REPORT ON TESTS FOR SOIL STABILIZATION.

BY THE SOIL STABILIZATION PANEL OF THE STANDARDIZATION SUB-COMMITTEE NO. 7—ASPHALTIC BITUMEN.

1. The following report constitutes the first account of the discussions and work of the Soil Stabilization Panel of the Institute of Petroleum Standardization Committee. It will be supplemented from time to time by further reports indicating progress achieved.

2. Status and Terms of Reference of the Soil Stabilization Panel.

The Asphaltic Bitumen Sub-Committee of the Institute of Petroleum at a meeting held on the 13th January, 1943, decided to appoint a Panel to consider tests for use in connection with Soil Stabilization. In view of the function and scope of the Institute of Petroleum, the work has been confined to stabilization by means of products of a bituminous nature.

3. Constitution of the Soil Stabilization Panel.

The Panel has the following membership :—

Mr. L. G. Gabriel (in the Chair).
Mr. J. F. T. Blott.
Mr. I. Cameron (alternate Mr. A. E. Lawrence).
Dr. F. J. Gillbe.
Mr. J. S. Jackson (*ex officio*).
Mr. A. H. D. Markwick (alternates Mr. K. E. Clare and Dr. L. Maddison).
Mr. A. Osborn (alternate Dr. H. G. Williams).
Mr. A. R. Stark.

Co-opted members :

Dr. B. A. Keen, F.R.S. (later Dr. R. K. Schofield).
Mr. R. Glossop.

4. Plan of Work.

The Panel considered it to be highly important in discussing tests for soil stabilization to adopt a logical plan of attack. The plan adopted in compiling this schedule of tests was to review and classify tests placed before the Panel into Groups, in which the individual tests differed from each other only in detail. The procedure adopted in accumulating the data for examination was to take all known published schedules of tests, together with certain tests known to be in use in laboratories in this country. The variations of detail were eliminated after discussion by the Panel, and an agreed final procedure was adopted to replace the numerous variants previously in use. It was realized that although it was inevitable that the adoption of these new agreed versions of the tests might, to a certain extent,

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cause difficulties in correlating new data with those previously obtained in any particular laboratory, it should provide for a great degree of interchangeability in the future between the results of different laboratories.

Where distinct methods of test exist covering similar properties of the materials (*e.g.*, the cone penetration resistance and the compression tests), no attempt has been made to eliminate one method in favour of the other where both are well established, but in certain cases attention has been directed to the main considerations for and against the alternative methods.

The Panel decided, in the first place, to concentrate on those tests which are devoted to evaluation of the properties of stabilized soil mixes, *i.e.*, the fundamental performance tests for stabilized soil. The schedule of tests presented with this report comprises certain tests which, in the opinion of the Panel, are of this type and suitable for standardization.

In addition to tests of the type discussed above, there may be a number of tests—one of which is included in the present report—which are used by individual laboratories, but which are not generally known and may be of recent development. In such cases the Panel may decide that certain of these methods are of sufficient interest to be included in the Schedule under the category of " tentative " tests.

In discussing the details of the tests now put forward for standardization, it has been found necessary to attempt a certain measure of definition of terms employed, and also to direct attention to certain fundamental considerations relevant to the practice of soil stabilization, without which the true terms of reference of the tests cannot accurately be appreciated. In this report, therefore, there are embodied notes on these matters which should be read in conjunction with the test procedures herewith presented.

5. Definition of Terms.

Soil.

The Panel has had before it the difficulty of defining accurately what is the meaning of " soil," and after very full discussion it has found itself unable to define soil in the sense at present under consideration.

Stabilization.

Soil stabilization involves the manipulation, treatment, and compaction of a soil in such a manner that it will remain in its initial compacted state without detrimental change in shape or volume when subjected to the stresses imposed by traffic or other agency and to the disintegrating and softening action of the weather and sub-soil water.

There are several distinct ways in which this can be done. Thus :—

(1) By imparting high internal friction to soil to promote resistance to deformation under stress (mechanical stabilization);

(2) By waterproofing designed to limit the ingress of water so that the material will not soften by absorbing water from the subgrade;

(3) By binding the grains of soil together either by the use of a cement or bituminous binders.

Frequently all three principles are applied in a single process.

Bituminous stabilization, with which alone the Panel is concerned, aims at providing mechanical stability—*i.e.*, capacity for supporting superimposed

loads without undue deformation, and resistance to such excessive absorption of water as would reduce the stability.

A subsidiary property which it is aimed to confer by bituminous stabilization is resistance to the disintegrating action of frost.

6. Interpretation of and Comments on the Schedule of Soil Stabilization Test Methods.

As indicated above, it was felt that it would be useful to record some of the reasons underlying the selection of the test conditions, and to discuss the nature of some of the problems which have to be solved.

Schedule.

The following tests are included in the present schedule :—

A.1. Preparation of Soil Mix.
A.2. Determination of Moisture Content.
A.3. Cone Penetration Resistance of a Compacted Stabilized Soil Mixture.
A.4. Compression Test.
A.5. Capillary Water Absorption Test.
A.6. Determination of the Bulk Density of Soil as present in Compacted Test Specimens of Stabilized Soil.
T.1. Water Absorption Test by Immersion.

" A " = Accepted test.
" T " = Tentative test.

Methods of Mixing and Compaction.

The processes which have been proposed for stabilizing soils cover a variety of petroleum products, and methods of operation. Thus the stabilizer may vary from a hard bitumen to a fluid oil or cutback, which may be applied as such or in the emulsified form, while the stabilizer may be incorporated into the soil with the aid of a stationary or travelling mixer or by mix-in-place methods. The methods used in practice are governed to a considerable extent by the type of stabilizer employed and by differences in construction technique which are likely to constitute important factors in the behaviour of the mix. Thus, for example, it is reported in the literature that the time and intensity of mixing can affect considerably both the mechanical stability and the water resistance of the compacted mix, but it does not necessarily follow that better results are obtained with the most thorough mixing. For these reasons, therefore, and since the investigation of a soil by the methods proposed will usually be made with a view to determining whether that soil can be successfully stabilized by a particular process, the Panel did not feel justified in presenting any standard mixing apparatus for the preparation of the soil mix, and has confined the standardization to certain treatments and precautions which are necessary to render the condition of the sample suitable for the subsequent testing operations. In Test Method A.I., however, it was thought advisable to recommend general methods of mixing which have been found suitable in the laboratory for oils and emulsions respectively, but it is recognized that

it may be desired to select some other method which is better suited to the particular process. It is recommended that in all cases details of the type of mixer used and the technique adopted should be given in reporting the results of the subsequent tests.

In regard to the compaction of the treated soil specimens, the question of the relation between conditions in practice and those in the test method is also one of importance. It is known that the degree of compaction achieved materially affects both the mechanical stability and the water resistance of the mix, but in view of the variations in compaction which are likely to occur under practical conditions, it is difficult to select one set of conditions in preference to another for test purposes. In addition, owing to differences in the size of the compacted specimens used in the different proposed tests, it is impossible for the moment to adopt conditions of compaction in the laboratory which are identical in every respect for all tests. Thus it is known that steady pressure of 3500-lb. total load as applied in Tests A.4 and A.5 does in fact normally produce densities higher than those obtained by the ramming technique of Test A.3 (similar to American Association of State Highway Officials (A.A.S.H.O.) designation T. 99–38) by about 5–10 per cent., according to the water content at which the measurements are carried out. It is also known that the densities given by the use of the steady pressure in Tests A.4 and A.5 are likely to be appreciably higher than those achieved in practice unless special attention is devoted to the compaction of the material, and for this reason the results given by Tests A.4 and A.5 may be more favourable than those actually obtained in the field. It is recommended that the method used for compaction and the densities obtained should be stated in reporting the results of tests.

7. Notes on Individual Tests.

*Test Method A.*1.

Instead of introducing a section on the preparation of the soil mix in the description of each test method, it was decided to give a general method of preparation as a separate test method. In accordance with the discussion given above, this method allows the variations of any particular process of stabilization to be taken into account.

*Test Method A.*2.

Owing to the possible presence of volatile components in the petroleum product used as stabilizer, the determination of the moisture content by drying in an oven is not likely to be satisfactory as a general method for a stabilized soil mix, and the distillation method I.P. 74/44 used for petroleum products has therefore been proposed by the Panel, and a suitable choice of the available alternatives in the original method is recommended.

*Test Methods A.*3 *and A.*4 (*Mechanical Stability Tests*).

The Panel was in general agreement that tests of the type which involve the measurement of the pressure necessary to extrude the compacted mix through an orifice at a constant rate were not to be recommended, owing to the empirical nature of the results, and while methods other than those adopted may give equally significant results, it was felt that the simplicity

of the cone-resistance test (A.3) and the compression test (A.4) rendered those methods most suitable for inclusion in the schedule.

The problem of measuring the load-bearing capacity is one of great complexity, on which there are many different points of view, and while the Panel is of the opinion that the tests adopted give measurements which will be qualitatively in line with the behaviour in practice and serve for comparing different mixes, no attempt is made to indicate their quantitative significance.

In regard to Test A.3, it is known that, with the mould specified (the standard mould used in A.A.S.H.O. T.99–38), the figures obtained may, in certain cases, be influenced by the proximity of the walls, and that the use of a mould of larger diameter would avoid this difficulty. This effect will, however, usually be slight, and since the test is not intended to have an exact quantitative significance, it was considered that the advantage of using a mould which is already standardized out-weighed the disadvantage mentioned.

The compression test A.4 has been developed largely in connection with the testing of soils stabilized with bitumen emulsions. The basic properties affecting the test results—*i.e.*, cohesion and internal friction of the soil—are the same as those governing the performance of stabilized soil specimens in the Cone Penetration Resistance Test A.3.

Test Methods A.5 and T.1 (Water Absorption Tests).

The Capillary Water Absorption Test A.5 is intended to simulate the weathering conditions that occur in the field when the subgrade is wet. The cylindrical test specimen is in contact with water over the base, and is allowed to absorb water for periods up to 28 days. If any changes in capillary properties of the material occur due to water absorption, the long duration of this test permits account to be taken of these. The test should be useful for all processes where the stability depends on the waterproofing of the soil.

In the different versions of the test now in use, various methods are specified for covering the walls, and in some cases the top of the soil cylinder with waterproof material. The Panel at first considered that it was advisable to cover both the walls and the top of the soil cylinder with an unperforated film of paraffin wax, in order to prevent entry of water at any part other than the lower face. Considerable discussion took place on the question of the possible influence of the top covering. With the top covered it was considered that water absorption would take place through the narrow pores of the specimen and air would be expelled through the wider pores; but, if this did not occur, the water absorption would be restricted by the development of an air pressure within the voids. Experimental work was done to check this point, and it was found that the anticipated restriction of entry of water was in fact very marked. It was therefore decided to recommend covering only the sides of the specimen, and this is the method adopted in Test Method A.5.

In the Rapid Water Absorption by Immersion, Test Method T.1, the rate of absorption of moisture is accelerated by increasing the exposed surface through which water can enter the sample and decreasing the effective thickness of the specimen by comparison with that used in other tests. In

this way it is possible to obtain results by immersion for a period of only 16 hours. This period is insufficient for any long-time changes to occur in the stabilized material due to absorption of water, and to curing of the material. Against this limitation, the test has definite advantages in the speed with which the results can be obtained.

Reproducibility of Tests.

It will be noticed that in the specified test methods no attempt has been made to fix the limits of reproducibility. It was felt that more experience will have to be gained in a greater number of test laboratories before these limits can be specified.

8. Future Programme.

In the immediate future, the Panel intend to consider standard methods for :—

(1) Determination of frost resistance of compacted mixes.
(2) Determination of stabilizer content of mixes.
(3) Sampling and treatment of samples in field testing.
(4) Standardization of methods of compaction applicable to all tests.

In regard to frost resistance, the Panel has already given the matter some consideration, and the following is a note on points brought out in discussion.

The need for adequate frost resistance is fully recognized by the Panel, but it was not found possible at the moment to include a test for this property. Methods in which isolated test specimens are subjected to cycles of freezing and thawing were discussed, but it was felt that such tests may not reproduce field conditions sufficiently closely. On the other hand, tests in which the specimen is frozen from the top downwards, with the base in contact with water, may be unduly severe. It was agreed that any decision on this question should be postponed until more information could be obtained on the correlation between the results of laboratory tests and experience in the field.

As regards methods of compaction adopted in preparing the test specimens for the various tests, the Panel has discussed at length the desirability of adopting procedures which will ensure that all tests are carried out on materials of approximately the same density.

In the absence of adequate field data, the Panel was unable to decide on the standard of density required, and therefore it proposed to investigate this matter in greater detail. The Panel will also endeavour to suggest the most desirable degree of compaction at which the tests should be carried out.

9. Methods of Test.

Test Method A.1. Preparation of Soil Mix.

1. *Introduction.*

This method describes the preparation of a soil mix having a desired water content and stabilizer content, for use in subsequent tests.

2. *Apparatus.*

(*a*) *B.S. Sieves.* No. 7 and $\frac{1}{8}$ in. B.S. 410 (1943).
(*b*) *Pestle and Mortar.* The mortar shall be at least 6 ins. in diameter.
(*c*) *Mixing Equipment.* An efficient laboratory mechanical mixer.

3. *Procedure.*

(*a*) The soil shall be air dried at 50 per cent. relative humidity to a state in which it may be crumbled. Normal air drying is generally a sufficient approximation to this condition of humidity.

Note.—Where there is no question of dispute, oven drying at temperatures not exceeding 110° C. may be used, but the results so obtained need to be checked against the results of the air drying method.

(*b*) The soil shall then be rubbed down gently in the mortar to reduce any aggregations which would be retained on the B.S.7 sieve. The whole sample shall then be thoroughly mixed and reduced by quartering until a representative sample of the necessary size is obtained. This sample shall then be screened through the B.S.7 sieve and the residue discarded.

(*c*) The moisture content of the fraction passing the B.S.7 sieve shall be determined by Test Method A.2. I.P.74/44. (In this case oven drying at 105–110° C. is also permissible.)

(*d*) The soil mix shall preferably be prepared by one of the methods suggested below, but it is recognized that other methods may have to be adopted when the test is used in relation to a particular process.

(*e*) The mix shall then be screened on the B.S. $\frac{1}{8}$-in. sieve and the residue gently rubbed or broken down in the mortar and re-screened until the whole of the mix has been passed through the sieve.

(*f*) It is recommended that a period of 24 hours shall elapse between the preparation of the soil mix and that of the test specimen, but it should be realized in this connection that many soils need a period of days before they reach equilibrium behaviour, so that this point should be watched in assessing the value of test results obtained.

4. *Recommended Mixing Technique.*

(i) *With an oil or asphaltic bitumen stabilizer.*

(*a*) The soil sample prepared as described under 3 (*b*) shall be placed in the mixing equipment, and sufficient distilled water added to give the final water content required. The material shall then be mixed for 10 minutes, or until it is judged by visual inspection that adequate dispersion of the water has been obtained.

(*b*) The required quantity of stabilizer and any other admixture shall then

be incorporated in a manner appropriate to the process of stabilization under consideration.

(ii) *With an emulsified oil or emulsified asphaltic bitumen stabilizer.*

(*a*) The soil sample prepared as described under 3 (*b*) shall be placed in the mixing equipment, and sufficient distilled water added to bring it approximately to the plastic limit. The material shall then be mixed for 10 minutes, or until it is judged by visual inspection that adequate dispersion of the water has been obtained. The required quantity of emulsion, diluted as considered necessary with distilled water, shall then be added to the soil and mixing started. Additional distilled water shall be added as necessary during the mixing to ensure a uniform distribution of the emulsified stabilizer. (This condition will usually be reached when the consistency of the mix is about that of soil when wetted to its liquid limit.) Any other admixture shall then be incorporated in a manner appropriate to the process of stabilization under consideration.

(*b*) The mixture shall then be allowed to dry in air until it reaches a consistency approximately equivalent to that obtained at the plastic limit, or until the water content is that required in the subsequent test.

5. *Reporting.*

The report giving the results of subsequent tests on the soil mix shall specify the technique used in the preparation of the mix.

Test Method A.2. Determination of Moisture Content.

The moisture content of the soil or of the soil mix shall be determined by Method I.P. 74/44 with the following details :—

Still.—Of type (i), (ii) or (iii) given under 2 (*b*).

Receiver.—25 ml. as given under 2 (*e*), Special Requirements (iv). The addition of 5 ml. of 10 per cent. caustic soda solution specified for bituminous emulsions shall be omitted.

Amount of sample.—100 gm.

Carrier Liquid.—Petroleum spirit, as given under 3 (*a*).

Test Method A.3. Cone Penetration Resistance of a Compacted Stabilized Soil Mixture.

1. *Introduction.*

This test gives a measure of the load-bearing capacity of a compacted stabilized soil mix. The test may be carried out on a single sample of soil mix selected for a specific purpose. Generally, however, results of greater significance are obtained by conducting a series of tests on samples of different water content, enabling the relationship between cone resistance and water content to be studied.

2. *Apparatus.*

(a) *Moulds.*—Cylindrical steel moulds each having a capacity of $\frac{1}{30}$ cu. ft. with an internal diameter of 4·0 in. and a height of approximately 4·6 in., and having a detachable collar assembly approximately $2\frac{1}{2}$ in. in height; the mould and collar shall be attached to a detachable metal base (Fig. 1).

(b) *Cover Plate.*—Metal or glass plates to act as covers for the moulds.

(c) *Rammer and Guide.*—A cylindrical steel rammer 2 in. in diameter, and weighing $5\frac{1}{2}$ lb., and any guide arrangements which will allow the rammer to be dropped freely and vertically through a distance of 1 ft. as shown in Fig. 2.

(d) *Cone Penetrometer.*—The cone shall be of steel, shall be right-angled, and have a rough surface. The surface may be conveniently roughened by means of concentric shallow V-shaped grooves, 40 to the inch. The dimensions of the cone are not specified, but a base diameter of about 2 in. is suitable. The cone shall be mounted on a shaft, and any type of penetrometer is permissible, provided it allows the shaft to move freely and vertically, is capable of applying the desired load, and is fitted with a locking screw and a device graduated in $\frac{1}{10}$ mm. for measuring the extent of the vertical movement of the shaft. The weight of the rod and cone assembly is not specified, but must be known and must not exceed about 5 kg. (see Fig. 3).

3. *Preparation of Specimen.*

(a) The soil mix prepared as described in Test Method A.1 shall be compacted into the mould in three equal layers to give a total compacted depth of about 5 in., each layer being compacted by twenty-five blows of the rammer dropping freely from a height of 12 in. above the upper surface of each finally compacted layer. The blows shall be distributed as evenly as possible over the surface of the specimen. In order to secure the best possible junction of successive layers, the top surface of each layer shall be loosened before the next portion is put in. After compaction, the collar shall be removed and the top of the soil specimen carefully trimmed level with the top of the mould with the steel straight edge.

(b) The moulds shall be covered with the cover plates and stored for 24 hours before the cone resistance is measured.

4. *Procedure.*

(a) The cone shall be adjusted until the tip makes scratch contact at the approximate centre of the surface of the prepared and stored specimen, and

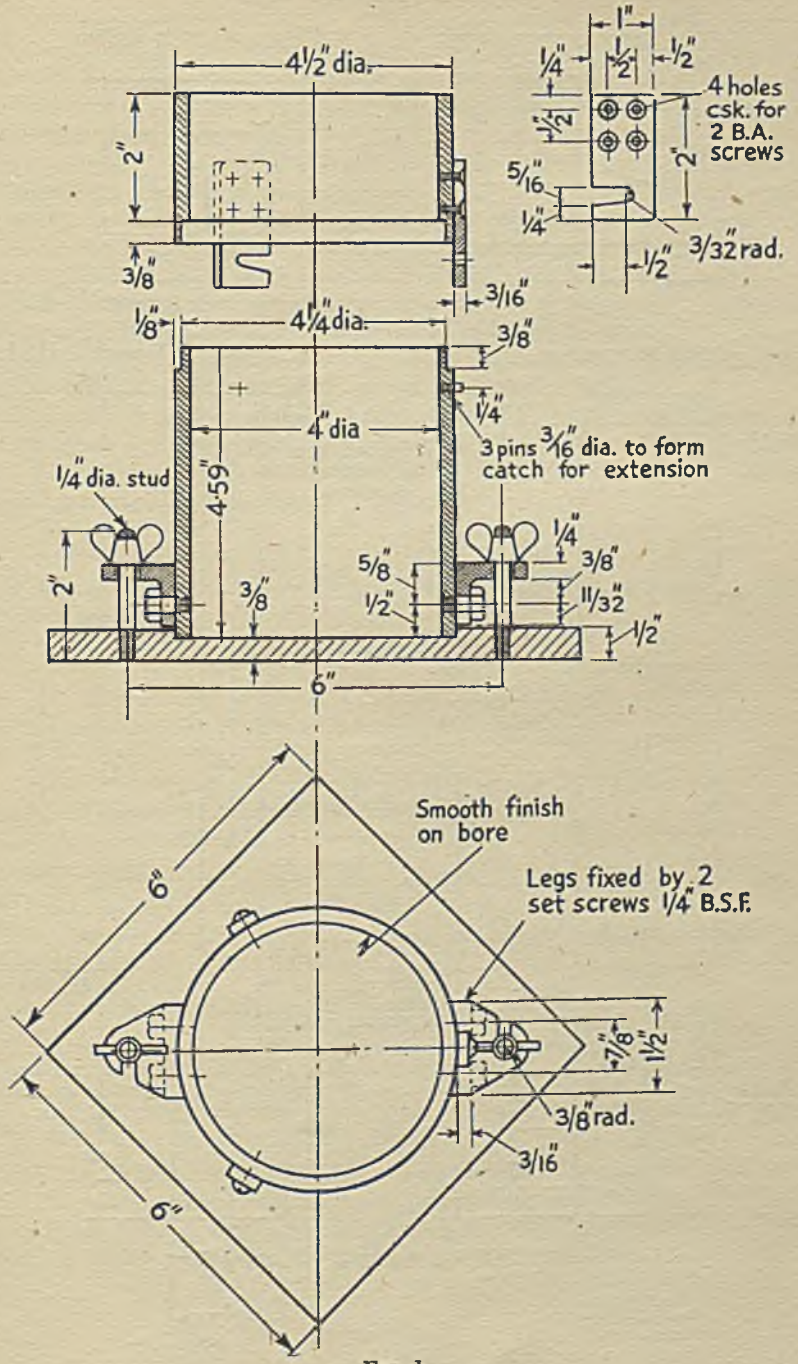

FIG. 1.

COMPACTION MOULD.

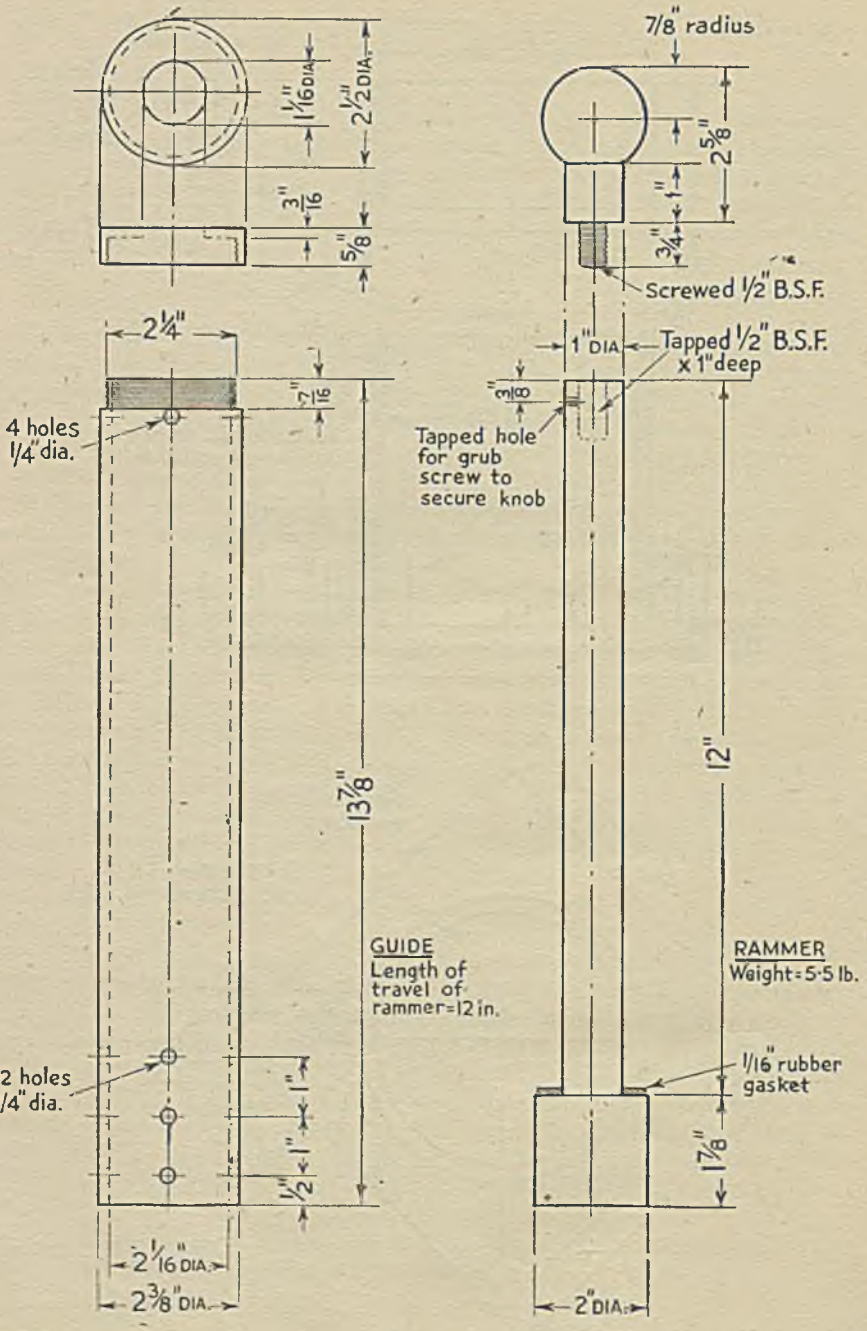

FIG. 2.

