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Oilfield Exploration and Exploitation.

Geology.

973.* Mathematical Chance of Finding Oil. V. G. Gabriel. *Oil Wkly*, 21.5.45, **117** (12), 49.—During the period 1938–1943, inclusive, the probability of obtaining a producing well from exploration was 1 : 6·1 for wells based on geology, 1 : 5 for wells based on geophysics, 1 : 4·4 for wells based on a combination of geology and geophysics, and 1 : 20·6 for wells based on sundry, non-technical reasons. The corresponding figures for Texas were respectively, 1 : 6·4, 1 : 5·2, 1 : 3·7 and 1 : 17·9.

A conservative and intelligent exploration programme calls for a balanced estimate of the most probable profit or loss which might accrue as a result of success or failure to discover an oilfield.

If the most probable present worth of future oil discovered in Texas is $3,000,000, the cost of drilling the well $120,000, the cost of preliminary geological and geophysical work $50,000, and the cost of leasing and other expenses $40,000, mathematical expectation indicates that the use of both geological and geophysical information in drilling for oil in Texas would probably result in a gain of $657,000; the use of non-technical information would probably result in a gain of only $16,000.

The expectation is given by : $E = pa - gb$, when a is the sum of money which can be won, and p the probability of winning it, while b is the sum of money which can be lost, and g the probability of losing it. G. D. H.

974.* U.S. Exploratory Drilling in 1944. F. H. Lahee. *Oil Wkly*, 14.5.45, **117** (11). 50.—In 1944 4796 exploratory wells were drilled in U.S.A. ; in 1943 there were 3843, The 1944 footage was 20,225,887 ft. ; in 1943 15,122,364 ft. Of the 1944 wells 944 were producers, of which 844 were drilled on technical advice, and 3007 wells drilled on such advice were dry. 10 producers and 110 dry holes were located for reasons unknown.

At the beginning of 1944 U.S.A. proved reserves were estimated to be 20,064,152,000 brl., and at the end 20,453,231,000 brl.

Tables give 1944 data on : number of oil, gas and condensate wells and dry holes drilled as exploratory tests ; basis for locating exploratory holes ; statistics on exploratory holes in eleven selected states ; distribution of exploratory wells by classes and results of drilling. G. D. H.

975.* Exploration Falls Short of P.A.W. Programme. L. J. Logan. *Oil Wkly*, 23.4.45, **117** (8), 52.—During March the U.S.A. exploratory completions averaged 71 per week, the February figure was 78 per week. For the first quarter the completion rate was on the basis of 4100 per year, whereas P.A.W. requires 5000. Apparently the deficiency is due to lack of incentive to take risks, and the relatively high present costs of wildcatting. The success ratio of 19% is higher than last year, when it was 17·6% during the first quarter. An increased proportion of the drilling has taken place in wholly unproved areas.

A new gas-field was found in California during March. It is 4 ml. north of the Rio Vista field and promises to be a major field. The only March success in the Rocky Mountain region was a well which extended the Kevin-Sunburst gas area 3 ml. east and gave 28-gravity oil and gas. The Cap Rock pool of Lea County, New Mexico, was extended 1¾ ml. south. Illinois had 3 new oil-pools in March ; 2 were extended and in another a new pay-zone was opened. Two oilfields and a new pay were discovered in Michigan in March. Kansas also had 3 discoveries ; an old field was extended, and a new gas-field was found. The Utica pool of Kentucky was extended. A small new oil-pool was discovered in Oklahoma. Five new oilfields were found in Louisiana.

Tables summarize the U.S.A. exploratory drilling results during March and the first three months of 1945. March discoveries are listed with pertinent data and are classified according to type, with comparative figures for February 1945 and the first quarters of 1944 and 1945. G. D. H.

976. Carthage Area Holds Promise of Becoming World's Largest Gas Reserve. N. Williams. *Oil Gas J.*, 19.5.45, **44** (2), 102.—Large gas reserves are being proved in the

Carthage area of Panola County, East Texas. The outpost wells of the present producing area embrace an area of about 300 sq. ml. Four producing horizons are known: Hill (4900–5050 ft. deep), Upper Pettit (5650–6000 ft.), Lower Pettit (5850–6200 ft.), and Travis Peak (6000–6400 ft.). Their gas content is estimated to be 4,235,100 million cu. ft., and the ultimate recovery may be 2·5–3 million million cu. ft. Recoverable condensate may be 39,500,000 brl. Higher figures have been given for the gas reserves.

The Carthage area is well-located with respect to various gas transmission systems. The field was discovered in 1936, but only 18 wells were drilled up to 1944, and over 9 were drilled in 1943. Now there are 54 wells, 33 being completed in two zones.

All the producing zones are in the Trinity Group of the Lower Glen Rose, and consist of oolitic limestones. The Hill zone is the least extensive. Porosity varies within each zone. The structure is a large low-relief dome, but porosity controls production. Every well does not necessarily find production in all the zones. Wells in the Hill zone have the greatest open-flow capacities, and average 120 million cu. ft./day. Rock pressures are abnormally high for the depths, and initially ranged 2300–3000 lb./sq. in. Development is on a 640-acre pattern.

At the beginning of March 1945 the gas production totalled 54,000 million cu. ft., and the condensate recovery 834,857 brl. Currently production is about 130,111,000 cu. ft./day. Existing pipe-line outlets have a capacity of 100–125 million cu ft./day. Other lines are proposed. A gasoline plant with a throughput of 25 million cu. ft./day is operating, and two others are to be built with twice this capacity each. A 100-million cu. ft./day plant is being built. G. D. H.

977.* San Joaquin Field Shallow Pay to be Investigated. Anon. *Oil Wkly*, 16.4.45, **117** (7), 71.—The San Joaquin, Venezuela, completions have been in the Eocene at about 7000 ft., the initial outputs being about 1500 brl./day. An Oligocene pay at 3600–3700 ft. is cased off in all but one well, in which a blow-out occurred before it was abandoned. G. D. H.

978. Pacific Northwest is Receiving Increased Exploratory Attention. Anon. *Oil Gas J.*, 26.5.45, **44** (3), 116.—A wildcat being drilled on the north side of Gray's Harbour near Aberdeen, Washington, is reported to have run into a gas-zone at about 3000 ft. Other wildcats have been drilled in this area and have found gas, but not in commercial quantities. Two structures are fairly well defined. A deep test in the Aberdeen area in 1932 was abandoned at 6726 ft., having encountered a strong flow of hot water. Gas was found in a shale between 2000 ft. and 3000 ft.

There is leasing activity in several areas: Whatcom County, Washington, Multnomah County, and Harney County, Oregon. G. D. H.

979.* The Red Beds and the Anadarko Basin. C. N. Gould. *Oil Wkly*, 21.5.45, **117** (12), 59.—The Permian Red beds consist of great thicknesses of red clay shale with lenses of sandstone and of evaporites. The beds are deltaic or estuarine, deposited by rivers emptying into a southwesterly retreating ocean. Inland seas were formed at times and produced the evaporites. They occur in Kansas, Oklahoma, Texas, New Mexico, and Colorado. An account is given of the evolution of knowledge concerning the Red Beds, their relationships and structure. G. D. H.

980.* Cantagallo Extension Test is Reported Successful. Anon. *Oil Wkly*, 7.5.45, **117** (10).—Cantagallo 6, an east flank extension test on the west bank of the Middle Magdalena, opposite Puerto Wilches, has been reported to be being completed as a flowing well. Tests were to be made in the Upper Cretaceous. The field has two other shut-in wells which produce 20-gravity crude and have a joint capacity of over 5000 brl./day. G. D. H.

981.* Santa Barbara Field Gets Extension Development. Anon. *Oil Wkly*, 30.4.43, **117** (9), 65.—Operations by Mene Grande on the Travieso 3 concession have considerably extended the Santa Barbara field westward. Efforts are being made to extend production to the south. The southern edge of the Santa Barbara-Mulata-Jusepin producing trend has not been established. G. D. H.

982.* Shell has another Dificil Producer; more Companies Plan Exploration. Anon. *Oil Wkly.* 7.5.45, **117** (10), 70.—Dificil 4 has been completed for 500 brl./day of 44-gravity oil, after two acid treatments. Development to west and south may give a sizeable commercial field.

A fourth dry test has been completed on the Doce concession, which may be surrendered.

North of the Dificil tract San Angel No. 1 was completed as a good gas-well; a second well was dry. G. D. H.

983.* Northern Egypt. D. L. Carroll. *Oil Wkly*, 16.4.45, **117** (7), 44.—55 ml. east of Suez, at El Nekhl, a test has been stopped at 5570 ft. in the Nubian sandstone owing to drilling difficulties. 34 ml. northwest of Cairo, at Khatatba, another wildcat has reached 5800 ft. South of Suez, on the east side of the gulf, a test has been started at Ain Musa.

Production has ceased in the Gemsah and Abu Durba fields. At Ras Gharib and Hurghada the output was forced to 25,000 brl./day between 1941 and 1944. Failure to find additional production in this area is largely due to the fact that only drilling is likely to provide reliable information on subsurface conditions in most of the area. Structural mapping by both geological and geophysical methods is hindered by the thick mantle of Miocene beds on the folded and faulted beds containing the Cretaceous and Carboniferous Nubian sandstone series in which most of the oil occurs. The Miocene is thin or absent in most of the Sinai Peninsula and northern Egypt. There geological and geophysical work is likely to be more successful. There are possibilities of finding oil accumulations in shoreline wedge-outs of Triassic beds. The El Nekhl wildcat found good shows in the Cretaceous.

In the Nile delta the Upper Tertiary beds are deeply buried by Pleistocene and Recent deposits. Little interest has been shown in this area, apart from its interior margin where the Miocene is not deeply buried. In Northeast Egypt outcrops show the attitude of the Eocene and Mesozoic beds. The Sinai Peninsula wildcat has good shows in the Cretaceous Upper Nubian beds. The well was low on structure with a view to testing wedge-out conditions in the Triassic and Jurassic, which beds are very thick farther north, but absent in southern Sinai. The well was inconclusive on this point. A second well is to be drilled farther south and higher on structure with a view to testing the Cretaceous further. The folds run northeast–southwest. To the southwest, on the Egyptian mainland, the folds are marked by lines of basaltic plugs.
G. D. H.

984. New Field Discovered in Arabia. Anon. *Oil Gas J.*, 12.5.45, **44** (1), 86.—It is reported that the Arabian American Oil Co. has discovered a new field. The discovery well is west of Qatif on the coast between Damman and Ras Tanura. G. D. H.

Drilling.

985. New Diesel-Powered Rig Incorporates Advances in Automatic Control. N. Williams. *Oil Gas J.*, 5.5.45, **43** (52), 97.—The drilling rig described in this article is one of the largest diesel-powered assemblies ever operated in Oklahoma. Particular reference is made to the three engines, which include a number of features developed during war years but not previously available to the drilling industry. This is the first hookup of three large-sized engines employing pneumatic throttle controls for synchronizing engine speed. A. H. N.

986. Modern Drilling. Anon. *Oil Gas J.*, 28.5.45, **44** (3), 150–151.—The Cardwell Model O Twin-engine draw-works is described and its chief features detailed.
A. H. N.

987. Modifications of Standard Methods Achieve Improved Drilling Efficiency. P. Reed. *Oil Gas J.*, 21.4.45, **43** (50), 118.—Changes in drilling practices, including modified plans for rig equipment layout and piping, and for application of starch drilling-mud treatment are discussed, as well as rotary speeds employed and policies adopted for reducing time consumed in drilling. A. H. N.

988. Prefabricated Foundations for Multiple-Engine Setup. Anon. *Oil Wkly*, 23.4.45, **117** (8), 72–73.—Recent practice in providing bases for multiple-engine rigs has been to manufacture one massive base to take the whole unit. One Pacific Coast contractor, operating several strings of rotary tools and relying on diesel power, gets away from the drawbacks of the single, comprehensive base by fabricating its equal in a number of like sections which, ranged together and tied with 8-beams overhead, offer the stability of the single piece, with the added advantage of being readily demountable and transportable on the truck along with other equipment. The individual or unit section consists of paired channel bases, the ends turned upward through 30° to provide skid-shoe for easy sliding of the unit into position over the sub bases or cribbing. These two channels are held rigidly as to spacing by means of channel spacers, welded to the skid members just behind the shoe section. These channels are inverted, with respect to the skid members, so as to afford a flat surface on which material can be stacked, if desired, and to afford good standing while aligning the overhead beams. On each skid, at the point where the spacer channels are welded in, the corner posts are welded in place. These corner posts are made from salvaged drill-pipe, and cut to uniform length to afford the desired headroom over the skids before being placed. The pairs of posts on a common skid are capped with sections of channel, the flanges being turned downward to fit over the pipe and to afford a smooth upper surface. Between these longitudinal channels are welded a second pair of spacers, with the flat side uppermost, and with the outer flange of the spacer unit set flush with the outer end of the cap member. There is thus formed a rectangle of beams, all flat, and levelled to a common height, which serves as base on which to set any desired equipment. Other details are given and illustrated. A. H. N.

989. Diamond Bit Cores Hunton Lime Pay in West Edmond. K. M. Fagin. *Petrol. Engr*, May 1945, **16** (8), 237.—Recovery of approximately 48 ft. of 2 21/32-in. cores representing 84% of the Bois d'Arc producing section of the Hunton lime formation in a well in the West Edmond field, Oklahoma, has been attained by the Sohio Petroleum Co. through the experimental employment of a special diamond core-bit and barrel suggested by U.S. Bureau of Mines engineers. Most of the cores obtained were from 2 to 21-in. long and in good condition despite the fractured, crystalline, and friable character of some of the layers. One single piece of core on the last run measured approximately 7¾-ft. in length, but the overall recovery amounted to only 95% of 12 ft. compared with 100% recovery on the preceding 10-ft. run. Reason for using diamond drilling and details of the method are discussed. Precautions to be taken and hazards of the methods are indicated. A. H. N.

