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THE ANALYSIS AND TESTING OF LUBRICATING GREASES.*

By M. W. Webber.

As this paper is based on work carried out in the laboratory of a works which is solely engaged in the manufacture of lubricating grease and allied products, there is no reference to service conditions. Its scope is confined solely to soap greases.

The appearance of the grease is the first item in its examination. From this it is possible to learn whether it is well made, smooth and of uniform texture, free from aggregates of soap, separated oil, whether it is made from lime or soda soap, and if of fibrous structure. The chemist has much to learn from this preliminary observation. A trained observer can tell at a glance much of what he will subsequently prove by a detailed laboratory examination. It is therefore important that the eye should be trained in observation. Then the nose should be familiarized with the odours emanating from greases. Much work can be eliminated if fats can be detected by smell. A cup-grease made from fatty acids has a different smell from one made from neutral fats, and most high-temperature soda greases possess characteristic odours.

Soap Base and Content.

At least 90 per cent. of the greases on the market contain either lime or soda soaps. As a rule, these are readily distinguished by dropping a little on to boiling water. Soda-soap greases immediately render the water milky, due to soap dissolving in the water and emulsification of oil, whereas lime-soap greases are unaffected by the water. When the two soaps are present in the same grease the test only gives indication of soda soap. Greases made from lead soaps frequently sink, due to their high specific gravity, but this depends on the percentage of lead and any aeration. Aluminium-soap greases are usually detected by their transparency and their elasticity when heated. Other soaps, such as zinc, barium, magnesium, and potassium, are encountered on rare occasions, and must be sought in the ash after incineration.

The soap content is usually determined by decomposing the grease with dilute hydrochloric acid, extracting with petroleum ether, and then titrating the washed ether solution, which contains both the fatty acids from soap and any free fatty acid originally present. After due adjustment for the latter, the soap content is calculated, using an acid value of 200. If greater accuracy is desired, the fatty acids can be separated and weighed, and the exact acid value determined.

The operations sound simple and straightforward, but difficulties in manipulation are often experienced. A simple alternative method is to extract the grease with acetone in a Soxhlet. Experience with greases of known composition has shown that an accuracy of 0·2 per cent. is readily

* Presented to a Meeting of the Lubrication Group of the Institute at The Royal Society of Arts, London, W.C. 2, on Thursday, 22nd February, 1940.

obtained. This method is particularly useful in the case of lime-soap grease made with wool-grease stearines, as the unsaponifiable portion is completely soluble in hot acetone. When using the normal method, which is described above, it is impossible to obtain sharp separations. It is preferable to dehydrate the grease by drying in an oven before extraction in the Soxhlet, and base calculations on the original weight of the grease.

About 5 grams of a lime-soap grease can be extracted satisfactorily with 60/70 mls. of acetone in 1 hour. Soda-soap greases may require extraction for at least 3–4 hours, particularly those of high soap content and pronounced fibrous structure. With this method there is a great saving of time and trouble in most cases, and it is equal in accuracy to the normal method. It may be that extraction can be speeded up by the use of a solvent of rather higher boiling point.

Should fillers be present, the contents of the thimble should be extracted again with alcohol in the case of soda-soap greases, and toluene in the case of lime-soap greases. The fillers can then be examined and weighed, and the necessary adjustment made.

The general adoption of a standard extraction method for the determination of soap content of lubricating greases would probably avoid difficulties sometimes experienced when the laboratory of the user is more accustomed to analysing quite different products.

From the user's point of view determination of the soap content is becoming less important, as is shown by the present tendency to omit strict details of the composition when formulating specifications.

Mineral Oil Content.

The mineral oil is determined by decomposing the grease with dilute hydrochloric acid and extracting with petroleum ether, separating the ether solution, saponifying the fatty acids and any fat present, and determining the unsaponifiable oil in the normal manner. The mineral oil will, of course, be contaminated with any unsaponifiable matter from the fats used in the grease, but this usually does not affect appreciably the examination of the mineral oil for colour, viscosity, gravity, flash point, and pour point.

Naturally, only a small quantity of oil can conveniently be extracted. Viscosity at 140° F. is usually determined in a small U-tube viscometer. The specific gravity is found by adjusting a mixture of alcohol and water so that a drop of the oil just remains in suspension, and then taking the gravity of the mixture. An approximate estimation of the open flash point can be made by carefully heating a little of the oil in a crucible on a sand-bath. The pour point can be determined by cooling the oil in a test-tube, but the Air Ministry apparatus can be used if sufficient oil is available.

An alternative method for the determination of the mineral oil content is by evaporation of the acetone extract resulting from decomposition of the grease with acetone in a Soxhlet. The residue is weighed and reported as mineral oil. The oil is contaminated with free fatty acid, neutral fat, and unsaponifiables, but the total of these is usually less than 1 per cent. If an accurate analysis is needed, separate determinations will be made of the free acid and free fat, and due allowance made. A separate estimation of the unsaponifiables from the fats is extremely difficult, and no method is suggested. The contaminated mineral oil can be used for the physical tests, as the contamination will not cause errors any greater than those due to the method of test of small quantities of oil.

Free Acid and Alkali.

The methods described in I.P.T. Serial Designation L.G.5 are reliable and satisfactory for routine estimation of free acid or alkali. However, in the case of soda-soap greases, containing appreciable amounts of free fat as well as free alkali, it is preferable not to boil the solution, as any error due to the presence of carbon dioxide will always be less than that caused by saponification of neutral fat on boiling. The determination of free acid in aluminium-soap greases can be effected by extraction with cold neutral alcohol and then titrating. A suitable procedure is to weigh 10–15 grams into a conical flask, shake thoroughly for 5 minutes with 50 mls. alcohol, allow to settle, and decant the alcoholic extract. This should be repeated, the extracts united and titrated in the normal manner.

While free alkali in soda- or lime-base greases may have little effect on bearing metals, the presence of a large proportion is definitely undesirable, as it affects adversely stability at elevated working temperatures. If the grease is to be used with alloys containing aluminium or magnesium, no free alkali should be allowed.

The determination of free fatty acid (mineral acid is, of course, never to be found in a compound lubricating grease) is most necessary, as the presence of any considerable amount is the principal cause of corrosion of bearing metals. A reasonable limit is an acid value of 0·2 mg. KOH per 1 gram of grease—*i.e.*, approximately 1 per cent. f.f.a. as oleic acid. A grease complying with this will normally be satisfactory from the point of view of corrosion, whilst the free fatty acid can be sufficient to ensure stability when heated.

Specifications have been issued which specify the *p*H value for the determination of freedom from acidity or alkalinity, but this would appear to be of limited value with lubricating greases, as appreciable quantities of free fatty acid make little or no difference to the apparent *p*H value.

Water Content.

The water content is most accurately determined by distillation using the Dean and Stark method as described in I.P.T. Serial Designation F.O. 14. It is not satisfactory to determine the water by heating in an oven, as this does not ensure the removal of all water from the grease. In addition, there may be some loss of volatile constituents of the mineral oil. These two errors seldom exactly counterbalance one another. The total loss of volatile matter may in some cases be considered to be of importance to detect the use of inferior oils.

In lime-soap greases the presence of a certain amount of water is essential for their stability, but an excess is to be avoided. Some specifications call for a limit of 1 per cent. for water without due concern about the soap content. In general the optimum proportion of water is 6 per cent. of the soap content. Such a limit would allow the presence of sufficient water for the manufacture of a stable grease, whilst there would not be an excess to cause corrosion.

In the case of sodium or aluminium base greases the water content may be reduced to negligible proportions, although in the case of greases containing large amounts of soda soap a quantity up to 0·5 per cent. of water may be retained, and this will persist however high the temperature of dehydration during manufacture.

Unsaponified Fat.

The content of unsaponified fat can be determined either from the petroleum ether extract after decomposition with hydrochloric acid and extracting with ether, or from the acetone extract resulting from the soap determination using the Soxhlet apparatus as described earlier in the paper. In both cases the free fatty acids in the solution are neutralized, followed by an estimation of the saponification value. The percentage of neutral fat can then be calculated with sufficient accuracy if the saponification value of the fat is taken as 195.

Until recently it was thought that the deliberate inclusion of unsaponified fat in a grease improved both stability and lubricating efficiency. It is now generally agreed that the presence of free fat is to be avoided. Its decomposition leads to the formation of undesirable products. Greases stable to heat can be made without excess neutral fat. Tests on the Timken machine have shown that the presence of free fat does not appreciably reduce friction or increase load capacity.

Ash Content.

The importance of the determination of ash left on ignition by a lubricating grease is often denied. It does, however, serve useful purposes. Glazed porcelain crucibles are quite satisfactory for the ignition. The grease should be slowly and steadily burnt off at as low a temperature as possible. The crucible is then heated to redness until all carbonaceous matter has disappeared and ignited to constant weight.

The ash can then be examined qualitatively or quantitatively by the usual methods for the determination of base and mineral fillers. In the case of pure greases the determination of ash will give a very good idea of the amount of soap present. The ash content can be used as a rapid routine check on successive deliveries of the same grade of grease.

Where mixed-base greases are under examination, analysis of the ash is a matter of importance, as it is often the only practicable means of determining the types and proportions of soaps present.

Impurities.

By impurities, as distinct from fillers, are meant such foreign matters as grit, dirt, particles of wood or metal from containers and plant. The presence of impurities is usually due to careless handling during packing, as most greases are carefully filtered during manufacture. Such adventitious matter can be determined visually by examination of the grease in a thin film on a sheet of glass, or on an opaque white surface. Soft lime-soap greases can also be examined by passing them through a piece of fine muslin, and stiffer greases by forcing through finely woven wire cloth. Alternatively, the grease can be dissolved in toluene, and passed through a filter-paper, or this can be done more rapidly by extraction in a Soxhlet.

Fillers.

The expression " fillers " is usually reserved for " loading " material, such as gypsum or barytes, but the term is often taken to include such ingredients as graphite, mica, asbestos fibre, wool yarn, granulated cork, all of which are deliberately incorporated to increase the efficiency of the grease for particular applications. Mineral fillers can easily be determined from the ash, whilst combustible fillers can be separated by filtration after decomposition of the grease with hydrochloric acid and petroleum ether.

If extraction in a Soxhlet with acetone has been employed for the estimation of soap, the fillers can be examined and weighed after elimination of the soap by further extraction of the residue in the thimble with toluene. If a separate determination of soap is not made, the original grease is extracted with toluene.

Addition Agents.

As in the case of lubricating oils to-day, a number of materials are being added in small or large proportions to lubricating greases to improve their efficiency for various purposes.

Chlorinated waxes and sulphurized oils (with or without the presence of lead soap) are added to increase the load capacity of greases destined for rolling-mills, and stamping and drawing operations. The proportion of sulphur or chlorine can be determined by fusing the dehydrated grease with a mixture of sodium carbonate and potassium nitrate or sodium peroxide. The resultant mass is dissolved in water and the sulphates or chlorides are estimated.

In order to increase the adhesiveness or stringiness of greases, such materials as rubber latex and highly polymerized products are incorporated in the grease. The proportion is usually less than 0·25 per cent., and as determination by analysis is extremely difficult, no method is suggested.

Solid addition agents, such as graphite, mica, asbestos fibre, and wool yarn, are determined as fillers using the methods described earlier in the paper.

In the case of colloidal graphite the proportion present is usually from 0·05 to 0·2 per cent. and determination by quantitative methods is beset with difficulties. I have found that the best method is to dissolve the grease in toluene and to compare dilute solutions with known standards.

Corrosion.

Any corrosion caused by a grease is usually due to excessive contents of free fatty acid and/or water, and in some cases to the presence of chlorides or sulphates. A suitable method of test is to take pieces of polished copper and steel, about 1 inch square, cover them partly with the grease, and allow to stand under inverted watch-glasses for a period of at least 24 hours. After cleaning, the test-pieces should show no discoloration or pitting.

The test can be carried out at room temperature, or higher if considered advisable.

Melting Point.

Many simple methods have been suggested for the estimation of the melting point, but it is obviously desirable to have a standard method. The Ubbelohde apparatus was originally designed for the melting point of petrolatums, but during recent years it has been applied to greases in general. To obtain consistent results with soap-greases it is essential that air bubbles should not be included with the grease when filling the cup. Apertures in the metal holder must be kept clear, and the rate of heating accurately controlled. Discrepancies in the results obtained with the Ubbelohde apparatus in different laboratories are principally due to lack of standardization of the cups, especially as regards the orifice. Standardization of the method has recently been undertaken by the British Standards Institution, and no doubt it is a subject which will be considered further by the Institute of Petroleum at an early date.

The obtaining of consistent results with high-melting-point soda-greases of fibrous and block types is difficult with the Ubbelohde apparatus. A suitable method of test for such greases, which will give consistent results, is to take a piece of wire about 3 inches long, make a small loop at one end, and then coil the wire round the thermometer stem and adjust so that the loop is level with the tip of the bulb. A small portion of the grease, sufficient to yield three or four drops, is then fixed in the loop so that it is in contact with the thermometer bulb. The thermometer is then placed in a test-tube, which is heated in the usual way in a bath of oil or glycerol.

The determination of the melting point of a grease is of great importance, but the conventional methods do not always give complete information of the results to be expected in service. A useful test to employ in this connection is to make 15 grams of the grease into a cone in a flat metal dish—the lid of a tin will serve quite well—and then to place this in an oven maintained at a temperature 30–40° F. below the apparent melting point of the grease. It will often be found that, of two greases having similar melting points, one will maintain its structure unchanged, whilst the other will break down and flow out to a common level.

Consistency.

The only method for the determination of the consistency of a lubricating grease that has received official recognition is that employing the penetrometer and procedure described under I.P.T. Serial Designation L.G.18 and A.S.T.M. D.217–33.T. The use of this apparatus does give reproducible results, and it is exceedingly useful for the control of works batches and for specification purposes. Alternative methods in regular use, such as the Karns–Maag, the method described in Air Ministry specification D.T.D. 143. B, and sundry others employed in various works laboratories, have in common the allowing of a solid plunger to penetrate the grease when dropped from a known height—the consistency being taken as a reciprocal factor of the distance to which the plunger sinks below the surface of the grease.

All these methods give results which are not compatible with those obtained with the I.P.T. apparatus. Investigation has shown that the difficulty is principally due to the fact that the cone penetrometer does not respond sufficiently to changes in the viscosity of the mineral oil content of the grease. For example, particulars are given of the comparative penetration figures obtained with the I.P.T. and the D.T.D. 143. B apparatus when testing two greases, of which " A " is based on 100 Pale Oil, and " B " on 500 Red Oil. Both greases were made by the same method and with the same fats, and have identical lime-soap contents—namely 12½ per cent. All tests were made on the worked greases.

	I.P.T. Method		D.T.D. 143. B Method	
	" A "	" B "	" A "	" B "
0° C. (32° F.) . . .	26·0 mm.	20·5 mm.	0·6 in.	0·25 in.
25° C. (77° F.) . . .	30·0 mm.	26·5 mm.	1·0 in.	0·55 in.
60° C. (140° F.) . .	34·2 mm.	31·5 mm.	1·45 in.	1·15 in.

In view of the almost universal use made of the I.P.T. apparatus, these results were checked by ascertaining the rates of feed of both greases at the three temperatures from a constant-pressure-spring grease cup. While the exact figures obtained varied with different cups, it was obvious that the plunger or D.T.D. 143. B method gave results which were the more truly indicative of the rate of feed. Further, as the outlet of the cup was a tube measuring 1 inch in length by ⅛ inch in diameter, it could be considered as a crude form of constant-pressure grease viscometer. Accordingly, it would appear that the plunger method gives results of more practical value than the cone penetrometer, although the latter is, as stated, very useful for checking works batches of greases made from the same oil, and at the same temperature.

The D.T.D. 143. B plunger method is the more readily adaptable, owing to its compactness, for use at widely varying temperatures, and it is, indeed, already in use for the testing of greases at temperatures ranging from as low as − 50° C. to as high as 100° C. Discrepancies between the Air Ministry and other similar methods arise from the fact that in the former the tube of grease under test is contained within another tube and the displaced grease rises round the plunger, whilst in the other methods the grease is in an open container giving a comparatively large free surface. In the Karns–Maag apparatus the plunger is spherical instead of cylindrical, and little heed is taken of the extent of the working to which the grease has been submitted.

Whatever the method of determination employed, it is essential that the grease should be tested in the " worked " condition. The I.P.T. worker is perfectly satisfactory. The determination of the unworked consistency is of little practical value, and in any case it is difficult to obtain consistent figures even when using original containers. However, the determination of the ratio between the unworked and worked penetrations does keep a check on manufacturers who draw their greases at rather high temperatures and send them out with false apparent consistencies. Modern mechanical greasing devices do thoroughly work the lubricant before delivery to the bearing, and it is the consistency at the delivery point that matters. In any case, greases should be preworked as far as possible during manufacture for such methods of application, in order to ensure that as consistent a grease as possible is supplied through the lubricator.

Stability at High Temperatures.

During recent years increasing interest has been taken in the behaviour of lubricating greases at high working temperatures, more particularly in the case of lime-soap ball and roller-bearing greases at temperatures above their melting point which would also cause more or less complete dehydration. This interest is justified, but the value of such a test is not so great as it would appear to be from the amount of discussion which it has caused. It must be remembered that a grease is only used for the lubrication of such bearings where retention and protection are of primary importance, and no grease is deliberately chosen for use at temperatures above its melting point. Accordingly, it would appear that a more prolonged stability test at, say, 65–70° C. has more practical value, and this also applies to greases intended for general machinery lubrication.

The result of the more stringent test of subjecting the grease to a temperature of 120° C. or over is not always correlated to the stability of the grease at more normal working temperatures. Such a test has, however, its value, in that it does ensure that separation will not take place if the grease is overheated for a short time. For example, this could occur in the event of particularly severe overloading, or if the grease should channel, in which case the lubricant would not be drawn into the ball grooves until sufficient heat had been generated to make the grease at least semi-fluid.

As regards the method of conducting such heat tests, that specified by Messrs. British Timken, Ltd., is the one in most common use in this country. While this test does give useful information, it is somewhat arbitrary, and the method specified by the War Department Chemist, the Air Ministry, and the London Passenger Transport Board is preferable. In both methods the temperature is practically the same—namely, 250° F. or 120° C.—and while the specified stirring of the grease in the Timken test does ensure more complete dehydration, this is balanced by the fact that the alternative method specifies heating at 1 hour instead of the Timken half-hour.

In the case of the Timken test the grease must re-set hard enough to allow of its retention in the silica tube by the cross wires, and a dehydrated grease which sets to a hard gel will usually break down rapidly when subjected to agitation. On the other hand, many greases when subjected to this heat test will return to a softer and more greasy gel which is more stable on agitation, and these pass in a more satisfactory manner the alternative test. From the point of view of the works chemist, the Timken test requires more time and manipulation than does the test used by the Government Departments, without giving any more useful information, and this is of some importance where a number of batches have to be tested each day.

Stability at Normal Working Temperatures.

As regards stability tests at more normal working temperatures, the original practice was to heat 20 grams of the grease in a porcelain dish in an oven for 24 hours at 70° C. Recently this test has been extended to periods of over a week, and useful information has been gained.

Apart from lime-soap greases, heat tests of high-melting-point soda-soap greases at temperatures below their melting points are definitely equally as important. These are normally carried out for periods of up to 24 hours' heating at temperatures of 100° C. or 150° C., according to the melting point of the grease and its intended application. It is essential that the grease should not harden excessively or separate oil, and much useful information can be gained by observation of the consistency and structure of the grease after heating at these temperatures.

In the case of high-melting-point block-greases, explanation of surprising differences in consumption can be found by placing cubes of the grease on, say, 10-mesh wire gauze and heating at 300° F. in an electric oven. It will sometimes be found that a block-grease will break down and percolate through the gauze at lower temperatures than another block-grease of nominally lower melting point.

Stability at High Pressures.

All compound lubricating greases tend to separate oil if exposed to high pressures for lengthy periods, and it has been necessary to develop methods of test in order to effect the necessary improvement in greases for use in spring pressure cups and modern high-pressure greasing equipment.

My own practice is to make use of two devices, the first being an ordinary spring pressure cup with a cap over the orifice, so that pressure can be maintained for any desired period, and this has the advantage of reproducing the exact conditions of use. The other device is a steel tube ¾ inch diameter and 4 inches long, with a screw cap at each end to facilitate filling and emptying; one cap is fitted with an ordinary nipple for a hand-grease gun. The tube is filled with the grease, the caps securely tightened, and pressure is then exerted by applying the hand-gun to the nipple. The tube can either be filled to capacity or air space allowed so that the effect of maintaining the grease in contact with air under pressure can also be observed. For high-temperature work the cap or tube can be placed in an electric oven.

It has been found possible to reduce separation of oil to negligible proportions in the case of lime-soap greases and stiff dehydrated soda-base greases, but soft fibrous lubricants will almost always show appreciable separation.

Stability on Storage.

It is essential that a lubricating grease should be capable of being stored either in a trade container or in a bearing for periods of at least six months, without deterioration, which may be due to any or all of three factors—oxidation, development of acidity, or separation of the mineral oil component. Of the three the latter is usually the most troublesome.

In general, it has been found that stability during storage is closely allied to stability of the grease when subjected to high pressure in contact with air, and the pressure tube previously described has been used in the development of stable greases. Also, a prolonged heat test—say, seven days at 70° C.—gives useful information. One can safely say that a grease which shows no appreciable separation of oil, oxidation, or increase in acidity when submitted for one week to the pressure and heat tests, will retain its characteristics without deterioration for at least twelve months in storage, and probably considerably longer.

Other tests consist of centrifuging the grease, or of observing the amount of oil extracted by capillarity when the grease is placed in contact with filter-paper. The first of these is of no great value, as the separation of oil during storage is not due to the force of gravity, and the second does not give reproducible results. Neither test gives any evidence of resistance to oxidation or acid formation.

Naturally, samples of grease should be kept in storage both in the usual containers and in bearings, and be examined at regular intervals for any evidence of deterioration in order to confirm the results of accelerated laboratory tests.

Load-Carrying Capacity.

The most convenient apparatus for the determination of the load-carrying capacity of a lubricating grease is the Timken Lubricant Testing Machine. Except in the case of greases having definite E.P. properties, it is best to run the machine at 400 r.p.m.—*i.e.*, 200 feet per minute rubbing speed—instead of the more usual 800 r.p.m., and it is then possible to obtain reproducible results of great value for comparative purposes.

In the case of lime-soap cup-greases it is found that load capacity increases with increasing soap content, especially in the case of those made with wool stearine, doubtless due to the presence of wool wax. In all cases the efficiency of the grease is much greater than that of the basic oil. In the case of soda-soap greases there is less variation with soap content, although the load capacity is still much greater than that of the mineral oil content. Some typical results are given below.

Approximate Composition.		Timken O.K. Value.
Oil Content. Per cent.	Soap Content. Per cent.	Lever Load. lb.
100 Palo.	Lime Soap.	
100	—	17
87	12	33
81	18	37
75	24	40
500 Red.	Lime Soap.	
100	—	21
89	10	36
84	15	41
100 Palo.	Soda Soap.	
80	20	31
70	30	33
500 Red.	Soda Soap.	
80	20	35
Bright Stock.	Soda Soap.	
85	15	38

The Cornell (Faville-Levally) Machine is of no use for testing greases, but these results with the Timken Machine may be compared with tests on the Almen Machine made by Evans (I.Mech.E. " Discussion on Lubricants "

1937). It is worthy of note that in the case of the Timken Machine the test-pieces are subject to a copious flow of oil, but with greases only a small supply is fed from the screw-down lubricator, and temperatures of the test-pieces are correspondingly high. The figures quoted also agree with the statement made by Garlick (*J. Instn Petrol. Tech.*, 1934) to the effect that ordinary cup-greases made with light spindle oils will give acceptable results under service conditions in which the lubricating oil alone would prove unsatisfactory.

Satisfactory extreme pressure greases for anti-friction bearings in rolling-mills are made by incorporating sulphurized fatty oil in a lead-soap-base grease, and lever-load capacities up to 70 lb. at 800 r.p.m. on the Timken Machine can be obtained. Lime- and soda-soap greases can also be treated with sulphur and chlorine compounds to give equal load capacities with, in some cases, greater stability than the lead-soap products. The difference between the two lies principally in the fact that the lead soap-sulphur greases more readily resist shock-loading without scoring, and when running tests at near the breakdown points this is of importance, as weights of 60–70 lb. can be easily applied a little too roughly.

Wear tests can also be carried out using the Timken Machine—the wear being measured both by the width of the scar on the block and the loss in weight of block and cup.

Low Temperature Efficiency.

Requests are sometimes made for information concerning the " cold test " of a grease, and it can be said that it is roughly equivalent to the pour-point of the mineral oil for soap contents up to approximately 12½ per cent. For higher concentration of soap there is a definite increase, which varies with the oil, soap stock, water content, etc.

Penetration tests at low temperatures can be readily carried out using the plunger-type apparatus described in Air Ministry Specification D.T.D. 143. B. In most cases there is a steady decrease of penetration with fall in temperature until it becomes negligible. Further information of the resistance due to stiffening of the grease at low temperatures can be obtained by making use of the apparatus described in Air Ministry Specification D.T.D. 201, which consists essentially of a steel ball rotated in a brass socket by means of weights and pulleys. Here the temperature at which there is a marked increase in the time taken for rotation of the ball is usually quite definite, and the cold test can be reported to within 5° C.

However, except for exceptional conditions of service, it is usually sufficient that the grease shall be easily workable after exposure to 0° C. for, say, 2 hours, and this stipulation is embodied in a number of specifications.

It is regretted that lack of time prevents giving more precise details of the various tests and their formation into a complete progressive scheme of grease analysis. Also, it has not been possible to include details of specific tests made with greases destined for specialized applications—for example, water-pump greases, wheel-bearing greases, steering-gear greases, universal joint greases, etc.

The author's thanks are due to Mr. L. A. Phillips, who has carried out most of the tests to which reference is made.

THE INSTITUTE OF PETROLEUM

A MEETING of the Institute of Petroleum was held at the House of the Royal Society of Arts, John Adam Street, London, W.C. 2, on Thursday, 22nd February, 1940, at 5.30 p.m. Mr. E. A. Evans, F.Inst.Pet., M.I.A.E., occupied the Chair.

The Chairman, in introducing Mr. M. W. Webber, said that the paper which was being read that evening was invited before the war commenced. The invitation was made with the express intention of producing a discussion upon the possibilities of standardizing tests for grease. The Institute had standardized tests for petroleum products, and had included a few tests for grease. The Council was of the opinion that greases should now receive further consideration.

Mr. Webber's paper would serve as a foundation stone upon which the standardization of grease testing could be erected. Mr. Webber was known to many as a specialist on grease, and a member of the Grease Panel of the Institute.

The following paper was then read :—

"The Analysis and Testing of Lubricating Greases" by Mr. M. W. Webber. (See pages 273–83.)

DISCUSSION.

THE CHAIRMAN said that members would appreciate the reasons for the limited supply of pre-prints. He knew that it was difficult to marshall all the facts as the paper was being read.

Mr. Webber had suggested the estimation of unsaponifiables by extraction with acetone. The method was simple, and accurate to 1 per cent.

He also suggested toluene extraction, subsequent to acetone extraction, for the estimation of soaps. The residue, after the extractions, was fillers, mica, graphite, and other solid additives.

No doubt members would express their opinions on these methods. If such methods were satisfactory, they would be very attractive.

Mr. Webber stated that in soda-soap greases both free fat and free alkali might be present. Therefore in the estimation of the free alkali the alcoholic solution should not be boiled. Members would probably remember that in "Standard Tests" a similar warning was given.

The dimensions of the Ubbelohde apparatus, which are given in "Standard Tests," were the result of careful consideration by the Institute. For the purposes of the British Pharmacopœia, it was felt that the actual thickness of material in the cup should be specified. At first it appeared to the British Standards Institution that to standardize the internal dimensions of the cup as well as the external might lead to manufacturing difficulties. Any serious modification of the present apparatus might easily lead to difficulties in the petroleum world. Happily, agreement was reached on behalf of the Institute of Petroleum and the British Pharmacopœia. It was believed that the B.S. apparatus would be satisfactory to members of the Institute. It might be prudent to remind members that the British Pharmacopœia contained legal standards.

Mr. Webber stated that worked samples were infinitely more important than unworked. If that was the case, were they not wasting their time testing unworked samples? A definite lead was required on that point.

The Institute definitely wanted a lead from the members on the question of standardization of grease tests. It was therefore important that members should give their views freely.

Dr. E. R. Redgrove said the meeting was a very important one, because it was the first which the Institute had held since the war broke out. The large attendance was a clear indication, he thought, that the meetings of the Institute should continue to be held in spite of the war.

The members were much indebted to Mr. Webber for his paper. Although it had been contemplated last August, he did not suppose that it had been written before the war broke out, and many members knew how busy Mr. Webber must have been since that day. It took a great deal of time to write any paper, and Mr. Webber must have devoted a great deal of time and thought to bring out what seemed to him some very important points, which he hoped would be fully discussed later on.

He did not propose to make any comments on anything which Mr. Webber had said specifically, but he wished to refer to the necessity of standardizing tests. It was the function of the Institute, he thought, to take charge of the matter, and not to allow a state of chaos to come into being in which different interests each had their own pet ideas on testing to which they expected manufacturers to adhere. If any body was to investigate any question connected with the testing of petroleum products in the broadest sense, he thought that that body should be the Institute of Petroleum.

The Institute had its Standardization Committee, and he was confident that the discussion to follow would give to that Committee a good indication of where revision or restandardization of grease tests was called for.

In conclusion, he wished to thank Mr. Webber for his very valuable and interesting paper.

Dr. E. R. Styles said there was one point that he thought might be made regarding the consistency. He felt that the I.P.T. method would cover a wider range of greases more satisfactorily than the D.T.D. 143 method. It had been found that with very soft greases the I.P.T. method could still be applied, whereas with the Air Ministry method the plunger would penetrate right to the bottom of the container. In the paper, attention had been directed to the relatively small difference in the numerical value of the comparative tests with the two greases " A " and " B " in the case of the I.P.T. method, and the relatively large difference between the same two greases when tested by the Air Ministry method. He thought that, if it was remembered that in one case a conical penetrator was used and in the other a cylinder of small cross-sectional area, the reason for that unfavourable comparison would be better appreciated.

