil is admitted at the surface to the annular space between the 3-in. and 1¼-in. tubing strings, passes downward to the power end of the pump, operates the pump, then exhausts into the flow of oil that is pumped from the well, and passes into the casing above the packer. From the perforations above the packer the oil is lifted by the gas that passes down through the annular space.

All three methods are illustrated, and certain difficulties encountered in their use and other characteristics are detailed. A. H. N.

595.* Acidizing to Remove Drilling-Mud and to Clean-up Sandstone Formations. S. C. Morian. *Petrol. Engr*, April 1941, **12** (7), 67.—To deal with the problem of removing mud-sheaths, " mud acid " was developed. Mud acid is composed of chemicals capable of dissolving and disintegrating practically all types of bentonitic clays such as are used in drilling-muds, and also many of the clay-like compounds that are a part of the reservoir rock itself. It also contains surface-tension lowering and wetting agents that aid in the removal of water that may have entered the formation from the drilling-mud when a well was drilled-in. The surface tension-lowering agents chosen specifically for mud acid permit the treating solution to be squeezed into the formation at lower pressures, give better penetration into the minute pore spaces, and more easily effect removal of the reaction products from the formation. Wetting agents and emulsion preventers are selected for each treatment according to the type of crude oil produced from the particular well being treated. A table and a graph show that mud acid will dissolve ⅓ lb. of a typical bentonitic mud, as compared with practically none in 15% hydrochloric acid.

The selection of a well, pool, or area producing from a sand formation where mud acid might be used beneficially should be guided largely by : (1) core analysis ; (2) initial completion methods ; and (3) decline curve behaviour.

Wells of the following types are suitable subjects for mud-acid treatments : (1) Any well the core examination of which shows 10–20% or more bentonite. (2) Any well surrounded by better producers in the same formation. (3) Any well that has been worked-over using drilling-mud or water in the operation. (4) Any well that has been completed recently. (5) Any well making water and oil in certain quantities or ratios. (6) Any well where strainer arrangement is set.

For recycling operations in gas-condensate fields, the injection pressures necessary in order that large volumes of gas may be injected into the intake well have in many cases been in excess of 3000 lb. The horse-power requirements in compressing gas to these high pressures is a very serious problem, so that any method of reducing the high input pressures or of increasing the input volume at constant pressure results in a tremendous saving in horse-power and consequently in operating expense. Mud acid has been used to increase the permeability and porosity of the area near the well-bore of gas-injection wells, and the results have been outstanding in the degree of success experienced in reducing the input pressures and increasing the capacity of the key wells. A. H. N.

596. Patents on Production. J. H. Howard. U.S.P. 2,234,493, 11.3.41. Appl. 19.7.38. Well-completing device consisting of a hollow tool-joint having a screw-threaded socket at its upper end and a reduced intermediate portion provided with coarse screw-threads and a wrench pin on the lower end of the joint.

V. B. Zacher. U.S.P. 2,234,790, 11.3.41. Appl. 13.2.39. Mud-wall disintegrator consisting of a weak acid and a salt which, on reaction, yield products which disintegrate the mud-sheath.

F. H. Ohland. U.S.P. 2,234,977, 18.3.41. Appl. 19.2.38. Sand-pump which induces a surge of liquid into the cylinder.

R. T. Cloud. U.S.P. 2,235,064, 18.3.41. Appl. 16.7.38. Determination of densities of fluids in wells by means of a weight suspended on a spring.

C. A. Shope. U.S.P. 2,235,265, 18.3.41. Appl. 5.6.39. Sucker-rod rack with a ratchet wheel.

F. C. Koch. U.S.P. 2,235,639, 18.3.41. Appl. 10.5.38. Resolution of oil and water emulsions.

I. X. Calhoun. U.S.P. 2,237,303, 8.4.41. Appl. 1.6.38. Pumping mechanism for oil-wells of the reciprocating type, fitted with pneumatic counterbalance between the walking-beam and the sucker-rod connection and utilizing the compressibility of air.

C. F. Prutton. U.S.P. 2,237,313, 8.4.41. Appl. 24. 12. 38. Method of treating well-bore walls with a liquid sealing mixture to seal the fine pores and then forming flow channels by means of explosives.

E. K. Burgher. U.S.P. 2,237,408, 8.4.41. Appl. 18.11.38. Well-pumping apparatus with a lift-tube and a piston which is stationary while the well-fluid is accumulating above it, and is moving when fluid under pressure acts upon it.

H. C. Block. U.S.P. 2,237,544, 8.4.41. Appl. 21.5.38. Collapsing tool seal for a well-bottom assembly.

C. C. Myracle. U.S.P. 2,237,612, 8.4.41. Appl. 8.8.39. Apparatus for washing perforations.

H. R. Mark. U.S.P. 2,237,680, 8.4.41. Appl. 13.12.37. Well cap.

D. W. Hoferer. U.S.P. 2,237,703, 8.4.41. Appl. 24.5.38. Well-pump lock for suspending a well-pump from a tubing-shoe having an internal seat and an opening of uniform diameter.

J. C. Donaldson. U.S.P. 2,237,863, 8.4.41. Appl. 23.2.40. Combined guide and scraper designed to encircle a well-string.

S. L. McCumber and F. Buck. U.S.P. 2,238,423, 15.4.41. Appl. 30.9.30. Tubing-rack in combination with a derrick structure.

D. H. Crepeau. U.S.P. 2,238,462, 15.4.41. Appl. 1.5.40. Pipe-joint.

E. H. McClease. U.S.P. 2,238,533, 15.4.41. Appl. 17.12.38. Tubing attached reinforcing trapping strainer adapted for lowering and pulling in a well and for occasional reciprocation to break up sand-bridges without pulling the well-tubing or assembly when attached.

J. C. Woodhouse. U.S.P. 2,238,671, 15.4.41. Appl. 9.2.40. Method of treating wells to increase production by introducing into the well a readily hydrolyzable substance.

B. McCollum. U.S.P. 2,238,701, 15.4.41. Appl. 9.1.39. Method of recovering oil from oil- and gas-bearing sands by returning the gas from one well into another.
A. H. N.

Transport and Storage.

597.* Constancy of Application is Important Factor in Cathodic Protection. N. Williams. *Oil Gas J.*, 5.12.40, **39** (30), 53.—Results of work carried out by Houston Pipe-line Co. over several years on the application of cathodic protection for its lines have led to the conclusion that one of the most important factors is the constancy with which the protective potential is maintained.

It has been established that with the cessation of the electric charge producing the cathodic protection the potential built up gradually dissipates. Research has indicated that corrosion of iron ceases when the negative potential built up is below −0·2853, and the problem of maintaining a negative charge below this point has been given particular consideration.

Where purchased power is not available, wind-driven generators are provided, and these are entirely dependent on wind conditions. To take care of the periods when the wind-charger is not working, the Company has installed two wind-chargers, one charging direct to the line and the other charging batteries. As soon as these chargers cease to function the storage battery is automatically cut in.

The discharge rate of the battery is only about one-quarter the average current supplied by the larger direct wind-charger, but it has been found adequate to hold the negative potential of the line over almost any period the wind-chargers might ordinarily be out of action.
D. L. S.

598.* Tank Contents Nomograph. D. S. Davis. *Industr. Engng Chem.*, 1940, **32** (10), 1412.—A nomograph is given which enables the volume of the contents of a horizontal cylindrical tank to be computed from the depth expressed as a percentage of the diameter.
J. W. H.

599.* Economic Pipe-size in the Transportation of Viscous and Nonviscous Fluids. B. R. Sarcket and A. P. Colburn. *Industr. Engng Chem.*, 1940, **32** (9), 1249.—A nomograph is given which enables the economic pipe-size at which pipe and pumping costs are at a minimum to be determined from a knowledge of the density, viscosity, and flow-rate.
J. W. H.

Crude Petroleum.

600.* Cracking Eastern Venezuelan Crude Oil. G. B. Zimmerman, D. Read, and G. Egloff. *Oil Gas J.*, 26.12.40, **39** (33), 141.—An examinatiom has been made of Temblador crude from Eastern Venezuela, showing yields on distillation to fuel and cracking results on a Dubbs pilot plant of topped and reduced crude. Temblador crude is a heavy asphaltic oil with specific gravity 0·920, sulphur 0·90%, cold test < −35° F., and viscosity S.U. at 100° F. of 191 secs. On laboratory distillation it yields (by vol.) 12·1% gasoline (23% to 100, E.Pt. 204° C., O.N. 65·5), 17·7% of kerosine, and 70% of residue (viscosity 134 secs. S.F. at 122° F.). The topped crude after removal of gasoline has a viscosity of 63·2 S.U. at 210° F. On cracking, the (*a*) reduced and (*b*) topped crudes yield respectively (by vol.) (*a*) 30·3% of gasoline (40% to 100° C. 204° C. E.Pt. O.N. 74) and (*b*) 32·4% of gasoline (of similar characteristics) and (*a*) 65·5% of residue (viscosity 224 S.F. at 122° F.) and (*b*) 63·0% of residue (viscosity 446 S.F. at 122° F.).

The straight-run gasoline is highly aromatic, and suitable for the production of aviation base-stock. The cracked gasoline contains 0·37% sulphur and is very sour, but is rendered satisfactory by vapour-phase clay treatment or acid-washing. The cracked gases (analysis given) can be polymerized to yield 2·4% of polymer gasoline.
C. L. G.

Cracking.

601.* Economic Factors in Catalytic Cracking. J. S. Carey and H. W. Ortendahl. *Oil Gas J.*, 17.10.40, **39** (23), 55.—Thermal cracking is now a well-established process, but the advent of catalytic cracking has brought additional variables and concepts which have to be considered.

The chief of these are :—

1. Catalyst activity.
2. Space rate.
3. On-stream operating conditions (temperature, pressure, etc.).
4. Regeneration conditions (amount of carbon to be removed, heat removal, and the related temperature control).

In this paper catalyst activity is defined by results obtained on a standard charging stock under standard conditions when operating a standardized type of laboratory pilot plant. It is essential that the catalyst be of a type that is easily regenerated.

With a fixed catalyst activity the space rate becomes the next prime factor. Thus for a given stock it is possible to vary the yield of once-through gasoline over a wide range. In this way a refiner may operate his plant to give him an amount of catalytic gas oil to use on his thermal cracking-plant.

The operation of a catalytic plant with a typical feed-stock is discussed, and yields, working costs, etc., are fully dealt with.

The authors conclude by stating their belief that the Houdry process has pointed the way to a new concept for the economic production of high-octane motor fuel.

D. L. S.

602. Patents on Cracking. Standard Oil Development Co. E.P. 534,856, 20.3.41. Appl. 15.9.39. Production of valuable low-boiling products, suitable for gasoline, from heavier hydrocarbons. The oil, which must be capable of being completely vaporized under cracking conditions, is forced through a pipe-coil while under sub-atmospheric pressure of at least 200 lb. per sq. in. and heated during its flow therethrough to 800–850° F., so as to cause complete vaporization. After vaporization a solid natural or synthetic siliceous cracking catalyst is added and contact maintained between the oil vapour and the catalyst for sufficiently long to effect substantial conversion of the oil into gasoline.

E. A. Ocon. E.P. 534,970, 25.3.41. Appl. 22.6.39. Production of motor fuel by cracking petroleum hydrocarbons, mixing the cracked product with highly oxidized unsaturated aliphatic hydrocarbons and reducing gases. Subsequently vapours boiling mainly below the gasoline range are separated out, together with the gases, and are caused to react in the presence of an alkaline metal base and a metal oxide dehydration catalyst.

G. W. Johnson. E.P. 535,049, 27.3.41. Appl. 8.9.38. Process for cracking hydrocarbon oils, in particular heavy benzine or middle oils. The initial material is passed in vapour phase over catalysts rigidly arranged. As catalysts natural or synthetic aluminium silicates may be used, and, if desired, these may have been treated with acids—*e.g.*, hydrofluoric acid. Alternatively, alumina or active carbon can be employed, or one or other of these substances in conjunction with the oxides of chromium, molybdenum, or zinc.

J. G. Alther. U.S.P. 2,236,083, 25.3.41. Appl. 5.5.39. Process for the catalytic conversion of hydrocarbon oils. Relatively light and heavy oils are subjected to independently controlled catalytic cracking in separate cracking zones. The resultant heated products are thereafter discharged from both zones into a reaction zone and subjected to the same non-catalytic cracking. Vapours are then removed, fractionated to form relatively light and heavy reflux condensates, and these supplied respectively to the light-oil cracking zone and the heavy-oil cracking zone. Finally the fractionated vapours are condensed.

H. B. M.

Hydrogenation.

603.* Rôle of the Catalyst. Homer Adkins. *Industr. Engng Chem.*, 1940, **32** (9), 1189.—In this article the author discusses in a general manner the requirements of catalysts in organic reactions, with particular reference to hydrogenation.

A catalyst is defined as a substance that accelerates or causes a reaction to take place. The characteristics of an effective catalyst are discussed, and it is stated that such a catalyst for hydrogenation must combine, in addition to maintaining its active state under reaction conditions, the following properties :

1. It must adsorb and activate hydrogen.
2. It must adsorb and activate the hydrogen acceptor.
3. It must hold them in the proper ratio and space relationship.
4. It must desorb the desired product.

The remaining topics discussed are : competitive reactions, effect of hydrogen pressure, active centres, selectivity of the catalyst, chemical structure of the reactants, equilibria and chemical rates, and catalyst poisoning. H. E. T.