990. Drilling Problems in Mississippi and Alabama Fields. K. M. Fagin. *Petrol. Engr*, May 1945, **16** (8), 51.—A brief summary of problems encountered in drilling Alabama fields is given, ranging over the subjects of transport and equipment supply difficulties, scarcity of fuel oil, mud troubles, and similar items. Practices adopted in the fields regarding type of bits and weights, cementing operation, and completion methods are also briefly indicated. A. H. N.

991. New Types Casing Shoes Pack Off Bottom of Hole during Cementing. K. B. Barnes. *Oil Gas J.*, 3.3.45, **43** (42), 57.—Sometimes after cementing an intermediate string which has been suspended in the hole, or an oil string on top of a pay, a cement plug is found below. When this occurs for the former, extra drilling time is required; for the latter, some of the pay-zone may remain "sheathed" or isolated from production. In this article new developments for packing off the lower hole during cementing are described. A new full-hole-type shoe is discussed. This is comprised of two main parts. One of these parts, in some respects, is not unlike a regular cementing shoe. The bottom portion has an internal bakelite guide and back-pressure valve, the same as a conventional float shoe. Above, on the outside, are two packer rubbers separated by a steel wedge ring. In the same unit, above the packer rubbers, are four keyhole-shaped slots. Other principal unit of the Cementrol shoe consists of a bakelite sliding cylindrical sleeve, which, in closed position, covers the four side ports of the shoe unit. The sliding sleeve contains a seat for a ball-check valve and is fastened, with four bakelite shear pins extending through the ports, to an outer steel ring which rests on top of the packer rubbers and by downward movement will compress and expand them outwardly. As long as the sliding cylindrical sleeve covers the four side ports, mud can pass only downwardly through the shoe in the same manner as in a regular float or guide shoe. Rubber gaskets are inserted in the top of the bakelite sleeve to prevent mud or cement by-passing it on the outside. Inserted in the outside metal ring that compresses against the top of the packer rubbers is a slip-type lock to keep the rubbers expanded and the ports open once this action has taken place. Setting of the shoe and opening its ports are detailed and results of field tests are discussed. A. H. N.

992. Casing Methods for Well Completions. W. A. Sawdon *Petrol. Engr*, May 1945, **16** (8), 242.—A discussion of the use of (1) water string and liners; (2) combination strings; and (3) gun-perforated blank pipe cemented through the producing zone. It is impossible to lay down hard-and-fast rules for the completion method to be used under any set of conditions, but, basing procedure on the advantages and disadvantages of the three methods considered, the following are given as general preferences under normal conditions. The use of selective gun perforating when series of productive strata are to be produced has become a rather well-established practice. Even in highly proved fields it is often the best method to use when there is any separation between the oil-bearing sections of the productive zone. For other conditions (including " intermediate waters " that may separate a sand body but not be an actual formation separation) the following tabulation is given as a summary of methods for general conditions: (1) *Wildcat and edge wells.* (*a*) Combination string (in extremely high-pressure areas water string would be preferable), (*b*) blank casing cemented and gun perforated, (*c*) water string (only when necessary to protect upper part of hole or when there is likely to be considerable testing); (2) *Proved field wells.* (*a*) Combination string, (*b*) water string and liner, (*c*) blank casing cemented and gun perforated; (3) *Loss of circulation or low-pressure zones.* (*a*) Water string and liner, (*b*) combination string, (*c*) blank casing cemented and gun perforated; (4) *Special drilling fluids.* (*a*) Water string and liner, (*b*) combination string possible to some extent with carbonated mud and acid, (*c*) blank casing cemented and gun perforated possible to some extent with carbonated mud and acid; (5) *Intermediate waters.* (*a*) Blank casing cemented and gun perforated, (*b*) water string and cemented liner, (*c*) combination string; (6) *Possibility of deepening.* (*a*) Large size combination string, (*b*) large size blank casing cemented and gun perforated, (*c*) water string and liner; (7) *Sand trouble.* (*a*) Water string and liner, (*b*) combination string, (*c*) blank casing cemented and gun perforated. A. H. N.

993. The Power Tong. J. Moon. *Petrol. World*, May 1945, **42** (5), 49–51.—The Hillman–Kelley Model 3000-power tong is described and its operations discussed. Design of the new power tong is extremely simple. A split-ring gear containing a self-energizing jaw mechanism is driven through a gear-reduction arrangement. This is all enclosed in a compact case and driven by an air motor. Driving the ring-gear as the split area which is approximately 4 in. wide is accomplished by having two driver gears for the ring-gear so that one will always be engaged while the other is passing the slot. The ring-gear floats on six ball-bearing mounted guide-rollers located radially about the case at the outside diameter of the gear. Since the ring-gear has no fixed centre, these rollers guide the ring-gear and tong jaws anchored to the ring-gear in a true circle, while the gear is being driven by one or both of the driver gears. The power is obtained pneumatically. In operation, the tong is hung in the derrick by means of a light line in a position where it can be swung on to the pipe. In the case of portable derricks it is usually left hung all the time, whether the derrick is in use or travelling over-the-road. In permanent derricks the tong can be hung by a line from the crown and counter-balanced, if desired. A back-up line, secured to the end of the handle and anchored to a derrick leg, completes the installation. In coming out of the hole the tong is swung against the pipe after a stand has been lifted and the slips set—the jaws latching automatically. The shift lever is placed in low-gear position, which will stop up the torque delivered to the pipe sufficiently to break the toughest joints without hammering the couplings. After one turn, the tong-gear drive is shifted into high and the pipe quickly unscrewed. A reverse is provided on the air motor so that the jaws may be backed off and the ring-gear slot matched with the case slot to permit removal of the tong from the pipe. Since direction of rotation when making up pipe is opposite to breaking out, a roll-over ring is provided so that the tong may be turned over when tubing is being run in the hole. Operational data are given in some detail. A. H. N.

994. Field Testing of Drilling Muds. V. B. Zacher. *Oil Gas J.*, 21.4.45, **43** (50), 108.—*Paper Presented before American Petroleum Institute.*—This paper is a treatment of some aspects of instruments and methods used in mud testing and control as applied at drilling rigs. In addition, various mud problems are discussed—their relation to drilling operations and the treatment thereof. Symptoms and treatment of mud troubles are tabulated. A. H. N.

995. Radioactivity Well Logging. V. J. Mercier. *Oil Gas J.*, 5.5.45, **43** (52), 90.—Radioactivity well logging can be applied through casing and cement. Examples are described of use of radioactivity well logging for detection of cased-off producing zones, for purposes of correlation, and for location of a casing shoe. G. D. H.

Production.

996. Mechanics of Producing Oil, Condensate, and Natural Gas. Part 18. P. J. Jones. *Oil Gas J.*, 3.3.45, **43** (42), 53–54.—The viscosity of reservoir gases may be estimated in terms of molecular weight, reservoir temperature, and pressure. However, for reservoir gases near their two-phase regions more information is needed. There seem to be no general rules for estimating viscosity of reservoir liquids. One method for estimating viscosity is based on the viscosity of oil at standard conditions, reservoir temperature, and saturation pressure. This method is not universal because it can be 100% wrong. But it gives results which are accurate enough for practical purposes when working with reservoir liquids similar to some other reservoir liquid for which viscosity data are known. A. H. N.

997. Mechanics of Producing Oil, Condensate, and Natural Gas. Part 24. P. J. Jones. *Oil Gas J.*, 21.4.45, **43** (50), 124.—Displacement of oil by gravity relative to gas takes place in many reservoirs. Equations are derived which may be used to estimate the rate of oil displacement by gravity parallel to bedding in brls./day/acre. Rate of oil advancement parallel to bedding in ft./day is also considered. Graphs showing the effect of dip, permeability, and gas saturation by gravity are included. Rate of advancement downdip in ft./day of a gas contact varies inversely with gas saturation. The lower the oil recovery the faster the rate of advancement of a gas contact. Time is a factor in displacement of oil by gravity. Because of the time factor, the faster the rate of oil production from a reservoir, the lower the oil recovery at a gas contact and the faster the rate of advancement downdip of a gas contact.
A. H. N.

998. Mechanics of Producing Oil, Condensate, and Natural Gas. Part 25. P. J. Jones. *Oil Gas J.*, 28.4.45, **43** (51), 126.—This part deals with the displacement of water by gravity relative to oil and gas. The shape of an oil-water interface is influenced by gravity. An oil-water interface can approach a well up to a point. Beyond that point, water is fingered into a well against gravity by the pressure drawn-down in the well. The distance over which fingering occurs can be estimated only aside from the draw-down required to overcome the resistance across liners, perforations, plugged screens, and the resistance imposed by mud and paraffin. Equations for linear and radial displacement by gravity of water and oil relative to a gas phase in approximately horizontal pays are included. The shape or pattern of oil-water and gas-water interface relative to injection wells may also be influenced by gravity. However, invasion patterns relative to injection wells will be considered in a later article. A. H. N.

999. Mechanics of Producing Oil, Condensate, and Natural Gas. Part 26. P. J. Jones. *Oil Gas J.*, 5.5.45, **43** (52), 103.—This article is limited to reservoirs having no primary gas-cap. If a reservoir liquid is under-saturated, a comparatively small percentage of the oil in place can be recovered by expansion of the reservoir liquid in absence of water encroachment. When reservoir pressure declines below saturation pressures, oil is recoverable by gas expansion. If a declining reservoir pressure is accompanied by water encroachment, gas injection, or water injection, the rate of pressure decline/brl. of oil produced is reduced and oil recovery is higher, relative to a given reservoir pressure, than if there were no reduction in reservoir space. Methods for estimating oil recovery by expansion are derived and illustrated by examples. Oil recovery is expressed in terms of reservoir pressure and gas–oil ratios. Examples of oil recovery *v.* declining reservoir pressure are included for (1) no water encroachment and no gas injection; (2) no water encroachment with gas injection, and (3) water encroachment. The need for controlling gas–oil ratios in producing oil expansion is illustrated by curves. Oil recovery by gas expansion and gas injection is very sensitive to gas–oil ratios. Under some conditions a 30% increase in gas–oil ratio can reduce oil recovery by 100%. A. H. N.

1000. Mechanics of Producing Oil, Condensate, and Natural Gas. Part 27. P. J. Jones. *Oil Gas J.*, 12.5.45, **44** (1), 124.—This article considers oil recovery by expansion from reservoirs having a primary gas-cap. Methods for estimating oil recovery by expansion of evolved solution gas and primary gas-cap are derived and illustrated by examples. The benefits resulting from non-production of gas-cap gas are threefold: (1) Much higher oil recovery/unit decline in pressure; (2) faster rate of recovery, and (3) larger fraction of ultimate recovery is flowed rather than pumped. In numerous cases gas-cap gas is produced because of adverse economic conditions. Royalty and working interests underlain by gas are not given sufficient equity in a reservoir by the royalty and working interests underlain by oil. The differences could be adjusted and conflicting interests reconciled if the royalty and working interests underlain by oil would realize that in most instances the value of their properties is increased anywhere from 50 to 150% by not producing gas-cap gas. If a fair share of the increase in value were assigned to royalty and working interests underlain by gas, benefits would accrue to both parties. An example is included to show the advantages resulting from non-production of gas-cap gas. A. H. N.

1001. Mechanics of Producing Oil, Condensate, and Natural Gas. Part 28. P. J. Jones. *Oil Gas J.*, 19.5.45, **44** (2), 128.—Recovery of condensate by cycling is expressed in terms of the invasion factor and the displacement factor. The invasion factor is the fraction of reservoir space invaded by injected gas. The displacement factor is the fraction of the condensate initially in place displaced by injected gas within the invaded region. Based on field experience with recovery of condensate to date, tentative data on relative permeability are included. These data are subject to revision in the light of further experience. Recovery of condensate from 1 brl. of reservoir space, point data, is expressed in terms of the percentage dry or wet gas in the production from a point. These data may be used to estimate condensate recovery from the region invaded by dry gas up to the time dry gas first appears in a producing well. As more gas is injected, the following conditions obtain: (1) recovery from the region invaded up to the time dry gas first appears in a producing well is increased; (2) percentage of dry gas in the production increases, and (3) the area invaded by dry gas also increases. The additional recovery from the region invaded up to the time gas first appears in a producing well can be estimated from point data in terms of the percentage dry gas that would be in the production if the invaded area does increase. Therefore relationship between condensate recovery and composition of production also depends on the invaded area. A. H. N.

1002. Mechanics of Producing Oil, Condensate, and Natural Gas. Part 29. P. J. Jones. *Oil Gas J.*, 28.5.45, **44** (3), 139.—Deals with displacement factors. Other things equal, recoveries of oil by displacement with gas or water and recoveries of condensate by displacement with gas are proportional to displacement factors. A displacement factor is equal to the average value of the recoveries from the individual points within a region invaded by a displacing fluid. The path along which an interface between a displacing fluid and a reservoir fluid advances is called a displacement line. Recovery from points along a displacement line varies with distance from the source of a displacing fluid. For example, recovery of oil or condensate from points in the vicinity of an injection well is higher than from points more remote. An equation is derived which enables estimation of recovery from any section (1) between the source of a displacing fluid and the position of an interface, and (2) between the source of a displacing fluid and any section for which composition of the production is known. Procedure for estimating recoveries is illustrated by examples on displacement of condensate by day gas and on displacement of oil by water. A. H. N.

1003. Bureau of Mines Analysis of Subsurface Oil Samples. A. B. Cook, E. J. Dewees, and H. M. Harris. *Petrol. Engr*, May 1945, **16** (8), 85.—With the view of securing subsurface oil samples, the authors studied the bottom-hole pressure data on the West Edmond field that had been compiled by the Corporation Commission of the State of Oklahoma and selected 2 wells in widely separated areas of the field where flowing pressures at the bottoms of the holes seemed to be near the initial reservoir pressure. Preliminary tests, which included measurements of gas–oil ratios, depth pressures, and depth temperatures, indicated that the reservoir oil in the vicinities of the two wells was not saturated initially with gas. The annuli between the tubings and casings of both wells were full of oil when the tests were made. Tabulated and graphical data are presented regarding volumes of oil, gas, and their mixtures, and of the field and reservoir characteristics. These are briefly discussed. A. H. N.