With regard to Mr. Webber's comments in relation to the working of greases during manufacture, the meeting might like to hear of an experience which he had some years ago, when engaged in the actual manufacture of greases. He had occasion to notice very big discrepancies in the apparent consistency of samples submitted to him by the works from what were alleged to be barrels of grease taken from the same batch. When the matter was investigated, it was found that the rate of cooling of the grease influenced the penetration obtained, even though that test was made after working by the I.P.T. method. Thus it was found that a sample drawn from the outside of a barrel gave a very stiff grease as the result of the rapid cooling, whereas one drawn from the centre subject to very slow cooling was much softer. The point regarding pre-working during manufacture to ensure uniformity appealed to him very strongly, because there was a great deal of difficulty in convincing customers that they had a satisfactory grease when they found that from one package they could get different test results according to the point from which the sample was taken.

The Chairman asked whether Dr. Styles could make any suggestion with regard to the matter from the inspection point of view.

Dr. Styles said that of course the grease had been drawn off into the containers at a relatively high temperature. He thought the more modern method was to allow the grease to reach something approaching atmospheric temperature in shallow trays, and then to shovel it out into the final package. In the case that he had quoted the material was poured into the container and then allowed to cool—a very slow process when wooden barrels were used, leading to a big difference in rate of cooling between the centre and outer part of the barrel. He was going back some years, but, if his memory served him aright, the figures were of the order of 200 on the outer material and 300 on the inner material by the A.S.T.M. method; that was on a medium cup grease. The samples were worked when they reached the laboratory.

The Chairman: And they still varied?

Dr. Styles: Yes.

Mr. F. J. S. Hall said he welcomed the paper because it seemed to him that hitherto no serious interest had been taken in lubricating greases by the higher technical minds engaged in the petroleum industry. He thought that was a pity, because the subject was a very important one, and he hoped that Mr. Webber's paper would be given as much prominence as possible. Hitherto he believed the ball-bearing manufacturers had to be thanked for enforcing greater attention to the academic side of grease-making. The Chairman had referred to the question of acetone extraction for the oil and free fat. Personally he thought that was an extremely good method and was one that he had often used himself. It was probably better carried out in a Stevens extraction apparatus than in a Soxhlet, and the grease mixed with previously extracted sawdust or similar material before being placed in the thimble. The only point in the paper which he wished to criticize was the question of acidity in the grease. He could not agree with Mr. Webber's suggestion of 1 per cent. being a desirable figure; he thought that desideratum should be nearer 0·1 per cent.

Mr. H. W. Chetwin said he wished to thank Mr. Webber for the very lucid, concise, and interesting paper that had been presented that evening. He did not think the Chairman had been quite fair to Mr. Webber in suggesting that all the tests described in the paper were extremely simple; Mr. Webber could probably agree that that was not really the case. They became simpler, of course, with constant use, but they necessarily required experience and care.

The paper covered the ground so thoroughly, in his opinion, that there was very little room for criticism. It was interesting to consider that the tests had been built up, or perhaps it would be better to say standardized, over a comparatively short period—*i.e.*, within the last twenty-five years—which was not a very long time to look back upon, though it seemed a good while in the future. Twenty-five years ago very little attention was paid to tests of lubricating grease. In fact, the average consumer had only two which he applied, and those two tests Mr. Webber had not thought it desirable to mention in his paper. The first was the colour test, which was quite easily made. The prospective buyer looked at the grease, and if it was of a colour that suited his æsthetic feelings, the grease was satisfactory; otherwise it was not. The other test might be briefly described as the thumb-and-finger test, which perhaps did not need any further explanation.

Since that time the requirements of engineers and of modern plant had necessitated a much greater knowledge on the part of the consumer, and the grease-makers had had to apply themselves to the manufacture of products which would give results never anticipated in the early days, and grease had, indeed, come into its own once more.

The specifications that were now drawn up were frequently not prepared by chemists who were acquainted with the principles of the manufacture of grease, with the result that specifications often included items which were entirely incompatible—a definite proportion of soap and a certain amount of ash which was much too low for that proportion, and requests for melting points of lime-soap greases which were far beyond the highest expectations of the salesman. There was also, he found, a tendency amongst those who were responsible for the specifications to try to do a little better every time. There were one or two well-known consumers who were constantly tightening up their specifications, with a view to seeing how much better, in their view, the grease could be—sometimes with somewhat unfortunate results.

He wished to take up the Chairman's challenge with regard to the Ubbelohde apparatus, which he considered a most unsatisfactory apparatus to use for taking a melting point. The results varied very much in the hands of different operators, due, as Mr. Webber had pointed out, to the difficulty of getting the cup standardized. Also, there was the very great difficulty of ensuring that there was no air occluded in the grease. A practice which he had found satisfactory in that connection was to press the grease through a very fine mesh before it was put into the cup, but even when that was done it was found that a number of results varied very considerably, and it seemed that certain operators invariably obtained a different result—that was to say, either a consistently higher or a consistently lower result than the results obtained by other operators.

MR. A. T. WILFORD, referring to Mr. Chetwin's remarks, said that he himself had re-drafted and revised many specifications, and had never consciously done so with a view to asking for something that could not be supplied. What he had generally done was to select the best supply obtained from a number of sources and to try to bring all the manufacturers up to that level, and that should give no cause of complaint to anybody.

With regard to tests of grease, one that he had found very useful was the penetration test, and in connection with that test there was one difficulty that he encountered as a user—namely, that it was often desired to examine the properties of a used grease, but there was not enough material to carry out the test. If there was standardization and a possibility of dealing with smaller quantities of material, it would be very useful. He had used the Ubbelohde melting-point method for some years, and it had at least kept him out of trouble.

With regard to stability, he thought the test laid down in the London Transport specification was certainly of some value and he applied it regularly. Whether it corresponded with actual service conditions he was not sure, one grease of which he had used very large quantities had consistently failed to meet the specification, but it was many years before it was discovered that there was anything wrong with the service behaviour of that grease, and then it was not very serious. The stability test did perhaps have some relation to the performance of a grease in wheel bearings and it was in this application that the particular grease to which he had just referred had eventually given trouble, thus confirming the results of the laboratory test, which indicated that the grease did not meet the specification.

THE CHAIRMAN asked Mr. Wilford whether he thought it was not necessary to standardize anything on stability.

MR. WILFORD said he did not think so. He rather liked the test to which he had referred, but, as he had pointed out, he had not any certain proof that it correlated very well with all service conditions. If heat and pressure could be combined in one test it would be a great advantage.

MR. HALL said he had been interested and surprised to hear that Mr. Webber found the acetone extraction method always satisfactory. Some years ago he had had to test universal joint greases, which generally had a soda base, though a certain number had a lime base, and he had not found the acetone extraction method at all satisfactory. He had been particularly interested in the properties of the oils separated from the grease, but it had proved absolutely impossible, at any rate within his own experience, to get the oil free from ash or sodium or calcium, as the case might be. He had tried centrifuging and the use of acid material, but the same trouble had been experienced, and in the end he had found the A.S.T.M. method, modified for large-scale work, was much the best.

Another point he wished to mention was in relation to the dark-coloured greases which were usually handled in the universal joint compounds. He did not think Mr. Webber had mentioned the A.S.T.M. method, in which the dark-coloured greases were treated with acid potassium sulphate in place of the ordinary treatment with hydrochloric acid. He had found that method so satisfactory that he had adopted it for all greases, light coloured as well as dark coloured.

He had experienced considerable difficulty, with dark-coloured oils, in getting a very satisfactory acid value by titration methods. He would like to know whether Mr. Webber had had any experience of the electrometric methods which had been used in America in recent years.

THE CHAIRMAN said that he thought that Mr. Hall felt the Americans had been somewhat ignored. It was fitting, therefore, that members should be reminded that the Institute of Petroleum had adopted, wherever possible, the A.S.T.M. standard methods. Consequently, when we referred to the Institute standard methods, we almost automatically referred to the A.S.T.M. standards.

MR. DE WAELE said that his remarks would scarcely be very constructive, as he had no special knowledge of the industry. He would, however, like to take the opportunity of inquiring as to the precise necessity for the measurement of consistency of greases so far as the exigencies of the trade were concerned. Thus, was it used as a means of more identification of constants, or as a method of control in manufacture?

He understood that the penetrometer was generally in the form of an instrument in which a cone or cylinder fell into a mass of the grease to be tested, the eventual depth of penetration or velocity of travel over a given depth being recorded as a characteristic. He thought he could assert that if two identical readings were returned from two different greases, it might be quite possible that the greases differed considerably in physical properties, and indeed might recognizably exhibit differences to the touch. This would be accounted for by the fact that the penetrometer was, after all, merely an instrument in which a constant weight was caused to induce an increasing viscous resistance as penetration proceeded: in other words, like a variable stress viscometer. In the case of the penetrometer, the velocity gradient diminished with progressive penetration. Grease being one of that class of substances in which the apparent viscosity diminished with rate of shear, the paths of the two stress/rate-of-shear lines might fortuitously cross. If the recorded point should fall at a crossing point, a recorded but otherwise quite false identity of properties would be registered.

With regard to the question of pre-working, he had examined a sample of grease made in his laboratory by dissolving slaked lime in a mixture of oleic acid and mineral oil, the excess of water being driven off by heat. The resulting grease was a translucent unctuous mass, very homogeneous and smooth. It might have been somewhat different from some commercial greases he had seen, which were often stringy and contained obvious soap crystals. In the grease in question, however, there was no difference in physical properties recorded whether the grease were pre-worked or not, and he attributed this to the fact that the phase responsible for the rigidity of the material, consisted of crystals which were very short in relation to their lengths and, withal, extremely small, and hence did not suffer any appreciable change in orientation on shear. On the other hand, he could quite imagine that in a grease containing rather coarse crystals the effect of pre-working would be to disarrange the crystals, or even break them into shorter units. In the case of the analogous petroleum jelly, which contained rather long, needle-shaped crystals, a great difference of consistency resulted from pre-working; a number of different consistencies might be recorded by pre-working, according to the intensity of the shear produced. The general tendency was for all the differing consistencies to rise to a common level on prolonged storage.

With regard to the application of consistency as a characteristic, he thought the two factors to be considered by the user were the lubricating value or viscosity, and the rigidity of the material. Would it not be possible, for instance, to imagine a material which, under dynamic conditions, would have a sufficiently low viscosity or consistence to lubricate quite adequately, and yet in the static or semi-static condition be too stiff to be forced out of the cup? In other words, one had to deal with two quite unrelated components in the characteristics of such a material as lubricating grease—the dynamic one of viscosity, and the static factor of rigidity, the analysis into which would not be furnished by penetrometer measurements.

He had been rather surprised that the industry had not adopted the more searching method of examination by the capillary plastometer, which would certainly give more illuminating data than did the penetrometer. He had seen published only one paper on capillary plastometric examination of lubricating grease—that by Arveson. He himself had been approached some two or three years ago by (he believed) one of the Ministries on the question of a suggested means for determining the consistency of petroleum greases, and he had submitted a proposition on the basis of the plastometer, which is, after all, only a variable pressure capillary viscometer adapted to handle plastic materials, but evidently the suggestion had not impressed the particular body, as he had heard no further. He might further add that the capillary plastometer has been used in his own practice for the examination of a wide variety of plastic solids, Newtonian, and non-Newtonian fluids, for a great number of years, both as a control and as a research instrument. He had found it to be indispensable for regulating the physical properties of materials, the closeness to standard constants of which he believed were needed to be of far greater stringency than were lubricating greases.

Mr. E. A. Goodchild said that several criticisms had been made of the efforts of those people who drew up specifications. These criticisms were to a large extent justified, but the grease manufacturers had paid too little attention to the study of the fundamentals of grease constitution, the fibre and gel structures, so that in our present state of knowledge it was impossible to correlate the results of physical tests and chemical analyses embodied in specifications, with the manner in which the greases would function in their intended applications.

Most people put certain chemical limits in their specifications, in the hope that they would get somewhere near the product they had previously found satisfactory, but they had to rely on practical tests to verify that the grease was suitable for their work.

He wished to criticize the method of corrosion testing using copper and steel. Copper was often used, yet it was a very corrosion-resistant metal. He had found that 60/40 brass, which had a duplex structure, was a very much more sensitive metal, being readily attacked by fatty and organic acids, and giving results more in conformity to the attack on bearing metals. The time of 24 hours for the test was very short.

With regard to chemical stability, he did not think there was any comment made in the paper on what the Americans now termed "storage stability" or resistance to oxidation. He would like to direct Mr. Webber's attention to the work of Wright and Lutz on the rate at which oxygen was absorbed when samples of grease were maintained at a certain temperature in an atmosphere of oxygen. In that work the rates of oxygen absorption had been correlated with the chemical storage stability of the grease.

THE CHAIRMAN asked Mr. Goodchild where the work had been published.

MR. GOODCHILD said that it had been published in a paper to the B.E.C. Committee and also in a periodical called "Product Engineering."

THE CHAIRMAN asked whether that was a journal which would normally come within the purview of the members of the Institute.

MR. GOODCHILD said he thought it would; he would let the Institute have the necessary references.

MR. L. O. MASKELL said he would like to add his thanks to Mr. Webber for the excellent paper that had been presented to the Institute that evening. He had not been able to obtain a pre-print of the paper, so that he had some difficulty in co-ordinating in his mind all the factors which Mr. Webber had brought out, but there were two points that he would like to raise.

With regard to the dropping point by the Ubbelohde test, his experience of that method was very satisfactory, particularly with the lower-melting-point greases, which generally had a lime base, and he had been surprised to hear the method condemned by Mr. Chetwin. In the case of soda greases and greases melting at much higher temperatures, he had certainly found some discrepancy in the results, which might be as much as 5° to 10° in the dropping point, but a modification had been brought out some months ago (he forgot who it was that had invented it) in which the grease was scooped out from the inside of the cup with wire, so as to leave a uniform thin layer of grease round the inside of the cup, and by the use of that method it was possible to obtain very consistent results, within 1°, or at the most 2°, of variation.

The other point that he wished to mention was with regard to stability tests. He had been rather surprised to hear Mr. Wilford express satisfaction with the Timken test, because he had found very considerable difficulty in obtaining consistent results with that test. In his view, a test which took into account the bleeding properties of the grease at lower temperatures would be more satisfactory. It seemed to him that the lubricating value of grease was largely determined by the small amount of oil which bled out during service. He thought that, if a test somewhat on the lines of one of those put forward in *Industrial and Engineering Chemistry* (February 1939, Vol. 31, No. 2, pp. 230–235), where a certain weighed quantity of grease was put under a definite pressure and the amount of oil absorbed by a porous plate or a pad of paper was weighed, could be devised and standardized by the Institute, it would be preferable to one of the very severe heating tests. He would like to see such a test put forward by the Standardization Committee.

MR. W. D. DOUGHTY said there was one little point that he would like to make with reference to the time factor in the penetration test at low temperatures. He had found that, particularly in the case of the Air Ministry test on soft greases, a matter of a few minutes made a considerable difference in the penetration. Consequently a grease might be condemned as not passing the D.T.D. 143 B test because the penetration test had been registered immediately on dropping (within two or three seconds), which one would think would be the normal way of measuring it, instead of waiting for perhaps 30 to 60 seconds, when, if the grease was fairly soft, the weight of the sinker was still causing it to continue its downward path.

Mr. A. Dunbar, referring to the consistency of greases, said that in his opinion the slightest trace of free alkali in a barrel of grease tended to prevent the grease becoming softer in the middle than on the outside.

Mr. G. H. Thornley said he had been very interested in the paper, especially the references to the melting point of greases and their stability at high temperatures. The Ubbelohde melting point was, he thought, quite misleading as a measure of the behaviour at high temperatures. What was required was a standardized test which would measure the degree of softening after exposure to working temperature. There might be two greases, one with a melting point of 400 and the other with a melting point of 330, but, if exposed to a temperature of 300° F. for 3 hours, the grease with the melting point of 400 might still be much softer than the other grease, and even quite fluid.

Mr. D. Clayton said he would like to know how the behaviour in squeezing a grease through the fine clearance of a bearing correlated with the penetrometer test; a similar comparison with the time taken for a rocking journal to sink through a film of grease in the clearance would be of great interest. These were the factors involved in grease lubrication of the chassis of a vehicle relating to the access to the bearings and the rate at which the grease would be squeezed out.

The Chairman asked Mr. Clayton whether his point was not similar to the point brought out by Mr. de Waele with regard to Arveson's work on the rate of shear and its effect on viscosity.

Mr. Clayton said he had not followed that point closely, but the rate of shear would not be great with a slowly rocking journal, even though the clearance was small. There would be the two conditions of well-worked grease, and that after it had been standing for some time. Very different results would be obtained, and it seemed to him that such a test might very much increase the scale of consistency.

Mr. H. L. West said he had used the acetone extraction method, and had found that in some cases it was quite satisfactory, but in other cases oil was extracted from the outer part of the grease, whilst the inner portion remained almost unchanged. The only way to overcome that difficulty was to mix the grease with sand or some such material.

He thought that Mr. Webber's views on the various tests were rather biased by the fact that he was a manufacturer, and that he therefore always knew the constitution of the greases with which he was dealing. A person buying a grease of unknown composition tried to find out something about it, and that made a very big difference, as he was dealing with something of unknown composition.

With regard to the Ubbelohde test of melting point, he thought most people would agree that with lime-base greases it was quite satisfactory. He had found some difficulty in obtaining a glass cup to comply with the specification, particularly with regard to the orifice, and had found metal cups much more satisfactory, as they could be machined to accurate limits.

He thought that a great deal of the variation in melting point and complaint arising therefrom was entirely due to the disregard of the structure of the grease. Lawrence's paper (*J. Instn Petrol. Tech.*, 1938, **24**, 207) on the structure of grease had not apparently been widely read, and he recommended all those present who had not done so to read it. In the case of a soda-base grease, if it separated oils at high temperatures, it might happen that a certain amount of soap would tend to congregate in the orifice and stop the separated oils from filtering through. If, on the other hand, the grease still maintained a uniform structure on heating and melted as a whole—*i.e.*, the soaps remained in suspension or solution—one would get something more like a true melting point, and not just the temperature of oil separation.

In referring to worked consistency, Mr. Webber had not mentioned block greases. He hoped he did not intend us to determine the worked consistency on these.

With regard to the various tests for stability, he thought most people disregarded the relation of structure to stability. It was necessary to look into the physico-chemical structure of the grease and to see how the stability was related to it, for the very simple reason that one might find two greases of different gel structure which might give satisfactory results in practice, but not in any arbitrary stability test.

Dr. S. Torrance said that, as he was not very happy about the present methods for the analysis of greases, he was very pleased to be able to attend the meeting that evening and to hear Mr. Webber's paper on the subject.

He was interested to hear about Mr. Webber's method of extracting unsaponifiables with acetone, but apparently there was another side to the question, as some of the speakers in the discussion had complained of some difficulty when using acetone, and he felt that Mr. Webber could give enlightenment on one or two of the points raised. As a railway chemist he was very well versed in the book on Standard Methods, where very specific details were given of the amounts to be taken and the volumes to be used. Mr. Webber had not gone into any great detail on those matters, but there were possibly some practical points Mr. Webber might care to add which would be of great use to the analytical chemist.

With regard to specifications, his experience of these was by no means extensive, but he thought they were usually drawn up not on what consumers wanted, but on what manufacturers were able to supply. The consumer tried out the various types of material which were offered, chose the best, and selected that as a specification for his requirements. When he found a better one he modified his requirements accordingly.

Mr. F. J. S. Hall said that the Timken separation test had been criticized, but personally he thought the test was of immense practical value. After all, when a grease broke down under conditions of the test it was usually through dehydration, and in service in the bearing at lower normal working temperatures over a prolonged period the same condition would operate. On the surface it would seem that tests at lower temperatures were of more importance, but he did not think that was altogether the case, as such would not provide sufficient information. In any event, he believed that the two conditions—namely, that of the ball-bearing grease after prolonged service at normal temperatures and that resulting from the tests at high temperatures were correlated—as was also the question of syneresis.

Mr. D. L. Samuel, referring to the consistency of greases, said he thought that some kind of penetration test might be very useful as a works control method, but would probably be of no use in showing how the grease would function in practice. After all, what was required was not a static method, but some method akin to the viscosity determination of a lubricating oil. It seemed to him that an effort should be made to ascertain whether some form of dynamic test could be evolved, so as to obtain some idea of what would happen to the grease when it had to flow.

Mr. R. A. Fraser, referring to the difficulty mentioned by Mr. Hall of obtaining a satisfactory acid value by titration methods in the case of dark-coloured oils, said he had found it very difficult to determine this, and he had substituted as an indicator thymolphthalein, which gave a dark blue colour. The result had been very satisfactory.

Mr. F. J. Burger, speaking with regard to the consistency of greases, said that an instrument had been developed by Dr. C. F. Goodeve to measure anomalous viscosity and thixotropy (*J. Sci. Instr.*, Vol. XVI, No. 1, January 1939). Its principle is similar to that employed in the Couette coaxial cylinder viscometer, the difference being that cylinders are replaced by cones. Thus it is possible to vary the rate of shear within wide limits. It would appear that when using Goodeve's viscometer for measuring the consistency of greases, this would be done under conditions more closely resembling those to which the greases are subjected in practice than when using either penetrometer or plunger type testing apparatus.

THE CHAIRMAN said that he thought members would agree that the principal criticisms in the course of the discussion had been upon the Ubbelohde apparatus and the penetrometer.

Dr. Redgrove would be interested to know that the standardization of the Ubbelohde apparatus for the British Pharmacopœia was necessary for the examination of lards and other comparatively low-melting-point materials used in pharmacy. In our own industry we had to consider the melting points of petrolatums, lime, and soda-soap greases. It was to be hoped that the standardized apparatus would receive sympathetic consideration.

Mr. Maskell was a little uncertain who suggested the scooping out of the grease from the cup in the Ubbelohde test with a wire, so as to leave the grease around the inside of the cup. It was the Shell Development Company of California who made a report on the subject, and sent it to this country for consideration.

Mr. de Waele had referred to Arveson's work. The work of Arveson had been extended by Barnard at the General Discussion on Lubrication in 1937, and by Blott and Samuel (*J. Industr. Engng Chem.*, January 1940). It was therefore quite clear that the subject was still occupying the minds of certain workers. Whether it was a subject which might be standardized was open to discussion.

MR. M. W. WEBBER, in replying to the discussion, said it was quite true that his views on the tests were largely due to the fact that he came from a manufacturing company, and at the beginning of his paper he had said that it was based upon routine work which was concerned largely with the control of works batches, but it must be remembered also with dealing with specifications and samples sent to his company by customers.

He was glad to have Dr. Styles' criticism of the D.T.D. 143.B. method. It was not suggested that that should become a general method, but that it would be a suitable method for development. Probably a combination of that method and the I.P.T. method could be made by fitting the I.P.T. penetrometer with a cylindrical plunger instead of with a cone, because the cone-faces obviously did not allow the viscosity of the oil to have the effect on the penetration that it should have. A plunger going with a constant thrust the whole time would probably give much better results. We had heard a great deal about the pressure-viscosity and rate of shear of lubricating greases, but so far no method of determination had proved capable of standardization from the manufacturers' point of view.

As to the question of acetone extraction, it was not suggested that that was a perfect method, but in the hands of most people it gave more consistent results than the ordinary methods of decomposition. In the case of soda soap Universal Joint Greases, his company certainly had trouble, largely due to the asphaltic content of the oil; they were investigating different solvents, and in all probability something of a higher boiling point would give better results. As to using toluene for the final extraction of the lime soap, lime soap would not be affected by most solvents, but toluene completely extracted it very rapidly. The boiling point of toluene was 300° F., and the temperature in the apparatus became so high that the solvent was always on the point of boiling round the thimble. If something like that could be found for soda-soap greases a much more rapid extraction would be obtained.

With regard to the Timken test, it was not suggested that a heat test which involved dehydration of lime-soap greases had no use, but stability at working temperatures was more important. The Timken test depended largely on the manipulation and the filling of the grease into the tube after dehydration in the cup.

With regard to the question of heat stability tests at temperatures below 200° F., there was some correlation in service when the stability test was carried out for lengthy periods.

Mr. West had commented on the structure of grease in the Ubbelohde apparatus. He thought that was the whole crux of the question as to the varying results obtained with soda-soap lubricants. Soda-soap grease could have a structure ranging from smooth non-fibrous to a heavy fibre, and the heavier the fibre the more oil was separated. Sometimes the oil drips from the cup giving a low apparent dropping point, whilst sometimes the heavy fibre clogs the orifice, thus giving too high a reading.

With regard to Mr. Maskell's suggestion that the bleeding or syneresis of oil from grease was of importance, that was a matter of doubt, because one got very useful lubrication with the Timken machine in particular before there was any separation of oil at all. Further, the difficulty in standardizing such a test was that, while in the laboratory a grease might release 1 per cent. of oil in a given period, there would in all probability be continued separation of the oil and breakdown of the grease in service or in storage.

As to the variation in consistency throughout a barrel of grease when drawn from a mixer, the question of avoiding that was largely one of improvements in manufacture, and not in testing, and the sampling was therefore important.

He was deeply indebted to Mr. Evans, who had given him a great deal of help and advice in the preparation of the paper.

THE CHAIRMAN, in expressing the thanks of the Institute to Mr. Webber for his admirable paper, said the large attendance at the meeting was evidence of the interest taken in Mr. Webber's paper, and in the subject of standardization of grease tests.

OCTANE RATINGS OF A NUMBER OF PURE HYDROCARBONS AND OF SOME OF THEIR BINARY MIXTURES.*

By J. Smittenberg, H. Hoog, B. H. Moerbeek, M.Inst.Pet., and M. J. v. d. Zijden.

Summary.

C.F.R.–A.S.T.M.-Motor method octane numbers have been determined of fifty hydrocarbons, the majority of which were in a very pure state. In addition the octane numbers of some binary hydrocarbon mixtures are given, and a method is described by means of which the octane numbers below zero and above 100 were estimated.

1. Introduction.

As the requirement of high octane fuels for aeroplane engines is still increasing, a knowledge of the behaviour in the engines of individual hydrocarbons of high octane number, becomes more and more important.

Much is known already about the octane numbers of the individual hydrocarbons. Reference may be made to the paper of Lovell and Campbell [1] in which the most important literature on this subject is cited. As a rule only small quantities of the hydrocarbons investigated were available. Their "octane rating" was therefore very often carried out on blends with other hydrocarbons or gasolines or in a small engine which differed markedly from the standardized C.F.R.-engine.

The publication of the octane numbers of fifty individual hydrocarbons, which we were able to determine in an accurate way by the standardized C.F.R.–A.S.T.M.-Motor method, may therefore be of value.

2. Preparation and Purification of the Hydrocarbons.

The majority of the hydrocarbons used were prepared synthetically. A description of their preparation and purification has been published in the "Recueil des Travaux Chimiques des Pays-Bas." [2]

As a rule a quantity of 2 kg. was prepared and purified by rectification. A small part of this quantity was purified further for the purpose of the determination of the physical constants. As this extreme purification was not necessary for the octane-number determinations, the latter have been carried out with preparations of a somewhat inferior purity.

For purposes of comparison the physical properties of the sample used for octane rating are quoted in the table, together with the properties of the purest available sample. *Unless otherwise stated the purity of the sample used for octane rating is at least* 98 *per cent.*

The origin of the hydrocarbons the preparation of which is *not* described in the above-mentioned paper is as follows.

Methane was obtained commercially and analysed by means of Podbielniak distillation; purity 99 per cent.

Ethene was prepared by dehydration of ethylalcohol ;

* Paper received 3rd November, 1939.

Ethane by hydrogenation of the ethene obtained. The purity of the ethene was only 91 per cent., that of the ethane 95 per cent.

Propane, n-*butane*, and 2-*methylpropane* were separated from natural gas by fractionation; purity 98–99 per cent.

Dimethylpropane (tetra-methyl-methane) was prepared synthetically by condensation of methylchloride and *tert.*-butylchloride; purity 95 per cent.

2 : 3 : 4-*Trimethylpentane* was prepared by isomerization of 2 : 4 : 4-trimethylpentene (di-isobutene) with the aid of phosphoric acid as catalyst, followed by hydrogenation and rectification of the product; the purity is estimated to be about 90–95 per cent.

2 : 2 : 3 : 3-*Tetramethylbutane* (hexa-methyl-methane) was prepared synthetically by condensation of *tert.*-butylchloride; purity > 98 per cent.

Propene was prepared by dehydration of sec.-propylalcohol; purity about 95 per cent.

The *olefines* n-*pentene* up to 2 : 4 : 4-*trimethylpentene* were obtained as intermediate compounds in the preparation of the corresponding paraffins; they may be contaminated with isomers, in which the position of the double bond is different. The content of olefines of the indicated carbon skeleton in each sample is at least 95 per cent.

Hexadiene-2-4 was prepared synthetically from crotonaldehyde.

The product obtained is a mixture of different isomers; total amount of hexadienes-2-4 estimated to be about 90 per cent.

Benzene and *toluene* were obtained commercially; purity > 98 per cent.

3. Determination of the Octane Number.

The octane numbers were determined according to the C.F.R.–A.S.T.M.-Motor method using *n*-heptane and *iso*-octane as reference fuels.

For the extrapolation of the octane scale below zero and above 100, the following method was applied.

Using a 65/35 blend of *iso*-octane/*n*-heptane and standard adjustment of the bouncing pin, the height of the compression chamber (= micrometer reading + 0·500″) was measured at standard knock intensity (knockmeter reading 50). The same was done for 0/100, 40/60, 60/40, 80/20, and 100/0 blends of *iso*-octane/*n*-heptane. The heights of the compression chamber measured were plotted against the octane number of the blend. The curve obtained appears to be in good agreement with the empirical formula

$$O = \frac{1{\cdot}369 - H}{1{\cdot}954 - H} \,.\, 178$$

as is shown in the following table :—

(O = octane number of the blend;
H = height of the compression chamber in inches.)