604.* Catalysts from Alloys. M. Raney. *Industr. Engng Chem.*, 1940, **32** (9), 1199.—Efficient nickel catalysts may readily be prepared from alloys of metals. The simplest form of alloy consists of two components, one being the catalytic material and the other a substance easily soluble in a solvent which does not attack the catalytic material. Some alloys of this type consist of mixtures of nickel and aluminium. The actual composition of the alloy in the most useful range is complex, and is probably made up of several combinations of nickel and aluminium, with perhaps traces of the free metals. Many alloys within the practical working range produce equally efficient catalysts. Some of the most useful proportions of nickel and aluminium for the alloy are : 50% Ni–50% Al, 42 Ni–58 Al, and 30 Ni–70 Al. These percentages correspond approximately to the nickel–aluminium compositions $NiAl_2$, $NiAl_3$, and $NiAl_5$, respectively. The latest studies of the nickel–aluminium system indicate the existence of Ni_3Al, $NiAl$, and Ni_2Al_3, but not of $NiAl_2$ or $NiAl_5$. Catalyst alloys of Ni–Al have little if any other uses. A 50–50 nickel–aluminium alloy, employed for making a finely divided nickel catalyst, has few of the physical properties of either nickel or aluminium. It is not ductile or malleable, has little tensile or compressive strength, and, in common with aluminium, is non-magnetic. It has a high melting point, cools rapidly, and is difficult to cast. It is friable and easily crumbled and reduced to a fine powder.

The equipment required for preparing nickel catalysts from nickel–aluminium alloys is of the simplest type, consisting in general of a mixing and drying tank.

The catalytic properties of nickel catalysts prepared from alloys are different in many respects from those of nickel catalysts prepared by other methods. A graph is given showing that cotton-seed oil hydrogenated with : (*a*) 0·5% Ravey nickel and (*b*) 0·5% reduced nickel, gave substantially the same product, indicating that catalysts of widely differing physical properties have practically equal hydrogenating characteristics. The Raney nickel catalyst was about 167 mesh and the reduced nickel about 325 mesh. The Raney catalyst was pyrophoric, whilst the reduced nickel was not. The maximum temperature employed in hydrogenating the cotton-seed oil was 385–390° F. under a pressure of 15 lb. per sq. in. H. E. T.

605.* Hydrogenation of Petroleum. E. V. Murphree, C. L. Brown, and E. J. Gohr. *Industr. Engng Chem.*, 1940, **32** (9), 1203.—In the petroleum industry the hydrogenation process has been adapted to the following processes :—

1. High-octane-number aviation gasoline production from kerosine and gas-oil fractions.
2. Motor gasoline production from gas oils.
3. Aviation blending agent production by saturation of branched-chain polymers.
4. Production of high-grade diesel fuels from low-quality gas oils.
5. Production of water-white paraffinic kerosines from inferior-quality distillates.

6. Production of high-viscosity-index lubricating oils from poor-quality lubricating distillates.
7. Refining (or " hydrofining ") of gasolines to low sulphur content and high stability.
8. Conversion of asphaltic crudes and refinery residues into lower-boiling gas ores of increased paraffinity.
9. Preparation of low-aniline-point high-solvency naphthas.
10. Preparation of high-flash–high-octane-number safety fuels.

The theoretical background of these various applications of hydrogenation is briefly discussed, and the commercial application of the more important processes are given in some detail. The economics of such processes are discussed. H. E. T.

606. Patent on Hydrogenation. Standard Oil Development Co. E.P. 535,091, 28.3.41. Appl. 19.9.39. Improved methods of dehydrogenating hydrocarbons, particularly commercial naphthas and other stocks boiling within or somewhat above the gasoline range. The catalysts employed are complex bodies containing nickel borate. H. B. M.

Polymerization.

607. Patents on Polymerization and Alkylation. Standard Oil Development Co. E.P. 534,456, 7.3.41. Appl. 2.6.39. Improvement in the production of relatively low-boiling saturated aliphatic hydrocarbons useful in the preparation of gasolines. A mono-olefin containing not more than 5 carbon atoms in the molecule is reacted with more than the molecular equivalent of an *iso*paraffin boiling below or within the gasoline range in the presence of a double salt complex catalyst. The reactants are maintained in contact with the catalyst for a sufficiently long period of time for saturated liquid hydrocarbons boiling within the gasoline range to be produced.

J. G. Fife. E.P. 534,492, 7.3.41. Appl. 28.9.39. Production of liquid-saturated benzine hydrocarbons. *iso*Paraffins are alkylated by reaction with alkenes in the presence of catalysts comprising strong inorganic polybasic acids and boron halides. The reaction mixture contains at least one molecule of *iso*paraffin per molecule of olefin.

C. Arnold. E.P. 534,539, 10.3.41. Appl. 8.9.39. Process of destructive alkylation for the production of motor fuels. Normally liquid hydrocarbons and normally gaseous hydrocarbons substantially free from hydrogen and methane are passed through a reaction zone at a temperature between 950° and 1050° F. and at a pressure between 500 and 1000 lb. per square inch in contact with a catalyst containing chromic oxide. Thereafter the reaction products are removed, and liquid hydrocarbon fractions suitable for use as motor fuel separated out.

N.V. de Bataafsche Petroleum Maatschappij. E.P. 534,876, 20.3.41. Appl. 9.11.39. Production of liquid-saturated hydrocarbons having high anti-knock values and being suitable for use in aero-engines, by thoroughly contacting neutral sulphuric acid alkyl esters in the presence of sulphuric acid of at least 85% concentration with *iso*alkanes.

Anglo-Iranian Oil Co., E.P. 535,062, 27.3.41. Appl. 21.9.39. Use of inexpensive materials as phosphoric acid catalysts in the polymerization of olefines, hydration of olefines and for use in other known reactions in which such catalysts are indicated. The catalysts consist of homogeneous mixtures of compounds of phosphoric acid, calcium and copper in a neutral, dry, porous and consolidated state.

Standard Oil Development Co. E.P. 535,064, 27.3.41. Appl. 21.9.39. Improvements in the alkylation of hydrocarbons and in the production of saturated hydrocarbons boiling within the motor-fuel range. A mixture containing at least one *iso*paraffin boiling below the final boiling point of the desired motor fuel is reacted with at least one member of the group consisting of normally gaseous mono-olefins or low-molecular-weight polymers or co-polymers thereof in the presence of concentrated sulphuric acid containing an oxide of the fifth group of the periodic system.

N.V. de Bataafsche Petroleum Maatschippij. E.P. 535,142, 31.3.41. Appl. 27.11.39. Production of liquid saturated hydrocarbons by treating butanes and/or pentanes with hydrocarbons of aliphatic character, obtained by the polymerization of alkenes. The treatment is carried out in the presence of aluminium halides and of substances having an activating effect—*e.g.*, hydrogen chloride, alkyl chlorides.

N.V. de Bataafsche Petroleum Maatschappij. E.P. 535,145, 31.3.41. Appl. 19.1.40. Production of alkyl halides from alkenes and hydrogen halide in the presence of catalysts. A solution of an acid-acting metal or boron halide which is known to be a catalyst for the addition of hydrogen halide to the double bond of an alkene, in an ether is used as a catalyst.

E. R. Kanhofer. U.S.P. 2,234,177, 11.3.41. Appl. 4.11.38. Method of polymerization of normally gaseous olefins in the presence of a solid polymerizing catalyst to produce polymer gasoline therefrom.

E. T. Layng. U.S.P. 2,237,822, 8.4.41. Appl. 9.11.39. Method of conversion of olefinic hydrocarbons into hydrocarbons of higher boiling points by polymerization. The olefinic hydrocarbons are contacted at elevated temperature with a catalytic contact agent comprising as an essential ingredient an acid metal pyrophosphate selected from the group consisting of $CuH_2P_2O_7$, $HgH_2P_2O_7$, $ZnH_2P_2O_7$, $MgH_2P_2O_7$, $Fe_2H_6(P_2O_7)_3$, $Al_2H_6(P_2O_7)_3$, and $CoH_2P_2O_7$.

K. Frolich and F. L. Miller. U.S.P. 2,239,501, 22.4.41. Appl. 12.12.33. Process for increasing the stability of hydrocarbon polymers by partly decomposing a mixture of linear substantially saturated hydrocarbon polymers which are oil-soluble and contain unstable constituents of relatively high molecular weight. The unstable components are broken down to constituents of lower molecular weight. H. B. M.

Synthetic Products.

608.* The Nitroparaffins. C. L. Gabriel. *Industr. Engng Chem.*, 1940, **32** (7), 887.—The large-scale production of nitroparaffins opens up a new chapter in the development of the synthetic organic chemical industry. The first commercial unit for the manufacture of nitroparaffin started production at Peoria, Illinois, during 1940. Nitromethane, nitroethane, 1-nitropropane, and 2-nitropropane are being made in this plant. The above four lowest members of the nitroparaffin series are simultaneously formed when propane and nitric acid and nitrogen oxides are contacted at elevated temperatures. The nitroparaffins are separated as a crude reaction product from unconverted propane and nitrogen oxides. The individual nitroparaffins are then obtained by distillation and chemical purification. The main emphasis of this article is placed on the various chemical reactions of the nitroparaffins, which are discussed in some detail. Although many hundreds of organic compounds have been synthesized from nitroparaffins, the commercial utilization of this class of compounds offers wide scope in the field of organic synthesis. H. E. T.

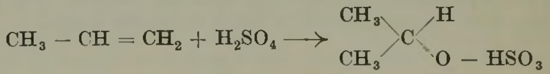
609.* Synthetic Chemicals from Petroleum. L. Rosenstein. *Oil Gas J.*, 14.11.40, **39** (29), 118. *Paper presented before Refining Division of A.P.I. Chicago, November* 1940.—The development in the production of synthetic chemicals from petroleum and natural gas by a major oil company is discussed and details are given of methods of production, properties, and applications of these products. Products manufactured include ammonia and ammonium sulphate (using sludge acid), *sec.*-buytl alcohol, *tert.*-butyl alcohol, *iso*propyl alcohol, acetone, methyl ethyl ketone, methyl *iso*butyl ketone, mesityl oxide, diacetone alcohol, *iso*propyl acetate and *sec.*-butyl acetate, *iso*propyl ether and carbon. A wide range of chemicals derived from the olefins by chlorination is produced on the semi-commercial scale, as also is butadiene. Possible development include the production of ethyl alcohol, glycol, and glycol ethers from ethylene, derivatives of acetylene (which can be produced from methane), etc.

The products have a high degree of purity and uniformity, their production entailing the development of special analytical procedures. Removal of *iso*butylene from the butylenes used for *sec.*-butyl alcohol synthesis by absorption in cold H_2SO_4 has led to the production of *iso*-octane on the large scale and to the development of the hot-acid polymerization and the alkylation processes. C. L. G.

610. Synthetic Super-fuels and Super-lubricants. C. H. Berthelot. *Chim. et Ind.*, Vol. 43, No. 7, April 1940, 538/548.—1. Reactions involved in the polymerization of olefines. Paper presented by Dr. Egloff at the Congres de Association Française pour l'Avancement des Sciences at Liége in July 1939.

Details are given of the polymerization process used by the U.O.P. This consists of isolating the butane contained in cracked gases and dehydrogenating to obtain a mixture of butane/butenes. The C_4 olefines are then polymerized at 250° C. and 40 atmos., the reaction taking place in the presence of phosphoric acid adsorbed on silica gel. In order to obtain the maximum yield it is essential that the butane/butenes should contain a certain percentage of water. The polymers are then rectified in two columns; the first serves to debutanize the polymers, the second separates the dimers (octenes) from the trimers. Finally, the dimers are hydrogenated in the presence of nickel and give octanes. The above results have also led to attempts to polymerize propene to produce *iso*hexane.

By hydrating 2 molecules of propene with 1 molecule of water, *iso*propyl ether is obtained, this substance having an anti-knock value slightly superior to that of pure *iso*octane. *iso*Propyl ether can be prepared from the propylene contained either in cracked gases or produced by the pyrolysis of natural gases. The C_3 hydrocarbons are easily separated from the rest by fractionation in a column fitted with plates, and are then treated under pressure in a scrubbing-tower with 75% H_2SO_4 at about 30° C., producing *iso*propyl/sulphuric acid and free propane



$$CH_3-CH=CH_2+H_2SO_4 \longrightarrow (CH_3)_2C(H)(O-HSO_3)$$

Hydrolysis of the acid solution gives *iso*propyl alcohol, which is then dehydrated by heating to about 100° C. The reaction is somewhat complex, and yields not only *iso*propyl ether, but also *iso*propyl alcohol and propylene, whilst the sulphuric acid is regenerated. The reaction products are separated by distillation followed by a rectification of the more volatile bodies, the propylene, acid, and alcohol being recycled for further reactions. *iso*Propyl ether is stated to be a dangerous compound owing to the ease with which it forms explosive peroxides under the action of heat. The explosive substance is largely the peroxide of tri-acetone, and it is only necessary to add a very small proportion of an anti-oxidant to prevent its formation. The anti-oxidant also acts as an inhibitor, and confers on the blends containing the *iso*propyl ether a very high stability. It is stated that from a European point of view *iso*propyl ether is cheaper to manufacture than *iso*-octane.

The U.O.P. process can also be used in the production of explosives by the transformation of aliphatic hydrocarbons into aromatics. The cycle is briefly as follows:

Hexane, heptane, or normal octane are treated in the presence of a catalyst (salts of chromium, molybdenum, or tungsten) adsorbed on alumina or clay. The reaction is carried out at about 700° C. and at atmospheric pressure, and yields benzene, toluene or orthoxylene.

For hexane the reaction is as follows:

$$CH_3-(CH_2)_4-CH_3 \longrightarrow C_6H_6+4H_2$$

and semi-plant-scale yields are stated to be about 75–90%. Owing, however, to parasitic reactions, the yield is in normal industrial practice below this figure, mainly due to the deposition on the catalyst of gums and tarry substances produced by the polymerization of certain olefines inevitably formed during the reaction.