1004. Application of Alignment Chart to Solving Rapidly Production Fore-casting Problems. Part 4. L. R. Merryman. *Petrol. Engr*, May 1945, **16** (8), 68.—The chart described is designed to determine the number of years required to produce a given amount of oil when the initial rate of production and decline rates are known or assumed. Like the others, it can also be used in reverse to solve other problems. It is based on the laws of the geometrical progressions. The general series and the derived formulæ were shown in the preceding articles. The principal application of this chart is the determination of the economic life of a property when the total future commercial production has been determined by a volumetric estimate and to make a quick check on the reasonableness of estimates of reserves made by volumetric means. Typical examples are worked out for a hypothetical case. A. H. N.

1005.* Method for Evaluating Available Oilfield Reserves. I. A. Charnuii. *Bull. Acad. Sci. U.R.S.S. Cl. Sci. Tech.*, 1943, (11–12), 15–21.—Reserves are calculated by the relationship between total flow of the field at a given time and sum of liquid withdrawn, reckoning from some datum line previous to this given time. Following a mathematical discussion, two types of production, involving wet oil, with a constant pressure at the flow level and with a diminishing pressure, are dealt with. Method of calculation is applied to one field in the Grozny region and results agree well with those found by another author using a different method. V. B.

1006. Completion Practice in Heidelberg Field are Undergoing State of Evolution. N. Williams. *Oil Gas J.*, 3.3.45, **43** (42), 50–52.—The development of the Heidelberg Field and its structural characteristics are briefly discussed. The field is only a year old. With the completion of the second well, a diagonal north-east offset, the practice was initiated of taking in the entire section, perforating casing in all sands showing saturation. This included a total 15 sand levels with 12 in the Eutaw and 3 stringers in the upper part of the Tuscaloosa, comprising a section of more than 5000 ft. topped at 4414 ft. In it there was 200 ft. of net sand, and a total of 852 casing perforations was made. The relationship of the various sand groups in the Eutaw was not understood at that time, and the plan was to take in everything showing likely saturation. The well flowed at the rate of 1000 brls. of clean oil daily through a 22/64-in. choke. Some of the subsequent early wells were perforated with as many as 1000–1200 shots. Often not only were the strictly sand-zones perforated, but also some of the shaly sands, and even shale. Normally the shale would be too impervious to give up any oil, but occasionally it would show signs of some saturation at places, and to avoid the chance of passing anything some shale zones also would be taken in. The practice was to core and drill through the section, set and cement casing on bottom, and then, with the aid of electric log determinations of zones of porosity and saturation, supported by core records, perforate everything which gave any indication of possible production. In recent practices less perforation is affected. Usually 2½-in. tubing is set near bottom with a production packer after perforation. The majority of wells are pumped from the start. A. H. N.

1007. Experimental Determinations of Water-Vapour Content of a Natural Gas up to 2000 lb. Pressure. G. F. Russell, R. Thompson, F. P. Vance, and R. L. Huntingdon. *Petrol. Tech.*, January 1945, **8** (1), *A.I.M.M.E.*, *Tech. Pub.* No. 1792, 1–7.—With the advent of higher pressures in the operation of natural-gas transmission lines, the removal of water vapour from the gas has become increasingly important, in order to prevent condensation or formation of gas hydrate from slowing down or stopping the flow of gas. Intelligent design of these dehydration or gas-drying plants has been hampered by the lack of experimental data on water-vapour content of natural gas at high pressures.

Previous work has been at pressures up to 600 lb./sq. in., and at higher pressures at temperatures exceeding 100° F. The apparatus and technique employed in new investigations at 600–2000 lb./sq. in. at atmospheric temperature are described. The water was absorbed in anhydrous magnesium perchlorate. The rate of gas-flow was 6 cu.ft./hr.

Plots of the logarithm of water content *v.* temperature give substantially straight lines for constant pressures from 1000 to 2000 lb./sq. in. On plotting water content against pressure at constant temperatures there is deviation from the lines calculated from the vapour pressure of water, assuming ideal gases. A plot of the ratio of actual to calculated water content against pressure for constant temperatures shows that the deviation from the ideal increases with a decrease in temperature.

G. D. H.

1008. An Introductory Discussion of the Reservoir Performance of Limestone Formations. A. C. Bulnes and R. U. Fitting. *Petrol. Tech.*, Jan. 1945, **8** (1), *A.I.M.M.E. Tech. Pub.* No. 1791, 1–23.—Field experience with limestone and sandstone production indicates the existence of wide differences between the reservoir behaviour of these two types of formation. Little attention seems to have been given to the separate study of the flow and retention of fluids in limestones.

There are two kinds of porous media—intergranular and intermediate. Intergranular rocks are those in which the porosity and permeability are determined by the geometrical properties and sorting of the sedimentary units; intermediate rocks are those in which there is no direct relationship between grain properties and porosity and permeability. Limestones in general are intermediate media. The partial relationship between porosity and permeability in any class of porous media is represented by an area of finite extent and definite shape on the permeability–porosity plane.

The horizontal and vertical variations of porosity and permeability in limestones and sandstones are discussed and compared. Comparisons are made of connate-water content, the relative permeability–saturation relationship, and capillary phenomena in the two kinds of rocks.

The application of classical mathematical analysis of flow to intermediate limestones is of doubtful value—in highly intermediate limestones because the generalized form of Darcy's law does not hold, and in moderately intermediate limestones because it is practically impossible to take into account the geometry of the system of internal boundaries which divide the reservoir into numerous (probably depletion type) sub-reservoirs of low permeability. The entire producing formation must be considered as the irreducible unit, rather than core behaviour integrated to represent the whole formation. The material-balance method fails to be entirely satisfactory in moderately intermediate limestones because the slow approach of such reservoirs to equilibrium pressure renders it difficult to determine the true pressure on the basis of shut-in periods of practicable duration. Complete co-ordination of geological and physical reservoir data is necessary in order to understand the reservoir performance of limestone formations.

In many limestone fields a considerable part of the oil appears to be held in and produced from thick zones of permeability less than 0·1 md. The rate at which these regions produce into the permeable zones connecting them with the well depends, among other things, on the pressure gradient across the boundary between the two. It is therefore advantageous to maintain this gradient at a high value if primary depletion of the low-permeability zones is to be complete. Since pressure maintenance would have the effect of partly or wholly nullifying this gradient, such secondary recovery operations should not be applied indiscriminately. G. D. H.

1009. Special Technique Promises to Change Future Lime-Completion Practices. P. Reed. *Oil Gas J.*, 19.5.45, **44** (2), 137.—During the past several months the method of recompleting wells producing from the Pettit lime in the Haynesville field indicates that a more uniform drainage of the producing zones in that formation can be obtained from producing wells. Injection wells can be improved by a more uniform distribution of the injection gas into the reservoir. Briefly, this method of recompletion consists of: (1) electric pilot determination of the location and magnitude of the permeability in place; (2) use of sand to block out the part of the zone having the highest permeability; (3) use of plastic-containing fillers to cap the sand and seal off between the pipe and the formation the section having the bulk of the permeability; (4) use of the electric pilot to control the injection of acid into the tighter zone above the plastic bridge.

Production and development of the field are discussed in some detail.

A. H. N.

1010. Detection of Spent Acid after Acidizing. R. G. Mihram. *Petrol. Engr*, May 1945, **16** (8), 64.—Two simple methods have been developed for determining the amount of spent acid being produced at any time following an acid treatment. The time required to make these determinations is also shown. The two methods are: pH measurement, and determination of ratio of calcium content to chloride content. Values of pH and ratio of calcium to chloride are tabulated against percentage of spent acid. From the table it is evident that fairly quantitative results down to mixtures containing about 1% spent acid can be obtained by one method or the other. Determinations below this value can be made, but much skill and care, as well as blank determinations, are necessary. For field use, an indicating paper is recommended, for no special equipment is necessary. For laboratory use, both the pH and calcium/chloride ratio methods are recommended, depending on time available and accuracy desired. In the laboratory the pH is used to indicate the presence of spent acid, and the ratio is used to obtain the relative dilution with formation water It is evident that the calcium/chloride ratio method is a little more sensitive to spent acid in the lower concentrations (1%) than the pH method. Fairly good working curves are obtained by plotting the percentage spent acid logarithmically against the calcium/chloride ratio or the pH plotted arithmetically. (The use of semi-log paper facilitates this, for it is not necessary to look up logarithms.) A working curve thus made up can be used on any given formation, and if necessary can be used on any formation water to give approximate results. A sample curve drawn from the data in the table is shown. A. H. N.

1011. Protecting Formations with Packers during Salvage Operations. K. H. Miner. *Oil Wkly*, 7.5.45, **117** (10), 46.—Many operators have helped solve their war-time casing-shortage problem by pulling unneeded inner strings from old wells. This has been successfully accomplished on wells which are still producing. Where casing is salvaged from wells that are to be returned to production every precaution must be taken to prevent damage to the producing formation. Packers are one means used to keep mud from clogging the perforations below the point where the upper portion of the casing was removed. The procedure has been used successfully in many shallow California fields, and is applicable in other areas. Many wells in California were completed by the early practice of running full oil-strings for production, and these wells have provided a valuable source of second-hand casing. Thousands of tons of good casing have been recovered in California during the war. One large company pulled approximately 150,000 ft. of this pipe during 1942, and more than 200,000 ft. during 1943. An examination of the company's properties revealed it might recover 1,150,000 ft. of casing of various sizes from old wells. A number of other large companies have pulled approximately equal amounts during the past two years. Procedure of using the packers and pulling the casing is briefly discussed and illustrated. A. H. N.

1012. Plastics Now Adapted to Remedial Work in Kansas Wells. Anon. *Oil Gas J.*, 28.4.45, **43** (51), 117.—The plastic used in Kansas has been developed especially for wells with low bottom-hole temperatures. It is a bifluid chemical, mixed at location and introduced into the well by means of a special bailer. It is compounded to set up, with the assistance of a catalyst, under existing bottom-hole temperatures at the end of 4 hours' time. While a considerable variation in formation temperatures would result in corresponding wide variations in time of solidification, the relatively narrow range of bottom-hole temperatures prevalent in western Kansas produce only inconsequential variations in setting times. As introduced into the well, the plastic is highly penetrative as well as adhesive. Its fluidity increases with increased temperatures, and at the temperature existing in Kansas wells very sizeable penetration is obtained even in tight dolomite cores. This penetrating quality of the mixture provides high bonding in the hardened material by providing innumerable intrusions of the fluid into the formation, and this quality is increased in value by a high contact bondage. The method is described in some detail. A. H. N.

1013. Illinois Limestone Successfully Water-Flooded. Anon. *Oil Wkly*, 23.4.45, **117** (8), 68.—Successful flooding of the McClosky limestone, Illinois, by the Pure Oil Co. is discussed. Data show initial production rates and rise of production.
A. H. N.

1014. Problems and Research in Water Flooding. S. T. Yuster. *J. Inst. Pet.*, May 1945, **31** (257), 121–128.—Testing the formation for its suitability to flooding is discussed, followed by a study of the methods used to overcome the troubles associated with non-uniform permeability of pays. These are multiple packer completions, delayed drilling, and corrective shooting. Finally, the use of surface-active chemicals and the limits imposed on the inlet pressure by the density and depth of the overburden are briefly studied. A. H. N.

1015. Flexible Equalizer Kicks Off Dead Wells. Anon. *Oil Wkly*, 7.5.45, **117** (10), 61.—Frequently a flowing well which has gone dead may be placed back on production simply by utilizing power stored within the casing in the form of compressed gas, if means be at hand to use this power. One company, experiencing considerable difficulty with a number of wells in a block devised a simple kick-off which effected substantial savings in time and money. The tubing and casing in a well are coupled together at the surface by ⅜-in. copper tubing which forms an equalizer connection between the pressure gauge-cocks on the respective strings. If the casinghead pressure be great enough when it is turned into the top of the tubing string, the action is to depress the level of the tubing fluid so that when the hydrostatic head thus formed has been removed the well will again flow naturally when the gas pressure built up has been vented and the tubing is again open to flow. The switcher can hook up the device in a very few minutes, loops in the tubing absorbing differences in distances between gauge-cocks on different christmas-tree hook-ups. After the loop is installed and casinghead pressure admitted to the tubing, it is necessary only to check as convenient the rate of equalization as indicated by a pressure-gauge, giving the well no further attention until it is ready for starting. As a rule, in the field in which the device was tried the dead well kicks off as soon as its tubing-head pressure has been increased to within 50 lb. of the casinghead pressure, the latter usually standing at about 750 lb. in the area. Service records show that equalization alone is successful in restoring production in 90 per cent. of all efforts. A. H. N.

1016. Salt Water Disposal in East Texas. Part 8. Anon. *Petrol. Engr*, May 1945, **16** (8), 294.—This part deals with the practices adopted by Sinclair Prairie Oil Co., Humble Oil and Refining Co., and East Texas Salt Water Disposal Co.
A. H. N.

1017. Fully Equipped Floating Tank-Batteries Used in Coastal Louisiana Operations. E. H. Short, Jr. *Oil Gas J.*, 26.5.45, **44**(3), 120.—The floating tank-batteries described are the first of the kind to be used on the Gulf Coast. Advantages are elimination of piling and reduction in time ordinarily required to place conventional tank battery in operation. Six such floating tank-batteries varying from 120 to 180 ft. in length are now in operation. A. H. N.