H (measured).	O_m (measured).	O_c (calculated).	$O_m - O_c$.
1·375	0	− 1·8	+ 1·8
1·200	40	39·9	+ 0·1
1·070	60	60·2	− 0·2
1·035	65	64·7	+ 0·3
0·885	80	80·6	− 0·6
0·620	100	99·9	+ 0·1

According to the above-mentioned formula the curve was extrapolated below zero and above 100; see Fig. 1. As an interesting point in this extrapolation method it may be mentioned that the octane number of an " absolutely knock-free hydrocarbon " appears to be 125.

In this way the height of the compression chamber for the hydrocarbons methane, ethane, 2 : 2 : 3-trimethylbutane, *n*-octane, 2 : 2 : 3-trimethylpentane, *n*-nonane, benzene and toluene was measured and used as a basis for the calculation of their octane number.

For the supply of gaseous and of very volatile hydrocarbons a special arrangement was used consisting of a bomb with Hofer needle-valve connected with the intake silencer of the carburettor.

4. Discussion on the Octane Numbers of the Pure Hydrocarbons.

In the *paraffin series* methane is undoubtedly the hydrocarbon with the highest octane number. The octane numbers of the normal paraffins decrease regularly with increasing chain length. Branching of the chain increases the octane number (an exception is dimethylpropane with a lower octane number than 2-methylbutane); other correlations between structure and octane number seem hardly to be justified by the available material.

Among the liquid paraffin hydrocarbons there are only two which have a higher octane number than 2 : 2 : 4-trimethylpentane, namely *2 : 2 : 3-trimethylbutane* and *2 : 2 : 3-trimethylpentane*. The highly branched 2 : 2 : 3 : 3-tetramethylbutane is a solid substance with a melting-point of + 101·5° C.

The dispersion among the octane numbers of the *olefines* is much less than among the paraffins. Some of them, *e.g.*, ethene, propene and some strongly branched olefines have lower octane numbers than the corresponding paraffins, whereas the octane number of others, *e.g.*, *n*-pentene, *n*-hexene, *n*-octene, 3-methylheptene and others is lowered on hydrogenation.

The octane numbers of the *naphthenes* investigated give an indication that the five-ring naphthenes may have higher octane numbers than the four- and six-ring naphthenes with the same number of carbon atoms.

The octane numbers of the *aromatics* investigated are above 100; the reproducibility of the octane number of pure benzene was unsatisfactory; on different days it spread between 103 and 110. The real octane number of benzene is probably much higher; see also Section 5 of this paper.

5. Octane Numbers of Binary Hydrocarbon Mixtures.

In addition to the octane numbers of the pure hydrocarbons we determined also the octane numbers of several hydrocarbon mixtures; partly to verify the applied extrapolation method of the octane scale, partly to get some insight into the " blending value " of the different hydrocarbons.

The results are plotted in Figs. 2–8.

Figs. 2, 3, and 4 are octane number curves of binary paraffin mixtures; the greater part of these curves show only minor deviations from a straight line.

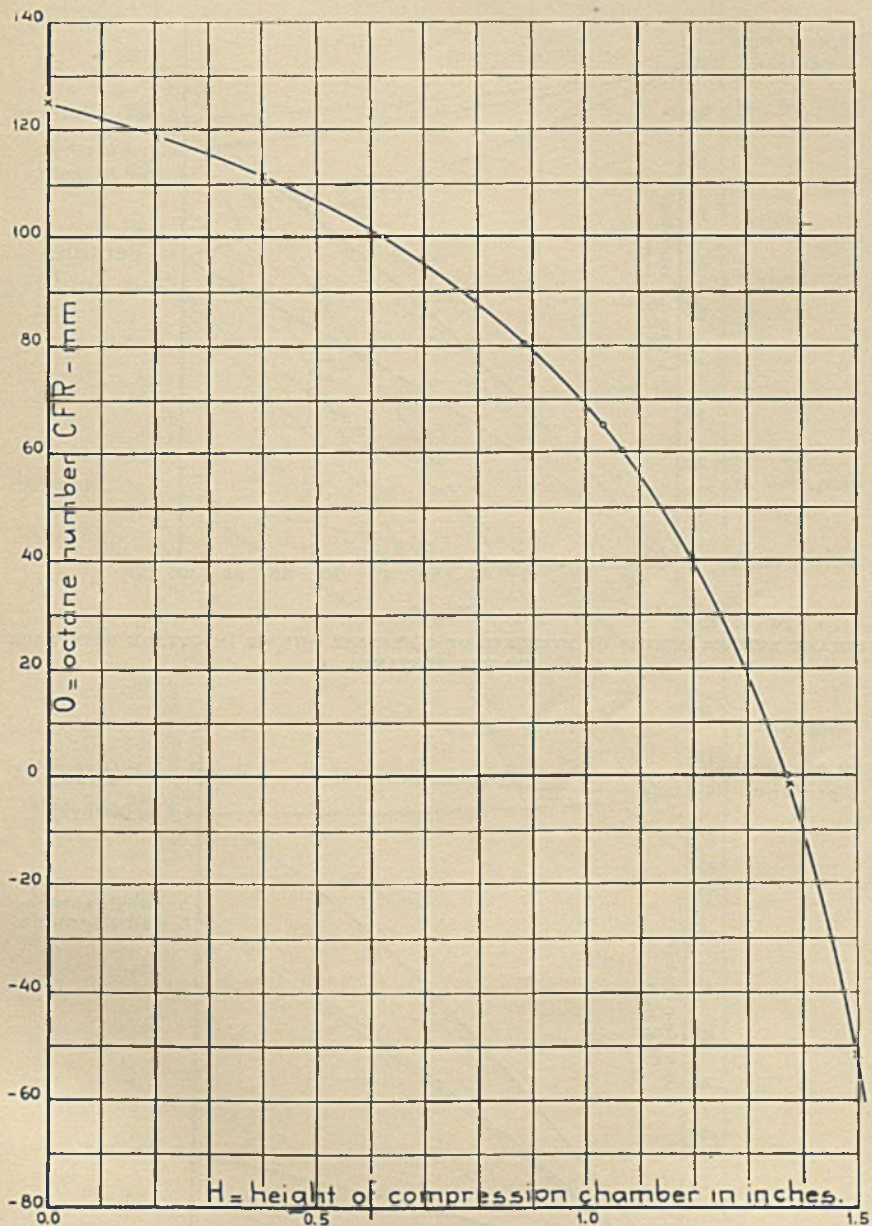

FIG. 1.

EXTRAPOLATION CURVE FOR OCTANE NUMBERS ABOVE 100 AND BELOW ZERO.

o = Observed.
x = Calculated according to the formula

$$O = \frac{1{\cdot}369 - H}{1{\cdot}954 - H} \cdot 178.$$

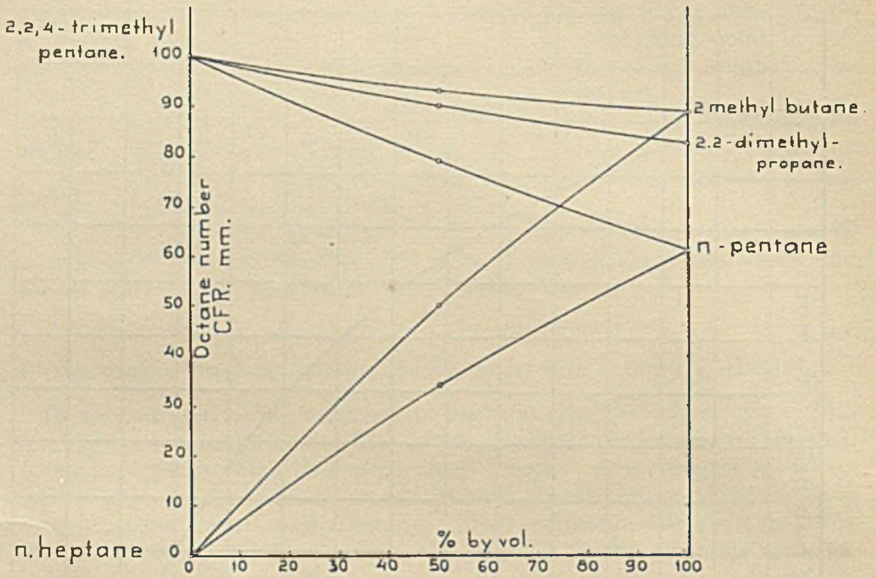

FIG. 2.

OCTANE NUMBER CURVES OF MIXTURES OF *n*-HEPTANE AND OF *iso*-OCTANE WITH EACH OF THE PENTANES.

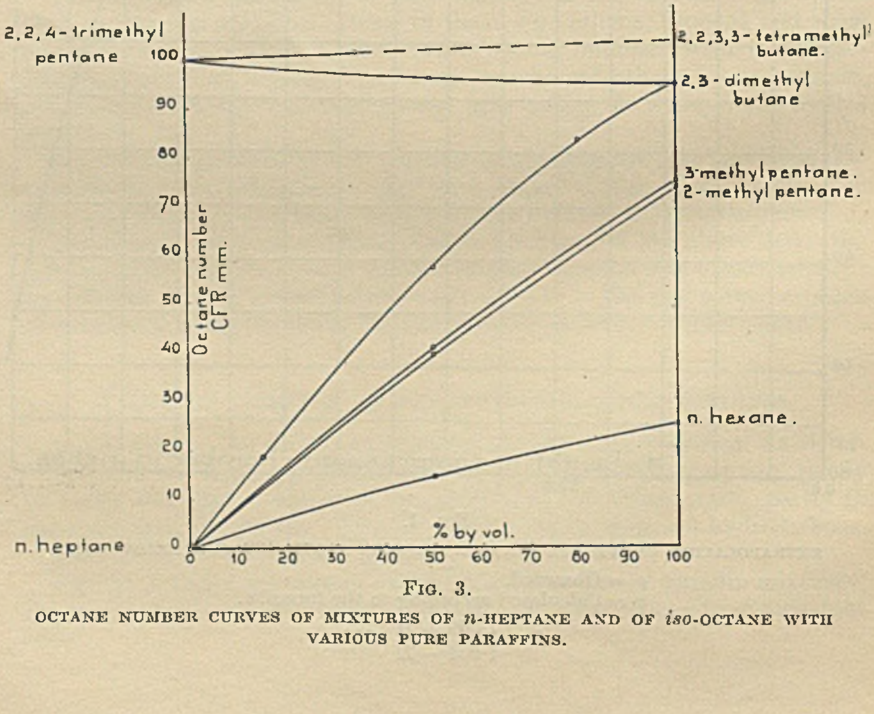

FIG. 3.

OCTANE NUMBER CURVES OF MIXTURES OF *n*-HEPTANE AND OF *iso*-OCTANE WITH VARIOUS PURE PARAFFINS.

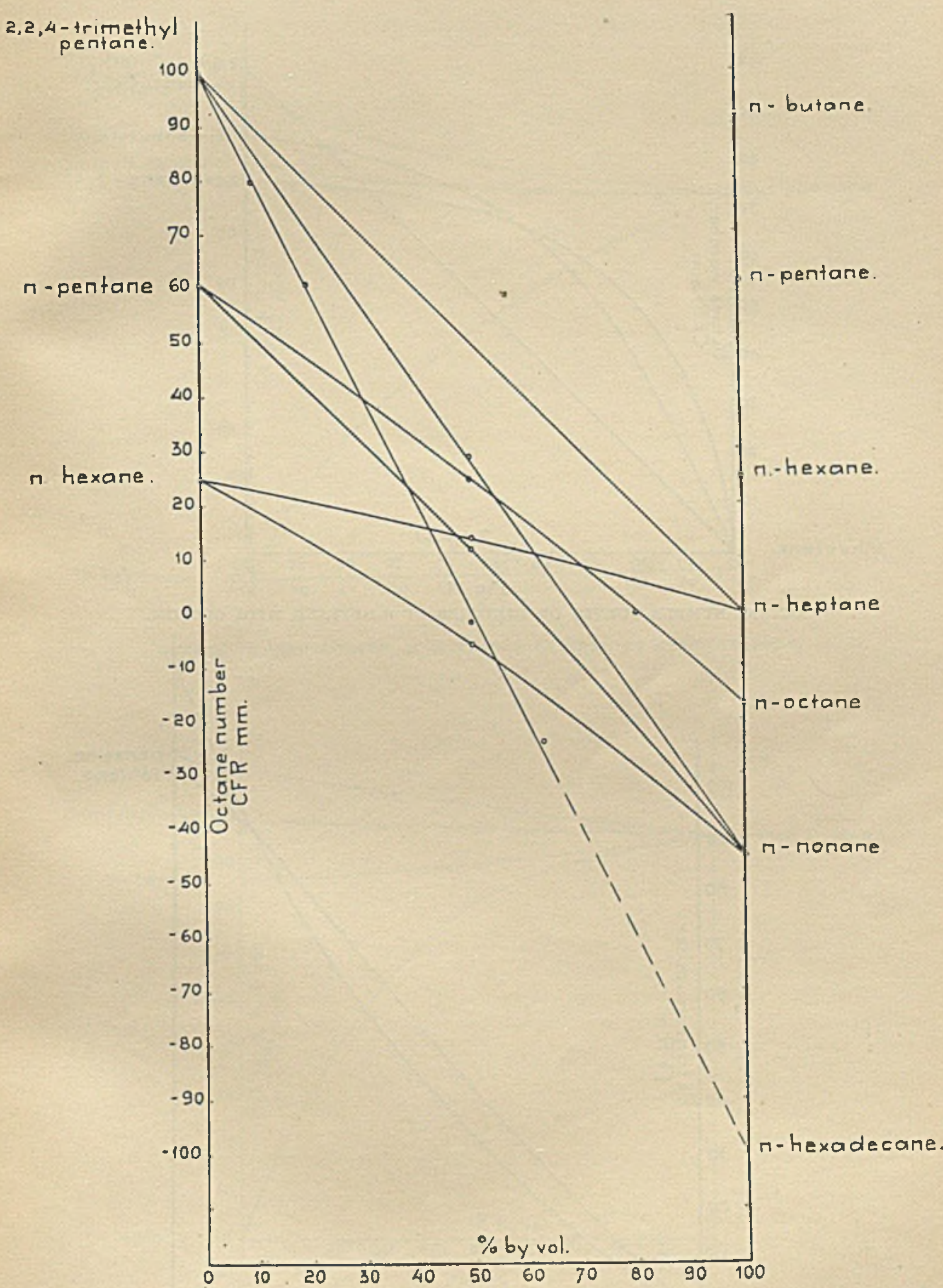

FIG. 4.

OCTANE NUMBER CURVES OF MIXTURES OF STRAIGHT-CHAIN PARAFFINS WITH STRAIGHT-CHAIN AND WITH BRANCHED PARAFFINS.

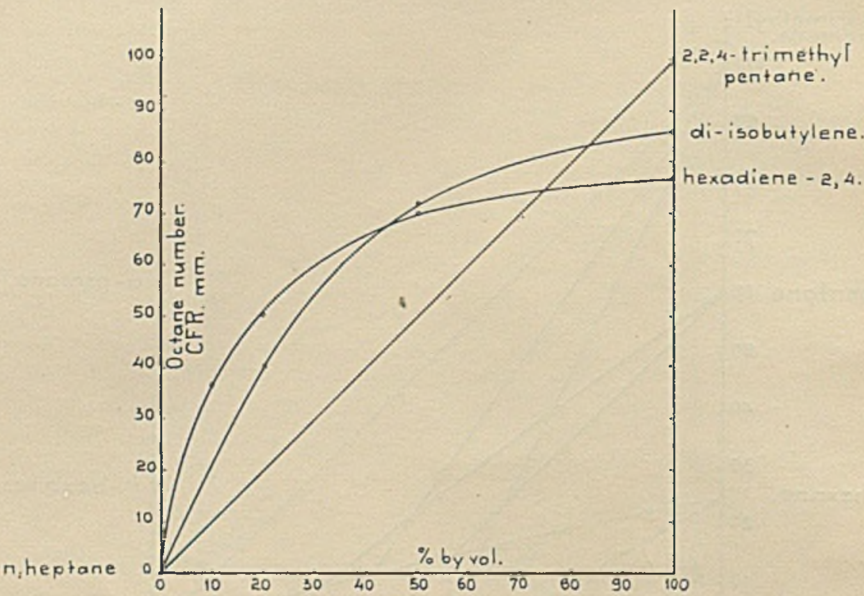

Fig. 5.

OCTANE-NUMBER CURVES OF MIXTURES OF n-HEPTANE WITH OLEFINS.

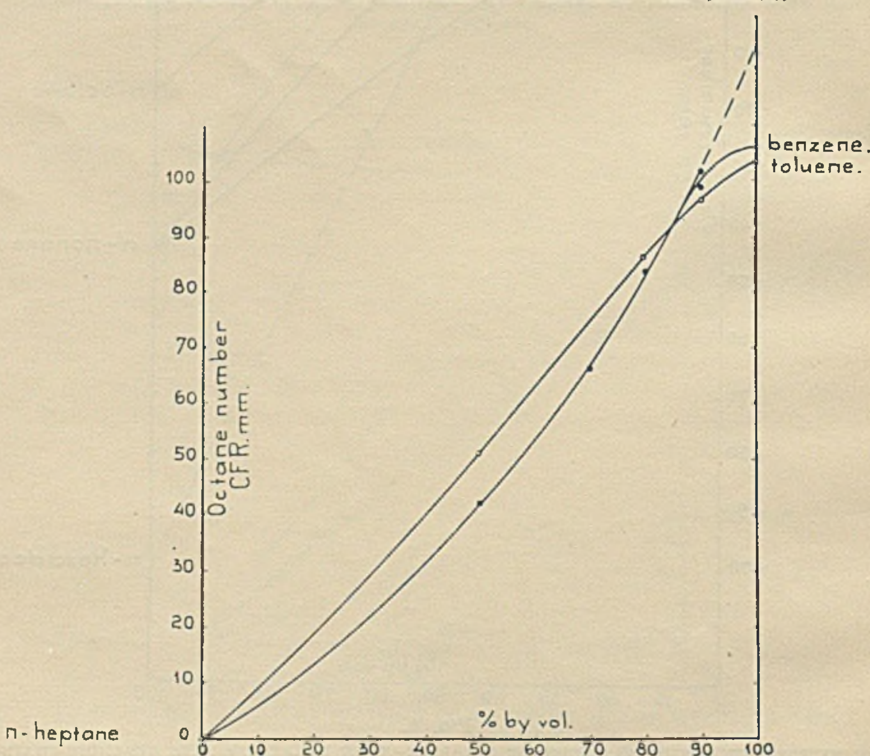

Fig. 6.

OCTANE-NUMBER CURVES OF MIXTURES OF n-HEPTANE WITH AROMATICS.

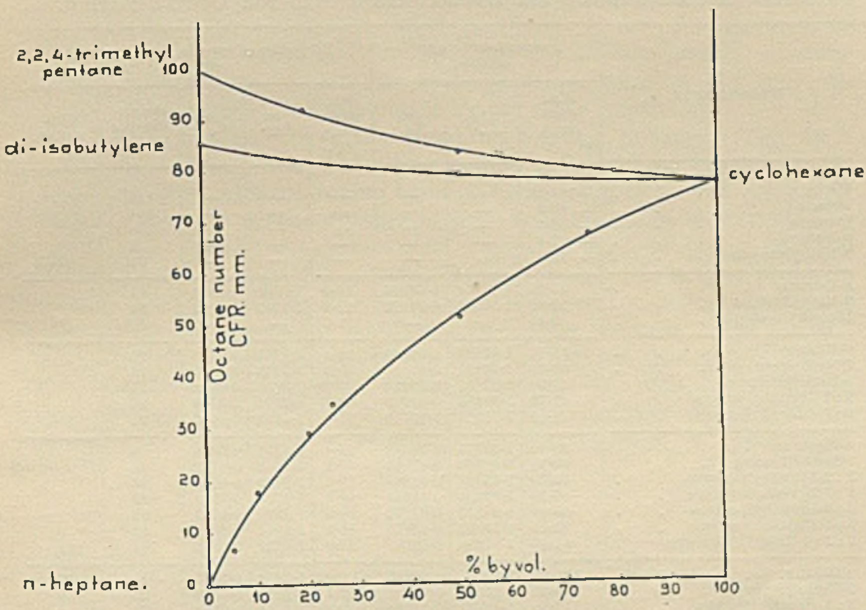

FIG. 7.

OCTANE-NUMBER CURVES OF MIXTURES OF VARIOUS HYDROCARBONS.

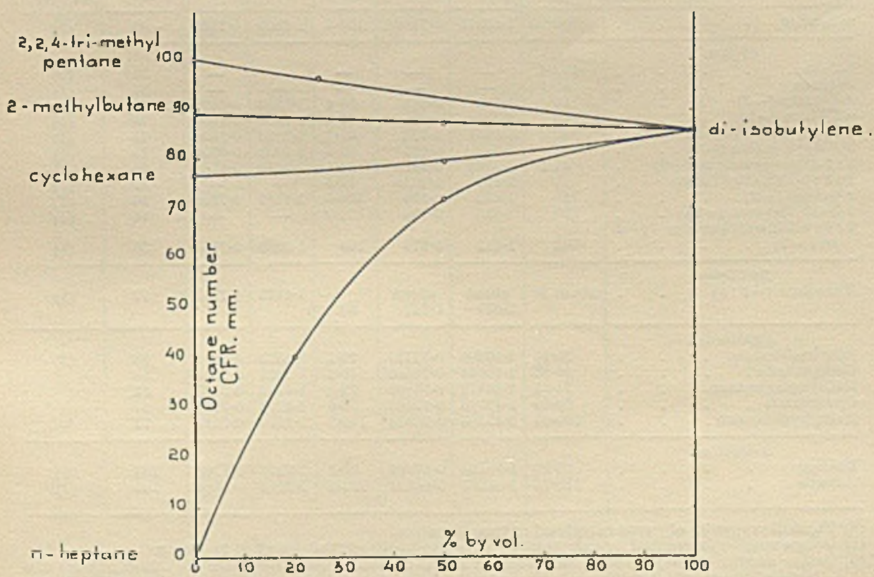

FIG. 8.

OCTANE-NUMBER CURVES OF MIXTURES OF VARIOUS HYDROCARBONS.

PHYSICAL CONSTANTS OF THE HYDROCARBONS USED FOR OCTANE RATING.

HYDROCARBON.	Properties of purest sample.			Properties of sample, used for octane rating.				
	B.p. (760 mm.), °C.	n_D^{20}.	d_4^{20}.	B.p. (760 mm.), °C.	n_D^{20}.	d_4^{20}.	Octane number A.S.T.M.	REMARKS.
Paraffins.								
Methane	−161·58	—	—	—	—	—	110	(1), (2)
Ethane	− 88·5	—	—	—	—	—	104	(1), (2)
Propane	− 42·2	—	—	—	—	—	100	(1)
n-Butane	− 0·5	—	—	—	—	—	92	(1)
2-Methylpropane	− 12·2	—	—	—	—	—	99	(1)
n-Pentane	35·95	1·35764	0·62624	36·0	1·3580	0·6263	61	
2-Methylbutane	27·80	1·35391	0·61972	27·8	1·3552	0·6198	89	
Dimethylpropane	9·45	—	—	9·6	—	—	83	(1)
n-Hexane	68·75	1·37494	0·65943	68·8	1·3751	0·6589	25	
2-Methylpentane	60·30	1·37151	0·65316	60·3	1·3714	0·6525	73	
3-Methylpentane	63·30	1·37657	0·66435	63·2	1·3766	0·6638	75	
2 : 2-Dimethylbutane	49·70	1·36882	0·64919	49·7	1·3691	0·6489	96	
2 : 3-Dimethylbutane	58·05	1·37504	0·66166	58·1	1·3752	0·6617	95	
n-Heptane	98·40	1·38770	0·68378	98·4	1·3878	0·6835	0	
2-Methylhexane	90·10	1·38493	0·67869	90·1	1·3852	0·6782	45	
2 : 2-Dimethylpentane	79·30	1·38221	0·67388	79·3	1·3822	0·6734	93	
2 : 3-Dimethylpentane	89·80	1·39205	0·69514	89·8	1·3921	0·6944	89	
2 : 4-Dimethylpentane	80·60	1·38148	0·67275	80·6	1·3820	0·6723	82	
3 : 3-Dimethylpentane	86·10	1·39092	0·69330	86·1	1·3911	0·6926	84	
2 : 2 : 3-Trimethylbutane	81·00	1·38949	0·69007	81·0	1·3899	0·6898	101	(2)
n-Octane	125·75	1·39765	0·70280	125·8	1·3979	0·7025	−17	(2)
3-Methylheptane	119·05	1·39851	0·70584	119·1	1·3988	0·7053	35	
2 : 3-Dimethylhexane	115·80	1·40131	0·71234	115·8	1·4015	0·7118	76	
2 : 5-Dimethylhexane	109·25	1·39281	0·69426	109·3	1·3930	0·6943	52	
3 : 4-Dimethylhexane	117·85	1·40431	0·71951	117·9	1·4044	0·7193	85	
2 : 2 : 3-Trimethylpentane	110·05	1·40297	0·71613	110·1	1·4032	0·7162	102	(2)
2 : 2 : 4-Trimethylpentane	99·10	1·39146	0·69196	99·1	1·3917	0·6920	100	
2 : 3 : 4-Trimethylpentane	113·4	1·4046	0·7195	112·8	1·4045	0·7197	97	(1)
3-Methyl-3-ethylpentane	118·35	1·40785	0·72742	118·4	1·4081	0·7270	91	
2 : 2 : 3 : 3-Tetramethylbutane	106·5	—	—	106·5	—	—	103	(1), (3)
n-Nonane	150·70	1·40556	0·71808	150·7	1·4060	0·7165	−45	(2)
Olefins.								
Ethene	−102·4	—	—	—	—	—	81	(1)
Propene	− 47·7	—	—	—	—	—	85	(1)
n-Pentene (−2)	36	1·380	0·649	36·4	1·3802	0·6498	80	(1)
n-Hexene (−2)	68	1·397	0·685	67·6	1·3950	0·6800	78	(1)
2-Methylpentene (−2)	66	1·3984	0·693	67·4	1·3997	0·6870	78	(1)
3-Methylpentene (−2)	68	1·400	0·695	69·5	1·4032	0·6956	79	(1)
2 : 2-Dimethylbutene (−3)	41·2	1·3766	0·6519	41·5	1·3769	0·6530	94	(1)
2 : 2 : 3-Trimethylbutene	78	1·402	0·7029	77·8	—	—	89	(1)
n-Octene (−2)	125	1·412	0·720	124·6	1·4142	0·7204	55	(1)
3-Methylheptene (−2)	122	1·418	0·730	122·0	—	—	74	(1)
2 : 4 : 4-Dimethylpentene (−1 and −2)	103	1·412	0·719	100	1·4108	0·719	86	(1)
Di-Olefins.								
Hexadiene (−2 : 4)	about 80	about 1·447	about 0·717	80	1·4479	0·7182	77	(1)
Naphthenes.								
Ethyl*cyclo*butane	70·70	1·40209	0·72787	70·7	1·4023	0·7276	68	(4)
*Cyclo*pentane	49·20	1·40644	0·74542	49·2	1·4065	0·7459	83	
Methyl*cyclo*pentane	71·85	1·40978	0·74869	72·0	1·4102	0·7484	82	
*Cyclo*hexane	80·80	1·42625	0·77867	80·8	1·4262	0·7783	77	
Methyl*cyclo*hexane	100·80	1·42305	0·76944	110·3	1·4230	0·7689	71	
Aromatics.								
Benzene	80·10	1·50123	0·87896	80·1	1·5011	0·8786	108	(1)
Toluene	110·68	1·49685	0·86697	110·8	1·4962	0·8666	104	(1)

(1) Physical properties of purest sample taken from literature.
(2) Octane number determined by extrapolation according to the method described in Sect. 3.
(3) Octane number of the pure compound which is a solid substance, calculated from the octane number of a blend of 35 per cent. by weight of the compound and 65 per cent. by weight of 2 : 2 : 4-trimethylpentane (octane number of the blend 101).
(4) Octane number of the pure compound, which was not available in sufficient quantity, calculated from the octane number of a blend of 50 per cent. by vol. of the compound and 50 per cent. by vol. of *cyclo*hexane (octane number of the blend 72·5).

Fig. 5 illustrates clearly the peculiar behaviour of mixtures of olefines and di-olefines with *n*-heptane. From this curve it can, for instance, be seen that the octane number of a 50/50 blend of *n*-heptane and di-isobutene is lowered twenty-two points on hydrogenation, whereas the pure di-isobutene gains fourteen octane points by the same treatment.

The octane number curve of *n*-heptane–benzene mixtures (Fig. 6) is not a straight line. The " blending octane number " of benzene in *n*-heptane increases with increasing benzene content up to 90 vol. per cent.; from this curve the octane number of pure benzene might be expected to be about 125; that means that in these *n*-heptane–benzene blends benzene behaves as an " absolutely knock-free hydrocarbon." It is very probable that the " knock " which occurs at high compression ratios when pure benzene is used as the fuel is another phenomenon than the " real knock " (" pink ") of the other hydrocarbons and of the heptane–benzene blends.

Figs. 7 and 8 are added merely to stress again the fact that the " blending octane number " of a hydrocarbon is useless if no mention is made of the basis-fuel and the quantity in which the hydrocarbon in question is blended.

References.

[1] Lovell, W. G., and Campbell, J. M., *Chem. Rev.*, 1936, **22**, 159.
[2] Wibaut, J. P., Hoog, H., Langedijk, S. L., Overhoff, J., and Smittenberg, J., *Rec. Trav. chim. Pays-Bas*, 1939, **58**, 329–77.

TWENTY-SIXTH ANNUAL REPORT.

1939.

The Twenty-Sixth Annual Report of the Council covering the activities of the Institute during 1939 is presented for the information of the members.

Membership.

The changes in membership which occurred during 1939, and the total membership of all classes on 31st December, 1939, are summarized in the Table below :—

	Total Dec. 31, 1938.	Changes during 1939.						Total Dec. 31, 1939.
		New.	Transferred to.	Resigned.	Deceased.	Transferred from.	+ or —	
Hon. Members	20	—	—	—	—	1	− 1	19
Fellows	—	26	381	—	1	—	+406	406
Members	736	57	96	18	6	349	−220	516
Assoc. Mems.	626*	54	38	15	2	155*	− 80	546
Students	96	46	—	2	—	10	+ 34	130
Totals	1478	183	515	35	9	515	+139	1617

* Associate Members and Associates.