M. M. L.

611.* Synthetic Rubbers. L. A. Wood. *Engineering*, 1940, **150**, pp. 316, 335, 356, and 419.—The trade names, manufacturers, and countries of origin of some thirty synthetic rubbers are given. These commercial products belong to ten chemical types. The structure of the monomer and unit polymer of each of these types is described, together with the principles of the syntheses. The physical properties are tabulated—viz., density, refractive index, electrical conductivity, dielectric constants, tensile strength, elongation, molecular weight, permeability to gases, water, and organic compounds, resistance to swelling in contact with petroleum products and organic solvents, and abrasion resistance. In general it is concluded that there are possibilities for use of synthetic rubbers in every application of natural rubber and in additional fields from which natural rubber is barred by some of its deficiencies. No synthetic rubber has so wide an application as natural rubber, but for a given application it is usually possible to select a type of synthetic rubber which excels natural rubber in some property of importance in that application. The values of certain of the specific uses of synthetic rubber are discussed. J. W. H.

612.* Synthesis and Octane Numbers of Some Unsaturated Alcohols and Diolefin Hydrocarbons. K. I. Karasev and A. V. Khabarova. *J. General Chem. U.S.S.R.*, 1940, **10** (18), 1641–1646. Translation by A. A. Boehtlingk. *For. Petrol. Tech.*, Feb. 1941, **9** (2), 42.—The following alcohols were synthesized : 5-methylhexene-1-OL-4, heptene-1-OL-4, heptene-2-OL-4, octene-2-OL-4, 6-methylheptene-2-OL-4, and the hydrocarbons heptadiene-1 : 4, heptadiene-2 : 4, 5-methylhexadiene-1 : 4, octadiene-1 : 4, and 6-methylheptadiene-2 : 4. The octane numbers were determined by the " Vokesh " method with an apparatus of the C.F.R. No. 3 type. The sulphone numbers were also determined to indicate the susceptibility of the hydrocarbons obtained to oxidation, and some constants of the chlorine and bromine derivatives were also investigated. Although the hydrocarbons had a high octane number (up to 130 O.N.), it was not sufficiently high to justify their utilization as anti-knock additions to motor fuels; moreover, their high oxidation ability would render them unsuitable for this purpose. Exceptions were found in the case of hydrocarbons with a normal structure with bonds in the 1 : 4-position which could be stored for quite a long time in contact with air without change. B. M. H. T.

Refining and Refinery Plant.

613.* Production of Aviation Motor Fuel from Natural Gasoline. K. E. Cody and D. M. Luntz. *Refiner*, April 1941, **20** (4), 112–116.—This article presents the results of evaluations which were made of two different natural gasolines to determine their potentialities as sources of base-stocks for the manufacture of aviation motor fuel. It was found that one of them contained appreciable quantities of a good base material, whilst the other was unsuitable for this purpose. This difference illustrates the danger inherent in failing to get accurate information as to the character of each stock it is desired to process. Thus, from a study of the results of the first evaluation it might have been erroneously concluded that a suitable-quality aviation fuel can be made from any natural gasoline by the method used.

The procedure consisted of debutanization, depentanization of the butane-free bottoms, since this butane-free material had too high a vapour pressure and was too light to meet the aviation distillation specifications, and then fortification of the depentanized material (with *iso*pentane) to meet the requirement of 7 lb. Reid vapour-pressure. *iso*Pentane was used as the blending agent, since in this way the clear octane number of the blend was made higher than if a mixture of normal and *iso*-pentane had been used. (*iso*Pentane's octane rating is about 92, whilst that of normal pentane is about 60.) Although other blending agents, such as alkylate, *iso*octane, *neo*hexane, or any combination of these, could have been used, they are not contained in the charge stock, as is the *iso*pentane, and, in addition to being less readily available, would be more expensive. At any rate, it is felt that the method used has the advantage of simplicity and gives results that are indicative of the ease or difficulty with which aviation gasoline can be made from the stock processed. A. H. N.

614.* Water Conditioning by Evaporator Method. L. L. Wakefield. *Refiner*, April 1941, **20** (4), 117–120.—The paper is confined to conditioning boiler-feed water and for engine-jacket cooling water by evaporator methods. The purpose of a water-conditioning system is to modify or eliminate the solids in the make-up water. Properly designed evaporators for providing distilled make-up water will keep the amount of total solids in the make-up water well below one-half grain/gall., which is equivalent to elimination of solids, even though the water fed to the evaporator has a concentration of 150–200 times this amount. However, it must not be considered that evaporation is the optimum treatment for all boiler-make-up waters.

Formerly the high percentage of boiler-feed make-up required in the typical industrial plant involved such a large investment for evaporators that usually it was difficult to justify their purchase. In recent years many improvements in the design of operating equipment have brought about reductions in water losses, thus reducing the amount of make-up required, and the practical and economical application of evaporators has been extended to an increasing number of industrial plants.

There are many and varied evaporator installations, but most of them will fall into one of the following three general classifications : (1) single-effect evaporators ; (2) multiple-effect evaporators ; (3) reducing-valve evaporators. These are briefly described.

A typical evaporator system is used to illustrate the problems of designing and working evaporator systems. The heating medium in the evaporator tubes is high-pressure steam (185 lb. gauge) direct from boilers. Condensate from these tubes is discharged by trap into a hot condensate header. Heated raw water from the raw-water heater enters the evaporator shell around the tubes, and high-pressure steam through the tubes.

Scale deposition on the outside of evaporator tubes is cracked off in the following manner : Steam to the tubes is shut off ; evaporator is then quickly emptied through the 6-in. blow-down line ; after which steam is opened full into tubes, expanding them to their maximum curvature (the tubes in the tube-bundle are of the bent-tube type) ; steam is again shut off and cold water is turned on full into the evaporator, completely submerging tube-bundle and splash-plate, thus contracting the tubes to their minimum curvature, cracking off the scale ; evaporator is again emptied through the 6-in. blow-down line to wash out the loose scale ; raw water is again turned into the evaporator, filling it to the proper level, and the operation starts another cycle.

A. H. N.

615.* Gum and Sulphur Removed from L.P.G. by Filtering. Anon. *Refiner*, April 1941, **20** (4), 127.—This filter is a vertical drum with a welded head at the top containing a 4-in. collar closed with a bull-plug. The collar is used for refilling the filter after cleaning. The filter-case is mounted on a 2-in. pipe tripod support set in concrete at the base of the filter. The lower end of the case has a flange welded to the body, to which may be connected a companion flange containing a drum-shaped head and the liquid outlet line. Between the two flanges is placed a slotted plate covered with a strip of filter cloth on which is placed 4 in. of hair felt to prevent the filtering agent from passing through the slotted supporting plate. The capacity of the case is 800 lb. of activated clay from Muroc Dry Lake in the Mojave Desert.

Since this filter has been placed in operation, all regulating equipment on engines using this fuel is free from the gummy film and all equipment is operating without disturbance. Tests on the filtered liquid with copper strips show no deposit or discoloration. Not only have the gums and sulphur been removed, but the product passes to storage tanks free from suspended water. A. H. N.

616.* Choice of Charging Stocks to Make High-Octane Fuels. H. N. La Croix. *Oil Gas J.*, 5.12.40, **39** (30), 50.—The new processes developed in the refining industry are highly dependent on chemical affinities and reactions, and successful operation requires consideration of equilibrium distributions, laws of mass action, and physical chemistry.

The preparation of high-octane gasolines is economically beyond the scope of simple thermal cracking, and requires the use of special processes—*e.g.*, polymerization, alkylation, etc.

The charging stocks are usually light hydrocarbons, and these are normally contaminated with organic impurities such as N or S compounds, which reduce the effective life of the catalysts employed. H_2S is one of the worst impurities from this point of view. It can, however, be easily removed by a number of methods, of which the most economical is the phosphate process.

One of the latest plants using this process is a liquid-extraction unit preparing liquid hydrocarbons for charging to a U.O.P. catalytic polymerization plant. This employs the Shell phosphate process using aqueous solutions of tri-potassium phosphate for removing H_2S.

The phosphate process is being used in many plants, and is attracting increasing attention of refiners as a simple and economical means of disposing of H_2S, and is especially valuable in the preparation of high-octane blending fuels. D. L. S.

617.* World Oil Refineries Survey. Anon. *Oil Gas J.*, 26.12.40, **39** (33), 66, 93.—A list is given of the location, type of plant, and the distillation and cracking capacity of the oil refineries of the world, including the U.S.A. C. L. G.

618.* Toluene-Benzene Purification. W. T. Ziegenham, *Oil Gas J.*, 2.1.41, **39** (34), 34.—A description is given of a chemical treating plant and fractionating unit with an unusually high degree of flexibility designed to recover practically pure benzene and toluene from coal-tar distillates of toluene content from 6 to 35%. The plant has a capacity of 20,000 gals. of coal-tar distillate per day, producing toluene and benzene distilling within a boiling range of 1° C., passing the Barrett acid wash No. 1 test, and showing negative corrosion, acidity, and H_2S test. Colours are 25+ and the benzene has a solidification point of +5° C.

The distillate is washed twice with 2% of acid (first with recycled, and then with new acid), caustic washed, and passed, after settling, to the fractionating unit, consisting of two 61-ft. columns. During the first run light paraffinic hydrocarbons are taken from the top of the first tower, and the residue, after reboiling, is passed to the second tower, where 1° benzene is taken off the top. The residue, containing toluene and xylene and higher-boiling oils, is charged to the unit during a second run, some further benzene being taken off the first tower and the 1° toluene off the second tower. The residue is refractionated to produce 3° xylene and heavy residue (sold for recovery of heavy coal-tar naphtha, resins, etc.). Particular attention is paid to efficient cooling and adequate instrumentation. C. L. G.

619.* Copper–Chloride Treater Handles Straight-Run or Cracked Gasolines. Anon. *Oil Gas J.*, 10.4.41, **39** (48), 15.—At a refinery at El Dorado, Arkansas, a copper–chloride-treating plant has been installed which eliminates injurious S and gum-forming compounds from gasolines. This apparatus consists of two systems: one for straight-run material and the other for cracked products.

Consumption of chemicals is low, due to complete rejuvenation of the active constituent, and the treated gasoline in many cases shows an increased lead susceptibility. Stabilized cracked gasoline is given a caustic wash followed by a water wash, and is then passed through a salt drum where moisture and some organic acids are removed. From there it passes to the chemical reactor, where it is contacted with copper chloride and treated with oxygen. D. L. S.

620.* Small Refinery Major Factor in Peru. J. P. O'Donnell. *Oil Gas J.*, 10.4.41, **39** (48), 15.—A small refinery of 1000 brl./day capacity has been constructed and is now operating at Zorritos, Peru. This, it is hoped, will supply 30% of Peru's motor fuel, 21% of its kerosine, and 12·5% of its fuel needs.

The bulk of the charging stock is a sweet, low cold test 35–40° A.P.I. gravity crude from Lobitos, the balance being obtained from a Government-operated field. The products are of high quality and need no subsequent treatment, yields on the initial run approximating 37% gasoline, 11·5% kerosine, 15% diesel oil, and 34% fuel oil.

The crude is taken to Zorritos in shallow-draft coastal tankers, and is delivered to the refinery by an 8-in. submarine line extending 1 mile into the ocean.

Processing equipment is entirely conventional, and the fractionating tower was shipped from the U.S.A. in sections. D. L. S.

621.* Solvent Extraction of Oils. *Engineering*, 1940, **150**, 496.—Types of plant for the solvent extraction of oil from waste materials, oil seeds, fuller's earth, etc., are described. Construction materials for use with various solvents are discussed, and the provision of solvent recovery equipment by distillation and absorption is dealt with. J. W. H.

622.* Heat Insulation on Cylindrical Surfaces. C. Turner. *Industr. Engng Chem.*, 1940, **32**, 904.—A graphical method is presented for the rapid estimation of heat-flow through cylindrical lagging. A multiplication factor is used to correct the heat-flow from a flat surface to that of a cylindrical surface having the same thickness of lagging. This factor varies with the ratio of the cylinder diameter to the diameter of insulation. J. W. H.

623.* Multi-component Rectification: Optimum Feed-Plate Composition. E. R. Gilliland. *Industr. Engng Chem.*, 1940, **32** (7), 918.—Equations are derived by means of which the optimum feed-plate composition, expressed in terms of light and heavy key components, may be calculated for three conditions of the feed—namely, all-liquid, partly vaporized, and superheated vapour. P. D.

624.* Action of Solutizers in Mercaptan Extraction. D. L. Yabroff and E. R. White. *Industr. Engng Chem.*, 1940, **32** (7), 950.—Aqueous caustic solutions containing certain organic solvents or organic salts (" solutizers ") are much better than straight aqueous caustic solutions for the extraction of mercaptans from gasolines.

A study of the action of solutizers indicated that, as expected from previous investigations, organic solvent solutizers increase the solubility of unneutralized mercaptan in the alkaline phase, thereby leading to a more complete mercaptan removal from the oil phase. Organic salt solutizers, on the other hand, exert a salting-out effect on the unneutralized mercaptan at low solutizer concentrations, but this effect is reversed at high solutizer concentrations. In addition, both types of solutizer appear to eliminate the marked salting-out effect of sodium hydroxide which was observed previously with unsolutized caustic-soda solutions. The paper gives the main results of a cursory examination on the rôle played by solutizers by a study of the constants involved in a simple extraction.

The organic solutizers employed were methanol and glycerol, whilst the organic salt solutizer was sodium *iso*butyrate. H. E. T.

625*. Multi-component Distillation Problems. H. J. Hibshmann. *Industr. Engng Chem.*, 1940, **32** (7), 988.—A graphical method for the estimation of plate compositions in multi-component distillation problems is given and an example worked out. The example chosen is one which has already been solved by two other methods, and direct comparison is possible. The method involves the construction of a Cox vapour-pressure chart on a transparent sheet. These vapour-pressure lines are used as equilibrium lines, and by appropriate superimposition of this chart on a graph of the vapour-liquid operating lines, the compositions present on any plate may be read off at any desired operating pressure. J. W. H.

626*. Multi-component Rectification. E. R. Gilliland. *Industr. Engng Chem.*, 1940, **32** (9), 1220.—A method of estimating the number of plates and reflux ratio to give any required separation is derived in which a function of the terms actual number of plates and minimum number of plates at total reflux is plotted against a function of the terms actual reflux ratio and minimum reflux ratio (at infinite plates). The number of plates at total reflux is estimated by Fencke's equation; and the minimum reflux ratio by the method proposed by the author (*Industr. Engng Chem.*, **32**, 1101).