COMPACTION RAMMER AND GUIDE.

the penetrometer scale set to zero. The weight of the rod and cone assembly shall be applied gently by first supporting the cone with the fingers and then gradually releasing the finger pressure. One minute after allowing the full weight of the assembly to bear on the sample, the reading of the penetrometer scale shall be recorded.

(*b*) The locking screw shall be tightened, and additional weights added to the platform. An additional weight of 20–25 kg. is suitable for general purposes, but a smaller weight shall be used for specimens with low cone resistance, so that the total penetration of the cone shall not exceed 7 mm. For specimens with high cone resistance larger additional weights may be used provided that the total penetration does not exceed 7 mm. The cone shall be allowed to penetrate further under the additional load by releasing the load gently as before, and the penetrometer scale reading recorded two minutes after allowing the full weight to bear on the sample.

(*c*) The water content of the soil mixture shall be determined by means of test Method A.2 on a sample taken from the centre of the specimen immediately after penetration, and shall be reported with the result of the determination of cone penetration resistance.

5. *Calculation and Reporting.*

(*a*) The cone penetration resistance of the soil shall be calculated from the following formula :—

$$R = \frac{(\sqrt{W_2} - \sqrt{W_1})^2}{\pi(p_2 - p_1)^2}$$

where R = cone penetration resistance in kg. per sq. cm.
W_1 = weight in kg. of cone assembly.
W_2 = weight in kg. of cone assembly plus additional weight,
p_1 = penetration in cm. with load W_1,
p_2 = penetration in cm. with load W_2.

(*b*) The bulk density of the soil as present in the compacted specimen is determined according to Method A.6. and recorded.

(*c*) A curve shall be plotted of the relation : cone penetration resistance against water content.

Note.—The use of two different loads avoids both the necessity of registering the zero accurately, and the errors which would be caused by any imperfection in the tip of the cone. If the cone penetration resistance is measured directly instead of by the differential method, a small error in registering the zero leads to large errors in the cone penetration resistance. Thus an error of 1 mm. in registering the zero causes an error of about 37 per cent. for a mix of cone penetration resistance 20 kg. per sq. cm. when tested under a load of 30 kg.

With the differential method it is only necessary to register the zero approximately in order that the total penetration shall not exceed 7 mm. The figure of 7 mm. is specified, since the disturbing effect of the sides of the mould is likely to be introduced at larger penetrations.

Test Method A.4. Compression Test.

1. *Introduction.*

This test provides a measure of the load-bearing capacity of a compacted stabilized soil mixture. The test may be carried out as such on any particular sample, and is of special interest when conducted in conjunction with the Capillary Water Absorption Test (Test Method A.5.), measurements being made on specimens treated according to the present method and on corresponding specimens which have been submitted to Test Method A.5. A comparison of the results permits the evaluation of the change in bearing capacity due to the absorption of water.

2. *Apparatus.*

(a) *A press* capable of exerting a total load of at least 5000 lb., which may be used for compaction and extrusion of the specimen.

(b) A screw or hydraulic press, which can be controlled to give a regular increase in load of 20 lb. per second. This press may be the same as that described in Section 2*a*.

(c) *Mould.* A cylindrical steel mould, open at each end, 2 in. in internal diameter and 5 in. in length.

(d) *Plunger.* A solid steel cylindrical plunger, 6 in. in length, with a polished circular base which shall be a sliding fit in the mould.

(e) *Base Plate.* A steel plate which may conveniently be of dimensions 6 in. × 6 in. × ½ in.

(f) *Tamping Rod.* A solid steel cylindrical rod, 8 in. in length and 1 in. in diameter.

3. *Preparation of Specimen.*

(*a*) The soil mix prepared as described in Test Method A.1 shall be tamped into the mould resting on the base plate in three approximately equal layers, each layer being tamped with twenty-five blows of the tamping rod, falling from a height of 1 ft. In order to secure the best possible junction of successive layers, the top surface of each layer shall be loosened before the next portion is put in. The moulds shall be filled to within about 1 in. of the top, and final compaction carried out by inserting the plunger and applying a load of 3500 lb. for 2 minutes.

This operation is best carried out by bringing the load to 3500 lb., then immediately releasing the pressure, ascertaining that the plunger is free in the mould, and finally increasing the load to 3500 lb. again and maintaining it for 2 minutes.

The specimen shall then be removed from the mould by extrusion in the press.

(*b*) The specimen shall be air dried until the loss in weight in 24 hrs. is less than 1 per cent. of the total loss in weight.

4. *Procedure.*

The specimen shall be placed in the press, and the load increased at the rate of 20 lb. per second. The maximum load shown on the gauge

before the sample collapses shall be noted. Three samples shall be tested.

5. *Reporting.*

(*a*) The pressure corresponding to the maximum loads recorded on each specimen shall be calculated, and the mean pressure evaluated and recorded.

(*b*) The bulk density of the soil as present in the compacted specimen is determined according to Method A.6 and recorded.

Test Method A.5. Capillary Water Absorption Test.

1. *Introduction.*

This test determines the resistance to water absorption of specimens of compacted stabilized soil.

2. *Apparatus and Materials.*

(a) *Mould.* A cylindrical steel mould, open at each end, 2 in. in internal diameter, and approximately 5 in. in length.

(b) *Plunger.* A solid steel cylindrical plunger 6 in. in length with a polished circular base which shall be a sliding fit in the mould.

(c) *Base Plate.* A steel plate which may conveniently be of dimensions 6 in. × 6 in. × ¼ in.

(d) *Compaction Apparatus.* A press capable of exerting a total load of at least 5000 lb., which may be used for compaction or extrusion of the soil specimens. Alternatively, a 5½-lb. rammer, with a guide arrangement which will permit it to be dropped freely and vertically through a distance of 1 ft. may be used in conjunction with a suitable press for extruding the specimen.

(e) *Absorption Bath.* A vessel closed with a tightly fitting lid and containing a layer of distilled water of sufficient depth to bring the level to a height of approximately 2 mm. above a horizontal perforated zinc shelf on which the soil cylinder rests. The level of the water shall be maintained by means of a suitable water feeding device.

(*f*) *Wire brush* with short stiff wires.

(*g*) *Waxing Equipment.* This shall consist of a metal plate with a smooth upper surface, which shall be kept horizontal. The upper surface shall be covered with a thin film of paraffin wax maintained in a molten state by means of a gas burner or other source of heat.

Paraffin waxes having melting points of about 50° C. and composed of fine crystals have been found suitable. To avoid the danger of contaminating the specimen with acids formed by oxidation of the wax on continued heating, fresh wax should be used on each occasion.

3. *Preparation of Specimen.*

(*a*) The water content of the soil mix prepared as described in Test Method A.1 shall be determined by Test Method A.2 on a sample taken immediately before proceeding with the following operations.

(*b*) The mould shall be stood upon the base plate, and the soil mix introduced in approximately three equal layers, which are gently tamped with the tamping rod. In order to secure the best possible junction of successive layers, the top surface of each layer shall be loosened before the next portion is put in. Sufficient material shall be added to bring the level of the mix to within about 1 in. of the top of the mould.

(*c*) The plunger shall then be inserted in the mould and the soil mixture compacted by either of the following methods :—

(i) Compression in the press to a total load of 3500 lb. (1600 kg.). This is best done by raising the load to 3500 lb., then immediately

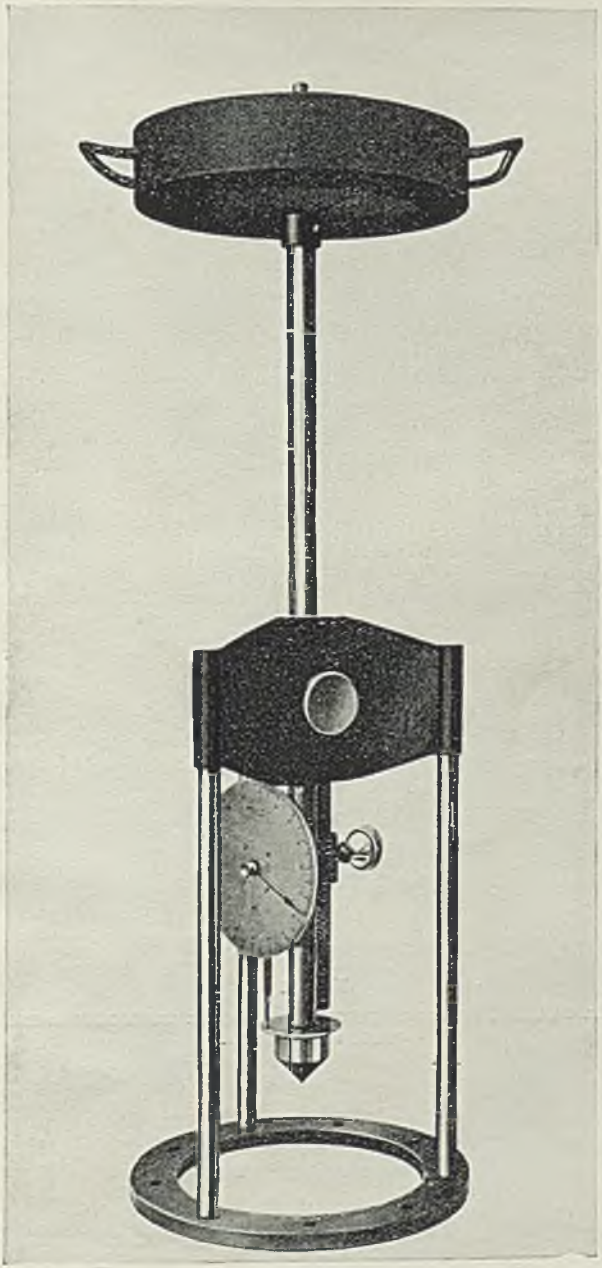

FIG. 3.
CONE PENETROMETER.

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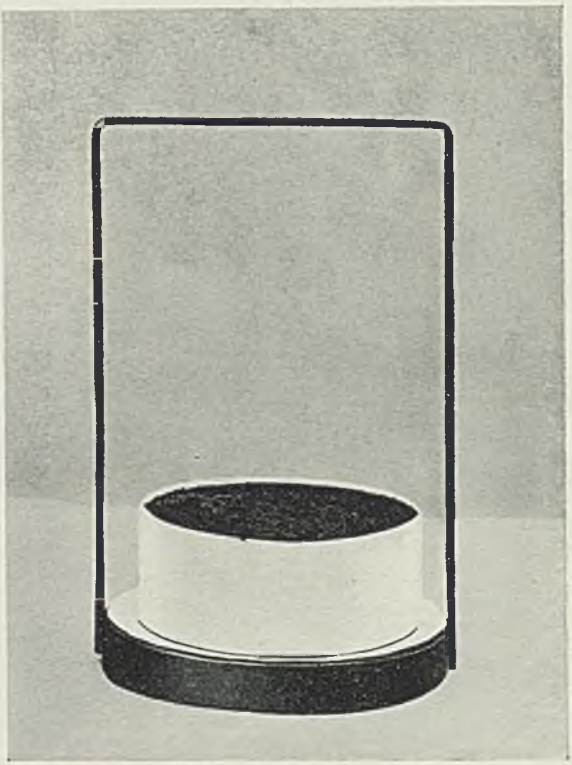


FIG. 5.

METAL CARRIER, SHOWING SPECIMEN IN PLACE WITH FILTER PAPER COLLAR ATTACHED.

releasing the pressure, ascertaining that the plunger is free in the mould, and finally raising the load to 3500 lb. again, maintaining this load for 2 minutes.

(ii) Compaction, using the rammer-and-guide arrangement. The head of the plunger shall be submitted to sixty blows of the rammer falling freely through a height of 1 ft.

(*d*) The base of the compacted specimen shall be extruded from the mould to a distance of approximately 2 mm. by means of the press. The extruded portion of the specimen shall then be removed by wire brushing. By means of the press, the specimen shall then be removed from the mould.

(*e*) If so desired, the specimen shall now be allowed to dry out in air until the loss in weight in 24 hours is less than 1% of the total loss in weight.

(*f*) The specimen either at the water content of compaction or after drying as specified under 3 (*e*) shall then be coated over the wall with a thin film of paraffin wax, by bringing the surface into contact with the waxing plate, avoiding waxing the base and top of the cylinder.

(*g*) Except when allowed to dry as described under 3 (*e*), the waxed specimen shall then be stored for 24 hours, supported above the water level in the absorption bath.

(*h*) The specimen shall then be weighed to the nearest 0·1 g.

4. *Procedure.*

(*a*) The specimen shall be stood in the absorption bath, with the wire-brushed face downwards and immersed in water to a depth of 2 mm. The bath shall be closed and kept at room temperature, which shall be recorded.

(*b*) After one day the specimen shall be removed, the surface cautiously dried with filter paper and weighed to the nearest 0·1 g. It shall then be replaced in the absorption bath and reweighed, as before, at convenient intervals.

5. *Calculation and Reporting.*

(*a*) The results shall be recorded as the total increases in weight after intervals of, for example, 1, 2, 3, 4, 7, 14, 21 and 28 days, either by plotting or by tabulation.

(*b*) When the specimen is immersed without drying out in air, the moisture content determined under 3 (*a*) shall be recorded as the moisture content before immersion. In cases where the specimen is dried out in air this shall be stated.

(*c*) The average room temperature over the period of immersion shall be recorded.

(*d*) The method used for compaction shall be stated.

(*e*) The bulk density of the soil as present in the compacted specimen is determined according to Method A.6. and recorded. In cases where wire brushing produces a very rough surface, this figure can only be approximate.

Test Method A.6. Determination of the Bulk Density of Soil as Present in Compacted Test Specimens of Stabilized Soil.

1. *Introduction.*

This method describes the determination of the amount of solid mineral matter in test specimens of compacted soil as required for use in Test Method A.3–A.5 and Method T.1.

2. *Specimen for Cone Penetration Resistance Test.*

Procedure.

(*a*) After the cone penetration resistance of the specimen has been determined, and before the moisture content has been determined, the mould containing the specimen shall be weighed to the nearest 1 g. $W(m + s)$.

(*b*) The sample shall be removed from the mould and shall be cut down the centre. Two specimens of appropriate size shall be removed from the middle of the two halves of the specimen.

(*c*) The moisture content of one of these samples shall be determined by the procedure given in Method A.2. Let this moisture content be m per cent.

(*d*) The stabilizer content of the other sample shall be determined by an appropriate method. Let this stabilizer content be s per cent. (see Note).

(*e*) The empty mould shall be weighed to the nearest 1 g. (W_m).

Calculation and Reporting.

(*a*) The weight in grams of the compacted specimen shall be calculated from the formula :

$$\text{Weight of specimen} = W_s = W_{(m+s)} - W_m.$$

(*b*) The bulk density of the specimen shall be calculated from the formula :—

$$\text{Bulk density of specimen (lb./cu. ft.)} = D_w = \frac{30 \times W_s}{453{\cdot}59} = \frac{W_s}{151{\cdot}2}.$$

(*c*) The bulk density of the solid mineral matter in the compacted specimen shall be calculated from the formula :—

$$\text{Bulk density of soil (lb./cu. ft.)} = D_s = \frac{D_w \times 100}{100 + m + s}.$$

3. *Specimen for Capillary Water Absorption or Compression Test.*

Procedure.

(*a*) After the specimen has been extruded from the mould, but before it has been subjected to either the capillary water absorption or the compression test, it shall be weighed to the nearest 0·1 g. (W_s).

(*b*) The height of the specimen shall be determined to the nearest 0·05 in. This shall be done by measuring the height in a direction parallel to the axis of the specimen, and at four diametrically opposite points. The mean of these four measurements shall be taken as the height (h) in inches.

(*c*) The moisture content of the mix from which the specimen was made

shall be determined by Test Method A.2. Let this moisture content be m per cent.

(*d*) The stabilizer content of the specimen shall be determined by an appropriate method. Let this stabilizer content be s per cent. (see Note).

Calculation and Reporting.

(*a*) The volume of the compacted specimen shall be calculated from the formula :—

$$\text{Volume of specimen (cu. ft.)} = V_s = \frac{\pi h}{1728} = \frac{h}{550}.$$

(*b*) The bulk density of the soil, water, and stabilizer in the compacted specimen shall be calculated from the formula :—

$$\text{Bulk density (lb./cu. ft.) of specimen} = D_w = \frac{W_s}{453{\cdot}59 \times V_s}.$$

(*c*) The bulk density of solid mineral matter in the compacted specimen shall be calculated from the formula :—

$$\text{Bulk density of soil (lb./cu. ft.)} = D_s = \frac{D_w \times 100}{100 + m + s}.$$

4. *Specimen for Rapid Water Absorption Test by Immersion.*

Procedure.

(*a*) The moisture content of the mix from which the specimen was made shall be determined by Test Method A.2. Let this moisture content be m per cent.

(*b*) The stabilizer content of the specimen shall be determined by an appropriate method. Let this stabilizer content be s per cent. (see Note).

Calculation and Reporting.

(*a*) The weight of the specimen in grams shall be calculated from the formula :—

$$\text{Weight of specimen} = W_s = W_2 - W_1 - w_1$$

where W_2, W_1, and w_1 are the weights determined for the carrier, filter paper and specimen; for the carrier; and for the dry filter paper, in Test Method T.1.

(*b*) The bulk density of soil water and stabilizer in the compacted specimen shall be calculated from the formula :—

$$\text{Bulk density of specimen (lb./cu. ft.)} = D_w = \frac{W_s}{453{\cdot}59 \times 0{\cdot}01152} = \frac{W_s}{5{\cdot}22}.$$

(*c*) The density of solid mineral matter in the compacted specimen shall be calculated from the formula :—

$$\text{Bulk density of soil (lb./cu. ft.)} = D_s = \frac{D_w \times 100}{100 + m + s}.$$

Note.—In the laboratory the weight of stabilizer originally added to the mix will generally be known and may be adopted for purposes of calculation. Where an actual determination has to be made, this can be effected by one of the published methods involving solvent extraction.

Test Method T.1. Water Absorption Test by Immersion.

1. *Introduction.*

This test provides a means for the rapid determination of the resistance to water absorption of a compacted stabilized soil mixture. In view of its rapidity, the method is specially suitable for testing samples on the construction site.

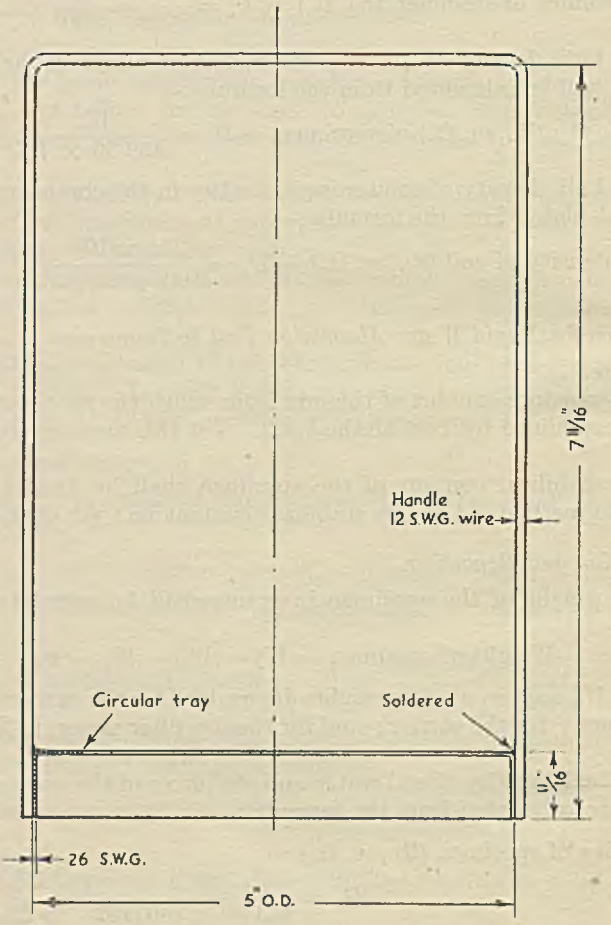


Fig. 4.

CARRIER FOR IMMERSION SPECIMEN.

2. *Apparatus.*

(*a*) *Moulds.* Cylindrical steel moulds each having a capacity of $\frac{1}{30}$ cu. ft. with an internal diameter of 4 in. and a height of approximately 4·6 in. and having a detachable collar assembly approximately $2\frac{1}{2}$ in. in height; the mould and collar shall be attached to a detachable metal base (Fig. 1).

(b) *Rammer and Guide.* A cylindrical steel rammer, 2 in. in diameter and weighing 5½ lb., and any guide arrangement which will allow the rammer to be dropped freely and vertically through a distance of 1 ft. as shown in Fig. 2.

(c) *Brass Cylinder.* A brass cylinder, 3 in. high and 4 in. in diameter, which shall be a sliding fit in the compaction mould. This cylinder is inserted into the mould to reduce the volume of the resulting specimen to about one-third of the standard compaction specimen.

(d) *Extraction Device.* A jack or other device suitable for removing the specimen from the mould.

(e) *Straight Edge.* A steel straight edge not less than 6 in. in length.

(f) *Metal Carrier* of the type and dimensions shown in Fig. 4.

(g) *Filter Paper,* 12·5 cm. in diameter (*e.g.,* Whatman No. 44).

3. *Preparation of Specimen.*

(a) The moisture content of the soil mix prepared as described in Test Method A.1 shall be determined by Test Method A.2.

(b) The brass cylinder shall be placed in the mould and about 100 g. of the soil mix added. This portion of mix is tamped lightly into the corners of the bottom of the resulting mould in order to form a good edge on the lower face of the specimen. 600–700 g. of mix shall then be placed in the mould and compacted by twenty-five blows with the rammer falling freely through a height of 1 ft. The blows shall be distributed as evenly as possible over the surface of the specimen. The collar shall then be removed, and the upper face of the specimen trimmed level with the top of the mould with the straight edge.

4. *Procedure.*

(a) A carrier shall be weighed to the nearest 1 g., and the filter paper placed on the tray. The specimen shall then be placed on the filter paper and the assembly weighed to the nearest 1 g. A strip of filter paper 1¾ in. in width shall then be fixed round the specimen in the form of a collar (Fig. 5).

(b) The assembly shall then be immersed in water at room temperature, so that the upper surface of the specimen is maintained 1 in. below the surface of the water.

(c) After 16 hours' immersion the assembly shall be withdrawn from the bath, the collar carefully removed, the free surface water on the specimen and carrier removed with the aid of filter paper and the assembly weighed to the nearest 1 g.

(d) The average room temperature during the period of immersion shall be recorded.

5. *Calculation and Reporting.*

(a) The water absorption of the specimen shall be calculated from the following formula :—

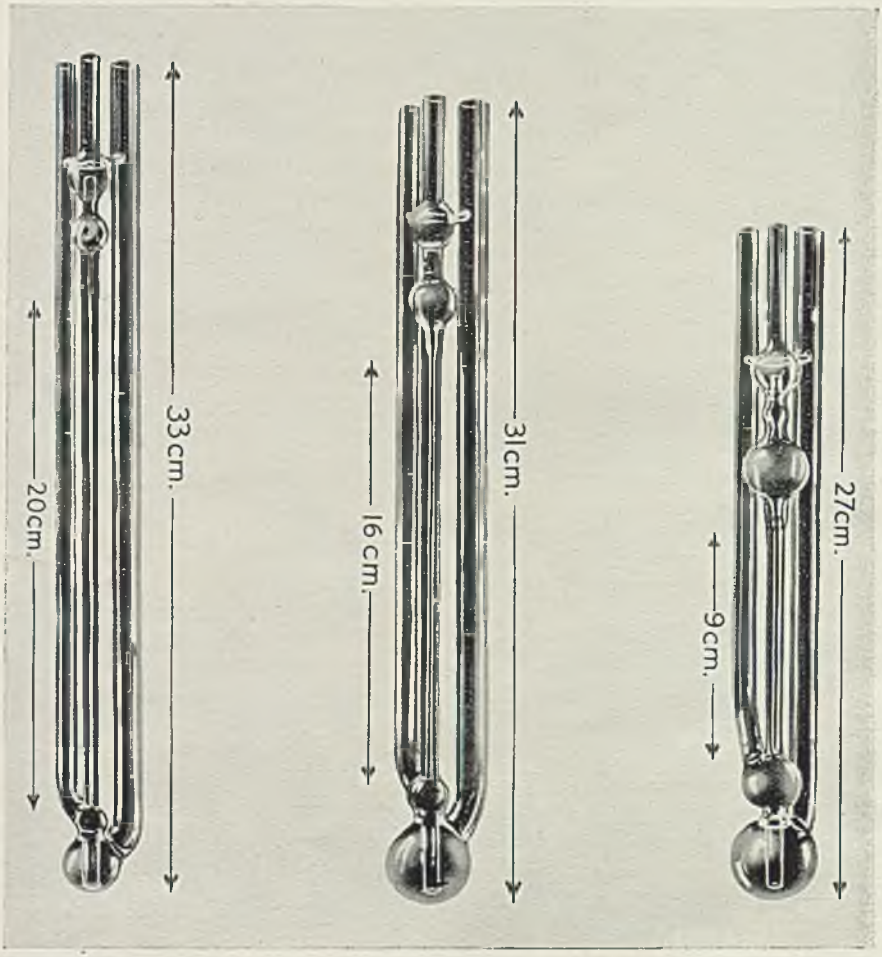
$$W_a = \frac{(W_2 - W_2 - w_2 + w_1)\,(100 + m + s)}{W_2 - W_1 - w_1}$$

Where W_a = g. of water absorbed per 100 g. of dry soil.
W_1 = weight of carrier (g.).
W_2 = weight of carrier + dry filter paper + dry specimen (g.)
W_3 = weight of carrier + wet filter paper + wet specimen (g.).
w_1 = weight of dry filter paper (g.)
w_2 = weight of wet filter paper (g.) (see Note).
m = original moisture content of specimen (per cent).
s = stabilizer content of specimen (per cent).