The Council has to record with deep regret the decease of the following members during 1939 :—

	Date elected.	Class of membership.
Barton, D. C.	1926	Fellow.
Buerger, C. G.	1922	Member.
Currie, J. L.	1936	Member.
Fuller, H. S.	1924	Associate.
Gibson, G. W. E.	1920	Fellow.
Jenkin, C. O. F.	1924	Member.
Mackenzie, W. L.	1920	Member.
Pearce, E. A.	1925	Associate.
Wheeler, R. V.	1925	Member.

Re-Classification of Membership.

A Special General Meeting was held on 10th January, 1939, to approve temporary regulations for the transfer of Members, Associate Members, and Associates under the former constitution of the Institution of Petroleum Technologists, to the classes of Fellow, Member, and Associate Member of the Institute of Petroleum.

These temporary regulations were forwarded to every member. They were to be in force up to 30th June, 1939, but in practice the Council has dealt with applications received up to the end of the year. A total of 540 applications were received. Every application was given individual consideration by the Election Committee, and the qualifications of each candidate assessed in relation to the definitions of the three categories of membership introduced in 1938.

The net result of the re-classification of membership is shown in the Table given above. The total increase of membership of 139 during the year is regarded by the Council as very satisfactory, although it must be qualified by the observation that no names were removed from the roll of the Institute during 1939 by reason of non-payment of subscriptions. Owing to the international situation remittances from members abroad were in many cases impossible, and the provisions of the By-Laws were not exercised.

Honours.

William Fraser, Esq., C.B.E. (Fellow), was created a Knight Bachelor in the Birthday Honours List, 1939.

Sir Thomas Holland, K.C.S.I., K.C.I.E., D.Sc., LL.D., F.R.S. (Past-President), was awarded the Albert Medal of the Royal Society of Arts in June, 1939.

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, Dr. A. E. Dunstan, Dr. F. H. Garner, and Mr. J. Kewley (Honorary Members of Committee D-2 on Petroleum Products and Lubricants).
- The British National Committee of the World Power Conference : Dr. A. E. Dunstan.
- The Technical Committee of the Chemical Engineering Conference : Lt.-Col. S. J. M. Auld.
- The British Standards Institution, Petroleum Industry Committee : Lt.-Col. S. J. M. Auld, Prof. J. S. S. Brame, Dr. A. E. Dunstan, Mr. B. J. Ellis, Dr. F. H. Garner, Mr. J. Kewley, and the Secretary.
- The Permanent Council of World Petroleum Congresses : Lt.-Col. S. J. M. Auld, Mr. T. Dewhurst, and the Secretary.
- XVIIIth International Geological Congress : The President and Mr. T. Dewhurst.
- Diesel Engine Users Association : Mr. L. J. Le Mesurier and Mr. N. Mitchell.
- Ramsay Memorial Laboratory : Mr. J. Kewley.
- Permanent International Association of Road Congresses : Dr. P. E. Spielmann.
- Parliamentary Science Committee : Lt.-Col. S. J. M. Auld, Mr. T. Dewhurst, Dr. E. R. Redgrove.
- S.A.E. World Automotive Engineering Congress : Dr. A. E. Dunstan and Mr. N. Mitchell.
- Viscosity Conference of Société Belge pour l'Étude du Pétrole : Dr. F. H. Garner, Dr. G. Barr, and the Secretary.

The Institute has also been represented on numerous Sub-Committees of the British Standards Institution.

Benevolent Fund.

The audited statement of Receipts and Payments of the Benevolent Fund during 1939 is submitted below. The receipts from all sources were £76 6*s*. 5*d*., as compared with £106 18*s*. 4*d*. in 1938.

Contributions to the Fund during 1939 were received from the following members, to all of whom the Council expresses its grateful thanks :—

Adams, A. C.	Crichton, R.	Kewley, J.	Sanders, J. McConnell.
Andrews, B. G.	Dalley, C.	Mackilligan, R. S.	Schlumberger, M.
Auld, S. J. M.	Downs, W. W.	Masters, J. S. S.	Smallwood, W.
Beavan, A. M. E.	Dunkley, G. W.	McCreath, T. T.	Smith, A. F. P.
Bell, O. A.	Dunstan, A. E.	Le Mesurier, L. J.	Southwell, C. A. P.
Blakiston, J. H.	Edeleanu, I.	Moon, C. A.	Spielmann, P. E.
Bolton, R. P.	Evans, R. J.	Nash, A. W.	Taitt, G. S.
Brame, J. S. S.	Everist, G. E.	Owen, A. G.	Taylor, T. M.
Brayfield, T. H. G.	Fay, E.	Parr, R. W.	Tullett, G. V.
Bressey, R. J.	Ferguson, B. C.	Parrish, J.	Tweed, R. R.
Brodie, N. M.	Frewing, J. J.	Perks, A. J.	Walsh, D. M.
Cameron, I.	Griffiths, P. M.	Porter, P. N. D.	Walter, G.
Charlton, H. E.	Henson, F. R. S.	Purdie, A. C.	Wood, C. W.
Clement, L.	Higgs, P. G.	Purves, A. R.	Young, J. H. M.
Clifford, G.	Hills, S. R.	Redgrove, E. R.	Shell Marketing Company, Central Laboratories.
Cohn, T.	Jackson, J. S.	Richards, G. A.	
Cole, F. A. J.	Jameson, J.	Sams, C. E. R.	
Cox, A. W.			

Whilst the calls on the Fund have fortunately been few in the past, they are likely to increase as time goes on. The Council earnestly appeals to all members to support their own Benevolent Fund more generously. It is pointed out that the total received by way of subscriptions and donations (£52 10*s*. during 1939) represents an average contribution of about eightpence per member.

Premises.

The outbreak of war caused serious dislocation to the work of the Institute. Early in September 1939 the Institute's new offices at the Adelphi were requisitioned by H.M. Office of Works for occupation by a Government Department. In the few days available it was not possible to find suitable alternative accommodation in the London district.

Professor A. W. Nash, on behalf of the University of Birmingham, generously offered accommodation at the Department of Oil Engineering and Refining, The University, Birmingham. The Council was pleased to accept this offer, and expresses its appreciation of the facilities which have been placed at the disposal of the Institute and its staff. Whilst the disadvantages of removal from London are obvious, the transfer to Birmingham has given the Institute the compensating advantage of association with one of the leading centres of petroleum education and research.

A large part of the furniture at the Adelphi, much of it new, was also requisitioned by H.M. Office of Works. Some of the furniture was stored; other items were removed to Birmingham. The question of compensation to the Institute under the provisions of the Compensation (Defence) Act, 1939, is still under consideration.

Finance.

The audited Revenue Account for the year and Balance Sheet as at 31st December, 1939, are given below. Items of the year's expenditure calling for particular observation are those relating to "Rent and Rates" and "Removal and Other Expenses in connection with the requisitioning of the Adelphi." The full year's rent and rates, amounting to £2808 19*s.* 4*d.*, have been shown on the Revenue Account. This amount has been paid in full in accordance with the Institute's lease, together with the first quarter's rent for 1940, paid in advance at Christmas 1939, notwithstanding the fact that the Institute did not have the use of its Adelphi premises after September 1939. No credit has been taken for any compensation which may ultimately be received from H.M. Office of Works, since no indication of the amount of such compensation had been made prior to 1st May, 1940. The item "Removal and Other Expenses," which includes certain provisions for senior members of the staff transferred to Birmingham, is also the subject of a claim to H.M. Office of Works.

The Council cannot but view the uncertainty of the present position with some concern and, in co-operation with the Institute's solicitors, is maintaining constant watch on a difficult situation.

A considerable reduction of income during 1940 will be inevitable, but economies in administration have been introduced since September 1939 whereby the Council hopes in part to off-set the loss of revenue.

National Service Register.

At the request of the Ministry of National Service and Labour, the Council authorized the issue in April 1939 of registration cards for the Central Register. The object of this register is to make available to H.M. Government a record of persons with scientific, technical, and administrative qualifications. Registration cards were issued to all Fellows, Members, and Associate Members in the United Kingdom; and to members of British nationality in certain other countries.

About 450 cards were returned out of a total of 700 issued to members in the United Kingdom. In view of the large number of members of the Institute who had completed registration cards for other scientific societies, this total is regarded as very satisfactory. One set of the cards is filed at the Ministry of National Service and Labour; a duplicate is retained at the Institute's offices.

An Oil Sub-Committee of the committee appointed by the Ministry of National Service to deal with mining and metallurgy was formed in March 1939. Mr. J. Kewley was invited by the Ministry of Labour to act as Chairman of this Oil Sub-Committee. Dr. F. B. Thole, Mr. S. E. Coomber, and the Secretary are also members. Regional Panels were established at twelve provincial centres, and many members of the Institute have consented to serve on these Panels.

Meetings of the Institute.

Four Ordinary Meetings of the Institute and the Annual General Meeting were held in London during 1939. In addition, special conferences were held on "Dangerous Gases" in London, and on "Fuels and Lubricants" in Birmingham, to which reference is made below.

The subjects of Papers presented at the Ordinary Meetings and at meetings of specialised Groups during the year 1939 are given in the following Table :—

Date. 1939.	Subject.	Authors.
10th Jan.	Special General Meeting *re* Temporary By-Laws.	
	"Tank Strapping."	P. Kerr.
14th Feb.	"Some Factors in Oil Accumulation."	V. C. Illing.
14th March.	"Dangerous Gases in the Petroleum and Allied Industries."	Various.
27th April.	Annual General Meeting.	
	"Control of Oil Fires."	A. F. Dabell.
22nd–24th May.	Birmingham Conference.	Various.
	Asphaltic Bitumen Group.	
28th March.	"Measurement of Flow Properties of Bitumens."	D. C. Broome.
9th May.	"Bitumen Emulsions."	L. G. Gabriel.
21st Nov.	Exhibition of Films on Asphalt Mastics.	G. J. Hancock.
	Lubrication Group.	
23rd Feb.	"High-Tension Piston Rings."	W. A. Wilson.

The average attendance at these Meetings (excluding the Birmingham Conference) was 70. This is lower than the average for 1938 (98).

Branch Lecture.

Mr. G. W. Lepper, A.R.C.S., B.Sc., Technical Adviser, H.M. Petroleum Department, delivered the Branch Lecture on "The Search for Oil in Britain" to members of Branches in Great Britain, as follows :—

27th January	at Swansea.
16th February	at Glasgow.
9th March	at Manchester.
10th March	at Birmingham.

CONFERENCE ON "DANGEROUS GASES."

A series of Papers on "Dangerous Gases in the Petroleum and Allied Industries" was discussed at a whole-day meeting of the Institute, held in London on Tuesday, 14th March, 1939.

Mr. W. W. Goulston, B.A., B.Sc., A.I.C. (Fellow), acted as organizer of the meeting on behalf of the Council.

Mr. A. R. Stark, B.Sc. (Fellow), acted as General Reporter for the meeting and presented a summary of the Papers at each Session.

This was probably the first occasion on which so much valuable but dispersed information relating to the detection, toxicity, and protection against inflammable and poisonous gases had been assembled at one conference. Papers were received from petroleum companies in Great Britain, Holland, and U.S.A., the Safety in Mines Research Board, the Chemical Defence Research Station, the Chemical Research Laboratory, and the University of Leeds. They were published in two special issues of the *Journal* in May and June 1939, and have also been reprinted and published by the Institute as a book.

In connection with the Conference an exhibition of apparatus and models, loaned by various Government Departments and companies, was held at the Institute's offices, The Adelphi, W.C. 2, from 13th to 25th March, 1939. The exhibits were arranged by Mr. C. L. Gilbert, B.Sc., A.R.C.S. (Member).

Charts and photographs from the Exhibition were subsequently presented on permanent loan to the Home Office Industrial Museum, Horseferry Road, London, S.W. 1.

Birmingham Conference on Fuels and Lubricants.

The 1939 Summer Meeting of the Institute was held in Birmingham on 22nd–24th May, 1939. It provided an opportunity, of which full advantage was taken, for technologists engaged in the petroleum and automobile industries to meet and discuss problems of mutual interest, relating to fuels and lubricants for internal-combustion engines. The Conference was attended by about 250 members of the Institute of Petroleum, the Institution of Automobile Engineers, and other scientific and technical bodies in this country and abroad.

Four Sessions were held for the presentation and discussion of Technical Papers, presided over by :—

The President (Prof. A. W. Nash).
Capt. G. E. T. Eyston, M.C.
Dr. D. R. Pye, F.R.S. (representing the Royal Aeronautical Society).
F. G. Woollard, Esq., M.B.E. (President-Elect, The Institution of Automobile Engineers).

Sixteen Papers were presented. These were published with the ensuing discussion in the *Journals* of September–December 1939. Two of these Papers were also presented to the World Automotive Engineering Congress organized by the S.A.E. in New York and opened in New York on 22nd May.

Included among the Papers presented at Birmingham was a Report of the Knock-Rating Committee of the Institute on "The Development of Fuels for Automobile Engines." This was published both in the May 1939 issue of the *Journal* and in the June 1939 issue of the *Journal of the Institution of Automobile Engineers*.

On May 23rd a Reception by the Lord Mayor of Birmingham (Alderman James Crump), the Pro-Chancellor (Mr. E. P. Beale, M.A.), and the Vice-Chancellor (Dr. R. E. Priestley, M.A.) was held in the Great Hall of the University, Edgbaston. The various engineering departments of the University were opened to the inspection of the visitors.

On 24th May a Dinner was held at the Grand Hotel, Birmingham. Speeches were made by the Lord Mayor, Dr. Priestley, Mr. C. A. P. Southwell, and the President. During the course of the dinner the Empire Day Speech of H.M. the King was relayed from Ottawa. The Dinner was followed by a Dance.

Visits were made on the afternoon of the 24th May to the works of the

Austin Motor Company, Ltd., and Morris Commercial Cars, Ltd., both companies entertaining their visitors to luncheon.

An interesting programme of excursions for ladies attending the Meeting included visits to Cadbury Bros., Ltd., Harry Vincent, Ltd., and Warwick Castle.

The Council expresses its grateful appreciation of the organization of this Meeting by the members of the Reception Committee (Messrs. W. E. Aylwin, J. P. S. Barber, W. Blackwell, H. C. S. Fothergill, J. F. F. McQueen, T. C. Rowland, and Major L. V. W. Clark, *Hon. Secretary*) and of the Ladies Committee (Mrs. Clark, Mrs. MacElewee, Mrs. McQueen, Mrs. Marshall, and Mrs. Brozyna).

International Congresses.

World Petroleum Congress.

The Third World Petroleum Congress was scheduled to be held in Berlin in June 1940. The Council had offered its co-operation in organizing British participation in the Congress and had appointed a Committee (Mr. J. Kewley, *Chairman*, and Messrs. C. A. P. Southwell, W. W. Goulston, J. A. Oriel, F. H. Garner, R. K. Fischer, A. C. Hartley and C. W. Wood) to invite Papers for presentation at the Congress. Owing to the difficulties of the international situation little progress was made, and all arrangements have been in abeyance since the outbreak of war.

Permanent Council of World Petroleum Congresses.

Two meetings of the Permanent Council of World Petroleum Congresses were held during the year :

28th January, 1939, at Brussels. Present : Col. L. Pineau, Prof. P. Erculisse, Ir. J. H. C. de Brey, S. Scheer, J. Filhol, S. J. Astbury, and Dr. F. H. Garner.

4th March, 1939, in Dusseldorf. Present : Col. L. Pineau, Dr. A. Bentz, Ir. J. H. C. de Brey, T. Dewhurst, Prof. Erculisse, S. Scheer, J. Filhol, S. J. Astbury, and Sr. Roberti.

At the meeting in Brussels Dr. A. Bentz (President of the Deutsche Gesellschaft fur Mineralölforschung) and Sr. U. Puppini (Director of Azienda Generale Italiane Petroli, representative of Italian interests) were co-opted members of the Permanent Council, and Dr. Streintz (former President of the Austrian Petroleum Institute) relinquished his membership of the Permanent Council.

At the meeting in Dusseldorf the organization of the Third Congress proposed by the German Committee was approved. A Preliminary Circular relating to the Third Congress was issued to all members of the Institute in June 1939.

World Automotive Engineering Congress.

A World Automotive Engineering Congress, organized by the Society of Automotive Engineers (U.S.A.), was held in New York, Indianapolis, Detroit, Chicago, and San Francisco between 22nd May and 8th June,

1939. An exchange of greetings was made between the Congress and the Institute.

Dr. A. E. Dunstan (Past-President) addressed the Congress in New York on 22nd May on " Petroleum, To-day and To-morrow."

The Congress was attended by many members of the Institute in U.S.A.

International Geological Congress.

The XVIIIth International Geological Congress scheduled to be held in London in August 1940, was postponed *sine die* on the outbreak of war.

Chemical Engineering Congress.

Arrangements for the holding of the Second Chemical Engineering Conference in Berlin in 1940 were well advanced during the early part of 1939, but were cancelled in September.

International Standards Association.

The Annual Meeting of I.S.A. was held in Helsinki in June 1939. The Institute was not directly represented at this meeting, but only indirectly through the British Standards Institution.

Publications.

The Journal.

Vol. 25 of the *Journal* was published in twelve monthly parts and contained 35 Papers presented at meetings of the Institute, 5 Papers presented at Branches, and 20 contributed articles. In addition, there were published 1406 Abstracts of technical literature and patents.

The issues of June and July 1939 contained the Papers presented at the Symposium on "Dangerous Gases." These Papers have also been reprinted as a book.

The Papers on " Fuels and Lubricants " presented to the Birmingham Meeting were published in the issues of the *Journal* of September–December, 1939.

Annual Reviews of Petroleum Technology, Vol. IV.

The fourth volume in the series of *Annual Reviews of Petroleum Technology* was published in August 1939. Additional chapters were included on " Refinery Plant and Engineering " and " Pyrolysis and Polymerization," respectively. The outbreak of war unfortunately seriously interfered with the sales of this volume of the *Annual Reviews*, but the Council contemplates the publication of a fifth volume in the series during 1940.

Awards.

Two scholarships of £40 each, tenable by Students of the Institute at the Universities of London and Birmingham for the year 1939–40, were awarded to H. A. de Freitas (Royal School of Mines), and D. G. Brunner (Department of Oil Engineering and Refining, Birmingham University), respectively.

V. G. Norris, Stud.Inst.Pet. (Birmingham University), was awarded the Students Medal and a Prize for an essay on "Porous Flow and its Application to Increased Recovery from Petroleum Reservoirs."

A Special Prize was also awarded for the highly commended essay of N. V. Munster, Stud.Inst.Pet. (Birmingham University), on "Addition Agents for Lubricating Oils."

Meeting of U.S.A. Members.

The fifth annual meeting of members of the Institute in U.S.A. was held at the Stevens Hotel, Chicago, on 15th November, 1939. Dr. Gustav Egloff presided over an attendance of about 250 members and their guests. Guests of honour included Mr. T. A. Boyd, Mr. E. W. Webb, and Mr. T. Midgley.

Dr. Graham Edgar gave an address on "The Manufacture and Use of Tetra-Ethyl Lead."

Trinidad Geological Conference.

April 18th–27th, 1939.

The Trinidad Branch of the Institute was associated with a Geological Conference convened under the auspices of the Petroleum Association of Trinidad and held in the island on 18th to 27th May, 1939.

The Hon. R. S. MacKilligin, O.B.E., M.C. (Fellow), acted as Chairman of the Organizing Committee; Mr. E. C. Scott (Member) was Vice-Chairman and Secretary.

A short report of the Conference was given in the March 1940 issue of the *Journal.*

Branches and Groups.

Reports of the activities of the Branches of the Institute in the United Kingdom and overseas will be published in the *Journal* as they become available.

Meetings of the Branches in the United Kingdom were discontinued in the latter part of 1939, but have been resumed in 1940.

The Asphaltic Bitumen Group and the Lubrication Group have considerably assisted the programme of meetings during the early part of 1940 by making their London meetings open to the general body of members.

Library.

During the period January–August, 1939, 240 books or periodicals were lent to members, approximately equal to the number lent over the same period during 1938.

Since the outbreak of war the Library has not been available for the loan of books. It was possible to transfer only a limited number of books to Birmingham, so that the bulk of the Library remains at the Adelphi. The bookcases have been covered over with plywood to ensure that the books remain untouched and in good condition.

The Council is indebted to the Institution of Mechanical Engineers and the Imperial College of Science and Technology for their courtesy in extending library facilities to members during such time as their own library is not available.

The following periodicals have been added to the list of those regularly taken by the library during the year :—

Germany.	*Automobiltechnische Zeitschrift.*
	Motortechnische Zeitschrift.
Japan.	*Journal of Society of Chemical Industry of Japan.*
Turkey.	*Maden Tetkik ve Arama.*
United Kingdom.	*Petroleum.*
U.S.A.	*Chemical Abstracts.*
U.S.S.R.	*Vostochnia Neft.*

The Council records its thanks to the various Government departments, authors, and publishers who have generously presented publications to the library.

Research.

International Research on Viscosity.

A conference of the International Standards Association Sub-Committee 28.a.18 (Viscosity of petroleum products) was held in Brussels on 26th–28th January, 1939. The Institute was represented by Dr. F. H. Garner (Chairman, Viscosity Panel), Dr. G. Barr (N.P.L.), and the Secretary. This conference agreed to initiate a series of international determinations of viscosity, in order that comparison could be made of centistokes as determined in various countries.

The Association Française de Normalisation was primarily responsible for this research, in its capacity as secretariat of I.S.A. Committee 28.a.18. The Viscosity Panel of the Institute of Petroleum, however, played a prominent part in the organization of the work, and the Research Fund of the Institute provided the necessary finance.

Sixteen laboratories agreed to co-operate in the tests, representing seven different countries. It was decided that these laboratories should purchase Ostwald Viscometers, Nos. 2 and 3, standardized at the National Physical Laboratory, England. The Institute placed the orders for the viscometers and agreed to pay the cost of calibration for those national standardizing associations not prepared to meet this expense. The laboratory of the Bataafsche Petroleum Mij., Amsterdam, prepared and circulated a set of samples of three oils to all participating laboratories.

The programme of tests to be carried out on the samples of oil comprised the determination of the times of flow on the Ostwald tubes and the determination of the kinematic viscosity in centistokes on the national standard instrument of the country concerned. In this way it was hoped to be able to check the differences between centistokes as determined in the various countries co-operating in the tests.

The first part of the programme was successfully carried out according to plan. Samples of oil and calibrated Ostwald tubes were despatched before the end of June 1939 to the following laboratories :—

L'Ecole Nationale Superieure du Petrole (France).

Laboratorium voor Chemische Technologie der Technische Hoogeschool, Delft (Holland).

Chemisch Laboratorium der N.V. tot Keuring van Electrotechnische Materialen (Holland).

Laboratorium der Staatsmijnen (Holland).
Centraal Institute voor Materialonderzoek (Holland).
Standard American Petroleum Co. N.V. (Holland).
Laboratorium der N.V. Bataafsche Petroleum Mj. (Holland).
Dansk Standardiseringgraad (Denmark).
Statens Provingsanstalt (Sweden).
Physikalisch-Technische Reichsanstalt (Germany).
Standard Inspection Laboratory (U.S.A.).
Esso European Laboratories (England).
National Physical Laboratory (England).
Anglo-American Oil Company (England).
Burmah Oil Company (England).
Texas Oil Company (England and U.S.A.).

The dates for the viscosity determinations were fixed for the end of September and the beginning of October. Unfortunately, the outbreak of war seriously interrupted the work. A few of the laboratories were able to carry out the tests on the dates agreed, but as the majority of the laboratories were unable to do so, fresh dates were selected in January and February 1940.

Results had been received prior to 1st May, 1940, from six of the co-operating laboratories. When further results have been received they will be correlated at the National Physical Laboratory, with reference to the times of flow.

Steels for Use at High Temperatures.

A grant of £25 was made to the British Electrical and Allied Industries Research Association in aid of investigations on the Creep and Corrosion of Steel at High Temperatures.

Other Research Grants.

Research grants in continuation of previous grants have also been made to Professor F. Challenger (University of Leeds) and Dr. G. M. Dyson (Loughborough Technical College).

Council and Officers.

Professor A. W. Nash, M.Sc., M.I.Mech.E., assumed the Presidency of the Institute in succession to Lt.-Col. S. J. M. Auld at the Annual General Meeting of 27th April, 1939. Professor Nash has been elected by the Council for a second term of office as President for the year 1940–41.

Mr. Ashley Carter, Mr. C. Dalley, Dr. F. H. Garner, Mr. J. McConnell Sanders, and Dr. F. B. Thole have been elected Vice-Presidents for the year 1940–41.

The following were elected members of Council as a result of the ballot declared at the Annual General Meeting of 1939: Mr. G. H. Coxon, Dr. E. B. Evans, Mr. A. C. Hartley, Mr. J. S. Jackson, Mr. H. C. Tett, and Dr. A. Wade.

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; Mr. T. Outen of Messrs. Ashurst, Morris, Crisp & Co., Solicitors, for his help and advice in many problems arising out of the war; and the members of the Staff.

It also wishes to thank the Council of the Institution of Chemical Engineers for permission to hold Council and Committee meetings at its premises in Victoria Street; 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.

2*nd May*, 1940.

THE INSTITUTE

REVENUE ACCOUNT FOR THE

	£	s.	d.	£	s.	d.	£	s.	d.	1938 £
To Administration Expenses :—										
Staff Salaries				1686	1	1				*1616*
Printing and Stationery				293	16	7				*281*
General Postages				203	7	1				*254*
Telephone, Cables, and Telegrams				20	0	5				*28*
							2203	5	2	
,, Establishment Charges :—										
Rent and Rates	2808	19	4							
Less Grant in aid of Rent	2000	0	0							
				808	19	4				*600*
Cleaning and Lighting				16	13	7				*75*
Repairs and Renewals				140	13	7				*45*
							966	6	6	
,, Publications :—										
Journal Expenses				1635	3	7				*1508*
Abstractors' Fees				221	6	7				*253*
Postage on Journals				216	12	8				*185*
Cost of other Publications				485	7	2				*907*
							2558	10	0	
,, Meetings :—										
Hire of Hall, Preprints, Reporting				283	9	1				
Birmingham Meeting Expenses				124	17	9				
							408	6	10	*461*
,, Professional Fees :—										
Legal Expenses				31	10	0				*146*
Auditors' Fee				42	0	0				*42*
							73	10	0	
,, Students Scholarships and Prizes							88	2	3	*80*
,, Library Expenditure							40	0	10	*60*
,, Branches and Sections :—										
Students Section				17	17	11				*39*
Trinidad Branch				40	0	0				*40*
Northern Branch				35	0	0				—
Scottish Branch				5	0	0				—
South Wales Branch				10	0	0				—
Rumanian Branch				3	3	0				—
Branch Lectures				49	4	6				—
							160	5	5	
,, Sundry Expenses							184	3	3	*164*
,, Depreciation of Office and Library Furniture and Library Books							50	0	0	*12*
,, Removal and other Expenses in connection with requisitioning of The Adelphi							236	4	3	—
,, Balance, being surplus for year, carried to Balance Sheet							154	15	11	—
							£7123	10	5	

RESEARCH FUND INCOME AND EXPENDITURE

	£	s.	d.	£	s.	d.	£	s.	d.
To Grants Made During Year :—									
B.E.A.I.R.A.				25	0	0			
Prof. Challenger (Leeds University)				20	0	0			
Loughborough Technical College (Dr. Dyson)				13	17	8			
				58	17	8			
,, Research on Viscosity	79	5	8						
Less Payments received from participating laboratories	62	8	3						
				16	17	5			
							75	15	1
,, Balance as at 31st December, 1939							147	14	4
							£223	9	5

OF PETROLEUM

YEAR ENDED 31 DECEMBER, 1939

	£	s.	d.	£	s.	d.	1938
By **Subscriptions for 1939 Received** . .	3893	16	6				
Special Subscriptions	20	0	0				
				3913	16	6	*3617*
,, **Subscriptions in Arrear Received During Year**				94	7	1	*157*
,, **Publications**				2890	14	7	*2922*
,, **Interest and Dividends, Gross** . . .				224	12	3	*212*
				£7123	10	5	

ACCOUNT FOR THE YEAR ENDED 31ST DECEMBER, 1939.

	£	s.	d.
By **Balance as at 31st December, 1938**	213	7	8
,, **Interest Received During Year**	10	1	9
	£223	9	5

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, 1938 . . .		762 15 0		
Additions during year. . . .		48 12 0		
			811 7 0	
Entrance and Transfer Fees—				
As at 31st December, 1938 . . .		3172 0 6		
Additions during year—	£ s. d.			
Entrance fees . . .	226 9 3			
Transfer fees . . .	139 13 0			
		366 2 3		
			3538 2 9	
Profit on Sale of Investments—				
As at 31st December, 1938			351 10 11	
Donations—				
As at 31st December, 1938			326 5 0	
				5027 5 8
Research Fund				147 14 4
T. C. J. Burgess Prize Fund				10 0 0
Members' Subscriptions Received in Advance .				115 6 6
Journal Subscriptions Received in Advance . .				259 0 6
Sundry Creditors—General Account . . .				1320 14 4
World Petroleum Congress				161 19 8
Revenue Account :—				
Balance as at 31st December, 1938			1791 8 10	
Add Surplus for year as per Separate Statement . .			154 15 11	
				1946 4 9
				£8988 5 9

ALFRED W. NASH, President.
C. DALLEY, Chairman, Finance Committee.
S. J. ASTBURY, Secretary.

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 opinion view of the state of the Institute's affairs at 31st December, 1939, according to the of the Institute.

3, FREDERICK'S PLACE,
OLD JEWRY, LONDON, E.C.2.

OF PETROLEUM.

and not having a Share Capital.)

AT 31ST DECEMBER, 1939.