The relation between the functions is an empirical one, and is derived by plotting the results of sixteen calculated separations, of which details are given. P. D.

627.* Calculation of Absorber Performance and Design. G. Horton and W. B. Franklin. *Industr. Engng Chem.*, 1940, **32** (10), 1384.—General equations for absorption and stripping factors are derived. The derivation is free from assumptions which made the equations of previous investigators of doubtful utility. The method of use is illustrated by examples. P. D.

628.* Factor *C* in the Performance of Ejectors. L. T. Work and A. Miller. *Industr. Engng Chem.*, 1940, **32** (9), 1241.—Experimental work on two ejectors on vapours of varying molecular weight was previously reported (*Industr. Engng Chem.*, **32**, 464).

These results are correlated in the present paper, where it is shown that an equation of the following form holds for both ejectors :

$$C = 1 - (aM_b/M_e + b)(w/W)(P_b/P_n)^n$$

where :

C = $(Pn - Pe)/(Pn - Po)$.
P_b = boiler pressure.
P_e = exhaust pressure.
P_n = entraining pressure.
P_o = suction pressure (no entrainment).
w/W = weight ratio of evaporator to boiler fluids.
M_b = molecular weight of boiler fluid.
M_e = molecular weight of entrained fluid.
a, b, n = constants.

Values of a, b, and n for the two ejectors are given. P. D.

629.* Mechanism of Desulphurization of Distillates with Zinc Chloride. K. A. Musatov and L. G. Krymova. *J. appl. Chem. (U.S.S.R.)*, 1940, **13** (2), 227–234. Translated by A. A. Boehtlingk. *For. Petrol Tech.*, Feb. 1941, **9** (2), 61.—The vapour-phase method of desulphurization adopted to the treatment of distillates with solid zinc chloride is described. Of decisive importance in the degree of desulphurization of the distillates and in the combination of hydrogen sulphide are the oxygen compounds of zinc chloride (hydrate, and oxide).

If due attention is paid to this in the rational selection of carriers (with hydrate characteristics) at the most favourable process temperature close to the optimum temperature of catalytic cracking in the presence of zinc chloride, it is possible to desulphurize sulphur containing distillates of the Ishimbaevo crude oils to limits close to the technical specifications for the permissible content of sulphur. In the desulphurization by this method, hydrogen sulphide and hydrogen chloride do not separate. B. M. H. T.

630. Patents on Refining and Refinery Plant. I. M. Colbeth. E.P. 534,338, 5.3.41. Appl. 4.8.39.—Apparatus for purifying crude oils in which the oil is divided into small droplets in the solution and the solution and oil are caused to pass by gravity in a counter-current relationship with each other at a speed which allows the impurities to be extracted without causing emulsification. The apparatus can be employed in the purification of petroleum oils containing naphthenic acids.

N. V. de Bataafsche Petroleum Maatschappij. E.P. 534,543, 10.3.41. Appl. 4.2.39. Process for the purification and decoloration of ketones and/or ketols or of mixtures containing same which are discoloured by the presence of colour-imparting impurities. The discoloured material is treated with ammonia and/or primary amines until substantially free from impurities and discoloration.

N. V. de Bataafsche Petroleum Maatschappij. E.P. 535,431, 9.4.41. Appl. 6.11.39. Method of removing a body of coke from the reaction chamber of an oil-cracking plant. First the body of coke is cut by impinging a substantially confined jet of water on to it. Thereafter the resulting lumps of coke, fines, and liquid are removed from the chamber.

Texaco Development Co. E.P. 535,449, 9.4.41. Appl. 31.1.40. Method of dewaxing lubricating oil containing relatively small amounts of wax, or from which the wax is precipitated in relatively dense form. The procedure is particularly useful in the dewaxing of residual cylinder stocks which tend to form relatively dense and compact filter cakes.

L. U. Franklin. U.S.P. 2,235,921, 25.3.41. Appl. 24.2.37. Method of sweetening a sour petroleum distillate by passing through a pervious bed of small, non-absorbent, non-porous, inert solid particles moistened with an aqueous medium containing cupric and chloride ions, which is capable of reaction with mercaptans present in the distillate to form disulphides and cuprous chloride capable of regeneration. Sufficient moisture is applied to the bed to supplant that removed in excess by entrainment in the distillate and to maintain the bed in a uniformly moist condition.

W. B. Lerch, C. H. Mathis, and E. J. Gatchell. U.S.P. 2,235,936, 25.3.41. Appl. 20.6.38. Process for the removal of sulphur compounds from hydrocarbons by passing the hydrocarbons through a bed of dry cyanamide.

A. L. Lyman, R. C. Mithoff, and H. B. Nichols. U.S.P. 2,236,216, 25.3.41. Appl. 6.12.38. Process for the catalytic desulphurization of hydrocarbons consisting in major part of liquid acyclic mono-olefins.

L. D. Jones. U.S.P. 2,237,670, 8.4.41. Appl. 2.12.38. In the dewaxing of hydrocarbon oils a mixture is used as diluent which contains symmetrical dichloroethane and trichloro ethylene in a ratio adapted to cause precipitation of wax from petroleum stock without substantial precipitation of paraffinic oil. The mixture also contains sufficient dichloromethane to render the resulting mixture non-inflammable.

H. B. M.

Chemistry and Physics of Petroleum.

631.* High-Pressure Absorption in Gas-Cycling Operations. L. S. Reid. *Refiner*, April 1941, **20** (4), 103–111.—The general characteristics of condensate reservoir fluids are reviewed. The advent of the high-pressure-absorption process into the field of gas cycling is due to certain inherent limitations of the existing condensation processes. One of the most important of these limitations is the large compression ratio often required to increase the pressure of the residue gas from the optimum condensation pressure to that pressure required to inject it into the formation from which it came. Thus with a fluid which has an optimum condensation pressure of 1000 lb./sq. in., if a pressure of 3000 lb./sq. in. were required to return the residue gas to the formation, the resulting compression ratio of 3·0 would require approximately 62 brake horse-power/million cu. ft. of gas handled. If, on the other hand, this same reservoir fluid could be processed at 2000 lb./sq. in., the compression ratio of 2·0 would require 38 horse-power/million cu. ft. of gas. Similarly, by processing at 1500 lb./sq. in., the compression ratio of 1·5 would require 23 horse-power/million cu. ft. of gas handled by the compressor.

A second important limitation of condensation processes is the relatively low extraction efficiencies obtained even when operating under optimum pressure conditions. Extraction efficiency may be expressed by the equation : Percent Extraction Efficiency $= \frac{V_r - V_g}{V_r} \times 100$, where V_r = total volume of desirable hydrocarbons in the reservoir fluid expressed in galls./thousand cu. ft., and V_g = total volume of desirable hydrocarbons remaining in the residue gas after processing, expressed in gallons/thousand cu. ft. of reservoir fluid processed.

This relationship applies only to the liquid which is extracted from the reservoir fluid either by absorption or by condensation, and is thus made available for stabilization and processing to finished products.

Laboratory investigations and field studies of the displacement of reservoir fluids by dry residue gas injected into condensate reservoirs indicate that a single cycle of residue gas will result in the production of from 50% to 60% of the original reservoir fluid. In other words, if a condensate pool were properly drilled and produced by cycling operations, from 50% to 60% of the original reservoir fluid would have been produced and processed by the time the residue gas breaks through into the producing wells and dilutes the rich gas. Cycling operations cannot continue long after this dilution sets in, and new producing wells must be drilled, or the project must be shut down and abandoned. It is imperative, therefore, to make every effort to secure maximum condensate recovery at minimum cost, and to this end the oil-absorption process has been adapted to gas-cycling operations.

Typical counter-current and concurrent absorption plants are discussed and illustrated. Extensive research on the behaviour of hydrocarbon mixtures at elevated pressures, coupled with experience gained from plant operations during the past two years, has resulted in the extension of satisfactory absorber performance from a pressure of 1200–1900 lb./sq. in. in counter-flow absorption processes, whilst the concurrent process is reported to operate satisfactorily at 2000 lb./sq. in. A. H. N.

632.* Elements of Vaporization and Condensation. Part XIII. R. L. Huntington. *Refiner,* April 1941, **20** (4), 133–136.—It has been found that the blending of small percentages of stabilized natural gasoline with crude oil offers several economic advantages in the transportation and storage of these commodities. There are, however, certain unfavourable factors which arise from this blending practice, such as: (1) increased vaporization losses in storage; (2) fire and explosion hazards in cleaning out tank bottoms which have settled out of crude-oil–natural-gasoline blends.

The first advantage to be recognized from the pipe-line transportation of the crude-oil–natural-gasoline blends was the large saving in freight. In the early twenties heavy withdrawal losses were experienced in the tank-car shipment of unstabilized gasoline. By blending from 1% to 2% of this "wild" gasoline with crude oil, vaporization losses were reduced materially below those suffered through rail transportation.

Reduction in the viscosity of the crude oil is another factor in favour of blending. This change in the physical property of the liquid brings about a saving in horsepower required to pump the crude, due to the lowering of friction losses.

Blending operations are also found to be desirable for some crudes which are high in paraffin-wax content. The natural gasoline acts as a solvent under certain conditions, thereby lessening the tendency for wax to form a coating on the inside walls of the pipe-line. The alternative of heating the crude and maintaining it at a temperature above the pour-point is entirely out of the question for long pipe-lines in cold weather. One company has increased its crude-oil deliveries 50% by blending natural gasoline (10% by volume) with crude oil in the winter season. This crude has a pour-point to 55° F., due to its high wax content. Evaporation losses were not excessive, as much smaller percentages of gasoline were required in summer to effect the same delivery capacity for the pipe-line.

Experimental data and laboratory technique to evaluate vaporization losses through wind and weather actions are presented. A. H. N.

633.* Use of Azeotropic Distillation in Separating Hydrocarbons from Petroleum. F. D. Rossini, B. J. Main, and A. R. Glasgow. *Oil Gas J.*, 14.11.40, **39** (27), 158. *Paper before Refining Division of A.P.I., Chicago, November* 1940.—The principles of azeotropic distillation, its use in the laboratory preparation of pure hydrocarbons, and its commercial possibilities are discussed. Reference is also made to the advantages of distillation under reduced pressure. Nearly all polar organic compounds with the proper volatility form minimum boiling azeotropic mixtures with hydrocarbons, paraffin hydrocarbons giving the lowest boiling point and aromatic hydrocarbons the highest. With binary azeotropic mixtures, the boiling point and the composition of the mixture approach, with increase in boiling point of the hydrocarbon, those of the pure azeotrope-forming compound. The products most successfully used in laboratory hydrocarbon separation include methyl alcohol, ethyl alcohol, methyl cyanide, acetic acid, ethylene glycol monomethyl ether acetate, ethylene glycol monobutyl ether, and diethylene glycol monomethyl ether.

Owing to the fact that the boiling points of aromatics hydrocarbons decrease more rapidly with decreasing pressure than naphthenes and the latter more rapidly than paraffins, separation is enhanced by distillation under reduced pressure.

Commercial applications of azeotropic distillation in use include the use of benzene or trichlorethylene to dehydrate ethyl alcohol, and the removal of low-boiling aldehydes from commercial dioxane by the addition of water and a volatile inorganic acid.

C. L. G.

634.* Catalytic Isomerization of Butane Yields 67–74% *iso*Butane. B. Moldavskii and T. Nizookina. *Nat. Petrol News*, 27.11.40, **32** (48), R 422.—The isomerization of *n*-butane with Al_2Cl_6 catalyst has been studied and the equilibrium composition of the resulting mixture at various reaction temperatures from 70° to 180° C. determined by Podbielniak fractionation. At 70° C. isomerization in the liquid phase of *n*-butane, *iso*butane, and mixtures led to the formation of an equilibrium mixture containing 73·9–74·3% *iso*butane and 26·1–25·7% *n*-butane, without formation of by-products. At higher temperatures decomposition takes place with the production of propane and methane. It has been shown that equilibrium concentrations given in the literature and based on theoretical calculations do not agree with those determined experimentally. C. L. G.

635.* Constitution Diagrams and Composition of Methane and Ethane Hydrates. O. L. Roberts, E. R. Brownscombe, and L. S. Howe. *Oil Gas J.*, 5.12.40, **39** (30), 37.—Gas hydrates have been studied recently from many angles. The present paper deals with the relation of the usual hydrate curve to the other equilibria curves for the water–methane and water–ethane systems. Use of the vapour–ice–hydrate data as well as the vapour–liquid–hydrate equilibrium, together with the incorporation of the compressibility factor of the gas, make possible a thermodynamically sound method of calculating hydrate composition.

A description of the apparatus, illustrated by a diagram and a photograph, is included. The results obtained are given in the form of a number of phase diagrams showing data over the temperature range 10–60° F.

Compressibility factors for ethane vapour have been determined at pressures ranging from 5 to 32 atmospheres at 32° F. and 54° F.

The heats of formation of methane and ethane hydrates from vapour and water and from vapour and ice have been calculated from the foregoing equilibrium data, correcting for the deviation of the gases from the ideal gas laws.

The composition of the gas hydrates has been calculated from equilibrium curves as follows: The heat of formation of hydrate per mol. of combined gas is determined for its formation from liquid water and gas and for its formation from ice and gas. The difference between these two represents the heat of fusion of the water present in hydrate with 1 mol. of gas. Dividing this heat by the heat of fusion of 1 mol. of water gives the number of mols. of water per mol. of gas in the hydrate. The composition of the hydrates has been found to be $CH_4 \cdot 7H_2O$ and $C_2H_67H_2O$. D. L. S.