Note.—The value to be taken for w_2 shall be determined by removing the specimen from the carrier after an immersion test, and carefully scraping any loose soil off the filter paper. The exposed parts of the carrier shall then be dried, and the carrier with the wet filter paper on it weighed to the nearest 1 g. Since the weight of the carrier (W_1) is known, the weight of the wet filter paper (w_2) can be calculated.

(*b*) The bulk density of the soil as present in the compacted specimen is determined according to Method A.6 and recorded.

(*c*) The water absorption shall be reported to the nearest 0·2 gm., and the bulk density to the nearest whole number.



MICRO VISCOMETER
TEST VOLUME 2 ML.

MINIATURE VISCOMETER
TEST VOLUME 5 ML.

SHORTENED VISCOMETER
TEST VOLUME 15 ML.

[*To face p.* 349.

MINIATURE AND MICRO SUSPENDED LEVEL VISCOMETERS.

By M. M. Lapitzky and S. Thompson.

The need has often been felt for a viscometer for use in the determination of viscosity when, for various reasons, only a small quantity of oil is available. A particular case in point is the determination of the K.V.I. of the mineral-oil portion separated from compounded oils and from greases. The normal suspended level viscometer (I.P. 71/44T) requires about 20 ml. of oil for a determination, whilst the quantities normally available from compounded oils or greases rarely exceed 5–6 ml. and are usually of the order of about 2 ml. Suspended level viscometers were therefore constructed for this work, the design being based on the Fitzsimons modification of the Ubbelohde Suspended Level Viscometer. By modifying the filling bulb and making it spherical, elongating the capillary, reducing the volume of the timing bulb, and altering the shape of the suspended level bulb, miniature and micro viscometers have been constructed, the former requiring 5 ml. and the latter as little as 2 ml. of oil, whilst retaining the accuracy prescribed by the I.P. for Method 71/44T.

The lengthening of the capillary has made it possible to time the flow of a very small volume of oil without appreciably decreasing the diameter of the capillary from that of the corresponding suspended level viscometer of the normal design.

According to Hagenbach's formula for calculating the kinetic energy correction, the 2-ml. viscometer should have a " B " factor approximately one-tenth of that used for the normal type of instrument, and this could be disregarded for normal routine work.

It has been found necessary in certain cases, particularly at low temperatures, to use the suspended level viscometer in shallower baths than those normally used. An application of some of the modifications described above has enabled a shortened viscometer to be constructed which, whilst retaining the specified volume of the timing bulb and the specified length of capillary, has a total length about 60 mm. shorter than the normal type of instrument.

A table showing typical results obtained on normal and micro types of viscometers is appended, and photographs of the micro, miniature, and shortened types described are shown opposite.

The authors wish to express their thanks to the " Shell " Refining and Marketing Co., Ltd., for permission to publish this article.

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A.S.T.M. Standard Methods of Test for Kinematic Viscosity—A.S.T.M. Designation D.445–42T.

Ogden Fitzsimons, " A Rapid Precision Viscometer," *Industr. Engng Chem., Anal.*, 1935, **7**, 345.

	Micro Type Suspended Level Viscometer.			Standard Type Suspended Level Viscometer.		
	Flow time in seconds.	Factor.	Kinematic Viscosity in c.s.	Flow time in seconds.	Factor.	Kinematic Viscosity in c.s.
Oil A.	234·75 234·76 234·73 234·73 234·70 Av. 234·73	C = 0·9516 B = 0·2	223·37	227·63 227·50 227·55 227·48 227·43 Av. 227·52	C = 0·9832 B = 2·8	223·69
Oil B.	544·05 543·93 544·06 Av. 544·01	C = 0·08875 B = 0·2	48·28	529·46 529·88 530·16 Av. 529·83	C = 0·09129 B = 2·8	48·37
Oil C.*	75·60 75·61 Av. 75·60	C = 0·8924 B = 0·2	67·47	66·70 66·70 Av. 66·70	C = 1·0144 B = 2·8	67·62
Oil D.	188·35 188·30 188·31 Av. 188·32	C = 0·12334 B = 0·2	23·23	218·34 218·40 218·34 Av. 218·36	C = 0·10652 B = 2·8	23·25

* Oil C shows that good correlation is obtained between the micro and normal types of viscometer using an oil with a flow time much lower than the minimum of 120 seconds prescribed by the I.P. (The lowest flow time permitted by the A.S.T.M. is 80 seconds.)

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Geology and Development.

1272. North Alaska Good Prospecting. D. L. Carroll. *Oil Wkly*, 24.7.44, **114** (8), 66.—The geological information on the 30,000 sq. ml. of territory between Point Barrow and the Brooks Mountains in extreme Northern Alaska suggests that this is one of the most promising of the undrilled sedimentary basins on the continent. However, the area is distant, difficult of access, lacks outcrops generally, and has only a two-month "open season." Geophysical studies do not seem practicable, and the same is true of geochemical studies. Extensive core-drilling seems necessary to locate closed structures.

About 25,000 ft. of Mesozoic beds, mainly Lower and Upper Cretaceous sandstones and shales, are present.

K K

The beds are well exposed and sharply folded near Cape Lisburne in the west, and on the Canning River in the east. There appear to be extensions of the east–west structural trends which characterize the Brooks Range and the De Long mountains. These structural lines are expressed in the southern part of the Cretaceous basin as far north as the Colville River, the folds becoming more open to the north. There seem to be gently folded anticlines as far north as the inner edge of the Arctic coastal plain, where the wedging Tertiary beds overlap the Cretaceous beneath Quaternary sands and gravels.

Oil-seeps occur at four points, all near the coast. On the west side of Smith Bay, below Cape Simpson, are multiple seeps. Oil issues from the Lower Cretaceous sandy shale east of Cape Lisburne.

The Lower Cretaceous appears to have both potential source and reservoir rocks. It is almost wholly marine. The Upper Cretaceous is mainly non-marine.

It is believed that in the area north of the Brooks Range the Cretaceous and younger beds show a general northerly dip, which decreases to the north, and there is a possibility of a reversal of the regional dip some distance inland from the northern coast, thus reducing the depth to the Cretaceous in the coastal area, and making it possible that much of the Upper Cretaceous has been eroded, thereby making the oil-bearing Lower Cretaceous nearer the surface. This would also account for the seepages which are most likely from the Lower Cretaceous. The Cretaceous beds reported at Wainwright and Point Barrow do not show the coal beds which should be present if the beds are of Upper Cretaceous age. G. D. H.

1273. Wells Completed in the United States in Week Ended July 22, 1944. Anon. *Oil Wkly*, 24.7.44, **114** (8), 71.—384 field wells and 87 wildcats were completed in U.S.A. in the week ended 22nd July, 1944, 246 of the former and 12 of the latter finding oil, while 40 of the former and 1 of the latter found gas.

The completions are summarized by States and districts. G. D. H.

1274.* Possible Future Oil Pools of Pennsylvania. R. E. Sherrill. *Oil Gas J.*, 29.7.44, **43** (12), 129.—The shallow oil possibilities of Pennyslvania are in the Upper Devonian and younger sands, and all commercial production to date has been from these. The pools are of the stratigraphic type with porosity pinch-outs in sands. The Permian, Pennsylvanian, and Mississippian sands in the upper part of this series are little known, although penetrated by tens of thousands of wells. Except where productive, the data on these sands has either been lost or has not been assembled and analysed. In the south-west some of the upper sands, like the Berea and Big Injun, have produced much oil, and at times yield small new pools. Many of the producing areas are only a few hundred acres in extent.

At present the Venango, Warren, Bradford, and other Upper Devonian sands are much better understood than shallower or deeper horizons, because of the intensive work by the State Geological Survey. It appears that prospecting along the trends and in gaps in producing areas in each shallow sand has been thoroughly done, but it is still possible that pools may be found in these sands. The Venango Second Sand-Nineveh belt is a beach sand with continental deposits at that horizon to the south-east and north-west, where productive off-shore bars like those of the Third Venango might lie, and it has been little prospected below the Berea. In other places wells have stopped short of potential shallow horizons, giving a false picture of dry-hole density. There has been failure to correlate sands correctly. Some sands offset, and prospecting has not followed this offset, but has prolonged the original trend. The Devonian sands become progressively lower stratigraphically to the east and south-east.

The deeper possibilities of the Oriskany and older horizons are even less well known than those of the shallow horizons. These rocks have produced much of the oil in Kentucky, and less in Ohio; only gas has been produced from them in Pennyslvania. There seems little to commend them as oil-bearing in Pennsylvania. It is, however, unwise to conclude that rocks below the Oriskany can only produce gas because the Oriskany is primarily a gas sand. Questions of porosity, permeability, and the occurrence of dry gas only at depth are involved. The shallow Venango sands are soft, porous, and permeable in the productive areas, while they are very "tight" and quartzitic elsewhere. There appears to be a direct relationship between grain size and porosity; depth does not affect it. Rocks of the same age (Ordovician) as the deepest

considered, and apparently lithologically similar, are porous and permeable, and highly productive of oil in the Mid-Continent at depths as great as considered here, and in folds as strongly compressed as in Pennsylvania. Unconformities are known to be associated with the deep limestones here, and in the Mid-Continent such conditions are major causes of limestone porosity. Flows of water and gas have been found in the deeper horizons penetrated in parts of western Pennsylvania and eastern Ohio. A granular porous dolomite (Lockport or Newburg) in the Niagara limestone has so far proved discouraging, although it has given oil commercially in Kentucky, and gas with a little oil in Ohio. In north-west Pennsylvania, salt water, gas, and shows of oil are reported in it from several wells. The Lockport's stratigraphic setting is comparable in many respects with the prolific Permian dolomites of West Texas and south-eastern New Mexico.

The Medina has gas-shows at widely scattered localities in western Pennsylvania, and it produces much gas with some oil in New York and central Ohio. In western Pennsylvania it may be lenticular, and its depth may be 3000–12,000 ft., depending on the area.

The Ordovician is marine, and few wells have reached it in Pennsylvania. There are several horizons of possible production. A well in Erie County had an oil-show in the Trenton, which formation produces oil and gas in north-east Ohio and in Kentucky. Over much of north-west Pennsylvania its depth may be 4500–9000 ft. The Erie County well had a gas-, oil- and brine-show in the St. Peter sand, which is apparently cut out by an unconformity in central Pennsylvania. The Beekmantown massive, cherty dolomite has not been reached by any well.

It is possible that slight features in the shallow rocks of Pennsylvania may overlie complex fault-blocks as in the Mid-Continent area, and hence the deep Ordovician possibilities of Pennsylvania require some consideration. G. D. H.

1275.* Drilling Forecast : Sharp Increase Indicated. H. S. Norman. *Oil Gas J.*, 29.7.44, **43** (12), 132.—The U.S. oil industry proposes to drill 14,985 development and exploratory wells in the second half of 1944, a programme exceeded only by the 15,122 completions of the first half of 1937. The proposed drilling totals 52,779,673 ft. of hole, 44% more than in the first half of 1944. The stripper-well subsidy has caused many companies in the eastern area greatly to increase their drilling programme as compared with the first half of 1944. The general increase is higher than is usual for the second half of a year, and most of the increases above normal expectations are in the south-west and in California.

63% of the completions are expected to be rotary wells, with a total footage of about 40,000,000 ft., and the rotary rigs are expected to be used almost exclusively in the deeper areas.

In the first half of 1944, about 16% of the completions were exploratory wells. In the rest of the year nearly 17% of the planned wells are exploratory wells.

Tables compare by States and districts drilling in the first half of 1944 with that planned for the second half, and give drilling data for the two halves of 1943. The data include the types of rigs, numbers of exploratory and field wells, and the footage. G. D. H.

1276.* Well Completions Increase 30 per cent. First Half of 1944. C. J. Deegan. *Oil Gas J.*, 29.7.44, **43** (12), 135.—Including input wells, 11,356 wells were completed in U.S.A. during the first half of 1944, 30·2% more than in the same period of 1943. New York, Pennsylvania, Ohio, and West Virginia accounted for 3437 completions, and 1822 of these were in the Alleghany-Bradford secondary-recovery area. Texas had 2619 completions, California 970, Kansas 897, Illinois 831, and Oklahoma 800.

1745 wildcats were completed during the first half of 1944, 15·8% more than in the same period of 1943.

In the 9 major producing States, oil-well completions increased by 45%, gas-well completions by 34·3%, and dry holes by 12·2%, a consequence of concentrating drilling in proven areas. In the Gulf Coastal region exploratory drilling was 19·5% above the 1943 level, with a slightly diminished discovery ratio, 1 in 5 wildcats finding production. The most promising discovery in South Louisiana seems to be Cankton.

Development at Heidelberg in Mississippi is accelerating, and in the second half of 1944 the Eucutta field will see fairly substantial development. 104 wildcats were

completed in West Texas during the first half of 1944, 14 finding oil. The most important discovery was probably North Monahans (south Winkler County), which produces from the Clear Fork. A new San Andres limestone pool was opened in Hockley County. Lea County, New Mexico, had 2 discoveries, 1 in the San Andres limestone between the South Lovington and Vacuum pools, and the other in an Upper Permian sand between the North-east Lea and East Lusk pools. There were no wildcat strikes in the Texas Panhandle, but West Central Texas had 5 discoveries, the most noteworthy being in the Strawn, 1 ml. south of Novice in Coleman County.

The Hildreth field of North Central Texas now covers 3000 acres, and is likely to extend. Production is from the Bend conglomerate and Simpson pays. Two discoveries in Cooke County seem disappointing. The Wynn pool of eastern Clay County has 4 good Mississippi limestone wells.

South of Tyler in East Texas a well has flowed 40-gravity oil from the Coquina limestone of the Lower Glen Rose at 9865–9960 ft. The Pettit and Travis Peak have yet to be tested.

Four new oil-fields have been found in California, a deeper oil zone at Buena Vista Hills, and 4 gas-fields. Rapid development of the new pay at Buena Vista is expected.

Twenty-seven producers were completed at Elk Basin in the Rocky Mountain area, and Oregon Basin had 14 oil-wells and 3 dry holes. In Montana completion activity was concentrated in the Cut Bank and Kevin-Sunburst areas. In Wyoming, 4 discoveries were made in the Tensleep, 1 in the Dakota, and 1 in the Muddy.

Thirty-three new pools were opened along the Central Kansas Uplift. The West Edmond field shows signs of becoming a major field, and is 9 ml. long and about 2 ml. wide. A wildcat in McClain County has raised hopes of developing Wilcox production in the Anadarko Basin.

Illinois development has been only slightly better than in the first half of 1943. Five pools were opened (Mount Erie North, Maple Grove, Keensburg South and Hoodville East).

Tables give by States and districts summaries of the wildcat and field completions in U.S.A. in the first half of 1944, and a comparison of the first halves of 1943 and 1944.

G. D. H.

1277.* Production Increases 100,742,000 brl. C. J. Deegan. *Oil Gas J.*, 29.7.44, **43** (12), 137.—810,512,000 brl. of oil was produced in U.S.A. in the first half of 1944, 100,742,000 brl. more than in the same period of 1943. Texas gave 94,373,000 brl. of the increase, California 11,293,000 brl. Gains in Louisiana and New Mexico were more than offset by losses in Kansas, Mississippi, Illinois, and Oklahoma.

Stocks of crude oil have shown a fairly steady decrease since the beginning of 1944, Marked increases in output in the near future seem practicable only in Texas and California, although numerous other areas show promise for the future. Mississippi, Wyoming, and Oklahoma are among these. Kansas' production is about 10% below the 1943 level. The decline of the past three years in Illinois has been checked, and this State may have a slight production increase in the second half of 1944.

At present California is producing about 850,000 brl./day. Buena Vista Hills has prospects of raising its output by 10,000–25,000 brl./day by the end of the year, and a 25,000-brl./day increase seems possible at Elk Hills. It seems likely that the total Texas production for the last half of 1944 will average 2,095,000 brl./day, with production about 2,140,000 brl./day at the end of the year. Production from the whole of U.S.A. will probably average 4,730,000 brl./day at the end of the year.

Tables give the U.S. production by States in the first half of each of the years 1943 and 1944, and during 1939, 1940, 1941, 1942, and 1943; the Texas production in the first half of 1943 and 1944 and the daily average output in the different parts of Texas in the first half of 1944, with estimates for the second half. G. D. H.

1278.* Summary of June Completions. Anon. *Oil Gas J.*, 29.7.44, **43** (12), 229.—2345 wells, including 200 service wells, were completed in U.S.A. during the five weeks ended 1st July, 1944. 1177 found oil and 323 found gas. The total footage was 7,511,320 ft.

The completions are analysed by States and districts, with the numbers in different depth ranges, and other information. G. D. H.

1279.* Wildcat Completions and Discoveries. Anon. *Oil Gas J.*, 29.7.44, **43** (12), 229. —During the week ended 22nd July, 1944, 97 wildcats were completed in U.S.A., 13 finding oil and 1 gas. 2019 wildcats have been completed during 1944 to the above and 1706 have been dry.

The wildcat completions are summarized by States and districts for the week ended 22nd July, 1944, and for 1944 to that date. G. D. H.

1280. Montana's Newest Discovery of Particular Significance. E. S. Perry. *Oil Wkly*, 31.7.44, **114** (9), 34.—Oil was discovered on the Gage dome of Montana in August, 1943, in the Upper Mississippian Amsden limestone, at a depth of 5960 ft. The discovery well went to 7490 ft., 50 ft. into the Madison, but did not find any oil-showings in that formation. A second producing well was completed 1½ ml. to the north-east, and a date, third ½ ml. to the north-east.

The 8 fields of the plains area along the mountain front in central Montana gave nearly 8,000,000 brl. of oil in 1943, 6,000,000 brl. coming from the Lower Cretaceous at Cut Bank. Kevin-Sunburst produces from the Madison at depths of 1400–1600 ft. Elk Basin produces from the Upper Cretaceous in small amounts, and from the Tensleep at 4900 ft. Minor oil shows have been found in the Ordovician and Devonian at Dry Creek. The Big Snowy yields black oil at Devil's Basin on a pronounced anticline.

The Gage field is associated with the Big Snowy-Porcupine uplift, which has steep structural slopes on the north and south. Igneous intrusions are present. Cat Creek is at the top of the northern steep slope; Devil's Basin is at the top of the southern steep slope, but has yielded little oil; the Gage dome is a minor flexure about half-way down the steep southern slope of the uplift. The width of the terrace area is about 5 ml., and its length 20 ml. The structural closure is about 200 ft. At Gage the Jurassic rests on the Mississippian, and there is an unconformity within the Mississippian. Thus there is 215 ft. of oil-producing Amsden limestone between two unconformities. The Amsden is porous and gas-bearing on the Ingomar dome, 50 ml. east of Gage. It is also porous along the Wyoming border 100 ml. to the south. It is possible that the oil accumulation at Gage may be due as much to porosity changes as to structural conditions. The Gage dome may be underlain by a deep-seated fault.

The development of porosity in the Amsden at Gage may be related to the extensive erosion surface immediately above the limestone, but such a relationship does not hold elsewhere in this general area. The Gage dome is the first anticlinal fold outward from the Bull Mountain syncline.

Structural maps and a cross-section are included. G. D. H.

1281. Wells Completed in the United States in Week Ended 29th July, 1944. Anon. *Oil Wkly*, 31.7.44, **114** (9), 53.—444 field wells and 103 wildcats were completed in U.S.A. in the week ended 29th July, 1944. 306 of the former and 13 of the latter found oil, while 35 of the former and 2 of the latter found gas. The completions in the above week are summarized by States and districts. G. D. H.

1282.* California Drilling Campaign Will Continue Vigorous in Postwar Era. L. P. Stockman. *Oil Gas J.*, 5.8.44, **43** (13), 32.—Production at the end of 1944 in California should be around 900,000 brl./day, considerably above present levels, due to increased development work at Elk Hills, Santa Maria Valley, Paloma, and elsewhere, but it is expected that Elk Hills, producing 65,000 brl./day, will be closed in at the end of the Japanese war or soon after.

By the end of the war, the crude and refined stocks in California will be down to rock bottom, giving about 125,000,000 brl. of empty storage which can be used as a stabilizing factor for several years, provided that refined-oil prices are high enough to permit the accumulation of stocks.

Development work will have to be continued vigorously for several years to offset the normal decline and to cushion the abrupt shut-down of Elk Hills. Secondary recovery and more efficient production methods will be applied, but developments of this type require several years to reach maximum efficiency, and this work calls for high prices.

About 2000 new wells will be completed in 1944, more than twice the annual number in several years before hostilities began.

Present plans contemplate the immediate shipment of about 25,000 brl. of crude per day by rail from Texas to California, with an increase to 40,000 brl./day if possible. The cessation of hostilities in Europe will probably not greatly affect the Californian oil industry, although refined oil will then be diverted from other areas to Pacific operations, and should alleviate conditions in California. G. D. H.

1283.* Geologic Aspects of Wyoming and Outlook for Development. P. La Fleiche. *Oil Gas J.*, 5.8.44, **43** (13), 38.—Wyoming has nine great intermontane basins, around the edges of which are the known oil- and gas-fields. The interiors of these basins are relatively untested by drilling, although it is believed that they possess oil and gas accumulations. In the north-east is the Powder River Basin with the Osage, Mule Creek, Lance Creek, Big Muddy, Salt Creek, and Billy Creek fields. To the south is the Julesberg (Denver) Basin, and, possibly excepting Horse Creek, this has not yet provided commercial oil- and gas-fields. West of the Julesburg Basin lies the Laramie Basin, with several fields in its western part, and on the north-west of this basin are the Hanna-Carbon Basins with the Allen Lake gas-fields, and a small oil-field on the dividing ridge. The Green River Basin covers most of south-west Wyoming, but this is split by an anticlinal arch into subsidiary basins (Bridger and Great Divide, which includes the Red Desert Basin and the Washakie Basin). Oil- and gas-fields are known in each of these subsidiary basins, and a gas-field occurs on one of the dividing uplifts.

The Wind River Basin is in central Wyoming, and possesses a number of oil- and gas-fields. The Big Horn Basin of north-west Wyoming has numerous anticlines and 33 oil- and gas-fields.

Beginning in the Cambrian, Wyoming has been mainly submerged by oceans and inland seas, with occasional fresh-water conditions, shallow lakes, and intervals of erosion. Not until the late Cretaceous and the Tertiary were extensive continental deposits formed; they totalled 30,000–50,000 ft. in their maximum development. Diastrophism began in late Cretaceous times, and became strong in early Tertiary times, when it created the principal mountains and basins now known. Erosion has exposed pre-Cambrian in the mountain cores.

Salt Creek is Wyoming's foremost field. The producing area covers 20,500 acres, and has 2383 wells. Production comes from the Shannon sand, Niobrara shale, First, Second, and Third Wall Creek, Muddy, Dakota, Fuson, Morrison, Sundance, and Tensleep sands. The cumulative production is over 308,000,000 brl., some 230,000,000 brl. having come from the Second Wall Creek sand. The Lance Creek field has given over 56,000,000 brl. of oil, Grass Creek over 32,000,000 brl., and Big Muddy over 28,000,000 brl. The Oregon Basin field has produced black oil from the Madison, Tensleep, and Embar to a total of over 25,000,000 brl. Production at Lost Soldier is from the Frontier, Dakota, Sundance, and Tensleep, and amounts to 27,000,000 brl. The current recovery, omitting that of the Tensleep, amounts to over 60,000 brl./acre. LaBarge was the first Wyoming field to yield Tertiary oil.

Oils from Jurassic and younger beds are paraffin to mixed base, of 30–70° A.P.I. gravity, and with less than 0·5% of sulphur. Heavy black oils are obtained from older beds, and they are mixed to naphthene base, of 14–30° gravity, with sulphur up to 4%.

In December, 1942, Tensleep oil was discovered in the old Elk Basin field, opening a new major pool. Initial outputs from these wells range 1000–6000 brl./day, from a 200-ft. saturated sand section. It is estimated that about 5000 acres will prove productive, giving a reserve of the order of 200,000,000–300,000,000 brl.

Early in 1944 the Winkleman dome (Fremont County) was discovered. Oil was found in the Embar and Tensleep, only the latter now being produced. The Steamboat Butte field, also a new discovery, produces from the Tensleep. Gebo yields oil from the Embar. Embar and Tensleep oil production has been found in the Little Buffalo Basin gas-field. Other new discoveries are Wagonhound, Cooper's Cove, Golden Eagle, and Spence.

At the beginning of 1942 Wyoming's reserves were estimated at 514,000,000 brl., but present reserve estimates amount to 750,000,000–1,000,000,000 brl. Up to the beginning of 1944, Wyoming had produced about 597,000,000 brl. of oil, and 1,000,000,000,000 cu. ft. of gas. The present production is about 95,000 brl./day.

Many ideas regarding oil accumulation and trapping in Wyoming have been exploded: that the closure must exceed 1000 ft. to retain oil against flushing; that the Dakota was a blanket sand containing water only; that if the Frontier sands were barren,

production could not be expected below that horizon; that the Tertiary could not produce; that stratigraphic traps were unfavourable for oil accumulation; and that some structures were too badly faulted or even too large to produce. G. D. H.

1284.* Wildcat Completions and Discoveries. Anon. *Oil Gas J.*, 5.8.44, **43** (13), 108.—90 wildcats were completed in U.S.A. in the week ended 29th July, 1944; 11 found oil, 1 gas, and 1 distillate. Up to the 29th July, 2109 wildcats had been completed during 1944, 1783 being dry.

The results of wildcat completions during the above week and during 1944 are summarized by States and districts. G. D. H.