	£ s. d.	£ s. d.
Investments :—		
On Account of Capital—		
£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 Company 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, 1956/8	151 4 9	
600 0 0 3% Bristol Corporation Redeemable Stock, 1958/63	597 7 3	
		4171 0 7
(Market Value at 31st December, 1939, £3796 19*s.* 1*d.*)		
Cash awaiting Investment on Deposit with Post Office Savings Bank		856 5 1
		5027 5 8
On Account of Revenue—		
£790 8 3 3% Conversion Stock	842 8 0	
On Account of Research Fund—		
£336 5 10 3% Conversion Stock	357 14 8	
		1200 2 8
(Market Value at 31st December, 1939, £1101 7*s.* 1*d.*)		
Office and Library Furniture (Excluding Presentations) :—		
As at 31st December, 1938	180 0 0	
Less Depreciation	30 0 0	
		150 0 0
Library Books (Excluding Presentations) :—		
As at 31st December, 1938	20 0 0	
Less Depreciation	20 0 0	
		—
Subscriptions in Arrears :—		
Not valued.		
Sundry Debtors and Payments in Advance :—		
Sundry Debtors, less Reserve for Doubtful Debts . .	334 11 7	
Payments in Advance	156 15 3	
		491 6 10
Cash at Bank		249 12 4
Cash on Deposit—		
Post Office Savings Bank	1707 18 7	
World Petroleum Congress Account	161 19 8	
		1869 18 3
		£8988 5 9

REPORT.

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

PRICE, WATERHOUSE & CO.

BENEVOLENT FUND.

Receipts and Payments Account for Year ended 31st December, 1939.

RECEIPTS.

	£ s. d.	£ s. d.
Balance on Current and Deposit Accounts on 1st January, 1939 :—		
Benevolent Fund Account	718 15 7	
Specific Endowment Fund	43 2 11	
		761 18 6
Receipts during 1939 :—		
Subscriptions	39 8 0	
Donations	13 2 0	
Interest	15 0 0	
Income Tax recovered	8 16 5	
		76 6 5
		£838 4 11

PAYMENTS.

	£ s. d.	£ s. d.
Benevolent Fund :—		
Grants in aid		32 0 0
Specific Endowment Fund :—		
Grant in aid	34 14 10	
Income Tax	8 8 1	
		43 2 11
Balance on 31st December, 1939 :—		
Benevolent Fund	763 2 0	
Specific Endowment Fund	nil	
		763 2 0*
		£838 4 11

* The Balance on Current and Deposit Accounts and invested on 31st December, 1939, was made up as follows :—

	£ s. d.
Cash on Current Account	34 5 0
Deposit Account	200 0 0
3% Local Loans at cost (Market value at 31st December, 1939: £483)	528 17 0
	£763 2 0

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, 1939: £763 2 0.

3, Frederick's Place,
Old Jewry, London, E.C.2.
1st *May*, 1940.

Price, Waterhouse & Co.

TRINIDAD BRANCH.

REPORT OF THE COMMITTEE ON THE WORKING OF THE BRANCH DURING THE SESSION 1938–1939.

THE Committee regrets that it was not possible to hold the Annual Meeting as usual in November.

Five Meetings were held during the session, at which the following papers were read :—

1939	
22nd Feb.	Sedimentary Conditions of Producing Horizons at Forest Reserve, by Mr. C. S. Lee.
22nd March.	Auger and Core Drilling for Geological Purposes in Trinidad, by Mr. E. C. Scott.
26th April.	Some notes on Plunger-lift Operation, by Mr. Frank R. Wellings.
31st May.	Geologist with a Camera, by Dr. Arthur G. Hutchison.
28th June. Film.	"The Inside Story" presented by the marketing division of T. O. F. O. Co.

The average attendance of members and guests at meetings was twenty-five.

There were seventy-nine members on the roll at the end of the year.

Mr. J. L. Harris was elected chairman and Mr. H. C. H. Thomas was elected Honorary Secretary and Treasurer for the session.

The Annual Dinner for the 1938 session was finally held on 14th January, 1939. The Acting Governor attended, and some ninety members and guests were present.

The Committee wishes to record its appreciation of the services to the Branch of Mr. J. L. Harris, who resigned the Chairmanship in August 1939 on leaving the colony. Mr. L. A. Bushe was elected Chairman for the remainder of the session.

The Committee also wishes to record the thanks of the Branch to Mr. F. Middleton and Mr. D. M. Walsh for their services as auditors.

(Sd.) *H. C. H. Thomas*, Hon. Secretary and Treasurer.

L. A. Bushe, Chairman.

TRINIDAD BRANCH.

Income and Expenditure Account.

Expenditure.			Income.	
Dinner Expenses :			Grants from Institute of Petroleum, London . .	$192·00
Expenditure	$293·29			
Income	276·64			
Loss on dinner		16·65		
Miscellaneous Expenses :				
Stationery, Printing, Stamps		40·41		
Clerical Assistance		17·00		
Excess Income for year		117·94		
		$192·00		$192·00

Balance Sheet as at 31st October, 1939.

Liabilities.			Assets.	
Subscription to Benevolent Fund, to be remitted to London		$72·90	Cash in Bank	$363·51
Income and Expenditure Account as at 31st October, 1938	$177·67		Cash in Hand	5·00
Add Excess Income for year ended 31st October, 1939	117·94			
As at 31st October, 1939		295·61		
		$368·51		$368·51

(*Sgd.*) L. A. Bushe,
Acting Chairman.

H. C. H. Thomas,
Hon. Sec. and Treasurer.

F. Middleton
D. M. Walsh
} *Auditors.*

SCOTTISH BRANCH.

REPORT FOR YEAR 1939.

The Branch made an auspicious start following upon the Empire Exhibition and the first year's activities have been characterised by much energy and enthusiasm.

The Inaugural Meeting held in Edinburgh on the 20th January was attended by a large audience representative of all important scientific societies in Scotland. The President, Lieut.-Col. S. J. M. Auld, O.B.E., M.C., D.Sc., after conveying the greetings and congratulations of the Council, took as his subject " The New Outlook on Lubrication."

At the second meeting on the 16th February held in Glasgow, Mr. G. W. Lepper, A.R.C.S., B.Sc., Technical Adviser to H.M. Petroleum Department, delivered a lecture on " The Search for Oil in Britain." The subject was of topical interest and gave rise to an interesting discussion.

Dr. Wm. Reid of the Fife Coal Co. described, at the third meeting on 24th March in Edinburgh, the problems involved in " The Planning of a Modern Colliery." The lecture was based on the experience gained in the development of the new Comrie Colliery, Fife, and evoked much interest.

The Chairman of the Branch, Mr. Robert Crichton, J.P., presided at all three meetings.

Mr. W. R. Guy, Honorary Recorder, has undertaken the work in connection with general publicity.

Dr. G. H. Smith, Honorary Treasurer, has reported that the Branch finances are in a satisfactory condition.

The Branch is now represented on the Association of Secretaries of Technical Societies in Glasgow, and on the Ramsay Dinner Committee.

The Committee has been engaged in drawing up rules for the conduct of the business of the Branch, but these have not yet been put into effect.

Although an interesting programme had been drawn up for the latter half of the year, including the first Dr. James Young Memorial Lecture by Mr. E. M. Bailey, and addresses by Professor A. W. Nash and Dr. A. E. Dunstan, the Committee unanimously decided, in view of the national emergency, to discontinue operations for the present.

The membership of the Branch, consisting of 55 Members and 51 Branch Members, is drawn from a wide area.

R. Crichton, *Chairman.*
W. M. Cumming, *Hon. Secretary.*

SCOTTISH BRANCH.

Financial Statement.

1939.

Income.

	£	s.	d.
To Branch Members' Subscriptions, 47 @ 7*s.* 6*d.* .	17	12	6
,, Grant received, 18th Jan., 1939. . . .	5	0	0
	£22	12	6

Expenditure.

	£	s.	d.	£	s.	d.
By Expenses of Meetings, Hire of Rooms, Advertising, etc. :						
20th Jan., 1939	13	4	0			
24th Mar., 1939	2	3	6			
				15	7	6
,, Stationery				2	6	3
,, Postages				1	9	0
				19	2	9
,, Balance, Cash in hand				3	9	9
				£22	12	6

3rd *May*, 1940.

G. H. Smith, *Hon. Treasurer.*
R. Crichton, *Chairman.*

ANNUAL GENERAL MEETING.

16th May, 1940.

THE TWENTY-SEVENTH ANNUAL GENERAL MEETING of the Institute was held at the Royal Society of Arts, John Adam Street, London, W.C. 2, on Thursday, 16th May, 1940, at 5.30 p.m. The Chair was taken by the President, PROFESSOR A. W. NASH.

The SECRETARY read the Notice convening the Meeting and the Reports of the Auditors.

The Minutes of the Twenty-sixth 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 1939 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. E. A. EVANS, W. E. GOODAY, C. A. P. SOUTHWELL, A. BEEBY THOMPSON, and C. W. WOOD. One new nomination had been received, on behalf of Mr. J. A. ORIEL, M.A., Manager of Shell Refineries, Ltd. The Council decided that, in view of the present circumstances, a postal ballot should not be held, and the names of the above six candidates were therefore submitted to the Meeting to fill six vacancies on the Council.

On the motion of the PRESIDENT, seconded by Mr. J. KEWLEY, the six gentlemen whose names had been read out by the Secretary were unanimously elected Members of Council.

The PRESIDENT then moved :—

> "That the Annual Report of the Council for the year 1939, together with the Accounts and Balance Sheet as at 31st December, 1939, 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 Report was a full and comprehensive survey of the activities of the Institute during 1939, and the greater portion of it related to the period prior to the outbreak of war.

He would like first to refer to the two honours mentioned in the Report—namely, those conferred on Sir William Fraser and Sir Thomas Holland. As many of the members were aware, another of the Institute's Past Presidents, Lord Cadman, had recently been elected a Fellow of the Royal Society. He was sure that the members present at the meeting would wish him to express their congratulations to the recipients of these honours. ("*Hear, hear.*")

During the year a re-classification of the membership had been carried out in accordance with the new constitution of the Institute which had been approved two years ago. That re-classification had entailed a long and difficult task for the Election Committee, and the thanks of the Institute were due to Mr. McConnell Sanders and the members of his Committee for the painstaking manner in which they had carried out their task.

A total of 406 Fellows had been elected during the year. A Fellow of the Institute must satisfy the Election Committee and the Council that he had occupied for at least five years a position of responsibility in the science and technology of petroleum. He could vouch for the fact that that high standard had been rigidly maintained. The Fellowship of the Institute would in future remain a hall-mark of technical standing in the industry.

At the same time the new constitution had been designed to provide for those with responsible positions in the industry, not primarily on the technical side. That had widened the scope of the Institute by making it open to those occupying administrative positions. On the 31st December, 1939, the Institute had 516 Members, 57 of whom had been elected during the year.

Dr. Dunstan would later be speaking to the meeting about the Benevolent Fund, and Mr. Dalley, in seconding the adoption of the Report, would deal more specifically with the accounts, so he would not refer to either of those items in detail.

He felt that the meeting would perhaps expect him to make reference to the transfer of the Institute's office to Birmingham. He had been very pleased to offer to the Council in September 1939 accommodation at the Department of Oil Engineering and Refining at Birmingham University. The Institute had been given less than a week's notice to find alternative accommodation to its offices at the Adelphi. He fully appreciated the disadvantages to the members of not having their own premises available in London. Apart from that, the work of the Institute had gone on as well as war conditions would permit. The *Journal* had been published regularly. Meetings of the Institute and its Groups had been held as far as authors had been available. It had to be remembered that 50 per cent. of the Institute's members were stationed abroad, in the United States, Trinidad, Iran, Iraq, Venezuela, South Africa, Burma, Australia, and other countries, and possibly to the overseas member. Birmingham was as good an address as London for the Institute at the present time.

The Institute's position at the moment was dealt with in the sections of the Report headed "Premises" and "Finance." Along with other members of the Council he was frequently asked when the Institute was coming back to London, and he would be happy to answer that question if he could be told to where it was to return. At the moment the Institute had no premises in London, and until the financial relationships with the Office of Works were straightened out, the Council would be foolish to undertake additional liabilities such as would be entailed by taking new offices in London.

The Institute's Conference on Fuels and Lubricants and its Conference on Dangerous Gases were both referred to in detail in the Report, and there was only one other activity of the Institute during the year to which he would like to direct attention. That was the co-operative research on Viscosity organized by the Institute's Viscosity Panel, under the chairmanship of Dr. Garner, which illustrated a principle operative throughout the whole work of the Standardisation Committee. In the petroleum industry, which spent very large sums every year on research, the contribution which the Institute could make to subsidize research directly would be very small indeed. What a technical society could do, in possibly a unique manner, was to co-ordinate the research proceeding in various countries and laboratories and to bring together the research work done by different companies to a common focus. Although no mention of it was made in the Annual Report, that principle was also being observed in work which was being carried out at the present time on the correlation of methods of testing high-octane fuels for aviation purposes. For obvious reasons details of that work could not be given at the present time, but he might say that it was being carried on with the full co-operation of the Air Ministry and other Government Departments and also of various petroleum companies.

Very little was said in the Report about the activities of the Institute's Branches, but they had made definite progress in the period prior to the outbreak of war. In the early part of 1939 both the Northern Branch and the South Wales Branch had successfully carried out a programme of meetings. The newly formed Scottish Branch had added between forty and fifty members to the Institute's roll. A new Branch had just been formed at Stanlow in Cheshire, in which area there was a very rapidly developing refining centre. The inaugural meeting had been held in the previous week under the chairmanship of Mr. J. S. Parker, and had been addressed by one of the Institute's Past Presidents, Dr. Dunstan. The Council had that day acceded to a request that the Stanlow section should be given the status of a full Branch of the Institute, and he was sure the meeting would like him to convey to that Branch its good wishes for its development and success.

He would like to pay a tribute to the work of Mr. Astbury and his staff, not only for the way in which they had overcome numerous war-time difficulties, but also for the work they had carried out in organizing the Institute's activities earlier in the year 1939, before the war broke out.

In conclusion, he wished to mention that between thirty and forty members of the Institute were now serving with His Majesty's Forces. He was sure the meeting would like him to send to those members its greetings and best wishes for their safe return. (*Applause.*)

Mr. C. DALLEY, in seconding the motion, directed attention to the market value of the Institute's investments. The market value of the investments on account of capital was given in the Balance Sheet as £3797 at 31st December, 1939, and the market value of the investments on account of revenue and on account of the Research Fund was given as £1101 at the same date. A valuation made more recently showed that they were now back almost at par. Altogether the Council had on deposit at the Post Office Savings Bank the sum of £2663. That would shortly be increased by the deposit of the balance of the World Petroleum Congress Account in the Post Office Savings Bank, so that one-third of the assets of the Institute would be available at short notice.

The difficult position of the Institute with regard to its premises was fully dealt with in the Annual Report, and there was little that he could add, but he would like to say that the Secretary and he had fought their way into the inner sanctuary of the Office of Works and tried every method of persuasion to induce that Department to give the Institute a little reasonable consideration, but all their efforts had been without avail. He could only assure the meeting that the Council and he were making efforts to obtain just compensation from the Office of Works, but their idea of what constituted just compensation seemed to be very different from that of the Office of Works. If any of the members could exercise any influence in the matter, the Council would be very grateful for their help. The oil companies which were making a very generous contribution to the Institute's rental at the Adelphi were standing behind it in its claim.

The Revenue Account called for little comment. The income of the Institute was £214 more in 1939 than it had been in 1938, and the expenditure was £600 less than in 1938. The surplus of £154 15*s*. 11*d*. had been transferred to the Balance Sheet and was available for revenue purposes.

The motion was carried unanimously.

ELECTION OF AUDITORS.

On the motion of Mr. J. T. WARD, seconded by Mr. G. J. C. VINEALL, Messrs. Price, Waterhouse & Co. were unanimously appointed Auditors for the ensuing year.

OTHER BUSINESS.

Captain W. H. CADMAN said that His Majesty's Government had paid a tribute to the importance of the petroleum industry by appointing a Secretary for Petroleum, and he thought it would be appropriate if the members present at the Annual Meeting expressed their appreciation of that appointment by asking the President and Secretary to draft a suitable letter to be sent to Mr. Geoffrey Lloyd, M.P., congratulating him on being appointed the first occupant of that office and wishing him every success in the important duties that he had to perform. He begged to move accordingly.

Dr. E. R. REDGROVE seconded the motion, which was carried unanimously.

The PRESIDENT said that when he and the Secretary had drafted the letter they would send it to each member of the Council for his approval before it was sent to the Secretary for Petroleum.

The proceedings then concluded, and the President declared the meeting closed.

BENEVOLENT FUND.

Annual Meeting of Members.

A meeting of corporate members of the Institute was held at the Royal Society of Arts, London, W.C.2 on Thursday, 16th May, 1940, following the Annual General Meeting, to discuss the position of the Institute's Benevolent Fund.

Dr. A. E. Dunstan (Chairman, Benevolent Fund Committee) occupied the Chair.

In moving the adoption of the Accounts of the Benevolent Fund for the year ended 31st December, 1939, Dr. Dunstan referred to the fact that the total received by way of subscriptions and donations represented only 8*d.* per capita of the total membership of sixteen hundred. He felt sure that members would agree with him that this measure of support was woefully inadequate. The Committee had therefore recently issued an appeal to every member in the United Kingdom to support their own Benevolent Fund more generously. The Institute was still a relatively young society, and the claims upon its Benevolent Fund would necessarily increase as time went on. He appealed particularly to those members in charge of laboratories, departments and offices to initiate whatever means were open to them for regular collections and donations to the Fund.

Mr. Ashley Carter wished to assure the members that every appeal made to the Fund was most thoroughly investigated; not only were full statements obtained, but wherever possible a personal visit was made to the home of the individual making the application. The Fund was operated without any administration expenses, so that members had an absolute assurance that every penny they subscribed to the Fund went to the relief of some unfortunate individual.

Mr. R. J. Bressey strongly urged the Council to adopt the practice of including a space on the annual subscription Form to be filled in with the amount which a member wished to contribute to the Fund. He hoped that members would consider making up their subscriptions of three guineas to £3 10*s.* or £4, the balance being handed over to the Benevolent Fund.

Mr. E. A. Evans, Mr. T. Dewhurst, Mr. J. Kewley, Dr. E. R. Redgrove and Mr. G. J. C. Vineall also made suggestions for increasing the income of the Fund, including a small Benevolent Fund "tax" on the price charged for tickets for various social functions of the Institute, the provision of a collecting box at meetings, etc.

The Chairman thanked the members for all the valuable suggestions which had been made, and which would be considered most carefully by the Benevolent Fund Committee.

The motion for the adoption of the Accounts was seconded by Mr. R. J. Bressey and carried unanimously.

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.

864. Geology and Coal Resources of the Minot Region, North Dakota. D. A. Andrews. *U.S. Geol. Surv. Bull.* 906-B, 1939.—It is reported in this bulletin that Fort Union rocks of Eocene age which crop out in the Minot Region of North Dakota have not so far been found to contain commercial quantities of oil and gas. The underlying Cretaceous rocks which yield oil in many localities in Montana and Wyoming are over 3000 ft. thick in the Minot area and have proved petroliferous in a well near Lonetree. They are, however, practically flat-lying, and structures usually favourable to the accumulation of oil or gas in commercial quantities are absent. Thus it is unlikely that notable quantities of oil or gas will be found. Little is known concerning the extent or possible petroliferous character of the older formations in the region, but it is probable that structurally they are similar to the Fort Union and Cretaceous rocks. H. B. M.

865. Mineral Industry of Alaska in 1938. P. S. Smith. *U.S. Geol. Surv. Bull.* 917-A, 1939.—This paper contains an account of the petroleum position in Alaska in 1938. In that year none was produced locally, and accordingly the ever-increasing demand for fuel and lubricants had to be met by imports from other parts of the United States. 45,785,418 gal. of crude oil, 9,441,726 gal. of gasoline, 326,970 gal. of illuminating oil, and 697,620 gal. of lubricating oil were imported in 1938. Comparison of these figures with those of earlier years reflects a tremendous increase in imports of heavy oils, due no doubt to the growing use of Diesel-equipped apparatus throughout the State. Gasoline imports were five times greater than in 1920, owing largely to the increased number of motor vehicles on the roads.

Search for new oil-fields in Alaska was again revived in 1936, and in 1938 was attracting considerable attention. Test wells were drilled in the Iniskin–Chinitna district on the west coast of Cook inlet, and at Bear Creek, north-east of Kanatak in Cold Bay. In the Iniskin area a depth of 7156 ft. was penetrated, the bottom of the hole probably reaching the Kialagvik formation, but the well on test died after flowing once or twice.

The conclusion was reached that the permeability of the formation was so low that the oil and gas could not readily escape into the hole. It is proposed, however, to continue tests at a later date and attempt to reach the base of the Kialagvik formation, where there is a sandstone member some 800 ft. thick which should form a good reservoir.

In February 1938 active work was begun in the Kanatak area, and showings of gas are reported to have been encountered during drilling. The work is being continued.

Apart from the drilling of actual test wells, geological investigations were in progress in 1938, in southern Alaska, notably at Controller Bay and Yakatago, where oil seepages have long been known. H. B. M.

866. Foraminifera, Diatoms, and Mollusks from Test Wells near Elizabeth City, North Carolina. L. G. Henbest, K. E. Lohman, and W. C. Mansfield. *U.S. Geol. Surv. Prof. Paper* 189-G.—In 1932 a number of test wells were drilled near Elizabeth City, North Carolina. The maximum depth penetrated was 482 ft. in one deep well, the others being sunk to depths between 25 and 93 ft. Beds penetrated were classified as follows : marine and brackish-water beds assigned to the Pleistocene ; brackish-water beds assigned to the interval from Pliocene to Lower Pleistocene ; and marine beds assigned to the Miocene. Samples were collected from each well as drilling proceeded and submitted to the Geological Survey for examination. A great many of these samples contained either foraminifera, diatoms, or mollusks, and their study forms the basis of the present paper. H. B. M.

867.* Winter Brings no Lull to Illinois Drilling. H. F. Simons. *Oil Gas J.*, 18.1.40, 38 (36), 11, 13.—The Salem field has been producing more than 180,000 brl./day from the Benoist, Aux Vases, and McClosky formations, and prolific production has been found in the Devonian Lime as well as good spotted production in the St. Louis Salem Lime. The twelve Devonian producers have had initial outputs of more than 3000 brl. each.

At Centralia a Devonian discovery has caused a revival, and Devonian production has also been obtained at Bartelso, Sorento, and Sandoval.

On the east side of the Illinois basin discoveries in the Chester series and in the McClosky have been important. At Storms the wells are big gas producers from the uppermost Chester.

Pipe-lines are being expanded to cope with the increased oil production.

G. D. H.

868. 254 New Oil-fields Discovered during 1939. Anon. *Oil Gas J.*, 25.1.40, **38** (37), 56–57.—The oil-fields discovered in U.S.A. during 1939 are listed and their positions are shown on a map. G. D. H.

869. Proven Reserves. Anon. *Oil Gas J.*, 25.1.40, **38** (37), 53–55, 218.—The estimated proven reserves in U.S.A. on 1st January, 1940, totalled 19,687,379,000 brl., an increase of 1,455,604,000 brl. during 1939. There were increases in the reserves in California, Texas, Louisiana, Illinois, and Arkansas, and Nebraska and Mississippi became producing States. Extensions to old and new fields far outdistanced new discoveries.

Details are given of the reserves at the beginning and end of 1939 for each State, the nature of the changes during the year—whether extensions or new discoveries, the production, etc. Where possible the acreage, formation thickness, etc., are given for the new proven reserves for individual fields. G. D. H.

870.* Oil Search in Georgia Covers Wide Front. A. C. Munyan. *Oil Gas J.*, 14.3.40, **38** (44), 24–26, 99.—The coastal plain of Georgia covers 60% of the total area, the crystalline area 35%, and the Palæozoic area of North-west Georgia 5%. The Palæozoic area is folded and faulted to such an extent as probably to preclude the retention of petroleum, except perhaps in the Cumberland plateau section. Gas may, however, occur.

The coastal plain outcrops range Upper Cretaceous to Recent. Much of the Upper Cretaceous is sandy at the outcrop, but down dip it changes to dark shale. The oil possibilities are undetermined. The Tertiary beds are briefly described. Overlaps are frequent. Many wells have been drilled for water, and the evidence they contribute shows that on the whole there is a gentle regional south-east dip, but there may be minor structures suitable for oil-traps. Definite traces of oil and gas have been noted in several recent wells. Palæozoic rocks have been proved beneath the Cretaceous, a fact of great interest as regards the search for oil. The logs are given of four of the recent wells. G. D. H.

871.* Activity in North Texas Area Approaching Record High. D. H. Stormont. *Oil Gas J.*, 28.3.40, **38** (46), 50–51.—Two new fields have recently been opened in Montague county, and interest also centres on Archer, Clay, and Cooke counties. Completions are now running 40% higher than a year ago. Some 67 wildcats are to be drilled, mainly to depths of 4000–5000 ft.

Near Bonita the discovery well yields oil from broken sand and granite wash in the Bend series at 5241–5249 ft. This well gave 254 brl. of oil in 3 hr. It was drilled on a seismic high, and failed to shown Strawn or Canyon production. The second discovery is near Ringgold. This also failed to find production in the Canyon or Strawn, but gave 240 brl. of oil in 3 hr. from an arkosic conglomerate in the Bend series at 5690–5704 ft.

Much leasing is taking place on the flanks of the Red River Uplift and where it merges with the Bend Arch. G. D. H.

872.* New Guinea. Anon. *Oil Gas J.*, 28.3.40, **38** (46), 72.—Two shallow wells are producing low-gravity oil from about 200 ft., and a showing of gas and several small showings of oil have been encountered in the two deep tests in the South Vogelkop. The wells are 4600–4950 ft. deep and not yet finished. G. D. H.

873.* Complete Flowing Well in Sparta–Wilcox Trend. F. L. Singleton. *Oil Gas J.*, 4.4.40, **38** (47), 23–24.—Production has been found in north-east Beauregard Parish, Louisiana, in the Wilcox at 8356–8373 ft. It follows the abandonment of a well in the same block which had Sparta–Wilcox showings.

In north-east Wharton county, on the Texas coast, gas and distillate have been logged in sand stringers at 9900–10,000 ft. Production tests are being made. Several wells had been drilled in this area, but were not taken down to the Wilcox.

Gas and oil showings have been found in a De Witt county well at depths of more than 7800 ft. Two blow-outs in the West Tuleta field and the old Bruni field are significant, and both had Sparta–Wilcox showings.

These recent wells add approximately 250 ml. to the prospective Wilcox trend. The area covers much virgin territory as well as numerous shallow Jackson shore-line fields. There is active leasing and much geophysical work in progress. G. D. H.

874.* Oklahoma City Field Enjoying another Periodic Flurry. D. Dalrymple. *Oil Gas J.*, 11.4.40, **38** (48), 14, 139.—Details are given of recent wells drilled in the Oklahoma City field. Many of them are encroaching on the city itself. Up to the beginning of 1940, 475,640,053 brl. of oil had been obtained, 343,894,914 brl. being from the Wilcox sand zone alone. There are twenty-two pay zones, including eight gas zones. Oil is found in the Wilcox sand, Lower and Upper Simpson, Pawhuska, Layton, Oswego detrital, Cleveland, Lower, Middle and Upper Hoover, Tonkawa, oolitic, and Prue formations. There are 13,253 productive acres. Tables are given of the distribution of the wells between the different zones, of the recoveries from these zones, and of production and other data for the various areas. G. D. H.

875.* Discovery of Small Geophysical Structure Arouses Mississippi. G. Weber. *Oil Gas J.*, 11.4.40, **38** (48), 25–26.—In east Yazoo county oil has been discovered 25 ml. north-east of Tinsley. A show was encountered in the Eutaw at 4871–4892 ft., and a little oil was recovered on testing. It demonstrates that small prospects, of which there are several hundred, are capable of production, in addition to the larger structures such as Tinsley and Jackson, which are evident from surface geology and subsurface information. Numerous wildcats are being drilled throughout Mississippi.

The Tinsley field has recently been extended in three directions. G. D. H.

876.* A.A.P.G. Growth Parallels Expansion of Petroleum Geology. J. E. Thomas. *Oil Gas J.*, 11.4.40, **38** (48), 30–33.—The parallel growth of the American Association of Petroleum Geologists with the greatest expansion in the oil industry and greatest improvement in exploratory technique is given. The growth of such important theories as the anticlinal theory and such vital subjects as geophysics is reviewed.

A. H. N.

877.* East Texas Looks Forward to Somewhat Dubious Future. G. Weber. *Oil Gas J.*, 18.4.40, **38** (49), 24, 25, 107.—The total oil production in 1939 was 146,969,889 brl. together with 60,000,000 brl. of salt water. At the end of the year the mean pressure was estimated at 1065 lb./in.^{2}. The pressure drop per 1,000,000 brl. of fluid extracted was 0·231 lb./in.^{2}, against 0·131 lb./in.^{2} in 1938. 381 wells were completed in 1939 and 269 wells were plugged. In November 1939 4405 producing wells were affected by water. 6300 wells are on the pump.

Most of the salt water is disposed of in evaporation pits, but some is returned to the Woodbine sand.

A number of tables give production details. G. D. H.

878.* Drilling Play Reflects Activity near Gulf Coast Salt Domes. Anon. *Oil Gas J.*, 25.4.40, **38** (50), 92, 95, 102.—New discoveries have been made on old salt domes. Such is the case at Anse La Butte and Bayou Blue. Of 104 known salt domes on the Gulf Coast, twenty-seven are not now producing, although eleven of these have done so. It is generally believed that all the domes will eventually be found to be productive. West Hackberry, known since 1902, did not yield oil until 1928, in spite of intermittent drilling, and important production was developed only in the last few years. Few domes have been completely explored.

Drilling is now proceeding on fifty-seven domes, including previously non-productive domes. G. D. H.

879.* Sparta–Wilcox Trend again in Limelight of Gulf Coast Activity. F. L. Singleton. *Oil Gas J.*, 25.4.40, **38** (50), 121, 123.—Production at Eola now covers 3000 acres, and is still undefined in the north-east and in the south-west. Since the discovery of Eola the only Wilcox production opened was at a depth of 10,000–10,250 ft. at Ville Platte. The succeeding period has had much wildcatting and many failures. However, one dry hole does not condemn an area, a fact which was demonstrated in Beauregard Parish, where oil has been found in the upper Wilcox at 8356–8373 ft.