636.* Formation of Propylene by Dehydrogenation of Propane. M. Kurokawa and Y. Takenaka. *J. Soc. Chem. Ind. Japan*, Feb. 1941, **44** (2), 45B–47B.—Results are given of experiments on the catalytic and non-catalytic decomposition of propane, carried out with the object of preparing propylene from propane by dehydrogenation. The optimum temperature for dehydrogenation of propane was found to lie between 600° and 650° C. The ratio C_3H_6/C_2H_4 increases with increase of gas velocity. Consequently, increase in gas rate facilitates dehydrogenation to a certain extent by breaking the C–H bond of propane and preventing the splitting of the C–C bond. Of the catalysts employed (UO_3, CuO, AgO, Al_2O_3, and Mn_2O_3), UO_3 was found to be the best, having the least reversible activity. B. M. H. T.

637.* Boiling Points of Benzene, 2 : 2 : 3-Trimethylbutane, 3-Ethylpentane, and 2 : 2 : 4 : 4-Tetramethyl Pentane within the Range 100–1500 mm. of Mercury. E. R. Smith. *Bur. Stand. J. Res.* (*Wash.*), 1941, **26** (2), 129–134.—The comparative method of Swietoslawski using water for the reference standard was used for this work. The benzene for these measurements was prepared during a previous fractionation; the other hydrocarbons were obtained from the Automotive Power Plant Section of the Bureau of Standards. Temperatures were measured to 0·001° C., and, having regard to the degree of purity of the hydrocarbons, it is believed that the results are accurate to better than 0·01°.

Data have been obtained from which were developed the following equations expressing the relationship between temperature and vapour pressure in the range of pressures 100–1500 mm. Hg:

Benzene :

$$\log_{10} p = 6{\cdot}905216 - \frac{1211{\cdot}215}{220{\cdot}870 + t}$$

2 : 2 : 3-*Trimethylbutane* :

$$\log_{10} p = 6{\cdot}799682 - \frac{1204{\cdot}997}{226{\cdot}615 + t}$$

3-*Ethylpentane* :

$$\log_{10} p = 6{\cdot}873058 - \frac{1249{\cdot}825}{219{\cdot}595 + t}$$

For 2 : 2 : 4 : 4-tetramethylpentane no single equation was found to fit the data sufficiently accurately over the entire pressure range. The following two equations have been developed:

(*a*) From 100–450 mm.:

$$\log_{10} p = 6{\cdot}643408 - \frac{1231{\cdot}620}{204{\cdot}975 + t}$$

(*b*) From 430–1500 mm.:

$$\log_{10} p = 6{\cdot}860684 - \frac{1368{\cdot}925}{221{\cdot}679 + t}$$

In these equations p is the vapour pressure in standard mm. of Hg exerted by the substance at temperature t° C. D. L. S.

638.* Effect of Pressure on the Enthalpy of Benzene. E. R. Gilliland and R. V. Lukes. *Industr. Engng Chem.*, 1940, **32** (7), 957).—Apparatus is described by means of which the isothermal change of enthalpy accompanying an expansion of a vapour from elevated pressure to one atmosphere can be measured. Measurements were made on benzene vapour up to pressures of 190 atms. P. D.

639.* Drying Oils and Resins. T. F. Bradley and D. Richardson. *Industr. Engng Chem.*, 1940, **32** (7), 963.—Ultra-violet absorption methods have been applied to a series of samples prepared in the course of a fundamental study of the mechanism of the polymerization of some drying oils. Partial interpretation of the absorption curves has been accomplished through studies of analogous and related compounds.

For the ultra-violet absorption measurements, a large Hilger, type E. 492, quartz prism spectrograph was used in conjunction with a Hilgar-Spekke photometer. Specially purified hexane *cyclo*hexane was used as the solvent, and the solutions were examined in an adjustable micrometer absorption cell with quartz and plates. The absorption curves are plotted in terms of the logarithm of the extinction coefficient k (ordinates) defined as

$$k = d/Lc$$

where d = optical density $\left(\log \frac{\text{incident light}}{\text{transmitted light}}\right)$

L = length, in cms., of solution of concentration c, in grams per 100 c.c. through which the light passes,

and with wave number as abcissæ, *i.e.*, reciprocal of wave-length in cm.

Absorption curves for the following hydrocarbons are given: hexane, *cyclo*hexane; 3-hexene (containing conjugated diene); *cyclo*hexene, dimethylbutadiene; 1 : 3-*cyclo*hexadiene; α-eleostearic acid, and *p*-cymene. Absorption curves were also obtained for:

(*a*) Tripalinetin, tristearin, methyl oleate (contained dienes); methyl oleate (after treatment with maleic anhydride); methyl ester of Neo Fat 3R (mainly 9 : 12 linoleate); 9 : 11 linoleic acid; and ethyl linoleate.
(*b*) A series of linseed oils, heat bodied in a vacuum at 575° F.
(*c*) Methyl esters of linseed oil.
(*d*) Tung oils and esters.
(*e*) Castor-oil esters.
(*f*) Esters of soya-bean oil, olive oil, Oiticica and sardine oils and their esters.

From these observations it is shown that absorption spectra can be particularly useful in cases where conjugated double bonds are important. Evidence can be deduced with regard to the presence of cyclic or aromatic molecules in a given sample. The distillation of heat-polymerized methyl esters of the acids from a drying oil, yields residues which absorb ultra-violet light more strongly than the monomeric distillates. This increased absorption is evidence of either increased unsaturation or increased complexity of molecular structure. The corresponding decrease in iodine value and other chemical evidence makes ring formation the most acceptable explanation. The changes in the absorption spectra of linseed and tung oil on heat bodying are given, indicating that considerable amounts of unreacted acids are still present in these oils as the gel point is approached. In the case of linseed oil there is a nett increase in the amount of conjugated acids present in the first stages of heat treatment, followed by a gradual decrease. H. E. T.

640.* Phase Equilibria in Hydrocarbon Systems : Propane–*n*-Pentane System. B. H. Sage and W. N. Lacey. *Industr. Engng Chem.*, 1940, **32** (7), 992.—Volumetric and phase behaviour of nine mixtures of propane and *n*-pentane have been measured throughout the two-phase region at temperatures above 130° F. The data obtained are used to construct graphs and tables showing compressibility factors, specific volumes, compositions of phases, and equilibrium constants. P. D.

641.* Nomographs for Correcting Volumes of Perfect Bases. J. G. Roof. *Industr. Engng Chem.*, 1940, **32** (7), 998.—Directions are given for the construction of two simple nomographs for correcting volumes of dry gases over small ranges of temperature (approximately 5°) and any range of pressure. J. W. H.

642.* P–V–T Relations of Propylene. W. E. Vaughan and N. R. Graves. *Industr. Engng Chem.*, 1940, **32** (9), 1252.—The P–V–T– relations of propylene have been measured over the pressure range 2–80 atms. and at temperatures from 0° to 300° C. The experimental technique is described, and the investigation covered the determination of all critical constants. J. W. H.

643.* Phase Equilibria in Hydrocarbon Systems. Methane–*n*-Butane System. B. H. Sage, R. A. Budenholzer, and W. N. Lacy. *Industr. Engng Chem.*, 1940, **32** (9), 1262.—The specific volumes of twenty-four mixtures of methane and *n*-butane were determined over the pressure range up to 3500 lb. per sq. in. and temperature range 70°–250° F. The results were interpolated to even values of pressure and temperature and are presented in tabular form. *iso*Thermal enthalpy coefficients are also derived for mixtures containing 0·60–1·00 weight fraction of methane. The partial thermodynamic properties of the two constituents are also given in tables. Further tables give the partial volumetric properties in the gas and liquid phases. Graphs are given showing the partial volumetric and thermodynamic properties over the concentration range at 160° F. P. D.

644.* Nomograph for the Clausius–Clapeyron Equation. C. L. Crawford. *Industr. Engng Chem.*, 1940, **32** (9), 1280.—A nomograph is presented enabling the latent heat to be estimated from a knowledge of the vapour pressure at two temperatures (one of which may be the B.P.), or the vapour pressure at any temperature may be estimated from latent heat and boiling-point data only. J. W. H.

645.* Nomograph for Paraffin-Wax Solubility in Petroleum Fractions. D. S. Davis. *Industr. Engng Chem.*, 1940, **32** (10), 1293.—The experimental data on the solubility of wax in petroleum fractions obtained by Berne-Allen and Work (*Industr. Engng Chem.*, 1938, **30**, 806) are presented in the form of a nomograph which is considerably more simple to use than the graphical presentation of the results given in these authors' paper. J. W. H.

646.* Oxidation of Aromatic Hydrocarbons. C. R. Downs. *Industr. Engng Chem.*, 1940, **32** (10), 1294.—Benzoic acid, anthraquinone, and its numerous derivatives produced in the United States is now manufactured almost exclusively from phthalic anhydride. The phthalic anhydride is prepared by catalytic oxidation of naphthalene, using vanadium oxide as the catalyst. Phthalic anhydride is also of great use in the manufacture of synthetic resins. The production of phthalic anhydride at the present time in the United States is approximately 70–75 million lb. per year, and there is no shortage of naphthalene if larger quantities of phthalic anhydride were required. The catalytic vapour-phase oxidation of naphthalene to phthalic anhydride has many important economic effects on other processes and raw materials. H. E. T.

647.* Solubility of Methane in *cyclo*Hexane. E. P. Schoch, A. E. Hoffman, and F. D. Mayfield. *Industr. Engng Chem.*, 1940, **32** (10), 1351.—Experimental procedure and results of the determination of the solubility of methane in *cyclo*hexane at pressures up to the critical pressure and at temperatures of 100°, 160°, and 220° F. are given. The specific volumes of the liquid phases, together with their compressibilities up to 6000 lb. per sq. in., are reported. J. W. H.

648. Velocity of Compressional Waves in Petroleum Fractions at Atmospheric and Elevated Pressures. R. Matteson and C. J. Vogt. *J. appl. Phys.*, October 1940, **11** (10), 658–665.—Velocities of compressional waves in thirty-seven petroleum fractions were measured at 100° F. and atmospheric pressure. The oils investigated ranged from light gas oils to viscous lubricating oils. Wave velocities were calculated from wave-length determinations made by means of a Hubbard ultrasonic interferometer used in conjunction with a quartz crystal ultrasonic wave-generator. Compressional waves in the oil were reflected from the face of a piston mounted on a micrometer screw, and the position of nodes was determined by the deflections of a galvanometer in the generator-plate circuit. The results of the measurements are essentially those corresponding to an infinite medium, since viscous drag and tube-wall expansion are negligible.

Curves are shown from which it is possible to estimate the velocity of compressional waves at 100° F. and atmospheric pressure if the specific gravity and kinematic viscosity are known. Velocity–temperature curves for a number of pure hydrocarbons are given to illustrate the effect of chemical composition.

Tests at elevated pressures up to 6000 lb./sq. in. and temperatures from 57° F. to 210° F. were made in a different apparatus. The passage of a pressure disturbance along a steel tube was measured by means of electromagnetic indicators coupled to a galvanometer-type oscillograph. The results of the tests made with the apparatus indicate that the more easily determined tests at atmospheric pressure can be reduced to the conditions found in diesel-engine fuel lines by the use of the Helmholz relation. The velocities encountered in the average injection system may vary as much as 25% through the range of operating conditions and oils used to-day, and this variation might easily be the cause of a change from satisfactory to unsatisfactory engine operation. J. G. W.

649. Flame Temperature. B. Lewis and G. v. Elbe. *J. appl. Phys.*, November 1940, **11** (11), 698–706.—The theoretical flame temperature corresponding to complete statistical equilibrium in the burned gas is distinguished from the experimental flame temperature measured by the gas-law equation and corresponding to equilibrium in the translational degrees of freedom. Experiments on fast flames in closed vessels show that the latter may be higher than the former, due to excitation lag in the internal, presumably vibrational, degrees of freedom.

The theory and technique of measuring flame temperatures by the line-reversal method, by the variation of resistance of wires, by thermocouples, and by the measurement of brightness and absorbtivity in the infra-red are described.

Methods of determining the temperature and emissivity of soot-forming luminous flames are given.

In industrial furnaces the differences between the theoretical and experimental temperatures should be negligible, but in internal-combustion engines excitation lag is likely to exist, but no experimental confirmation is available. J. G. W.

650. Improved Radiation Pyrometer. T. R. Harrison and W. H. Wannamaker. *Rev. Sci. Instrum.*, 1941, **12** (1), 20.—If a radiation pyrometer of conventional design is calibrated at a given ambient temperature, and the latter is then altered, the calibration is in error. The error may be decreased by an increase in the amount of heat conducted away from the hot junction. A mathematical analysis is presented, from which general conclusions were reached pointing to the possible methods of reducing the error. As a result an instrument with very greatly diminished error was designed. This is fully described and its operational characteristics given. P. D.

651.* Rapid Discharge of Gas from a Vessel into the Atmosphere. E. Giffen. *Engineering*, 1940, **150** (3892, 3893, and 3895), 134–136, 154–155, and 181–183.—A method of calculating the rate of discharge of gas from a cylinder, based on the consideration of wave action, is described, and is applied to a typical problem. By taking the discharge over a series of time intervals, the pressure–time relation is built up and a value for the depression below atmospheric pressure at the end of discharge is obtained.

A second method, based on the assumption of uniform pressure in the vessel, is also given, and calculations are made to give a comparison with the first method. Little difference is shown between the results obtained by the two methods, and the latter, which is much simpler, may be regarded as giving a good idea of the actual time of discharge, and the rate of decrease of pressure. However, it is only by the former method that the depression at the end of discharge can be estimated, and in this respect it represents an advance on the latter, and approaches nearer to the true conditions. J. G. W.

652.* Copolymerization of Acetylene and Butylene in Silent Electric Discharges. A. D. Petrov and D. N. Andrev. *J. appl. Chem.* (*U.S.S.R.*), 1940, **13** (9), 1341–1347. Translated by A. A. Boehtlingk. *For. Petrol. Tech.*, January 1941, **9** (1), 1–12.—The product of joint polymerization of an equimolecular mixture of acetylene and butylene in silent electric discharges was found to be different from the polymerizates of acetylene and butylene alone. A characteristic peculiarity of the polymerizate is the presence in it of about 10% of acetylene hydrocarbons of the composition C_nH_{2n-2}, as well as the ability of about 70% of the hydrocarbons of the polymerizate to become converted into a rubber-like polymer as a result of auto-polymerization. B. M. H. T.