1285. Possibilities for Oil and Gas in Tennessee. K. E. Born. *Oil Wkly*, 7.8.44, **114** (10), 54.—Oil-seeps were known in Tennessee a century ago, and the first commercial oil production was obtained in 1866 at Spring Creek in southern Overton County. Since then sporadic drilling has located small, often short-lived fields. The deepest production was less than 2000 ft.

In East Tennessee there are pre-Cambrian, Cambrian, Ordovician, and Silurian beds, which are generally so intensely folded and faulted as to preclude the chance of finding oil and gas in commercial amounts. In the Cumberland Plateau there are Pennsylvanian sandstones, shales, and coals, and Upper Mississippian limestones, shales, and sandstones, with a general east and south-east dip. Most of the drilling on the Cumberland Plateau has been in the northern part, where oil was found in Chester limestones in 1915, 5 ml. north-west of Oneida. In 1916 oil was found in Mississippian limestones at Glenmary in south-west Scott County on a faulted east–west anticline. Oil was discovered along Boone Camp Creek in Morgan County in 1924, in the Lower Mississippian Fort Payne formation, probably trapped by porosity conditions. Nearby, at Seabolt and Coon Hollow, pools were opened in Mississippian limestones, and wildcats have found gas in Middle and Lower Mississippian beds. Some surface work and a little drilling have been carried out in the northern part of the Plateau.

The Highland Rim encircling the Nashville Basin is capped by Middle and Lower Mississippian beds. Several pools have been discovered in the north-west part of the Highland Rim, the more important including Celina, Peterman Bend, Fox Springs, Mitchell Creek, Spurrier, and Riverton. Production has generally been from the Ordovician (Trenton, Black River and Stones River groups), but in one case the Lower Mississippian yielded oil. Shows have been found in the upper part of the Knox dolomite group. Small gas-fields have been developed in the eastern part of the Highland Rim in fissured Ordovician limestones. A little oil has been obtained from Silurian dolomitic limestones in the northern part of the Highland Rim. Structure seems to be important in controlling oil accumulation in the Highland Rim.

The Nashville Dome is the major structure in the Central Basin, where Ordovician and Silurian rocks outcrop. Only a little oil and gas have been found.

Most of Western Tennessee belongs to the Gulf Embayment where Palæozoic rocks are covered by Upper Cretaceous and Eocene beds. Ordovician to Mississippian beds outcrop along the Tennessee River, and the major structural feature of this area is a general north–south upwarp. The Upper Cretaceous and Tertiary beds dip gently westwards, and surface mapping is difficult. Geophysical prospecting seems desirable. Oil and gas shows have been found in Upper Cretaceous and Palæozoic rocks.

Lists are given of the oil- and gas-fields in Tennessee, with pertinent data, and a map and generalized columnar section are included. G. D. H.

1286. Wells Completed in the United States in Week Ended 5th August, 1944. Anon. *Oil Wkly*, 7.8.44, **114** (10), 75.—286 field wells and 88 wildcats were completed in U.S.A. in the week ended 5th August, 1944. 185 of the former and 12 of the latter found oil, while 13 of the former and 3 of the latter found gas.

The completions are analysed by States and districts for the above week. G. D. H.

1287.* Wildcat Completions and Discoveries. Anon. *Oil Gas J.*, 12.8.44, **43** (14), 126.—During the week ended 5th August, 1944, 96 wildcats were completed in U.S.A., 7 finding oil and 3 finding gas. The corresponding cumulative totals for 1944 to the

above date are 2205, 244, and 72, respectively, and there have been 20 distillate discoveries. The completions are analysed by States and districts. G. D. H.

1288. Critical Shortage of Oil Supply Dooms Germans to Defeat. Anon. *Oil Wkly*, 14.8.44, **114** (11), 26.—The advance of the Russians into the Sambor-Boryslaw oil-producing region, and Allied bombing of refineries and synthetic oil-plants in Nazi-held Europe have created a critical oil-supply situation for the Germans. Germany no longer has sufficient oil even to fight a defensive war for any length of time, for this would require 300,000 brl. of finished oils per day. The current supply may be only about 167,000 brl./day. Reserves may have been accumulated in periods of little military activity, but such stocks must have been heavily drawn upon.

In 1943, the Polish fields gave 5·5% of all European crude-oil production outside Russia, providing 9600 brl./day of the Axis-Europe total of 175,000 brl./day. The Polish output was about 2·8% of the production of all oils in Nazi Europe.

Tables give estimates of the crude and synthetic-oil production in the various countries of Nazi-Europe in 1943, and estimates of the minimum German requirements for waging war, and the deficiency following upon the heavy bombings of recent months. G. D. H.

1289. Wells Completed in the United States in Week Ended 12th August, 1944. Anon. *Oil Wkly*, 14.8.44, **114** (11), 67.—383 field wells and 88 wildcats were completed in U.S.A. in the week ended 12th August, 1944. 264 of the former found oil and 19 found gas, while 13 of the latter found oil and 3 found gas.

The completions results are analysed by States and districts for the above week. G. D. H.

1290. Completions Reach Highest Rate Since Curb of Drilling after Pearl Harbour. Anon. *Oil Wkly*, 14.8.44, **114** (11), 60.—During July 1944 well completions in U.S.A. averaged over 500 per week. In April, 1944, the rate was approximately 400 per week. States which have contributed markedly to this sharp rise are Oklahoma, Kansas, Arkansas, Illinois, Michigan, Pennsylvania, and New York (40–50% increase). Mississippi's rate of completions has been doubled.

The expansion in drilling is due to better supplies of rigs and drilling equipment, and stimulation of field development and wildcatting by crude price subsidies.

The July completion rate was the highest since February 1942. 13,245 wells were completed in the first seven months of 1944, 30·1% more than in the corresponding period of 1943. The main gains over 1943 were in California, Kentucky, South Louisiana, Mississippi, Montana, New Mexico, Oklahoma, West Virginia, and Texas (over 40%). The July and cumulative completions for 1944 are summarized by States and districts, giving the types of completions, footage, numbers of rigs in operation at the beginning of August 1944 and some comparative figures for 1943. G. D. H.

1291.* The Structure Diorama. F. Squires. *Oil Gas J.*, 19.8.44, **43** (15), 86.—When several sands produce in a field, a single map often does not show the outline and extent of each producing horizon clearly, and it may be preferable to draw a separate map for each horizon. If each of these maps is transferred to a sheet of glass and marked in a distinctive colour, the sheets of glass can be superimposed in a frame, thus showing the plan relationships of the different sands, although not the structure. An effort has been made to display structure by the use of contours on the glass sheets, with colours for different levels to give by tone differences the effect of modelling. However, this cannot be applied to more than one horizon at a time because of the opacity of the paint.

A peg model was built showing the different producing horizons, and nitro-cellulose plastic was filled into the upper surface of the lower stratum. A grid was marked on this surface in a distinctive colour, and more plastic was put on to fill up to the next stratum. On this second surface a grid was drawn in a different colour. This method was continued to give a series of surfaces with coloured grids within a solid block. However, on hardening, shrinkage, of the plastic destroyed the accuracy of the modelling.

Finally a model of horizontal superimposed glass sheets was employed. Each sheet

represented a single contour level, and different colours were used for marking the contours of the various horizons. The top sheet was marked with topographical features, and the model was electrically illuminated from below. G. D. H.

1292.* Wildcat Completions and Discoveries. Anon. *Oil Gas J.*, 19.8.44, **43** (15), 135. —89 wildcats were completed in U.S.A. in the week ended 12th August, 1944, 11 finding oil, 1 distillate, and 3 gas. Up to that date 2294 wildcats had been completed during 1944, and 1943 of them were dry.

The results of the completions are analysed by States and districts for the above week, and for 1944 to the same date. G. D. H.

Drilling.

1293.* Drilling Precautions Adopted to Ensure Hole Protection in Heidelberg Field. N. Williams. *Oil Gas J.*, 11.5.44, **43** (1), 111–112.—The development of this new field in Mississippi is given, followed by drilling practice adopted in it. No major problems have as yet arisen, but one gas blow-out is studied in some detail. Casing and cementing programmes are given. Mud control is somewhat complicated by the fact that there is quite a bit of limy shale which contaminates the mud. As in the case of the surface hole, there is also much sand, and, except for the Eutaw, which contains the producing section, the formations do not make good mud. Purchased drilling clays and bentonite generally must be used. These are treated with tannic acid, caustic and other chemicals to control their viscosity and water loss characteristics. The viscosity carried can be slightly lower than that required for effective drilling of the surface hole. Particular attention, however, must be paid to reducing the water loss as low as possible for drilling the Midway shales and the remainder of the hole. The possibility that gas pressures may be encountered in the Selma chalk, such as occasioned the blow-out in the Sun Oil Co. well, with the added potential hazard of sands above the Selma chalk having become charged, may complicate mud control. Because of lower pressure in the deeper formations, including the producing sands, and the likelihood of losing circulation, it has been desirable and necessary to hold weight of mud to a minimum, never over 9·8 lb. Now, if higher mud weights are to be required to control gas pressures in the upper formations, prevention of lost returns may become a problem. A. H. N.

1294.* Coring With a Reverse-Circulation Rig. L. Finch, Jr., and W. M. Elias. *Oil Gas J.* 3.6.44, **43** (4), 49. *Paper Presented before American Petroleum Institute.*—See Abstract No. 1188. A. H. N.

1295.* Problems in Drilling Through Steeply Dipping Formations. E. H. Short, Jr. *Oil Gas J.*, 10.6.44, **43** (5), 61.—Steep formation dips and highly faulted condition existing in the recently developed deeper sand producing area on the Vinton dome flank, Calcasieu Parish, Louisiana, have presented a number of drilling problems, chief of which was a crooked-hole hazard. These are briefly discussed. A. H. N.

1296.* Geometrical Orientation of Cores. P. Subkow. *Oil Gas J.*, 10.6.44, **43** (5), 79. —After giving a brief *résumé* of the usefulness of knowing the orientation of cores, the author describes a new method of determining the dip of cores from geometrical properties of deviated cores. Two cores are required to be taken in the formation whose dip is to be determined. The core axis should differ either in direction or in inclination, or be different in both direction and inclination. Both cores may be taken from the formation, or one of the cores may be taken from a parallel stratum. The direction and inclination of the cores when taken must also be known. This may be determined by an orientated single shot or by well survey of the hole where the cores are taken. The method also requires the apparent dip of the core stratum in each core. This may be determined from the cores themselves, as is conventional. The steps of the method are as follows: (1) Both cores are orientated by placing the core axes in the direction and inclination determined for each by the well-survey or single-shot determination. (2) The cores are each rotated about their respective axes until the core strata are parallel. (3) The direction of dip and the angle of dip of the core strata are

determined when in their parallel positions. A diagram illustrates the principles involved and photographs show the instrument in different phases of the operations necessary. Examples are given in detail to show the method. A. H. N.

1297.* Radiographic and Magnetic Inspection Reduces Equipment Failure. E. H. Short, Jr. *Oil Gas J.*, 8.7.44, **43** (9), 135.—Failure of equipment due to causes other than fatigue are often prevented by means of radiographic inspection. Many manufacturers are using this type of inspection on castings before the machine work is done, thus saving the machine time which would otherwise be wasted if defects were found a short distance below the surface during the machining operation. These manufacturers feel that the radiographic method of inspection is superior to the conventional hydrostatic test to which valves, christmas-tree connections, and pressure vessels are subjected as a final test, since a piece of equipment might withstand the hydrostatic test and still fail through a hidden defect after only a short period of operation. Such falures are due to the action of corresion or erosion, or a combination of the two, in the vicinity of a defect which did not show up during the pressure test. Even in cases where high-pressure equipment performs its duties with no defects at all, extremely bad conditions of corrosion and erosion might seriously weaken the equipment, and for this reason some operators have had such equipment tested to minimize the possibility of a dangerous failure.

The theory and practice of magnetic and radiographic methods of inspection are given. Examples illustrating the methods in some detail are given. A. H. N.

1298. Electrical Well Logging. Part 1. H. Guyod. *Oil Wkly*, 7.8.44, **114** (10), 38.—A general study of requirements of well-logging methods is made, followed by a brief description of the various methods available—*i.e.*, acoustic, chemical, electrical, gravitational, intake, magnetic, mechanical, optical, radioactive, seismic, and thermal. Some of these are further classified into sub-sections. Tables then give the chief characteristics of the methods and of the suitability of different methods for detecting particular properties.

The paper ends with a discussion of possible improvements. Research on the electrical properties of rocks might lead not only to better methods of interpretation of the present logs, but also to novel techniques which could offer a better solution of the problem of logging. The most important of these problems is probably that of a positive detection of permeability, whether the porous beds carry water or petroleum. If this information were available, the danger of passing up oil-sands would be considerably minimized. Sands, sandstones, and lime have physical properties so different from those of non-porous beds that it is difficult to believe that their detection is not possible by physical methods. The answer might not be the making of one single measurement, but possibly several of them which would be interpreted simultaneously. A long step forward for the solution of this problem has been made recently, with the introduction of the neutron log (artificial radioactivity), interpreted simultaneously with a gamma-ray log (natural radioactivity). There is good evidence that the simultaneous interpretation of these two logs can sometimes locate porous beds where other methods failed.

If a really reliable method of identifiying the fluid content could be developed also, well logging would, of course, almost achieve perfection. The fairly good knowledge we have now of the resistance of the ground leads us to believe that this technique will never be completely successful for the determination of the fluid content of porous formations, even when used in conjunction with permeability curves. There will always be cases where the interpretation will be doubtful or erroneous. The introduction of more resistance curves cannot solve the problem. In fact, the shortcoming lies in the specific resistance of the formations themselves, and not in how the resistance measurement is carried out. A satisfactory answer to the problem of the fluid content seems, therefore, to be the measurement of a different property. Offhand, nuclear physics seems to offer the best possibilities for the solution of this problem. A. H. N.

Production.

1299.* Increased Oil Recovery by Gas Injection from Old Producing Sands at Salt Creek. N. Williams. *Oil Gas J.*, 18.3.44, **43** (2), 57–58.—Benefits to be derived by injections of

gas into old producing sands facing early depletion of pressures are demonstrated in the results of such a project in the Salt Creek field. The present rate of injection into the two sands concerned is approximately 20,000,000 cu. ft. daily. As a result of the project, started in 1926, average pressure has declined less than 3 lb. during the past 10 years, and daily oil withdrawals are being sustained at a rate estimated at double that which would otherwise be possible. Oil-production practices are designed to obtain the most effective recoveries consistent with the gas-injection programme. Most of the wells were completed with 7-in. casing for the oil-string with 2-in. tubing. Fluid levels are low and, except in the downstructure edge-wells, are generally below the top of the sand. Pumps in many cases are set in a rat-hole below the bottom of the sand with the rat-hole serving as a sump for the oil. Straight plunger pumps with cups are most common, although some inserts with small bore are also used. Most of the wells are pumped with standard rig fronts powered with electric motors, this being the type of equipment which has been in service in the field since the start of pumping. There are also some back-crank installations. Stanolind generates electric power which is used extensively in operating producing facilities throughout the field.

Pumping schedules vary greatly, depending on the most effective results in the individual wells. Some are on 24-hr. schedules; others are on 16-hr. or 8-hr. schedules, while still others may be pumped 8 hrs. twice a week, or even 8 hrs. once a week. Schedules and production are frequently checked, with a view to changing schedules to meet changing conditions and a generally flexible programme is followed. A. H. N.

1300.* Rotation-Type Gas-Lift System. E. H. Short, Jr. *Oil Gas J.*, 18.3.44, 43 (2), 67–68.—The " rotation " type of gas-lift system is being employed in a number of production operations on the Gulf Coast. This type of gas-lift involves the use of a small compressor plant with well input and output lines representing a closed system. Gas is compressed, injected into the annular space between tubing and casing, admitted into the lower end of the tubing intermittently, the accumulated fluid is ejected up through the tubing, and thence to the central separator. The gas from the separator, under 15- or 20-lb. pressure, is then taken back into the intake of the compressors, thus making a complete round. This method of lift differs in a number of respects from the compressed-gas method of gas-lift extensively used in various fields (notably Seminole) during past years. Except for a few experimental installations, all Seminole wells, for example, were produced on straight flow, whereby the gas was injected down the tubing, and flow established in the annular space between tubing and casing. Under the gas-rotation system, the wells are produced by means of surface-controlled intermitters.

The subsurface equipment consists of a string of tubing, surface-controlled valves, a control-head-type packer, and a wire line equipped with a weight bar. The surface-controlled valves are inserted into the tubing string as it is run, and the number of valves used depends on two factors, the fluid level and the maximum pressure available for kick-off. The packer is run on the tubing below the lowest valve, and also, depending on the fluid level and the capacity of the well, may be set at any point in the casing. Usually, however, it is set in the casing as close to bottom as possible. The only other subsurface equipment used is a wire line which extends (inside the tubing) from the surface to the lowest valve. A long round weight bar is attached to the lower end of the wire line, and the valves may be opened by a gas-operated piston at the surface, which pulls the wire line. This operation, the interval of which is controlled by an intermitter located at the well, causes the weight bar to move up into the valve, which opens it and permits gas from the annular space to expel the fluid accumulated during the " off " period. A. H. N.

1301. A Study of the Smackover Limestone Formation and the Reservoir Behaviour of its Oil and Condensate Pools. W. A. Bruce. *Petrol Tech.*, May 1944, 7 (3), A.I.M.M.E. Tech. Pub. No. 1728, 1–32.—Studies of reservoir behaviour of twelve Smackover limestone oil and condensate pools are presented. Buckner, Midway, McKamie, Magnolia, Mt. Holly, Schuler (Reynolds), and Village are treated in considerable detail, and their data were subjected to analysis with an electrical device for analysing reservoir behaviour. Results and comparisons of these analyses are presented. All the pools show evidence of water-drive.

In addition to these reservoir-behaviour studies, an attempt is made to assemble

transmissibility and storage data on the Smackover limestone formation from cores and logs taken in dry holes and producers. This, together with the behaviour of individual reservoirs, leads to a better understanding of the formation as a permeable aquifer.

Laboratory experiments on Smackover samples indicate water-drive efficiencies of 50–95%, with a most likely value of 80%. Information on the Village pool indicates a flushing efficiency of 58–82%, but this may be rather higher than in some of the other pools.

The ultimate purpose of this study is to improve predictions concerning the future behaviour of pools in a permeable aquifer, and predictions are presented for several of the pools. G. D. H.

1302. Waters from the Frio Formation, Texas, Gulf Coast. F. W. Jessen and F. W. Rolshausen. *Petrol. Tech.*, May 1944, 7 (3), A.I.M.M.E. Tech. Pub. No. 1729, 1–16.—The examination of 116 water analyses from the Frio formation of 63 fields and 14 wildcat wells on the Texas Gulf Coast, has indicated a few trends, but having regard to the wide area from which only a few samples are available from numerous sands, it is realized that conclusive statements cannot be made at present. The indications are as follows: (1) The chloride salinity increases and the sulphate salinity decreases from Starr County northward. (2) The chloride salinity increases with depth down-dip, and reaches a maximum value between 4500 and 6500 ft., and apparently decreases with depth below 6500 ft. (3) The chloride salinity seems to have a maximum value in the upper 500 ft. of the Frio, and to decrease as a greater interval of Frio is penetrated. This is especially evident in Harris and Fort Bend Countries. (4) No definite conclusions may be drawn from this observation, however, as to the possible relationship between this concentration of salts in the Upper Frio and oil and gas accumulation, or the changes that may have been effected in the waters by contact with oil or gas, since an insignificant number of samples is available for study. (5) These waters show that the Frio sands from which the samples were obtained are not in contact with the salt. If these sands were in contact with the salt, it would be expected that much higher chloride concentration would occur. G. D. H.

1303. A Statistical Approach to the Interstitial Heterogeneity of Sand Reservoirs. J. Law. *Petrol. Tech.*, May 1944, 7 (3), A.I.M.M.E. Tech. Pub. No. 1732, 1–20.—Core analysis data comply with the requisite of random sampling as stipulated by theoretical statistics. Permeability frequency distributions within a given stratigraphic interval have been constructed with samples plotted in the order of their appearance with depth (accession number) against their permeability values. These distributions were asymmetrical about the central class, being skewed to the right. An array constructed on the basis of accession number against the logarithms of permeability gives a symmetrical distribution of values about a central trend of greatest density of points. A frequency distribution that would be symmetrical can be derived from this array by a technique which is described.

If the composite effect of the numerous scattered values of permeability encountered in a well can be evaluated, oil-well performance can be put on a rational basis. Accordingly, a procedure is outlined for attempting to predict the initial production, and this procedure is applied to twelve wells in a single zone at Dominguez. The results are sufficiently compatible with both theory and oil-field experience, and the mechanism of increase in specific productivity index with increased standard deviation in phi ($\sigma\phi$) sufficiently reasonable, strongly to support the belief that oil-wells perform in accordance with their permeability distributions.

The effectiveness of a gas- or water-drive is a function of the uniformity of the sands being flushed. The $\sigma\phi$ appears to be the proper criterion of uniformity. The sharply increasing specific productivity indexes of permeability assemblages as a function of $\sigma\phi$ indicates that a major portion of the early production of a well comes from a minor portion of the exposed sand. A tentative example is given of the application of normal curves to the solution of problems of secondary recovery.

The screen analysis profile of an interval was similar to the permeability profile.

Porosity distributions gave symmetrical arithmetic normal curves, and the standard deviations encountered by the author show a small range. G. D. H.

1304.* Exclusion of Water from Oil-Wells. E. A. Stephenson and R. T. Amstutz. Jr. *Oil Gas J.*, 3.6.44, **43** (4), 45. *Paper Presented before American Petroleum Institute.*—See Abstract No. 1214. A. H. N.

1305.* Treatment of Gas Sands to Prevent or Overcome Detrimental Effect of Water. K. J. Sonney and C. E. Williams. *Oil Gas J.*, 3.6.44, **43** (4), 51–55. *Paper Presented before American Petroleum Institute.*—See Abstract No. 1201. A. H. N.

1306.* A Method of Handling Salt-Water Disposal Including Treatment of Water. H. W. Ellison and W. B. Davis. *Oil Gas J.*, 3.6.44, **43** (4), 59–61. *Paper Presented before American Petroleum Institute.*—This report covers an initial investment of $4,204,965·85 for 256 systems, an operating cost of $1,213,253·05 for 86 systems which includes 387·58 miles of pipe-line made up of 151·31 miles of cement asbestos pipe, 27·83 miles of cement asbestos and cement-lined pipe, 44·38 miles of cement-lined and steel pipe, 7·30 miles of cement asbestos and fibre pipe, 18·77 miles of fibre pipe, 78·23 miles of cement asbestos and steel pipe, 31·31 miles of steel pipe, 25·75 miles of cement asbestos, fibre, and cement-lined steel pipe, 2·2 miles of cement-lined steel pipe, and steel, and 0·5 mile of cement asbestos, cement-lined steel, and steel pipe.

The open, closed, and semi-closed typed of systems are described and compared. A. H. N.

1307.* Repressuring Programme for Plymouth Pool Maintains Improved Production Rate. P. Reed. *Oil Gas J.*, 10.6.44, **43** (5), 58.—Examination of results of repressuring stripper properties over considerable periods reveals what is accomplished by operations to recover more crude oil than could be expected by conventional primary operations. For approximately 10 years Ohio Oil Co. has repressured the Plymouth pool in western Illinois, which is the largest secondary-recovery project of the company in the State. When data were prepared for a survey of what had been accomplished up to the beginning of 1944, there were 65 key wells for the project, having a total of 1445 acres. Production comes from the Hoing Sand of the Devonian age. Average bottom depth of producing wells is 468 ft.; average sand thickness is 14 ft. The Hoing sand consists of rounded quartzitic grains; it lies in lenses on top of the Maquoketa shale and under Devonian limestone. There is no connection between the sand lenses in the south area and the east area to which repressuring has been applied. Oil produced is 37° A.P.I. gravity, classified as sweet.

A review of 14 years of the company's repressuring at the beginning of this year, when 21 projects were being produced by this type of secondary recovery, indicated that the Plymouth project had sustained its production rate, above the rate before repressuring, for a longer period than is normally to be expected in such operations in Illinois. A. H. N.

1308.* Methods for Prevention and Removal of Paraffin Deposits. J. Zaba. *Oil Gas J.*, 8.7.44, **43** (9), 140.—As far as pumping wells are concerned, the paraffin problems can be divided into two groups. To the first group would belong problems resulting from deposition of paraffin in the tubing. To the second group would belong problems resulting from deposition of paraffin on the face of the producing sand or in the perforations of the liners. The pumping operations are also affected by deposition of paraffin in surface lines, and indirectly by paraffin deposits in tanks. The problems of the first group include increased wear and tear on equipment, increased power demands, decreased ability of rods to fall freely, rod failures, difficulties in pulling rods, and others. The problems of the second group manifest themselves primarily in decline of production. Paraffin deposits in lead lines may result in decrease of production, increased power demand, and wear of certain parts of pumping equipment. Precipitation of wax from oils is studied in brief, followed by a discussion of its removal. In general the methods of removal of paraffin deposits can be divided into three classes —mechanical methods, thermal methods, and use of solvents.

Mechanical methods, as the name implies, depend on mechanical action of different devices for removal of paraffin deposit from walls of tubing or pipe. Thermal methods use heat for melting of waxes, which are then removed from the well in liquid form. Different procedures are used for creation of heat. Steaming down the tubing or

introducing of hot liquids is quite often employed or chemicals are used, whose reaction results in creation of heat. An efficient and economical method of intermittent electrical heating has been developed. The third class of method of paraffin removal utilizes solvents, such as kerosene, gasoline, or benzole, or commercially produced chemicals to dissolve the paraffin waxes, thus making possible their removal. Different techniques of application are employed. The important thing to remember in using thermal and solvent methods of paraffin removal is that the melting or softening of waxes is only one portion of the problem. Fully as important to the success of the cleanout is removal of suspended waxes. A. H. N.