1018. Shell Oil Re-establishes Control in Louisiana's West Lake Verret Field. E. H. Short, Jr. *Oil Gas J.*, 12.5.45, **44** (1), 95.—The sudden appearance of a water boil at a well, which was quickly followed by similar eruptions in other parts of the swampland field, posed a perplexing problem. Remedial methods that brought control in the field are described. The final remedy was the use of a relief well for pumping mud to block the geysers. Several unsuccessful attempts were made, using fluorescein dye pumped into the relief well, to trace the fluid to the surface eruptions. Finally sodium thiosulphate (Hypo) was introduced with the fluid pumped down the relief well, and returns from a nearby boil, when tested with a detector consisting of sodium oxide in iodine solution, showed positive evidence that the relief well fluid was reaching the surface. This occurred in 3–6 hours after the introduction of the hypo solution down the relief well. All boils and geysers were tested, and convincing evidence was obtained indicating that positive contact had been established between the relief well and 1 Norman Breaux. At this time calculations showed that an ample amount of mud had been pumped into the relief well and, since it had served its purpose, operations were suspended. Subsequent observations showed that the water-boils and geysers were subsiding. A. H. N.

1919. Patents on Drilling and Production. W. E. Campbell, Jr., assr. to Standard Oil Co. U.S.P. 2,363,499, 28.11.44. Appl. 5.5.41. Non-aqueous drilling fluid.

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M. C. Johnson. U.S.P. 2,363,793, 28.11.44. Appl. 14.7.41. Well-testing apparatus.

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H. C. Hayes. U.S.P. 2,368,217, 30.1.45. Appl. 2.8.40. Electrical prospecting.

H. C. Hayes. U.S.P. 2,368,218, 30.1.45. Appl. 6.12.44. Electrical prospecting.

R. C. Baker, assr. to Baker Oil Tools, Inc. U.S.P. 2,368,399, 30.1.45. Appl. 23.6.41. Well packer.

R. C. Baker, assr. to Baker Oil Tools, Inc. U.S.P. 2,368,400, 30.1.45. Appl. 14.11.41. Releasable well packer.

R. C. Baker, assr. to Baker Oil Tools, Inc. U.S.P. 2,368,401, 30.1.45. Appl. 15.8.42. Lock device for well tools.

C. E. Burt, assr. to Baker Oil Tools, Inc. U.S.P. 2,368,409, 30.1.45. Appl. 14.11.41. Well packer.

T. A. Creighton. U.S.P. 2,368,413, 30.1.45. Appl. 14.6.41. Apparatus for orienting well tools.

P. V. McGivern and J. Chastian, assr. to Baker Oil Tools, Inc. U.S.P. 2,368,419, 30.1.45. Appl. 18.3.40. Well cementing apparatus.

C. E. Reistle, Jr., assr. to Standard Oil Development Co. U.S.P. 2,368,424, 30.1.45. Appl. 15.4.39. Producing oil.

D. F. Saurenman, assr. to Baker Oil Tools, Inc. U.S.P. 2,368,428, 30.1.45. Appl. 30.6.41. Multiple-zone production apparatus.

J. J. Mullane, assr. to Standard Oil Development Co. U.S.P. 2,368,486, 30.1.45. Appl. 2.2.42. Well logging.

R. D. Zimmerman, assr. to Ingersoll-Rand Co. U.S.P. 2,368,511, 30.1.45. Appl. 6.8.42. Guide for drill steels.

R. D. Zimmerman, assr. to Ingersoll-Rand Co. U.S.P. 2,368,512, 30.1.45. Appl. 14.9.42. Drilling implement.

R. E. Fearon, assr. to Well Surveys, Inc. U.S.P. 2,368,532, 30.1.45. Appl. 27.12.39. Well survey method and apparatus.

L. C. Badgley. U.S.P. 2,368,737, 6.2.45. Appl. 23.8.41. Spring dog assembly and the like.

E. F. Price. U.S.P. 2,368,777, 6.2.45. Appl. 30.1.42. Method of preventing paraffin deposits in oil wells.

A. D. Garrison, assr. by mesne assignments to The Texas Co. U.S.P. 2,368,823, 6.2.45. Appl. 25.8.37. Preparation of drilling muds.

C. M. O'Leary. U.S.P. 2,368,999, 6.2.45. Appl. 7.2.42. Bottom-hole intermitter.

E. D. Every, assr. by mesne assignments, to Artesian Well and Equipment Co., Inc. U.S.P. 2,369,222, 13.2.45. Appl. 21.5.42. Well scraping tool.

G. E. Nevill, assr. to James V. Robinson. U.S.P. 2,369,403, 13.2.45. Appl. 18.3.35. Means and method of surveying wells.

W. W. Robinson, Jr., assr. to The Texas Co. U.S.P. 2,369,407, 13.2.45. Appl. 13.1.44. Drilling fluids.

A. Frosch, assr. to Standard Oil Development Co. U.S.P. 2,369,550, 13.2.45. Appl. 30.6.41. Well logging.

G. R. Gray, assr. to Standard Oil Development Co. U.S.P. 2,369,560, 13.2.45. Appl. 9.4.42. Drilling fluid.

D. G. C. Hare, assr. by mesne assignments, to The Texas Co. U.S.P. 2,369,672, 20.2.45. Appl. 21.10.41. Method and apparatus for logging boreholes.

R. W. Stuart, assr. to Stanolind Oil & Gas Co. U.S.P. 2,369,811, 20.2.45. Appl. 3.7.41. Drill mud logging recording system or the like.

P. H. Jones and M. T. Flaxman, assr. to Union Oil Co. U.S.P. 2,369,831, 20.2.45. Appl. 13.4.45. Treatment of oil-producing sands.

C. E. Reed, assr. to Chicago Pneumatic Tool Co. U.S.P. 2,369,979, 20.2.45. Appl. 2.1.40. Earth boring tool.

J. T. Phipps, assr. to H. C. Smith Oil Tool Co. U.S.P. 2,370,070, 20.2.45. Appl. 8.5.42. Bit.

D. G. C. Hare, assr., by mesne assignments, to The Texas Co. U.S.P. 2,370,162, 27.2.45. Appl. 16.10.41. Method and apparatus for logging boreholes.

C. D. Hathcock. U.S.P. 2,370,310, 27.2.45. Appl. 28.6.44. Elevator.

C. S. Nation. U.S.P. 2,370,413, 27.2.45. Appl. 1.4.44. Deep-well pump.

C. F. Reed, assr. to Charles L. Horn. U.S.P. 2,370,421, 27.2.45. Appl. 20.3.42. Treatment of oil wells.

W. E. Lynd, assr. to Lane-Wells Co. U.S.P. 2,370,476, 27.2.45. Appl. 11.8.41. Dual-production device. A. H. N.

Oilfield Development.

1020. Petroleum in England. C. A. P. Southwell. *J. Inst. Petrol.*, Feb. 1945, **31** (254), 27–39.—The drilling and production practices followed in English fields controlled by the Anglo-Iranian Oil Co. are given in some detail. A. H. N.

1021.* Venezuela Proved Reserves Nearing 7,000,000,000 Brl. Anon. *Oil Wkly*, 16.4.45, **117** (7), 71.—It is estimated that 1944 drilling operations have added more than 600,000,000 brl. of oil to the Venezuelan known reserves. At the end of 1945 the unproduced reserves may be 7,000,000,000 brl. G. D. H.

1022.* Creole to Resume Development in El Roble Field after Two-Year Lapse. Anon. *Oil Wkly*, 21.5.45, **117** (12), 78.—After a thorough study of reservoir conditions, development is to be resumed at El Roble. The field gives 51-gravity oil at high gas–oil ratios from a series of non-condensate pays with no gas–oil separation capable of being utilized to improve the gas–oil ratios. Former technique will be followed, and large amounts of gas will have to be vented. At present there are 10 producing wells, with a total capacity of about 6000 brl./day. Gas–oil ratio has risen from 3425 at the beginning of 1943 to 6000 at the beginning of 1945. The field is only partly developed. G. D. H.

1023.* Colombian Improvment Confirmed by Final Data. Anon. *Oil Gas J.*, 26.5.45, **44** (3), 116.—During 1944 Colombia produced 22,647,476 brl. of oil, compared with 13,261,065 brl. in 1943. 18,561,431 brl. of oil was exported in 1944. The output of Colombian refineries was sufficient to supply most of the petroleum products consumed in Colombia.

United States companies have combined holdings of about 10,000,000 hectares in Colombia. G. D. H.

1024.* Colombia's Production Still Below 1944 Level. Anon. *Oil Wkly*, 30.4.45, **117** (9), 65.—During February Colombia produced 1,503,698 brl. of oil, 134,000 brl. more than in January, but well below the 1944 average of about 2,000,000 brl./month. Current producing potential is estimated to be over 2,500,000 brl./day. G. D. H.

1025. Summary of April Completions. Anon. *Oil Gas J.*, 26.5.45, **44** (3), 198.—2157 wells were completed in U.S.A. in April. 1151 obtained oil and 224 obtained gas. The completion results are summarized by States and districts, and the numbers of wells in different depth ranges are given. G. D. H.

1026.* April Drilling shows New Gain. Anon. *Oil Wkly*, 14.5.45, **117** (11), 56.—During April an average of 504 wells/week were completed in U.S.A.; the March figure was 448/week. 1072 of the April completions found oil and 196 gas. Total footage as 6,962,481 ft. Fourteen states showed a decrease in activity in April, the largest drop being in California. A table summarizes by States and districts the completion results during April and the first four months of 1944. G. D. H.

Transport and Storage.

1027. Effect of Supercompressibility of Natural Gas upon Compressor Performance. R. S. Ridgway. *Refiner*, May 1945, **24** (5), 177–184.—Methods are presented for calculating the compression-cylinder capacity and compressor horse-power under high pressure conditions when the effects of super compressibilities of natural gas are significant. The effect of supercompressibility is to reduce the horse-power necessary to compress a gas, in some cases by as much as 15%. In one particular recycling installation this reduction in compressor horse-power meant the elimination of one compressor unit, which, including installation costs, represented a saving that ran into six figures (American money). The simple and easy methods presented are illustrated by examples. A. H. N.

1028. Petrol Pipe-lines under the English Channel. Anon. *Engineer*, 1945, **179**, 410–411, 433–435, 454–456, 466–467.—A total of 20 pipe-lines have been laid across the English Channel since D-day, and more than 1,000,000 gal. of petrol a day delivered for some months from the pipe-line system in Great Britain to as far into Germany as Frankfort-on-Main.

Two types of line were employed : a cable-type line consisting of a 3 in. bore lead sheath strengthened by steel tape and wires to withstand working pressures in excess of 1200 p.s.i. ("H.A.I.S." = Hartley, Anglo-Iranian, Siemens) ; and a 3-in. steel pipe welded into lengths of 30 miles or more ("H.A.M.E.L." = Hammick, Ellis), with short lengths of H.A.I.S. pipe attached to the ends for greater flexibility in starting and finishing the laying operation. The H.A.M.E.L. pipe was welded from 20-ft. lengths at the rate of 10 miles a day and wound on to 6 floating drums ("Conundrums"), which were steel cylinders 60 ft. long and 40 ft. diameter. The overall dimensions of the Conundrums were 90 ft. long (including conical ends) and 50 ft. diameter, and when fully wound each weighed 1600 tons and carried 70 miles of pipe-line.

The H.A.I.S. lead pipe was joined from 700-yd. lengths by burning, and made up into 10-mile lengths with its armour, special problems having to be overcome with regard to space for coiling and storing such lengths. It was laid filled with water at 200 p.s.i., the pressure being retained by copper-alloy bursting discs at the ends. A special union was devised for joining lengths, each union incorporating a bursting disc, which was designed to fracture at 400 p.s.i. Some of the H.A.I.S. pipe-line was made in the U.S.A.

The pumping arrangements involved provision of 3 terminals, at Sandown, Shanklin, and Dungeness. 54 reciprocating pumps and 7 centrifugal pumps were installed, all designed to work at 600 lb. suction pressure and 1500 lb. discharge. Pumps were housed in seaside bungalows, wooden boathouses, cafés, etc., inside which bullet and blast-proof concrete walls were built.

The longest time taken to lay a line was 10 hrs., from the Isle of Wight to Cherbourg. The pumping and storage responsibilities for the main operation fell on the technical staff of the Royal Army Service Corp., trained during a full-scale trial with a H.A.I.S. line laid from Swansea to Ilfracombe in December 1942 and kept in operation for more than a year, supplying North Devon and Cornwall with petrol. A. C.

Refinery Operations.

Refineries and Auxiliary Refinery Plant.

1029. Economic Comparison of Batch and Continuous Processing. R. M. Crawford. *Chem. Met. Eng.*, 1945, **52** (5), 107.—The continuous method lends itself well to conservation of sensible heat, power and labour, but the conservation of capital is a debatable point. With a new industry or process where the market is uncertain it is safer to keep to the batch process, in which plant investments and risks are kept as low as possible but where the processing costs may be high. When an industry or product is well established, it is essential to aim for the lowest unit cost of production and therefore employ a continuous process. A number of other factors governing the choice of process are discussed. L. B.

1030. Continuous Flow Processes. An Introduction. R. B. MacMullin and M. Weber, Jr. *Chem. Met. Eng.*, 1945, **52** (5), 101.—In the ideal condition of continuity no mixing occurs along the axis of the path, but theoretically perfect mixing is obtained in a direction normal to the axis. This state is, however, never actually attained in practice.

Variations in the order of continuity are represented by (1) batch, (2) batch with surge volume to iron out discontinuities, (3) constant flow of fluid through a series of vessels in which a fluid is contacted with a solid, the latter being renewed batchwise.

All are essentially batch, although bearing similarity to the continuous process. It is only when true continuity is approached that the situation becomes complex theoretically. When a continuous process is carried out in a single agitator tank, various portions of the outflow will have remained in the tank for various lengths of time, and in order to ensure an average retention time for each portion of outflow it is essential to divide the tank contents between several vessels.