653.* Cracking Methane is an Electric Arc at Reduced Pressure. N. P. Bozhko. *J. appl. Chem.* (*U.S.S.R.*), 1939, **12**, 1816. Translated by A. A. Boehtlingk. *For. Petrol. Tech.*, January 1941, **9** (1), 13.—In the cracking of methane in the electric arc it has been shown that at sub-atmospheric pressure it is possible to obtain high concentrations of acetylene and to decompose more than 90% of methane at a cracking down to carbon of 11–13%. The separation of carbon takes place mainly in the piping, and not in the zone of the discharge. It is the result of the thermal decomposition of acetylene which is removed from the discharge at a fairly high temperature. The consumption of the energy in the cracking in the arc at a pressure of 80–50 mm. may be lowered to 11–12 Kw./$M.^3$ of C_2H_2 at an acetylene concentration of 9–16% in the final gas. The consumption of energy increases to 16–17 Kw./$M.^3$ of acetylene at a pressure of 30–35 mm., when an almost complete decomposition of methane takes place. B. M. H. T.

654.* Isomerization of Polymethylene under the Influence of Aluminium Chloride. M. B. Turova-Polyak and T. A. Slovokhotova. *J. Gen. Chem.* (*U.S.S.R.*), 1940, **10** (15), 1435–1438. Translated by A. A. Boehtlingk. *For. Petrol. Tech.*, January 1941, **9** (1), 33.—By the action of aluminium chloride on *iso*propyl*cyclo*pentane at 125–130° C. a mixture of hydrocarbons is obtained in a proportion of 87% by weight of the hydrocarbon used in the reaction. The mixture is composed of 87·7% hexamethylene, 9·4% pentamethylene, and 2·9% paraffin hydrocarbons. The hexamethylene hydrocarbons are composed of a mixture of *p*- and *m*-dimethyl*cyclo*hexanes. The structure of the side-chain of the *cyclo*pentane hydrocarbon does not affect the structure of the products of its isomerization. B. M. H. T.

655.* Separation of Pure Methane from Hydrocarbon Gas Mixtures by Means of Selective Absorption. Yu. G. Mamedaliev and A. Kuliev. *J. appl. Chem.* (*U.S.S.R.*), 1940, **13** (5), 738–742. Translated by A. A. Boehtlingk. *For. Petrol. Tech.*, February 1941, **9** (2), 53.—The selective adsorption of mixtures of gaseous saturated hydrocarbons composed of methane, ethane, propane, butanes and pentanes, was investigated by the dynamic method. The analysis of the discharging gases was carried out in an apparatus specially constructed for the purpose, by means of which a determination of the heavier hydrocarbon content could be carried out in a few minutes. The selective action of the adsorbent was found to increase with decrease in the velocity of the movement of the gas. At a velocity of 1·59 litres of gas per sq. centimetre of cross-section of adsorber per hour, ethane makes its appearance after the passage of 250 litres of gas per kilogram of activated carbon. On increasing the velocity up to

6·36 the volume of the separated pure methane is lowered to 200 litres. Of great importance is the ratio of the height of the layer of the adsorbent to its diameter. The selective action of the adsorbent increases with the increase of this ratio. The appearance of methane homologues is of the type of a sharp jump, and the moment of their appearance depends on the ratio of the components of the gas mixture, the speed of its flow, the ratio of the height of the adsorbent to its diameter, the quality of the adsorbent, and other conditions. Under the most favourable conditions, 1 kg. of activated charcoal removes higher homologues from about 300 litres of dry and 88 litres of wet gas. The separated methane contains in the first case 0·04% and in the second less than 0·2% of ethane. B. M. H. T.

Analysis and Testing.

656.* Method for Determining Total Chloride Content of Heavy Oils. W. A. Schulze, J. P. Lyon, Jr., and L. C. Morris. *Oil Gas J.*, 10.4.41, **39** (48), 40.—The commonly used methods for determining the chloride content of crude oils by analysing an aqueous extract will not determine the organic chlorine. The recommended procedure consists of (1) burning the oil sample mixed with pelleted chloride-free carbon-black, (2) absorbing the gaseous products in an alkaline solution to which is added the residue after combustion, (3) titrimetric determination of chloride in this solution.

The apparatus used is described and illustrated.

For a test about 13 ml. of carbon-black is placed in the combustion tube followed by 5 ml. oil. Another 10 ml. of carbon-black is added, followed by 5 ml. oil, this being repeated until the desired weight of sample has been added. The absorbers are filled with *N*-sodium bicarbonate solution. The combustion tube is gently heated to drive out lighter constituents, which are then burned and the residual mass ignited. The absorbent solution containing the residue of combustion is concentrated, made slightly acid with dilute HNO_3, and heated gently to expel CO_2 and SO_2. An excess of $AgNO_3$ is then added, the solution warmed to coagulate the AgCl, and filtered. The filtrate is titrated with 0·02N ammonium thiocyanate, using ferric alum as an indicator.

Results obtained with heavy oils containing known quantities of organic and inorganic chlorine compounds have indicated an absolute accuracy of ±2·5% when a sample equivalent to 5–15 mg. of chlorine is analysed. D. L. S.

657. Conductivity of Insulating Oils under Alternating Stress. J. B. Whitehead and B. P. Kang. *J. appl. Physics*, 1940, **11** (9), 596.—Conductivity measurements were made on a sample of insulating oil as manufactured and after oxidation. The measurements were made under a voltage gradient of 20–80 volts per mil, and special arrangements were made to record the initial or short-time conductivity. The ratios of initial to final conductivities were in the range 3–5·5.

The dielectric loss under 60 cycle A.C. agreed with the loss computed as leakage loss due to the initial conductivity. P. D.

Motor Fuels.

658.* Use of Activated Glycerides for Stabilizing Gasoline. F. W. McCurry. *Oil Gas J.*, 12.12.40, **39** (31), 53.—This article is a report of part of a discussion on lubricants presented at the 1940 meeting of the A.P.I.

It shows how an activated glyceride is able to hold metallo-organic compounds in solution in gasoline and is also able to eliminate haze. Some fuels can be stabilized with as little as 1 part in 200,000 parts of gasoline, whilst others may require 1 : 40,000. D. L. S.

659. Recent Developments in the Production of Aviation Spirits. The Use of Safety Fuels. Anon. *Fuel*, 1940, **19** (9), 200.—Despite existing doubts regarding the degree of safety conferred by the use of high-flash-point fuels—*i.e.*, those with flash-points above 105° F.—certain interest continues to be shown in the development of the solid-injection-fuel system for spark-ignition engines and the multiplication of refining and synthetic processes giving fuels of high-boiling range with satisfactory octane number. The present two possible types of high-octane safety fuel are: (1) an aromatic type prepared from selected crudes by distillation and solvent extraction, perhaps augmented by highly aromatic material from cracking or destructive hydrogenation processes; (2) a purely synthetic paraffinic type produced by the sulphuric-acid alkylation process from *iso*butane and olefinic refinery gases. Both types of fuel may readily be produced with an octane number of 88 or more, but even with considerable addition of tetraethyl lead 100 octane does not appear attainable in either case.

The use of safety fuels in aircraft engines as at present contemplated involves the adoption of solid injection, for which system several advantages are commonly claimed; on the other hand, there are possibilities of trouble arising when running light, and when starting, due to the washing of lubricant from cylinder walls, and to crankcase dilution. Fuel consumption would be slightly greater than with normal spirits, although evaporation losses would be negligible and vapour lock eliminated.

It would appear on the whole that the major advantages of safety fuels might be in the diminution of fire risk in ground installations. To take full advantage of their properties in aircraft engines unwarranted changes in design and methods of operation would be required. Considerably more investigation will be necessary for safety fuels to prove their outstanding advantages in aviation. E. J. C.

660.* Use of Lecithin in Gasoline. H. V. Rees, W. S. Quimby, and J. C. D. Oosterhout. *Oil Gas J.*, 14.11.40, **39** (27), 176. *Paper before Division of Refining, A.P.I., Chicago, Nov.* 1940.—A review is given of laboratory work and several years' refinery experience on the reduction of decolorization, haze, and deposit formation in gasolines exposed to sunlight after the addition of lecithin and on its effect on the corrosion of iron and galvanized-iron containers by gasolines. Lecithin—a phosphatide obtained from soya beans by hexane extraction—has been found to reduce cloud formation on exposure of gasoline to sunlight, the effect being more pronounced on cracked and leaded fuels than on straight run. It has no effect on octane rating, lead susceptibility, copper-dish gum contents, and on the colour of the base gasoline before dyeing and leading. Sweetening before steam distillation renders gasoline more susceptible to the inhibiting effects of lecithin. With some leaded gasolines combination of lecithin with strong gum inhibitors and commercial phenol greatly improves the sunlight stability from the standpoint of cloud formation and colour changes. Lecithin is also useful for stabilizing the increase in accelerated gum content of aviation gasolines on storage. Its general effect is maintained in dark storage. Engines which have used refinery produced lecithin-treated gasolines for several years showed no deleterious effects.

Storage tests for 1 year on leaded and unleaded gasolines in the absence and presence of water and with and without lecithin showed that: (1) in the absence of water no corrosion took place; (2) in the presence of water the leaded gasolines caused more corrosion than the unleaded gasoline, the presence of alkali or of 5–10 lb. of lecithin per 1000 bbl. considerably reducing the corrosion of both iron and galvanized iron. In these proportions lecithin considerably reduces the formation of zinc oxide and decolorization in galvanized containers with leaded aviation gasolines. Corrosion of aluminium fuel tank-bottoms by leaded aviation gasolines is very largely eliminated by the use of lecithin. The dosages required vary from 1 to 15 lb. per 1000 bbl. of gasoline, costing $0·0056 per bbl. C. L. G.

661.* The Octane-Number Race. H. D. Lord and K. V. Gopalam. *Petroleum*, Feb. 1941, **3** (2), 39.—Following a brief reference to the relationship between thermal efficiency and the compression ratio of an engine, the phenomenon and cause of knocking and methods of rating fuels are discussed. The trend of automobile development and the improvement in the anti-knock qualities of fuels, present methods of manufacturing improved aviation fuels, and possible and probable future aviation fuels are dealt with. C. L. G.

662. Patents on Motor Fuels. N.V. de Bataafsche Petroleum Maatschappij. E.P. 535,054, 27.3.41. Appl. 14.7.39.—Conversion of saturated hydrocarbons boiling below 200° C. into isomeric hydrocarbons—*e.g.*, butane into *iso*butane, pentane into *iso*pentane, hexane into branched-chain hexanes, octane into branched-chain octanes, and mixtures of normal hydrocarbons or straight-run gasoline into mixtures containing branched or more highly branched hydrocarbons. Aluminium halides are employed as catalysts at temperatures not exceeding 200° C., and the formation of by-products is repressed by carrying out the reaction in the presence of hydrogen under a total operating pressure greater than atmospheric.

E. A. Ocon. E.P. 535,210, 2.4.41. Appl. 28.6.39. Manufacture of branched-chain aliphatic hydrocarbons from straight-chain aliphatic hydrocarbons occurring largely in natural gas and crude petroleums and from oxygenated derivatives of such hydrocarbons. The *iso*-aliphatic hydrocarbons so produced are suitable for use as high anti-knock motor fuels.

Etna Carburettor, Ltd. E.P. 535,358, 7.4.41. Appl. 3.1.40. Method of production of fuel and air mixtures from liquid fuels, for use in internal-combustion engines. Liquid fuel is passed under pressure to a chamber heated by the exhaust gases of the engine, and is therein converted into a fixed and safe gas, which is directed through a restricted outlet to a mixing chamber open to the atmosphere. A fuel-and-air mixture is therein formed for delivery to the engine.

N.V. de Bataafsche Petroleum Maatschappij. E.P. 535,394, 8.4.41. Appl. 9.10.39. Treatment of hydrocarbons in the liquid phase with metal halides, particularly in the isomerization of saturated hydrocarbons with straight or only slightly branched chains to hydrocarbons with branched or relatively highly branched chains. According to the invention, for example, *n*-butane can be converted into *iso*-butane, *n*-pentane into *iso*-pentane, etc., and saturated gasolines with relatively low anti-knock values into gasolines with relatively high anti-knock values.

Standard Oil Development Co. E.P. 535,398, 8.4.41. Appl. 17.10.39. Conversion of normally liquid straight-chain paraffin hydrocarbons into branched-chain paraffin hydrocarbons by subjecting the former to the action of a catalyst of the aluminium chloride type and an activator for the catalyst, in the presence of free hydrogen and a light paraffinic gas containing a substantial amount of propane.

E. A. Ocon. U.S.P. 2,235,329, 18.3.41. Appl. 7.2.38. Process for converting hydrocarbon oils into relatively low-boiling hydrocarbons suitable for use as motor fuel with negligible coke formation.

A. J. Van Peski. U.S.P. 2,235,466, 18.3.41. Appl. 6.6.38. Preparation of an improved anti-knock motor fuel consisting of a gasoline-type motor fuel and a small amount of a normally liquid mixture consisting of cupric methyl amino-methylene acetone and cupric ethyl amino-methylene acetone.

C. Ellis. U.S.P. 2,237,660, 8.4.41. Appl. 14.1.39. Production of an anti-knock motor fuel for high-compression spark-ignition engines. The fuel consists of a major proportion of gasoline hydrocarbons blended with a substantial anti-knock improving amount of an aliphatic mono-ester having two branched alkyl terminals and containing seven to twelve carbon atoms in the molecule, with oxygen present only in the ester linkage. H. B. M.

Gas, Diesel, and Fuel Oils.