1309. How to Determine Proportions of Sucker Rod String. E. N. Kemler. *Oil Wkly*, 7.8.44, **114** (10), 28.—The design of a string of sucker rods involves two problems, first the determination of the size of rods which are to be used, and second the determination of the amount of each size of rods in case a tapered string is to be used. For shallow wells the smallest size of sucker rods available is generally used. In this case there is no alternative but to use an entire string of that size of rod. In the case of deeper wells, where larger rods are used, it is possible to make appreciable savings by using smaller-diameter rods on the lower part of the string. The high expense of dies and gauges necessary for the manufacture of sucker rods, together with increased cost of manufacturing and stocking, handling, etc., in smaller lots has limited the number of sizes of sucker rods to $\frac{5}{8}$, $\frac{3}{4}$, $\frac{7}{8}$, and 1-in. diameters. The practical factors which limit the number of sizes of rods to this number makes possible a definite procedure in determining the proportion of sucker rod strings, and also in determining the sizes which should be used. Tables and charts are given for determining proportions of sucker-rod strings in a practical manner. A. H. N.

1310. Operators Using Orifice Buttons to Cause Wells to "Kick Off" and Flow. D. D. Kinley. *Oil Wkly*, 7.8.44, **114** (10), 30.—During recent months it has been common practice in many Gulf Coast oil-fields to use orifice buttons injected into the well-tubing by gun or mechanical perforator run from the surface on a wire line. Then gas in the annular space between the tubing and casing can enter the tubing to lift the fluid in the tubing from that point to the surface, thus "kicking off" a well which will not flow without assistance. In some instances gas from outside sources is applied to the casing, and the orifices act as gas-jets, lifting the fluid in the tubing. This practice has enabled many operators to continue flowing wells, which have ceased to flow from their own formation pressure, without even pulling the tubing string, which has not only reduced expense, but, in these days of material and labour shortage, has had additional benefits. Several other uses for the technique have been made. Two types of perforator for placing these buttons in the tubing have been developed. One of these utilizes the force of a small charge of powder to drive a wedge downward forcing the button into the tubing, while the other forces a wedge down by the action of a set of jars manipulated by the wire line at the surface. Each accomplishes substantially the same result. Both types of perforators are run on a wire line through a stuffing-box using a lubricator above the tubing gate-valve. A separate run is required for each button to be put in the tubing, but the time for the entire operation can be measured in hours. All necessary equipment is mounted on a light truck, which can be moved readily from location to location. The methods used are described in some detail, and illustrated photographically. A. H. N.

Crude Oil.

1311.* A Comparative Study of the Petroleum Crude Oils of the U.S.S.R. Part 3: Hydrocarbons of the Petroleum Ether Fractions of Vereisk and Namursk Crudes of the Krasnokawsk Field. N. D. Zelinsky. *Bull. Acad. Sci. (U.S.S.R.)*, 1941, No. 7/8, p. 41.—A detailed investigation of the lighter fractions of some Russian crude petroleum oils. The proportion of aromatic to paraffinic constituents is determined by measurement of the refractive index and specific gravity, from which the refractivity may be determined by the Lorenz–Lorentz formula. This is carried out on the original fraction, after catalytic dehydrogenation and after sulphonation. The theoretical basis of the method is developed, and various formulæ and tables of results given. D. A.

1312.* The Influence of Temperature on the Yield of Crude Petroleum Oil. N. P. Chidjevsky. *Bull. Acad. Sci.* (*U.S.S.R.*), 1941, No. 7/8, p. 53.—Experiments are carried out on an apparatus intended to duplicate oil-field conditions, consisting essentially of a pressure vessel containing sand, so that oil may be siphoned out of sand by the application of pressure. The pressure-vessel may be maintained at any desired temperature. Experiments were carried out with various oils, using different pressures and temperatures, employing carbon dioxide instead of air, and repeatedly repressuring after flow had ceased. The amounts of oil remaining in the sand were determined in all cases, and tables of results are given.

In a second series of experiments the drainage of various oils through sands was investigated, the gas used for expelling the oil, and the sand column being capable of being maintained at a given temperature, separately or together as desired. Tables of results are given. The rates of percolation of various oils through sand at various temperatures were also investigated, and tables of results and graphs given.

It was found that raising the temperature of the sand enabled a greater yield of oil to be obtained both initially and after subsequent repressuring. D. A.

1313.* The Variability of Ishimb Petroleum Crude Oils. S. S. Nametkin. *Bull. Acad. Sci.* (*U.S.S.R.*), 1943, No. 5/6, p. 5.—In a survey of the Ishimb petroleum field specific gravity and viscosity are used to characterize the various types of petroleum crude. The type of oil yielded by any one well is shown to vary from time to time in certain cases. Maps of the field are given with " contours " joining points yielding petroleum crudes of equal specific gravity and viscosity. The geological structure of the field is discussed at some length. D. A.

Gas.

1314. Maximum Hydrocarbon Utilization with Natural Gas as a Chemical Raw Material. J. W. Pew and F. H. Dotterweich. *Refiner*, April 1944, 23 (4), 130–134. *Paper Presented before the Southern Gas Association.*—Natural gas reserves and the various materials available in it are discussed. New and old methods of utilizing natural gas as a chemical raw material are then studied. Present-day use of natural gas for production of carbon black for rubber, hydrogen for ammonia synthesis, and starting point for a number of chemicals, tabulated in two tables, is used as a basis for forecasting the future demands on the industry. A. H. N.

Cracking.

1315. Gas Oil Cracking by the Cycloversion Process. W. A. Schulze and C. J. Helmers. *Oil Gas J.*, 13.4.44, 42 (49), 225–235.—The results of experimental tests carried out in pilot and semi-commercial Cycloversion plants using gas-oil and naphtha feed-stocks are described. The two major lines of investigation were : (1) Conversion of gas-oil with high yields of highly olefinic high-octane motor fuel, (2) conversion of gas oil and naphtha into light olefinic hydrocarbons with concurrent production of high-octane motor fuel.

The Cycloversion plant, methods of operation and of catalyst regeneration are described. Tables show the properties of seven gas oils used as feed-stocks and the properties of butane-free gasolines produced from each with process periods of 6 hrs. duration. Octane numbers, motor method, range from 75 to 80 and olefine contents 65% to 88% by wt. Some typical analyses of gases, C_4 and lighter, obtained from a gas-oil subjected to the Cycloversion process at 75 lb. pressure and temperatures ranging from 980 to 1050° F., show high molecular percentages of olefines and indicate the effects of steam diluent. Increasing the depth of conversion per pass from 36% to 80% and maintaining the process period at 3 hrs., increased the production of C_2–C_4 fractions from about 8% to 47% expressed as liquid volume, of butane-free gasoline from 28% to 32% liquid volume, and of carbon from 1·2% to 8·3% weight. The olefine contents of the C_3 and C_4 fractions range from 60% to 80%. The octane rating of the gasoline from the deep conversion was three numbers higher than that from the lower. Comparison of yields of products obtained by single and 2-pass operations to approximately the same overall conversion shows that the 2-pass method yields slightly more gasoline, but much less carbon. Effects of 2-pass treatment on plant operations are discussed.

By raising the operating temperature to approximately 1200° F., it is possible to operate the unit so as to produce mainly light olefines with high-octane gasoline as secondary product. It is desirable to use high flow rates, low partial pressures, and deep conversion to promote formation of the light olefines. Results obtained on gas-oil and kerosine feed-stocks are tabulated. R. A. E.

1316. Patent on Cracking. G. C. Connolly. U.S.P. 2,336,597, 14.12.43. Appl. 23.8.40.—In a cracking process, hydrocarbon oils are passed in vapour form in contact with a catalyst formed by mixing silica gel with alumina hydrosol. Contact is maintained under conditions designed to effect substantial conversion of the oil to motor fuel constituents. H. B. M.

Polymerization and Alkylation.

1317. Patent on Polymerization and Alkylation. W. Ullrich. U.S.P. 2,337,360, 21.12.43. Appl. 15.11.41.—In the polymerization of normally gaseous olefin hydrocarbons to gasoline hydrocarbons the reaction temperature is maintained at a relatively constant level in the following way. An olefin-containing gas is passed through a heating zone and raised to the temperature of reaction. It is then passed to a substantially unheated reaction zone and kept there for a sufficient length of time to effect substantial polymerization of gaseous olefins to gasoline. By maintaining the resulting mixture of gases and polymer vapours under substantial pressure while in the reaction zone and gradually reducing it, the excess exothermic heat of reaction substantially balances the cooling effects resulting from reduction in pressure. H. B. M.

Refining and Refinery Plant.

1318.* The Production of High-Octane Petrols from High Pressure Distillates of Soviet Two-Stage Cracked Oils by Zinc-Chloride Treatment. N. P. Chidjevsky. *Bull. Acad. Sci.* (*U.S.S.R.*), 1942, No. 3/4, p. 3.—The treatment is carried out in vapour phase at temperatures of about 200° C., the vapours being passed through a tower packed with coke saturated in zinc chloride solution. This method of treatment is compared with sulphuric acid and clay treatment, the octane numbers and induction periods with and without inhibitors being used as criteria.

Several petrol fuels are treated by these methods and examined, tables of results being given.

The zinc chloride treatment enables the production of a petrol having octane number 75/76 as compared with 72 obtained by the other methods. In addition, the stability toward gum-formation is enhanced, as is evidenced by increased induction period. D. A.

1319.* The Desulphurization of Gasolines, Petroleum Ethers and Diesel Fuels. S. S. Nametkin. *Bull. Acad. Sci.* (*U.S.S.R.*), 1942, No. 3/4, p. 11.—The method consists of passing the fuels in vapour phase at temperatures of about 400° C. at atmospheric pressure over specially prepared bauxite. The bauxite is regenerated with air and retains its full activity up to 30 cycles. A typical cycle consists of 5/6 hours working followed by one hour's regeneration. Results obtained with various fuels are tabulated, and also those from experiments on gas oil into which thiophene was deliberately introduced. A petroleum ether containing 0·465% sulphur has the content reduced below 0·1%. Desulphurization of heavier gas oils does not take place to the same extent, but nevertheless occurs to a significant degree, unpleasant odours, and gum forming portions being removed.

The process of desulphurization improves the octane value of gasolines, particularly their susceptibility toward tetra-ethyl lead. Thus a crude gasoline of octane number 45 which can be raised to 56 with tetra-ethyl lead, has its octane number raised to 48 on desulphurization and to 70 on addition of tetra-ethyl lead. D. A.

1320.* The Purification of Petroleum Gases and the Regeneration of Acid Tars. S. S. Nametkin. *Bull. Acad. Sci.* (*U.S.S.R.*), 1942, No. 5/6, p. 29.—Sulphuric acid, even when dilute, can be reduced to sulphur dioxide almost quantitatively in contact with coal at comparatively low temperatures in the region of 300° C. This basic reaction may be used industrially in the following ways.

Dilute sulphuric acid may be reduced to sulphur dioxide and by further catalytic oxidation to concentrated sulphuric acid.

It is possible to replace the coal by " acid tar," suitably prepared, and thus reduce " black acid," giving gases rich in sulphur dioxide (about 80%) at about 270° C. The gas is, in fact, richer in sulphur dioxide than the gases obtained from pyrites burners. Coking of " acid tar " only takes place at 600–800° C., and gases much lower in sulphur dioxide content are obtained. Thus sulphur dioxide, or by further catalytic oxidation, sulphuric acid can be made from " black acid " and " acid tar " both of which are useless by-products of petroleum refining.

Sulphuretted hydrogen may be oxidized with the production of elementary sulphur by passing it over sulphuric acid in contact with coal. This reaction can be used for the purification of petroleum gases, although olefines may also removed. Alternatively the sulphur dioxide produced by reaction of " black acid " and " acid-tar " can be used to react with the sulphuretted hydrogen in petroleum gases with the production of elementary sulphur, olefines not being absorbed in this way (see " Trinidad process," Brit. Pat. 370,911, 1932). D. A.

1321.* Gas Turbines Offer Opportunities for Process Use. S. A. Tucker. *Chem. Met. Engng*, March 1944, **51** (3), 96.—The use of gas turbines in the Houdry process to supply large volumes of air to burn the carbon deposit off the catalyst is described. The theory of gas-turbines is given in brief, followed by their general characteristics. High efficiency is a prime requirement of the compressor—in fact the inherently low efficiency of centrifugal compressors led to the conclusion in the 1920's that the continuous combustion process would never be practical. However, aerodynamic designs of axial-flow blading and compressors can now be built with over-all efficiency of more than 85% adiabatic basis. In principle, ordinary air is compressed to any convenient pressure, say 60-lb./sq. in. gauge, and passed through a combustion chamber where enough oil is fired to bring the " flue " gas up to operating temperature, say 1200° F. Products of combustion, together with the excess air, expand through the turbine blades to atmosphere. Since more work is available from the expanding high-temperature gas than is required by the low-temperature compression, the turbine has an excess of power available for the generator.

The use of gas-turbines in various forms up-to-date is discussed, with a brief study of future development. A. H. N.

1322. Pumping Light Hydrocarbons. R. G. Lovell. *Refiner*, April 1944, **23** (4), 117–122.—The development of the positive displacement and centrifugal pumps to deal with pumping light hydrocarbons is reviewed. Sealing troubles are discussed in some detail, and sealing methods are well illustrated. A. H. N.

1323. Test Pressure and Safe Dimensions of Welded Pressure Vessels. H. F. Lassner. *Refiner*, April 1944, **23** (4), 135–138.—This article is a repetition, with additions and corrections, of the identical subject as printed in the December 1943 issue of the *Refiner*, **22** (12), 89–92 (Abstract No. 502). Because of miscarriage of mail, the author did not make corrections in proof, with the result that repetition of the article was necessary. Since it was being repeated, some later code developments were added and another illustration used. For all indexing this article should be used and the same subject in December ignored. It is demonstrated that in the conception of both codes, the test pressure based in the full wall thickness necessary to stand the internal design pressure leads many designers to " over-dimensioning " parts of shell openings. This is particularly true with regard to the API-ASME Code ruling that the longitudinal weld of a vessel be given the full test pressure proportional to its thickness after completed construction. It is emphasized that thickening such parts as manhole covers and reinforcing pads merely to let them match a temporarily applied test pressure appears as an unnecessary expenditure, particularly when the stress in the engaged parts remains under the yield-point of the material. Further, it is questioned if the application of alloy bolts justifies the use of a higher value for the bolt load applied to achieve a tight joint, than that resulting when carbon-steel bolts were used instead. The practice of applying such a higher bolt load in the design seems to increase flange and cover thickness beyond values commensurate with safety, and therefore appears

uneconomical. In the interest of conserving material and labour, these questions are brought to the attention of the interested parties, especially to the API-ASME committee on unfired pressure vessels, and to the insurance companies in charge of inspections. A. H. N.

1324. Application of Unit Operations to Fractionation and Other Vaporization Processes. Part 3. R. L. Huntington. *Refiner*, April 1944, **23** (4), 139–142.—P-V-T relationship of hydrocarbons and their mixtures is studied, together with illustrative examples of how to use such data., A. H. N.

1325. Refinery Operation Demands Effective Maintenance of Motor Starters. M. A. Hyde and L. E. Markle. *Refiner*, April 1944, **23** (4), 143.—A long discussion of maintenance and operation practice to be adopted in using motor starters is given. A. H. N.

1326.* Bauxite as an Adsorbent, Catalyst and Catalyst Carrier. Part I. H. L. King, C. D. Laughlin and H. M. Gwyn. *Oil Gas J.*, 13.4.44, **42** (49), 236–244.—Methods of obtaining bauxite ore, of selection for specific purposes and of manufacturing activated bauxite, are described. In the manufacture of the isomerization catalyst Isocel, de-ironed activated bauxite is heated in impregnators with the proper percentage of anhydrous aluminium chloride, and the tests applied to determine the suitability of each batch are described. One vapour-phase isomerization process applied to *n*-butane uses this type of prepared catalyst, but another employs activated bauxite as support and develops the catalyst *in situ* by injection of aluminium chloride vapour. The product stream from the isomerization reactors passes through a guard tower filled with bauxite, a hydrogen chloride stripper, and a caustic washer, prior to the fractionator in order to remove aluminium and hydrogen chlorides. The bauxite used in the guard tower must be specially prepared to give maximum adsorption of aluminium chloride and minimum water content. The iron content must be low to avoid reaction with HCl. Adsorbed water can be driven off by the use of hot gases. It is pointed out that the potential economies of vapour-phase isomerization have not always been fully realized during war-time, owing to the need for maximum output, involving early discarding of catalysts and disregard of impurities in the feed deleterious to the catalyst.

A specific grade of activated bauxite has also been successfully employed in H.F. alkylation units to dehydrate the feed to reaction vessels, thus reducing corrosion and loss of H.F., and also to remove fluorides from the reaction products prior to the re-run unit. It is thought that bauxite might also be used with advantage for drying the feed to sulphuric acid alkylation units, not only to conserve acid, but to improve product yield and quality. R. A. E.

1327.* Bauxite as an Adsorbent, Catalyst and Catalyst Carrier. Part 2. H. L. King, C. D. Laughlin, and H. M. Gwyn. *Oil Gas J.*, 20.4.44, **42** (50), 71–74.—Catalytic desulphurization of high-sulphur-content gasolines is achieved in the vapour phase, using activated bauxite as catalyst, at a temperature of about 725° F. and a low pressure. The H_2S formed may be removed by the Girbotol process, by a caustic wash, or by fractionation. Only heat exchangers and coolers, where liquids containing H_2S are present, require the use of corrosion-resistant materials. Catalyst life-cycles of up to 5000 bbl. throughout per ton of gasoline are obtained with straight-run or natural gasolines. With cracked and polymer gasolines catalyst life is reduced by formation of refractory compounds of unsaturates and sulphur. It is reported that dissociation of H_2S and also carbon deposition can be depressed by addition of hydrogen, thus lengthening catalyst life. Generally 85% or more of the sulphur present in the untreated gasoline can be removed by this process, and increases in T.E.L. susceptibility and output of aviation gasolines thereby resulting are discussed. Desulphurization of propane used in the preparation of hydrogen for hydrogenating edible oils is to be achieved by this process in a plant under construction.

The H_2S formed during the desulphurization process may be converted to sulphur by a modification of the Claus process, using bauxite as catalyst for reacting H_2S with the SO_2 formed by burning part of it.

The cycloversion process of Phillips Petroleum Co. employs a catalyst prepared from

a selected bauxite-ore base, and the rugged nature of catalysts prepared from bauxite is expected to be of value in catalytic cracking and reforming processes.

The dehydration of natural and refinery gases and also of liquids such as the liquefied gases, aromatic hydrocarbons required for further processing, technical white oils, electrical oils, etc., is of the greatest importance for varied reasons. The use of solid adsorbent materials for this purpose has increased in recent years for reasons given. The application of bauxite dessicants, *e.g.* Driocel, for such purposes is described, and information on design, operating conditions, and regeneration given.

Activated bauxite is also used in finishing processes applied to lubricating oils, waxes and petrolatum and advantages obtained are described. A chart shows the application of bauxite in petroleum hydrocarbon processes and literature and patent references of various applications are appended. Other uses are as catalyst in the dehydrogenation of ethylbenzene to styrene and dehydration of certain alcohols to olefins. R. A. E.

1328.* Low-Cost H_2S Extraction and Mercaptan Reduction. Anon. *Oil Gas J.*, 25.5.44, **43** (3), 80.—The method used at the Santa Fe Springs Refinery of the Eagle Oil and Refining Co. is described with a flow-sheet and photograph.

Cracked gasoline from a Dubbs stabilizer is pumped through 15° B. caustic soda in a horizontal drum, hydrogen sulphide being removed without recirculation; the gasoline then passes through two contacting sets, in series, consisting of outside contacting vessels and vertical settling columns through which 22° B. caustic soda is circulated and regenerated continuously and which removes the mercaptans. A back pressure of 30 lbs. is maintained in the units against the flow from the stabilizer, and a ratio of gasoline to caustic soda is held at approximately 5 : 1. The cost of treating is quite low, the quantity of caustic soda required for complete removal of the hydrogen sulphide is 0·105 lb. per barrel, and that required to reduce the mercaptans from 0·29 to 0·03% is 0·07 lb. per barrel. W. H. C.

1329.* Cathodic Protection, its Application to a Pipe Line. L. C. Secrest. *Oil Gas J.*, 25.5.44, **43** (3), 82.—The various data and information necessary for planning cathodic protection to a pipe-line are outlined. The paper describes some of the problems encountered when applying it to an 8-in. pipe-line in Colorado and Wyoming in 1939. A description is given of the protective coating of the pipe sections before and after welding the joints. A year after its installation it was decided to apply cathodic protection, and from the data accumulated it was considered that if the line could be maintained at 0·3 volt (0·85 volt to a copper sulphate electrode) or more, negative to the soil, no corrosion would occur; and so spacing of the cathode units was based on minimum 0·3 volt at overlap points between the units. As electric power was not available, wind-driven generators to give 25–30 amps were installed. The tests carried out for spacing the units is described. Briefly, electrodes placed 300 ft. from the line were connected to the positive element, and the line to the negative pole of the current. After a few hours, pipe-soil potentials were determined along the line on each side of the unit, and the current spread and extent of protection were determined. From the data the approximate location for the generating sets were obtained. Tests were then made by the Megger tester, to determine the positions and depths giving the lowest resistances for the ground bed and form of electrode needed at the points selected. Where low resistance could not be found, except at depths of 30–40 ft., verticle tube electrodes were placed in holes 40–50 ft. deep, their tops being connected together and with a cable to the generator. Horizontal tube electrodes were employed at depths around 6 ft., these had V or crowsfoot shapes and were perforated at the bottom. They were connected with a vertical leading tube extending above the surface, to which the electric cable was connected, and also served to admit salt water to the soil. The ground beds were placed 300–650 ft. from the pipe-line, depending on the best resistance found.

The distance between the generator units varied from 7 to 21 miles for the protected pipe-line section, and from 1½ to 2 miles for the unprotected section. A series of test-plates buried near the line, one connected and the other not connected to the pipe, were examined; the former were not corroded, but the latter were corroded even to pitting.

Total maintenance costs for a period of from 4 to 5 years for the 28 units amounted to $6·05 per year per unit. W. H. C.

1330.* Controlled Water-Jacket Cooling Reduces Maintenance Costs. B. C. Thiel. *Refiner*, June 1944, **23** (6), 197–203.—The requirements of cooling waters are discussed in some detail. The following is an analysis of water to be used in cooling engine and compressor cylinders :

Dissolved Oxygen : preferably 0, but not over 0·05 c.c. per litre.
pH value : Not less than 8.
Oil : None.
Suspended solids : None.
Hardness : Calcium and magnesium sulphates, added, not over 15 ppm. Calcium and magnesium carbonates, added, not over 75 ppm.
Organic matter : Not over 5 ppm.
Chloride : Not over 6 ppm. in terms of chlorine.

Any make-up water should be of the same analysis. Muddy water, no matter how non-scaling, should never be used. Water of this nature should be first settled in settling basins, and then filtered until all mud has been removed. It will pay plant operators good dividends if a competent water chemist is consulted and his recommendations followed. Lay-out for cooling systems are discussed. A. H. N.

1331.* The Design of Ring Girders for Horizontal Tanks. A. C. Barton. *Refiner*, June 1944, **23** (6), 207–217.—Detailed analysis of the problem is given, with full mathematical evaluation of stresses and dimensions. A. H. N.

1332. Application of Unit Operations to Fractionation and Other Vaporization Processes. Part 5. R. L. Huntington. *Refiner*, June 1944, **23** (6), 223–225.—The use of vapour-pressure data to calculate vapour losses from large atmospheric storage tanks is illustrated by a worked-out example. A. H. N.

1333.* Oil Dewaxed and Wax Deoiled in Simultaneous Operation. E. E. Ebner and F. T. Mertens. *Refiner*, June 1944, **23** (6), 230–234.—See Abstract No. 997. A. H. N.

1334.* Problems Confronting the Smaller Refineries. R. G. Atkinson. *Refiner*, July 1944, **23** (7), 241–243.—The author describes recent processes which will be available to the small refinery plant after the war. A. H. N.

1335.* What Constitutes a Hazardous Area in the Petroleum, Rubber and Chemical Industry. G. G. Griffin. *Refiner*, July 1944, **23** (7), 244–246.—The installation and safety precautions to be adopted in the use of electrical plants in hazardous areas are discussed. In locations judged to be hazardous the following provisions should be observed : (1) Transformers should be installed outside of the hazardous area. (2) Service equipment and panel boards should be of explosion-proof type and installed as required by the National Electric Code. (3) Conduit should be rigid type and with threaded explosion-proof joints. (4) Fittings should be of the explosion-proof type, with five full threads or more in each hub. All covers should be treated with a compound to prevent corrosion. Screw-threaded flame-paths give most reliable protection and require but little maintenance. Flexible connections of explosion-proof construction are available for connecting to conduit systems, motors, or equipment installed on moving bases.

All conduit runs should be sealed off in an approved manner : (1) Where conduit terminates immediately adjacent to an enclosure in which arcing or sparking occurs, as at breakers, panel boards, branch circuits, motor starters, lighting units, switches, receptacles, and similar devices. (2) Wherever a conduit leads from a hazardous to a non-hazardous location, such as between buildings. (3) Within 2 ft. of terminal and junction boxes to which rigid conduit runs, 4-in. size or larger, are connected. Other precautionary rules are given in connection with starters, lamps, and other portable equipment. A. H. N.