Fairly close agreement between results in batchwise and continuous operation are obtained when reactions are of the zero order, a condition closely approached in cracking operations and in co-polymerization of butadine and styrene. The discrepancy becomes greater the higher the order of the reaction, and in such cases continuous operations are difficult to justify unless special circumstances demand them—*e.g.*, when filling, cooling down and emptying times form a high proportion of the batch cycle, or if the products are relatively unstable and the reaction sensitive. Batch processes are usually better for reactions of high orders, for non-reversible reactions, or when extreme completion of the reaction is desired. L. B.

1031. Historical View of Continuous Process Development. R. Norris Shreve. *Chem. Met. Eng.*, 1945, **52** (5), 103.—Factors governing the retention of batch processing in certain cases and the change-over in others to continuous processing are considered. L. B.

1032. Control of Material Feed Rate. D. M. Considine. *Chem. Met. Eng.*, 1945, **52** (5), 112.—Accurate control of feed rate is an essential premise of continuous processes. The rate may be controlled volumetrically or gravimetrically. Flow of gases and liquids is best measured by displacement pumps, orifice, and venturi meters; solids, by star-wheels, apron-feeders, rotary disc-feeders, totalizing conveyor scales, weigh feeders, and automatic hopper scales. L. B.

1033. Problems in Dissolving, Reaction, and Mixing. E. S. Bissell. *Chem. Met. Eng.*, 1945, **52** (5), 112.—Agitation is applied in blending miscible liquids, mixing of immiscible liquids, control of crystal size, gas absorption and dispersion, suspension of solvents, and in improvement of heat transfer. In providing for agitation in continuous processes, it is necessary to bear in mind that very few chemical reactions proceed instantaneously, so that reaction time must be allowed for. These reactions are in general independent of the energy expended in agitation, but in physical processes, such as the blending of miscible liquids, retention time may be reduced by increasing the intensity of mixing. " Short circuiting " is a common difficulty, but this might be obviated by using a number of vessels in series, or by recycling some of the material. Continuous agitation in a single-vessel, flow-through system will not provide the dynamic conditions provided for in counter-flow processes. L. B.

1034. How Batch Unit Processes are Made Continuous. M. G. Larian. *Chem. Met. Eng.*, 1945, **52** (5), 114.—Conversion to continuous methods usually involves changes in unit operations rather than unit processes, and has been achieved by (1) the elimination of reason for batchwise operation, *e.g.* scaling of condensers through absence of softening treatment of water, (2) removing reaction products which retard the process, (3) adapting the process to equipment best suited for continuous operation, and (4) altering process of manufacture. Examples are quoted. L. B.

1035. Pitfalls in Working Continuous Processes. H. L. Bullock. *Chem. Met. Eng.*, 1945, **52** (5), 116.—A number of difficulties encountered by the author in the conversion of batch to continuous processes are described. L. B.

1036. Technical Aspects of Continuous Process Systems. J. F. Olsen and E. J. Lyons. *Chem. Met. Eng.*, 1945, **52** (5), 118.—Continuous systems are grouped under the headings of batch-continuous, recycle, concurrent and countercurrent, and mixing devices commonly used in each case are illustrated. Circulation and energy patterns for optimum results in various operations dependent on agitation, *e.g.*, blending, emulsification, reaction, treating, solution, heat exchange, gas absorption, crystallization, and flocculation, are discussed with diagrams. L. B.

1037. Continuous Mixing and Reaction Equipment Design. A. Brothman, G. N. Warren, and S. M. Feldman. *Chem. Met. Eng.*, 1945, **52** (5), 126.—Continuous devices for mixing may be classed under two headings : (1) single-pass in which no recirculation takes place, (2) multipass in which recirculation does occur. Advantages and disadvantages of each type are presented. The method of carrying out appropriate design calculations is demonstrated, and a number of basic equations listed. It is concluded that single-pass systems are suitable for fast reactions, those characterized by short induction periods, those where operation is somewhat intermittent, and those where the products may retard the process. Multipass systems are best suited for slow reactions with long induction periods, reactions which are associated with a critical mixing problem, where the reaction products exert a desirable autocatalytic effect, and especially where large amounts of exothermic heat of reaction have to be removed by recycling through a suitable heat exhanger. L. B.

1038. Procedure for Application of Stainless-Steel Strip Liners to Refinery Vessels in the Field. K. E. Luger. *Refiner*, May 1945, **24** (5), 173–175.—Reference is made to a previous paper on this subject by the author (*Refiner*, February 1940, **19** (2) 41). In the present paper rules and procedures are given so that welding stainless steel liner strips may be made as foolproof as possible. Instructions in detail and illustrations are reproduced. A. H. N.

1039. Ceramic Linings for Acid Tanks. R. Neuhaus. *Refiner*, May 1945, **24** (5), 194.—The method of making ceramic lining for acid containers is briefly described and illustrated. A. H. N.

1040. Management from the Superintendent's Viewpoint. Part I. O. B. Wendeln. *Refiner*, May 1945, **24** (5), 65–169.—Criticism of present-day utilization of the potentialities of a good superintendent's work by the management are made and remedial or alternative methods suggested. A. H. N.

Distillation.

1041. Fractional Distillation of Ternary Mixtures. Part I. A. J. V. Underwood. *J. Inst. Petrol.*, April 1945, **31** (256), 111–118.—An analytical method is presented for computations relating to the fractional distillation of ternary mixtures. It is also shown that the principle of the method can be extended to mixtures of more than three components. A. H. N.

Absorption and Adsorption.

1042. Some Chinese Clays as Adsorbing Agents. T. J. Suen and F. H. Yao. *J. Inst. Petrol.*, June 1945, **31** (258), 179–187.—In a previous paper it was reported that " white clays " produced in Szechuan could be used to reduce the gum content of gasoline obtained by cracking vegetable oils. In continuation some more clays produced in Nanchuan and Tsunyi have also been tried. They seem to be more suitable than the white clays previously studied and, while further work is being carried on, the results so far obtained are reported. A. H. N.

Cracking.

1043.* Cracking of Heavy Petroleum Products on Heated Surfaces. A. Ya. Larin. *Bull. Acad. Sci. U.R.S.S. Cl. Sci. Tech.*, 1944, 42–47.—A description of laboratory apparatus for continuous cracking by means of immersed electrically heated wire spirals made of W, Mo, Pt, Fe, Ni and also from alloys (*e.g.* constantan) and heated to 800–1000° C. Gas produced (31–91%) has high (30–90%) unsaturated content, and yield per KwH decreases for various types of charging stocks in the order : paraffin (wax), fuel oil, lubricating distillates. Analyses are given on the gaseous cracking products but only yields are shown for the liquids. V. B.

1044.* Data on Problem of Chemistry of Oxidative Cracking of Hydrocarbons in the Vapour Phase. II. S. S. Nametkin and L. M. Rosenberg. *Bull. Acad. Sci. U.R.S.S. Cl. Sci. Tech.*, 1943 (11–12), 3–14.—Pure tetralin and decalin were subjected to cracking (reaction time 19–31 sec.) at 575° C. and 575–625° C., respectively, in O_2/N_2 mix-

tures containing 0–50% of O_2. In the case of tetralin the principal reaction was dehydrogenation to naphthalene; subsidiary reactions are indicated by identification of benzene, toluene, *m*- and *o*-xylene, and oxygen-containing compounds. Mechanism of tetralin decomposition in these circumstances is discussed. Decalin does not undergo dehydrogenation, no napthalene being found in the reaction products, which contain a larger quantity of unsaturated gases. Main direction of cracking reaction in this case appears to be scission of one of the rings, resulting in naphthenic hydrocarbons (ethyl*cyclo*pentane was identified), which later lose hydrogen, yielding aromatics.
V. B.

Special Processes.

1045. British Research on Petroleum Substitutes. 6. Fischer-Tropsch Synthesis. R. M. Bridgwater. *Petroleum*, June 1945, **8** (6), 109.—Although 7 million gals. of methyl alcohol were produced in Britain in one year before the war by the interaction of carbon monoxide and hydrogen, and about 600,000 tons of oil by Fischer–Tropsch process in Germany annually, by 9 plants, little experimental work appears to have been carried out in Britain.

British work concerned the development of robust catalysts and techniques for large-scale operation. Synthetic Oils, Ltd., worked on a process yielding a product rich in olefines, using specially prepared catalysts. A plant was built to process about 200,000 cu. ft. of gas per day, yielding 136–180 gal. per day, and said to substantiate the results obtained in the pilot plant using blue water gas. With cobalt and thorium carbonates supported on kieselguhr the Fuel Research Station produced lubricating oils from blue water gas and hydrogen in a small plant. Little has been reported on the quality of motor spirit or diesel oils produced, but a fraction boiling between 210° and 300° C. has a cetene number of 93. The 7–10% wax contained in liquid products from Fischer–Tropsch process can be treated to yield marketable commodities. Studies have been made of the mechanism of the process, it being concluded that cobalt carbide is first formed.
G. A. C.

Metering and Control.

1046. Measurement of Oil Depths. The Measurement of Oil Depths Panel of Standardization Sub-Committee. No. 1. Measurement and Sampling. *J. Inst. Petrol.*, Feb. 1945, **31** (254), 40–72.—The work of Panel II of the Sub-Committee on measurement of oil depths in (*a*) shore tanks of various types, (*b*) ship and barge tanks, (*c*) rail and road tank cars, and (*d*) pipe-lines, is reported. Use of oil-meters is also briefly discussed.
A. H. N.

1047. Bulk Oil Measurement. E. Stokoe. *J. Inst. Petrol.*, July 1945, **31** (259), 224–235.—Calibrating vertical and horizontal tanks is discussed. Water calibration, dipping, gauging by means of gauge-glasses, and ullaging are described, together with various precautions to be taken in these methods and in associated operations of bottom water measurements, temperature measurements, sampling, etc. A. H. N.

Products.

Chemistry and Physics.

1048. Increase in Viscosity of Oils Under Influence of a High-Frequency Electro-Magnetic Field. G. M. Panchenkov. *Symp. Visc. Liquids and Colloids, Acad. Sci. U.S.S.R.*, 1941, **1**, 191–195.—Baku spindle, engine, and cylinder oils were subjected to two sets of experiments: (*a*) using frequencies of 12,000–100,000 Khz. for 6 hrs. when the oils were placed in glass bottles, between the plates of a condenser connected to the generator, and (*b*) using frequeucies of $1{\cdot}6 \times 10^7$ Khz. for 10 hrs. and subjecting the oil to the effect of the inductive discharge in the space above the oil, in an evacuated vessel. Both types of treatment increased the viscosity of the oils, the increase being more marked in the case of (*b*); V.I. was little affected in either case. Results are expressed graphically, including, in the case of (*a*), curves relating increase in viscosity to wave length of the discharge.
V. B.

1049. Viscosity of Mineral Oils. G. M. Panchenkov. *Symp. Visc. Liquids and Colloids, Acad. Sci. U.S.S.R.*, 1941, **1**, 139–147.—Consideration is given to three aspects of the viscosity of mineral oils, namely its variation with temperature, molecular constitution, and pressure. The principal published data relative to each of these is considered and typical figures and conclusions are quoted. It is pointed out that the latter are largely empirical, since there has not yet been developed a satisfactory theory of the viscosity of liquids, particularly for complex mixtures such as are mineral oils. V. B.

1050. Determination of Oil Viscosity at Low Temperatures. A. F. Dobryanskii, A. P. Sivertzev, and I. Ya. Fridman. *Sym. Visc. Liquids and Colloids, Acad. Sci. U.S.S.R.*, 1941, **1**, 173–180.—A description of a new rotating viscometer actuated by falling weights. The oil film is of small thickness (approx. 1–2 mm.) and only 2–3 ml. of oil is required. It is recommended that the time per revolution should be 50–250 sec. It is claimed that the instrument has a repeatability of 1% and that it is effective in the range 50–14,000 poises over the temperature interval 0 to − 50° C. Calibration was by a 40% resin solution in castor oil, whose viscosity was determined by the falling sphere method. Among examples given of the use of the viscometer, is the investigation of the super-cooling of compounded oils. V. B.

1051. " True " and " Extrapolated " Viscosity of Lubricating Oils at Low Temperatures. D. S. Velikovskii. *Symp. Visc. Liquids and Colloids, Acad. Sci. U.S.S.R.*, 1941, **1**, 161–172.—A comparison is made between values of viscosity obtained experimentally and by extrapolation for temperatures in the range 0 to − 50° C. Extrapolated figures were derived by the use of three formulæ, which in most cases all gave viscosity figures considerably higher than those found experimentally, although the Walther expression (on which A.S.T.M. Charts are based) gave, on the whole, the least divergence. Variation between true and extrapolated values arises in the region where the lubricant begins to lose true fluidity. Experimental determinations were carried out in a special viscometer, whereby effect of static resistance is eliminated, by the oil being in movement when the determination is made. Variation of viscosity with rate of movement is discussed. It is concluded that, pending development of a correct mathematical expression, which will vary with the type of oil (*i.e.*, residual or distillate) and its degree of refining, the only means of obtaining accurate low temperature viscosities is by actual experiment. V. B.

1052. Determination of Lubricating Oil Viscosity at Low Temperatures. Yu A. Pinkevich. *Symp. Visc. Liquids and Colloids, Acad. Sci. U.S.S.R.*, 1941, **1**, 181–189.—A description is given of a modification of the Lee viscometer. The apparatus is adapted to determining viscosity under a pressure of 200 mm. Hg and is suitable for operation down to − 35° C. The instrument was calibrated in the range − 3° to 20° C. against an Ostwald pipette; the accuracy is claimed to be 1–2%, which is deemed adequate for low-temperature work. Within this temperature interval application of Hg pressure to standard oil used for calibration had no effect on its viscosity, although a marked effect was noticeable at − 5° C., thus showing a change at this point, for this particular oil, from the properties of a Newtonian fluid. Determinations are given of a series of viscosities in the interval − 25° to 100° C. on both straight and additive-containing oils. Results clearly show viscosity-lowering effect, at low temperatures, of additives of " paraflow " type, which destroy crystalline structure of oils at low temperatures, thus cancelling marked viscosity-increasing effects of such structures. V. B.