In Montgomery and Wharton counties two wildcats are in process of testing. One has flowed oil and shown several hundred pounds of gas pressure.

Just west of Thomaston, in De Witt county, a large distillate producer has been completed in the top of the Wilcox at 7855–7883 ft. Late in 1939 high-pressure gas was found in the Sparta and Wilcox at Bruni and West Tuleta.

The upper limit of production from the Sparta–Wilcox series is generally considered to be 5000 ft., in view of the large amount of freshwater sands at the outcrop which has prevented the accumulation of oil at lesser depths.

The De Witt discovery has extended the line of Sparta–Wilcox fields over 160 ml. through virgin territory. G. D. H.

880.* Summary of Operations on Texas and Lousiana Gulf Coast. Anon. *Oil Gas J.*, 25.4.40, 38 (50), 185–186.—The names of the pools, year of discovery, number of producing wells in each pool, daily average production, accumulated production by pools, number of active operations, and production depths in each pool are tabulated. G. D. H.

881.* Fields Better than Tinsley Likely for Mississippi. J. H. Todd. *Oil Wkly*, 15.4.40, **97** (6), 17–26.—The Cockfield and Sparta have definite possibilities over a limited part of southern Mississippi, but the most promising horizon above the Cretaceous is the Wilcox. Heavy oil has been found in sands in the basal Wilcox on the flanks of the Jackson uplift. There have also been shows in several wells in the south of the State. The Ripley formation has sizeable sand bodies. The Eutaw is expected to be a major oil-producing horizon, and at Tinsley the Woodruff sand is at the Eutaw–Selma contact. There have been various evidences of petroleum in the Eutaw. The Tuscaloosa, the basal member of the Cretaceous, is largely non-marine gravels, sands, and shales, but has oil showings at various points. Its oil potentialities are considered good. In the central and southern part of the State the Comanche occurs, and has already proved a good producer. Hopes are entertained for the Jurassic, Permian, and older beds.

The Jackson uplift is of igneous origin, and raises the beds for 2500 ft. The crestal gas field is almost exhausted.

Parts of north-east Mississippi are affected by the Cincinnati arch. Igneous plugs occur in many parts, but so far oil has not been found over them. It is possible that the weaker magnetic anomalies will be better oil prospects. There are large anticlines and also salt domes. Deep-seated salt structures, of which type the Tinsley dome is believed to be, are being sought. Tinsley has 300–600 ft. of closure on the top of the Selma, and is a N.N.W.–S.S.E. anticline. There are several faults. The twenty-eight producers lie in a proved area of 2000–2500 acres. The Woodruff sand averages 20 ft. thick and has a maximum of 100 ft. The Stevens sand is 10 ft. thick, and the Hunt sand 15 ft.

There are possibilities of stratigraphic traps in Mississippi, for the Eutaw and Tuscaloosa both pinch out. G. D. H.

Geophysics.

882.* Some Practical Results of Micromagnetic Prospecting. W. P. Jenny. *Oil Gas J.*, 25.4.40, **38** (50), 132–134.—In Texas during 1939 1103 out of 1196 wildcats were failures.

Magnetic anomalies are more commonly due to the magnetic content of the sediments than to the basement. The method whereby sedimentary structures are determined has been called micromagnetics. At Eola the developed field agrees well with the micromagnetic predictions. The experience at Eola and at other Sparta–Wilcox structures seems to show that the magnetic anomaly is the result of magnetic beds of Wilcox or Lower Eocene age.

At Anahuac micromagnetics indicated a fault which was proved later. Other examples of the use of micromagnetics are given. G. D. H.

883.* **Geochemical Well Logging.** E. E. Rosaire. *Oil Gas J.*, 25.4.40, **38** (50), 114, 119.—Geochemical anomalies are due to the slow effusion over geological time of hydrocarbons driven into and through the surrounding and overlying sediments by reservoir pressure. Anomalies of the same magnitude occur over a field 13,000 ft. deep as over one only 1500 ft. deep. Geochemical prospecting has been used at the surface with soil samples, but well cuttings also yield suitable data. By this means "dry" holes can be graded qualitatively as to closeness to an oil deposit. Zones can be recognized which have significant amounts of hydrocarbons and therefore require careful coring. Blowouts may be avoided. In effect the geochemical well log extends the vertical hole 500–1000 ft. downwards and $\frac{1}{4}$–$\frac{1}{2}$ ml. laterally. G. D. H.

Drilling.

884.* **California Drilling Speed Record Broken.** L. P. Stockman. *Oil Gas J.*, 11.4.40, **38** (48), 89.—The record for fast deep drilling is broken by drilling 13,157 ft. of hole and landing 12,878 ft. of $6\frac{5}{8}$-in. casing in 60 days. The equipment used is described. A. H. N.

885.* **Deep Cable-tool Drilling in Appalachian District.** J. A. Fox. *Oil Gas J.*, 18.4.40, **38** (49), 62; and also in *Oil Wkly*, 22.4.40, **97** (7), 23.—*Paper presented before American Petroleum Institute.*—Two unsolved problems in connection with cable-tool drilling to depths exceeding 5000 ft. in the Appalachian district are particularly important at this time. The problem of improving drilling technique to achieve a longer working life for wire drilling-cables is considered of major importance because the cost of wire lines is one of the largest items of expense chargeable to deep wells. The second problem is to devise a means of overcoming the disastrous and expensive effects of the gas blowouts which are encountered in several parts of the Appalachian area through a zone beginning approximately 300–500 ft. above the top of the Onondaga line.

The author discusses the experiences of his own firm in these fields and presents the practical and admittedly empirical conclusions reached therefrom.

It is found that the life of the wire drilling-cables can be materially extended by drastically reducing the total weight of the tools and, at the same time, lengthening the drilling stroke. The weight of the tools is reduced by shortening the stem (or bar) below conventional lengths. Full details are given.

The blowouts are due to high-pressure gas pockets which occur in quantities just sufficient to throw up the tools and cavings some distance up the well, but not enough to eject them out of the well completely. Consequently the tools fall back and the cavings follow down, resulting in extremely difficult fishing jobs.

The use of salt water and a special technique evolved in the fields, and described in detail in the paper, is believed to have solved the problem, not so much as preventing these blowouts, but in rendering them comparatively harmless. A. H. N.

886.* **Marine Drilling on Gulf Coast.** N. Williams. *Oil Gas J.*, 25.4.40, **38** (50), 74.—A description is given of two of the largest and most completely outfitted marine rigs assembled on the Gulf Coast. Designed to meet the greater requirements and emergencies occasioned by deep drilling in water-located areas, these rigs are materially expediting development in this field, in which important production is being found in sands from 8000 to 9000 ft. deep.

Wells are now being drilled to 9000 ft. and completed in less than 3 weeks, including moving time. Unusual drilling conditions have been experienced so far, in that the formations are exceptionally soft, permitting the hole being made almost as rapidly as the drill stem can be lowered and cuttings removed. A. H. N.

887.* Ten Holes Drilled from One Marine Location. Anon. *Oil Gas J.*, 25.4.40, **38** (50), 105.—Directional drilling has resulted in successfully exploring and proving up an area nearly a mile square, from a single, centrally located drilling pier. In this project ten wells have been completed so far, in addition to nine others drilled into exploratory locations. This represents nineteen tests drilled from a single pier. The nine uncompleted wells were original holes, of some of the ten completed wells, which failed to get production at their respective subsurface locations and then were side-tracked at some point up the hole, and new holes drilled to other entirely separate location or different sands. By these means of side-tracking unproductive tests there have been no actual failures in the field, judged ultimately. The first test was drilled vertically.

For the most part the courses of the holes were governed by controlled drilling. Deflecting tools were run only for sharp changes in course. The usual practice was to drill vertically to 1200–1400 ft., where a $9\frac{5}{8}$-in. casing was run. The deflecting tool was run to make the first deflection and establish the right direction in which a uniform sweeping drift would end the hole at the desired horizontal displacement and depth. Single-shot surveys were run regularly to check the course of the drift.

Data and a plat are reproduced, together with a description of the operations in attaining the final results. A. H. N.

888.* Record Keeping Reduces Costs, Increases Rotary Rig Efficiency. H. F. Simons. *Oil Gas J.*, 25.4.40, **38** (50), 124.—Drilling in the Gulf Coast is constantly tending towards deeper horizons than previously exploited. A method of predicting costs of proposed tests is described. It provides the oil company with a permanent record of all the essential facts and makes it possible to apply preventive measures instead of the more expensive remedial ones.

The system consists essentially of compiling in concise form all the pertinent data developed by drilling each test. Two charts are used, one showing mud conditions and mud treatment throughout the drilling of the well, and the other showing drilling and completion information.

The mud chart shows a driller's log of the well, mud weight, viscosity, percentage of solids, and sand content at the flow-line and at the pump suction, as well as a summary of treating materials used and, sometimes, pH values too.

The drilling chart gives footage made each day, driller's log of the well, bit record, core record, breakdown of drilling time, casing and tubing record, screen assembly and well size at various depths. Orientation points and amount of deflection is shown in directionally drilled wells. A. H. N.

889.* Standardized Layout Decreases Time Required to Assemble Rig. Anon. *Oil Gas J.*, 25.4.40, **38** (50), 131.—Handling of the mud in Gulf Coast drilling operations is a major difficulty, due to the rapidity with which deep holes are drilled, depths of 10,000 ft. are reached in approximately 30 days. Mud conditioning and handling have led to the development of some unusual mud systems and also to a standardization which increases the efficiency. These are discussed. A. H. N.

890.* Deep-drilling Practices. Anon. *Oil Gas J.*, 25.4.40, **38** (50), 150.—In this long paper a review is made of deep-drilling practices used in the Gulf Coast area. It is one of a series of papers published in this number of *Oil and Gas Journal* dealing with drilling, production, transportation, and refining activities in the Gulf Coast fields of the U.S.A. A. H. N.

891.* Deep Development Showing Increase. Anon. *Oil Gas J.*, 25.4.40, **38** (50), 170.—According to a recent compilation, 349 wells, including active operations in first week of April, have been drilled to 10,000 ft. on the Gulf Coast. Tables and data are presented giving number of wells drilled and producing below 10,000 and 11,000 ft., by years and localities. A. H. N.

892.* Electrical Well Logging and Core Analysis. P. B. Leavenworth. *Oil Gas J.*, 25.4.40, **38** (50), 197.—*Paper presented before American Petroleum Institute.*—The author compares the utility and characteristic advantages of electrical well logging with those of core analysis, and concludes that :—

For regional correlation the electrical log is probably sufficient.

For field correlation use electrical log for the determination of structure; use both methods for details of the producing section.

For well completion both are of value, as great detail is often necessary to successful completion, particularly in thin sand fields and where gas and water problems are important.

For estimates of oil and gas both are of value, as the same problems exist as in well completions.

For well spacing both are of value, as core analysis may indicate rate of efficient withdrawals and electrical logs the structure and thickness of pay members.

A. H. N.

893.* Pioneering the Rotary in California. L. B. Little. *Petrol World*, April 1940, **37** (4), 23–26.—The paper is an interesting historical sketch of the early development of rotary drilling practices, written in a light vein. A. H. N.

894.* Application of Chemicals to Drilling and Producing Operations. W. W. Robinson. *Petrol. World*, April 1940, **37** (4), 32.—Without elaborating upon the details of any one type of development, this paper considers broadly the steadily growing trend in the application of chemicals to problems affecting the drilling for, and production of oil. Chemicals for the treatment of muds, the control of heaving shales, treatments for lost circulation, special cements, the use of acid, selective water shut-offs, and the application of surface-tension reducing agents are reviewed.

The growth in importance of chemical technology, which has already been of material assistance to the driller and producer, is emphasized. A list of 86 references is presented. A. H. N.

895.* Drilling-rig Layout for Water Locations in the Gulf Coast. I. W. Alcorn. *Petrol. Engr*, April 1940, **11** (7), 77–80.—The total cost of an average setup for either a steam or diesel rig containing a drilling barge, power or boiler barge, mounting equipment, piping, etc., is about $85,000. Straight piling structures supporting the entire rig would cost from $10,000 to $20,000. A programme involving eight or ten wells would about amortize the barge investment.

As opposed to these two solutions, it is suggested that an economical solution to the problem is a compromise of the two methods. The method which is now in use involves mounting on a piling foundation the derrick, draw-works, engine, rotary table, and shale shakers, whilst a barge is used to carry the boilers, pumps, boiler-feed unit and generators, suction mud tank, settling-tank and fuel-oil tank as well as a pipe-rack and a small 10-ton derrick mast with a 35-ft. boom.

An engineering and economic study of the piling problem resulted in the elimination of twenty-five piles by using steel structural members, the cost being further reduced because the steel was used on more than one location. The design was for 150,000 lb. rotary load plus 100% impact, or total of 300,000 lb. and assuming that the four piles under the rotary table were out of the picture, as it is possible for them to be, due to washout of the hole. Drawings are reproduced showing the chief components and their dispositions in the design.

After placing the barge in operation it was noted that only a very slight movement, relative to the pilings, was perceptible even during fairly rough weather. This led to considerations of the relationship of mass, depth of water, submergence of barge, and its length as affecting the stability, and it is believed that the entire setup lends itself particularly well to much deeper water, and possibly to tideland operations in some instances.

Costing of the combination of piling and barge system compares favourably with either of the two methods used separately. A. H. N.

896.* Deepening and Completing a Well in the Lisbon Field, Louisiana—a Study in Modern Co-operative Practice. Pt. 3. P. D. Torrey and F. H. Miller. *Petrol. Engr*, April 1940, **11** (7), 118.—This paper forms the third part of an exhaustive article detailing every operation undertaken in drilling and deepening a certain well. In this part a discussion is given of the methods used to prevent blowouts, and of the precautions, tests, and analysis of mud performed in drilling through potentially dangerous strata.

A fluoroscope is described, which is adapted to test muds for oil contents. Mercury vapour lamps are used to emit invisible rays which impinge on the oil and after being absorbed and their wave-length changed are emitted as visible light waves. Crude oil in minute quantities can be detected as well as differentiated from refined oil, as the two emit different wave-lengths, and hence are of different colours.

Similarly gas detectors are described and their operations detailed. The use of the audible signal is a qualitative test of the presence of gas in the mud; the number of points required to turn the dial of the " preselector " to silence the horn is a rough quantitative measure of the gas—the larger the quantity of gas the greater the number of points required.

Electrical logging and time logging are next discussed with the same detail regarding the well. The study of the rate of penetration and bit performance concludes Part 3 of this paper. Further parts are to be published in forthcoming issues of the *Petroleum Engineer*. A. H. N.

897.* Rotary Super-rig of Advanced Design is Largest in Operation. W. A. Sawdon. *Petrol. Engr*, April 1940, **11** (7), 153–155; cf. also *Petrol. World*, April 1940, **37** (4), 27.—The paper describes, with photographic illustrations, what is believed to be the largest well-drilling plant ever assembled, which is anticipated to meet the heaviest duty demands likely to be encountered in deep drilling for some time to come. It is steam driven and has the largest draw-works yet built and a combination standby draw-works and rotary table driven by one engine.

Detailed dimensions and capacities for the chief components are given. To present the potentiality of the rig the following illustrates its performance. One week after a well was spudded-in, a depth of approximately 6700 ft. had been reached with 12¾-in. surface string run and cemented. The well will probably be drilled to a depth of about 11,500 ft. Completion, including running and cementing 7⅝-in. casing, and running 5¾-in. liner and 2½-in. tubing, is expected in less than 40 days.

A. H. N.

898.* Steam Saving Set-up Used on Dominican Concession. E. S. Post. *Oil Wkly*, 15.4.40, **97** (6), 15–16.—A steam saving set-up used in the Dominican Republic has not only provided a material saving in drilling costs, but has also further increased the operating efficiency. The equipment is designed to drill wells not exceeding 6000 ft. in depth.

The chief revision in the equipment was in the pump power. Instead of using two conventional-type 14½ in. × 7½ in. × 18 in. pumps, only one was included in the arrangement. A special 7½ in. × 18 in. power slush-pump was connected to a horizontal twin 7 in. × 7 in. steam engine by the use of a V-belt. The conventional type of pump is used as an auxiliary unit, whilst the specially designed power unit is employed in the regular drilling.

This hook-up has reduced the steam demand of the entire rig by approximately 40%. In terms of fuel oil, the demand was lessened from 130 brl./day to approximately 70 brl./day. Two boilers were found sufficient for the operations instead of three; this fact considerably reduced transportation and equipment costs.

A. H. N.

899.* Methods of Recovering Stuck Drill Pipe. Pt. 2. J. E. Warren. *Oil Wkly*, 15.4.40, **97** (6), 27 (cf. Abstract No. 752).—*Paper presented before American Petroleum Institute.*—In Part 1 the various factors that may cause drill-pipe to stick in the well-bore were considered in detail. In this Part a number of methods of recovering the pipe are studied in the event of the precautions previously outlined having been overlooked or an accident having occurred.

Recovery methods are outlined both for releasing the pipe intact and in sections. These methods include bumping the pipe, the use of clear water or mud colloids in circulation, gas slugging, the use of hydrochloric acid, backing-off pipe, the use of inside cutters, the use of left-hand drill pipe, recovery by shooting, washing-ove pipe, the use of outside cutters and various other methods adapted for specific cases. Details of most of these methods are presented in a simple and straightforward manner. A. H. N.

900.* Heaviest Drilling Rig Points Way to Lower Drilling Costs. Anon. *Oil Wkly*, 22.4.40, **97** (7), 18–22.—The largest equipment ever assembled is installed on a drilling rig in the Rio Bravo field, California, which is expected to be drilled to 11,500 ft. The trend towards over-size equipment for rapid drilling of deep wells in California has already resulted in cutting down drilling time for depths below 11,000 ft. from several months to current averages ranging from 36 to 45 days, spudding until the oil is turned into tanks.

Whilst a drilling layout as described in the paper represents a heavy capital investment, probably approaching $500,000, such equipment is pointing the way to substantial savings in drilling costs. In the early development of this field wells cost in the neighbourhood of $180,000 each to complete. With heavier equipment wells are now drilled at an approximate cost of $100,000. The new equipment being used is believed to involve still lower drilling costs. Thus, with numerous locations to drill a large investment in improved equipment is sound business.

It is estimated that with 4-in. drill pipe the equipment could reach depths ranging from 15,500 to 16,000 ft., and that if 3-in. drill pipe of sufficient strength could be developed it would be capable of going considerably deeper.

Although the equipment was not designed with the view of establishing new drilling records, but for lowering drilling costs in deep fields, a new California record for fast drilling—1385 ft. in one 8-hour shift—was established. A well of 11,223 ft. took 27 days from spudding until the time it was ready for electric logging.

Photographic illustrations of the various components are given, together with explanatory notes regarding dimensions and capacities. A. H. N.

901.* Spudder Use Increasing with New Applications. Anon. *Oil Wkly*, 29.4.40, **97** (8), 45–50.—This is the first of a series of composite reviews which it is proposed to present from time to time covering new developments and important features in design, construction, application, operation, and maintenance of various types of oil-field and pipe-line equipment. The articles are illustrated with specific examples taken from manufacturers' current offerings. A. H. N.

902.* New Magnetic Method for Orienting Deflecting Tools. Anon. *Petrol. Times*, 18.5.40, **43** (1114), 460.—A description is given of a new method of accurately orienting deflecting tools at the bottom of bore-holes which is extremely accurate, requires less time than methods hitherto known, and which provides a positive photographic check of the actual position of the deflecting tool.

The orientation is accomplished by the use of a non-magnetic sub, containing two small magnets and provision for seating a directional magnetic single-shot instrument. The brief description of the instrument and its operation is illustrated by a sectional drawing of the non-magnetic sub and of a sample record.

This method has been successfully used in the field for more than a year. Correct bottom-hole orientation of the deflecting tool to within $\frac{1}{2}°$ in azimuth can be obtained.
A. H. N.

903. Drilling Patents. W. G. Milne. U.S.P. 2,196,320, 9.4.40. Appl. 7.12.38. Dead end cable clamp.

E. G. Simmons. U.S.P. 2,196,366, 9.4.40. Appl. 26.7.39. Tool puller comprising a grip adapted to grip the drill rod.

J. Kahn, W. F. Schulz, and C. Schofield. U.S.P. 2,196,454, 9.4.40. Appl. 10.12.38. Pipe-thread protector.

R. K. Hertel. U.S.P. 2,196,460, 9.4.40. Appl. 13.4.36. Safety hook with shank supported on compression spring and anti-friction bearing.

R. F. Bolton. U.S.P. 2,196,517, 9.4.40. Appl. 28.10.37. Winged whipstock for deflecting drill bits.

J. D. Hughes. U.S.P. 2,196,528, 9.4.40. Appl. 28.10.37. Knuckle anchor for whipstocks.

F. J. Spang. U.S.P. 2,196,538, 9.4.40. Appl. 8.3.38. Apparatus for cementing wells.

B. F. Shepherd and R. D. Zimmerman. U.S.P. 2,196,598, 9.4.40. Appl. 30.9.37. Rock drill-bit.

R. C. Baker. U.S.P. 2,196,652, 9.4.40. Appl. 10.10.36. Apparatus for cementing well-bores with circulation ports which are opened progressively in an upward direction.

R. C. Baker and C. E. Burt. U.S.P. 2,196,653, 9.4.40. Appl. 5.5.39. Cementing, washing, and acidizing retainer for perforated well casings.

C. E. Burt. U.S.P. 2,196,656, 9.4.40. Appl. 12.12.38. Well-cementing apparatus.

C. E. Burt. U.S.P. 2,196,657, 9.4.40. Appl. 21.4.39. Well-cementing apparatus.

C. E. Burt. U.S.P. 2,196,658, 9.4.40. Appl. 5.5.39. Cementing, washing, and acidizing retainer for oil wells.

J. H. Grubb. U.S.P. 2,196,661, 9.4.40. Appl. 14.1.39. Circulating well-packer.

W. C. Markle. U.S.P. 2,196,704, 9.4.40. Appl. 3.11.38. Windbreak for oil derricks.

L. A. Parnell. U.S.P. 2,196,938, 9.4.40. Appl. 24.10.39. Dead end clamp for cables.

E. L. Potts. U.S.P. 2,196,940, 9.4.40. Appl. 25.7.38. Deflecting bit.

F. W. Sharp. U.S.P. 2,196,944, 9.4.40. Appl. 21.8.37. Deflecting bit.

O. Hammer. U.S.P. 2,196,966, 9.4.40. Appl. 24.10.39. Well-pipe joint embracing a tapered pin and box with mutually engageable threads, and shoulders capable of transmitting compression stresses.

D. B. Monroe. U.S.P. 2,197,019, 16.4.40. Appl. 23.12.38. Drill-guide for rotary rigs.

C. H. Sweet and L. S. Chambers. U.S.P. 2,197,062, 16.4.40. Appl. 11.6.37. Orienting core-barrel by attaching a surveying instrument to the top of core-barrel.

W. A. Norman and T. M. Norman. U.S.P. 2,197,222, 16.4.40. Appl. 27.1.37. Plug for wells and the like.

T. C. Strength. U.S.P. 2,197,227, 16.4.40. Appl. 17.10.38. Directional well-drilling tool with surveying tool adapted to be run through the pipe to record the position of the deflecting means.

P. C. Matlock. U.S.P. 2,197,344, 16.4.40. Appl. 25.2.39. Setting tool.

D. G. Hawthorn. U.S.P. 2,197,392, 16.4.40. Appl. 13.11.39. Drill-stem section containing an electrical conductor attached to and insulated from the inside of the pipe.

F. Maines. U.S.P. 2,197,396, 16.4.40. Appl. 29.12.37. Oil-well cementing plug, provided with passage for mud fluid and cement, the passage-way being closed by a membrane which ruptures upon exerting a predetermined pressure.

H. C. Block and L. A. Layne. U.S.P. 2,197,403, 16.4.40. Appl. 25.9.37. Bottom connection-screw through setting-tool.

A. S. Volpin. U.S.P. 2,197,455, 16.4.40. Appl. 28.6.37. Slush pump-valve.

W. G. L. Smith. U.S.P. 2,197,531, 16.4.40. Appl. 12.1.38. Drill-pipe protector.

T. H. Stancliff. U.S.P. 2,197,541, 16.4.40. Appl. 20.3.39. Drill-bit of roller type.

J. W. Millington and W. T. Evans. U.S.P. 2,197,571, 16.4.40. Appl. 3.10.38. Bore-hole exploring apparatus containing a motor which moves proportionately to the motion of an electric cable lowered into a well.

G. Jensen and G. Jensen. U.S.P. 2,197,580, 16.4.40. Appl. 25.4.38. Cable-lift well-auger.

L. S. Dewees. U.S.P. 2,197,790, 23.4.40. Appl. 13.8.38. Drill-stem orienting device which allows free axial translational motion of drill-stem, but which gives a direct reading of rotational component of the motion of stem.

C. C. Brown. U.S.P. 2,197,920, 23.4.40. Appl. 5.4.38. Cementing apparatus, a retainer for cased wells.

J. C. Wright and M. H. Wright. U.S.P. 2,197,991, 23.4.40. Appl. 10.10.36. Tool for straightening well-bores utilizing a body of higher specific gravity than ferrous materials and a flexible joint so that gravity will tend to pull the bit vertically.

J. C. Rogers and J. D. Hall. U.S.P. 2,198,016, 23.4.40. Appl. 18.8.38. Lateral drilling mechanism using a rotary flexible drilling stem and a deflection member for horizontal drilling in a vertical well.

J. E. Hoffoss. U.S.P. 2,198,083, 23.4.40. Appl. 3.6.38. Core taking apparatus.

R. L. Smythe. U.S.P. 2,198,093, 23.4.40. Appl. 28.4.37. Dead-end cable-clamp.

W. B. Lerch, C. H. Mathis, and E. J. Gatchell. U.S.P. 2,198,120. Appl. 19.5.38. Method of sealing or fixing casing tubes in wells using 50 parts sodium silicate, 50 parts water and 100 parts of hydrochloric acid and carbon black.

W. Tarkington. U.S.P. 2,198,490, 23.4.40. Appl. 20.3.39. Oil-well bailer of the pressure type. A. H. N.

Production.

904.* Acidizing Illinois Limestones Presents Many Problems. W. W. Love. *Oil Gas J.*, 11.4.40, **38** (48), 74.—Acidizing operations have been of continuously increasing importance in Illinois since the discovery of the Clay City Pool in 1937. The structure and characteristics of the producing horizons are described, followed by present acidizing practices. The development of Illinois acidizing is sketched.

In one instance, acidizing by a two-stage process, injecting 1000 gal. in the first stage and 3000 gal. in the second, produced no sustained increase in production. It is found that a single-stage process using 5000 gal. is the best method of treating the pay.

In numerous cases wells have required clean-out or re-acidizing due to the presence of oolites, closely cemented by calcium carbonate.

Approximately 87% of all acid used in the Illinois basin contained an additive agent to prevent the formation of emulsions between the spent acid and crude oil. Simple experiments are described to determine which of any number of acids will be best suited to acidize a formation carrying a certain crude oil.

Sustained-action acid is used where the limestone is too easily attacked by the acid. Neither increasing the quantity of acid nor the rate of injection is found to render the acid effective along a wide radius from the well when the limestone is highly soluble in acid.

Jelly seal has been used extensively in acidizing wells having thick producing sections with varying porosities and separate producing zones. When long saturated sections are treated, the tighter of the two is always treated first. Methods of setting jelly seals are described for various positions of the more permeable section compared with the less permeable one.

The use of mechanical treating devices—*e.g.* packers, jet guns—is discussed and illustrated. A. H. N.

905.* Illinois Uses Several Explosives and Tamping Methods. H. F. Simons. *Oil Gas J.*, 11.4.40, **38** (48), 81.—There is no standard method of shooting in the Illinois fields. Each company uses procedures which are suited to the problems presented in the areas where operations are conducted.

Shooting too close to the casing-shoe frequently results in wrinkling, splitting, or buckling of the casing. One company seldom gets within 15–20 ft. of the casing-shoe, although in one case shooting is reported to have been successfully done within 3 ft. of the shoe.

The general practice is to use solid tamping, either the special quick-setting gypsum cement, sand, or gravel, or a combination of these three.

When fluid tamping is used, the well must be kept constantly full of oil. No water is used, as it may cause water-logging after the shot is discharged. If the well is not full, the concentration of the vibrations at the fluid level may result in splitting the casing. Similarly an oil/water interface may have the same consequences.

Practical hints and procedures are detailed. A. H. N.

906.* Metals in Production—Balls, Seats and Polished Rods. W. L. Nelson. *Oil Gas J.*, 11.4.40, **38** (48), 92.—Recommendations are given for use as a guide in specifications for metals used in balls, seats, and polished rods. These are taken from recognized manufacturers of equipment and metallic materials. Percentage composition in terms of carbon, manganese, nickel, chromium, molybdenum and others, yield-points, elongation, and Brinell hardness, as well as notes on heat treatment, are presented for metals to be used in balls and seats and in polished rods. Seven references to literature on metals for these parts are appended. A. H. N.

907.* Ohio's First Water-flood Project Promises Moderate Success. J. P. O'Donnel. *Oil Gas J.*, 18.4.40, **38** (49), 42–43.—After more than nine months' operation, an evaluation of the first water-flood in Ohio indicates that this process is adaptable to the new locality, although the practice as developed in Pennsylvania will have to be changed to meet the new conditions.

The chief conclusions reached are that while development costs are lower than at Bradford, because of shallower drilling and lower pressures, this factor is offset by the much lower price of the crude oil. Extremely wide and unpredictable variations in sand thicknesses and the total absence of sand in some places indicate that development should be undertaken progressively. A. H. N.