1336.* Pressure Drop for Flow through Beds of Granular Adsorbents. H. V. Allen, Jr. *Refiner*, July 1944, **23** (7), 247–252.—Pressure-drop data useful in the design and

operation of industrial adsorption equipment have been determined from experimental studies on the flow of liquids and also of gas through various mesh sizes of activated bauxite and fuller's earth packed in a steel tower 6·065 in. in diameter and 10 ft. high. A general relation based on a simplification of the mechanical energy balance and the so-called Fanning equation for friction, and plotted in the form of friction factor *vs* Reynolds Number, where

$$f = \frac{\Delta P \; D_p g_c \; \rho ave}{2 G_0{}^2 L}$$

and

$$\mathrm{Re} = \frac{D_p \; G_0}{\mu}$$

all expressed in consistent units, is recommended for calculating pressure drop to within ±10% for a single fluid flowing through a standard grade of bauxite and fuller's earth of experimentally determined equivalent particle diameter. The symbols have the following significances: f = friction factor in Fanning equation, dimensionless; Δp = pressure drop, lb./sq. ft.; D_p = effective particle diameter, ft.; g_c = gravitational constant, ft./sec.²; ρ_{ave} = average density, lb./cu. ft.; G_0 = superficial mass velocity, lb./sq. ft. of pounds/sq. ft. of tower cross section/sec.; L = length of packing, ft.; Re = Reynolds Number, dimensionless; μ = absolute viscosity in ft.-lb. sec. units. A. H. N.

1337.* Application of Unit Operations to Fractionation and Other Vaporization Processes. Part 5. R. L. Huntington. *Refiner*, July 1944, **23** (7), 269–271.—This part deals with stage separation of mixtures containing three or more hydrocarbons, by means of distillation and fractionation. As usual, a numerical example, worked out in full, illustrates the method. A. H. N.

1338.* Practical Refinery Engineering. No. 5—Heat Transfer Film Coefficients—Water being Heated. P. Buthod and B. W. Whiteley. *Oil Gas J.*, 22.7.44, **43** (11), 66.—For liquids being heated inside tubes under forced convection, the film coefficient is usually computed by the Nusselt type of dimensionless equation proposed by Dittus and Boelter, whose constants correlate closely with experimental data over a wide range of liquids and flow conditions.

Values of the heat transfer film coefficient for water being heated under such conditions may be obtained from the chart presented. The chart is based on the Dittus and Boelter equation; it employs, instead of the film coefficient, the thermal resistance (the reciprocal of the film coefficient). This value can be used directly in the basic equation for rate of heat transfer. To obtain the termal resistance, the average temperature of the water, the mass velocity and pipe diameter are required. Two examples of the use of the chart are given. W. H. C.

1339.* Practical Refinery Engineering. No. 6.—Heat Transfer Film Coefficient—Water being Cooled. F. Buthod and B. W. Whiteley. *Oil Gas J.*, 29.7.44, **43** (12), 197.—The calculation of the film coefficient (h) for water being cooled on the inside of a pipe is based on the Dittus–Boelter equation. The heat exchanged is computed from the several resistances ($1/h$) both on the inside and outside of the tube and the resistance of the metal wall, by the basic heat transfer equation. Equations are given for correcting the outside film resistance and metal-wall resistance to equivalent resistances based on the inside area of the pipe. A chart is presented from which the value of the thermal resistances can be obtained from the mass velocity, the pipe diameter, and the average water temperature. A simple equation is given for the case of water flowing through annular areas in double-pipe heat-exchangers. Two examples of the use of the chart are given, and in the solution of one, a step-by-step procedure is carried out in determining the sizes of a practical heat-exchanger installation. W. H. C.

1340. Patents on Refining and Refinery Plant. M. Bonotto. U.S.P. 2,336,589, 14.12.43. Appl. 29.10.41.—Hydrocarbon fluids containing soluble gums, resins, and heavier components are refined by dispersing in water and afterwards treating the dispersed liquid hydrocarbon with a solution of a metallic hydroxide in an aqueous

solution of a strong alkali. In this way the gums are rendered insoluble in the hydrocarbon and they can readily be separated.

A. Szayna. U.S.P. 2,337,358, 21.12.43. Appl. 20.10.39.—Oils are desulphurized by heating to a temperature above 700° F. and passing the heated oil over a porous mass having nickel extended in the surface thereof. The oil is separated from the mass before all the sulphur is removed from it and cooled to below 650° F. Remaining sulphur is removed by contacting it with a porous mass comprising free nickel in highly active extended surface form.

D. E. Carr. U.S.P. 2,337,448, 21.12.43. Appl. 24.1.40.—Sulphur is separated from asphaltic oils by separating the oil into an asphaltene fraction and an oil fraction and heating the former in the absence of added hydrogen at a temperature of approximately 675° F. for a sufficient length of time to separate sulphur in the form of hydrogen sulphide.

M. W. Lee. U.S.P. 2,337,826, 28.12.43. Appl. 2.12.40.—In the treatment of a gasoline distillate containing sulphur-bearing compounds, a hydrocarbon fraction having a higher boiling point is added. Afterwards the mixture is treated at a temperature between 0 and 100° F. with concentrated sulphuric acid. H. B. M.

Chemistry and Physics of Hydrocarbons.

1341.* The Viscosity of Petroleum Vapours. S. S. Nametkin. *Bull. Acad. Sci. (U.S.S.R.)*, 1942, No. 3/4, p. 21.—The following empirical formula is given for the calculation of the viscosity of a hydrocarbon vapour :

$$\eta_t = \eta_0' \frac{T}{273}$$

This is claimed to be rather more accurate than Sutherland's formula, and a graph is given comparing the two equations. The constant η_0' in the above equation can be calculated from a formula of the following type :

$$\eta_0' = K_1 - K_2 \log M$$

where M is the molecular weight of the hydrocarbon, and K_1 and K_2 are constants which are given numerical values for paraffins, olefines and aromatics.

The viscosities of mixtures of hydrocarbon vapours can be determined by an equation of the following form :

$$\eta_{mix.} = \eta_1 g_1 + \eta_2 g_2 + \cdots$$

where g represents the fractional weight content of the individual hydrocarbon.

Thus the above logarithmic equation can be used to determine η_0' for mixtures by putting the mean molecular weight for M in the equation.

A nomogram is given for obtaining the viscosities of individual hydrocarbon vapours, and of mixtures of hydrocarbon vapours, when the molecular weight (or mean molecular weight) and the temperature are known. D. A.

1342. Comparative Osmotic and Viscosity Measurements with Polystyrene Fractions. T. Alfrey, A. Bartovics, and H. Mark. *J. Amer. chem. Soc.*, 1943, **65**, 2319–2323.—Osmotic and viscosity measurements have been made on fractions obtained by successive precipitations from three samples of styrene polymerized at 60°, 120°, and 180° C., respectively. The results obtained indicate that, although solutions of fractions of one of the three samples in the same solvent may be regarded as one system, similar solutions using another sample must be regarded as another system. Thus fractions which have substantially the same (osmotic) molecular weights, but which were obtained from different samples, possess different intrinsic viscosities.

The precipitability of a high polymer appears to be not so much a function of its molecular weight as of its intrinsic viscosity (an expression for the internal structure of the dissolved macromolecules). C. F. M.

1343. Chain Transfer in the Polymerization of Styrene : The Reaction of Solvents with Free Radicals. F. R. Mayo. *J. Amer. chem. Soc.*, 1943, **65**, 2324–2329.—It is postulated that certain solvents reduce the molecular weight of polymerizing styrene because

they transfer hydrogen or chlorine atoms to growing polymer radicals. The activity of the polymer radical is thus transferred to the solvent residue, which may then start a new chain. In order to compare solvent reactivities in these chain transfer reactions, a simple theoretical development leads to definition of the "transfer constant" which is characteristic of a solvent. Several transfer constants have been calculated from data in the literature. The results give support to the theoretical development and permit quantitative comparisons of solvent activities. Activation energies for chain transfer are calculated for some hydrocarbon solvents. C. F. M.

1344. The Polymerization of Styrene in the Presence of Nitrothiophene and Chloranil. C. C. Price. *J. Amer. chem. Soc.*, 1943, **65**, 2380–2381.—Analysis of samples of polystyrene prepared in the presence of α-nitrothiophene and chloranil has demonstrated the presence of the elements of these substances in the polymer. Nitrothiophene acts as a retarder; chloranil appears to act merely as a chain-transfer agent. C. F. M.

1345.* Combustible Gases as Substitute Motor Fuels. G. Egloff and M. Alexander. *Refiner*, June 1944, **23** (6), 235–240. *Paper Presented before American Chemical Society.*—Since abundant sources of methane, ethane, and, to a far lesser extent, propane and the butanes are available in many parts of the world, their use in internal-combustion engines will undoubtedly continue after the war. Research and actual use have proved their practicality in the operation of motor vehicles. The future of acetylene, ammonia, and hydrogen as motor fuel is indefinite. The most disadvantageous features of using the paraffin gases are the heavy weight of equipment required, the hazards involved, and the scarcity of filling stations. As interest in these fuels continues, these objections will probably be removed. High-pressure equipment, light enough to use on pleasure cars, may be developed. As knowledge of handling because more widespread and equipment is improved, the hazards involved will diminish. Fire hazard is a greater problem with the gases than with gasoline. More filling stations will come into being when demand for these fuels increases. The lower calorific value of gases/volume is partly compensated for by their better combustion and the higher compression ratios at which they can be used in specially designed engines. Since crankcase oil is not diluted and carbonaceous deposits are practically eliminated under proper operating conditions, the cost of lubricating oil and liquefied gases and repairs is cut down. Good refrigeration may be obtained with liquified gases and trucks which carry perishable cargo often burn the same fuel in the engine that has been used to cool the refrigerator compartment.

A selected list of references is included in the bibliography. A. H. N.

1346.* What Takes Place in Polymerization. P. H. Faust. *Refiner*, July 1944, **23** (7), 253–258.—The chemistry of the simpler reactions of thermal and catalytic polymerisation processes is discussed. A. H. N.

1347.* The Synthesis of Lubricants from the Fischer-Tropsch Process. Part 1. F. Fischer and H. Koch. *Refiner*, July 1944, **23** (7), 260–266. Translated from *Brennst.-Chemie*, 14, 463–468.—Various procedures are given to prepare synthetic lubricants, and their properties and composition are compared with those oils obtained from natural petroleum. Starting with kogasin one can also obtain lubricants from the olefine hydrocarbons present in the low-boiling benzine range—the synthetic benzine obtained in the water-gas reaction. Kogasin II, that is, the gas-oil fraction of the synthetic petroleum from carbon monoxide and hydrogen, was converted into a series of chloro-products and these were condensed in a Friedel-Crafts reaction with aromatic hydrocarbons. Variations of various factors on the properties of the viscous oils were investigated. A closer analysis of two synthetic oils showed that they simulate very closely the properties of naphthene-base-petroleum lubricants. By way of hydrogenation the synthetic hydrocarbons prepared from kogasin can be converted into less dense and water-white oils. These hydro-oils appear to possess extremely great stability toward oxidation, a minimum of carbon formed on coking, and a very desirable low pour-point. A. H. N.

1348. Patents on Chemistry and Physics of Hydrocarbons. W. G. Cole and W. D. Buckley. U.S.P. 2,336,468, 14.12.43. Appl. 2.10. 39.—A bituminous emulsion which

is liquid at ordinary temperatures is prepared by dispersing bitumen in an aqueous alkaline solution selected from the group consisting of from approximately 0·12%–0·18% NaOH in water and 0·18–0·24% KOH in water. The emulsion is stabilized with glycinin.

F. Rieber. U.S.P. 2,337,414, 21.12.43. Appl. 18.2.39.—Lubricating oils are tested by introducing a film of oil between a pair of opposed surfaces, continuously pressing the surfaces together and moving one surface relative to the other through a number of repeated uniform cycles and in a direction transverse to the direction of pressure. Durations in the cycles are measured in relation to total cycle periods during which the surfaces are entirely separated by lubricant. H. B. M.

Analysis and Testing.

1349.* The Analysis of the Sulphur Compounds in Light Petroleum Fractions. A Critical Survey of Existing Methods. S. S. Nametkin, V. G. Poutsillo and E. I. Shtchegloff. *Bull. Acad. Sci.* (*U.S.S.R.*), 1943, No. 1/2, p. 10.—A detailed experimental investigation of the methods of estimating the different forms of sulphur compounds in petroleum fractions. Faragher's and Brown's methods are examined in particular. The existing methods are only suitable for the simplest forms of sulphur compounds. Thus where free sulphur and mercaptans are present together, mercury removes all free sulphur and also part of the mercaptons. Thiophene in particular is absorbed by nearly all reagents, so that low results are obtained for its content, and high results for the other forms of sulphur present. The existing methods of estimating sulphur compounds are quite inadequate. D. A.

1350. Use of the Mass Spectrometer in the Routine Analysis of Refinery Gas Samples. J. G. Schaafsma. *Refiner*, April 1944, **23** (4), 123–127. *Paper Presented before California Natural Gasoline Association.*—See Abstract No. 1008. A. H. N.

Synthetic Products.

1351.* California's Synthetic Rubber Project is now in Full Operation. L. P. Stockman, *Oil Gas J.*, 27.4.44, **42** (51), 34/36.—The synthetic rubber project started by Rubber Reserve Co. in September 1942 in California is now in full operation, and is planned to produce 12½% of all the GR-S type. Six operational units and six companies are involved in the project, three in the production and refining of butadiene, one producing styrene and two operating the co-polymer plants.

Part of the butadiene is obtained by dehydrogenation of butane, and part from the cracking of naphtha and low-grade gasoline. The C_4 cut from the second process is passed to Shell Chemical Co. for extraction of the butadiene, and the process is linked up with other plants to ensure maximum utilization of the C_4 cut in aviation gasoline and synthetic rubber manufacture.

Styrene is synthesized via ethyl benzene which in turn is synthesized from ethylene produced from alcohol and pure benzol derived from coke-oven benzol.

The daily output of the co-polymer plants is approximately 9000 bales of 75 lb. each. R. A. E.

Motor Fuels.

1352.* Recent Developments in Fuel Supply and Demand. Arno C. Fieldner. U.S. Bur. Mines. Information Circ. No. 7261, Nov. 1943.—In this paper changes in fuel supply and demand since 1937 are reviewed, and some indication of probable postwar trends is given. It is pointed out that with the exception of motor spirit, war conditions have greatly increased the demand for virtually all kinds of fuel. Two-thirds of the tonnage of all materials consumed in expeditionary forces, including their transportation and protection, is said to be petroleum. Increasing quantities of bituminous coal and anthracite are needed both to meet the requirements of the expanded industrial programme for which coal is normally used and also to replace fuel oil. The maximum possible quantity of natural gas is being transmitted to domestic and commercial consumers and to a number of new war industries and military camps. Expansion of the steel industry has involved a corresponding increase in the production

of metallurgical coke. Production of anthracite increased from 51 million tons in 1940, to 56 million tons in 1941. Bituminous coal and lignite production figures showed a comparable increase. In short, every type of fuel has been of fundamental importance, and although there have been severe shortages in certain areas, the aggregate supply has equalled the demand.

Evaluation of post-war trends of fuel supply and demand is dependent on the duration and victors of the war, and on the discovery of new reserves of oil. It is, however, probable that post-war policy will be in the direction of greater conservation of petroleum resources and their more effective utilization. For instance, progress in the production of aviation spirit may well lead to its use in improved types of high-compression internal-combustion engines which, in turn, will greatly increase the mileage obtainable from a gallon of fuel. It is anticipated also that the weight of motor-cars and lorries will be considerably reduced owing to facilities available for the production of vast quantities of light metals. This again will result in reduction of fuel requirements. In fact, it is thought probable that 50% greater mileage per gallon will be obtained by the use of such cars and fuels, and that the development and wider use of diesel engines will effect still further economies in the use of liquid fuels.

It remains for the petroleum industry to develop methods of recovering oil more completely from partly depleted reserves and to obtain greater yields and improved quality of refined products. H. B. M.

1353.* The Specific Heat of 100-Octane Fuel in the Gaseous State. H. M. Spiers. *J. Inst. Fuel*, April 1944, **17** (95), 130.—On the basis of the formula for mol. heat capacity at constant pressure of gaseous paraffins above ethane devised by Pitzer, the specific heats of the paraffins propane to octane at constant pressure and temperatures of 0° C. and 100° C. have been calculated, by dividing the formula by the mol. wt. of the hydrocarbon. At 0° C. the formula for specific heat reduces approximately to

$$0{\cdot}4028 - \frac{1{\cdot}43}{14n + 2},$$

where n = the number of carbon atoms in the molecule. At 100° C., the calculated specific heat is approximately 0·482 for all paraffins above C_2H_6. The formula has been shown to be applicable to branched as well as straight-chain paraffins. Values at constant volume are obtained from those calculated at constant pressure by deduction of 2/mol. wt.

Similarly, values have been calculated for aromatic hydrocarbons on the basis of molecular-heat capacities given by Pitzer and Scott. Information regarding naphthenes is scanty, but on the basis of available data, values appear to be intermediate between those of paraffins and aromatics.

The composition of the 100-octane fuel assumed is 64% paraffins, 17% aromatics and 19% naphthenes. Taking heptane as prototype for paraffins and toluene for aromatics, the calculated specific heats in the gaseous state are: at 0° C., 0·350 at constant pressure and 0·329 at constant volume; at 100° C. 0·443 and 0·423 respectively.

Using Bahlke and Kay's formula, values at constant pressure of 0·357 at 0° C. and 0·450 at 100° C. were obtained on the assumption of a specific gravity of the fuel of 0·72 at 15·5° C. In all cases the specific heats refer to cals. per gm. per °C. for the material in the gaseous form. R. A. E.

1354. How Will the 100 Octane Aviation Gasoline Programme Affect Post-War Motor Gasoline? B. K. Brown and D. P. Barnard. *J. Soc. aut. Engr*, 1944, **52** (3), 87–93.—This paper describes how 100-octane fuel is being and will be made in the future during and after the war, and estimates regarding the post-war requirements for aviation and other uses, and the amount available for motor fuel are given.

The authors conclude that under peace-time conditions, the amount of such gasoline necessary will be a fraction of war-time requirements, and the amount which it will be possible to produce economically after the war will not exceed half the present schedule. Marketers will probably be able to offer house-brand products of about 80 and premium grades of about 85 octane number.

It is not concluded that 100 octane motor gasoline will never be feasible, but that improvements in octane number will be "evolutionary rather than revolutionary." C. H. S.

1355.* Socony-Vacuum Uses Continuous Automatic Lead Blender. J. P. O'Donnell. *Oil Gas J.*, 27.4.44, **42** (51), 43/47.—A continuous, automatic system of blending T.E.L. with gasoline has been designed and installed by Proportioneer's, Inc., in co-operation with the refinery staff, and has been in use for 4 years at the East St. Louis, Ill., refinery of the Socony-Vacuum Oil Co. The system which is now being applied in other refineries is a modification of the standard " weigh " tank and eductor unit, and is so designed that in case of emergency it would be possible to resort immediately to conventional batch blending. The system is entirely automatic apart from manual setting of a control which fixes the quantity of T.E.L. to be blended per gal. of gasoline. The system, method of operation, and safety feature incorporated are described and illustrated. Advantages claimed over the batch method include : closer control of T.E.L. content of treated gasoline, reduction in operating tankage required, economy in labour and power requirements, reduction in gasoline loss, prevention of heavy lead concentrations in lower sections of storage tanks. R. A. E.

1356. Patents on Motor Fuels. E. R. Kanhofer. U.S.P. 2,336,746, 14.12.43. Appl. 12.8.39. To produce a substantially saturated motor fuel of high anti-knock value, cracked gasoline is first separated into a lower boiling fraction having an end point between 200° and 250° F., and a higher-boiling fraction having an end point between 300° and 400° F. The lower-boiling fraction is mixed with a hydrogen-containing gas and contacted with a catalyst to effect substantial hydrogenation of the olefins. The higher-boiling fraction is contacted with sulphuric acid to reduce the olefine content. The hydrogenated low-boiling fraction and acid-treated higher-boiling fraction are mixed together to obtain the desired product.

E. T. Layng, L. C. Rubin and R. F. Ruthruff. U.S.P. 2,336,793, 14.12.43. Appl. 29.2.40. Low boiling olefinic hydrocarbons are converted to higher-boiling hydrocarbons within the gasoline range by contacting them at high temperature with a granular catalytic material consisting essentially of an intimate mixture of at least one pyrophosphate and carbonaceous supporting material.

W. A. Schulze. U.S.P. 2,337,003, 14.12.43. Appl. 3.1.39. The anti-knock value of hydrocarbons boiling within the gasoline range is increased by passing them in vapour form at a temperature between 900° and 1200° F. over a catalyst consisting essentially of zirconium oxide.

E. F. Pevere, L. A. Clarke and G. B. Hatch. U.S.P. 2,337,492, 21.12.43. Appl. 11.4.40.—To obtain a safety fuel boiling in the range 285–500° F., an *iso*paraffin selected from the group consisting of *iso*pentane and *iso*butane is reacted with an olefin polymer having 8–16 carbon atoms per molecule and selected from the group consisting of *iso*-butylene polymers, butylene polymers, cross polymers of normal and *iso*butylene, mixed C_3 and C_4 olefin polymers, C_4 olefin polymers and mixtures thereof. The *iso*-paraffin is present in the proportion of at least five molar parts to one part of olefin and the reaction is carried out in the presence of a catalyst having as its active constituents a relatively large amount of aluminium halide and a smaller amount of hydrogen halide. H. B. M.

Gas, Diesel and Fuel Oils.

1357.* Future Rôle of Oil Fuels. A. L. Foster. *Oil Gas J.*, 20.4.44, **42** (50), 52/68.—In the post-war period, an increased demand for motor gasoline of quality equal to or higher than that marketed pre-war, may be anticipated. Limitations in crude supply are therefore expected to increase the requirements of refiners for virgin gas oil as cracking stocks. This will tend to decrease the availability of such gas oil for diesel fuel purposes, and also to increase their market value.

A survey of the cetane-number specification of some diesel-engine manufacturers for 1943 models of medium and high-speed types indicates a range from 35 to 60 min. with an average of 46·6, and it is considered that a cetane rating of more than about 45 is not needed by most engines. Tabulated results of engine tests on five fuels of varying cetane numbers and calorific value show no relation between these properties of the fuels and power output obtained by their use in the engine, but show that fuels of the highest cetane value are not necessarily the most efficient in operating engines. The cetane number range of the fuels tested was 33/56.

In order to ensure low fuel costs, it therefore seems desirable that engines should be designed for, and operate on, fuels other than virgin gas oils. Statistics and tables are presented to show that large quantities of suitable blended fuels could be prepared by mixing virgin stocks with suitable cracked fuels. Such cracked fuels would be selected as suitable for engine use in all respects, except cetane number, which would be improved to the extent necessary by blending with the requisite amount of virgin gas oil. Blending tables are provided. It would appear from available data that catalytically cracked recycle stocks are likely to possess cetane values higher than those from thermal processes, thus requiring less virgin oil to raise to the desired level. Consideration is given to the use of addition agents for improving the cetane value of fuels, and also to the possibilities of applying solvent extraction processes to low cetane stocks. The economics of these two possibilities are discussed. The general conclusion is reached that supplies of diesel fuel of 45 cetane value will probably be available in adequate quantity and at non-premium prices. R. A. E.

Lubricants and Lubrication.

1358.* Oil Aeration. R. J. S. Pigott. *J. Soc. aut. Engrs*, 1944, 52 (3), 73–86.—The article presents details of experimental work supplementing a theoretical study of the subject. Details are given of a laboratory set-up for measuring entrained air in oil in aeroplane tanks. An analysis is given, showing why the oil delivery from a pump is less than 90% of its capacity when the mixture taken into the pump is 90% oil and 10% air by volume, and the design and limitations of spur gear-pumps are also dealt with, together with the effect of tank design on air retention and return to the pressure pump. A method is described of getting good air separation by dividing the scavenge pump into two sections totalling the normal capacity. The measurement of air in any system can be accurately determined by passing a sample of the oil/air mixture through a pump running at a fixed speed and delivering through a fixed resistance such as a disc orifice, and measuring the suction and discharge pressures. Among the author's conclusions are the following :—

(1) All suction side resistance of pressure and scavenge pumps must be as low as possible.

(2) Velocities in suction piping should not exceed 5 ft. per sec.

(3) Spur gear-pumps can be improved by optimum exposure of teeth on the suction side and the use of side pockets.

(4) Centrifugal boosters situated at the oil tank and at the sump with zero lift can solve the problem if aeration is not large.

(5) Existing tanks can be altered to give much better results without much trouble. C. H. S.

1359.* Castor Oil from Nigeria as a Lubricant. Anon. *Petrol. Times*, 2.9.44, 48 (1229), 574.—In view of the shortage of mineral oil, trials have been made in Nigeria to ascertain the extent to which castor oil, produced locally from home-grown castor seed, could be used as a lubricant. According to the annual report of the Agricultural Dept. for 1942, the Nigerian Railway is now using the oil as lubricant for locomotives. It has been found suitable for lubricating crossheads and motions. Other tests indicate that the oil can, under certain conditions, be satisfactorily used as a gear-box lubricant for automobiles, but not as an engine lubricant. A sample of the oil examined by the Imperial Institute (London) was found to meet the requirements of Air Ministry specification D.T.D.71 except in respect of unsaponifiable content, and the B.S.S. Specification 650–1936 for castor oil (" Firsts " Quality) except in respect of colour. The free acidity of this sample is well below the maxima of both specifications, and in this respect particularly is an improvement on a previous sample from Nigeria. R. A. E.

1360. Patents on Lubricants and Lubrication. V. A. Salmi. U.S.P. 2,336,505, 14.12.43. Appl. 27.1.41. Asphaltic hydrocarbons may be converted into lubricating oil in the following way. Two free surfaces of molten metal are provided, one for contact and the other for separation. They are separated by a baffle which allows fluid flow between the surfaces under differential pressure. The first surface is contacted with a stream of hydrocarbons, and in this way conversion is effected. Suffi-

cient pressure is maintained on the first surface to cause the converted material to pass to the second surface. Afterwards the hydrocarbon material is separated from this second surface, which is smaller in area than the first.