1053. Viscosity-Temperature Characteristic of Lubricating Oils. M. M. Kusakov, *Symp. Visc. Liquids and Colloids, Acad. Sci. U.S.S.R.*, 1941, **1**, 149–160.—The formulæ that have been proposed for defining the viscosity/temperature relationships of mineral oils are, in the absence of a suitable theoretical basis, of an empirical nature. The present work (theoretical) is not intended as another viscosity index system, but as a consideration of the basic principles underlying the choice of suitable parameters, which would indicate both the viscosity of an oil at a given temperature and the nature of the viscosity/temperature curve. In order to characterize these features with reasonable accuracy, three parameters are required, one of which denotes the viscosity of the oil at a given temperature and the remaining two the shape of the curve $\eta = f(t)$.

Of the formulæ available that of Vogel–Fulcher–Tammann is preferrred, and it is proposed to use this in the following modified form $\nu = \nu_{\infty} e^{\frac{C}{t - t_0}}$ where ν is the kinematic viscosity of the oil and ν_{∞}, C, and t_0 are constants. ν_{∞} represents the viscosity of the oil at an infinite temperature, and C is a constant denoting the change of viscosity with temperature. The expression is applicable to all oils (including fatty oils) within the temperature range where they behave as Newtonian liquids. The construction of a nomogram is described whereby, from a knowledge of the viscosity at three temperatures, the values of the constants ν_{∞}, C and t_0 may be determined. V. B.

1054. Use of Viscometry for Characterising the Properties of Greases. V. P. Varentzov. *Symp. Visc. Liquids and Colloids, Acad. Sci. U.S.S.R.*, 1941, **1**, 197–210.—A study was made of viscosity of greases in the temperature range 20° to − 40° C. A viscometer with a horizontal capillary, to which pressure could be applied, was used. 5%, 10%, and 20% concentrations of Al, Ca, and Na soaps, and of ceresin, in transformer oil, were examined. Results are also given for viscosities of 4 mineral oils at these temperatures. Viscosity of greases, at all the temperatures, and of the mineral oils below − 20° C., is a function of applied pressure, thus showing that there is structure-formation in these systems. The three main characteristics defining flow under these conditions are η_0 the viscosity at low pressures, η_{∞} the viscosity at high pressures, and γ the modulus of elasticity. These constants are tabulated for the materials investigated and may be obtained graphically by plotting experimental results on coordinates of pressure and speed of flow. Of the greases examined, Na greases showed the steepest viscosity/temperature curve. Increase in viscosity of greases on lowering the temperature is, in the main, due to a rise in viscosity of the oil component. V. B.

1055. Applicability of the Formula and Graphic Method of Philipoff to the Extrapolation of the Viscosity of Greases. A. A. Konstantinov. *Symp. Visc. Liquids and Colloids, Acad. Sci. U.S.S.R.*, 1941, **1**, 211–214.—Viscosity values, calculated according to the method of Philipoff (*Kolloid-Z.*, 1936, **75**, 142), were compared with the experimental results of Arveson (*Ind. Eng. Chem.*, 1934, 26, 628). Agreement was unsatisfactory, and it is concluded that the method is not applicable to technical use. V. B.

1056. Mechanical Equivalent of the Internal Friction of Greases. D. S. Velikovskii, *Symp. Visc. Liquids and Colloids, Acad. Sci. U.S.S.R.*, 1941, **1**, 215–231.—By "internal friction" is meant the physical effect, as such, irrespective of its mechanism. The term "viscosity" is restricted to its accepted sense, denoting the internal friction of Newtonian fluids. The coefficient of internal friction of greases cannot conveniently be measured experimentally owing to the necessity for high shear stresses and rates of shear. It is, however, practicable to determine the mechanical equivalent of this internal friction, and this is the figure which is of practical importance. A Dettmar friction machine was used to find the viscosities of oils giving the same coefficient of mechanical friction as the grease under test. Examination was made of Na and Ca greases and of a ceresin/oil mixture. The amount of solid phase was 15%, 20%, and 25%. The materials were worked prior to test. The mechanical equivalent of internal friction, $\epsilon\eta$, increases linearly with an increase in the concentration of the solid phase. Increase in rate of shear causes a slight decrease in $\epsilon\eta$ which is, however, increased by a rise in viscosity of the oil component. Results are given both in tables and graphs. In one example, for four greases (at 30° C.) the internal friction, with a rate of shear equal to 1 sec.$^{-1}$, was 700–2000 poises, whilst the mechanical equivalent was 2·38–3·8 stokes. $\epsilon\eta$ is, in the range examined (3–5 kg./cm.^{2}), little affected by the loading. In the case of ceresin/oil blends, with a viscous oil phase, the $\epsilon\eta$ value is less than that for the oil alone. The multiplicity of grease types makes it impossible to develop a single expression giving coefficient of internal friction as a function of the rate of shear, pressure and temperature. V. B.

1057. A Study of Viscosity of Coal-Fuel Oil Suspensions. V. F. Kustov and L. L. Khotuntzev. *Symp. Visc. Liquids and Colloids, Acad. Sci. U.S.S.R.*, 1941, **1**, 405–413.—Examination was made of suspensions, produced by a colloid mill, containing 10–50% of coal. Several varieties of the latter were used having 4·8–9·4% moisture and 4·9–30·6% ash and ground to 150–325 mesh. Use was made of a viscometer with a horizontal capillary of length 100 cm. and diameter 0·4–0·8 cm. Viscosities in the temperature range 25–80° C. were studied. Viscosity increases rapidly with increase in concentration of the disperse phase (*e.g.*, 20% coal, 4 poises, 40%, 16·8 poises, at 40° C.), but such increase is non-linear. Optimum concentrations of coal for technical application are 30–40%, concentrations of 50% yield mixtures which are non-fluid at ordinary temperatures. Coals with a greater adsorbing power yield suspensions of higher viscosity for equivalent concentrations. Increase in fineness from 150 to 325 mesh causes only a small fall in viscosity. The viscosity–temperature coefficient of the suspensions is similar to that of the oil phase. V. B.

1058. Fundamentals of Wetting and Detergent Compounds. J. Hetzer. *Refiner*, May 1945, **24** (5), 199–200. *Translated by E. J. Barth from " Fette und Seifen "* No. 5, May 1942, p. 364.—Detergent compounds for the textile industry are particularly studied. Textile aids possess the fundamental property of greatly lowering the surface tension of water, and all possess the property of giving foamy solutions, as well as being wetting, washing agents, and detergents. Not all detergents are strong wetting agents, however. For instance, a wetting agent may have a low wetting ability and at the same time show excellent emulsion characteristics; or again, a wetting agent might show only medium detergency and yet be an excellent textile aid. The greatest number of textile agents manufactured to-day are organic materials consisting mostly of aliphatic hydrocarbons. These materials can be grouped as follows: (1) soaps; (2) Turkey-red oils; (3) sulphonic acids of the aliphatic hydrocarbons and their derivatives; (4) fatty alcohol sulphates; (5) cation-active textile aids; (*c*) petroleum sulphonates. Each of items is briefly discussed, compositions, chief properties, and peculiarities being given. A. H. N.

1059. X-Ray Diffraction. Part 2. F. G. Firth. *Refiner*, May 1945, **24** (5), 191–193.—The different types of crystals which are developed in matter due to the different types and strengths of the bending forces between the lattice planes are described. Thus crystals of substances characterized by covalent, ionic, and metallic bonds are described.

The effect of preferred orientation of crystals in powders on the X-ray diffraction pattern is to produce arcs of intensity which in the extreme case of perfect orientation result in spots of maxima.

Alloy formation is briefly discussed and illustrated by the formation of the different brasses, from copper and zinc. Finally, the study of organic material by X-ray methods is very briefly indicated. A. H. N.

Analysis and Testing.

1060. Quantitative Liquid-Phase Hydrocarbon Analysis by Infra-Red Absorption. R. R. Gordon and H. Powell. *J. Inst. Petrol.*, July 1945, **31** (259), 191–212.—The absorption spectra of pure hydrocarbons published hitherto have been peculiar to the instrument employed for their determination. As attempt is made in this paper to evaluate such factors as cell zero, the effect of scattered radiation of short wave-lengths, and the variations of absorption with thickness of absorbing material, on a quantitative basis, with the object of removing the individuality among published spectra. Advantages of using a variable-thickness absorption cell for this purpose are demonstrated. The application is discussed of a variable-thickness absorbing cell to the infra-red absorption analysis of mixtures containing five hydrocarbons. The method of computation involving the corrections described in Part 1 is given in detail. A numerical example of the application of these corrections is given as an Appendix. A. H. N.

1061.* Qualitative Determination of Diene Hydrocarbons having Conjugated Double Bonds. III. V. I. Esafov. *J. Appl. Chem.* (*U.S.S.R.*), 1943, **16**, 283–295.—Halogen absorption methods were examined to test their applicability to analysis of unsaturated hydrocarbons, using hexadiene-2 : 4; 2-methyl-decadiene-1 : 3; 3-methyl-5-ethyl-heptadiene-3 : 5; di*iso*butylene, tri*iso*butylene, and octadiene (a mixture of 2-ethyl-4-methyl-pentadiene-1 : 3 and 2 : 4-dimethyl-hexadiene-2 : 4). Comparative tests were done by the McIlhiney, Hubl-Waller, Hanus, and Margosches methods. A considerable difference in result is obtained, depending both on method used and structure of the unsaturated hydrocarbon. It is concluded that the Hubl–Waller and Hanus methods are the most suitable, yielding iodine values of theoretical magnitude in the case of olefines, *cyclo*-olefines, and polyene compounds with isolated double bonds, and having a normal structure. Olefines with an *iso* structure give low results, the divergence being the larger the greater the degree of branching. In the case of dienes with conjugated double bonds, and those with one side-chain in the form of a CH_3 group, the I.V. obtained is about 60% of theory; for dienes with 2 carbon side-chains, joined to the carbon atoms by a conjugated system, the I.V. is theoretical, or in excess of theory. Examination of a pressure distillate showed that, despite a diene content of only 1% as shown by the Kaufman diene number, iodometric methods indicated this to be considerably greater. V. B.

1062. Analysis of Liquefiable Hydrocarbons by Distillation. The Liquefied Gases Panel of Sub-Committee No. 3.—Liquefied Petroleum Gases, Gasoline, Kerosine, and Light Distillates. *J. Inst. Petrol.*, Jan. 1945, **31** (253), 16–22.—The method consists essentially of fractionation into narrow cuts, followed by an Orsat analysis for olefin content of each fraction. A. H. N.

1063. Diagnostic Characteristics of Crude Oils : Fluorescence Analysis in Ultra-Violet Light. J. N. Mukherjee and M. K. Indra. *J. Inst. Petrol.*, June 1945, **31** (258), 173–178.—Analytical methods described were used to distinguish between refined oil samples, crude samples, artificially made crude oils, and an extract of resin. The intensity of fluorescence is measured quantitatively by the amount of nitrobenzene required to quench it in a sample. A. H. N.

1064. Determination of Viscosity of Standard Oils for Viscometer Calibration. Yu A. Pinkevich. *Symp. Visc. Liquids and Colloids, Acad. Sci. U.S.S.R.*, 1941, **1**, 233–238.—Procedure for viscometer calibration is described. Method and apparatus used are conventional; the viscometer is of the Fenske type. Water is used as the primary standard. Refining procedures (nitrobenzol followed by clay or $AlCl_3$ followed by clay) for stabilizing the standard oils are recommended. Viscometer calibrations at 50° C. are approximately 0·1% below the value at 20° C. V. B.

1065. Relative Viscosity Measurements made with Constant-Level-Flow Viscometer. N. S. Serinis. *Chem. Met. Eng.*, 1945, **52** (5), 140.—Main feature of the instrument is the automatic regulation of the flow rate by control of the hydrostatic head on the orifice. Viscosities are determined relative to water, and may be measured either by comparing times to fill a standard volume or by comparing volumes run out over a fixed period of time. Temperature control is provided. L. B.

1066. Melting Points of Binary Wax Mixtures " Melting Points " 2. W. J. Ellis. *Petroleum*, June 1945, **8** (6), 115.—Determination of melting points of waxes follows method devised by Koch, Hable and Wrangel (*Ind. Eng. Chem. Anal. Ed.*, 1938, **10**, 166). Each of the 28 melting-point curves depicted was determined by testing 10 equally spaced mixtures, usually 5 tests being made with each mixture.

Wax mixtures can be classed into 4 main groups, the first having melting points higher than their corresponding simple mixture-rule values, the second group being characterized by melting points lower than calculated values. Mixtures of the third group are in approximate agreement with the latter, whilst those of the fourth group have melting-point curves crossing the mixture-rule line. There is often no relation between melting point and hardness. G. A. C.

1067. Estimation of Sulphur Content of Petroleum Distillates. A. R. Javes. *J. Inst. Petrol.*, May 1945, **31** (257), 129–153.—A series of tests were performed to ascertain the accuracy of the lamp method of estimating the sulphur content of petroleum distillates. As a result of this work a lamp was evolved which will give a very rapid and smokeless combustion of samples, including those with a high aromatic content. The results obtained with the apparatus finally adopted—a lamp system—have been found to be accurate and reliable using gravimetric and turbidimetric methods for working up the test solutions. Particular importance was attached to sulphur contents of less than 0·01% for which the existing volumetric methods were not suitable, though higher sulphur contents were not excluded from the investigation. This apparatus, except for the large lamp, has since been adopted by the Institute of Petroleum as an extra standard method for sulphur determination. A. H. N.

1068. Corrosion Problems in the Petroleum Industry. 2. Methods of Measurement. A. H. Stuart. *Petroleum*, June 1945, **8** (6), 116.—In devising laboratory tests many variables concerning corrosion under practical conditions have to be taken into account. Results from accelerated tests should be accepted with reserve until reasonable correlation with practical experience has been found.