908.* Electrification of Pumping Equipment in Illinois. R. E. Hammond. *Oil Gas J.*, 18.4.40, **38** (49), 44–46.—*Paper presented before American Petroleum Institute.*—The operator who has elected to use electric power for oil-well pumping should consider a variety of factors in selecting his electrical equipment and planning its installation. A few of the most important of these are as follows : (1) advantages of " high slip " induction motors ; (2) possibilities of time-switch control ; (3) location of field substations to permit " looping " and under-building of secondary lines ; (4) decreased well-service investment when pumping unit is set on side of well towards power line ; (5) danger of over-building generating plants, and possibility of savings by use of purchased power for excess requirements during temporary peak-load period.

After the electric system has been built and placed in operation, attention should be given to the following considerations : (1) power system stabilization through load control and intermittent pumping ; (2) possible advantages of power-factor correction ; (3) increased power requirements during cold winter months.

A. H. N.

909.* Experimental Gas Lift at Sulphur Effective in Recovering Oil. Anon. *Oil Gas J.*, 25.4.40, **38** (50), 76.—Production records are reproduced and discussed, together

with the equipment used for gas-lifting operations in Sulphur Mines fields, Louisiana. A study of these records and of cost estimates shows that the operations were successful in effecting additional economical recovery of oil from wells in which the limit of commercial productivity by other means was believed to have been reached.
A. H. N.

910.* **Formation Pressure Increased by Gas Injection.** Anon. *Oil Gas J.*, 25.4.40, 38 (50), 98.—During the 14-month period from January 1938 to March 1939, while one well in a 7900-ft.-deep gas-sand was blowing wild after a blowout and cratering, all other wells in the sand were opened wide to relieve pressure on the sand, in order to minimize the hazard of charging of sands and spread of blowouts and craters. An estimated production of from 70 to 80 billion cu. ft. of gas was taken from the sand. These excessive withdrawals have reduced pressures to such an extent that fluids precipitated in the sand as a result of retrograde condensation.

By injecting gas at higher pressures it is believed that pressure in the sand will rise to a point where retrograde condensation is prevented and all the fluid be eventually made recoverable. Experiments have shown that as the pressure in the sand is building up, the gasoline content of the gas is rising.

Each well constitutes a separate recycling unit. The gas, stripped of its fluid content, is directly returned to the formation through the same well from which it has been produced. Equipment and procedure are described. A. H. N.

911.* **Rapid Expansion in Recycling and Pressure Maintenance.** Anon. *Oil Gas J.*, 25.4.40, 38 (50), 165.—A review is given of recycling and pressure-maintenance operations at present working and of those under way in the Gulf Coast area in this, the " Gulf Coast Number " of the *Oil and Gas Journal*. The paper is extensive.
A. H. N.

912.* **Evaluation of Leases Subjected to Proration and Drainage.** I. I. Gardescu. *Oil Wkly*, 22.4.40, 97 (7), 30.—If an oil-field is subjected to proration and active water drive, such as the East Texas or Hastings field, it is generally assumed that the producing life expectancy and the ultimate recovery of wells drilled up-structure will be greater than the average for the field. The paper attempts to find quantitatively how much greater these characteristics are.

To ascertain, for instance, how much oil a 40-acre lease located in the Hastings field will actually produce when all the geological and production facts are known, two actual cases are discussed in detail. The first case is located in the East Texas field, and the second in the Hastings field. The actual production behaviours of two wells are discussed as a preliminary.

The vital and secondary considerations to be made in solving such an essentially practical problem are given in detail. Economic and financial factors are taken into account in estimating the worth of the leases. A. H. N.

913.* **Mathematical Analysis Applied to Specific Selection of Well Service Equipment.** W. G. Wilson. *Oil Wkly*, 22.4.40, 97 (7), 44–46.—Mathematical formulæ are derived to solve the general problem of selecting the most suitable pumping equipment for a certain lease which is subject to recurrent floods of varying duration and intensity. Probabilities are assumed to find the probable production loss resulting from inabilities to service the wells during flood periods, and then to compare this loss with the cost of preventing it. Actual conditions over specific intervals may never correspond to the expectancy as calculated by assuming probability laws, but over a period of years the average correlation should be reasonably close.

To illustrate the significance and use of the formulæ and chart thus developed, the following specific problem is solved completely.

The present-day production of 50 brl. of oil/well/day is assumed, together with the facts that no water production exists and that sucker-rod equipment requires service every 45 days on similar leases in the field, and that like service requirements may be expected on the lease in question. Analysis of flood records for the stream adjacent to the lease indicates that over a period of many years there was an average of four floods every three years and that the average duration was 20 days.

The probable loss in production per well per annum is calculated. A convenient comparison of the merits of possible types of pumping equipment may be secured by determining the annual cost for each. This should include normal operation and maintenance expense, production losses, depreciation, and interest on unamortized investment, which may be averaged as interest on one-half the total investment.

A. H. N.

914.* Injection Method for Salt Water Disposal. Pt. I. B. Mills. *Oil Wkly*, 29.4.40, **97** (8), 15.—The East Texas field is the site of research programmes with the injection method of brine disposal. The field appears to possess all the requirements for adoption of the method and several conditions which limit the use of other systems. The paper presents, in three parts, a complete discussion of the procedure and methods employed by East Texas injection systems.

Both an experimental well, drilled in 1936, and more recent injection efforts in and near the field have proved the feasibility of returning the salt water to the producing formation in the Woodbine sand. Sufficient work has been done, however, to indicate that certain objectionable constituents must be removed from the water before returning it to the formation, a practice which adds materially to injection costs. On the other hand, injection of salt water is considered as a form of pressure maintenance by recycling.

The cost of converting an old oil-well into an injection well is much less than that of drilling a new well. This statement is discussed in detail.

Several wells take water by gravity or natural hydrostatic head, but in others it is necessary to pump the water into the formation. The use of pumps adds appreciably to injection costs, but in many wells pressures are nominal. An average analysis of several samples of Woodbine water is given and shows total solids amounting to 64,494 parts/million. Static head in injection wells is 1000–1100 ft. from the surface; the hydrostatic head at the sand is therefore about 500 lb./sq. in.

Treating plants are described to reduce the concentration of injurious constituent salts in the brine. Calcium carbonate is reduced from 114 parts to 5 parts/million in normal cases using one type of these plants. Diagrams, photographs, and a discussion detail the Tide Water plant for treating water before injection. Similarly, the Magnolia treating system is detailed. The first plant is a sludge-blanket type, and consists mainly of concrete skimming pit, centrifugal pump, treater tank, filter, and a control or clear-water tank. In the second type a more decided use of chemicals than has been practised by many operators is reflected. A. H. N.

915.* New Multi-sand Completion Departures Introduced at Loudon. A. J. Sullivan. *Oil Wkly*, 29.4.40, **97** (8), 29.—Newly developed completion practices, in so far as they affect producing wells, are of two classes: those where a removable alloy is used in the production string, and those where the steel production string itself is partly removed.

In the first class are drillable casings made of an alloy consisting of 1% silicon, 1% magnesium, 0·3% chromium, with tolerances of − 0·2%, + 0·2%, and ± 0·05%, respectively, the balance being aluminium. Physical characteristics are quoted to indicate the strength of the alloy. Procedure in well completion using drillable casing and gravel packing is given.

A second type of removable casing is an acid-soluble casing made of an alloy of 3·3–4·7% aluminium, 0·2% minimum of manganese, 0·3% maximum of zinc, 0·5% maximum silicon, with the balance made of magnesium, save for 0·08% other impurities such as nickel and copper. The strength and other physical characteristics of the alloy are given, together with the practice of setting and removing such casing.

The second type of completion practice, where the steel production string itself is partly removed, is similarly detailed. The first use of shooting gave discouraging results, and rotary tools have now been evolved capable of milling steel casing economically. A window is milled in the casing, the hole is plugged back or bridged, loaded, and tamped down with 50 ft. of gypsum cement, topped out with water, and shot. The method promises to be a success.

Input well practices are also described. Aiming at maximum efficiency for the input wells drilled in these zones, a system of manifolding both surface and subsurface well equipment has been designed to achieve simultaneous control of gas to three sands through a common well. Detailed drawings and descriptions of the system are given. Both surface and subsurface equipment are reproduced.

A. H. N.

916.* Classified Code for Well Troubles. R. L. Bradley. *Oil Wkly*, 29.4.40, **97** (8), 60–61.—The paper deals with the production side of well troubles, and not with all well troubles. The major subdivisions are: (1) surface and (2) subsurface troubles or causes of troubles. Two tables further subdivide these items as follows:—

1. Well trouble causes on surface equipment: A, engines; B, clutch; C, countershaft; D, belt or chain, etc., till M, miscellaneous. These items are further subdivided—*e.g.* AA-1, air starting unit; AB-1, battery, etc.

2. Well trouble causes on subsurface equipment: N, oil-well pumps; O, sucker rods, etc.—to U, air-, or gas-lift. Flowing and swabbing wells are also listed. These items are further subdivided—*e.g.* N-1, rod coupling; N-2, adaptor rod, etc.

The code may be used not only as a quick reference to past work, but also as a reference to logically needed repairs or replacements in the future. Examples illustrate the use of the code index. A. H. N.

917.* Microfilming Facilitates Petroleum Engineering Field Studies. C. V. Sidwell. *Petrol. Engr*, April 1940, **11** (7), 73–76.—An account is given of the practice of using reduced facsimiles of original oil company records preserved on film and filed in small space, thus rendering all field and office data easily accessible for reference and study. The usual film used in the motion-picture industry has a nitrate base and is very inflammable. When stored in closed space this type of film may lead to the formation of explosive fumes. The records, however, are taken on an acetate-base film which is no more inflammable than, and which is found to be as durable as, rag paper, and is entirely free from explosive fumes hazards.

The preservation of original oil-field records greatly facilitates petroleum engineering field studies, particularly as current records can be filed and made much more accessible than by the more conventional methods. The preservation of obsolete records not only results in a great saving of space and economical saving, but also insures against loss of valuable records. Portable equipment has been designed and developed that makes it possible to take the equipment to the work for the purpose of obtaining necessary data on any problem, in contradistinction with the present method of the application of photography by photostating, which can be used only when the work can be taken to the equipment, and which involves a cost that is prohibitive when copying is voluminous. A. H. N.

918.* Analysis of Delayed Drilling Programme in Water-flooding Project. P. M. Phillippi. *Petrol. Engr*, April 1940, **11** (7), 103.—The usual or "no-delay" drilling programme in water-flooding areas is to drill the oil-well first and follow up at a later date with the water-wells. The initial production is small, but it gradually increases to a maximum, and the peak in oil production is reached. Wherever the characteristics of the sand vary over a wide range a great amount of bypassing occurs, with resultant shortening of the economic life of the field.

To overcome these difficulties the "delayed drilling" is used where the water-wells are drilled first and water under constant pressure is forced into the sand. The water first penetrates the looser streaks, and then, having no outlet, the tighter portions of the sand. After 6–18 months the oil-well is drilled in the centre (a five-spot system being followed) and peak production is at once encountered. A careful study of the permeabilities of the sand and balanced flooding operations are essential to the successful realization of the project. On a small lease it is possible to operate delayed drilling in the recommended manner, but it is not possible to maintain an absolutely balanced flood on a large property that is constantly undergoing development. Only a portion of the property can be developed at a time, and the water from the edge wells is certain to get beyond control.

Data covering an 8-year operating period on a Bradford oil-lease are presented to show the merits of the various plans of exploitation. These plans are: (1) no delay,

(2) balanced delay, (3) unbalanced delay, (4) two sides balanced, (5) three corner delay, and (6) one side only delay.

Balanced delay drilling in a heterogeneous body of sand in conjunction with selective shooting, where tight formations receive proportionately large quantities of nitroglycerine as compared with permeable formations, represents the best known method of operating efficiently.

When the sand exhibits uniform permeability no advantage is gained by delay drilling over the normal no delay programme. A. H. N.

919.* Improved Acidizing Mixtures Speed Separation of Spent Acid and Oil. C. E. Clason. *Petrol. Engr*, April 1940, **11** (7), 166.—Spent acid remains in solution with oil from a well, in varying quantities, for more than ten weeks following acidizing. Salt content of the oil increases for a long period after treatment. Lately it has been discovered that certain types of crude oil react with the acid, forming a stable emulsion which never breaks in some cases, and in others will break in comparatively short periods.

When acid is treated with substances which change the interfacial tension between the acid and the oil, thus permitting faster penetration through both large and small channels, the spent acid possesses the same characteristics. Hence acid thus treated will shorten the time during which the oil is subjected to contact with the acid. This fact will in turn reduce the deleterious effects produced in the refineries due to the presence of the spent acid in the oil.

The use of emulsion preventers is advocated, therefore, not only from the point of view of production of oil, but also from an easy and economic refining viewpoint.
A. H. N.

920. Annual Report of the Petroleum and Natural-Gas Division. Fiscal Year 1939. Anon. *U.S. Bur. Mines, Rep. Invest.* 3501, March 1940.—Once a year the Petroleum and Natural Gas Division of the Bureau of Mines takes stock of its various activities and gives an account of progress made in its endeavour to develop and carry out a co-ordinated system of research projects pertaining to oil and gas. The present report is divided into four main sections, as follows: Oil and Gas Production and Related Transportation; Chemistry and Refining; Special Chemical and Engineering Problems; and Helium.

In the production section emphasis is laid on the need for instruments to measure and record accurately subsurface pressures and temperatures; the development of standard methods of obtaining and analysing subsurface samples of crude oil; the physico-chemical properties of natural hydrocarbon mixtures; water as a source of energy in reservoirs and its use in propelling oil to wells; the use of a pressure core-barrel for bringing samples intact to the surface for analysis. Studies of factors affecting the flow of fluids through porous mediums, compaction of reservoir sands and rocks as oil and gas are withdrawn, spacing of wells with particular reference to Cutler's rule, and the control of gas–oil ratios as a means of bringing about gas conservation and efficient production of oil, also appear in this section.

The second section reflects the Bureau's desire for more efficient utilization of petroleum based on greater knowledge of its constitution. Problems concerned with distillation, hydrogenation, and refining each contribute their quota towards this desideratum.

Among the special chemical and engineering problems to which the Bureau has given attention are the disposal of oil-field brines, particularly in agricultural areas; the regular cleaning out of wells as a necessity for efficient production; the removal of salt from crude oil; and lastly the ever-searching question of prevention of accidents in the various phases of the industry.

The final section of the report covers the Bureau's activities in connection with the Government's plant at Amarillo, Texas, for the extraction of helium from natural gases. Brief accounts are given of the process, working conditions, and also of reserves of helium-bearing natural gases. In approximately ten years of operation ending 30th June, 1939, about 91½ million cub. ft. of helium were extracted in the Amarillo plant, and even then the plant was operated at only about one quarter of its capacity. H. B. M.

921. Production Patents. C. K. Holt. U.S.P. 2,196,439, 9.4.40. Appl. 20.6.39. Well-cleaner for washing the perforations in the oil string or liner.

A. G. Horvath. U.S.P. 2,196,453, 9.4.40. Appl. 22.12.37. Jet pump adapted to work at the bottom of deep wells.

A. Hollander. U.S.P. 2,196,462, 9.4.40. Appl. 12.9.38. Semi-submersible motor pump.

H. C. Otis. U.S.P. 2,196,535, 9.4.40. Appl. 27.9.37. A well flowing-control device setting a maximum value on the velocity of flow of the well fluid.

R. J. Bean. U.S.P. 2,196,622, 9.4.40. Appl. 27.6.38. Detachable pipe-coupling.

J. L. Kofahl. U.S.P. 2,196,664, 9.4.40. Appl. 22.9.39. Control valve.

T. M. Ragan. U.S.P. 2,196,668, 9.4.40. Appl. 21.4.39. Packing for well devices.

W. E. Saxe. U.S.P. 2,196,816, 9.4.40. Appl. 6.9.38. Method and apparatus for automatically counterbalancing pumping apparatus on oil-wells.

J. H. Kidder. U.S.P. 2,196,993, 16.4.40. Appl. 17.10.36. Expansion well pump.

B. R. McKinley. U.S.P. 2,197,078, 16.4.40. Appl. 25.10.37. Formation tester.

S. F. Cunningham. U.S.P. 2,197,685, 16.4.40. Appl. 16.11.38. Means for controlling well flow, consisting of a bean with a barrel provided with many ports of various sizes, one of which is to be opened at a time by a reciprocating cylindrical valve, the other ports being closed.

T. R. Cowan. U.S.P. 2,197,778, 23.4.40. Appl. 20.5.38. Tubing protector particularly adapted to oil well tubings.

S. P. Hart. U.S.P. 2,198,435, 23.4.40. Appl. 30.8.38. Treatment of wells for removing mud sheaths by the action of an aqueous solution of an alkali metal perborate.

W. W. Robinson. U.S.P. 2,198,563, 23.4.40. Appl. 4.6.37. Method of completing wells using as a drilling fluid a suspension of bentonite, calcium carbonate, and water, and removing the sheath on the pay face by acid.

E. L. Davis, H. S. Cole, W. E. Larson, and N. C. Wells. U.S.P. 2,198,573, 23.4.40. Appl. 29.3.38. Method and apparatus for gravelling wells. A. H. N.

Transport and Storage.

922. Inhibition of Sulphate-reducing Bacteria by Dyestuffs. T. Howard Rogers. *J. Soc. chem. Ind.*, 1940, **59**, 34–39.—Bacteria which reduce inorganic sulphates with the production of hydrogen sulphide are of considerable economic importance because of corrosion by the hydrogen sulphide. Particular attention is directed to the corrosion of petroleum storage tanks and transports. Inhibition of these bacteria by the use of ordinary disinfectants is often impracticable, as the presence of the disinfectant may be itself objectionable. The article demonstrates that certain dyestuffs are eminently suitable for the purpose. Many dyestuffs have been tried, but those derived from 3 : 6-diaminoacridine (*e.g.* acriflavine and proflavine) are the best. These dyestuffs are non-corrosive and effective in concentrations down to 1 in 750,000, although 1 in 250,000 seems to be the most suitable concentration, depending, of course, on the strength of the bacteria. The application of the principle is covered by B.P. 497,829, 1938. T. C. G. T.

Gas.

923. Utilization of Natural Gas for Chemical Products. H. M. Smith. *U.S. Bur. Mines, Inf. Circ.* No. 7108, April 1940.—The manufacture of chemical products from natural gas was retarded for many years owing to the prevalent belief that the hydrocarbons composing the gas were non-reactive. During recent years, however, research has shown that these hydrocarbons will react when activated by the effects of heat, pressure, chemical reagents and light, and that good yields of useful products can be obtained. This Circular describes by means of ten charts and relevant annotation the story of the manufacture of chemical products from natural gas.

The earlier charts give an indication of the general composition and major uses of natural gas; consumption in 1938 for domestic, commerical, and industrial purposes; basic methods of converting natural gas hydrocarbons into other products; and the relationship between various reactions that may be applied to ethane.

Charts VI, VII, VIII, and IX trace the development of chemical syntheses from primary products obtained by methods of hydrocarbon conversion previously described, *i.e.* decomposition, oxidation, halogenation, and nitration.

Finally, Chart X is devoted to the uses of non-hydrocarbon constituents of natural gas. Of these some are valuable even when present in very small quantities—*e.g.* helium. Others, such as hydrogen sulphide, are objectionable and must be removed. Certain natural gases are composed almost entirely of carbon dioxide which can be utilized for refrigeration purposes, fire extinguishers, food preservatives, etc., if the wells are easily accessible. H. B. M.

Hydrogenation.

924.* Hydrogenation of Boldesti Kerosine with Regard to Chemical Composition. C. Candea and J. Kühn. *Monit. Pétr. roum.*, 1940, **41**, 73–76.—The effect of various types of hydrocarbon on the hydrogenation of a kerosine from Boldesti crude has been investigated.

The original kerosine contained 4% unsaturateds, 13% aromatics, and possessed a specific gravity of 0·807. Hydrogenation conditions were 100 atms., initial pressure rising to 250 atms. and molybdenum oxide catalyst at 450° C. The yield was 53% of 150° C. end-point gasoline, which consisted of 60% paraffins, 28% naphthenes, and 7–8% aromatics.

The admixture of limited amounts (11%) of benzene or naphthalene effect no appreciable change in the yield, although the naphthalene is hydrogenated to tetrahydronaphthalene (tetralin).

Paraffin-wax hydrogenation is very susceptible to temperature, thus at 420° C. the yield of gasoline is 14%, while at 450° C. it is 71%. The gasoline so produced is 90% paraffinic.

Naphthenic acids from Rumanian gas oil under similar conditions are converted into naphthenes with production of carbon dioxide, whilst the unsaturateds in cracked kerosine or kerosine + amylene are completely saturated. T. C. G. T.

925.* Synthetic Gasoline Plants in Germany. M. N. Constantinescu. *Monit. Pétr. roum.*, 1940, **41**, 133–138.—The author estimates that Germany will produce 2,000,000 tonnes of synthetic gasoline in 1940. In 1933 production was 296,000 tonnes and in 1939 more than 1,300,000 tonnes. Production is equally divided among three groups: (1) the Leuna plants of the I.G. Farb., (2) the Bohlen, Magdeburg, Zeitz, and Schwarzheide plants of the Braunkohlen Benzine A.-G., (3) several plants in the Ruhr area belonging to Krupps, Ruhr Chemie A.-G., and the Rheinpreussen Co., etc.

The history of the development of the processes and the present-day technique are described. The article is largely based on a visit by the author to the Leuna works. The general scheme of the plant is presented diagrammatically, together with some photographs. T. C. G. T.

926.* Hydrogenation and Petrography of some Low-rank Coals from the Western United States. A. Eisner, G. C. Sprunk, L. Clarke, M. L. Fein, C. H. Fisher, and H. H. Storch. *U.S. Bur. Mines, Rep. Invest.* 3498, March 1940.—It is pointed out in this report that the time may come when petroleum is less plentiful, and when low-rank coals as found in the western United States will become an important source of liquid fuels and organic chemicals. There are vast quantities of these coals available; in fact, the lignites and sub-bituminous deposits of Texas, North Dakota, Montana, Wyoming, Colorado, and other western States comprise more than half of the total coal resources of the United States.

While these coals cannot be used for the production of coke, and are generally inferior to the coals of the central and eastern States, they can nevertheless be converted into liquid motor fuel. Hydrogenation characteristics of a number of samples, including peat, brown coal, lignite, sub-bituminous coals, and low-rank bituminous coals, have accordingly been studied. The samples tested contained only small proportions of fusain and opaque attritus and the resin content was moderately high. 85–95% of the dry, ash-free coal substance was converted into liquid and gaseous products.

The higher oxygen content of sub-bituminous coal and lignite caused the formation of more water and carbon dioxide and less oil than in the case of bituminous coal, but liquefaction took place readily and yields were excellent considering the quality of the coal. H. B. M.

927. Patent on Hydrogenation. Synthetic Oils, Ltd. E.P. 519,722, 4.4.40. Appl. 31.8.38.—Production of hydrocarbon oils from carbon monoxide and hydrogen. A gaseous mixture containing carbon monoxide and hydrogen in a ratio of between 1 : 1 and 1 : 1·5 by volume is subjected to a catalysed synthesizing reaction. A product of the reaction boiling between 180 and 330° C., which is useful as a diesel oil, is segregated and treated by reaction, in the presence of a hydrogenating catalyst in conditions similar to those employed in the first reaction. H. B. M.

Synthetic Products.

928. Patents on Synthetic Products. E. I. Du Pont de Nemours and Co. E.P. 519,381, 26.3.40. Appl. 21.9.38.—Manufacture of maltosamines by reacting hydrogen with maltose and ammonia or a primary or secondary aliphatic amine in the presence of a hydrogenation catalyst.

Société des Produits Azotés. E.P. 519,570, 1.4.40. Appl. 24.6.38.—Direct manufacture of sulphur trioxide in the liquid state by causing a gaseous mixture, containing at least 30% of sulphur dioxide and at least sufficient oxygen to combine therewith, to pass over an active catalyst such as platinum or vanadium oxide. The sulphur trioxide formed is separated by direct condensation in the liquid state.

G. W. Johnson. E.P. 519,613, 1.4.40. Appl. 15.7.38.—Production of valuable liquid hydrocarbons from liquid carbon monoxide reduction products by catalytic treatment in the vaporous phase, preferably in the presence of hydrogen, *e.g.* by cracking or destructive hydrogenation. The formation of undesirable low-molecular hydrocarbons is considerably reduced by the addition of cyclic hydrocarbons boiling within the range of middle oils and which are at least partly vaporous under the reaction conditions.

W. Baird and A. G. Murray. E.P. 519,617, 2.4.40. Appl. 25.6.38.—Manufacture of *cyclo*-hexylbenzthiazylsulphonamides by oxidizing a *cyclo*-hexylamine salt of mercaptobenzthiazole in which each carbocyclic ring may carry a methyl substituent.

G. T. Morgan and J. Stewart. E.P. 519,660, 2.4.40. Appl. 28.9.38.—Manufacture of mono-nitro-1 : 3-diazalines by heating a dinitro-secondary amine, preferably in a medium of high boiling point, until nitrous fumes are evolved.

F. Meyer. E.P. 519,661, 2.4.40. Appl. 20.11.37.—Process for obtaining water-soluble, polyhydroxyl amino-aromatic sulphonamides from amino-sulphonamides by reacting an amino-aromatic sulphonamide with an aldose.

Society of Chemical Industry in Basle. E.P. 519,683, 3.4.40. Appl. 22.9.38.—Manufacture of melamine from dicyandiamide or cyanamide with addition of liquid ammonia. The conversion is begun at a temperature not substantially above 110° C., and then, while the ammonia is being distilled off, it is completed at a higher temperature and under a pressure lower than 200 atoms.

Bakelite, Ltd. E.P. 519,721, 4.4.40. Appl. 30.8.38.—Dealkylation of alkyl-substituted phenols to obtain lower phenolic homologues by passing a mixture of hydrogen and an alkyl-substituted phenol over a heated catalyst obtained solely by heating nickel sulphide, or the silicate, oxide, or sulphide of barium, cadmium, iron, aluminium, or zinc, in a finely divided form in an atmosphere of hydrogen.

E. I. Du Pont de Nemours. E.P. 519,750, 4.4.40. Appl. 30.9.38.—Preparation of alkali metal salts of sulphuric esters of long-chain aliphatic alcohols in extruded form by neutralizing a sulphuric ester of a long-chain aliphatic alcohol with a concentrated aqueous solution of an alkali metal base, in the presence of an inert solid diluent, and preferably under reduced pressure, and effecting extrusion of the neutralized mass in the form of threads or needles.

Society of Chemical Industry in Basle. E.P. 519,776, 5.4.40. Appl. 14.9.38.—Manufacture of derivatives of fluoranthene by causing a halogen substitution product of fluoranthene to react with a compound containing at least one hydrogen atom combined with nitrogen and the radical of a compound capable of being vatted.

Houdry Process Corporation. E.P. 519,808, 5.4.40. Appl. 4.10.38.—Manufacture of contact masses for use in the treatment, conversion, or production of fluids, including hydrocarbons and their derivatives. A zeolitic body is formed from reactant solutions and afterwards treated with a solution, incapable of dissolving nuclear substance by acid reaction, and containing a volatile or unstable cation capable of base exchange. H. B. M.

Refining and Refinery Plant.

929.* Treating High Sulphur Cracked Distillate with Acid Process. F. A. Apgar and C. A. Day. *Oil Gas J.*, 28.3.40, **38** (46), 187.—A description, with flow sheet and test-run data, is given of a Stratcold treating plant installed at a Watson (Calif.) refinery and designed to treat 11,000 brl. per day of heavy cracked naphtha with 9 lb. of 98% H_2SO_4 per brl. in three stages, at 30° F., 30° F., and 20° F., respectively. Each stage consists of a chiller, horizontal refrigerating contactor and sludge settler. The naphtha is cooled to treating temperature in a shell-coil ammonia chiller and passed to the contactor, where acid and distillates are rapidly circulated by an impeller over tubes cooled by ammonia. The treated material is then passed upwards through a clarifier or rock packed tower, water washed and neutralized with NaOH solution. Mercaptan sulphur was reduced in one test from 50 to 2 mgms. per 100 c.c., with a treating and polymer loss of 5·54%, and octane number loss of 1. Caustic soda consumption for neutralization is 0·06/0·08 lb. per brl., and electric power consumption 0·7/0·9 kw. per brl. C. L. G.

930.* Measuring Internal Diameter of Still Tubes. W. A. Howard. *Oil Gas J.*, 28.3.40, **38** (46), 78.—The accurate measurement of the internal diameter of still tubes is reduced by the presence of scale, the varying lengths and diameter, and the general inaccessibility of such tubes. An internal electro-caliper has been devised and is now in use at several refineries. It gives direct readings in any diametrical plane, accurate measurement of small pockets and grooves, and is rugged and rapid to manipulate. Measurement is made in the de-scaled tube by the motion of two opposing plungers expanded by spring pressure and geared to a common rotating shaft. A special type of wire-wound potentiometer is mounted about the rotating shaft, and the variation in voltage obtained through the potentiometer, due to the movement of the plungers and the rotating of the potentiometer arm, is transmitted by an electric current through a voltmeter calibrated directly in inches. A pair of plungers covers a range of measurement of $\frac{1}{2}$ in., extensions and centring springs being provided for larger tubes. An accuracy of 0·005 in. is possible with this instrument. By the addition of suitable arms it is possible to use the instrument as a gauge for the presence of oversize areas.

A complete picture of the size of the tube may be obtained by the addition of external tube calipers equipped with a dial gauge. C. L. G.

931.* Oxidation of Thiophen-sulphur by Calcium Hypochlorite Solution. E. G. R. Ardagh, W. H. Bowman, and A. S. Weatherburn. *J. Soc. chem. Ind.*, 1940, **59**, 27–28.—Factors influencing the proportion of thiophene-sulphur converted into sulphate as a result of the oxidative action of calcium hypochlorite solutions are discussed. The range of pH values found most effective for the oxidation of thiophen by this method is in the neighbourhood of 8 to 7. T. C. G. T.

932. Patent on Refining. N.V. de Bataafsche Petroleum Maatschappij. E.P. 519,397, 26.3.40. Appl. 21.10.38.—Process for the removal of mercaptans from an alkaline-reacting mercaptide solution. H. B. M.

Analysis and Testing.