E. Lieber. U.S.P. 2,336,620, 14.12.43. Appl. 4.10.39. A condensation product is described which is soluble in lubricating oils and is capable of depressing the pour point of waxy oils and of imparting to lubricating oils of poor colour and cast characteristics a deep reddish colour by transmitted light and a golden-green colour by reflected light. The product is prepared by adding a low-boiling aliphatic compound containing more than 5 carbon atoms to an unreacted mixture of an aromatic compound and an aliphatic poly-halide having less than 10 carbon atoms and not more than 2 halogen atoms and a condensing agent.

W. L. Finley, M. P. Kleinholz and F. M. Watkins. U.S.P. 2,337,380, 21.12.43. Appl. 19.12.41. A calcium salt of a dialkyl salicylic acid amine in which the alkyl groups contain at least 3 carbon atoms is used as an addition agent to petroleum lubricating oil.

B. H. Lincoln and G. D. Bykrit. U.S.P. 2,337,478, 21.12.43. Appl. 15.4.42. A lubricating oil has added to it a small amount of arsenanilino dibenzyl ether.

H. B. M.

Asphalt and Bitumen.

1361.* An Investigation of the Acid Portions of Bitumens. S. S. Nametkin. *Bull. Acad. Sci. (U.S.S.R.)*, 1943, No. 5/6, p. 18.—A detailed investigation into the nature of the acids found in certain Russian bitumens. This series of acids of high molecular weight and aromatic character is considered to have been formed by oxidation, and approaches the gum acids (of coals) in properties. D. A.

Special Products.

1362. Carbon Black. Part 2. J. F. Gallie. *Refiner*, April 1944, **23** (4), 149–158.—Properties of rubbers using carbon blacks are given, followed by a study of the availability and future demands of the material. A. H. N.

1363. New High Temperature Styrene. C. L. Jones and M. A. Brown. *Modern Plastics*, August 1944, **21** (12), 93.—A new resin, Styramic H.T. has been produced on the pilot plant scale from dichlorostyrene by the Monsanto Chemical Co. to overcome heat distortion difficulties in the use of polystyrene at temperatures of 212° F. and over. Polystyrene itself has a heat distortion point of 168–176° F., though this can be improved to the extent of 15° F. by addition of chlorinated diphenyl resins. The new product has a heat distortion point of 236° F., and possesses better electric properties and water resistance than polystyrene, as well as being non-inflammable. It requires higher moulding temperatures (475–550° F.), but this is still within the range of standard injection or intrusion machines, and gives no difficulties in machining.

C. L. G.

1364. Allyl Plastics. F. Strain. *Modern Plastics*, August 1944, **21** (12), 97.—Detailed information is given on the mechanical, thermal and electrical properties of a range of new thermosetting plastics produced from allyl derivatives. They represent a new type by the monomers undergoing addition-polymerization reactions, as with thermoplastics, but producing thermosetting resins. The reaction produces no gaseous or other by-products and the monomers are of low viscosity so that they are very suitable for the impregnation of porous materials. With glass fibres, composites have been produced superior in certain mechanical properties to the light metals and alloys. Polymers are available in the form of transparent castings or laminates. The resins have been used for aircraft windows and sight-gauges in view of their transparency, solvent resistance, low weight and shock resistance. Laminated allyl plastics have been used as panels for self-sealing aircraft, full tanks, and light-weight containers. At present their cost is high, owing to limited production, but they have great possibilities in the future, owing to the ease with which their properties may be modified. A modification is being developed for use in the protective coatings field, and it is expected that compositions suitable for moulding will be developed.

C. L. G.

1365. D.D.T. Synthetic Insecticide. Its Properties and Potentialities. G. A. Campbell and T. F. West. *Chem. Tr. J.*, 25.8.44, **115**, 195.—A brief review is given of the development of D.D.T. (*para*-dichlorodiphenyltrichloroethane) as a general insecticide. Its value is considered to depend on the following factors. (*a*) It is white, stable, relatively odourless, and harmless to warm-blooded animals at concentrations normally employed. (*b*) It is effective against a very wide range of insects, including agricultural and horticultural pests. In this connection its effect on useful insects will have to be considered. (*c*) It is readily adsorbed on surfaces which remain toxic to insects for a long time. (*d*) It is very soluble in many organic solvents, though insoluble in water, and is therefore easily applied.

Replacement of pyrethrum against flying insects is limited by the slow knockdown characteristics, but it may be valuable as substitutes for rotenone and derris preparations. Spectacular results have been obtained with D.D.T. in the lice-proofing of clothing and in the complete control of a typhus epidemic in Naples by its use as a dusting powder.

Data are given on the solubility of D.D.T. in a wide range of organic solvents.

C. L. G.

1366. Recent Developments and their Effect upon the Plastics Industry. J. J. Pyle. *Sept.* 1944, **16** (184), 411.—Recent developments in the plastics field are discussed from the point of view of their effect on the scope and direction of emphasis of the industry. These developments include (*a*) increased production and reduced cost, (*b*) new applications, and (*c*) new and improved materials.

The synthetic rubber industry will utilize in 1944 approximately 400 million lb. of styrene, so that a large quantity will be available after the war for the plastics industry. The cost may reach 8–11 cents per lb. Its excellent electrical properties, colour, chemical resistance, etc., will undoubtedly lead to extended application. Similarly, there has been a large increase in production of vinyls, acrylates and polyvinyl acetals, synthetic adhesives and synthetic fibres.

New applications include the manufacture of dies and jigs from cast resins, the reinforcing of paper with phenol-formaldehyde resins, the use of plastics in printing, and new methods, the use of pulp preforms to obtain articles with mechanical properties between those of moulded and laminated plastics, and the post-forming of laminates.

The new and improved products include, H.M.122 Lucite with improved heat resistance, a series of co-polymers, alkyl ether and ester liquid resins which cure with the aid of organic peroxide catalysts and phenol-formaldehyde liquid resins, new cellulose derivatives, liquid resins, improved polyvinyl alcohols, silicones, and polyethylene lignin.

C. L. G.

1367.* Characteristics of Lighter Fuels. E. W. Steinetz. *Petrol Times*, 16.9.44, **48**, 604.—An investigation has been made of the properties of pre-war lighter fuels and of their behaviour in practice, with a view to the possibility of supplying an improved product. The criteria of a satisfactory fuel were taken as: (1) Little or no odour, (2) Production of a clear flame without smoke or soot or imparting taste to tobacco, (3) Immediate ignition, (4) Slow evaporation, and (5) Absence of oily residues which clog the wick and packing. The samples of lighter fuel examined fell into three classes, according to their boiling range: (*a*) 35–45° C. to 170–180° C., (*b*) 65° C. to 95–98° C., and (*c*) 100° C. to 122–125° C. The class (*a*) products appeared to be straight-run gasolines and gave immediate ignition but were unsatisfactory in most of the other respects. The class (*b*) products were of the petroleum ether type, and were satisfactory, apart from some sooting if the wick is set high. The class (*c*) products gave the best results of all, though at very low temperatures ignition is somewhat poor. Of a number of pure hydrocarbons tested, *cyclo*hexane appears to give the best results, the boiling range and vapour pressure being ideal for the purpose.

To achieve better combustion of present types of lighter spirit, a modified design of burner is suggested in which air is introduced into the flame. Alternatively, oxygen-containing fuels such as alcohols could be incorporated into the fuel. It is also recommended that more attention should be given to sealing off the burner, and to the best type of material for packing.

C. L. G.

1368. Patents on Special Products. Standard Oil Development Co. E.P. 557,410, 19.11.43. Appl. 3.11.41. A dihalide of an aliphatic mono-olefin containing at least

4 carbon atoms is produced by contacting the olefin with a free halogen in a liquid medium in the presence of a small amount of a ferric halide.

Shell Development Co. E.P. 557,513, 24.11.43. Appl. 4.2.42. An improved method is described for synthesizing aryl ethers of trihydric alcohols.

Shell Development Co. E.P. 557,519, 24.11.43. Appl. 1.4.42. A process is described for separating *meta*-substituted alkyl phenols from mixtures of *meta* and *para*-substituted alkyl phenols. H. B. M.

Detonation and Engines.

1369.* The Oxidation of Fuels in the Induction Systems of Internal Combustion Engines. N. N. Semenoff. *Bull. Acad. Sci.* (*U.S.S.R.*), 1942, No. 3/4, p. 27.—Considerable experimental evidence shows that in the case of certain fuels, notably cracked fuels and unsaturated hydrocarbons, there is a considerable decrease in anti-detonating stability (which is much lower than would be expected from the octane numbers as determined in the laboratory) with increase in engine speed and correspondingly in engine temperature. This state of affairs cannot be due to an increase in the rate of "pre-flame" reactions, since the temperature coefficient for the rate of "pre-flame" reaction corresponds rigidly to the laboratory determined anti-detonation stability (octane number). This decrease in the anti-detonation characteristics of certain fuels is due to oxidation of certain portions of the fuel at elevated temperatures, thus giving rise to products which impair the original anti-detonation stability of the fuel. Experiments were carried out with an apparatus consisting essentially of an engine driven by an electric motor, a carburettor to give known fuel/air mixtures, an induction pipe capable of being maintained at a desired temperature, an air preheater, orifices for measurements of rates of flow, and arrangements for sampling the fuel mixture before entering the engine. It was possible to determine the proportion of fuel remaining unevaporated (*i.e.* in the form of droplets). Peroxides in the sample were determined, using stannous chloride solution and determining the unoxidized stannous chloride by titration with ferric chloride, this method being considered superior to the iodine method in the presence of unsaturated hydrocarbons. Polarographic analyses were also carried out. The oxidation of certain portions of these fuels takes place only in the liquid phase on the walls of the induction pipe. The effect of rise in temperature is twofold: firstly, increasing the rate of reaction to form peroxides, and secondly, improving evaporation, thus reducing the liquid phase and peroxide formation.

By suitably preheating the air it was found possible to eliminate the liquid phase, thus preventing the formation of peroxides, with the attendant deterioration of anti-detonating stability. D. A.

1370. Physical Characteristics of Roughness in Internal-Combustion Engines. L. Withrow and A. S. Fry. *J. Soc. aut. Engrs*, 1944, **52** (3), 101–112.—The article describes experiments to determine the relationship between the primary causes and the outward effects of roughness in a single cylinder and a straight eight engine.

A multi-element oscillograph was used which produced oscillograms simultaneously from sound pressures near the engine; vibrations of the crankcase structure; lateral vibrations of the flywheel; lateral vibrations of the crankshaft; and pressures in the combustion chamber.

Reproductions of many of these oscillograms under different conditions are given from both engines, and the effects of many variables are discussed.

It is shown that roughness in both engines is closely related to a shock-type excitation developed in the crankshaft-flywheel system.

In the single-cylinder engine this phenomenon was affected by changes in engine conditions which altered the development of combustion pressures: whilst in the eight-cylinder engine changing the piston weight, and thus altering the inertia forces acting on the crankshaft, also affected the roughness. C. H. S.

1371.* Influence of Ozone on Diesel Engine Performance. W. J. Armstrong and C. E. Thorp. *Refiner*, June 1944, **23** (6), 204–206.—Experimental results are described. It is found that (1) The addition of ozone to a diesel engine is without effect on power output or operating characteristics. (2) The ozonization of fuel oil likewise causes no

change in fuel consumption or power output of engine. (3) Ozone, introduced into the manifold, did not affect the analysis of the exhaust gases from engine. A. H. N.

1372.* Ignition Accelerators for Compression-Ignition Engine Fuels. J. S. Bogen and G. C. Wilson. *Refiner*, July 1944, **23** (7), 272–282. *Paper Presented before the Annual S.A.E. Meeting, January* 1942, *but has been reviewed and brought up-to-date.*—This paper gives in detail the cetane number improvement that may be expected when ethyl nitrate, *iso*amyl nitrate, commercial amyl nitrate, and acetone peroxide are added to straight-run and cracked diesel fuels from Pennsylvania, Mid-Continent, East and West Texas, and California. Curves are given which show the average cetane number improvement that may be expected when any of the above ignition accelerators are added to typical diesel fuels. The effects of several other ignition accelerators when added to straight-run fuels are shown. Illustrations of the effects of ignition accelerators on the physical properties of diesel fuels are given, and it is shown that the most critical physical property is the flash point. Engine data are given which show that ignition accelerators do not increase combustion chamber depositions despite the increase in the Conradson carbon of doped fuels. It is shown that the engine economy is lowered in direct proportion to the amount of ignition-accelerator added.

It is also pointed out that if extensive use of ignition accelerators is to be made, a study of their corrosive properties under engine operating conditions must be undertaken. Cost figures for doping various fuels to a requirement of 50-cetane number are given and show a maximum of about 0·12 cents/cetane number/gallon for California stocks. An extensive literature and patent search is appended for those who wish to pursue the subject further. A. H. N.

Economics and Statistics.

1373.* History of Water Flooding of Oil Sands in Oklahoma. D. B. Taliaferro and David M. Logan. U.S. Bur. Mines. Report of Investigations No. 3728, Nov. 1943.—The object of this report, which runs into 182 pages, is to survey water-flooding projects throughout the State of Oklahoma and to give data such as volume of oil produced monthly, volume of water injected monthly, spacing of wells, number of injection wells and oil wells, etc., in each individual case. It is believed that collation of these data has made it possible to analyse water-flooding operations in the area more completely than has been done hitherto.

Tables 3 to 10 inclusive summarize water-flooding operations by years from 1935 through the first six months of 1942. According to the data presented, the volume of oil produced annually by water-flooding increased rapidly at the beginning of this period and in 1940 amounted to 3,665,580 brls. In 1941, however, production declined to less than 3 million brls. and since then has continued at approximately the same rate.

Up to 1st July, 1942, 73 water-flooding projects had been started in the State and 61 were in operation at that time. 8,157 acres of oil-sand on approximately 350 leases had been flooded and the total oil produced by injection of 200,588,661 brl. of water amounted to 15,495,937 brl., or about 1 brl. of oil for every 13 brl. of water injected into the sand.

Decline in the number of water-flooding operations in the State is attributed to the scarcity and increased cost of labour and supplies, and the low price of oil. Even before the cost of labour and equipment started to increase, the average cost of developing a water-flooding project with like wells spaced 330 ft. and producing from a depth of 500 ft. exceeded $1000 per acre. Consequently, with the increased cost of development and production, many water-flooding projects are being deferred until the price of oil compares more favourably with production costs. H. B. M.

1374. Sources, Disposition, and Characteristics of the Capital Employed by Thirty Oil Companies During the Nine-Year Period 1934–1942. J. E. Pogue and G. G. Coqueron. *Petrol. Tech.*, May 1944, **7** (2), A.I.M.M.E. Summary of Contribution No. 133, 1–2.—An analysis of the funds invested by a group of thirty oil companies during the years 1934–42 leads to the following broad conclusions: 1. The oil industry generates the capital needed for its expansion almost entirely from its own operations. 2. The long-term debt in the financial structure of the industry is small relative to the total

capital employed, and less than the net working capital. 3. During the nine years the group capital expenditure was $6,100,000,000, 58·3% of which went into crude-oil producing facilities. This part of the expenditure has been trending downwards since 1937. 4. During the same period the net working capital of the group rose by $380,000,000. At the end of the period the ratio of combined current assets to current liabilities was 3·21. 5. The net income of the group showed an upward trend, but with rather sharp cyclical fluctuations. 6. In 1942, Government funds entered the industry for the first time in substantial amounts. 7. Over the period the group has paid a relatively low percentage of net income in the form of dividends (an average of 55%). 8. The rate of return on invested capital for the group averaged 6·4% for the period (A group of over 1100 manufacturing companies averaged 8·8%). Integrated oil companies showed a lower rate of return than producing companies. 9. The group had combined net assets of over $6,000,000,000 at the end of 1942, 12% being outside U.S.A. 10. The combined net investment in properties, plant and equipment of the group at the end of 1942 was distributed as follows: production 45·6%; transportation 13·7%; refining 19·8%; marketing 18·7%; all others 2·2%. 11. The combined results of the group indicate a declining trend since 1937 in capital expenditure per barrel of crude oil produced. 12. The group increased its crude-oil production by 57% and its refining throughput by 43% between 1934 and 1942, as compared with an expansion of 25% in gross fixed assets, 19% in net fixed assets, and 11% in borrowed and invested capital. 13. The combined statements indicate that the oil economy is functioning soundly and effectively. G. D. H.

1375.* National Motor-Gasoline Survey, Summer 1943. A. J. Kraemer and O. C. Blade. U.S. Bur. Mines. Report of Investigations No. 3735, Dec. 1943.—This report is a continuation of a series issued in accordance with an agreement between the Co-ordinating Fuel Research Committee and the Bureau of Mines giving data on motor fuels sold through service stations in the United States. It covers the summer of 1943 and presents analytical data for 775 samples, representing the products of approximately 77 companies.

Samples are classified into three groups—namely, regular-price, medium-price, and third-grade fuels—and each group is averaged separately. Table 1 gives data on gravity, sulphur content, vapour pressure and distillation characteristics for commercial gasolines sold in 20 marketing areas in the United States during the summer of 1943. Subsequent tables give the minimum, maximum, and average figures for each characteristic of each of the three groups of gasolines. H. B. M.

BOOKS RECEIVED.

Charts for the Solution of Problems of Non-Axial Crank-Connecting Rod Mechanisms. (In Russian.) Academy of Sciences of the U.S.S.R., Moscow.

B.S.57: 1944—B.A. Screws, Nuts and Washers. Pp. 16. British Standards Institution, 28, Victoria Street, London, S.W.1. Price 2*s.* net.

B.S. 350: 1944—Conversion Factors and Tables. Pp. 95. British Standards Institution, 28, Victoria Street, London, S.W.1. Price 3*s.* 6*d.* net.

B.S. 989: 1944—Bitumen and Fluxed Pitch Roofing Felts. Pp. 21. British Standards Institution, 28, Victoria Street, London, S.W.1. Price 2*s.* net.

Economical Lubrication of Steam Turbines and Reciprocating Steam Engines. Pp. 19. Industrial Bulletin issued by the Ministry of Fuel and Power.

Plan for the Economical Distribution, Application and Reclamation of Cutting Oils and Coolants. Pp. 28. Industrial Bulletin issued by the Ministry of Fuel and Power.

BIBLIOTEKA POLITECHNIKI

INSTITUTE NOTES.

NOVEMBER, 1944.

FORTHCOMING EVENTS.

The next meeting of the Institute will be held at 26, Portland Place, W.1., on 13th December, when Professor V. C. Illing will read a paper entitled " Exploration."

PERSONAL.

R. E. Fitz-Symons Bampton, A.M.Inst.Pet., has been appointed Principal, Liquid Fuel and Petroleum Products Section, European Zone, U.N.R.R.A.

Dr. Gustav Egloff (Member of Council) has been elected a director of the Chicago Technical Societies Council, and a trustee of the Western Society of Engineers.

SIR JOHN CASS INSTITUTE.

The above Institute will start a course of special lectures on Petroleum Technology early in January, 1945.

Further information can be obtained from the Principal, 31, Jewry Street, London, E.C.3. (Telephone : Royal 3383).

MEETINGS OF COUNCIL.

An Ordinary Meeting of Council was held at Manson House, 26, Portland Place, W.1., on Wednesday, 11th October, 1944, with Professor F. H. Garner (President) in the Chair. There were also present : Messrs. Ashley Carter, G. H. Coxon, T. Dewhurst, A. E. Dunstan, E. B. Evans, H. Hyams, V. C. Illing, J. S. Jackson, J. Kewley, J. A. Oriel, C. A. P. Southwell, H. C. Tett, F. B. Thole, R. R. Tweed, W. J. Wilson, C. W. Wood.

Reports were received from the Election, Finance, Research, Standardization Executive and Standardization Committees.

One Fellow, one Member and four Associate Members were elected.

The Annual Accounts for 1943 were approved, and the Annual Report of Council for 1943 was approved for publication.

A Scholarship of £50 was awarded to Mr. R. B. Shearn of Birmingham University.

ELECTION TO COUNCIL.

The attention of Members is drawn to the following extracts from the By-Laws governing election to the Council of the Institute :—

(*a*) The Council of the Institute shall be chosen from the Fellows and Members only.

(*b*) Every Fellow, Member, and Associate Member of the Institute may send in writing to the Council the name of a Fellow or Member whom he desires to recommend for election to the Council. This nomination must be signed by at least nine other Fellows, Members, or Associate Members and delivered to the Secretary not later than 30th day of November in any year. No Fellow, Member, or Associate Member may sign more than one Nomination Paper in any one year.

APPLICATIONS FOR MEMBERSHIP.

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

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

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

BATCHELOR, Clifford Henry, Asst. Manager, Petroleum Board Installation. (*E. Evans-Jones ; F. Tipler.*)

CLARKE, John William, Chemist, Anglo-American Oil Co., Ltd. (*E. B. Evans ; A. Matsell*).

DAVIES, Gilbert Marr, Installation Superintendent, Anglo-American Oil Co., Ltd. (*F. Tipler ; C. Chilvers.*)

EDWARDS, Francis Dare, Development Chemist, National Oil Refineries Ltd. (*R. B. Southall ; E. Thornton.*)

ELLIS, Percival Francis, Development Chemist, National Oil Refineries Ltd. (*R. B. Southall ; E. Thornton.*)

GREEN, Joseph Albert, Refinery Superintendent, National Oil Refineries Ltd. (*R. B. Southall ; E. Thornton.*)

PAYSANT, Charles Jules, Chief Development Chemist, National Oil Refineries Ltd. (*G. H. Coxon ; M. Hubbard.*)

PERRY, Richard Gilbert, Chemist and Asst. Manager, British Emulsions (India) Ltd. (*Iain Cameron ; R. M. Kerry.*)

RICHARDSON, Ernest Frederick, Manager, Petroleum Information Bureau. (*H. E. Medlicott ; G. H. Coxon.*)

SAWDY, Alfred Eustace, Managing Director, London & Thames Haven Oil Wharves Ltd. (*Alfred C. Adams ; Iain Cameron.*)

SIMMONS, Thomas Mortimer, Lt.-Col., R.A.S.C. (*T. Dewhurst ; R. B. Southall.*)

NEW MEMBERS.

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

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

As Fellow.

PEEL, David Hallam Primrose.

As Member.

JACKSON, John Sharpe.

As Associate Members.

CLIFTON, Frederick Walter.
EADIE, Alastair Gordon.
KELLY, Eric James Kellas.
THOMSON, Alexander Francis.