A test circuit is described which has given satisfactory results. A calomel half-cell, filled with a saturated solution of potassium chloride, has a capillary entering a beaker of the same solution. The beaker is connected to the test cell containing the attacking liquid in contact with the test metal, by a bridge. Electrical connections are carried to a potentiometer, and thus an electric potential measured. Graphs are given showing the results on mild, stainless, and bright drawn steels. They also show that converting the surface of a steel from the crystalline to the amorphous condition (the latter structure being known as the Beilby layer) increases the tendency to corrosion. Tests have also shown that graphoidal films formed on machinery lubricated by oil containing colloidal graphite reduce the corrosive tendency. The method described gives a reliable index of corrosive reaction within a relatively short time, and records differences which no visual method could detect. G. A. C.

1069. Improved Accuracy of C.F.R. Motor Method Test for High-Octane Rating; with Continuous Scale from 40 to 120 O.N. L. B. Sweetland and P. Draper. *J. Inst. Petrol.*, April 1945, **31** (256), 105–110.—A brief examination of the 17° Motor Method without the throttle plate led to the finding that there was a break in continuity of test conditions at 100 O.N. The Guide Tables for micrometer setting for standard knock intensity below 100 O.N. could not be extrapolated to cover ratings in the higher octane range because excessively high-compression ratios and knock intensity would be encountered. As investigation has been made on the relationship of octane number to compression ratio at standard knock intensity with various ignition settings. It was established that the A.S.T.M. ignition setting at high compression ratios creates unstable conditions of engine operation, with the result that slight fluctuations in spark timing have a very marked effect on the knock intensity. This condition probably accounts for much of the rough-running and difficulty of octane rating experienced on fuels of 100 O.N. and over. This can be overcome by setting the spark for maximum knock, as this allows a considerably lower compression to be used with standard knock intensity. A smooth curve then relates O.N. and compression ratio from 40 to 120 O.N., and a separate method above 100 O.N. is unnecessary. It is recommended that a fixed spark setting of 25° advance be considered for the I.P. and A.S.T.M. Motor Method throughout the range from 40 to 120 O.N. The 17° Motor Method would then become obsolete. A. H. N.

1070. Calibration of C.F.R. Reference Fuels. Sub-Committee No. 5 (Engine Tests) of Standardization Committee. *J. Inst. Petrol.*, July 1945, **31** (259), 236–237.—The calibration curve for the secondary reference fuel C. 13 + T.E.L. by the C.F.R. Motor Method I.P. 44/45(T) is given for T.E.L. up to 4 ml./Imp. gal. and O.N. range 71–87. Results are tabulated in intervals of 0·05 ml. T.E.L./Imp. gal. A. H. N.

Crude Oil.

1071. Classification of Crude Oils. K. G. Margosches. *J. Inst. Petrol.*, Jan. 1945, **31** (252), 1–8.—A detailed study of recent attempts at classifying crude oils according to: (*a*) evaluation of base; (*b*) a decimal system; and (*c*) to type of products. 48 references are given. A. H. N.

1072. Analysis of Trinidad Crude Oils. Part II. Paraffinic Oils. F. Morton and A. R. Richards. *J. Inst. Petrol.*, June 1945, **31** (258), 159–172.—Analysis of 14 individual crude oils drawn from 4 different areas are reported and discussed. These are typical of hundreds of similar analyses, and show the variations encountered within a single type oil. Naphtha from distillate wells are found identical in properties with those associated with heavier oils in the same areas. A. H. N.

Gas.

1073. Chemical Utilization of Natural Gas. B. Miller. *Refiner*, May 1945, **24** (5), 195–198.—The paper was prepared as a report to the Technical and Research Committee of the Natural Gas Department of the American Gas Association. As such it becomes an attempt to point out those ways in which natural gas is used in addition to its principal use as a fuel and source of energy. Greatest weight is placed on those uses which take the greatest volumes; other uses have been mentioned briefly. It is pointed out that the present principal uses as a group will probably not consume as much natural gas in peace-time as at the war-time peak, that the minor uses will probably grow but cannot conceivably increase enough to become really important from the standpoint of natural-gas consumption. Nor does this discussion make marked division between natural gas as such and refinery gases in chemical uses. The data on volume should interest those who have visualized early exhaustion of the supply of natural gas on which a new chemical industry is to be based. Finally, attention is directed to the Fischer–Tropsch process, which can be used to make motor fuel from natural gas, and which may develop into a major use for gas. A. H. N.

Engine Fuels.

1074. Microbiological Aspects of Gasoline Inhibitors. F. H. Allen. *J. Inst. Petrol.*, Jan. 1945, **31** (253), 9–15.—A new theory is presented to account for the delay in the deterioration of gasoline motor and aviation fuels produced by the addition of inhibitors. The bactericidal properties of the commercial inhibitors are strongly adsorbed at the gasoline–water interface, where they are able to exert their greatest bactericidal activity. The microbiological aspects of inhibitor intensifiers and metal deactivators are also discussed. This biological concept of gasoline inhibitors is intended to supplement the extensive chemical research which has been conducted on the deterioration of gasoline motor fuels in storage. A. H. N.

Lubricants.

1075. Parameters Characterising Pumpability of Aircraft Oils at Low Temperatures. S. L. Peisakhodina, R. N. Shneerova and C. S. Tarmanyan. *Symp. Visc. Liquids and Colloids, Acad. Sci. U.S.S.R.*, 1944, **2**, 155–160.—The claims of pour point (as determined by the U.S.S.R. method), viscosity index, and viscosity at low temperatures, as criteria for the suitability of aircraft engine oils for low-temperature operation are discussed. The differential between pour point and minimum temperature of pumpability (as determined in special equipment) varies considerably, but, on the average, the pour point is 15° C. lower. A comparison of viscosities (determined in a capillary under slight pressure) and pumpability shows that the latter corresponds to a viscosity of 330–460 strokes, although some oils that do not flow in a capillary viscometer are capable of being pumped at the same temperature. Viscosity index is not a reliable guide to low-temperature behaviour, since a trace of wax raises the V.I. and low-temperature viscosity without appreciable effect on the pour point. Actual pumpability trials in special equipment, are, pending the development of suitable laboratory apparatus, the only reliable test. V. B.

1076. Synthesis of Molecules with Lubricant Properties. M. Piganiol. *Refiner*, May 1945, **24** (5), 185–190. *Translated by E. J. Barth from La Societe Chimique de France, Nov.* 13, 1942.—Modern theories defining the mechanism of lubrication with viscous mineral oils and fats have specified certain conditions necessary for the molecular structure of the oil in order to obtain various desirable qualities, such as resistance to pressure, adhesion, etc. These principles have explained certain empirical methods of procedure and have directed organic syntheses into new paths. Thus lubricant oiliness agents, sometimes assymetrical and polar in character, improve lubricants, even though they are used in small proportions.

The influence of chemical constitution on viscosity and lubrication qualities of oils is studied, followed by a study of methods of synthesis of the best type lubricants and of addition agents to increase oiliness. A. H. N.

1077. Extreme Pressure Lubricating Properties of some Chlorinated Compounds as Assessed by the Four-Ball Machines. W. Davey. *J. Inst. Petrol.*, March 1945, 31 (255), 73–88.—A study of the Extreme Pressure (E.P.) lubricant properties of some chlorinated compounds has been made, using the Four-Ball machine. A proprietary chlorinated compound was used as the standard reference material, and other materials were rated on their performance relative to this standard. On this rating, benzotrichloride, benzyl chloride, hexachlorethane, and carbon tetrachloride are superior to the reference material, whilst tetrachloroethane, chloroform, *p*-chloronitrobenzene, ethylene dichloride, trichlorethylene, and *p*-dichlorbenzene are inferior in E.P. properties. The mechanism of the development of E.P. properties due to chlorinated compounds is discussed. The results enable the E.P. properties of a chlorinated compound to be predicted from its formula. A. H. N.

1078. Some Observations on the Mechanism of the Development of Extreme Pressure Lubricating Properties by Reactive Sulphur in Mineral Oils. W. Davey. *J. Inst. Petrol.*, May 1945, **31** (257), 154–158.—Mineral oils containing free sulphur or active sulphur compounds possess extreme-pressure (E.P.) lubricating properties not shown by straight mineral oils. It has been suggested that the development of these properties is due to the formation of sulphide films on the metal surfaces which prevent metal-to-metal contact. Sulphide films were formed on the surfaces of steel balls subjected to test in the Four-Ball Extreme-Pressure Lubricant Testing Apparatus. E.P. properties were observed using these treated balls, and a straight mineral-oil lubricant, similar to those obtained using untreated balls and an oil-containing reactive sulphur. The friction/time curves obtained using the treated balls show preliminary " sulphur curves " followed by " straight mineral-oil curves " as the sulphide film is worn away. The results, although somewhat irregular, offer some confirmation of the " sulphide layer " theory. A. H. N.

1079. Variation of Viscosity of Lubricating Oils with Temperature, Pressure and Velocity Gradient. K. S. Ramaiya. *Symp. Visc. Liquids and Colloids, Acad. Sci. U.S.S.R.*, 1941, **1**, 125–137.—A discussion and review of data, published in the literature, relative to these questions. 47 references. V. B.

1080. Determination of the Low-Temperature Viscosity of Lubricants for Wagon Axles. I. F. Blidchenko and V. N. Tishkova. *Symp. Visc. Liquids and Colloids, Acad. Sci. U.S.S.R.*, 1944, **2**, 167–172.—Various lubricating mixtures, either wholly distillates or else distillate/residue blends, and all having a viscosity of $2 \pm 0{\cdot}2°$ E. at 50° C., were examined with respect to their viscosities at − 50° C. As the low-viscosity components there were used gas oils with viscosities of 1·24–1·84° E. at 50° C. Viscosities were measured in a modified Ubbelohde–Holde tube; all oils were preheated at 50° C. for 10 min. Results at − 50° C. for viscosities in the range 800–8000 poises show a repeatability of about 2%. Crudes from various fields were used to provide the components. It is concluded that the most favourable viscosity/temperature relationship is given by a blend of a light Bibi-Eibat gas oil with a low viscosity (10° E. at 50° C.) residual fuel. Such blends, and those incorporating bitumens, have viscosities at − 50° C. of 800–1600 poises, as compared to values of 2400 poises for the lubricants in current use. The satisfactory performance of such lubricants was verified in a friction machine operating at − 50° C. and by actual trials in winter (− 53° C.) conditions. V. B.

1081. Improvements in Lubricating Greases. M. W. Webber. *J. Inst. Petrol.*, March 1945, **31** (255), 89–102.—A panoramic discussion of the requirements of ordinary and special type greases is made. Recent developments and improvements of greases are analyzed and immediately urgent problems requiring solution are indicated. A. H. N.

1082. Lubrication Vade Mecum (2)3 Lubrication Charts X.–XII. E. W. Steinwitz. *Petroleum*, June 1945, **8** (6), 113.—Continuing the lubrication charts, based on classification of machinery and uses, Chart X concerns modes of Transportation, XI refers to Building and Agricultural Machinery and XII to the Wood-working industry. To use the chart, the particular machine is found in Part II, the " Lubricant Code Number " noted and the specified lubricant determined from Part I. G. A. C.

Bitumen, Asphalt and Tar.

1083. Bitumen and the Bitumen Industry. 2. Manufacture of Asphaltic Bitumen. J. S. Jackson. *Petroleum*, June 1945, **8** (6), 102.—Asphaltic and mixed base crudes form material for manufacture of asphaltic bitumen, and a " topped " crude oil of Venezuelan origin, from which the lighter fractions have been removed, is used in Britain.

Flash distillation of the topped crude is carried out under vacuum, thus avoiding damage to bitumens or distillates. The oil is heated in pipe-stills, and volatile constituents flashed off in a column, the liquid bitumen being stripped by superheated steam at the steaming trays near the bottom. Temperature and liquid levels are automatically controlled. Laboratory control consists in periodic penetration and softening point determinations on the bitumen produced. Process is flexible so that bitumen with melting points as high as 120° C. or as low as 34° C. can be produced. Hard grades are run into bays to solidify, whilst soft grades are delivered hot in bulk or barrelled.

As distinct from straight bitumens produced by this process, blown bitumens of rubbery nature are made by blowing air through the heated bitumen. This process is also continuous, and the air/bitumen ratio and temperature of the bitumen in the blowing chamber must be closely controlled. Laboratory control is again in terms of penetration and softening point. G. A. C.

Coal, Shale and Peat.

1084. Production of Synthetic Liquid Fuel from Natural Gas. V. I. Komarewsky. *Refiner,* May 1945, **24** (5), 170–172. *Paper Presented before Petroleum Panel, Chicago War Production Conference.*—The development of Kogasin production from the early Sabatier synthesis of methane to the present-day production of mixed hydrocarbons is briefly discussed. It is concluded that future developments of the Fischer–Tropsch synthesis must proceed in the following directions: (*a*) development of sulphur-resisting catalyst; (*b*) utilization of carbon monoxide-hydrogen mixtures of various composition; (*c*) synthesis of branched-chain hydrocarbons. The last goal can probably be achieved by developing a " complex-action " catalyst combining the hydrogenating, polymerizing, and isomerizing ability. A. H. N.

1085. Thermal Solution of Solid Fuels. III. Coals and their Petrographic Ingredients. M. K. D'yakova and N. V. Melent'eva. *J. Appl. Chem.* (*U.S.S.R.*), 1943, **16**, 296–307. (Cf. Abstract No. 522/1945).—Six samples of (Donbass) coal ranging from bituminous to anthracite were subjected to thermal solution in tetralin at 400° C. Solubility varied from 6 to 69% and was the greater the lesser the degree of carbonization of the coal. A sample of graphite examined was only soluble to the extent of 0·6%. Individual examination of petrographic constituents of coals showed that solubility decreased in the order clarite, vitrite, durite, fusite. Among the products obtained from the less carbonized coals was 5–9% of crude gasoline. Main product is a coal extract in the form of a pitch-like material having a m. p. 70–90° C., and which is suitable for hydrogenation. V. B.