663. Recent Developments in the Production of High-speed Diesel Fuels. M. E. Kelly. *Fuel*, 1940, **19** (10), 219.—Following a discussion in which he suggests possible causes for the lack of desirable standardization of diesel fuels, the author quotes American opinions as to power and economy characteristics of fuels for automotive service. It is concluded that the present trend of fuel quality in the U.S.A. appears to be towards volatile, highly paraffinic fuels necessarily having low specific gravity. It is suggested that heating value, ignition quality, and possibly fuel viscosity are the only important fuel properties affecting engine power and economy. It has been stated that the upper limit of fuel viscosity, which is fixed primarily by the filtering system, is about 175 secs. Redwood No. 1 at 100° F. As regards the lower limit, it has been suggested that the use of fuels of lower viscosity than 37 secs. Redwood

No. 1 at 100° F. necessitates additional maintenance of the fuel-injection system, but this has not yet been proved to be the case.

It is pointed out that ignition quality, measured as cetane number, in general increases with decreasing specific gravity, and authorities are quoted stating that there is a certain correlation between the cetane number and physical properties. While there is no proof that ignition quality is the single factor controlling combustion, if the cetane number is satisfactory the probable combustion course can be predicted with reasonable accuracy. The same authorities consider the combustion process in the high-speed diesel engine to be more critically affected by minor changes in inherent design than by improvements in fuels. The possible benefits of improvements in high-speed diesel fuels therefore appear small. In the U.S.A. in order to conserve certain types which also form motor-spirit cracking stock there will be every incentive to change to less volatile fuels when the volume of demand is greater. E. F. C.

664. Patents on Gas, Diesel, and Fuel Oils. Standard Oil Development Co. E.P. 535,401, 8.4.41. Appl. 25.10.39. Production of an improved fuel of the diesel type, which consists of a hydrocarbon base fuel to which has been added a small amount of an alkyl nitrate having at least 10 carbon atoms per molecule. The base fuel comprises a distillate having a boiling range between 450° and 650° F., an A.P.I. gravity between 30° and 45°, an aniline miscibility point above 140° F., a flash-point above 150° F., and a cetane number in the range 60–100.

E. W. Thiele. U.S.P. 2,234,207, 11.3.41. Appl. 19.10.39. Conversion of gas-oil cracking stock into gasoline and merchantable fuel oil. The oil stock is separated by the action of a selective solvent into a raffinate and an extract fraction; the raffinate fraction subjected to cracking; and the cracked products separated into heavy tar, cycle oil, gasoline, and gaseous hydrocarbon constituents. The cycle oil is thereafter recycled to the cracking operation and the viscosity of the tar reduced by combining therewith a sufficient amount of the extract fraction to produce the desired fuel oil. H. B. M.

Lubricants and Lubrication.

665. Studies in Lubrication IX. The Effect of the Pressure Variation of Viscosity on the Lubrication of Plane Sliders. M. Muskat and H. H. Evinger. *J. appl. Phys.*, November 1940, **4** (11), 739–748.—The Reynolds theory is applied to the case of plane sliders or thrust bearings with lubricants the viscosities of which increase exponentially with pressure. The coefficient of friction, minimum film thickness, and oil-flow were calculated both for fixed-wedge angle and pivoted sliders. The effect of the viscosity variation with pressure is determined, and the analysis shows that in all cases there will be a limiting position of the pivot line of the slider or of the equivalent Sommerfeld variable at which the film pressures and frictional forces become infinite. Moreover, the maximum load per unit area that can be carried by such a system is equal to twice the reciprocal of the viscosity-pressure exponent.

Specific calculations give curves of coefficient of friction against load or Sommerfeld variable quite similar to those from experimental determinations. At high loads the friction coefficient curves split and follow the behaviour generally interpreted in terms of boundary lubrication. J. G. W.

666. Recent Developments in the Production of Lubricating Oils: the Use of Additives. M. E. Kelly. *Fuel*, 1940, **19**, 180.—References are given to papers on various types of additive agents incorporated in lubricating oils: pour-point depressors, antioxidants, anti-lacquers, viscosity-index improvers, oiliness-increase agents, substances which increase pressure at the film-rupture point, corrosion inhibitors, and detergent compounds to assist in removal of carbon. J. W. H.

667. Patents on Lubricants and Lubrication. R. Rosen. U.S.P. 2,234,581, 11.3.41. Appl. 30.9.37.—Preparation of a lubricant consisting of a major proportion of a hydrocarbon oil and a minor proportion of an organic boron compound, the latter containing at least one carbon–boron bond.

S. E. Jolly. U.S.P. 2,234,915, 11.3.41. Appl. 11.10.39. Addition of a minor percentage of a nitrile to lubricating oil. The nitrile has been derived from petroleum and halogenated and contains from 5% to 50% of the halogen.

A. J. Morway and J. C. Zimmer. U.S.P. 2,235,161, 18.3.41. Appl. 20.9.38. Preparation of a lubricant consisting of a sulphide of phosphorus and a mineral lubricating oil. The lubricant is capable of carrying heavy loads.

N. D. Williams. U.S.P. 2,235,860, 25.3.41. Appl. 19.10.38. Preparation of a halogenated extreme-pressure lubricant consisting of mineral lubricating oil and a compound selected from a particular group of halogenated ketones and halogenated esters.

T. Hasselstrom. U.S.P. 2,235,926, 25.3.41. Appl. 2.12.39. Preparation of a grease including as a setting agent the crude, non-crystalline, brownish, insoluble product obtained by treating a mixture of dehydrogenated and hydrogenated rosin with concentrated sulphuric acid under conditions which promote sulphonation and removing the sulphonic acid by aqueous extraction.

N. F. Toussaint. U.S.P. 2,236,120, 25.3.41. Appl. 17.1.39. Preparation of a lubricant for use in internal-combustion engines consisting of a major proportion of a petroleum lubricating oil and a small amount of nickel naphthenate.

M. A. Dietrich. U.S.P. 2,236,168, 25.3.41. Appl. 27.2.40. Preparation of a lubricant consisting of a major proportion of a viscous petroleum oil and a small proportion of an oil-soluble organic sulphonamide, devoid of free sulphuric acid and free sulphonic acid groups.

R. L. Humphreys. U.S.P. 2,237,526, 8.4.41. Appl. 12.12.34. Manufacture of a lubricating composition consisting of a lubricating oil and at least 0·5% by weight of benzothiazol tetrasulphide.

H. E. Ries. U.S.P. 2,237,632, 8.4.41. Appl. 25.5.38. Method of improving the lubricating properties of a hydrocarbon lubricating oil by incorporating therewith a small proportion of an alkylated triphenyl phosphate in which each alkyl group contains 10 or more carbon atoms.

L. W. McLennan. U.S.P. 2,237,682, 8.4.41. Appl. 24.8.35. Preparation of a grease consisting of a major proportion of mineral oil thickened with calcium soap in an amount sufficient to impart cup-grease consistency, and from 10% to 25% of an air-blown asphalt having a melting point (R and B) between 140° and 155° F. and a penetration at 77° F. between 30 and 40. H. B. M.

Special Products.

668. Patents on Special Products. British Thomson Houston Co., Ltd. E.P. 534,573, 11.3.41. Appl. 1.9.39. The invention is based on the discovery that highly chlorinated paraffin and paraffinic materials, such as paraffin wax and paraffin oil, when suitably prepared and purified, and in admixture with or dissolved in a stable liquid chlorinated benzene, are chemically stable and inert, and can be used without corrosive effects when in contact with metals in electric devices.

N.V. de Bataafsche Petroleum Maatschappij. E.P. 535,468, 9.4.41. Appl. 11.3.40. Production of colourless or light-coloured sulphonium compounds by reacting sulphuric acid or an aryl sulphonic acid ester of a primary aliphatic alcohol of low molecular weight with a mixture of thio-ethers, prepared from a mercaptan mixture originating from the refining of a mineral oil or mineral-oil product. H. B. M.

Detonation and Engines.

669.* Some Fallacies Concerning the Petrol Engine. W. T. David. *Engineer*, 1940, CLXX, 388–389.—It is thermodynamically desirable that the chemical energy of the charge in a spark-ignition engine should be wholly released—up to the limit imposed by dissociation—by the time the peak pressure is reached. The common assumption that a sharply defined peak pressure indicates that the chemical energy has been fully released is disproved by the author:

> (1) By comparing the actual rise of pressure after explosion with carefully calculated theoretical values in which allowance is made for heat loss after explosion. Several experimenters, including the author, have found that between 70% and 81% of the chemical energy of the charge was released by the time the peak pressure was reached. In a specially designed hemispherical combustion space of a gas engine the exceptional value of 90% was obtained.
>
> (2) By comparing the expansion curve of an actual indicator diagram with a theoretically calculated adiabatic expansion curve drawn through a peak pressure of the actual indicator diagram. Since the actual expansion curve lies well above the theoretical curve in all cases examined, it is clear there is a continued evolution of heat during the expansion stroke.

The author stresses the importance, from the aspects of fuel economy, engine reliability and life, of the desirability of securing as perfect homogeneity as possible. He has previously shown imperfect mixing to be the cause of incomplete combustion of the charge at peak pressure, with attendant higher exhaust gas and valve temperatures.

In discussing the effect of normal fuel types on engine efficiency, the author shows that, contrary to some beliefs, even under non-detonating conditions differences up to 5% in efficiency may be expected from a given engine running on various fuels. In the case of gaseous fuels the efficiency may be expected to vary widely, according to their nature.

In conclusion, heat-loss distribution in high-speed engines during explosion and expansion is discussed and discrepancies between the work of well-known authorities are indicated. E. F. C.

670.* Cylinder-Liner Wear in Gas Engines. Anon. *Engineering*, 1940, **150** (3896), 216–217.—Information has been collected by the National Gas and Oil Engine Co., Ltd., in respect of cylinder-liner wear in two gas-engine installations manufactured by themselves. One consists of four 12-cylinder 1500-h.p. engines of the vertical type, there being six cranks with two cylinders in tandem to each crankpin. The cylinder diameter is 26 in., and the engines operate on blast-furnace gas as fuel. Two of the engines were started up in 1921 and two in 1924. The other installation dealt with comprises six 6-cylinder 600-h.p. engines running on producer-gas generated from wood. These engines, which are installed in the power-station of a South American gold-mine, have a cylinder diameter of 17 in. and a stroke of 21 in.; they have been at work for about 11 years, representing some 70,000 hours' running.

The average liner wear in the top cylinders of the four blast-furnace gas engines was 0·001 in. per 1000 hrs.' running, and the maximum allowable wear was fixed at 0·1 in. before relining was carried out. The average rate of wear in the bottom cylinders was less than half that in the top cylinders.

In the producer-gas engine installation, except in the case of two engines which also showed a wear of 0·001 in. per 1000 hrs., the average liner wear was rather lower at about 0·0007 in. per 1000 hrs.

Although new liners have been fitted to these engines, the original pistons are still in use. Piston-ring groove clearances measured on one engine after 70,000 hrs.' running showed the average groove wear to be 0·012 in., 0·007 in., and 0·005 in. for top, middle and bottom rings, respectively, and it is thus assumed that the pistons should be still quite good for a further 70,000 hrs.' running. E. F. C.

671.* Exhaust-Pipe Pressure Waves. L. J. Kastner. *Engineering*, 1940, **150** (3901), 301–303.—The theoretical expressions for the velocity of waves in pipes are discussed with reference to such factors as temperature, pipe diameter, frequency, and the effect of large amplitudes. Although very high velocities may occur near the source of disturbance, these have but little influence on the average velocity of propagation.

A method of calculating the initial pulse is given, but it is pointed out that this is laborious. A little experience allows the shape of the pulse to be guessed, or it may be obtained experimentally.

The formation of the pressure wave in the pipe is examined, and it is shown how it may be arranged to assist the charging of the engine. Various curves are given, and their use in estimating suitable exhaust-pipe lengths for two-stroke engines is described.
J. G. W.

672.* Loss of Power in Petrol Engines Running on Producer Gas. H. Heywood. *Engineering*, 1941, **151** (3915), 61–63.—It is shown that when a petrol engine is converted to use producer gas as fuel there is an unavoidable decrease in power of about 40–50% due to :

(1) The low calorific value of the gas-and-air mixture.
(2) Reduction in volume of products of combustion from the original charge volume.
(3) Reduced density of cylinder charge due to high gas temperature and/or pressure drop through the producer and filter.

This power loss may be reduced in the following ways :

(1) By increasing the compression ratio from the standard assumed value of 6·25 to 8·5, 15% more power may be obtained.
(2) By increasing the calorific value of the gas. It is shown that variations in gas quality can account for differences in power output of between 35% and 40%.
(3) By supercharging the gas–air mixture. With about 9 in. Hg. boost the power developed would be equal to that normally obtained on petrol.
(4) By the addition of petrol vapour to the mixture. This expedient is, however, regarded as only a temporary measure, and involves combustion difficulties, owing to air shortage at full throttle.

By using an entirely new engine of approximately double the capacity of the original petrol engine, comparable powers may obviously be obtained. E. F. C.

673. Condenser-type High-speed Engine Indicator. Louis C. Roess. *Rev. Sci. Instrum.*, June 1940, 11 (6), 183–195.—The basic principle involved in the indicator is the modulation of a high-frequency carrier wave by the capacity variations of a condenser-type microphone or pick-up. This element, which is screwed into an indicating hole in the engine cylinder, consists essentially of a stainless-steel shell rigidly supporting inside it a mica-insulated electrode. The lower end-plate of this forms a condenser with a diaphragm integral with the lower screwed end of the steel shell, an air gap of the order of 0·003–0·005 in. normally being used. The diaphragm thickness is chosen by compromising between sensitivity, which varies inversely as the thickness cubed, and fidelity of reproduction, which is mainly determined by the lowest natural frequency of the diaphragm. Practical values vary from 0·035 to 0·070 in., with natural frequencies from 50,000 to 100,000 cycles per second.