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

STEELS

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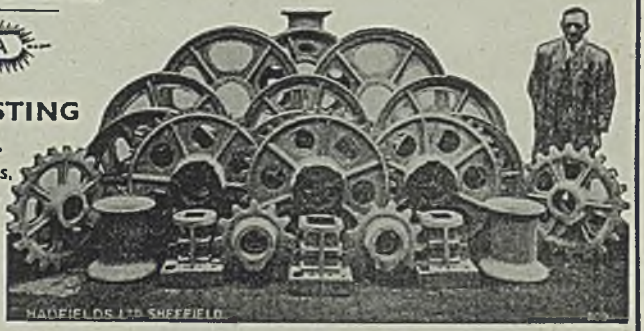

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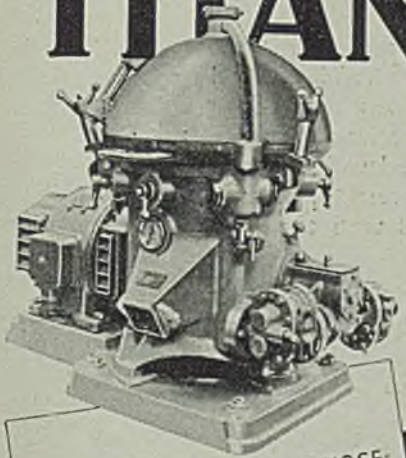

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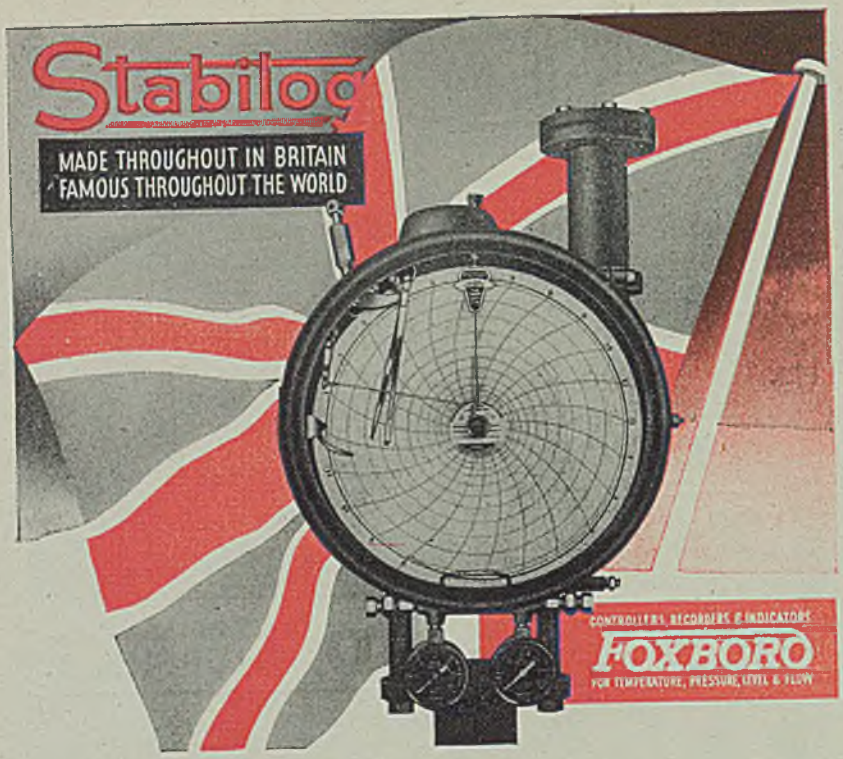

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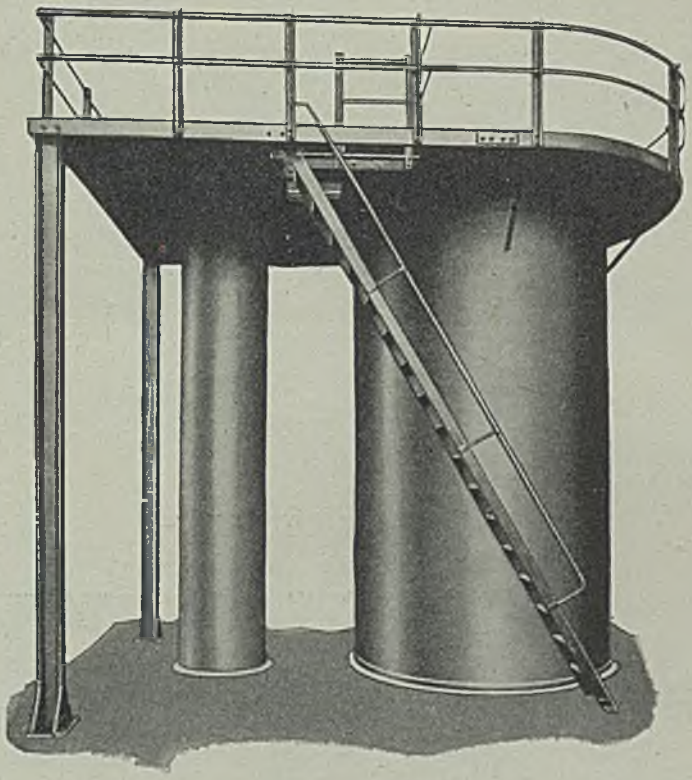

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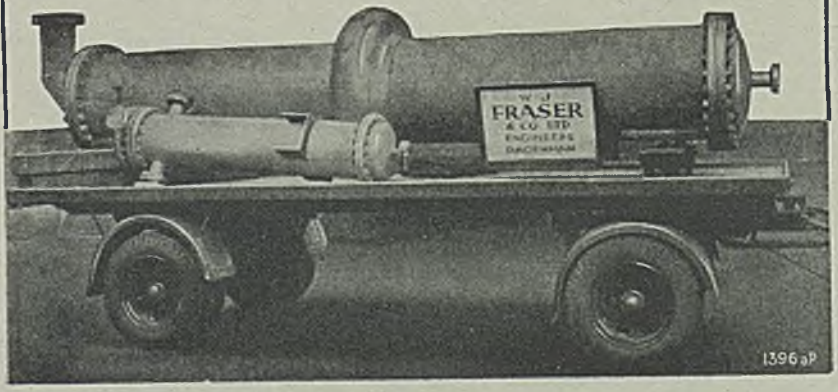

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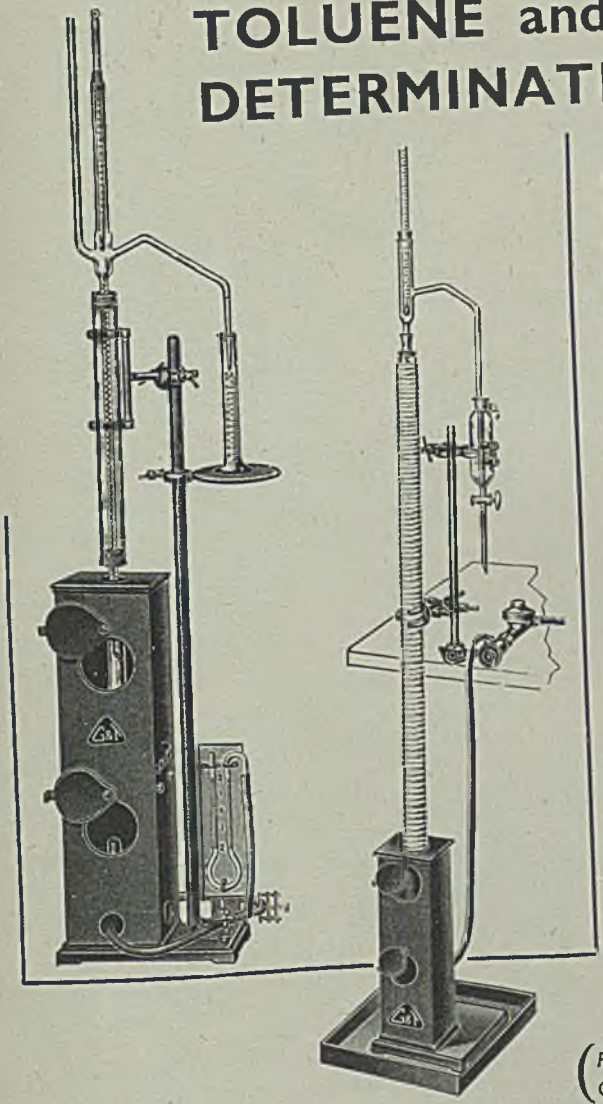

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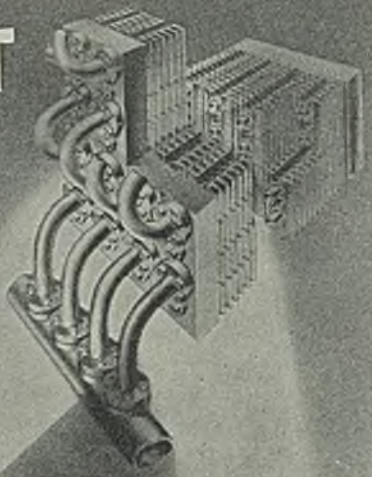

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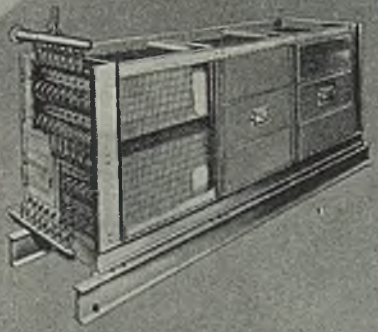

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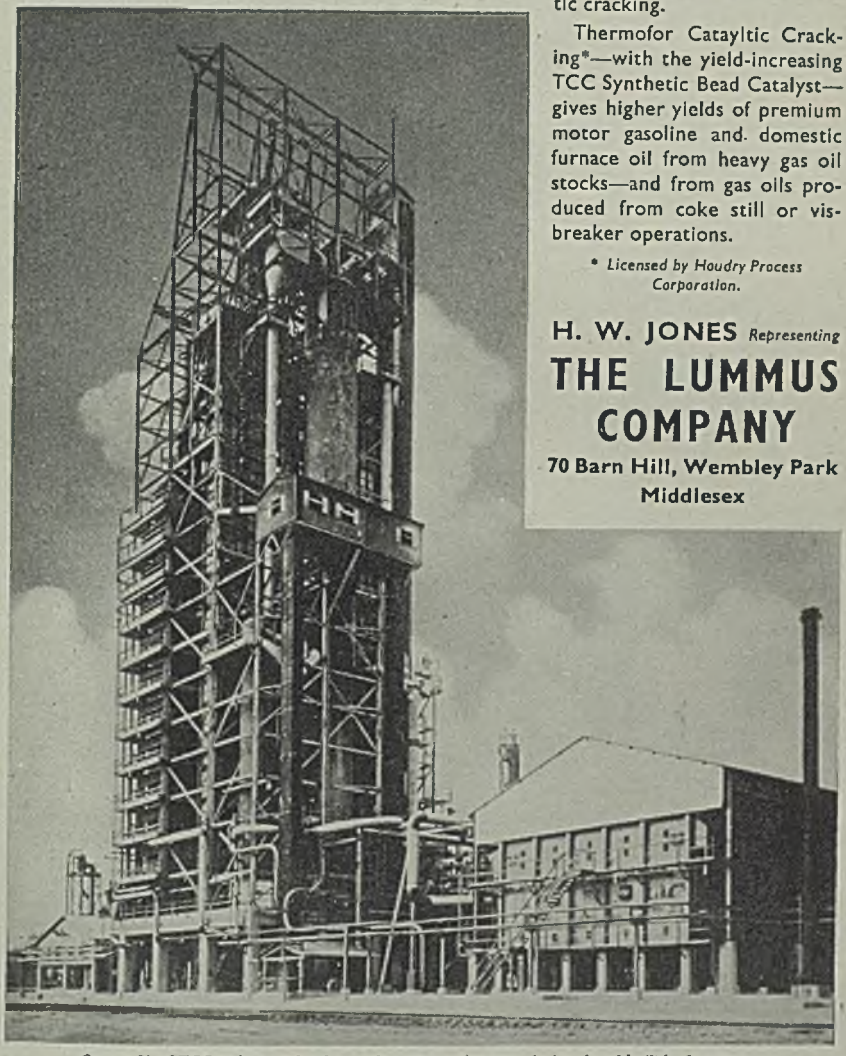

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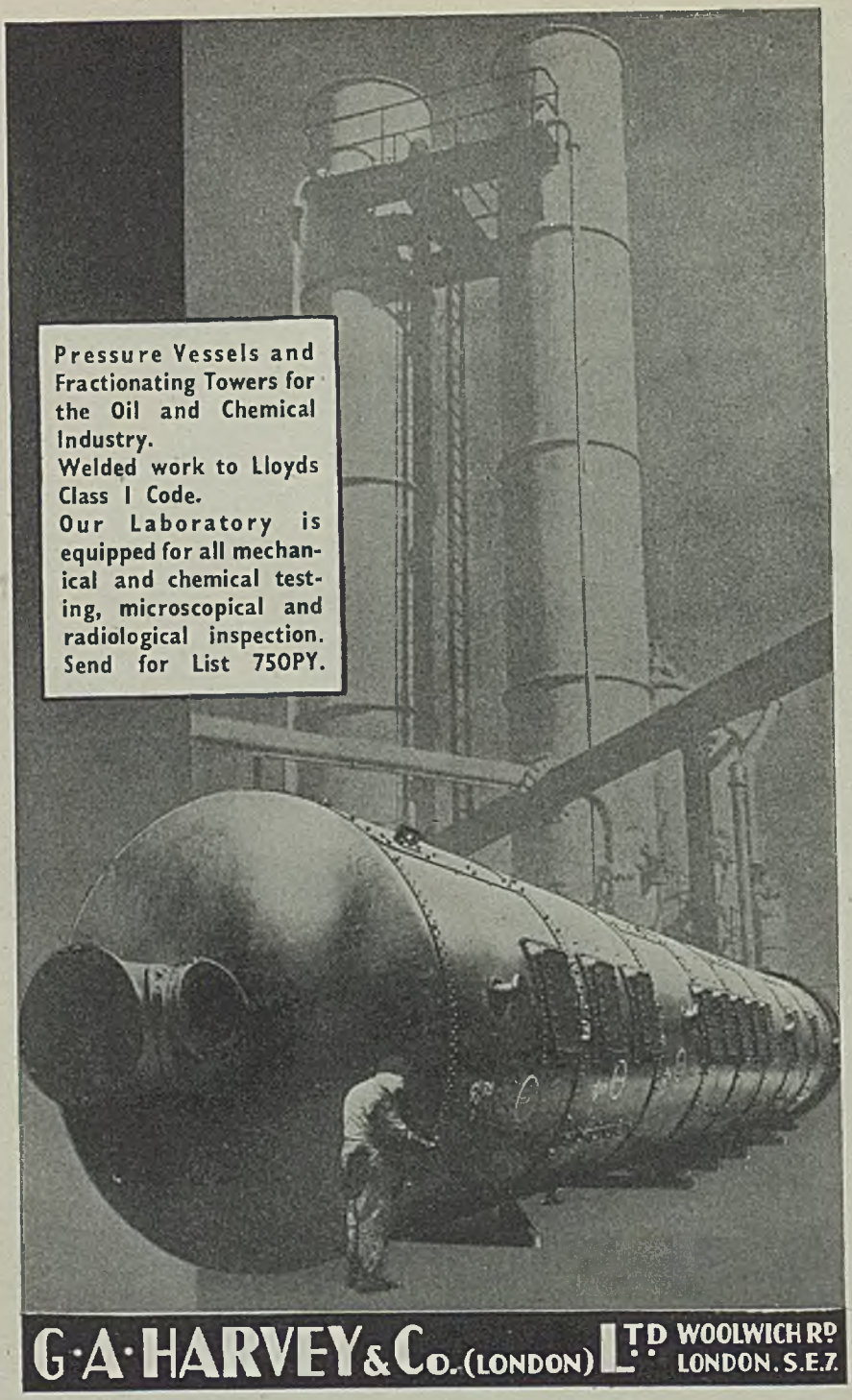
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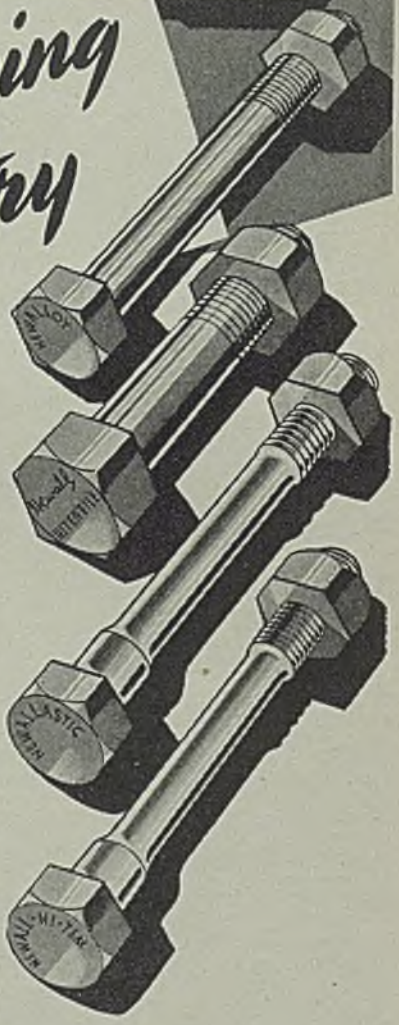

One of the leading Research Engineers had stated in the course of a paper, that there had been no basic changes in steel for twenty-five years and that he sees no immediate prospect of any such changes. He goes on, however, to say that by adapting certain well-known processes, immense improvements can be made. This is illustrated by the fundamental changes which were made when 'Newall Hitensile' bolts were developed many years ago.

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This is a short résumé of the development of Newall bolts which are all branded with their distinctive marks.

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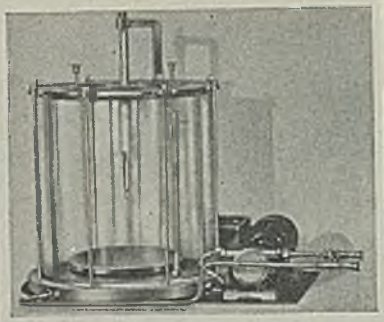

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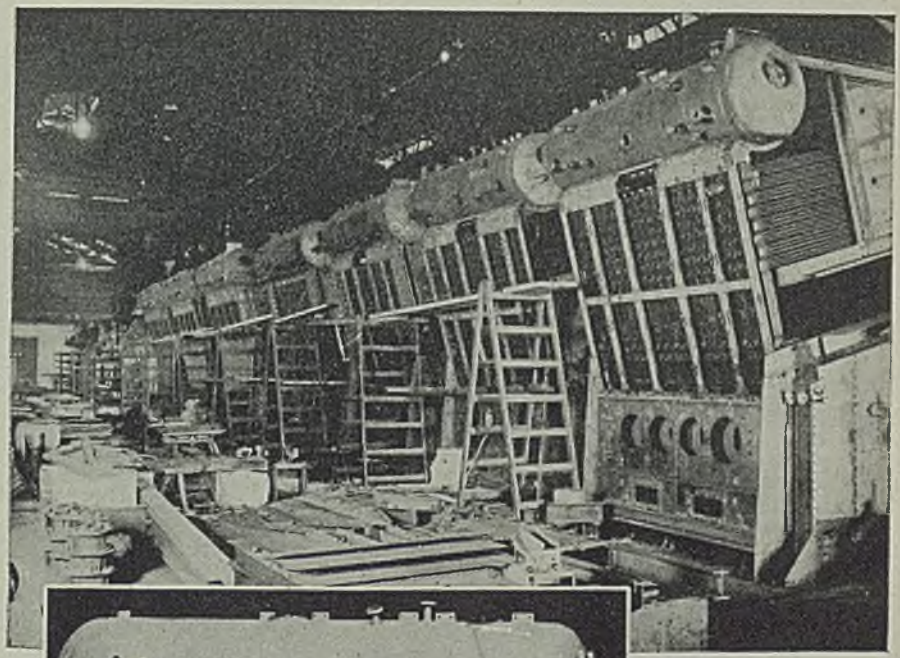

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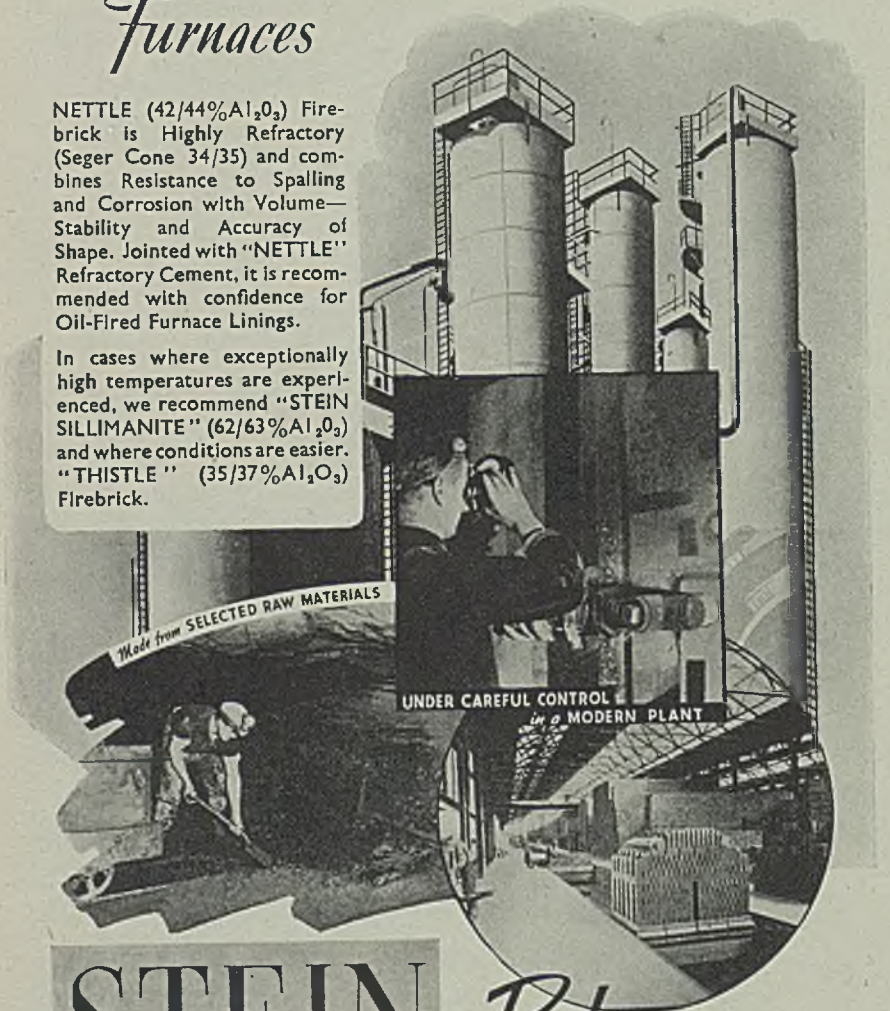

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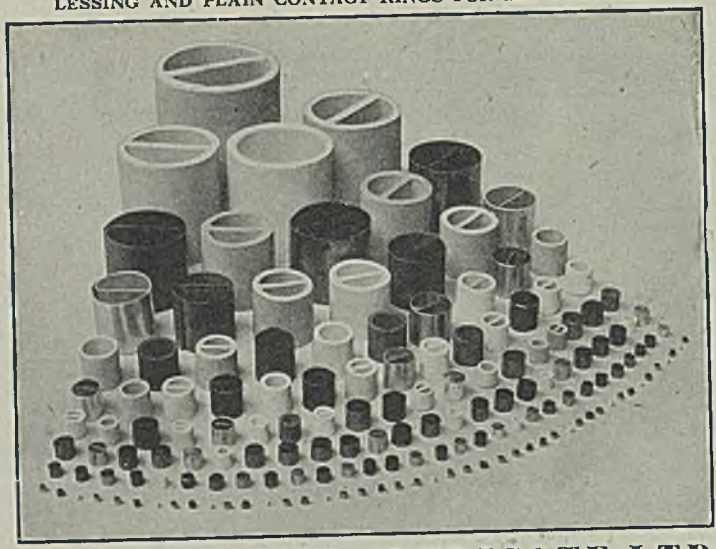

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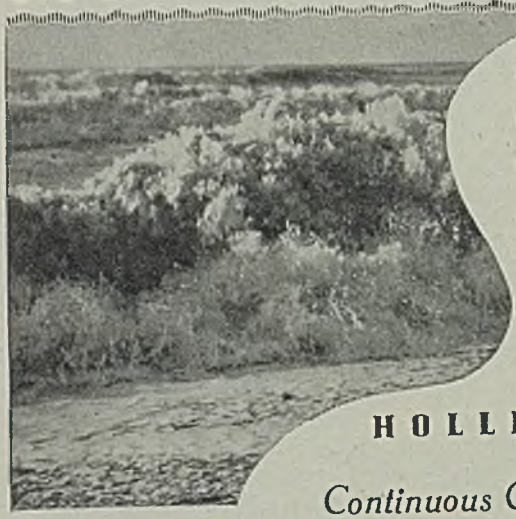

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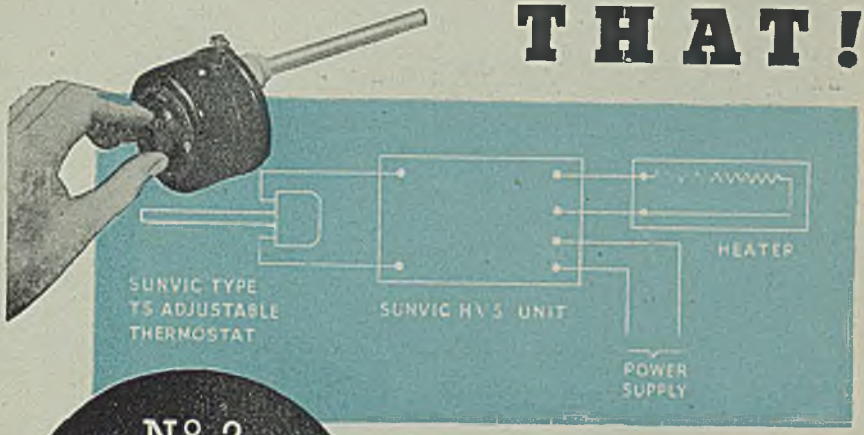

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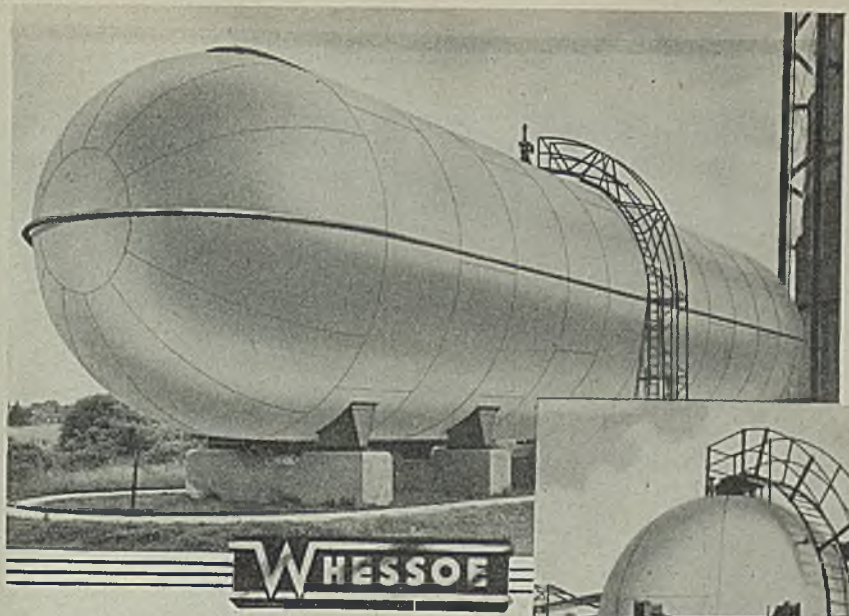

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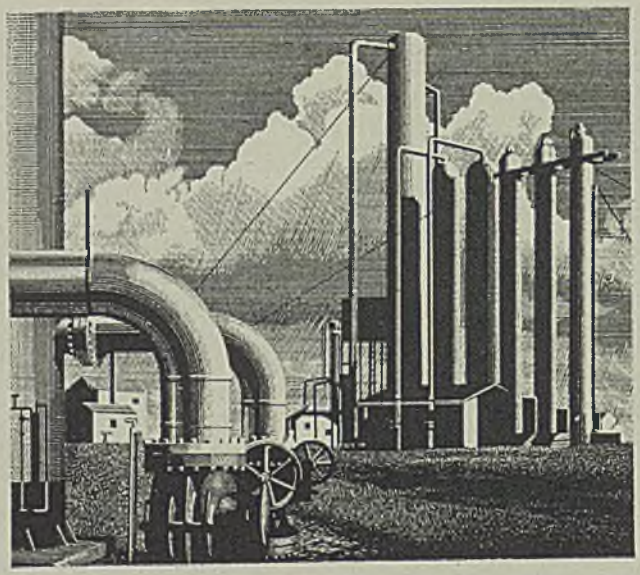

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