Engines and Automotive Equipment.

1086. Ammonia—A Fuel for Motor Buses. E. Kroch. *J. Inst. Petrol.*, July 1945, **31** (259), 213–223.—Due to war conditions in Belgium, a substitute for diesel fuel was necessary, and this paper reports the use of ammonia and its advantages over the use of coal gas. In combination with coal gas it has been tried on a fairly large scale during one year. When properly installed and when adequate care is taken, this motor fuel gives excellent results comparing favourably with those previously obtained with gas oil. There was no loss of power, no corrosion, and no increase of the lubricating-oil consumption. Coal gas as the ignition promoter for ammonia may be replaced by other gases (or liquids), particularly by hydrogen. By doing so the fuel combination ammonia–hydrogen becomes entirely independent of coal. Hydrogen can be obtained from electrolytic cells and nitrogen from air. The necessary energy can be obtained from water turbines. No comparison of costs has been attempted, as the operations have taken place during a period of price control and all kinds of restrictions, which would not give a true picture of the possibilities of this fuel in normal circumstances. A. H. N.

Miscellaneous.

1087. Second List of Definitions. Standardization Sub-Committee No. 11. Nomenclature. *J. Inst. Petrol.*, June 1945, **31** (258), 188–190.—The following items are defined: aromatics, asphalt, asphaltic bitumen or bitumen, asphaltic cement, aviation gasoline, benzene, benzole, black oils, bloom, blown bitumen, bright stock, bunker oils or fuel, cracking, cutback, cylinder stock, ethyl fluid, extreme pressure lubricant, flux oil, gear oil, hypoid lubricant, lake asphalt, natural asphalt, mastics, octane-number, road oil and tetraethyl lead. A. H. N.

INSTITUTE NOTES

SEPTEMBER, 1945.

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.

AGREN, Per Henning Wilhelm, Superintendent and Manager of A. Johnson & Co., Oil Refinery, Nynasham, Sweden. (*Harold Moore ; H. E. Charlton.*)

ASH, William Mathews Valy, General Manager, United British Oilfields of Trinidad, Ltd. (*J. S. Gaynor ; S. T. Waite.*)

BAILEY, Dennis Raymond, Chemical Assistant, " Shell " Refining & Marketing Co., Ltd. (*W. R. P. Hodgson ; P. G. Higgs.*)

BAILY, George Arthur, Analyst, C.R.A.S.C., B.L.A. (*O. A. Bell ; A. C. Mauchan.*)

BAXTER, George William, Geologist, Trinidad Petroleum Development Co., Ltd. (*G. W. Halse ; C. C. Wilson.*)

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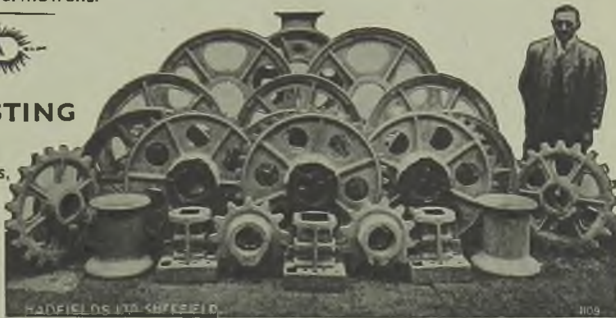

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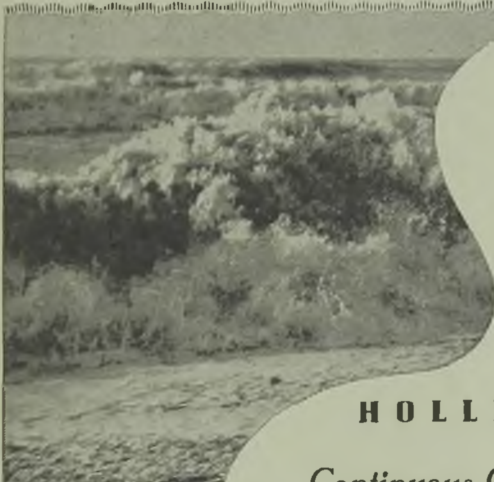

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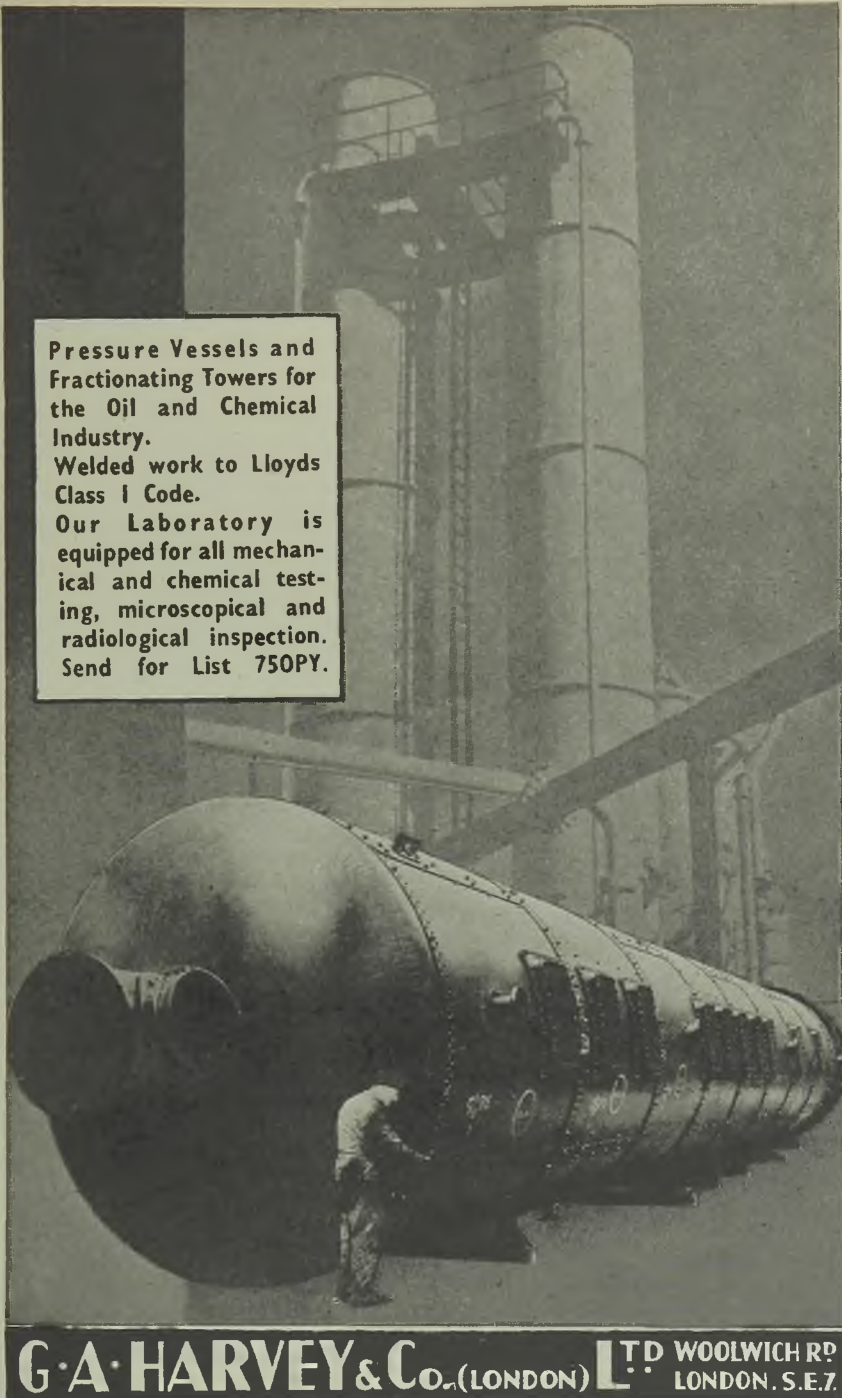
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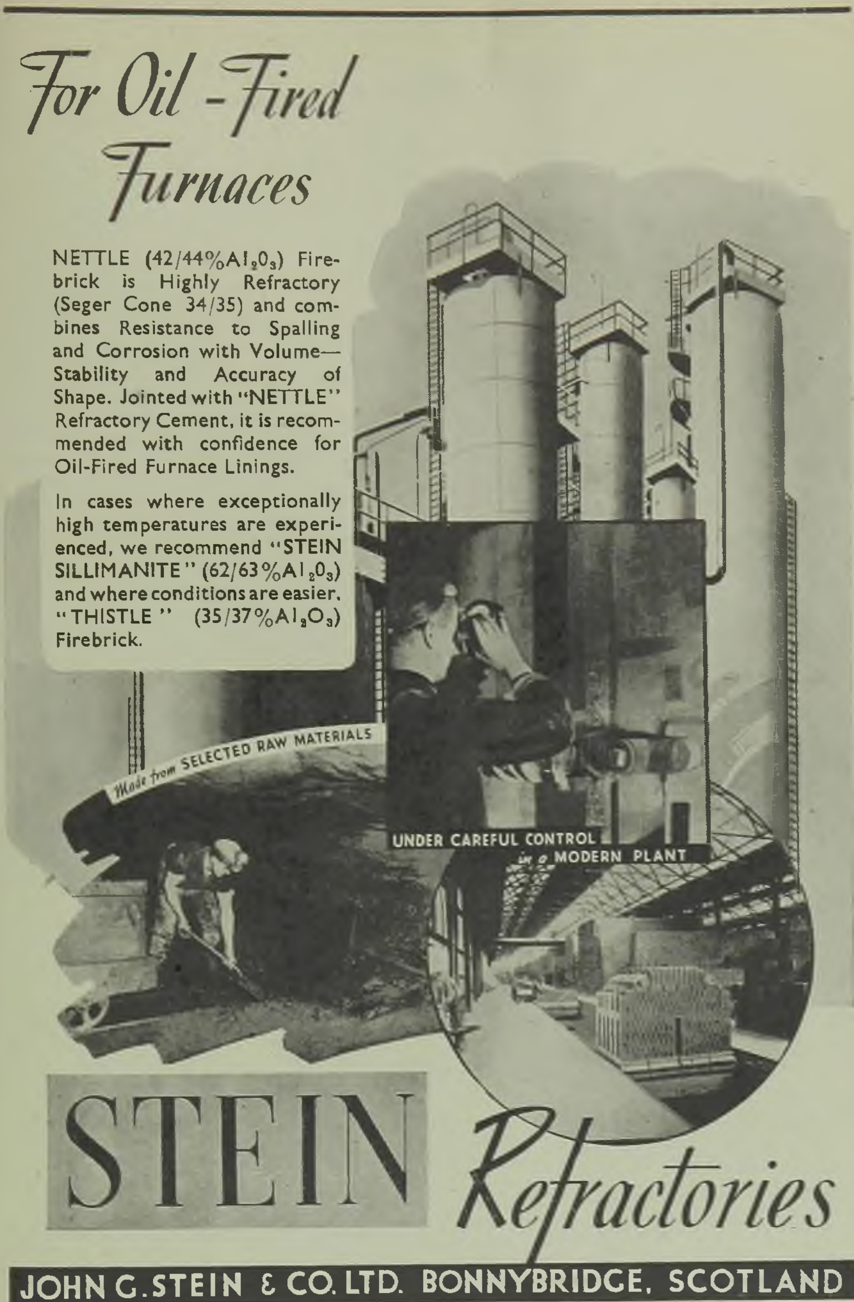

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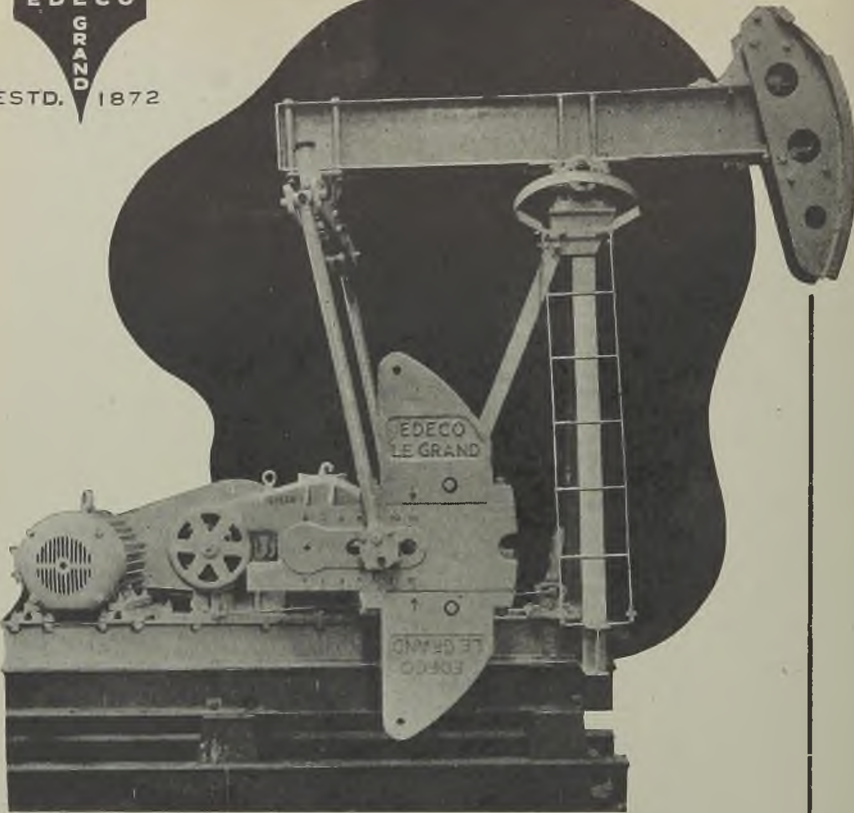

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