Problems usually associated with the condenser type of pick-up—viz. capacity changes produced by the motion of microphone parts other than the diaphragm and vibration effects of the pick-up-amplifier leads—have been successfully overcome ; the latter effect by the use of a special balancing circuit described in detail. Because of the sensitivity of the circuit, very little amplification is required to operate the cathode-ray oscillograph ; both pressure-time and rate of pressure change-time diagrams can be observed.

The sweep circuit used to provide the time axis on the screen is synchronized with the engine by means of the output of a magnetic pick-up actuated by a stud on the flywheel, whilst a similar pick-up operating a thyratron impulse circuit in conjunction with a series of flywheel studs produces a calibration of the time axis in crank-angle degrees.

Photography by individual engine cycles has been greatly facilitated by the use of an electron-beam intensifying circuit, which operates only at the correct instant and for the length of time to record the desired portion of the engine cycle.

Because of its wide frequency response, limited only by the elastic characteristics of the diaphragm, it is claimed that the indicator is particularly applicable to the study of knocking combustion. E. F. C.

674.* **Car-Design Trends.** T. A. Bissell. *J. Soc. aut. Engrs*, 1940, **47** (5), 445–460.—A survey of innovations and design features incorporated in the latest models of American passenger cars. Easier operation is a feature of several new cars, outstanding examples being the new Chrysler automatic 4-speed transmission, for use with fluid drive, and Packards new semi-automatic clutch. There is also a wider application of Oldsmobile Hydra-Matic drive. The only completely new car is the Nash Ambassador 600. The V. 16 Cardillac, Lincoln V.12, Ford V. 8, 60, and the La Salle have been discontinued. Buicks " compound carburetion " is one of the most important 1941 innovations, employing two dual carburettors, one of which operates only after the throttle of the other is opened about half-way. Greater fuel economy and power output are claimed. Practically all engines have been stepped up in power output, and compression ratios are still definitely increasing to take full advantage of the higher anti-knock properties of available fuels ; ratios of 7–1 being used on the Buick 60, 70, and 90, and 7·25–1 on the Cardillac V. 8 and the Hudson 6-cylinder "L" head engines. C. H. S.

675.* **Performance of Modern Aircraft Diesels.** Paul H. Wilkinson. *J. Soc. aut. Engrs*, 1940, **47** (5), 474–479.—This paper reviews the development work on aircraft diesel engines which was in progress just prior to the war in Germany, France, Great Britain, and the U.S.A. Descriptions and some details of performance of several engines are given, most of which were experimental models. These engines include the latest German Junkers Jumo, B.M.W.-Lanova ; the French Clerget ; and the American Guiberson, and N.A.C.A. developments. C. H. S.

676.* **Wear-resistant Coatings of Diesel Cylinder Liners.** J. E. Jackson. *J. Soc. aut. Engrs*, 1941, **48** (1), 28–32.—This paper discusses the influence of chemical surfacing on the running-in of diesel liners.

Photomicrographs illustrate the condition of the liner surface after finish-honing before and after running-in, and the alteration in the surface before and after running-in produced by treating the surface in a concentrated water solution of sodium hydroxide and a small amount of sulphur. The process described is known as the " Surfide Process," and was developed by the Standard Oil Co. of California.

The process is one of etching, and any free ferrite at the bore surface is etched from the matrix. The important surface metal to be removed by the etching is the strain-hardened metal formed on the surface by honing. The etching process produces a matt surface which retains and spreads the lubricating oil and gives a greater degree of safety during the initial period of running-in. The coating formed by the process consists of ferrous oxide and ferrous sulphide tightly bonded to the unetched underlayer of iron. C. H. S.

677.* **The C.U.E. Co-operative Universal Engine for Aviation Single-Cylinder Research.** A. W. Pope, Jr. *J. Soc. aut. Engrs*, 1941, **48** (1), 33–40.—This article describes and illustrates the C.U.E. engine which was first developed for aero-engine spark-plug research and was first displayed at a meeting of the S.A.E. in 1937. The original design did not cater for the requirements of the petroleum industry, which was interested primarily in lubricating oil and fuel tests. After completing five designs, a combination was developed which appeared to meet all requirements, and fifteen of this latest type have been completed, and a further fifteen are now on order. The detailed description covers the major features in the design, including the balancing system ; main roller bearings ; the crank chamber ; lubrication system ; crankcase seal ; temperature control ; accessory drives ; crankshaft ; conn. rod ; dynamometer coupling ; reverse rotation ; and fuel-injection system.

One of the main features of the engine is the balancing system which is contained in a sub-base entirely separate from the crank chamber, which remains clean and smooth, and the balancing system is thus quite separate and independent from the main engine-lubrication system. C. H. S.

678.* **Bearing Metals and their Suitability for Modern Requirements.** M. Melhuish. *J. Inst. aut. Engrs*, 1940, **9** (1), 1–12.—High-grade tin-base white metals which have been almost exclusively used for internal-combustion engine bearings until comparatively recently are now being supplanted by bearings of other materials. The author lists eight groups of bearing alloys in use at the present time and reviews the properties of each group. High-grade tin-base white metal has many advantages over other materials if the alloy is selected to suit the duty it has to perform. It has high anti-frictional properties, the property of bedding down to its shaft, and if short of oil will flow and give greater clearance. The present problem seems to be to develop a bearing material which, whilst retaining the advantages of a high-grade tin-base babbitt, will stand up to the heavy pounding loads which bearings are now called upon to withstand. C. H. S.

Coal and Shale.

679.* Oil Shales, Torbanites, their Allies and Some of their Problems. G. W. Himus. *Petroleum*, April 1941, **4** (1), 9.—There has so far been little fundamental work carried out on the chemical nature of the organic and inorganic matter present in shale, most of the investigation work relating to extraction and refining of the oils. The present discussion covers the work done and in hand on the determination of the kerogen content and its chemical composition, microscopic examination of the shale to indicate the origin of the kerogen-forming material, determination of the nature of the inorganic matter and of the relation of the kerogen to the mineral matter.

Determination of the ash of shale by combustion (and hence of the kerogen by loss) is rendered difficult by the presence of hydrated minerals and by their decomposition on heating. Removal of ash is best effected by treatment with dilute HCl followed by dilute HF, although this is not complete, about 1% of ferric oxide being left, pointing to the presence of ferro-organic compounds in the kerogen. After ash removal, ultimate analyses can be carried out. Microscopic examination of oil shale generally reveals macerated plant debris, seldom recognizable spores or algae, some, however, showing animal remains. Kerogen is believed to be mainly of vegetable origin, in evidence of which it has been shown that higher yields on carbonization are given by cannel coals containing higher proportions of algae. In some respects (*e.g.*, behaviour with alkaline $KMnO_4$) kerogen appears to be chemically allied to coal, although Esthonian kukersite appears to be from a different source, or produced under different conditions. The inorganic matter present varies widely from the Esthonian limestone to the fine siliceous silt of Newnes (N.S.W.), and to a large extent is not combined with kerogen, although a small part, so far impossible to separate, may be combined.

A petrological classification has been suggested (A. L. Down, *J. Inst. Petrol.*, 1940, **26** (201), 329) covering torbanites, boghead, and cannel coals, suggesting their relationship to the coals of the peat to anthracite series. This is based on the nature of the organic matter, quantity, and nature of the inorganic matter, and the structure of the rock. C. L. G.

Economics and Statistics.

680.* World Crude Production up 3·33%. *World Petrol.*, February 1941, **12** (2), 19–21.—In 1940 U.S.A. produced 1352 million barrels of oil, 6·83% more than in 1939. This was 63% of the world total. The rest of the world gave 794 million barrels, 2·11% less than in 1939. As compared with 1939, decreases in production during 1940 took place in Venezuela (10·21%), Iran, Netherland India (2·02%), Rumania (5·88%), and Iraq (16·45%), whilst there were rises in the U.S.S.R., Colombia (18·28%), Argentina (9·38%), Canada (14·27%), Trinidad (4·92%), and Egypt (31·47%).

Detailed figures are given by months and years for the more important producing countries. G. D. H.

681.* Economic Aspects of Hydrogenation Process. L. A. Stengel and R. N. Shreve. *Industr. Engng Chem.*, 1940, **32** (9), 1212.—The economic aspects of the hydrogenation process as applied to the manufacture of cheap commercial products is outlined. H. E. T.

BOOK REVIEW.

The Physics and Chemistry of Surfaces. By N. K. Adam. Pp. x + 402. 2nd Edition, O.U. Press, 1938. Price 22*s*. 6*d*.

This second edition of Professor Adam's book follows essentially the plan of the first, except for the omission of the chapter on the properties of molecules as deduced from methods other than those of surface chemistry, and the inclusion of one dealing with electrical phenomena at interfaces. In view of the enormous growth of the subject since the first edition in 1930, it has very wisely been largely rewritten.

Beginning with a short introductory chapter on the fundamental properties of liquid surfaces and the molecular interpretation of surface tension, he then deals very comprehensively with insoluble films on liquids. This is one of the best sections, as might be anticipated from his intimate association with this particular field, and shows an excellent balance in discussing the work of his own and other schools. After outlining the historical development, the experimental technique and types of monolayers encountered are discussed at some length. Mention is made of the large number of diverse problems for which this technique can be employed, such as structure determination for complex organic molecules, and chemical reactions at interfaces.

From insoluble monolayers we are led naturally to adsorbed films at the gas/liquid and liquid/liquid interfaces, including the thermodynamical proof and experimental test of the Gibbs adsorption isotherm. The behaviour of surface films in emulsification, a question of great interest to the petroleum technologist, and one which has been much to the fore recently, concludes this section.

Turning now to solid surfaces, an excellent account is given of their general properties, such as surface structure, contact angles, and work of adhesion to liquids which bear so directly on the flotation method of mineral separation, and emulsification by solid powders. This leads up to a discussion of the spreading of liquids and the mechanism of lubrication by boundary films. The catalytic and adsorptive powers of solid surfaces are well discussed in the light of modern concepts, although in a rather condensed fashion.

The general review of electrical phenomena at interfaces gives a clear discussion of the definition and origin of electrical potential differences, of the rôle of surface films in contact and electrode potentials, and of the ζ potential and electrokinetic phenomena. The book concludes with a useful chapter on the methods of measuring surface tension.

By restricting the details and more controversial points to small type, the author has provided a very readable treatment for the new-comer to this field. At the same time its critical treatment and comprehensive bibliography make it invaluable to all interested in this large and rapidly growing branch of physical chemistry.

A. E. Alexander.

BOOK RECEIVED.

Aeroplane Fuel and Oil Systems. Editors : E. Molloy and E. W. Knott. Pp. vi + 124. Illustrations 103. George Newnes, Ltd., Tower House, Southampton Street, Strand, W.C.2. Price 6*s*.

This book deals with the inspection and maintenance of fuel and oil systems from the point of view of the aircraftsman and ground engineer. After a detailed survey of present-day fuel-supply systems, including an account of the general arrangement of tanks, pipe-lines, and control cocks, and of important accessories such as fuel-tank contents gauges, some typical examples of fuel and oil systems of both British and American aircraft are dealt with. In particular may be mentioned the Westland "Lysander," the Bristol "Blenheim," and the North American "16–3." A section is devoted to the testing of aeroplane fuel, the following most important tests being described : gravity, volatility, knock-rating, gum content, sulphur content, and vapour pressure. This is followed by instructions relating to the installation and maintenance of fuel and oil pipe-lines. Some notes on the testing of these lines are also included, together with practical notes on the de Haviland A.C. fuel pump, the Amal dual fuel pump, and the Standard Gipsy VI oil pump and their assembling.

INSTITUTE NOTES.

June, 1941.

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 Fellow.

Hyams, Harry	England.

As Member.

Goodhind, William Henry	England.

Transferred to Member.

Ives, Herbert Charles	England.
Skilling, Norman L.	England.

As Associate Members.

Goldstein, Richard Frank	England.
Wardlaw, Harold Wilberforce	Trinidad.
Williamson, David Kenneth Caird	Sydney.

Transferred to Associate Member.

Jennings, W. Munro, Jr.	England.
Streeton, Reginald Douglas	England.

As Students.

Hirst, Norman	England.
Hughes, Fred	England.
Turner, Eric Braybrooke	England.

CANDIDATES FOR ADMISSION.

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

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

The names of the candidate's proposer and seconder are given in parentheses.

Kronstein, Joseph Alexander, Economist, Ragosine Oil Company. (*G. J. Vineall; C. W. Wood.*)

Leitch, James Morton, Engineer, H.M. Forces. (*C. M. Leitch.*)

ARTHUR W. EASTLAKE,
Honorary Secretary.

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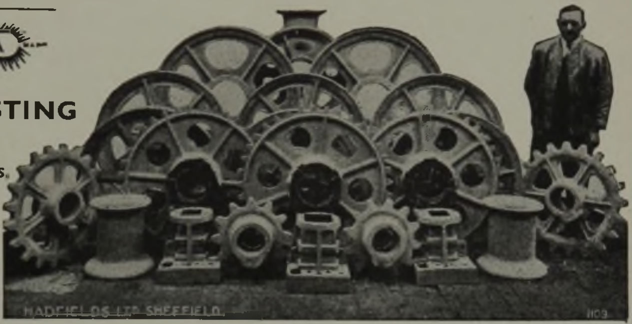

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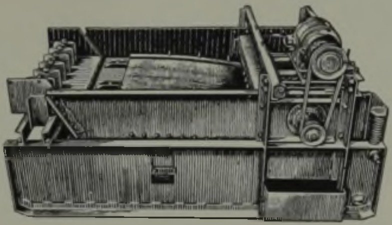

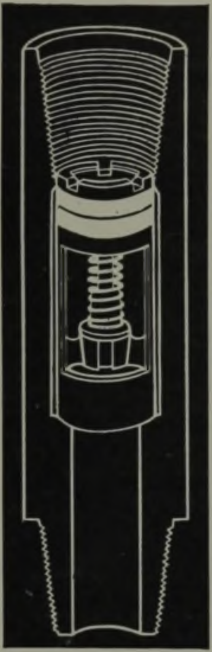

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