933.* Occurrence of Free Sulphur in Lignite Coke. E. Graefe. *Oel u. Kohle*, 1940, **36**, 14–16.—The presence of free sulphur was demonstrated by extracting samples of four types of lignite coke with carbon disulphide and removing the solvent by evaporation. Only in one case were the typical yellow crystals formed, the other samples yielding oily drops. In each instance, however, the product was proved to be elementary sulphur by reaction with a silver mirror. This method had to be used on account of the minute amounts being dealt with, the estimated weight of one crystal being 0·00002 mg. The article is illustrated with microphotographs.
T. T. D.

934.* Estimation of Lead in Ethyl Fuels. H. Sieboneck. *Oel u. Kohle*, 1940, **36**, 16–17.—The author describes a colorimetric method which takes only 45 min., compared with the 4–5 hr. required by the standard method.

The fuel is treated with Br and the lead bromide converted into nitrate in the usual manner. The nitrate solution is either evaporated to dryness and taken up in distilled water and a little HNO_3, or neutralized with ammonia and made just acid with HNO_3. An aliquot of this is treated with an ammonium chloride-glycol buffer, and standard sodium sulphide solution added. This forms a brown solution, which is compared in a colorimeter with a similarly treated standard lead solution containing 0·1 mg. Pb/ml.

The author describes the modification necessary when dealing with highly olefinic gasolines. He contends that this method is very accurate and agrees excellently with the gravimetric estimation, while taking one-sixth of the time. T. T. D.

935. Equilibrium Cell for Investigating Properties of Fluids from Petroleum and Natural-gas Reservoirs. K. Eilerts, R. V. Smith, and R. C. Wright. *U.S. Bur. Mines, Rep. Invest.* No. 3514, April 1940.—The term " combination well " has been applied to those wells from which gas and light volatile hydrocarbon liquid in quantities of economic significance are recovered at a relatively high ratio of gas to liquid. During the course of development and operation of such wells many new problems have arisen, the solution of which depends on an intimate knowledge of the characteristics of the fluids produced at the relatively high pressures obtaining in the reservoirs.

It was found impossible to predict the behaviour of these fluids by comparing them with that of low gas–liquid ratio fluids at identical pressures and temperatures. Accordingly, in order to obtain the desired experimental information, an equilibrium cell was constructed at the Petroleum Experimental Station of the Bureau of Mines, Bartlesville, Ohio.

This report contains a full account of the cell, which is designed to operate at pressures up to 5000 lb. per sq. in. absolute and for the range of temperatures common in the production of petroleum. The cell is capable of measuring dew point, saturation pressure, and specific volume of hydrocarbon mixtures. In addition, phases of natural hydrocarbon mixtures in equilibrium can be provided by means of the apparatus for subsequent sampling and analysis by fractionation.

It is hoped that when sufficient experimental data have been accumulated, it may be possible to make dependable estimates of the phase relations for high gas–liquid ratio fluids at the pressures and temperatures characteristic of " combination well " reservoirs. H. B. M.

936.* New Method of Gas Analysis. W. J. Gooderham. *J. Soc. chem. Ind.*, 1940, **59**, 1–8.—The simplest form of gas analysis can be obtained by passing gas through a series of accurate metres and absorption reagents and recording the gas flow after each absorption.

Accurate gas meters have been developed by timing the rate of travel of a soap film pushed by the gas through a calibrated vessel. The soap films are produced by solutions of " Igepon " and " Aerosol," these latter being the proprietary names of certain complicated organic sulphonates.

Using diaphragm pumps, a new form of gas holder made of corrugated metal rings, and a special type of governor, average gas samples can be readily collected, stored under pressure, and analysed.

The advantages claimed for the method are :—

(1) Accurate results, which can be quickly repeated, are obtained in a few minutes from stop-watch readings.

(2) There are no taps or mercury to clean, only reagents to be replaced.

(3) Breakages do not occur ; the moving parts revolve easily, the apparatus is not handled, and it is completely enclosed.

(4) New reagents, which attack mercury and tap grease, can be used (*e.g.* activated nitrating mixture for unsaturated hydrocarbons).

(5) The use of mercury, with the attendant dangers of poisoning, is avoided.

(6) Appreciable errors due to the dissolution of gases in reagents and of absorption of carbon dioxide on the oxides are obviated.

(7) There is no appreciable dead space in the apparatus, the soap is churned up by a spiral, and thus brought more readily into equilibrium condition with the gas. T. C. G. T.

937.* Determination of Dissolved Oxygen in Gasoline. W. A. Schulze, J. P. Lyon, and L. C. Morris. *Oil Gas J.*, 28.3.40, **38** (46), 149.—A description is given of a modification of the manganous hydroxide–iodine method for the determination of oxygen in water, which has increased its accuracy and enabled it to be used for the field testing of dissolved oxygen in gasoline. The test is carried out by introducing 100 ml. distilled water and 10 ml. $MnSO_4$ solution (480 gm. $MnSO_4.4H_2O$ per litre) into a calibrated sampling bottle, removing the air by evacuation, and flushing with air-free propane or nitrogen, and 7 ml. of alkaline iodide solution (700 gm. KOH or 500 gm. NaOH + 150 gm. KI per litre), followed by 8 ml. of distilled water. Manganous hydroxide is precipitated and the gasoline is introduced, followed by vigorous shaking for 1 hr. The aqueous solution is carefully separated and the liberated iodine titrated with standard thiosulphate solution. With straight-run gasolines the test is accurate to within $\pm$ 5%, but with cracked gasolines the absorption of iodine by the unsaturateds present causes inaccuracies.

Full details of the test and precautions necessary are given. C. L. G.

Motor Fuels.

938. Patent on Motor Fuels. A. McKellar. E. P. 519,855, 8.4.40. Appl. 4.10.38.—Production of a blended fuel by dissolving an alkali in alcohol and then adding the result to a fat or fatty acid until the product is neutral. The said neutral product is used as a blending agent to blend a hydrocarbon fuel with hydrous alcohol.

H. B. M.

Diesel Fuels.

939.* Characteristics of Diesel Fuels Influencing Power and Economy. A. J. Blackwood and G. H. Cloud. *J. Soc. aut. Engrs*, 1940, **46** (2), 49–53.—This paper presents data obtained during an extensive fuels research programme and deals very largely with power and fuel economy obtained when using fuels of varying physical and chemical characteristics. Engine performance characteristics, such as smoke, cold starting, carbon formation, ring sticking, are not dealt with. The authors present all data relating to fuel economy on a volume basis, in preference to a weight basis, as they point out that diesel fuels are invariably sold by volume, and results based on weight are therefore apt to be misleading.

A selection of gas oils from widely different crudes were each fractionated into four cuts of approximately 100° F. boiling range, providing in all about 30 fuels. The majority of the tests were run on a 6-cylinder, $3\frac{1}{4} \times 4\frac{1}{2}$ ante-chamber engine. Tests on fuels of various mid-boiling points having the same cetane number show that volumetric fuel economy improves with increasing mid-boiling point, which is no doubt due to the fact that, for either constant gravity or cetane number, an increase in mid-boiling point is accompanied by a corresponding increase in B.T.U.'s per gallon. As speed increases from 800 to 2400 r.p.m. the effect of cetane number is gradually reversed, the lower-ignition-quality fuels showing the best volumetric economy at the lower speeds, and the higher-ignition fuels being better at the higher speeds. It is stated that as speed increases ignition lag becomes more significant and consumption deviates from the heat content basis in favour of cetane number, whilst at the lower speeds ignition lag is of less importance, and the reverse is true. Tests on the effect of viscosity on pump leakage show that power loss from this cause can better be remedied by keeping the pumps in good mechanical condition than by using fuel of higher viscosity.

Assuming complete combustion, fuel volatility affects the specific volumetric consumption only in so far as it is related to heating value and ignition quality. An interesting chart shows the cross-relationship of heating value, ignition quality, and viscosity to other fuel properties commonly available from routine fuel inspections.

C. H. S.

Lubricants and Lubrication.

940.* Lubrication of I.C. Engines with Mineral Oils Compounded with Stabilized Vegetable Oils. M. Freund and St. Thamm. *Oel u. Kohle*, 1940, **36**, 18–22, 55–57.—The most suitable inhibitors and blends for use in engine tests were determined by laboratory oxidation. The method used was to pass oxygen at 2 bubbles/sec. for 5 hr. through 60 ml. of oil maintained at 200° C. Specific gravity, viscosity at 50°, acid value, and Conradson number were determined before and after oxidation, to assess stability. The oils investigated were castor oil and olive oil, rape oil with and without inhibitors, and, for comparative purposes, a Rumanian mineral lubricating oil. From the results obtained it was inferred that in the presence of a suitable inhibitor, rape oil is as satisfactory as the stable vegetable oils.

Engine tests were carried out in a single-cylinder four-stroke water-cooled petrol engine directly coupled to a dynamo, so that its output could be measured. Owing to the viscosity requirements of the engine, pure rape oil could not be used in it, so tests were run on a mixture of rape oil and blown rape, with and without inhibitors; on rape-mineral oil blends containing an inhibitor; and on soluble castor-rape-mineral oil blends.

Full tables are given of the results obtained, and photographs illustrate the condition of the cylinder and piston at the end of various runs.

The results of the tests showed that a great improvement in the condition of the engine was apparent if inhibitors were used, compared with the unstabilized vegetable oils. Compared with mineral oils, rather more carbon was deposited in the combustion chamber, but analysis of the sump oil and performance of the engine were similar. In the authors' opinion, stabilized rape oil is quite satisfactory for the lubrication of I.C. engines.

T. T. D.

Asphalt and Bitumen.

941. Report of the Road Research Board for the Year Ended 31st March, 1939.—The investigation of soil problems has been continued, and new apparatus has been constructed for taking undisturbed soil samples and for carrying out consolidation tests. The value of soil surveys has been confirmed, and the Ministry of Transport has made increasing use of these before laying new trunk roads. Laboratory tests indicate that mechanical compaction of soil merely causes a reduction in air-voids and does not expel moisture from the soils, thus limiting the degree of compaction obtainable. The addition of binder was found to cause a considerable increase in the volume of a given weight of soil. Experience gained with earth roads stabilized with bituminous emulsions or concrete indicated that it is inadvisable to lay bituminous stabilized soil after July, since it would not dry out properly.

It has been found unnecessary to use many sizes of sieves for an aggregate grading analysis, and the B.S.I. now recommend only twenty sieves, ranging from 200 mesh to 3 in., whilst for many purposes only eleven sieves are necessary. The distribution of particle size in a "single-sized" aggregate can be expressed in terms of the mean size and standard deviation, and thus a consistent degree of quality can be obtained by specifying the limits of variation from the nominal size. Tables giving the covering power of chippings for any grading, size, or shape have been drawn up, but their utility is limited at present by the variability of chipping sizes. The aggregate crushing test, which measures the percentage passing a 7-mesh sieve after crushing $\frac{3}{8}$–$\frac{1}{2}$ in. under 40 tons, has been standardized. Improvements have been effected in equipment for mechanical tests on bituminous materials, and preliminary tests have been made on the transient load-testing machine to duplicate loads on the roads. Marked changes in the mechanical properties of aggregate-filler binder mixtures with and without sand have been found to occur when the optimum proportion of the filler-binder constituent is exceeded. Investigation of methods of designing bituminous mixtures on a basis of simple laboratory tests has reached the point at which it is felt that full-scale trials are justified and arrangements have been made for these, varying the quantity and nature of the binder, filler and coarse aggregate in order to vary the mechanical properties.

The co-operative work with the Asphalt Roads Association has been continued and the range of bitumens has been extended to include some abnormal materials which may throw light on some factors which affect normal bitumens. Further study of the visco-elastic properties of asphalts by means of modified Couette and Ostwald viscometers shows that when a bitumen is subjected to constant stress the resulting shear exhibits elastic, thixotropic, and viscous flow components, and if applied for a sufficient length of time, the rate of shear ultimately attains a constant value. It also appears that in comparing one bitumen with another differences in plastic and elastic properties are of more practical significance than differences in temperature coefficients of viscosity. The mechanical properties of laboratory prepared mixtures are being examined and compared with those obtained from the road. The essential properties appear to be the rate of deformation under unit stress, the plastic flow index, the temperature coefficient of deformation, and the extensibility. Sections laid on the Colnbrook By-pass, some with shortage of fines to accelerate failure, have in general hardened considerably, as shown by the resistance to deformation, but this is not shown by a corresponding fall in the penetration of the recovered bitumen. Work has also been commenced on the effect of weather on the properties of bitumens.

The co-operative work with the Road Tar Research Committee has been continued with similar aims, and an attempt is being made to relate the durability of tar under road conditions to the results of durability tests made in the laboratory. For this purpose tars made by a number of different processes, etc., including those containing up to 10% of bitumen, have been used. The mechanical properties of sand–filler–tar mixtures have also been examined. It has been found that for both asphaltic bitumen and tar binders the temperature coefficients of deformation of laboratory prepared specimens are the same as those of binders alone. Full-scale work is being carried out with tar-chlorinated rubber mixtures in conjunction with the British Rubber Producers Research Association. The method of preparing the mixtures has a great influence on the resultant properties; as well as improving the elastic recovery of tars, chlorinated rubber markedly increases the adhesive properties. Granular dispersions of latex and vultex in bitumen are also being investigated, and show increased elastic characteristics and adhesion.

Various technical improvements have been made in the methods of analysing bituminous mixtures, and it is found that pure benzene gives better results in recovering bitumen than does carbon disulphide, since the latter is particularly affected by the presence of water. A technique has also been evolved for recovering liquid binders of a wide range of viscosity from solution.

The experiments to compare results on the Colnbrook By-pass with those on the road machine have been continued. In many cases the carpets were designed as the result of road failures elsewhere, and their unexpectedly long life may be due to the long time allowed before traffic was permitted or to the accurate carrying out of specifications. The work on No. 2 Road Machine, using solid rubber tyres, a moderate temperature, and a constantly wet surface, has shown that it places materials in a different order from that obtained on the road, since the types of failure found are different. There appears to be little doubt that the development of the best type of road machine must include provision for control of temperature and moisture conditions similar to those found in practice, otherwise serious anomalies arise. It is noted that with failures on No. 1 Road Machine the displaced stones are in general well coated on their undersides with binder, and this machine and No. 3, both with pneumatic tyres, reproduce the type of wear found on the road, although the use of continuous wet testing is open to question.

Laboratory tests on the use of hydrochloric acid to reduce the slipperiness of smooth concrete surfaces have been continued on a full scale, and it has been shown that the method is practicable and cheap. A considerable amount of work is being carried out to improve the skidding resistance of wood-block surfacings, and the use of a cast-iron surface with much smaller studs has increased the sideway force coefficient (s.f.c.) from 0·25 to 0·45. Since tyre-tread rubber hardness and viscosity of water both decrease with rise of temperature, these two effects tend to cancel each other with regard to the s.f.c.; it is also independent of the degree of wetness of the road. By means of texture prints it has been found that open-textured tar or bitumen carpets show little change, but that the close-textured either become progressively smoother or self-roughened owing to uniform abrasion. Some of the phenomena of slipperiness, such as the large seasonal variations, are not yet fully understood, and it is hoped that further data will be obtained on a special 2000 ft. long skidding track. The track will also form a useful calibration surface for the various machines used by the laboratory for studying the non-skid properties of roads, and will be used for tests for weathering only on bituminous surfacings.

The apparatus for carrying out tests on skidding at high speeds was completed during the past year, and a few tests have been made at 70 m.p.h. Results show that the s.f.c. continues to decrease at the higher speeds. By means of a cathode-ray oscillograph the maximum normal pressure under a tyre moving at 0–40 m.p.h. has been found to be approximately 1·5 times the inflation pressure. By this means also measurements of the horizontal shear stresses have also been made, and one interesting indication already obtained is that whereas these stresses are compressive in character under a pneumatic tyre, due to excess tensile forces in the tyre, they are tensile under a solid tyre.

The statistical investigation of the traffic and weather on the Colnbrook By-pass has been continued, and it has been found that the most densely trafficked strips of the 30 ft. wide road occur at 9–10 ft. from the kerb. After any prolonged period of sunshine the temperature of the road surface is greatly in excess of that of the air, being higher the darker the road, whilst in dull weather it approximates to that of the air. The lowest temperature observed for an asphalt surface was − 6·5° C., and the highest 48° C. The average daily loss of stones per week from the Colnbrook By-pass thin surfacings has been found to be inversely proportional to the minimum temperature for that week. H. G. W.

942. Patents on Asphalt and Bitumen. Standard Oil Development Corporation. E.P. 519,463, 27.3.40. Appl. 15.9.38. Improvement in the adhesivity of bituminous compositions comprising a bitumen cutback or emulsion by the addition of a phenolic compound of a metal.

Naamlooze Vennootschap Maatschappij tot Beheer en Exploitatie Van Octrooien. E.P. 519,549, 29.3.40. Appl. 3.10.38.—A binder consisting of a mixture of finely divided, inorganic material and an organic bituminous substance capable of pyrolytic reaction is incorporated with a mass of glass fibres to produce a tough, strong product of low density. H. B. M.

Special Products.

943.* Recent Development in the Field of Synthetic Rubber. H. Mark. *Chem. and Ind.*, 1940, **59**, 89–90.—The article represents a digest of a review presented to the Montreal section of the Society of Chemical Industry. Developments in production and the desirable features of the synthetic rubbers are outlined. T. C. G. T.

944. Studies of Carbon-black. V. Effect of Gas Composition on Production and Properties of Carbon Obtained by Non-Impingement Methods. L. M. Pidgeon. *Canad. J. Res.*, 1939, **17**, 353–363.—Lamp-black is produced from hydrocarbon gases, methane, ethylene, and propane, by burning them in restricted air supply. The carbon is removed from the burnt gases by filtration. Maximum yields are obtained when the combustion tube is heated externally at 550–1100° C. and when an air/gas ratio slightly below theoretical is used. Under these conditions the yields are ethylene 8·3 lb./1000 cu. ft., 85% methane + 15% ethane: 3·9 lb., 70% propane + 30% butane — 13 lb.

The carbon from burning olefins resembles carbon-black in its ability to reinforce rubber, whilst the carbon from paraffins resembles lamp-black and does not reinforce rubber.

Experimental data are summarized in tables and graphs, and a diagram of the combustion apparatus is included. T. C. G. T.

Coal and Shale.

945. Patent on Coal. N.V. Nieuwe Octrooi Maatschappij. E.P. 519,310, 21.3.40. Appl. 17.9.38.—Process for the production of coke with a very low volatile content. A hydrocarbon mixture is separated by heating into a relatively light vaporous part and a relatively heavy liquid part. The vaporous part is cracked and the products are cooled. The heaviest fractions are thereafter separated in liquid form and passed into one or more liquid cracking chambers in which cracking to coke is effected while passing heat carrier gas therethrough. H. B. M.

Economics and Statistics.

946.* Rumania's Internal Consumption of Petroleum Products. Anon. *Monit. Pétr. roum.*, 1940, **41**, 189–196.—Rumania's own consumption of petroleum products is tabulated for each of the ten years 1930–1939. In 1939 the home consumption was 1,784,750 tonnes (out of a total production of 5,962,321 tonnes), consisting of: light gasoline 134,228; heavy gasoline 29,353; kerosine 193,903; gas oil 126,836; special fuels 133,264; heavy fuel 1,077,235; lubricating oil 25,253; asphalt 45,348; wax 3814; and coke 15,516.

The increase in consumption from 1,674,046 tonnes in 1938 is shared by all products with the exceptions of heavy spirit and coke, both of which register declining consumption.

Over the ten years figures recorded the most notable increase has been that of asphalt. In 1930 only 6701 tonnes of this product were consumed, against 45,348 tonnes in 1939. This represents 577% increase, compared with only 42% increase in the grand total consumption.

Further tables illustrate the amount of each product contributed to home consumption by most of the oil companies operating in Rumania, and also the amounts consumed by these companies for their own use. T. C. G. T.

947.* Developments in the Prices of Rumanian Petroleum Products During 1939. Anon. *Monit. Pétr. roum.*, 1940, **41**, 123–130.—The gradual increase in the prices commanded by exported Rumanian petroleum products during 1939 shows a rapid increase during the critical months of the summer. Motor spirit in particular showing more than 100% increase between March and December.

The prices are closely analysed and discussed in relation to the fluctuation of the American prices and to the international situation. The article consists largely of tables of prices which should be consulted. T. C. G. T.

948. Survey of Fuel Consumption at Refineries in 1938. G. R. Hopkins. *U.S. Bur. Mines, Rep. Invest.* 3485, Dec. 1939.—According to this report the average amount of heat units required to refine a barrel of crude oil rose from 562,000 B.T.U. in 1937 to 567,000 B.T.U. in 1938. This increase was due chiefly to the decline in total runs to stills. Additional crude runs give lower average heat requirements because they involve comparatively small amounts of auxiliary heat and also because they represent simple topping arrangements. Thus it is that the decline of 1·6% in crude runs to stills in 1938 reflected only an 0·4% decrease in total heat consumption. The rise in average heat requirement per barrel might also be partly explained by the fact that the aggregate yield of complex products requiring more operating steps to produce increased in 1938 by about 1%. In spite, however, of the influence of crude runs on average heat requirements, there was noted definite improvement in firing efficiency, due to increased use of heat-exchangers, the development of combination units, and the trend from solid to gaseous fuels. H. B. M.

BOOK REVIEW

Lubricants and Lubrication. By James I. Clower. Pp. viii + 464. McGraw-Hill Publishing Co., Ltd., London. 1939. Price 33*s.*

A considerable amount of work has been published on the subjects of lubricants and lubrication, mostly scattered in scientific and technical journals for the information of those engaged on more fundamental problems, but there is still a paucity of literature dealing with them in a comprehensive manner which is suitable for the practical engineer.

Most books of this nature are usually unbalanced, in that they either have a strong leaning towards the chemical and physical side of the study of lubricants, or they are overweighted with practical engineering details dealing with the subject of lubrication itself. No criticism of this book can be made on this score, as the author has shown himself to possess a wide knowledge of both branches.

Few users of lubricants have more than an obscure idea of the source, production, and refining of petroleum and its products, and the first three chapters of this volume deal with these subjects clearly and quite adequately for the purpose in mind. A description of the physical and chemical properties of the fixed oils and fats, together with their refining and uses for compounding purposes, then follows.

The majority of books on lubricants are content to describe the manufacture of greases as an art which depends largely on the experience of the maker, but the author explains how the manufacture of both lime-base and soda-base greases has now passed into the hands of the laboratory chemist, who, with the aid of scientific temperature-measuring and control instruments, improved weighing and measuring devices, and easily regulated steam-heated kettles, is able to govern his methods scientifically. That section of the chapter which deals with physical tests is comprehensive, and a valuable table is given of the classification, composition, and uses of various classes of greases for many purposes.

No book on this subject would be complete if it did not include a description of the standard chemical and physical tests employed in the evaluation of lubricating oils, but in this case more attention has been given to the significance of such tests than to their details, which latter information can be obtained by turning to the A.S.T.M. official references which are given in each case. Care has been taken to explain that the results of such tests may bear little relation to actual service performance, and that they give no indication of the lubricating value of oils. The mechanical testing of lubricants is also dealt with in a clear manner, and the Almen, Timken, and S.A.E. machines for testing extreme pressure lubricants, as well as the Herschel instrument, are described, but it is emphasized that these are capable of evaluating lubricants only in terms of wear, scuffing, seizure, and perhaps film strength. The author has wisely refrained from expressing an opinion as to whether any correlation of results is possible between them, or whether reproducible readings can be obtained from any particular apparatus with any degree of accuracy.

In the chapters dealing with the fundamentals of lubrication, the principles of the various types of friction met with in moving parts, and of viscosity and shear, are explained clearly and simply. The accepted conception of oil-film formation and film rupture are also described in detail, and practical hints are given in regard to grooving. Engineers will also find brief hints on the lubrication of ball and roller bearings in the succeeding chapter.

Two subjects which are of considerable economic importance to bulk oil-users are oil purification and also storing and handling. In describing mechanical purifiers such as gravity settlers, centrifuging plant, pressure and streamline filters, and other devices, readers are warned that lubricating oils become unfit for further use, not because they "wear out" or lose their lubricating properties, but on account of the fact that they undergo certain chemical and physical changes which may be aggravated by catalysis, quite apart from any question of contamination with foreign substances. For the guidance of those responsible for storing oil in bulk, a detailed diagram of a central oil-storage house is given and other means of storage are discussed.

Those portions of this book which will appeal most to the engineer are, first, Chapter IX, which deals with oiling and greasing appliances commencing with the simple oil-cup and grease-gun, and leading up to the most complicated methods of lubrication for all types of machinery and plant, and also Chapters XII–XVI, which together fill practically half of the volume.

In these later chapters are to be found descriptions of the arrangement and construction of steam engines and turbines, internal-combustion engines, compressors and refrigeration machinery, as well as their lubrication problems, such as is rarely met with in such detail in technical books of this character. In writing of the internal and external lubrication of steam engines, the author has dealt fully with the various methods and devices, which depend on heat, pressure, centrifugal force, absorption, baffling, and filtration, for the purpose of separating oil from steam and condensate; a subject which, although it may scarcely be classified under the heading of lubrication, is, nevertheless, the direct result of essential lubrication, and is of extreme importance to the steam engineer.

The various methods of lubrication of internal-combustion engines are dealt with fully and the cycles of operations and the types of fuels are also taken into consideration. Finally the cause of ring sticking, blow-by, cylinder wear and ring wear are discussed in an interesting manner.

Some readers will find, no doubt, much which is familiar to them in this book, but the author claims nothing more than that it is "essentially practical"—presumably this is the reason why no references to cognate literature are given—and that it is intended as a book of reference for "buyers, sellers and users of lubricants and for those who design and operate machinery."

This book can be highly commended not only to such readers, but also as a practical treatise to students of engineering and petroleum science, and to those theorists whose knowledge of lubricants and lubrication does not extend beyond laboratory technique.

The diagrams and drawings are very clear indeed, particularly in detail, and the print and blocks are up to the publishers' usual high standard. A. W. Nash.

BOOK RECEIVED

Oil and Petroleum Year Book, 1940. Walter E. Skinner, 15 Dowgate Hill, London, E.C.4. Price 10*s*.

The present volume is the thirty-first annual issue of this well-known year-book of reference to the commercial structure of the oil industry. With one exception, all the customary features of previous volumes are included. The exception is the section of statistics of company crude production, the inclusion of which was prohibited in the national interests.

The company records section covers references to 775 companies engaged in every branch of the industry throughout the world, and is supplemented by comprehensive lists of the names of more than 3300 executives connected with these companies, Other useful sections include a list of 813 trade names of proprietary petroleum products, Statistics of World Crude Production since 1931, and a Glossary of Technical Terms.

INSTITUTE NOTES.

JUNE, 1940.

TELEGRAPHIC ADDRESS.

Telegrams and cables for the Institute should be addressed: "INSTPETECH BIRMINGHAM."

NEW FORMS OF TRANSFER.

The temporary forms of application for Transfer from one category of membership to another, which were used during 1939, are no longer accepted by the Council. The Council has approved a new Form of Application for transfer, requiring particulars of a candidate's experience and qualifications obtained subsequent to the date of election or previous transfer. This Form must carry two supporting signatures from Fellows, Members or Associate Members of the Institute.

Copies of the Transfer Form are obtainable from the Secretary.

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.

GIBBS, Eric Clarence, Engineer, 15, Worsley Road, Hampstead, London, N.W. 3. (Pilot-Officer, R.A.F.V.R.) (*C. B. Horwood.*)

HAWORTH, Alfred John, B.Sc., A.R.S.M., Geologist, c/o the Burmah Oil Co., Ltd., Chauk, Upper Burma. (*J. Coates; T. J. F. Armstrong*) (*Trans. to A.M.*)

JEFFREYS, Lynn John Lewis, Chemist, The Pharmacy, 213, Neath Road, Briton Ferry, Glam. (*W. C. Mitchell; A. E. Holley.*)

LEWIS, Robert Illtyd, B.Sc., Chemist, c/o Asiatic Petroleum Co., Ltd., St. Helens Court, Great St. Helens, London, E.C. 3. (*E. C. Williams; J. Kewley.*)

MILLS, Leonard, Chemist, 55, County Road, Ormskirk, Lancs. (*Vigzol Oil Refining Co., Ltd.*) (*P. Bilton; S. Elliman.*)

MOON, Alec, Engineer, c/o Messrs. Shell-Mex & B.P., Ltd., Shell-Mex House, London, W.C.2. (*R. G. Strickland; H. E. Priston.*)

MOORE, Lancelot Frederick, Manager, 22, Matham Road, East Moseley, Surrey. (*W. B. Dick & Co., Ltd.*) (*J. C. Jennings; A. J. Sear.*)

PINDER, John Cuthbert, A.I.C., Chemist, 63, Marshall Drive, Bramcote, Nottingham. (*British Celanese, Ltd.*) (*J. E. Haslam; H. S. Kiernan.*)

ROUGHSEDGE, Norman Donovan, Manager, "Conway" Silksworth Lane, Sunderland, Co. Durham. (*Sunderland Oil Co., Ltd.*) (*R. B. Hobson; F. J. Cox.*)

LIST OF ADVERTISERS.

Kindly mention this Journal when communicating with Advertisers.

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The friction clutches of the high and low speed drive engage the load smoothly and add greatly to the drilling speed.

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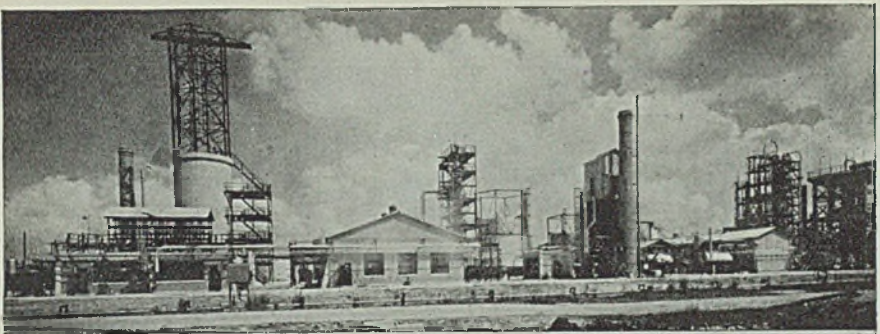

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